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ABSTRACT

Twelve PLATO lessons are reproduced in this document to show the status of computer guided experimentation (CGE) instructional programs. The lesson topics include a description of the CGE-PLATO instructional laboratory, an introduction to CGE-PLATO tests and special software routines, router lesson for two electrical engineering courses, and an introduction to the CGE station. Lesson five is the operation and uses of the oscilloscope Analab 1120, and lesson six concerns the operation and uses of the audio oscillator, HP 200AB. Lessons seven, eight, and nine introduce the operation and use of the function generator Exact 251; the D.C. supply, Harrison 865B; and the vacuum tube voltmeter, HP400D. Lesson ten is an experiment in the measurement of transients, lesson eleven is an experiment in measurements of impedance, and lesson twelve is an experiment in measurement of two-port networks. (CH)

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**THE CGE-PLATO
ELECTRONIC LABORATORY
INSTRUCTIONAL PROGRAMS**

J.P. Neal

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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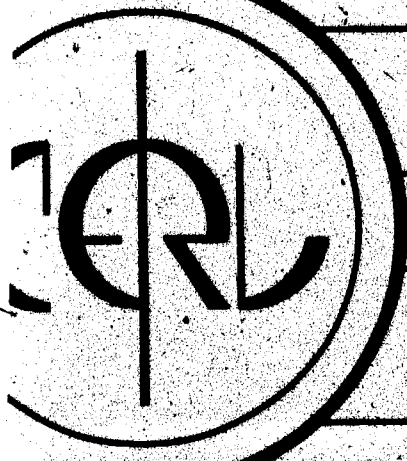
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THE CGE-PLATO ELECTRONIC LABORATORY
INSTRUCTIONAL PROGRAMS

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ABSTRACT

The twelve PLATO Lessons reproduced as Varian Prints in this report show the status of the CGE Instructional Programs as of August, 1974. This MTC Report supplements MTC Report #4, "The CGE-PLATO Electronic Laboratory Station Structure and Operation," and MTC Report #5, "Electronic Laboratory Instruction Using the CGE-PLATO Laboratory Station."

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and
TAB LESSON-LOCATOR

PLATO Lesson cge' _____

PLATO Lesson cger1 _____

PLATO Lesson cgeindex _____

PLATO Lesson eex00 _____

PLATO Lesson eex01 _____

PLATO Lesson eex02 _____

PLATO Lesson eex03 _____

PLATO Lesson eex04 _____

PLATO Lesson eex05 _____

PLATO Lesson eex06 _____

PLATO Lesson eex07 _____

PLATO Lesson eex08 _____

block 1a, cgeid

2 stop
 3 **** For Neal, CGERL, Room 248 EEB.
 4 One line description of this lesson --
 5 A Description of the CGE-PLATO Instructional Laboratory.

6	Divisions of this Lesson:	Block	Unit
7	Log of users of this lesson	cgeid	cgeida
8	Description of cge	cgem0a	cgem0a
9	Recent userlog	userlog	
10	Common for log of users of cge	uselog	

11 Final edit 26 aug 74 neal.

12 *list info
 13 *list symbols
 14 *list varian,charset,cgeindex,cgechar

15 *****

16 start

17 ext 0

18 dataon

19 area cge

20 course n70

21 jump n70='eocge',cgem0a,x

22 ***

23 unit cgeida \$\$ logs all noncge users into uselog

24 common cge,uselog,322

25 jump nc2=315,cgem0a,x

26 calc nc1=cgedata',nc1+'cgedata', 'cgedata'+0(nc2+4)

27 name nc(nc2)

28 calc nc(nc2) enc(nc2)+o55

29 calc nc(nc2 enc2+1) en70+o55

30 date nc(nc2+nc2+1)

31 calc nc(nc2 enc2+1) + (int (station+320) +27) 8¹⁰

32 calc nc(nc2 enc2+1) enc(nc2 enc2+1) + (frac (int (station/32) /10) *10+27) 8⁸

33 calc nc(nc2 enc2+1) enc(nc2 enc2+1) + (o46) 8⁶

34 calc nc(nc2) enc(nc2) + (int (frac (v3+station+32) *3.2) +27) 8⁴

35 calc nc(nc2) enc(nc2) + (frac ((frac (v3+station+32) *3.2) *10+27) 8²+o55

36 nc2 enc2+2

37 jump cgem0a

38 ***

39 unit cgeidb \$\$ provides jumpout to sample

40 term sample

41 at 1617

42 write One moment please..... returning to SAMPLE.



43 inhibit jumpchk
44 jumpout sample
45 next cgeidb

-----part=1, block=b-----

block 1b, cgem0a

47 unit cgem0a
48 base
49 next cgem0b
50 at 205
51 write A Description of the CGE-PLATO Instructional Laboratory
52 in CGERL, Room 248 EEB, University of Illinois

53 As outlined herein, Computer-Guided Experimentation
54 (CGE) instructional experiments are designed for use at
55 a special CGE-PLATO laboratory station which has a CGE
56 hardware interface linking sensors on adjacent electronic
57 laboratory equipment with the PLATO console.

58 For an operational demonstration of CGE, contact:

59 Dr. J. P. Neal, Prof. Emeritus
60 Department of Electrical Engineering
61 University of Illinois,
62 Urbana, Illinois 61801

63 217-333-4351 or 333-3496 or 344-6116

64 Or come visit the CGE Research Laboratory (CGERL) at:

65 Room 248 EEB, University of Illinois, Urbana, Ill.

66 Press -NEXT- to proceed.

-----part=1, block=c-----

block 1c, cgem0b

68 unit cgem0b
69 back cgem0a
70 next cgem0c
71 at 804
72 write The object of this CGE-PLATO research is to demonstrate,
73 that the Computer-Guided Experimentation-PLATO system will
74 provide unique and worthwhile improvements in undergraduate
75 or technician laboratory instruction, when properly used

76 by competent instructors.

77 The CGE station consists of a PLATO IV console, a
78 CGE-PLATO Interface Logic System, five rack-mounted
79 electronic instruments, and various experimentation
80 circuit boards for student use in learning electronic
81 instrumentation and measurements.

82 Students presently active in CGE Research are:

83 Borth, David E.
84 Derrig, Daniel P.
85 Zanter, Douglas L.

86 ***

87 unit cgem0c
88 back cgem0b.
89 next cgem0d
90 at 504

91 write The CGE-PLATO Interface Logic System enables any author
92 to order the automatic sensing of the interconnections
93 between 30 terminals on the rack-mounted equipment or on
94 the currently-used circuit board and/or the settings of
95 22 of the dials, knobs, or switches on the equipment.

96 The panel layout of the present CGE station is
97 illustrated in the next display. The present CGE
98 rack-mounted instruments are:

99 Analab Dual-trace Scope Type 1120 and Plug-In Type 700
100 Exact Function Generator Type 251
101 Hewlett-Packard Audio Oscillator Model 200AB
102 HP Vacuum Tube Voltmeter Model 400D
103 Harrison Lab. Model 865B Power Supply

104 The CGE-PLATO Interface Logic System is mounted behind
105 the instrument rack panel, beneath the Function Generator.

106 On the next display, the automatically-sensed terminals
107 may be identified by T numbers, and the automatically-
108 sensed dials may be identified by D numbers.

----- part=1, block=d -----

block 1d, cgem0d

110 unit cgem0d
111 back cgem0c
112 define panel
113 switch=1
114 trmnl=2
115 ground=3
116 dcsw=4
117 solid=5

```

118 char trmnl
119      0000016,0000033,0000021,0000033,0000016,0000000,0000000,0000000
120 char switch
121      0000000,00000340,00000760,0001777,0001777,00000760,00000340,0000000
122 char ground
123      0000000,0100000,0120000,0124000,0124000,0120000,0100000,0000000
124 char dcsw
125      00000600,00000600,00000600,00000600,0001700,0003740,0003740,0001700
126 char solid
127      0177777,0177777,0177777,0177777,0177777,0177777,0177777,0177777
128 draw 509,133;0,133
129 zero n5
130 zero n6
131 calc n7+1314
132 join cges1a
133 join cges1b
134 add1 n5
135 calc n7+1534
136 join cges1a
137 join cges1c
138 add1 n5
139 calc n7+1552
140 join cges1a
141 join cges1d
142 add1 n5
143 calc n7+2212
144 join cges1a
145 join cges1e
146 add1 n5
147 calc n7+2243
148 join cges1a
149 join cges1f
150 add1 n5
151 join cges1a
152 join cges1g
153 at 3117
154 write Press -LAB- for sensed dials.
155      Press -DATA- for sensed terminals.

156 entry cgem0de
157 pause
158 calc n1+(key=next$or$key=back) - (key=lab) -2 (key=data)
159 join n1,x,x,cges2a,cges3a/x
160 jump (key=next) - (key=back),cgem0e,x,cgem0c
161 goto key=0216,x,cgem0de,x
162 press 0216
163 ***

```

----- part=1, block=e -----

block 1e, cgem0e

```

165 unit cgem0e
166 back cgem0d

```

167 next cgem0f
168 at 705
169 write Actual laboratory experiments are programmed by
170 experienced laboratory instructors on the PLATO system.

171 The instructor writing a program provides for the
172 automatic sensing of terminal interconnections and/or
173 dial settings wherever he deems necessary.

174 The response of the program to the feedback information
175 of the student's physical operations can be used in any
176 manner the instructor devises for improving the student's
177 learning.

178 Each student can work independently at a CGE station
179 and learn at his own rate how to use the equipment,
180 and perform or devise meaningful experiments.

181 ***

182 unit cgem0f
183 back cgem0e
184 next cgem0g
185 at 903
186 write CGE is an entirely new instructional system, and
187 research is required to develop its teaching capabilities
188 and demonstrate their superiorities in comparison with
189 conventional laboratory instruction or training simulators.

190 CGE is not simply a new Teaching Aid, it is a New Teaching
191 Method with unexplored and unknown capabilities.

192 The manner in which a student at a CGE station in a
193 laboratory is provided ready access to laboratory facilities,
194 theoretical material, computer assistance, and
195 instructor assistance is visualized in the next display.

----- part=1, block=f -----

block 1f. cgem0g

197 unit cgem0g
198 back cgem0f
199 next cgem0h
200 calc n1*.5
201 circle 129,256,368
202 at 427
203 write Student
204 in
205 Laboratory
206 delay n1
207 circle 129,256,144
208 at 2626

209 write Student
 210 in
 211 Theory Course
 212 delay n1
 213 circle 128,320,256
 214 at 1746
 215 write Instructor
 216 delay n1-2
 217 at 2238
 218 write Instructor
 219 Aid
 220 at 1038
 221 write Instructor
 222 Aid
 223 delay n1
 224 circle 128,192,256
 225 at 1711
 226 write Computer
 227 delay n1-2
 228 at 2219
 229 write Computer
 230 Aid
 231 at 1019
 232 write Computer
 233 Aid
 234 delay n1+2
 235 at 244,192
 236 write CAI
 237 delay n1+2
 238 at 244,304
 239 write CGE
 240 delay n1+2
 241 size 1
 242 at 212,249
 243 write CGE Station
 244 delay n1-2
 245 size 8
 246 mode reumite
 247 at 3007
 248 write The CGE Station provides the student with complete
 249 access to Computer Aid and Instructor Aid for both lab-
 250 oratory and theoretical learning.
 251 mode write

----- part=1, block=g -----

block 1g, cgem0h

253 unit cgem0h
 254 back cgem0g
 255 next cgem0f
 256 at 204
 257 write All the PLATO lessons used by CGE are open for inspection
 258 by authors. These lessons are:

259	CGE-PLATO	TOPIC
260	LESSON	
261	cge	A Description of the CGE-PLATO Instructional Lab.
262	cgerl	CGE-PLATO Tests & Special Software Routines
263	ee244	Student List for CGEPL Course
264	eece	Author List for CGERL Course
265	cgeindex	Router Lesson for Courses ee244 and eece
266	cgedata	Data File for courses ee244 and eece
267	eex00	An Introduction to the CGE Station
268	eex01	The Oscilloscope
269	eex02	The Audio Oscillator
270	eex03	The Function Generator
271	eex04	The Constant Voltage/Constant Current Supply
272	eex05	The Vacuum Tube Voltmeter
273	eex06	Measurements of Transients
274	eex07	Measurements of Impedance
275	eex08	Measurements of Two-Port Networks

276 Note: Authors in the student mode can press -MICRO-
 277 to pass OK through a check. Students cannot do this.

278 MTC Report #4, July 1974, CERL, is entitled
 279 "The CGE-PLATO Electronic Laboratory Station Structure
 280 and Operation", by J. P. Neal.

281 ***

282 unit cgem0i
 283 back cgem0b
 284 next cgeend
 285 at 707
 286 write To review this Description of CGE-PLATO, press -BACK-.

287 To access the CGE Experiments, press -NEXT-.

-----part=1, block=h-----

block 1h, cges1a

289 unit cges1a
 290 at n6
 291 mode erase
 292 writed n5-1, Dual-Trace SCOPE, Audio Oscillator, VTVM,
 293 Function Generator, DC Supply,,
 294 calc n6#n7
 295 at n7
 296 mode write
 297 writed n5, Dual-Trace SCOPE, Audio Oscillator, VTVM,
 298 Function Generator, DC Supply,,
 299 ***
 300 unit cges1b

301 draw 606;635;1235;1206;606
302 circle 35,103,369
303 circle 3,55,366
304 circle 6,55,396
305 circle 6,55,336
306 circle 6,149,336
307 at 146,360
308 plot switch
309 at 165,327
310 plot trmnl
311 at 165,335
312 plot trmnl
313 at 179,327
314 plot trmnl
315 at 191,327
316 plot trmnl
317 at 260,327
318 plot trmnl
319 at 248,327
320 plot trmnl
321 at 236,327
322 plot trmnl
323 at 260,335
324 plot trmnl
325 circle 6,149,396
326 circle 3,181,392
327 circle 10,181,392
328 circle 3,213,392
329 circle 10,213,392
330 circle 3,245,392
331 circle 10,245,392
332 circle 6,255,352
333 circle 6,227,352
334 circle 6,199,352
335 circle 6,171,352
336 ***

337 unit cgesic
338 draw 637;647;1447;1437;637
339 circle 13,328,368
340 circle 35,328,368
341 circle 5,328,329
342 circle 10,353,311
343 circle 10,304,311
344 at 327,294
345 plot trmnl
346 at 337,294
347 plot trmnl
348 at 317,294
349 plot trmnl
350 at 358,400
351 plot switch
352 ***

353 unit cgesid
354 draw 649;659;1459;1449;649;skip;394,404;453,404;453,364;394,364;394,404
355 circle 44,424,334,135,46

356 draw 419,377;408,396
357 circle 13,424,327
358 at 452,339
359 plot switch
360 at 452,309
361 plot trmnl
362 at 452,295
363 plot trmnl
364 at 393,295
365 plot trmnl
366 at 393,309
367 plot trmnl
368 ***

369 unit cgesie
370 draw 1606;1635;2135;2106;1606
371 circle 8,160,217
372 circle 25,160,217
373 circle 4,184,199
374 circle 10,224,227
375 circle 6,224,227
376 at 256,245
377 plot trmnl
378 at 256,235
379 plot trmnl
380 at 256,225
381 plot trmnl
382 at 256,215
383 plot trmnl
384 at 256,185
385 plot trmnl
386 at 240,185
387 plot trmnl
388 at 222,185
389 plot trmnl
390 circle 5,201,185
391 circle 8,115,230
392 circle 8,83,230
393 at 51,237
394 plot trmnl
395 at 51,227
396 plot trmnl
397 at 51,217
398 plot trmnl
399 at 88,188
400 plot switch
401 ***

402 unit cgesif
403 draw 2141;1841;1853;2153;2141
404 draw 357,218;325,218;325,194;357,194;357,218
405 circle 6,401,194
406 circle 6,401,213
407 circle 6,376,203
408 at 393,181
409 plot trmnl
410 at 381,181

411 plot trmnl
412 at 369,181
413 plot trmnl
414 at 329,177
415 plot dcsu

-----part=i, block=i-----

block ii, cgesig

417 unit cgesig
418 at 2810
419 write Location behind the panel of the complete and
420 operable CGE-PLATO Interface Logic System
421 draw 272,171;40,171;40,138;272,138;272,171
422 draw 143,155;143,151;160,151;160,155;143,155
423 draw 348,78;194,132;skip;194,132;skip;192,134;178,148
424 178,144;182,148;178,148
425 at 46,165
426 plot trmnl
427 at 55,165
428 plot trmnl
429 pause
430 mode erase
431 draw 348,78;194,132;skip;194,132;skip;192,134;178,148
432 178,144;182,148;178,148
433 draw 272,171;40,171;40,138;272,138;272,171
434 draw 143,155;143,151;160,151;160,155;143,155
435 at 46,165
436 plot trmnl
437 at 55,165
438 plot trmnl
439 at 2810
440 write Location behind the panel of the complete and
441 operable CGE-PLATO Interface Logic System
442 mode write

-----part=i, block=j-----

block ij, cges2a

444 unit cges2a
445 join cges2b
446 join cges2c
447 join cges2d
448 join cges2e
449 join cges2f
450 ***

451 unit cges2b
452 draw 50,339;22,345

453 at 1101
454 write D8
455 draw 243,397;243,427
456 at 227,427
457 write D1
458 draw 211,397;211,427
459 at 195,427
460 write D2
461 draw 179,397;179,427
462 at 163,427
463 write D3
464 draw 169,352;153,442
465 at 137,442
466 write D7
467 draw 197,352;191,442
468 at 175,442
469 write D6
470 draw 226,352;226,452
471 at 210,452
472 write D5
473 draw 254,352;270,452
474 at 254,452
475 write D4
476 draw 146,333;127,310
477 at 111,290
478 write D9
479 ***

480 unit cges2c
481 at 146,261
482 write D12
483 draw 162,231;162,261
484 draw 224,227;240,267
485 at 224,267
486 write D14
487 draw 218,237;202,277
488 at 186,277
489 write D13
490 draw 198,180;182,160
491 at 166,140
492 write D15
493 draw 81,237;81,267
494 at 65,267
495 write D10
496 draw 113,237;113,267
497 at 97,267
498 write D11
499 ***

500 unit cges2d
501 draw 353,304;370,283
502 at 354,263
503 write D19
504 draw 300,303;292,279
505 at 276,259
506 write D20
507 draw 327,386;327,436

508 at 311,436
509 write D21
510 ***
511 unit cges2e
512 draw 425,333;474,378.
513 at 474,368
514 write D22
515 ***
516 unit cges2f
517 draw 374,204;374,234
518 at 358,234
519 write D16
520 draw 399,214;415,234
521 at 399,234
522 write D17
523 draw 399,194;431,194
524 at 431,184
525 write D18

part=i, block=k

block=k, cges3a

527 unit cges3a
528 join cges3b
529 join cges3c
530 join cges3d
531 join cges3f
532 join cges3g
533 join cges3h
534 ***
535 unit cges3b
536 draw 3044;2444;2423;3023;3044
537 at 3023
538 write CIRCUIT BOARD
539 at 176,104
540 write T1 T2 T3 T4 T5
541 at 2723
542 write T6 T7 T8 T9 T10
543 at 176,56
544 write T11 T12 T14 T15
545 ***
546 unit cges3c
547 draw 165,335;153,309
548 at 142,289
549 write T16
550 draw 191,327;191,307
551 at 181,287
552 write T18
553 draw 261,337;245,307

554 at 235,287
555 write T17
556 ***

557 unit cges3d
558 draw 256,215;288,195
559 at 288,185
560 write T22
561 draw 256,225;288,215
562 at 288,205
563 write T21
564 draw 256,235;288,235
565 at 288,225
566 write T20
567 draw 256,245;288,255
568 at 288,245
569 write T19
570 draw 222,185;238,165
571 at 222,145
572 write T23
573 draw 51,237;19,257
574 at 3,257
575 write T24
576 draw 257,185;289,165
577 at 286,148
578 plot ground
579 ***

580 unit cges3f
581 draw 327,294;311,274
582 at 295,254
583 write T28
584 draw 337,294;349,270
585 at 333,250
586 write T27
587 ***

588 unit cges3g
589 draw 393,309;409,279
590 at 393,259
591 write T29
592 draw 452,309;468,289
593 at 468,279
594 write T30
595 ***

596 unit cges3h
597 draw 369,181;353,161
598 at 337,141
599 write T25
600 draw 381,181;389,161
601 at 373,141
602 write T26
603 draw 393,181;402,168
604 at 398,152
605 plot ground

block 11, cgeend

607 unit cgeend
 608 at 710
 609 write Now jumping to an Index of CGE Experiments.
 610 inhibit jumpchk
 611 jumpout cgeindex
 612 stop

user log

613 stop
 614 cgedata
 615 d0
 616 sellers arizona 08/12/74 2
 617 0
 618
 619 -
 620 30
 621 imsssl stan 08/12/74 1
 622 2
 623
 624 -
 625 19
 626 imsssl stan 08/12/74 1
 627 2
 628
 629 -
 630 10
 631 eichmann e 08/13/74 0
 632 2
 633
 634 -
 635 12
 636 demo wright 08/13/74 2
 637 2
 638
 639 -
 640 08
 641 eichmann e 08/13/74 0
 642 2
 643
 644 -
 645 12
 646 lachman uioc 08/13/74 0
 647 1
 648
 649 -
 650 03
 651 sample cen1 08/13/74 1
 652 4

653
654 -
655 16
656 davis matha 08/13/74 0
657 3
658
659 -
660 21
661 student cu 08/14/74 0
662 2
663
664 -
665 00
666 student cu 08/14/74 0
667 2
668
669 -
670 00
671 student cu 08/15/74 0
672 2
673
674 -
675 00
676 visitor ee244 08/16/74 0
677 7
678
679 -
680 12
681 student cu 08/16/74 0
682 2
683
684 -
685 00
686 brown d siu 08/16/74 0
687 2
688
689 -
690 18
691 wetstone conn 08/16/74 2
692 3
693
694 -
695 06
696 wetstone com 08/16/74 2
697 3
698
699 -
700 06
701 sample cerl 08/18/74 0
702 3
703
704 -
705 22
706 sample cerl 08/18/74 0
707 3
708
709 -

710 22
711 smith arizona 08/19/74 2
712 0
713 /
714 -
715 28
716 smith arizona 08/19/74 2
717 0
718
719 -
720 28
721 cherub block 08/19/74 0
722 2
723
724 -
725 11
726 becky cerl 08/20/74 0
727 3
728
729 -
730 26
731 becky cerl 08/20/74 0
732 3
733
734 -
735 26
736 paul phys 08/20/74 1
737 6
738
739 -
740 03
741 ashworth siu 08/22/74 0
742 7
743
744 -
745 27
746 ashworth siu 08/23/74 0
747 3
748
749 -
750 13
751 ashworth siu 08/23/74 0
752 3
753
754 -
755 13
756 dan mathk 08/23/74 0
757 3
758
759 -
760 24
761 p-mast p 08/23/74 0
762 30
763
764 -
765 32
766 martin pdg 08/26/74 0

767	1										
768											
769	-										
770	16										
771	start										
	ogeend	ogeend	607		284						
	ogeida	ogeid	23								
	ogeidb	ogeid	39		45						
	ogem0a	ogem0a	47		21	25		37		69	
	ogem0b	ogem0b	68		49	85		283			
	ogem0c	ogem0b	87		70	111		160			
	ogem0d	ogem0d	110		89	166					
	ogem0de	ogem0d	156		161						
	ogem0e	ogem0e	165		160			183			
	ogem0f	ogem0e	182		167			198			
	ogem0g	ogem0g	197		184			254			
	ogem0h	ogem0h	250		199						
	ogem0i	ogem0h	282		255						
	oges1a	oges1a	289		132	136		140	144	151	148
	oges1b	oges1a	300		133						
	oges1c	oges1a	337		137						
	oges1d	oges1a	350		141						
	oges1e	oges1a	369		145						
	oges1f	oges1a	402		149						
	oges1g	oges1g	417		152						
	oges2a	oges2a	444		159						
	oges2b	oges2a	451		445						
	oges2c	oges2a	480		446						
	oges2d	oges2a	500		447						
	oges2e	oges2a	511		448						
	oges2f	oges2a	516		449						
	oges2g	oges2a	507		159						
	oges2h	oges2a	535		528						
	oges2i	oges2a	546		529						
	oges2j	oges2a	567		530						
	oges2k	oges2a	500		531						
	oges2l	oges2a	586		532						
	oges2m	oges2a	596		533						
	Back	panel	158	160							
	data	panel	158								
	data	panel	116	124	415						
	inac	panel	32	34	35	35					
	round	panel	115	122	576	605					
	int	panel	31	32	34						
	key	panel	158	158	158	158	160	160	160	161	
	lab	panel	158								
	nc	panel	27	28	28	29	30	32	31	33	32
			33	34	34	35	35				
	nc1	panel	26	26							
	nc2	panel	25	26	27	28	28	30	29	30	29
			31	31	32	32	32	33	32	33	33
			33	34	34	35	35	36		36	
	next	panel	158	160							
	n1	panel	158	159	200	206	212	227	216	234	223
			237	240	244						
	n5	panel	129	134	138	142	146		150	217	292
	n6	panel	130	290	294						

n7	panel	131	135	139	143	147	294	295
n70	panel	120	21	29				
solid	panel	117	126					
station	panel	31	32	34	35			
switch	panel	113	120	308	351	359	400	
trmnl	panel	114	118	310	312	314	320	316
		324	345	347	349	361	307	363
		379	381	383	385	387	396	389
		409	411	413	426	428	436	438
v3	panel	34	35					

lesson information

lesson name = cge

starting date = 07/17/73

last edited on 08/26/74 at 11.31.45

by neal of course ecge

at site 7, station 27

author name = J. P. Neal

department = E.E.

telephone number = 333-4351

discipline = Elec. Engineering

grade level = Any

description of lesson = A Description of the CGE-PLATO Instructional Laboratory.

block 1a, cgerlid

```

2 stop
3 **** For Neal, CGERL, Room. 248, EEB.
4 One line description of this lesson ---
5 CGE-PLATO Tests & Special Software Routines
6
6 Divisions of this Lesson:      Block      Unit
7 Id for this lesson              cgerlid
8 Access from the student mode    rlm0a      rlm0a
9 Cge index of lessons            rlm0a      rlm1a
10 Listing of connections          rlm0a      rlm2a
11 Cc test                         rlm3a,rlm3a
12 Listing of dial settings       rlm3a      rlm4a
13 Dc test                         rlm5a      rlm5a
14 Transmit over ext channel      rlm5a      rlm6a
15 Repeated check of 1 dial       rlm5a      rlm7a
16 Cge checker authoring aids     rlm7b      rlm8a
17 Slide display                  rlm9a      rlm9a
18 Cge software record-maintenance rlm10a     rlm10a
19
19 final edit 21 aug 74 neal.
20 *list info
21 *list symbols
22 *list varian,charset,cgeindex,cgechar
23 *****
24 start
25 ext 0                          $$ clears cge hardware
26 dataoff
    
```

block 1b, rlm0a.

```

28 unit rlm0a
29 course n51
30 jump ((n51='ecge')$and$user='author'),x,rlm0b
31 back rlmend
32 base
33 erase
34 at #11
35 write Type the number of the following topic in
36 which you are interested:
    
```

37 1. Index to CGE Lessons and Stations
 38 2. Listing of Current Connections
 39 3. CC Test
 40 4. Listing of Current Dial Settings
 41 5. DC Test
 42 6. Transmit Data over External Channel
 43 7. Repeated Check of a Selected Dial
 44 8. CGE Checker Authoring Aids
 45 9. Slide Display
 46 10. CGE Software Record-Maintenance
 47 arrow 2725
 48 match n150,1,2,3,4,5,6,7,8,9,10
 49 jump n150,x,rlm1a,rlm2a,rlm3a,rlm4a,rlm5a,rlm6a,rlm7a,rlm8a,rlm9a,rlm10a
 50 ***

51 unit rlm0b
 52 jumpout plato
 53 ***

54 unit rlm1a
 55 base
 56 back rlm0a
 57 next rlm0a
 58 at 305
 59 write

CGE-PLATO LESSONS

60	LESSON	TOPIC
61	cge	A Description of the CGE-PLATO Instructional Lab.
62	cgerl	CGE-PLATO Tests & Special Software Routines
63	ee244	Student List for CGERL Course
64	eece	Author List for CGERL Course
65	cgeindex	Router Lesson for Courses ee244 and eece
66	cgedata	Data File for courses ee244 and eece
67	eex00	An Introduction to the CGE Station
68	eex01	The Oscilloscope
69	eex02	The Audio Oscillator
70	eex03	The Function Generator
71	eex04	The Constant Voltage/Constant Current Supply
72	eex05	The Vacuum Tube Voltmeter
73	eex06	Measurements of Transients
74	eex07	Measurements of Impedance
75	eex08	Measurements of Two-Port Networks
76	at	2603
77	write	CGE-PLATO stations in CGERL at 248 EEB:
78		
79		Site 7, Station 12, Console #118 w/o experimental equipment
80		Site 7, Station 27, Console #324 w/CGE-PLATO I/O & exp. eqpt.
81	***	

82 unit rlm2a
 83 base
 84 back rlm0a
 85 next rlm2a
 86 join rlm2b
 87 at 3112
 88 write Press -NEXT- to check connections again.

Press -BACK- when done.

part=1, block=c

block 1c, rlm2b

```

91 unit rlm2b
92 define rlm2b
93 cc=040
94 check=n1 $$ marks a checked terminal
95 start=n2 $$ first terminal in a node
96 termc=n3 $$ marks terminal to be examined
97 keytime=v4 $$ records time since last key
98 datac=n5 $$ stores data from key
99 namterm=n6 $$ name of terminal to be displayed
100 screen=n7
101 node=n8
102 at 310
103 write LISTING of CURRENT TERMINAL INTERCONNECTIONS
104 calc check=0
105 start=termc+1
106 keytime=clock
107 screen=320
108 node=0
109 time 1
110 enable
111 ext cc+termc $$ first request for terminal data
112 entry rlm2c
113 pause
114 goto (key=timeup) - (key=next$or$key=stop), rls2a, x, rls2b
115 goto (key$mask$01000)=0, rlm2c, x $$ locks out keyboard
116 calc datac=key$mask$037 $$ bottom 5 bits are data bits
117 check+check,$union$(1$cls$(termc-1)) $$marks terminal
118 keytime=clock
119 goto datac=start, rls2c, x
120 goto (termc=start)$and$node=6, rls2e, x
121 writec n3=n2, (at, -5+n7+n7+200)Terminals Connected to NODE (a,07000+n8+n8+1),,
122 size 0
123 calc namterm=termc
124 calco termc=start, screen=screen+100, screen=screen
125 at screen
126 join termc=start, rls2d,
127 calc namterm=datac
128 at screen=screen+100
129 join rls2d
130 goto where>3000, rls2e, x
131 calc termc=datac
132 ext cc+termc
133 goto rlm2c
134 ***
135 unit rls2a

```

```

136 time 1
137 goto (clock-keytime>1.5),x,rlm2c
138 calc keytime+clock
139 ext cc+termc
140 goto rlm2c
141 ***

142 unit rls2b
143 pause

144 entry rls2e
145 ext 0
146 writec (bitont (check) <30) - (screen=320), (at,screen+198)* AND MORE *,
147 (at,screen+200)* CHECK COMPLETED *,
148 (at,screen+394)* Terminals are not interconnected *
149 size 0
150 ***

151 unit rls2c
152 goto start>30,rls2e,x
153 calc start+start+1
154 calc termc+start
155 goto (check$ars$(start-1)$mask$1)=0,x,rls2c
156 ext cc+termc
157 goto rlm2c
158 ***

159 unit rls2d
160 writec namterm,,Term 1,Term 2,Term 3,Term 4,Term 5,Term 6,Term 7,
161 Term 8,Term 9,Term 10,Term 11,Term 12,GROUND,Term 14,
162 Term 15,Scope: A input,Scope: B input,Scope: Trigger,
163 Fun-gen: Sqr-wave output,Fun-gen: Trng-wave output,
164 Fun-gen: Sine-wave output,Fun-gen: Ramp output,
165 Fun-gen: Atten'd output,Fun-gen: Trigger output,
166 DC-sup: (+) term,DC-sup: (-) term,Aud-osc: Right output,
167 Aud-osc: left output,VTVM: input,VTVM: output

```

----- part=1, block=d -----

block 1d, rlm3a

```

169 unit rlm3a
170 define rlm3a
171 cc=040
172 termc=n1-9
173 at 227
174 write CC Test
175 at 318
176 write (Press -DATA- to restart)
177 at 604
178 write term "octal decimal"
179 at 634
180 write term octal decimal
181 calc n1+10

```

```

182 calc v50←v52←clock
183 n51←0
184 time 1
185 enable
186 ext cc+termc

187 entry rlm3b
188 pause
189 goto (key=timeup) - (key=next$or$key=stop), rlm3c, x, rlm3d
190 calc n(n1)←key
191 n1←n1+1
192 v50←clock
193 goto termc>30, rlm3d, x
194 ext cc+termc
195 goto rlm3b
196 ***

197 unit rlm3c
198 time 1
199 goto clock-v50>1.5, x, rlm3b
200 calc v50←clock
201 n51←n51+1
202 ext cc+termc
203 goto rlm3b
204 ***

205 unit rlm3d
206 ext 0
207 calc v53←clock
208 at 3010
209 write Number of DATA Transmission Repeats =
210 showt n51
211 at 3110
212 write Total DATA Transmission Time =
213 showt v53-v52, 4.3
214 write seconds.
215 calc n4←0
216 n3←605
217 do rlm3f, n2←1, (n1-10) + 2
218 calc n3←635
219 do rlm3f, n2←((n1-10) + 2 + 1), n1-10

220 entry rlm3e
221 pause
222 jump (key=next$or$key=back) - (key=data), rlm3a, x, rlm3a
223 goto rlm3e
224 ***

225 unit rlm3f
226 calc n3←n3+100
227 n145←n2
228 at n3
229 showt n2, 2
230 write
231 showt n(n2+9), 4
232 at n3+9
233 calc n99←n(n2+9) $mask$077

```

```

234 showt n99
235 ***

236 unit rlm4a
237 base
238 back rlm4a
239 next rlm4a
240 join rlm4b
241 at 3115
242 write Press -NEXT- to check dials again.
243 Press -BACK- when done.

```

part=1, block=

block 1e, rlm4b

```

245 unit rlm4b
246 define rlm4b
247   dc=0000
248   dial=n1
249   code=n2
250   screen=n3
251   keytime=v4
252 calc n22+nc2+nc2+1
253 do rlm4c
254 calc screen+511
255   dial+1
256   keytime+clock
257 time 1
258 enable
259 ext dc+dial

260 entry rlm4d
261 pause
262 goto (key=timeup) - (key=next$or$key=stop),rlm4e,x,rlm4f
263 goto (key$mask$01000)=0,rlm4d,x /$$ lockout keyboard
264 calc code+key$mask$037
265   keytime+clock
266 do rlm4g          $$ generates display
267 calc dial+dial+1
268 goto dial>22,rlm4f,x
269 ext dc+dial
270 goto rlm4d
271 ***

272 unit rlm4e
273 time 1
274 goto clock-keytime>1.5,x,rlm4d
275 calc keytime+clock
276 ext dc+dial
277 goto rlm4d
278 ***

279 unit rlm4f

```



```

280 ext      0
281 exit     1.
282 ***

283 unit     rlm4g
284 at       screen+screen+100
285 writtec  dial,,,PLUG-IN,,,,,SCOPE,,FUN-GEN,,,,,
286         DC-SUP,,,AUD-OSC,,,VTVM
287 at       screen+8
288 writtec  dial,,,B VOLTS,TIME,A VOLTS,B PREAMP,
289         SWEEP MODE,TRIGGER.SOURCE,A PREAMP,
290         Y DISPLAY FUNC,X DISPLAY FUNC,
291         TRIGGER,MULTIPLIER,CYCLES/SEC,
292         OUTPUT,ATTENUATOR,DC LEVEL,METER,
293         VOLTAGE,CURRENT,AMPLITUDE,
294         RANGE,FREQUENCY,RANGE
295 at       screen+23
296 do       dial,x,x,d1,d2,d1,d4,d5,d6,d4,d8,d9,d10,x
297 do       dial-10,x,x,d11,d12,d13,d14,d15,d16,d17,d18,d19,d20,d21,d22
298 ***

299 unit     d1
300 writtec  code,-,0,1 m,2 m,5 m,10 m,20 m,50 m,0.1 ,0.2 ,0.5 ,
301         1.0 ,2.0 ,5.0 ,10 ,20 ,50 ,100 ,200
302 write    V full scale
303 ***

304 unit     d2
305 writtec  code,-,0,10 u,20 u,50 u,100 u,200 u,500u,
306         1 m,2 m,5 m,10 m,
307         20 m,50 m,100 m,200 m,500 m,1,2,5,10,20,50,ext
308 write    sec. full scale
309 ***

310 unit     d4
311 writtec  code,-,0,-AC,+AC,+DC,-DC,OFF,BAL SET
312 ***

313 unit     d5
314 writtec  code,-,0,ARM - variable length,
315         MAN - variable length,
316         AUTO - variable length,
317         DRIV - variable length,
318         DRIV - variable sweep rate,OFF,
319 ***

320 unit     d6
321 writtec  code,-,0,LINE,AC - ext - 20,DC - ext + 20,AC - ext,
322         DC - ext,AC - int,DC - int,,
323 writtec  code-8, OFF,

```

----- part=1, block=f -----

block 1f. rlm4g

```

325 unit rlm4c
326 at 419
327 write Dial Current Setting
328 at 419
329 write -----
330 ***

331 unit d8
332 writec code,-,0,A,B,A & B (CHOP),A & B (ALT),A vs B
333 ***

334 unit d9
335 writec code,-,0,SWP*5,SWP,EXT
336 ***

337 unit d10
338 writec code,0,INT,EXT
339 ***

340 unit d11
341 write times
342 writec code,-,0,0.001,0.01,0.1,1.0,10,100,1000,
343 ***

344 unit d12
345 writec code,-,0.1,1.1,1.5,1.9,2.3,2.7,3.2,3.6,4.1,4.5,
346 5.0,5.4,5.9,6.3,6.8,7.2,7.7,8.0,8.5,9.0,9.4,9.9,10.2
347 write Hz (not incl. MULT.)
348 ***

349 unit d13
350 writec code,-,0,RAMP,SINE,TRIANGLE,SQUARE,
351 ***

352 unit d14
353 writec code,-,0,2.7,3.5,4.8,6.1,7.2,8.1,8.7,9.8,10.4,11.1,11.5,
354 12.0,12.5,13.0,13.3,13.5,14.0,14.1,14.4,14.8,15.0,15.1
355 write volts
356 ***

357 unit d15
358 writec code,-,0,0.0,0,-56.5,-55.5,-52.5,-48,-44,-39,-35,-31,-27,
359 -24,-20,-17,-14,-13,-13,-10,2,30,50
360 write volts
361 ***

362 unit d16
363 writec code,-,0,VOLTS,AMPS,
364 ***

365 unit d17
366 writec code,-,0,0.1,0.9,3.3,5.6,8.2,11.0,13,15,17,20,21,23,26,
367 28,30,32,34,36,39,40,42,44
368 write volts
369 ***

```

```

370 unit      d18
371 writec    code, -, 0, 0.0, 0.0, 0.01, 0.05, 0.07, 0.10, 0.14, 0.17, 0.20, 0.25,
372           0.27, 0.29, 0.31, 0.35, 0.37, 0.40, 0.43, 0.46, 0.50, 0.52, 0.55, 0.59
373 write     amperes
374 ***

375 unit      d19
376 writec    code, -, 0, 0.04, 1.0, 2.0, 4.0, 6.0, 8.0, 9.0, 10, 11, 12, 14, 15, 17,
377           19, 20, 21, 23, 25, 26, 28, 29, 30
378 write     volts rms
379 ***

380 unit      d20
381 write     times
382 writec    code, -, 0, 1, 10, 100, 200,
383 ***

384 unit      d21
385 writec    code, -, 0, 17, 19.2, 20.5, 21.8, 23.4, 25.4, 28, 31.2, 35,
386           40, 46, 53, 61, 71, 82,
387           94, 108, 122, 140, 160, 185, 210
388 write     Hz (not incl. RANGE)
389 ***

390 unit      d22
391 writec    code, -, 0, 0.001, 0.003, 0.01, 0.03, 0.1, 0.3, 1.0, 3.0, 10, 30,
392           100, 300
393 write     R.M.S. VOLTS full scale

```

-----part=1, block=g-----

block ig, rlm5a

```

395 unit      rlm5a
396 define    rlm5a
397           dc=0100
398           dial=n1-9
399 base
400 at        128
401 write     DC Test
402 at        218
403 write     (Press -DATA- to restart)
404 calc      n1+10
405           n101+0      $$ counter for number of repeats
406 time      1           $$ time slice between repeats
407 calc      v100+clock
408           v102+clock
409 ext       dc+dial
410 enable
411 goto      rlm5b

412 entry    rlm5c
413 ext      dc+dial

```

```

414 entry rlm5b
415 pause
416 goto key=timeup,rlm5f,x $$ go to rlmrf for retry
417 calc n(n+1)*key
418 n1=n1+1
419 v100=clock
420 goto key=next$or$dial>22,x,rlm5c
421 ext 0
422 calc v103=clock
423 calc n4#0
424 at 410
425 write Dial Alpha Octal Binary
426 do rlm5d,n2+1,27
427 at 3010
428 write Number of Repeats=
429 showt n101
430 at 3110
431 write Total Transmission Time=
432 showt v103-v102,4.3
433 write seconds.
434 back rlm0a
435 next rlm0a
436 data rlm5a
437 ***

438 unit rlm5d
439 calc n3+400+100*n2
440 at n3+12
441 write at,n3,2) (a,n(n2+10)$mask$077) (at,n3+28)(o;n(n2+10),4)
442 at where+7
443 do rlm5e,n120+1,2
444 at where
445 do rlm5e,n120+3,10
446 exit -(n2*n1-10)
447 ***

448 unit rlm5e
449 showt (n(n2+10)$ars$(10-n120))$mask$01,1
450 ***

451 unit rlm5f $$ handles retries
452 time 1
453 goto clock-v100>2,x,rlm5b
454 calc v100=clock
455 n101=n101+1
456 ext do+dial
457 goto rlm5b
458 ***

459 unit rlm6a
460 back rlm0a
461 erase
462 at 510
463 write Enter the code which you wish to transmit
464 over the external channel.
465 next rlm6a
466 arrow 310

```

467 store n1
 468 ok
 469 at 1210
 470 write Press -NEXT- to transmit same code again.
 471 Press -BACK- to transmit a different code.
 472 inhibit erase
 473 jump rlm6c
 474 ***
 475 unit rlm6b
 476 at 1210
 477 write EXT OUTPUT
 478 back rlm6a
 479 next rlm6b
 480 ext n1
 481 at 1510
 482 showo n1,5
 483 ***
 484 unit rlm6c
 485 inhibit erase
 486 ext n1
 487 back rlm6a
 488 next rlm6c
 489 ***
 490 unit rlm7a
 491 back rlm7a
 492 ext 0
 493 at 510
 494 write Type the CGE number of the dial you wish to
 495 have checked repeatedly.
 496 arrow 814
 497 store n20
 498 ok
 499 jump rlm7b

----- part-1, block-h -----

block 1h, rlm7b

501 unit rlm7b
 502 at 210
 503 write REPEATED CHECK of a SINGLE DIAL
 504
 505 Press -STOP- to stop test.
 506
 507 Then, press -NEXT- to chose another dial,
 or -BACK- to return to index.
 508 at 914
 509 write Dial Number = (z,n20)
 510 at 933
 511 write Code =
 512 at 1139

```

513 write Code Time
514 at 1314
515 write Total checks =
516 Changes =
517 Repeats =
518 at 1814
519 write Total time =
520 Time/Check =
521 mode rewrite
522 enable
523 ext o100+n20
524 pause
525 calc n3=key$mask$077
526 calc n2+n6+n
527 n1+1
528 n11+n
529 n12+n
530 n13+1240
531 v7+clock
532 v5+clock
533 time 1
534 ext o100+n20

535 entry rlm7be
536 pause
537 calc v10+clock
538 calc n13+n13+100
539 goto n13>3200,rlm7bf,x
540 at n13
541 write (a,n3) (z,v10-v7)

542 entry rlm7bf
543 goto (key=stop$or$key=next),rlm7c,x
544 goto key=timeup,rlm7d,x
545 goto (key$mask$01000)=0,rlm7be,x $$ locks out keyboard
546 calc n3=key$mask$077,n12+n12,n12+n12+1
547 calc n3=key$mask$077
548 at 940
549 showa key$mask$077
550 at 944
551 write c(c,key,4)
552 calc n1+n1+1
553 calc y8+clock
554 at 1329
555 write (z,n1)
556 (z,n6)
557 (z,n12)
558 at 1829
559 write (z,v8-v7)
560 (z,(v8-v7)+n)
561 calc v5+clock
562 ext o100+n20
563 goto rlm7be
564 v v

565 unit rlm7c
566 calc v8+clock

```

```
567 ext 0          $$ clears hardware
568 pause          $$ waits for last timeup key
569 mode rewrite
570 at 1329
571 write (z,n1)
572 write (z,n6)
573 write (z,n12)
574 at 1829
575 write (z,v8-1)
576 write (z,(v8-v7)+n1)
577 at 2214
578 write CHECK COMPLETED
```

```
579 entry rlm7ce
580 pause          $$ loop absorbs spurious keys
581 goto key=next$or$key=back,x,rlm7ce
582 jump key=next,rlm7a,rlm0a
583 ***
```

```
584 unit rlm7d
585 time 1
586 goto clock-v5>1,x,rlm7be
587 calc n6+n6+1
588 write v5*clock
589 ext o100+n20
590 goto rlm7be
```

```
591 unit rlm8a
592 erase
593 back rlm0a
594 at 510
595 write CGE Checker Authoring Aids
```

```
596 This demonstration is intended to give authors
597 an opportunity to explore the use of the ckc and
598 ckd series subroutines.
```

```
599 Press c for connection check subroutine demo.
```

```
600 Press d for dial check subroutine demo.
601 at 2210
602 write NOTE: Authors in the student mode can press -MICRO-
603 to pass OK through a check. Students cannot do this.
604 arrow 1910
605 long 1
606 answer c
607 jump rlm8b
608 answer d
609 jump rlm8e
```

-----part=1, block=i-----

block 11, rlm8b

```

611 unit rlm8b
612 erase
613 inhibit erase
614 back rlm8a
615 next rlm8b
616 at 510
617 write - Connection Check.Subroutine Demonstration

618 Current Author Codes
619 at 910
620 write Author Code n33= <a,n33,30>

621 Best Match = <a,n36,30>

622 Hardware Code =
623 at 1428
624 do rlm8c,n75+1,30
625 at 1610
626 write Press DATA to change Author Code
627 data rlm8d
628 at 1910
629 write Type the number of the ckc subroutine you wish to try.

630 1) ckc (performs a connection check)
631 2) ckaw (performs a CC and writes errors)
632 3) ckc1 (counts errors of new pack vs ckc)
633 4) ckc1w (same as ckc1 and writes errors)
634 5) ckc2 (counts errors of best match vs ckc)
635 6) ckc2w (same as ckc2 and writes results)
636 arrow 2010
637 long 1
638 specs nookno
639 match n51,1,2,3,4,5,6
640 join n51,x,ckc,ckaw,ckc1,ckc1w,ckc2,ckc2w
641 at 3110
642 write <z,-n47> Errors Found in Setup
643 back rlm8b
644 ***

645 unit rlm8c
646 calc n76+0
647 move n30,n75,n76,10
648 calcc ((n76+0) - (n76="0")),n76+"0",n76+n76,n76+"4"
649 showa n76
650 ***

651 unit rlm8d
652 at 1010
653 write Desired Code
654 arrow 1020
655 copy n33,30
656 long 20
657 storea n33,30
658 ok
659 jump rlm8b

```



```

660 ***
661 unit rlm8e
662 erase
663 inhibit erase
664 base
665 back rlm8a
666 next rlm8e
667 at 510
668 write Dial Check Subroutine Demonstration

669 Current Author Codes
670 at 910
671 write Author Code n33=
672 at 928
673 write <a,n33,50>
674
675
676 at 1310
677 write Best Match = <a,n39,50>
678
679 Hardware Code = <a,n80,22>
680 at 1710
681 write Press DATA to change Author Code.
682 data rlm8f
683 at 1910
684 write Type the number of the ckd subroutine you wish to try.

685 1) ckd (performs a dial check)
686 2) ckdw (performs a DC and writes errors)
687 3) ckd1 (counts errors of new pack vs ckd)
688 4) ckd1w (same as ckd1 and writes errors)
689 5) ckd2 (counts errors of best match vs ckd)
690 6) ckd2w (same as ckd2 and writes results)
691 arrow 2810
692 long 1
693 match n51,1,2,3,4,5,6
694 join n51,x,ckd,ckdw,ckd1,ckd1w,ckd2,ckd2w
695 at 3110
696 write <z,-n47> Errors Found in Setup
697 back rlm8e
698 ***

699 unit rlm8f
700 at 1110
701 write Desired Code
702 arrow 1126
703 copy n33,50
704 long 50
705 storea n33,50
706 ok
707 end

```

-----part=1, block=j-----

block 1j, rlm9a

709 unit rlm9a
710 back rlm9a
711 next rlm9b
712 calcc (station=251),n101+256,512
713 slide noslide
714 at 107
715 write SLIDE NO. CGE SLIDE

716 0 Test Slide
717 1 CGERL Entrance
718 2 The EE244 Laboratory
719 3 CGE-PLATO System Description
720 4 Orientation of the CGE Station
721 5 Scope & Function Generator
722 6 Aud. Osc., VTVM, & DC Supply
723 7 Layout of Sensed Dials & Terminals
724 8 List of Sensed Dials & Terminals
725 9 - 18 Dial Setting Codes
726 19 Resistor Color Code
727 20 - 21 E E Symbols & Units
728 22 Recommended Unit Prefixes
729 23 Defined Physical Values
730 24 - 26 Physical Constants
731 27 - 32 SCOPE - Use of Dials and Terminals
732 33 - 35 SCOPE - Manufacturer's Specifications
733 36 - 44 PLUG-IN - Use of Dials and Terminals
734 45 - 50 PLUG-IN - Manufacturer's Specifications
735 51 - 53 FUN:GEN. - Use of Dials and Terminals
736 54 - 56 FUN:GEN. - Manufacturer's Specifications
737 57 - 60 AUD.OSC. - Use of Dials and Terminals
738 61 - 62 AUD.OSC. - Manufacturer's Specifications

739 Press -NEXT- to see remainder of Slide List:

----- part=1, block=k -----

block 1k, rlm9b

741 unit rlm9b
742 back rlm9a
743 next rlm9c
744 calcc (station=251),n101+256,512
745 slide noslide
746 at 107
747 write SLIDE NO. CGE SLIDE
748 63 - 66 VTVM - Use of Dials and Terminals
749 67 - 68 VTVM - Manufacturer's Specifications
750 69 - 71 DC SUPP - Use of Dials and Terminals
751 72 - 75 DC SUPP - Manufacturer's Specifications

```

752      76      Graph of a Transient
753      81      CGE Station Picture

754      88      Gunther Frank at CGE
755      89      Doug Dowden & Frank at CGE
756      90      Dave Borth at CGE
757      91      Doug Zanter & Borth at CGE
758      92      Borth & Dan Derrig at CGE
759      93-97   CGE-PLATO Interface

```

```

760      Type slide no.      ,press -NEXT-, or -BACK- to return.

```

```

761  arrow  3121
762  store  n100
763  ok
764  erase
765  goto   (n100<=255),rlm9c,rls9a
766  ***

```

```

767  unit   rls9a
768  back   rlm9a
769  next   rlm9a
770  at     1210
771  write  NO! Type a number less than 256..
772  ***

```

```

773  unit   rlm9c
774  back   rlm9a
775  next   rlm9d
776  at     3204
777  write  This is slide (z,n100). Press -NEXT- for next slide
778  slide  n100
779  ***

```

```

780  unit   rlm9d
781  back   rlm9a
782  next   rlm9a
783  calc   n100+n100+1
784  goto   (n100<=255),rlm9c,x
785  slide  512
786  at     1210
787  write  You can't show a slide greater than 255.
788  ***

```

```

789  unit   rlm9e
790  slide  n100+512
791  back   rlm0a
792  next   rlm0a
793  goto   rlm0a

```

-----part=1, block=1-----

block 11, rlm10a

```

795 unit rlm10a
796 back rlm0a
797 next rlm0a
798 *calc nc(1)*10033 $$ format for changing cc counter
799 *calc nc(2)*11869 $$ format for changing dc counter
800 at 505
801 write CGE Software Record-Maintenance

```

```

802 CAUTION: In order to avoid interference with automatic
803 record keeping and avoid loss of log records, the
804 following tasks will only be performed by a CGE author
805 specifically authorized by the Director of CGERL.

```

```

806 If specifically authorized, select the operation
807 you wish to perform:

```

```

808 A. Record chronologically a remark in the cgedata record.

```

```

809 B. Print and clear the uselog maintained in the common
810 in lesson cge:

```

```

811 C. Print and clear the statlog maintained in lesson
812 cgeindex.z,

```

```

813 arrow 2810
814 long 1
815 specs bumpshift
816 match n150,a,b,c
817 jump n150,x,rlm10b,rlm10c,rlm10d
818 ***

```

```

819 unit rlm10b
820 calc n21*nc(4)
821 nc(4)*nc(4)+3
822 nc(n21)*'inst
823 at 907

```

```

824 write At the beginning of each day of operation, type
825 the present date or, to record a note about a student
826 difficulty, type the student's name:

```

```

827 arrow 1311
828 long 0
829 storea nc(n21+1)
830 ok
831 at 1509

```

```

832 write Type the desired code or remark:

```

```

833 ok - CC and DC checked and new day started.

```

```

834 pdn - Plato down.

```

```

835 odn - CGE hardware down.

```

```

836 unxabs - unexcused absence.

```

```

837 xabs - excused absence.

```

838 or any other 8 character remark.
 839 arrow 2911
 840 long 8
 841 storea nc(n21+2)
 842 ok
 843 jumpout plato
 844 ***

845 unit rlm18c
 846 next rlm18a
 847 back rlm18a
 848 at 806
 849 write The uselog in cge should be printed when 300
 850 lines have been entered therein. Do this as follows:

851 1. Copy the common, uselog, from cge into cger1 as
 852 block 1b, rename it userlog, convert it to a source,
 853 and mark it so it will not be readin.

854 2. Insert "*list label, user log (date)" as the
 855 first line in userlog and "*list off" as the last
 856 line in userlog in cger1.

857 3. Request a print of cger1.

858 4. Enter cge, convert the common uselog to a source,
 859 delete all entries, then reconvert uselog to a common,
 860 so it can continue to record users of lesson cge.

861 5. After the print of the userlog in cger1 has been
 862 received, delete the block userlog from cger1.

-----part=1, block=m-----

block 1m, rlmend

864 unit rlm18d
 865 help1 rlm18e
 866 lab1 rlm18i
 867 next rlm18a
 868 back rlm18a
 869 at 506
 870 write The statlog in cgeindex should be printed when 300
 871 lines have been entered therein. Do this as follows:

872 1. Warning- this step must be done only once !!
 873 Convert the common, statlog, to printable form from
 874 here by pressing -HELP1-, once.

875 2. Copy the common statlog into cger1, convert it to
 876 a source, rename the block studstat, move it to
 877 block 1b, and mark it not to be readin.

878 3. Zero the original copy of the common by pressing

879 -LAB1- while in here in the student mode.
880 5. Enter *list label, student statistics (date) as
881 the first line in studstat, and "*list off" as
882 the last line in studstat.

883 6. Request a print of lesson cgerl.

884 7. After the print of studstat in cgerl has been
885 received, delete the block studstat from cgerl.

886 ***

887 unit rlm10e
888 calc ni+1 \$\$ changes 6 to 11

889 entry rlm10e1
890 calc ni50+nc(ni-1)
891 calcc ni50='inst',ni+ni+3,ni+ni
892 jump ni50='inst',rlm10e1,x
893 itoa nc(ni+1),nc(ni+1)
894 itoa nc(ni+2),nc(ni+2)
895 itoa nc(ni+3),nc(ni+3)
896 itoa nc(ni+4),nc(ni+4)
897 itoa nc(ni+6),nc(ni+6)
898 jump rlm10g
899 ***

900 unit rlm10f
901 calc ni+ni+8 \$\$ next student
902 jump ni≤322,rlm10e1,x
903 at 410
904 write Common is now printable.
905 pause
906 jumpout plato
907 ***

908 unit rlm10g
909 calc v50+vc(ni) \$\$ chgd from ni+5 so counters prt.
910 calc n51+int(v50)
911 calc n52+100000*frac(v50)
912 jump n51≤9,rlm10g1,x
913 jump n51≤99,rlm10g2,x
914 jump n51≤999,rlm10g3,x

915 entry rlm10g1
916 calc n53+1
917 goto rlm10h

918 entry rlm10g2
919 calc n53+2
920 goto rlm10h

921 entry rlm10g3
922 calc n53+3
923 goto rlm10h
924 ***

925 unit rlm10h
 926 calc n54+1
 927 itoa n51,n51
 928 itoa n52,n52
 929 move n54,1,n51,n53+1,1
 930 move n52,1,n51,n53+2,1
 931 calc nc(n1+5) on51
 932 jump rlm10f
 933 ***

934 unit rlm10i
 935 calc nc(4)+10
 936 zero nc5,318
 937 calc nc322+0
 938 jump rlm0a
 939 ***

940 unit rlmend
 941 press next
 942 end lesson
 943 ***

944 use eex00,ck1
 945 use ck2
 946 use ck3
 947 use ck4
 948 use ck5

ckc not found
 ckcw not found
 ckc1 not found
 ckc1w not found
 ckc2 not found
 ckc2w not found
 ckd not found
 ckdw not found
 ckdi not found
 ckdiw not found
 ckd2 not found
 ckd2w not found

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d1 rlm4b 299
 d10 rlm4c 337
 d11 rlm4c 340
 d12 rlm4c 344
 d13 rlm4c 349
 d14 rlm4c 352
 d15 rlm4c 357
 d16 rlm4c 362
 d17 rlm4c 365
 d18 rlm4c 370
 d19 rlm4c 375
 d2 rlm4b 384
 d20 rlm4c 380
 d21 rlm4c 384
 d22 rlm4c 390
 d4 rlm4b 310
 d5 rlm4b 313
 d6 rlm4b 320
 d8 rlm4c 331

296 296
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89	rlm4c	334	296					
rlm4d	rlm4d	940	31					
rlm5a	rlm5a	20	56	57	84	434	222	435
			448	491	582	771	593	742
			793	796	797	867	846	865
			938					847
			307					
rlm5b	rlm5a	51	49					
rlm5a	rlm5a	54	49					
rlm10a	rlm10a	795	49					
rlm10b	rlm10a	819	817					
rlm10c	rlm10a	845	817					
rlm10d	rlm4d	864	865					
rlm10e	rlm4d	887	892					
rlm10e1	rlm4d	889	932	982				
rlm10f	rlm4d	900	908					
rlm10g	rlm4d	908	912					
rlm10g1	rlm4d	915	913					
rlm10g2	rlm4d	918	914					
rlm10g3	rlm4d	921	917	920	923			
rlm10h	rlm4d	925	866					
rlm10i	rlm4d	934	49	85				
rlm2a	rlm2a	82	86					
rlm2b	rlm2b	91	115	133	137	148		157
rlm2c	rlm2b	112	49	222				
rlm3a	rlm3a	169	195	199	283			
rlm3b	rlm3a	187	189					
rlm3c	rlm3a	197	189	193				
rlm3d	rlm3a	205	223					
rlm3e	rlm3a	220	217	219				
rlm3f	rlm3a	225	49	239				
rlm4a	rlm3a	236	240					
rlm4b	rlm4b	245	253					
rlm4c	rlm4c	325	263	278	274	277		
rlm4d	rlm4b	260	262					
rlm4e	rlm4b	272	262	268				
rlm4f	rlm4b	279	266					
rlm4g	rlm4b	283	49	436				
rlm5a	rlm5a	395	411	453	457			
rlm5b	rlm5a	414	420					
rlm5c	rlm5a	412	426					
rlm5d	rlm5a	438	443	445				
rlm5e	rlm5a	448	416					
rlm5f	rlm5a	451	49	465	478	487		
rlm6a	rlm5a	459	479					
rlm6b	rlm5a	475	473	488				
rlm6c	rlm5a	484	49	582				
rlm7a	rlm5a	490	499					
rlm7b	rlm7b	501	545	563	586	598		
rlm7be	rlm7b	535	539					
rlm7bf	rlm7b	542	543					
rlm7c	rlm7b	565	581					
rlm7ce	rlm7b	579	544					
rlm7d	rlm7b	584	49	614	665			
rlm8a	rlm7b	591	607	615	643	659		
rlm8b	rlm8b	611	624					
rlm8c	rlm8b	645	627					
rlm8d	rlm8b	651						

rlm8e	rlm8b	661		689	666	697				
rlm8f	rlm8b	696		682						
rlm9a	rlm9a	709		49	742	768	781	769	782	774
rlm9b	rlm9b	741		711						
rlm9c	rlm9b	773		743	765	784				
rlm9d	rlm9b	788		775						
rlm9e	rlm9b	789								
rls2a	rlm2b	135		114						
rls2b	rlm2b	142		114						
rls2c	rlm2b	151		119	155					
rls2d	rlm2b	159		126	129					
rls2e	rlm2b	144		128	138	152				
rls9a	rlm9b	767		765						
back	rlm3a	222								
back	rlm5a	581								
bitcnt	rlm2b	146								
cc	rlm2b	93	111	132	139	156				
cc	rlm3a	171	186	194	202					
check	rlm2b	94	104	117	117	146		155		
clock	rlm2b	106	118	137	138					
clock	rlm3a	182	192	199	200	207				
clock	rlm4b	256	265	274	275					
clock	rlm5a	407	408	419	422	453	532	454	507	531
		553	561	566	586	588				
code	rlm4b	249	264	300	305	311	323	314	322	321
		335	398	342	345	350	363	353	366	358
		371	376	382	385	391				
data	rlm3a	222								
datac	rlm2b	98	116	119	127	131				
dc	rlm4b	247	259	269	276					
dc	rlm5a	397	409	413	456					
dial	rlm4b	248	255	259	267	267	276	268	285	269
		288	296	297						
dial	rlm5a	398	409	413	420	456				
frac	rlm5a	911								
inft	rlm5a	910								
key	rlm2b	114	114	114	115	116				
key	rlm3a	189	189	189	190	222		222		222
key	rlm4b	262	262	262	263	264				
key	rlm5a	416	417	420	525	543	545	543	546	544
		547	549	551	581	581		582		
keytime	rlm2b	97	106	118	137	138				
keytime	rlm4b	251	256	265	274	275				
n	rlm3a	190	231	233						
n	rlm5a	417	441	441	449					
namterm	rlm2b	99	123	127	160					
nc	rlm5a	820	821	821	822	829	831	841	835	890
nc2	rlm4b	252	252							
nc322	rlm5a	937								
nc5	rlm5a	936								
next	rlm2b	114								
next	rlm3a	189	222							
next	rlm4b	262								
next	rlm5a	420	543	581	582	941				
node	rlm2b	101	108	120						
noslide	rlm5a	713	745							
nl	rlm2b	94								

n1	rlm3a	172	181	198	191	191	217	219	219	
n1	rlm4b	240								
n1	rlm5a	398	484	417	418	418	480	446	482	467
		486	527	552	552	555	576	568	888	571
		848	891	891	891	891	902	901	709	901
		931								
n188	rlm5a	762	765	777	778	783		783	790	784
n181	rlm5a	485	429	455	455	712		744		
n11	rlm5a	528								
n12	rlm5a	529	546	546	546	546		557		573
n120	rlm5a	443	445	449						
n13	rlm5a	538	538	538						
n145	rlm3a	227			539	548				
n150	rlm2b	48	49							
n150	rlm5a	816	817	890	891	892				
n2	rlm2b	95	121							
n2	rlm3a	217	219	227	229	231		233		
n2	rlm4b	249								
n2	rlm5a	426	439	441	441	441		446	526	449
n20	rlm5a	497	509	523	534	562		589		
n21	rlm5a	820	822	829	841					
n22	rlm4b	252								
n3	rlm2b	96	121							
n3	rlm3a	216	218	226	226	228		232		
n3	rlm4b	250								
n3	rlm5a	439	440	441	525	541		546		547
n30	rlm5a	647	679							
n33	rlm5a	620	655	657	673	783		785		
n36	rlm5a	621								
n39	rlm5a	677								
n4	rlm3a	215								
n4	rlm5a	423								
n47	rlm5a	642	696							
n5	rlm2b	98								
n51	rlm2b	29	30							
n51	rlm3a	183	201	201	210					
n51	rlm5a	639	640	643	694	910	914	912	924	913
		930	931							
n52	rlm5a	911	930							
n53	rlm5a	916	919	922	929	938				
n54	rlm5a	926	929							
n6	rlm2b	99								
n6	rlm5a	526	556	572	587	587				
n7	rlm2b	100	121	121						
n75	rlm5a	624	647							
n76	rlm5a	646	647	648	648	648	648	648	649	648
n8	rlm2b	101	121	121						
n89	rlm3a	233	234							
screen	rlm2b	100	107	124	124	124	128	124	128	125
		146	146	147	148					
screen	rlm4b	250	254	284	284	287		295		
start	rlm2b	95	105	119	120	124	153	126	153	152
		154	155							
station	rlm5a	712	744							
stop	rlm2b	114								
stop	rlm3a	189								
stop	rlm4b	262								

stop	rlm5a	543								
termc	rlm2b	96	105	111	117	120	126	123	121	124
		132	139	154	156					
termc	rlm3a	172	186	193	194	202				
timeup	rlm2b	114								
timeup	rlm3a	189								
timeup	rlm4b	262								
timeup	rlm5a	416	544							
user	rlm2b	30								
vc	rlm5a	909								
v10	rlm5a	537	541							
v100	rlm5a	407	419	453	454					
v102	rlm5a	408	432							
v103	rlm5a	422	432							
v4	rlm2b	97								
v4	rlm4b	251								
v5	rlm5a	532	561	586	588					
y50	rlm3a	182	192	199	200					
v50	rlm5a	909	910	911						
v52	rlm3a	182	213							
v53	rlm3a	207	213							
v7	rlm5a	531	541	559	560	575		576		
v8	rlm5a	553	559	560	566	575		576		
where	rlm2b	130								
where	rlm5a	442	444							

lesson information

lesson name = cger1

starting date = 11/20/73

last edited on 08/21/74 at 10.52.53

by neal of course eecge

at site 7, station 27

author name = J. P. Neal

department = Elec. Engg.

telephone number = 333-4351

discipline = E E

grade level = CGE authors

description of lesson = CGE-PLATO Tests & Special Software Routines.

block 1a, cgeindexid

```

2 stop
3 **** For Neal, CGERL, Room 248; EEB.
4 One line description of this lesson --
5 The Router Lesson for Courses ee244 and eecge.
6 Divisions of this Lesson:      Block   Unit
7 Router unit                    cgestart cgestart
8 Index of cge experiments       cgeind   cgeind
9 End-exp questionnaire         quest1   quest1
10 Table of plato characters      charplato
11 Table of cge characters        charcge
12 Chars for cge character set    cgechar
13 Common for student statistics  statlog
14 final edit 29 aug 74 neal.
15 *list info
16 *list symbols
17 *list charset, (* )
18 *list varian, charset, cgeindex, cgechar
19 *****
20 start
21 write (at, 1010) Loading the CGE Character Set
22 stop
23 goto 8loop, n3=0, 127      $$ this sequence will insert
24 char n3                    $$ blanks in all r/w charset
25 0,0,0,0,0,0,0,0          $$ spaces before loading the
26 8loop                       $$ cge character set
27 start
28 charset cgeindex, cgechar
29 erase
30 dataon
31 ext 0
    
```

block 1b, cgestart

```

33 unit cgestart
34 common cgeindex, statlog, 322
35 name n2
36 jump n2='inst', instruct, x
37 jump user='student'$and$station#251,x,cgeind
    
```

```

38 jump user='student'$and$station#236,x,cgeind
39 at 1214
40 write At this time you may only have access to CGE-PLATO
41 at the CGE Research Laboratory, Room 248 EEB.
42 pause 3
43 jumpout plato
44 ***

45 unit instruct
46 at 1210
47 write One moment please
48 jumpout cgerl,inst
49 ***

50 unit cgeind3
51 next cgeind3
52 at 510
53 write You are not at the CGE station in Room 248 EEB.

54 Therefore, I will send you back to our title page.
55 pause 3
56 jumpout cge
57 at 1010
58 write Please be patient.
59 ***

60 unit cgeind4
61 jump n2# 'ee244',cont1,x
62 join n3=nc(nc(4)-8)$and$restart1=nc(nc(4)-7),old,new,
63 x $$ 8,7 instead of 6,5
64 calc nc(n21)+n3
65 nc(n21+1)+restart1

66 entry cont1
67 jumpout resume
68 ***

69 unit cgeind2
70 at 1210
71 write You are not at the CGE Station. You will be
72 taken to Sample when you press next. Press
73 Shift-Stop if you want to leave.
74 pause
75 inhibit jumpchk
76 at 3224
77 write One Moment Please!
78 jumpout sample
79 ***

80 unit skiper
81 at 510
82 write now going to lesson CGE
83 inhibit jumpchk
84 jumpout cge

```

part=1, block=c

block 10, cgeind.

```
86 unit cgeind
87 route end lesson,cgeind
88 route error,cgeind $$ specify where to go on exec. error.
89 term index
90 at 207
91 write COMPUTER-GUIDED EXPERIMENTS REFERENCES
```

```
92 0. An Intro. to the CGE Station Chap. 1,2,3
93 1. The Oscilloscope Chap. 9
94 2. The Audio Oscillator Chap. 13
95 3. The Function Generator Chap. 14
96 4. The DC Supply Chap. 8
97 5. The Vacuum Tube Voltmeter Chap. 4,12
98 6. Measurements of Transients Chap. 14
99 7. Measurements of Impedance Chap. 3
100 8. Two-Port Networks
```

101 The above experiments should be completed in
102 sequence. Prior to attempting an experiment, you
103 should have read the above references in:

104 Guide to Electronic Measurements and Laboratory
105 Practice, by S. Wolf, Prentice-Hall, 1973.

106 While in any experiment:

107 To return to this page, -TERM- index.

108 To record your comments, -TERM- comment.

109 To read tech. data and spec., -TERM- slides.

110 Select an experiment by typing its number, or
111 reenter where you shift-stopped out by pressing r.

112 arrow 3010

113 long 1

114 match n1,0,1,2,3,4,5,6,7,8,r

115 course n2

116 jump station=236∧n2='ee244',cgeind2,x

117 jump station=251∨n2='eecge',x,cgeind3

118 jump n1,x,cgeind1

119 judge no

120 at 3110

121 write Type the number 0,1,2 ... etc.

122 ***

123 unit cgeind1

124 course n2

125 name n3

126 calc n3+n3\$mask\$077777777777777777770000

127 jump n1,x,x,x,x,x,x,x,x,x,cgeind4

128 jump n2#'ee244',cont,x

129 calcs n1,nc(3)←'x','eex00','eex01','eex02','eex03','eex04','eex05','eex06','eex07','eex08'

130 join n3=nc(nc(4)-8)\$and\$nc(3)=nc(nc(4)-7),old,new

131 calc nc(n21) + n3
132 calc nc(n21+1) + nc(3)
133 entry cont
134 at 510
135 write Now going to experiment selected.
136 inhibit jumpchk
137 jumpout n1;x;cex00;cex01;cex02;cex03;cex04;cex05;cex06;cex07;cex08
138 ***

139 unit old
140 calc n21 + nc(4) - 8 \$\$ 8 instead of 6
141 exit 1
142 ***
143 unit new
144 calc n21 + nc(4)
145 nc(4) + nc(4) + 8 \$\$ 8 instead of 6
146 exit 1

----- part=1, block=d -----

block id, quest1

148 ***** End of Experiment Questionnaire *****

149 unit quest1
150 at 810
151 write You have completed this experiment.

152 Please complete the following questionnaire,
153 in order to bring your comments to date.

154 Please type the number of the multiple-
155 choice statement below which best reflects
156 your present opinion.

157 A. I believe my last CGE experiment is worthwhile.

- 158 1. Strongly Agree
159 2. Agree
160 3. Undecided
161 4. Disagree
162 5. Strongly Disagree

163 arrow 2510
164 long 1
165 ok
166 ***

167 unit quest2
168 at 1210
169 write B. I would have learned more about the
170 topic of this experiment in a conventional
171 laboratory course.

- 172 1. Strongly Disagree
- 173 2. Disagree
- 174 3. Undecided,
- 175 4. Agree
- 176 5. Strongly Agree

177 arrow 2510
 178 long 1
 179 ok
 180 ***

181 unit quest3
 182 at 810
 183 write C. How would you advise a friend who
 184 is considering taking a Computer-Guided
 185 Experimental section of the Introductory
 186 EE Laboratory course, EE244.

- 187 1. Fight tooth and nail to get into CGE.
- 188 2. Take the CGE section if reasonably possible.
- 189 3. Take the CGE section only if convenient.
- 190 4. Avoid the CGE section if convenient.
- 191 5. Avoid CGE like a plague.

192 arrow 2510
 193 long 1
 194 ok
 195 ***

196 unit quest4
 197 at 1210
 198 write D. Have you previously covered the topic of your
 199 last CGE experiment in any other laboratory course ?
 200 arrow 1640
 201 long 1
 202 ok

-----part=1, block=e-----

block 1e, comment1

204 unit comment1
 205 back cgeind
 206 at 510
 207 write You are invited to type any final comments you
 208 care to offer!

209
 210 Press -NEXT- to enter another line of comment.

211 Press -BACK- when finished.
 212 calc 1 n1+1110

213 entry comment2
 214 arrow n1+n1+100
 215 ykey back

216 ok
217 endarrow
218 goto key=next,comment2,x
219 press back

----- part=1, block=f -----

block 1f, charplato

221 *** The following PLATO character sets are in use:

222 *id Normal lower case (lc):

223 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z

224 *lc2 0 1 2 3 4 5 6 7 8 9 = + - * / ; , . /

225 *id Normal upper case (uc):

226 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z

227 *uc1 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

228 *lc2 0 1 2 3 4 5 6 7 8 9 = + - * / ; , . /

229 *uc2 < > [] \$ % _ ' * () Σ Δ φ ψ : " ! ?

230 *id MICRO then key above the character:

231 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z

232 *char α β δ λ μ ° π ρ σ θ ω

233 *lc2 0 1 2 3 4 5 6 7 8 9 = + - * / ; , . /

234 *char () @ > 7 ≠ & ~ + \

235 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z

236 *uc1 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

237 *char + \ + | + +

238 *lc2 0 1 2 3 4 5 6 7 8 9 = + - * / ; , . /

239 *uc2 < > [] \$ % _ ' * () Σ Δ φ ψ : " ! ?

240 *char ≤ ≥ { } # % _ ' * () Σ Δ φ ψ : " ! ?

241 *id ACCESS then key above the char (ACCESS = shift □):

242 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z

243 *char α β δ λ μ ° π ρ σ θ ω

244 *lc2 0 1 2 3 4 5 6 7 8 9 = + - * / ; , . /

245 *char () 2 3 4 @ > 7 8 9 ≠ & ~ + * . \

246 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z

247 *uc1 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

248 *char + B C → E F G H I J K L M N O P Q R S T U V + + Y Z

249 *lc2 0 1 2 3 4 5 6 7 8 9 = + - * / ; , . /

250 *uc2 < > [] \$ % _ ' * () Σ Δ φ ψ : " ! ?

251 *char ≤ ≥ { } # % _ ' * () Σ Δ φ ψ : " ! ?

252 *** End of PLATO Character listings.

-----part=1, block=g

block 1g, charge

254 *** The following characters are in the CGE Character Set:

255 *id FONT then key above the char (FONT = shift MICRO):

256 ** Position numbers of cge characters (read down):

257 * 1 2 3 4 5 6 7 8 9 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2

258 * Ø 1 2 3 4 5 6 7 8 9 Ø 1 2 3 4 5 6

259 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z

260 *char / - # + * > < ↓ ↑ | ↑ ↓ Ω

261 ** Position numbers of cge characters (read down):

262 * 2 2 2 3 3 3 3 3 3 4 3 5 3 4 5 5 6 6 4

263 * 7 8 9 Ø 1 2 3 4 5 6 4 7 3 8 8 2 9 1 2 Ø

264 *lc2 Ø 1 2 3 4 5 6 7 8 9 = + * - / ; , . /

265 *char ~ + -

266 ** Position numbers of cge characters (read down):

267 * 6 6 6 6 6 7 7 7 7 7 7 7 7 8 8 8 8 8 8 8 8 8 8 8 9

268 * 5 6 7 8 9 Ø 1 2 3 4 5 6 7 8 9 Ø 1 2 3 4 5 6 7 8 9 Ø

269 *lc1 a b c d e f g h i j k l m n o p q r s t u v w x y z

270 *uc1 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

271 *char | - € ~ } []] } - / * ♦

272 ** Position numbers of cge characters (read down):

273 * 1

274 * 9 9 9 9 9 9 9 9 9 Ø Ø Ø Ø 1 1 2 6 2 Ø

275 * 1 2 3 4 5 6 7 8 9 Ø 8 1 2 2 6 3 Ø 4 4

276 *lc2 Ø 1 2 3 4 5 6 7 8 9 = + * - / ; , . /

277 *uc2 < > [] \$ % - ' * () Σ Δ * u : " ! ?

278 *char -

279 *id FONT then shift □ then key above the character:

280 ** Position numbers of cge characters (read down):

281 * 3 4 4 4 4 4 4 4 5 5 5 5 5 5 5

282 * 9 1 2 3 5 6 7 9 Ø 1 4 5 6 7 8

283 *lc1 a b c d e f g h i j k l m n o

284 *char □

285 ** Position numbers of oge characters (read down):

286 * 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 287 * 0 0 0 0 0 1 1 1 1 1 1 2 2 2
 288 * 3 5 6 7 9 0 1 3 4 5 8 9 0 1 2

289 *|c| a b c d e f g h i j k l m n o
 290 *uc| A B C D E F G H I J K L M N O
 291 *char

292 *** End of OGE Character listings.

ogeind	ogeind	86	37	38	87	88	205
ogeind1	ogeind	123	118				
ogeind2	ogestart	69	116				
ogeind3	ogestart	50	51	117			
ogeind4	ogestart	60	127				
ogestart	ogestart	33					
comment1	comment1	204					
comment2	comment1	213	218				
cont	ogeind	133	128				
cont1	ogestart	66	61				
instruct	ogestart	45	36				
new	ogeind	143	62	130			
old	ogeind	139	62	130			
quest1	quest1	149					
quest2	quest1	167					
quest3	quest1	181					
quest4	quest1	196					
skiper	ogestart	80					
back		219					
key		218					
inc		62	62	62	62	64	130
		130	130	130	131	132	145
		145					
next		210					
n1		114	118	127	129	212	214
n2		35	36	61	115	116	117
n21		64	65	131	132	140	144
n3		23	24	62	64	125	130
rstart1		62	65			126	131
station		37	38	116	117		
user		37	38				

lesson information

lesson name = ogeindex

starting date = 01/29/73

last edited on 09/03/74 at 11.28.26

by neal of course eecge

at site 7, station 27

author name = J.P. Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

description of lesson = The Router Lesson for Courses ee244 and eece

block 1a, eex00id

2 stop
 3 *** For Neal, CGERL, Room 248, EEB.
 4 One line description of this lesson --
 5 An Introduction to the CGE Station.

Divisions of this Lesson: Block Unit

7	Id for this file	eex00id	
8	Experiment eex00:		
9	Description of cge station	x00m0a	x00m0a
10	Conclusion	x00m0g	x00m1a
11	Cge s.r. and terms	chl-ck6	
12	Final edit 29 aug 74 neal.		

13 *list info
 14 *list symbols
 15 *list variant, charset, cgeindex, cgechar
 16 ***
 17 start
 18 finish endymit
 19 while :at,1000 Loading the CGE Character Set
 20 charset :ccindex, cgechar
 21 cgechar
 22 title n
 23 area, eex00
 24 exit

block 1b, x00m0a

26 unit x00m0a
 27 erase
 28 name n2
 29 next x00m0a1
 30 help x00m0a
 31 callcc n10=400,n30=400,0
 32 jump n20=400,x00m0a1,x
 33 *arg n 0
 34 at *4
 35 while Hello (a,n2)

This PLATO terminal is externally interfaced with the

37 adjoining electronic experimentation equipment.

38 At this CGE-PLATO station, PLATO can automatically
39 determine the external interconnections between terminals
40 of the experimentation equipment or check the settings
41 of the dials on that equipment.

42 This lesson will acquaint you with the uses of PLATO and
43 the names of the panel controls and terminals of the
44 instruments and circuit boards of the CGE station.

45 Subsequent experiments will guide you to learn worthwhile
46 methods for operating the electronic instruments and making
47 electronic measurements.

48 Experienced instructors have programmed connection
49 checks and dial checks where necessary to sense your
50 progress through the experiments and to provide you
51 with additional assistance, if you seem to encounter
52 undue difficulty or request help or information.

53 If you are unacquainted with PLATO, press -HELP-
54 otherwise, press -NEXT-.

55 ***

56 unit x00m0a1
57 back >00m0a
58 next x00m0a2
59 zero n30
60 at 1010

61 write If you want to see a sample of the
62 variety of lessons now programmed on PLATO,
63 -TERM- sample. Otherwise, press -NEXT-.

64 ***

65 unit x00m0a2
66 back x00m0a1
67 next x00m0b
68 at 503

69 write Now that you are acquainted with the Plato operation, you
70 are ready to proceed with the Computer Guided Experiments.

71 If you are somewhat familiar with electronic instruments
72 or are exceptionally alert, you will find that you can
73 rapidly accomplish the sequential learning tasks presented
74 to you in the subsequent experiments.

75 Do not be dismayed if you encounter difficulties. If you
76 have no difficulties and breeze through the tasks presented
77 to you, you may be learning very little.

78 As Alice in Wonderland said,
79 "Oh, a knot! Do let's untie it!"

----- part=1, block=c -----

block 1c, x00m0b

81 unit x00m0b
82 back x00m0a
83 next x00m0b1
84 name n2
85 at 905
86 write Hello again (a,n2)

87
88 After this brief introduction you should be able to
89 communicate with me and set the instruments in the
90 "safe initial mode". This initial mode is specified
91 and rechecked whenever you start a new experiment.

91 ***

92 unit x00m0b1
93 back x00m0b
94 next x00m0c
95 at 907
96 write In front of you are five rack-mounted electronic
97 instruments.

98 Each instrument has a number of terminals between
99 which you can make interconnections, and a number of
100 knobs, switches, and dials by which you can adjust
101 the instruments.

102 I will list the names we use to refer to each of
103 the instruments, terminals, and dials, and I suggest
104 you locate each of them on the instrument panels.

105 ***

106 unit x00m0c
107 back x00m0b1
108 next x00m0c1
109 at 510

110 write At the top left of the equipment rack is the
111 Analab DUAL-TRACE SCOPE Type 1120. Note that red
112 labels pertain to red knobs, and black labels
113 pertain to black dials.

114 Important dials of the SCOPE are:

115 BEAM FINDER (a black dial)	SCALE
116 INTENSITY (a red knob)	FOCUS
117 A & B SEPARATION	Power
118 Y DISPLAY	X DISPLAY
119 Y POSITION	X POSITION

120 ***

121 unit x00m0c1
122 back x00m0c
123 next x00m0d
124 at 506

125 write To the right of the SCOPE, in the same frame,

126 is the Analab TYPE 700 PLUG-IN.

127 Important dials of the PLUG-IN are:

128 A VOLTS TIME B VOLTS

129 NULLS (red knobs)

130 A PREAMP TRIGGER SOURCE SWEEP MODE B PREAMP

131 TRIGGER SLOPE

132 Important terminals of the PLUG-IN are:

133 A INPUT TRIGGER INPUT B INPUT

part=1, block=d

block id, x00m0d

135 unit x00m0d

136 back x00m0d1

137 next x00m0d1

138 at

139 write Directly below the SCOPE and the PLUG-IN is the

140 FUNCTION GENERATOR:

141 On the FUN. GEN. there are:

142	Dials	Terminals
143	TRIGGER	SQUARE
144	MULTIPLIER	TRIANGLE
145	CYCLES/SEC.	SINE
146	OUTPUT (black knob)	RAMP
147	AMPLITUDE (red knob)	OUTPUT (red terminal)
148	EQ LEVEL	TRIG OUT

149 ***

150 unit x00m0d1

151 back x00m0d1

152 next x00m0d1

153 at

154 write Directly to the right of the PLUG-IN is

155 the AUDIO OSCILLATOR.

156 The dials of the AUD. OSC. are:

157 RANGE, Frequency, and AMPLITUDE. The frequency dial

158 is the large one in the center.

159 The terminals of the AUD. OSC. are:
160 GROUND (black), and the left and right red OUTPUT
161 terminals.
162 ***
163 unit x00m0e
164 back x00m0d1
165 next x00m0e1
166 at 807
167 write Next to the AUD. OSC. is the VACUUM TUBE VOLTMETER.

168 The RANGE dial is the only dial of the VTVM.
169 INPUT terminals of the VTVM are red and black.
170 OUTPUT terminals of the VTVM are red and black.
171 In each case here, the black terminals are GROUND.
172 ***

173 unit x00m0e1
174 back x00m0e
175 next x00m0g
176 at 807
177 write The CONSTANT VOLTAGE/CONSTANT CURRENT or
178 DC SUPPLY is located below the AUD. OSC. and the VTVM.

179 The dials of the DC SUP. are:
180 METER, VOLTAGE, and CURRENT.

181 The terminals of the DC SUP. are:
182 + (red), - (black), and GROUND.

183 Incidentally, the ground terminals of all of the
184 instruments are interconnected at the power receptacles,
185 so GROUND is essentially only one common terminal.

----- part=1, block=e -----

block 1e, x00m0g

187 unit x00m0g
188 back x00m0e1
189 next x00m0h
190 lab x00e0b
191 at 807
192 write The CGE-PLATO system has the capability of

193 automatically checking the interconnections between
194 30 terminals and automatically checking the settings
195 of 22 dials on the experimentation equipment.

196
197 If you want to see a record of a present check,
198 press -LAB-.

199 Otherwise, press -NEXT-.

200 ***

201 unit x00m0h
202 join inmodal
203 entry icheck
204 join inmodeck
205 jump n47, icheck, x00mia
206 ***

207 unit x00mia
208 back x20m0h
209 next x00m1b
210 name n1
211 at 007
212 write Hello again (a,n2)

213 At any time during an experiment, you can reach a
214 slide display showing descriptions of the purposes of
215 the important dials and terminals, the manufacturer's
216 specifications for the instruments, and other generally
217 useful information by the -TERM- slides.

218 You can do the experiments listed later in any order.

219 Consequently, if you attempt to perform the
220 experiments out-of-sequence, and encounter too
221 much difficulty, you may be automatically
222 suited to stop your selected experiment and
223 complete a prior-listed experiment, in order for
224 you to learn how to properly use an instrument.

-----part=1, block=f-----

block if, x00end

226 unit x00m1b
227 next x00end
228 back x00mia
229 at 009
230 write You are now ready to explore physical reality
231 using this Computer-Guided Experimentation
232 relation.

233 Leave all dials and connections in the safe
234 initial mode, then press -NEXT- to go to the

235 Index of Experiments.

236 ***

237 unit x00s0a
238 calc n25='ee000'
239 n26=0
240 n30=400
241 join jmpmes
242 jumpout help
243 end
244 ***

245 unit x00s0b
246 base
247 back x00m0g
248 next x00s0c
249 join rlm2b
250 ***

251 unit x00s0c
252 back x00s0b
253 next x00m0h
254 join rlm4b
255 ***

256 unit x00end
257 course n2
258 calcc n2='ee244'
259 nc(n21+1)\$(nc(n21+1)\$mask\$07777777770000000000)+o4603000000,
260 nc(n21+1)\$(nc(n21+1))
261 course n1
262 join n1='ee244',endunit,x
263 join jmpmes
264 jumpout cgeindex
265 ***

266 unit endunit
267 course n2
268 jump n2='ee244',leave,x
269 calc nc(n21+7)\$(nc(n21+7)+ahelp
270 vc(n21+6)\$(vc(n21+6)+atime/60000

271 entry leave
272 ***gives this lesson use of talk routines on cger1
273 use cger1,rlm4b
274 use rlm4c
275 use rlm2b

-----part=1, block=g-----

block 1g, ckl

277 unit +cc
278 common cgeindex,statlog,322

```

279 define ckc
280 cc=o40
281 authorc=n33
282 ccdata=n30
283 bestcod=n36 $$ author code for best match
284 besterr=n39 $$ number of errors in best match
285 segment,acode=authorc,6
286 segment,ccode=ccdata,6
287 errors=n47
288 print=n49 $$ -1=print off 0=print on
289 start=n1
290 search=n2
291 termc=n3
292 keytim=v4
293 dtac=n5
294 count=n6
295 acode1=n4
296 acode2=n5
297 ccode1=n6
298 ccode2=n7
299 state=n8

300 unit ckow
301 erase
302 calc print#0
303 goto cc1

304 unit ckc
305 calc print#-1
306 goto cc1

307 unit ckot
308 calc print#-1
309 goto cc3

310 unit ckotw
311 erase
312 calc print#0
313 goto cc3

314 unit cc1
315 Data Collection Routine. *****
316 calc n22=nc1+1
317 n23=-1
318 mode rewrite
319 do connect
320 mode write
321 pack ccdata,*****
322 calc start#termc#1
323 keytim#clock
324 count#0
325 time 1
326 enable
327 ext cc#termc

328 entry cc1a
329 pause

```

```

330 goto (key=timeup) - (key=micro$and$user='author'),cc1b,x,cc1out
331 goto (key$mask$01000)=0,cc1a,x $$ throw out keyboard key
332 calc keytime=clock
333 datac=key$mask$037
334 count=count+1
335 calc termc=0,termc+1,termc+termc $$stops array error
336 * when hardware not turned on
337 goto (datac=start) - (count>31),cc1c,x,cc1e
338 calc ccode(termc)←start
339 termc+datac
340 ext cc+termc
341 goto cc1a

342 unit cc1c
343 calc ccode(termc)←0
344 goto termc=start,cc1d,x
345 calc ccode(termc)←start
346 goto cc1d

347 unit cc1d
348 calc start=start+1
349 datac←ccode(start)
350 goto ((datac=" ")$and$(start≤30)) - (start>30),cc1d,x,cc2
351 calc termc←start
352 ext cc+termc
353 goto cc1a

354 unit cc1b
355 time 1
356 goto clock-keytim>1.5,x,cc1a
357 calc keytime=clock
358 ext cc+termc
359 goto cc1a

360 unit cc1e
361 * Error if more than 30 keys recieved!!
362 mode rewrite
363 at 3123
364 write An Error Has Occurred!

365 unit cc1out
366 calc n22+nciencf-1
367 pack author,+++++
368 goto cc2

369 unit cc2
370 ext 0
371 disable
372 calc besterr=100 $$init errors
373 mode erase
374 do ccmess
375 mode write
376 goto cc3

377 unit cc3
378 calc errors←0
379 start←termc←0

```

```

380 do      cc4
381 goto    n23<0,x,skipc
382 goto    nc(322)<0,skipc,x
383 goto    n21<5$or$n21>310,skipc,x
384 calc    nc(n21+4)+nc(n21+4)+1
385 calcc   n47<0,nc(n21+5)+nc(n21+5)+1,nc(n21+5)+nc(n21+5)
386 zero    n23

387 entry   skipc
388 do      besterr+errors-1,x,cc9
389 exit    -print
390 do      cc8
391 exit    1

```

-----part=1, block=h-----

Block 1h, ck2.

```

393 unit    ckc2w
394 erase
395 calc    print#0
396 block   bestcod,authorc,3
397 goto    cc3

398 unit    ckc2
399 calc    print#-1
400 block   bestcod,authorc,3
401 goto    cc3

402 unit    cc4
403 calc    print#print    $$dummy calc to enter loop
404 1      start#start+1    $$next terminal number
405      branch start>30,4,x    $$branch out when done
406      ccod1#ccode(start)    $$get cc code
407      acod1#acode(start)    $$get author code
408      state:(ccod1=#$and$acod1=#0)$or$(acod1=#+)
409      branch state,1,x
410      search#start    $$set search at present terminal
411 2      search#search+1    $$increment term. num.
412      branch search>30,1,x    $$go away if too big
413      ccod2#ccode(search)    $$get cc code
414      acod2#acode(search)    $$get authors code
415      state:(acod1=acod2$and$acod1=#0)
416      state#state-2(ccod1=ccod2$and$ccod1=#0)-4(acod2=#+)
417      branch state,x,2,2,x,2
418      errors#errors-1    $$add 1 to number of errors
419      branch print,1,x
420 4      print#print    $$dummy calc to exit loop
421 goto    (start>30)-2((errors<-6)$and#print=#0),cc5,x,cc6
422 at     501-200 errors
423 calc    term#start
424 do      cc7
425 writec  state, should be connected to ,*** man you are in trouble ***,
426         shouldn't be connected to ,

```

```

427 calc      termc+search
428 do        cc7
429 goto      cc4

430 unit      cc5
431 exit      1

432 unit      cc6
433 calc      errors←-7
434 at        521-200*errors
435 write     *** AND MORE ***
436 exit      1

437 unit      cc7
438 writec    termc,-,0,Term. 1,Term. 2,Term. 3,Term. 4,Term. 5,
439           Term. 6,Term. 7,Term. 8,Term. 9,Term. 10,
440           Term. 11,Term. 12,Ground,Term. 14,Term. 15,
441           Scope: A volts,Scope: B volts,Scope: trigger,
442           Fun-gen: sq. wave output,Fun-gen: triangle,
443           Fun-gen: sine output,Fun-gen: ramp output,
444           Fun-gen: attn'd output,Fun-gen: trigger out,
445           DC supply: (+) ,DC supply(-),
446           Aud-osc: right output,Aud-osc: left output,
447           VTVM: input,VTVM: output,

448 unit      cc8
449 at        711-200n47
450 writec    errors,*** WIRING ERRORS *** (Press -NEXT-),
451 exit      1

452 unit      cc9
453 block     authorc,bestcod,3
454 calc      besterr←errors

455 unit      comess
456 at        3219
457 write     CONNECTION CHECK IN PROGRESS

```

part=1, block=1

block 11, ck3

```

459 unit      +dc
460 define    ckd
461           dc=0100
462           authorc=n33
463           dcode=n30
464           bestcod=n39    $$ author code for best match
465           besterr=n44    $$ number of errors in best match
466           segment,acode=authorc,5
467           segment,dcode=dcode,6
468           errors=n47     $$ errors= -(number of errors found)
469           print=n49      $$ -1=print off  0=print on
470           dial=n1

```

```

471      keytime#2
472      match=n3
473      acod=n4
474      dcod=n5
475      info=n16
476      cannot=n17
477      acod1=n18
478      dcod1=n19
479      state=n6
480      paren=n7
481      search=n8
482      screen=n9

483 unit   ckdl
484 erase
485 calc   print#0
486 goto   dc

487 unit   ckdl
488 calc   print#-1
489 goto   dc

490 unit   ckdl
491 calc   print#-1
492 goto   dc1

493 unit   ckdlw
494 calc   print#0
495 erase
496 goto   dc1

497 unit   ckdlw
498 erase
499 block  bestcod,authorc,6
500 calc   print#0
501 goto   dc1

502 unit   ckdl
503 block  bestcod,authorc,6
504 calc   print#-1
505 goto   dc1

506 unit   dc
507 calc   n22+enc2+enc2+1
508 calc   n23#-1
509 mode   reurite
510 do     dcncss
511 calc   dial#1
512       keytime#clock
513 time   1
514 enable
515 ext    do+dial

516 entry  dc0
517 pause
518 goto   (key=timeup) - (key=micr#and#user='author'),dc0a,x,dcout
519 goto   (key#mask#010000)=0,dc0,x  ##throw out keyboard keys

```



```

520 calc dcode (dial) ekey $mask $o77
521 dial+dial+1
522 keytime=clock
523 goto dial>20,dc0b,x
524 ext dc+dial
525 goto dc0
526 unit dc0a
527 time 1
528 goto clock-keytime<1.5,dc0,x
529 calc keytime=clock
530 ext dc+dial
531 goto dc0
532 unit dc0b
533 disable
534 ext 0
535 mode erase
536 mode dc0mesg
537 mode write
538 calc besterr=1000 $$ init no. of errors in best match
539 goto dc1
540 unit dc0c
541 calc n22=nc2+nc2-1
542 pack authorc,+++++
543 calc n36=nc37+nc38+n $$fill out rest of authorc with blank
544 unit dc0d
545 unit dc1
546 calc dial+search+parent+errors+n
547 screen=310
548 do dc2 $$ go look for errors
549 goto n230,n,x,skipd
550 do n230,n,skipd,x
551 do n215,for'n21>310,skipd,x
552 calc n21=n21+2+nc (n21+2)+1
553 calc n47=n,nc (n21+3)+nc (n21+3)+1,nc (n21+3)+nc (n21+3)
554 goto n21
555 entry skipd
556 do besterr+errors-1,x,dc5 $$ is this a best match?
557 ext 1+print=0
558 goto
559 unit dc3
560 nt screen-1
561 write These dials are incorrectly set
562 draw 000:349
563 calc rc=screen+screen+300

```

part=1, block=j

block i, ck

```

565 unit      dc2
566 calc      printprint    $$dummy calc to enter loop
567 1         dialdial+1
568          match=0        $$ set no match found yet flag
569          branch dial>22,999,x
570          doodedcode(dial)
571 100      search=search+1    $$ incr author loc.
572          acod=acode(search)  $$ get author code
573          state=(acod="( ")- (acod=") ")-2(acod="+")-3(acod="<")-4(acod=">")
574          branch state,400,x,300,1,600,500
575          branch carpot,700,x
576          match=match+(acod=dcod)    $$ check for match
577          branch paren,100,x        $$ branch for paren loop
578          branch match,1,000        $$ was there a match?
579 300      paren=0          $$ clear paren loop flag
580          branch match,1,000        $$ was there a match?
581 400      paren=-1        $$ set paren loop flag
582          branch 100          $$ go look at next author code
583 500      carpot=0
584          branch match,1,000
585 600      carpot=-1
586          dial=dial+1
587          doodedcode(dial)
588          branch 100
589 700      carpot=0
590          search=search+1
591          acod=acode(search)
592          int$=int(acod1="( ")- (acod1=") ")
593          int$=int$+(acod=dcod)and(acod1=dcod1)
594          branch int$,000,100,100
595 800      error=error+1    $$ add to error count
596          branch print,1,x        $$ should we print?
597 900      print " "    $$ dummy calc to exit loop
598          quit when done
599          code=10;dc3.
600          screen 1000;dc4,x
601          screen
602          title III-3,Discipline,Function generator,
603          Function generator,DC power supply,
604          Power oscillator, Vacuum tube voltmeter,
605          write
606          title A,B volts, time, A volts, B preamp,
607          write
608          display func, display func,
609          integer, multiplier, multiplier,
610          write, attenuator, DC level, meter,
611          write, current, amplitude,
612          write, frequency, time,
613          write
614          calc      screen=screen+200
615          title
616          unit      14
617          screen+100
618          write      ** END FILE **

```

619 unit; dc5
620 block authorc,bestcod,6
621 calc besterr+abs(errors)
622 unit dcmess
623 at 3023
624 write DIAL CHECK IN PROGRESS

-----part=1, block=k-----

block 1k, ck5

626 unit comment
627 term comment
628 dataon
629 erase
630 at 510
631 write Please type your comment at the arrow.
632
633 Press -NEXT- to enter another line of comment.
634 Press -BACK- when finished.
635 calc n1+1110

636 entry comment1
637 arrow n1+n1+100
638 key back
639 ok
640 rndarrow
641 goto key=next,comment1,x
642 press back

643 unit sample
644 term sample
645 at 710
646 write Now returning you to SAMPLE!
647 inhibit jumpchk
648 jumpout sample

649 unit cgerl
650 term cgerl
651 do jmpmes
652 jumpout cgerl

653 unit index
654 term index
655 do jmpmes
656 jumpout cgerindex,cgerind

657 unit jmpmes
658 write (at,1516)One moment please
659 inhibit jumpchk

660 unit jmpdeck
661 pack n37,+++ofhe++a+++a(abcd)+a(ab)a++1

662 join ckd
 663 join n47, inmode, x
 664 join n47, x, inmodec
 665 unit inmodec
 666 pack n10, 0000000000000000a00000000000000000a00
 667 join flow
 668 join n47, inmodep, x
 669 unit inmodep
 670 pause .5
 671 pause
 672 unit inmode
 673 erase
 674 set 1210
 675 write the equipment was not set in the initial mode.
 676 pause 1.5
 677 erase

678 enter inmode1
 679 term inmode
 680 at 100
 681 write Please: Remove all plugged-in connections
 682 Securely fasten all ground links
 683 Set the dials in this safe initial mode:

SCOPE:
 INTENSITY fully CCW

PLUG-IN:
 NULLS at zero
 A and B PREAMPS OFF
 TRIGGER SOURCE OFF
 SWEEP MODE OFF

FLIN GEN:
 TRIGGER INT
 HORIZONTAL FULLY CCW
 DC LEVEL CCW and click

AUX OSC:
 RANGE MODE zero

DC SUPPLY:
 VOLTAGE 0
 CURRENT 0

VTM:
 RANGE 300

ALL POWER SWITCHES ON

782 When ready to proceed, press NEXT.
 783 pause .5
 784 pause

```

706 unit imode
707 erase
708 at 1007
709 write Before proceeding, please return the equipment to
710 the Safe Initial Mode.
711 pause
712 join imodeck
713 exit

```

part=1, block=1

block 11, ck6

```

715 unit slides
716 next slidel
717 term slides
718 erase
719 caloc (station=251),n101+256,256
720 slide n101
721 al 007
722 write SLIDE NO. CGE SLIDE

723 1 CGERL Entrance
724 2 The EE244 Laboratory
725 3 The CGE-PLATO System Description
726 4 Orientation of the CGE Station
727 7 Layout of Sensed Dials and Terminals
728 8 List of Sensed Dials and Terminals
729 19 Resistor Color Code
730 20 - 21 E E Symbols and Units
731 22 Recommended Unit Prefixes
732 23 Defined Physical Values
733 24 - 26 Physical Constants
734 27 - 32 SCOPE - Use of Dials and Terminals
735 33 - 35 SCOPE - Manufacturer's Specifications
736 36 - 44 PLUG-IN - Use of Dials and Terminals
737 45 - 50 PLUG-IN - Manufacturer's Specifications
738 51 - 53 FUN.GEN. - Use of Dials and Terminals
739 54 - 56 FUN.GEN. - Manufacturer's Specifications
740 57 - 60 AUD.OSC. - Use of Dials and Terminals
741 61 - 63 AUD.OSC. - Manufacturer's Specifications
742 64 - 66 VTVM - Use of Dials and Terminals
743 67 - 68 VTVM - Manufacturer's Specifications
744 69 - 71 DIC SUPP - Use of Dials and Terminals
745 72 - 75 DIC SUPP - Manufacturer's Specifications
746 76 Graph of a Transient
747 75 CGE-PLATO Interface.

748 Type slide no. ,press -NEXT-, or -BACK- to return.
749 arrow 0021
750 store n100
751 ok
752 erase
753 goto (n100+96),slidel,slideno

```

754 ***
 755 unit slideno
 756 back slides
 757 next slides
 758 at 1210
 759 write 101 Type a number less than 96.
 760 ***

761 unit slide3
 762 slide n100+512
 763 ***

764 unit slide1
 765 back slides
 766 next slides
 767 at 100
 768 write This is slide <z,n100>. Press -NEXT- for next slide
 769 slide n100
 770 ***

771 unit slide2
 772 back slides
 773 next slides
 774 calc n100+n100+1
 775 ext. (n100*96),slide1,x
 776 slide 512
 777 at 1010
 778 write You can't show a slide greater than 96.

ccm1	ch1	455	319	374			
ccm2	ch1	314	303	306			
ccm3	ch1	323	331	341	353	356	359
ccm4	ch1	354	330				
ccm5	ch1	341	337				
ccm6	ch1	307	344	346	350		
ccm7	ch1	360	317				
ccm8	ch1	365	330				
ccm9	ch1	369	350	368			
ccm10	ch1	377	300	313	376	397	401
ccm11	ch1	402	300	429			
ccm12	ch1	430	421				
ccm13	ch1	432	421				
ccm14	ch1	417	424	428			
ccm15	ch1	448	300				
ccm16	ch1	457	300				
ccm17	ch1	649					
ccm18	ch1	304					
ccm19	ch1	300	667				
ccm20	ch1	307					
ccm21	ch1	310					
ccm22	ch2	308					
ccm23	ch2	393					
ccm24	ch1	407	662				
ccm25	ch1	403					
ccm26	ch1	400					
ccm27	ch1	493					
ccm28	ch2	502					



ckd2w	ck3	497					
comment	ck5	626					
comment1	ck5	636	641				
dc	ck3	506	486	489			
dcmess	ck4	622	510	536			
dcout	ck3	540	518				
dc0	ck3	516	519	525	528	531	
dc0a	ck3	526	518				
dc0b	ck3	532	523	544			
dc1	ck3	545	492	496	501	505	539
dc2	ck4	565	548	615			
dc3	ck3	559	599				
dc4	ck4	616	600				
dc5	ck4	619	55				
endunit	x00end	266	18	262			
icheck	x00img	203	205				
imode	ck5	706					
index	ck5	653					
immode	ck5	672	663				
immodec	ck5	665	664				
immodeck	ck5	660	204	712			
immodep	ck5	669	668				
immode1	ck5	678	202				
jmpres	ck5	657	241	263	651	655	
leave	x00end	271	268				
rim0b	not found		249				
rim4b	not found		254				
sample	ck5	643					
skip0	ck1	387	381	382	383		
skipd	ck3	555	549	550	551		
slide0	ck6	755	753				
slide1	ck6	715	756	757	765	772	773
slide1	ck6	764	716	753	775		
slide2	ck6	771	766				
slide2	ck6	761					
x00end	x00end	256	227				
x00m0a	x00m0a	36	57	82			
x00m0a1	x00m0a	56	29	32			
x00m0a2	x00m0a	65	58		66		
x00m0b	x00m0b	81	62	93			
x00m0b1	x00m0b	92	83	107			
x00m0b2	x00m0b	106	94	122			
x00m0c1	x00m0c	121	108	136			
x00m0c1	x00m0c	135	123	151			
x00m0c1	x00m0c	150	137	164			
x00m0e	x00m0d	163	152	174			
x00m0e1	x00m0d	173	165	188			
x00m0g	x00m0g	187	175	247			
x00m0h	x00m0g	201	189	208	253		
x00m0a	x00m0g	207	205	228			
x00m0b	x00end	236	209				
x00m0a	x00end	237	30				
x00m0b	x00end	245	100	252			
x00m0c	x00end	251	243				
tdc	ck1	277					
tdc	ck1	400					
abs	ckd	621					

acod	okd	479	572	573	573	573	573	573	573	573
acode	okc	385	407	414						
acode	okd	466	572	591						
acodf	okc	395	407	408	408	415	415			
acodi	okc	477	591	592	592	593				
acodf	okc	396	414	415	416					
ahelp	okc	369								
atime	okc	370								
authanc	okc	381	285	367	396	400	453			
authanc	okd	463	466	499	503	542	620			
back	okd	642								
ballod	okc	383	396	400	453					
basicon	okc	364	499	503	620					
besterr	okc	384	372	398	454					
besterr	okd	465	550	556	621					
cam gl	okc	476	575	583	585					
cc	okc	380	327	340	352	358				
ccdata	okc	282	286	321						
ccode	okc	386	338	343	345	349	406	413		
ccodi	okc	393	406	408	416	416				
ccodf	okc	398	413	416						
clock	okc	399	382	356	357					
clock	okd	512	522	528	529					
count	okc	294	324	334	334	337				
qubar	okc	293	303	337	339	349	350			
ck	okd	461	515	534	530					
ddata	okc	463	467							
diod	okc	474	570	576	593					
diodc	okd	467	520	520	567					
diodf	okd	473	587	593						
dial	okc	394	511	515	520	521	521	523	530	
		546	547	567	569	570	586	586	588	598
		600	606							
errord	okc	383	378	388	418	418	421	422	434	
		400	417							
errona	okd	400	586	556	595	595	621			
umb	okc	474	570	591	592	594				
low	okc	398	399	391	393					
low	okc	516	517	519	520	641				
lowtam	okc	398	399	392	396	397				
lowtam	okd	471	512	522	520	520				
match	okc	472	560	576	576	570	580	584	593	
micro	okc	397								
micro	okd	513								
no	okc	250	254	260	260	269	269	382	384	
		305	305	335	385					
no	okd	550	502	557	553	553	553	553		
no1	okc	316	316	366	366					
no2	okc	507	507	541	541					
no-t	okd	641								
ni	okc	261	262	209						
ni	okd	470	605	637	637					
ni00	okc	750	763	763	760	769	774	774		
ni1	okc	710	716							
ni2	okc	475								
ni3	okc	476								
ni4	okc	477								

n19	ckd	478							
n2	cke	28	35	84	86	210	212	257	267
		268	290						
n21	cke	259	259	260	260	269	269	270	303
		383	384	384	385	385	385	385	
n21	ckd	551	551	552	552	553	553	553	
n22	cke	316	366						
n22	ckd	507	541						
n23	cke	317	381	386					
n23	ckd	508	549	554					
n25	cke	238							
n26	cke	239							
n3	cke	291							
n3	ckd	472							
n30	cke	31	31	32	33	59	240	282	
n30	ckd	463							
n33	cke	281							
n33	ckd	467	661	666					
n36	cke	283							
n36	ckd	543							
n37	ckd	543							
n38	ckd	543							
n39	cke	284							
n39	ckd	464							
n4	cke	295							
n4	ckd	473							
n44	ckd	465							
n47	cke	205	287	385	449				
n47	ckd	468	553	663	664	668			
n49	cke	380							
n49	ckd	469							
n5	cke	293	296						
n5	ckd	474							
n6	cke	204	297						
n6	ckd	479							
n7	cke	298							
n7	ckd	480							
n8	cke	299							
n8	ckd	481							
n9	ckd	482							
paren	ckd	480	546	577	579	581			
print	cke	288	302	305	308	312	389	395	483
		483	419	420	420	421			
print	ckd	469	485	488	491	494	500	504	566
		566	596	597	597				
screen	ckd	482	547	560	563	563	599	600	614
		614	617						
search	cke	290	410	411	411	412	413	414	
search	ckd	481	546	571	571	572	590	590	
segment	cke	285	286						
segment	ckd	466	467						
start	cke	289	322	337	338	344	345	348	349
		350	350	351	379	404	404	405	407
		410	401	423					
state	cke	299	400	400	415	416	416	417	
state	ckd	479	573	574					
station	ckd	719							

termc	ckc	291	322	327	335	335	335	335	339
		340	343	344	345	351	352	358	423
		427	438						
timeup	ckc	330							
timeup	ckd	510							
user	ckc	330							
user	ckd	510							
v0	ckc	270	270						
v2	ckd	471							
v4	ckc	292							

lesson information

lesson name = eex000

starting date = 10/07/72

last edited on 09/05/74 at 18.56.55

by borth of course eecge

at site 7, station 27

author name = J P Neal

department = EE

telephone number = 333-4351

discipline = elect. engr. lab

grade level = Freshman

description of lesson = An Introduction to the CGE Station

block 1a, eex01id

2 stop
3 **** For Neal, CGERL, Room 248, EEB.
4 One line description of this lesson --
5 The Operation and Uses of the Oscilloscope, Analab 1120.

6	Divisions of this Lesson:	Block	Unit
7	Id for this file	eex01id	
8	Experiment eex01:		
9	Objectives	x01m0a	x01m0a
10	Find crt spot	x01m1a	x01m1a
11	Measure constant v	x01m2a	x01m2a
12	Measure v	x01m3a	x01m3a
13	Use null dials	x01m4a	x01m4a
14	Display 2 voltages	x01m5a	x01m5a
15	Lissajous figure	x01m5a	x01m6a
16	Final test	x01m7a	x01m7a

17 final edit 21 aug 74 neal.

18 *list info
19 *list symbols
20 *list varian; charset, cgeindex, cgechar
21 ****
22 start
23 finish endunit
24 write (at,1010) Loading the CGE Character Set
25 charset cgeindex, cgechar
26 erase
27 dataon
28 area eev01
29 ext 0

block 1b, x01m0a

31 unit x01m0a
32 restart
33 base
34 next x01m1a
35 join imode
36 jump n47, x01m0a, x
37 erase

38 at 500
39 write THE OPERATION and USES of the OSCILLOSCOPE,
40 ANALAB, DUAL TRACE SCOPE TYPE 1120
41 with TYPE 700 PLUG-IN

42 When you have completed this experiment
43 you should be able to :

- 44 1) Find and Adjust a Spot on the CRT Screen.
- 45 2) Measure Constant Voltages.
- 46 3) Measure Time-Varying Voltages.
- 47 4) Use the NULL dials.
- 48 5) Display Two Voltages vs Time simultaneously.
- 49 6) Display a Lissajous Figure.

----- part=1, block=c -----

block 10, x01mia

51 unit x01mia
52 base
53 erase
54 back x01mia
55 next x01mb
56 help x01sia
57 at 1010
58 write Find the spot on the screen and position it at
59 (0,0), i.e., the center of the CRT screen.

60 CAUTION: Keep the INTENSITY only as high as
61 you need to see the spot. Otherwise, damage to
62 the screen may occur.
63 at 0020
64 write -HELP- is available.
65 yw

66 unit x01mb
67 base
68 back x01mia
69 next x01mc
70 help x01sia
71 at 1005
72 write The spot should be a sharp point of light with no halo.

73 If it is not, adjust the INTENSITY and FOCUS
74 controls to correct the condition of your spot.
75 at 3020
76 write -HELP- is available.
77 ***

78 unit x01mic
79 restart
80 base
81 back x01m1b
82 next x01mic1
83 lab x01sid
84 help x01sig
85 at 1210

86 write Now that the spot is centered, balance the
87 A PRE AMP before proceeding. Press -LAB- for an
88 explanation of the PRE AMP Balancing Procedure.

89 When you have verified the balance of the A PRE
90 AMP, set the dials so the spot will be deflected
91 5 cm when a voltage of + 10 volts is applied
92 to the A INPUT of the SCOPE.

93 at 3020
94 write -HELP- is available.
95 ***

96 unit x01mic1
97 pack n33, ++n+fh(cd) ++++++
98 join ckd
99 jump n47, x, x01m2a, x
100 pack n33, +++++ (cd) ++++++
101 join ckd1
102 jump n47, x01s1i, x01s1f

part=1, block=d

block 1d, x01m2a

104 unit x01m2a
105 back x01mic
106 next x01m2a1
107 help x01s2a
108 at 1007
109 write "Great! You correctly set the dials."

110 Now, make connections and dial settings so you can
111 display the voltage from the DC Supply on the A channel
112 of the SCOPE. A positive voltage should cause an
113 upward deflection.

114 As usual, press -NEXT- when you finish.

-HELP- is available.

```
115
116 ***

117 unit      x01m2a1
118 jump      user='author'$and$station#251,x01m2b,x
119 pack      n33,+++++++a++b00000000ba0+00
120 join      ckd
121 jump      n47,x01m2a2,x01m2a3
122 ***

123 unit      x01m2a2
124 pack      n33,+++++++a++b00000000ba0+00
125 join      ckd1
126 jump      n47,x01s2a,x01m2a4
127 ***

128 unit      x01m2a3
129 pack      n33,++n+fh+(ae)(ab)+++++++
130 join      ckd
131 jump      n47,x01s2a1,x
132 pack      n33,+++++c+++++++
133 join      ckd1
134 jump      n47,x01s2b,x01m2b
135 ***

136 unit      x01m2a4
137 pack      n33,++n+fh+(ae)(ab)+++++++
138 join      ckd
139 jump      n47,x01s2a1,x
140 pack      n33,+++++d+++++++
141 join      ckd1
142 jump      n47,x01s2b,x01m2b
143 ***

144 unit      x01m2b
145 back      x01m2a
146 next      x01m2b1
147 at        1207
148 write     Without changing anything on the SCOPE, deflect
149           the spot to Y = 5 cm.

150
151           HINT. To make the DC Supply function properly,
152           you must set the CURRENT dial to about 100 ma then,
153           adjust the VOLTAGE dial until the 5 cm deflection
154           is achieved.

155 unit      x01m2b1
156 pack      n33,++n+fh(cd)(ae)+++++(def)(bcdefghijklmnopqrstuv)++++
157 join      ckd
158 jump      n47,x01s2c,x01m2c
159 ***

160 unit      x01m2c
161 back      x01m2b
162 next      x01m2d
163 at        1210
```



```

205 unit x01m2d3
206 pack n33,n++(od) fhe+++++++ (bcd), (bcdefghi jklmnopqrstuv) ++++
207 join ckd1
208 jump n47,x01s2e,x
209 pack n13,00000000000000g20+a00000000ag0+00
210 join cke
211 jump n47,x01s2e,x01m2e
212 ***

```

```

213 unit x01m2e
214 back x01m2d
215 next x01m2e1
216 at 707
217 write Without changing A VOLTS or B VOLTS dials,
218 deflect the spot to:
219 X=3cm Y=3cm

```

```

220 Try to do this and then press -NEXT-, as always.
221 You will be guided automatically if you have difficulty.
222 ***

```

```

223 unit x01m2e1
224 jump user: 'author' $and $station=251,x01m2f,x
225 pack n33,n+n(od) ++(cd) e+++++++ (bcd) (bcdefghi jklmnopqrstuv) ++++
226 join ckd1
227 jump n47,x,x,x01m2e2
228 pack n13,+++++++ (bcd) (bcdefghi jklmnopqrstuv) ++++
229 join ckd1
230 jump n47,x01s2g,x01s2f
231 ***

```

```

232 unit x01m2e2
233 pack n13,+++c+++c+++++++
234 join ckd1
235 dials n47,n70e0,-1
236 pack n13,+++++++a+++bb00000000ba0+00
237 join cke
238 jump n47,x01m2e3,x
239 jump n70,x01m2f,x01s2h
240 ***

```

```

241 unit x01m2e3
242 pack n33,+++++++a+++bb00000000aba0+00
243 join ckd1
244 jump n47,x01s2i,x
245 jump n70,x01s2h,x01m2f
246 ***

```

```

247 unit x01m2f
248 back x01m2e
249 next x01m3a
250 at 710
251 write GOOD!

```

```

252 Do not change the dial settings on the SCOPE.

```




```

298 appears as a vertical line.
299 no
300 at x01m
301 write You should see a vertical line.
302 If you don't, press -BACK- to go through
303 this section again.
304 ***

305 unit x01m3c
306 back x01m3b
307 next x01m3d
308 help x01s3h
309 at 1410
310 write In order to make this waveform appear
311 on the SCOPE as a sine wave, it is
312 necessary to sweep the display horizontally:

313 To do this, you must apply a periodic
314 linearly-increasing voltage to the SCOPE's
315 horizontal input for a timed sweep.

316 Turn the A FRE-AMP to OFF and apply a 0.9 Hz
317 non-adjustable PAMP wave from the FUNCTION
318 GENERATOR to the B INPUT of the SCOPE.

319 Set B VOLTS to 50 V.
320 at 1000
321 write -HELP- is available.

```

----- part=1, block=g

block 1g, x01m3c1

```

323 unit x01m3c1
324 pack n03,+++++heee+ac(nst)++(abcde)+++ (cd) a (bc) +
325 join c+d
326 jump n47,x01s3i,x01m3c2
327 ***

328 unit x01m3c2
329 pack n03,+++++g++ab000000000000ag00
330 join c+d
331 jump n47,x,x01m3d
332 pack n03,+++++g++a+++++ag++
333 join ckd1
334 jump n47,x01s3i,x
335 at 1410
336 write You did not apply the non-adjustable
337 PAMP wave correctly!
338 pause
339 jump x01m3c
340 ***

341 unit x01m3d

```

```

342 back x01m3c
343 next x01m3d1
344 at 510
345 write As you see, this makes the spot sweep across
346 the screen as a linear function of time.

347 Now, set the A FRE AMP to DC+ and the FUNCTION
348 GENERATOR to 9 Hz.
349 ***

350 unit x01m3d1
351 pack n03,0+ncf(hce+ad(nst)++(abcde)+++++++
352 join chd
353 jump n47,x,x01m3e
354 at 1410
355 write Read the problem carefully!!! You
356 were given only two dials to change.
357 pause
358 jump x01m3d
359 ***

360 unit x01m3e
361 base
362 back x01m3d
363 next x01m3e1
364 help x01s3k
365 at 307
366 write Good! You should now have a sine wave
367 displayed on the screen.
368 However, there are 2 things wrong with this display:

369 1) There is a visible retraces when the spot
370 comes quickly back to the left.

371 2) The display is not stable.

372 To solve the first problem:

373 The SWEEP system of the SCOPE can be used to internally
374 generate a ramp wave and blank out the return trace.

375 To solve the second problem:

376 The TRIGGER SOURCE of the SCOPE can automatically
377 start the SWEEP at the beginning of each period.

378 Make the necessary adjustments to solve both these
379 problems, and remove any unnecessary connections.
380 at 3070
381 write -HELP- is available.
382 ***

383 unit x01m3e1
384 pack n03,++n++(fg)+a+++++++ (cd) a(bc) +
385 join chd
386 jump n47,x01s3l,x

```

```
387 pack n33,+++++g++a000000000ag00
388 join clc
389 loop n47,x01s3m,x01m4a
```

-----part=1, block=h-----

block 1h, x01m4a

```
391 unit x01m4a
392 repeat
393 join imode
394 jump n47,x01m4a,x01m4a0
395 **
```

```
396 unit x01m4a0
397 back
398 back x01m4e
399 next x01m4a1
400 help x01s4s
401 at 507
```

```
402 write Display on the A channel of the SCOPE, a
403 nonadjustable SINE wave having a frequency of
404 200 Hertz from the FUNCTION Generator.
```

```
405 Externally trigger the SCOPE from the FUNCTION
406 GENERATOR.
```

```
407 -HELP- is available:
```

```
408 ***
```

```
409 unit x01m4a1
410 pack n33,+++++a+b00a00b000+00
411 join clcw
412 next n47,x01m4a0,x
413 jump n47,x,x01m4a2
414 **
```

```
415 unit x01m4a2
416 pack n33,++++(cd)(de)(abcd)abaf(bcd)+++++
417 join clcd
418 next n47,x01m4a0,x
419 jump n47,x,x01m4b0
420 **
```

```
421 unit x01m4b0
422 next x01m4b
423 back x01m4a
424 at 1210
425 write Leave this waveform on the screen. You will
426 need it again later on.
427 **
```

```
428 unit x01m4b
```

429 base
430 back x01m4a
431 next x01m4c
432 help x01s4b
433 zero n70
434 at 1207

435 write The NULL dials, with the TIME and the A and B
436 VOLTS dials, can be used in measuring values on the
437 CRT display. For this use, the NULL dials must be
438 set at zero initially.

439 The value of a voltage point is measured by
440 rotating the associated NULL dial until the voltage
441 point being measured is returned to the zero voltage
442 level of the display. The manner in which the value
443 of the voltage is read will be discussed when you
444 press -NEXT-.

445 Press -HELP- if you do not understand the meaning
446 of the phrase 'zero voltage level'.
447

448 unit >01m4c
449 circle 144,248,256
450 circle 40,248,256
451 at 237,368
452 size 1
453 write 0.0
454
455 0.0
456
457 0.0
458 size 1
459 rotate -90
460 at 358,269
461 write 2.0
462 at 328,270
463 write 0.8
464 at 299,270
465 write 0.4
466 rotate 180
467 at 256,198
468 write 0.8
469 at 256,167
470 write 1.6
471 at 256,137
472 write 4.0
473 draw 1632;skip:1632
474 draw 192,389;134,447;skip:305,387;364,446
475 circle 512,248,268,57;122
476 draw 730;215,417;skip:734;275,419
477 circle 116,333,303,99,119
478 circle 124,260,296,83,61
479 circle 174,247,275,121,58
480 rotate 0
481 calc n7000
482 at 243,403

483 write V
484 goto x01m4d
485 rotate 0
486 size 0

part=1, block=i

block ii, x01m4d1

488 unit x01m4d
489 calc n70+n70+1
490 jump (n70=4), x01m4e, x, x
491 mode erase
492 at 275, 424
493 writec n70, ... 1, 2
494 mode write
495 at 285, 424
496 writec n70, ... 1, 2, 5
497 rotate 180
498 join n70, x, x, x01m4d1, x01m4d2, x01m4d3
499 rotate 0
500 size 0
501 mode erase
502 join n70, x, x, x, x01m4d4, x01m4d5
503 mode write
504 join n70, x, x, x01m4d4, x01m4d5, x01m4d6
505 size 1
506 pause
507 goto x01m4d
508 ***

509 unit x01m4d1
510 at 202, 312
511 write +
512 ***

513 unit x01m4d2
514 mode erase
515 at 222, 312
516 write +
517 mode write
518 at 222, 344
519 write +
520 ***

521 unit x01m4d3
522 mode erase
523 at 222, 344
524 writec +
525 mode write
526 at 222, 375
527 write +
528 ***

529 unit x01m4d4
530 at 2810
531 write When either the A or B VOLTS dial is set at
532 1, 10, or 100, read the NULL on the bottom scale.
533 ***

534 unit x01m4d5
535 at 2810
536 write When the A or B VOLTS dial is set at
537 2, 20, or 200, read the NULL on the middle scale.
538 ***

539 unit x01m4d6
540 at 2810
541 write When the A or B VOLTS dial is set
542 5, 50, or 500, read the NULL on the top scale.
543 ***

544 unit x01m4e
545 next x01m4f
546 size 0
547 at 1410
548 write Now that you know what scale to read on the NULL
549 dial, you can measure a voltage point by taking the
550 reading on the NULL and moving the decimal point
551 to the right by the number of zeros in the number
552 displayed in the FULL SCALE window.
553 ***

554 unit x01m4f
555 back x01m4b
556 next x01m4g
557 at 1210
558 write If the A VOLTS dial was set at 100 mV and
559 the NULL reading was .5, what would be the voltage?

- 560 a.) 5 mV
- 561 b.) 50 V
- 562 c.) 500 mV
- 563 d.) 5000 mV

564 arrow 2215
565 specs bumpshift
566 answer c
567 wrong b
568 at 2410
569 write The answer is in mV not V.
570 wrong (a,d)
571 at 2410
572 write There are two zero's in the A Volts
573 reading, and $10^2 \times .5 = 50$.
574 ***

575 unit x01m4g
576 next x01m5a
577 back x01m4f
578 help x01m4b
579 pack n33,+++++a+b00a00b000+00

```

580 join ckc
581 jump n47,x01s4c,x
582 pack n33,++++ (cd) (de) (abdc)labaf (bcd) ++++++
583 join fld
584 jump n47,x01s4c,x
585 at 1308
586 write Measure the peak-peak voltage of the sine wave
587 displayed on the Scope using the A VOLTS NULL DIAL.

588 What is the measured voltage volts
589 arrow 1640
590 ansy 41,10

```

----- part=1, block=j -----

block 1j, x01m5a

```

592 unit x01m5a
593 restart
594 join lmode
595 jump n47,x01m5a,x01m5a0
596 ***

597 unit x01m5a0
598 base
599 back x01m4f
600 next x01m5a1
601 lab x01s1e
602 at 910
603 write This oscilloscope is capable of displaying two
604 waveforms at the same time, which is very useful
605 in comparison measurements.

```

```

606 Using the FUNCTION GENERATOR, apply a nonadjustable
607 SINE wave to channel A and a nonadjustable SQUARE
608 wave to channel B of the SCOPE.

```

```

609 Trigger the SCOPE from the FUNCTION GENERATOR.

```

```

610 Each time you begin a new series of measurements,
611 it is advisable to recheck the dc balance of the
612 A and B PRE AMPs, and rezero the traces.

```

```

613 Press -LAB- to review the balancing procedure.

```

```

614 ***

615 unit x01m5a1
616 pack n33,+++++abcb0a00c000+000
617 join ckcw
618 next n47,x01m5a0,x
619 jump n47,x,x01m5b
620 ***

```

```

621 unit x01m5b

```



```

622 back x01m5a0
623 next x01m5b1
624 at 510
625 write Set the frequency at 40 Hertz, and display
626 both traces simultaneously, with TIME FULL SCALE
627 at 100 ms.
628 ***

```

```

629 unit x01m5b1
630 pack n33,+m+(abcd) (cd) (de) (abcd) cbae (ghi) ++(abcd) ++++++
631 join ckdw
632 jump n47,x,x01m5c
633 next x01m5b
634 ***

```

```

635 unit x01m5c
636 back x01m5b
637 next x01m5d
638 at 1207
639 write For the most stable display of a low frequency
640 signal the CHOP setting of the Y DISPLAY is desirable.
641 ***

```

```

642 unit x01m5d
643 back x01m5c
644 next x01m6a
645 at 1210
646 write Experiment on your own for awhile. Change
647 the frequency of the wave and the TIME dial.

```

```

648 Note which setting of the Y DISPLAY (ALT or CHOP)
649 gives the best display.
650 ***

```

```

651 unit x01m6a
652 back x01m5d
653 next x01m7a
654 at 1214
655 write Set the Y DISPLAY FUNCTION to A vs B.
656 pause
657 pack n33,+++++e+++++
658 join ckd
659 jump n47,x01s6a,x
660 at 1210
661 write The pattern you see on the SCOPE is called
662 a LISSAJOUS figure. Change the wave INPUTS to
663 the SCOPE (SQUARE, SINE, TRIANGLE, RAMP) to get
664 different patterns.

```

block k, x01m7a1

part=1, block=k

```

666 unit x01m7a

```

667 restart
668 join mode
669 jump 347, x01m7a, x01m7aa
670 ***

671 unit x01m7aa
672 back
673 back x01m7a
674 next x01m7a1
675 ***

676 write Set the FUNCTION GENERATOR at 4000 Hz and connect
677 the nonadjustable SQUARE wave to channel B.

678 Connect the AUDIO OSCILLATOR to the A channel
679 with a frequency of 3000 Hz, and adjust the AMPLITUDE
680 to a comfortable level.

681 Trigger the SCOPE from the FUNCTION GENERATOR.

682 Adjust the display until both voltages appear.
683 The A-B SEPARATION knob, to the left of the CRT
684 screen, adjusts the separation of the zero base lines
685 of the A and B traces.

686 You may superpose the traces by reducing the
687 separation of the zero base lines to zero. Or, you
688 may separate them by raising the B zero base line
689 to +2 and lowering the A zero base line to
690 -2. If you turn both the PRE GNEs to OFF while
691 doing this, your adjustments will be made accurate.

692 ***

693 unit x01m7a1
694 next x01m7a2
695 back 347, x01m7a, x01m7aa
696 join
697 jump 347, x01m7a
698 ***

699 unit x01m7a2
700 back x01m7a1
701 back 347, x01m7a, x01m7aa (abcd) (cd) (de) (abcd) (d) (e) (fghi) ++ (abcd) ++++ (fghi) +
702 join
703 jump 347, x01m7a
704 ***

705 unit x01m7b
706 back x01m7a
707 next x01m7c
708 ***
709 write Are both traces stable?
710 answer YES
711 ask
712 write The SCOPE is being triggered by the FUNCTION GENERATOR.
713

714 Which is the stable trace? (square or sine)

```

715 no
716 at 710
717 write ' If they are, then you aren't!!!
718 arrow 1037
719 spegs bumpshift
720 answer (square) <wave>
721 ***

722 unit x01m7c
723 back x01m7b
724 next x01m7d
725 at 507
726 write Set the TRIGGER SOURCE so that both traces are stable.
727 ***

728 unit x01m7d
729 back x01m7c
730 pack n33,++++ (fg) ++++++
731 join ckd
732 jump n47,x01s7a,x
733 at 1010
734 write Correct! On the INT trigger settings, the
traces trigger independently.
735 next n47,x01m7c,x01end

```

----- part=1, block=1

block 11, x01s1a1

```

737 unit x01s1a
738 next x01s1b
739 back x01s1c
740 at 1007
741 write Adjust the INTENSITY and FOCUS controls so that
742 the spot is a sharp point of light with no halo.

743 The X POSITION and Y POSITION controls are used
744 to move the spot around the screen.

745 If no spot appears on the screen, even at full
746 INTENSITY, use the BEAM FINDER control to locate it.

747 Press -NEXT- for information on use of BEAM FINDER.

748 Set the SCALE illumination control at 8.0.

749 When the spot is properly adjusted, press -BACK-.
750 ***

751 unit x01s1b
752 back x01s1a
753 next x01s1c
754 at 507
755 write USE OF THE BEAM FINDER:

```

756
 757 1) Turn and hold the black BEAM FINDER knob fully CW.
 758 2) The spot should appear on the screen. Center it,
 759 using the red X and Y POSITION knobs.
 760 3) Release the BEAM FINDER when the spot is within
 761 a few cm of the center, and the spot should remain.
 762 at 3005
 763 write If you still can't locate the spot call your instructor.
 764 end
 765 ***

766 unit x01sic
 767 press next
 768 end
 769 ***

770 unit v01sid
 771 back x01mic
 772 next x01sie
 773 at 1007
 774 write Before using the SCOPE for any investigation,
 775 the A and B preamplifiers must be balanced. This
 776 is essentially an adjustment of the linearity of
 777 their dc amplifiers.

778 Balance the A PRE AMP using the procedure you
 779 will see when you press NEXT-.
 780 ***

781 unit v01sie
 782 at 510
 783 write BALANCING PROCEDURE

784 For the preamplifier you want to balance:
 785 1) Set PRE AMP to OFF.
 786 2) Set VOLTS FULL SCALE to 1mv, and center the trace.
 787 3) Set PRE AMP to BAL SET and use the BAL screw
 788 to center the spot. Use the beam finder if
 789 needed. (BAL Screw has both fine and coarse
 790 adjustment. Adjust slightly past center and
 791 then back for finer control)
 792 4) Check to see that the preamplifier is balanced by
 793 switching the PRE AMP between OFF and BAL SET.
 794 If the spot moves, repeat the balancing procedure.
 795 5) Return VOLTS FULL SCALE to desired setting.
 796 Call your instructor, if you are unable to
 797 properly balance the PRE AMPS
 798 end

block 1m, x01sif1

```

800 unit | x01sif
801 back | x01sig
802 next | x01sig
803 at | 1210
804 write |
805 |      Something is wrong with your setup.
806 |      You will be given information on the dials
807 |      before you are allowed to try again. Press
808 |      -NEXT- for this information.
809 |
810 |
811 |
812 |
813 |
814 |
815 |      With A.VOLTS FULL SCALE set at 20 volts, the
816 |      sensitivity (volts/cm.) would be
817 |      arrow | 1043
818 |      answer | <volts,volt,cm>(2)
819 |      at | 1207
820 |      write |      What is the minimum number of cm needed to deflect
821 |      the spot to the edge of full scale from (0,0) ?
822 |      arrow | 1530
823 |      answer | <cm>(5)
824 |      at | 2007
825 |      write |      Setting A VOLTS FULL SCALE to 10 volts provides
826 |      a deflection of 10 cm for a 10 volt signal. However,
827 |      since the spot is now at (0,0), a setting of 20 V
828 |      will allow the spot to remain on the screen when a
829 |      10 volt signal is applied.
830 |      wrong | 10
831 |      at | 1710
832 |      write |      If the spot were centered at the bottom of
833 |      the screen, full scale deflection would be 10
834 |      Try again remembering the spot is at (0,0)
835 |      ***
836 |
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845 ***

846 unit >01s1i
847 back >01mic
848 next >01mic
849 at 1310
850 write You cannot deflect the spot with the A PRE AMP
851 in the OFF position.

852
853
854 To what position should the A PRE AMP be set
855 to deflect the spot?

856 arrow 1340
857 space jumpshift
858 answer (dc)
859 wrong (ac)
860 at 1310
861 write No! You are applying a dc or constant voltage.

----- part=1, block=n -----

block 1n, >01s2a

863 unit >01s2a
864 back >01m2a
865 next >01m2a
866 at 1307
867 write Connect the "+" terminal of the DC SUPPLY to the
868 A INPUT of the SCOPE and the "-" terminal to ground.

869 The DC SUPPLY generator circuit is not internally
870 grounded, that is, it is floating. However, there
871 is a common-ground terminal to the right of the +
872 and - terminals to which an external ground
873 connection can be made.
874 ***

875 unit >01s2a1
876 next >01m2a
877 back >01m2a
878 at 1306
879 write You have unnecessarily changed some of the dials.
880 The only dials you may have needed to change were
881 the A PRE AMP and the X DISPLAY. Return all other
882 dials to where they were before.
883 ***

884 unit >01s2b
885 back >01m2a
886 next >01m2a
887 at 1310
888 write You did not set the A PRE AMP to allow
889 a positive voltage to cause upward deflection.
890 ***

891 unit x01s2c
892 base
893 back x01m2b
894 next x01m2b1
895 lab x01s1e
896 at 1310

897 write You did not deflect the spot 5 cm properly.
898 On the DC SUPPLY, verify that you have set the CURRENT
899 to at least 100 mA and the VOLTAGE to provide a 5
900 cm deflection. Press -LAB- if you want to
901 rebalance a PRE AMP.
902 ***

903 unit x01s2d
904 at 1210
905 write The B channel deflects the spot in
906 a manner similar to that of the A channel.

907 The A channel deflects vertically and the B channel
908 deflects horizontally with A vs B.

909 After you return to the task statement,
910 you can repeat the A channel again by pressing -BACK-.
911 end

----- part=2, block=a -----

block 2a, x01s2e1

913 unit x01s2e
914 back x01m2a
915 next x01m2d
916 at 1210

917 write You seem to have trouble deflecting the spot
918 horizontally. You should have turned the A PRE AMP to
919 OFF or should have disconnected the connection to
920 the A INPUT. Press -NEXT- to try again.

921 Press -BACK- to repeat the vertical deflection task.
922 ***

923 unit x01s2f
924 back x01m2e
925 next x01m2e
926 at 1210

927 write You incorrectly set the dials.
928 pause
929 erase

930 at 810
931 write The vertical deflection is controlled
932 by the channel with Y DISPLAY at A vs B.
933 arrow 917
934 specs bumpshift

935 answer a
936 at 1210
937 write The horizontal deflection is controlled
938 by the channel with the Y DISPLAY at A vs B.

939 arrow 1317
940 specs bumpshift

941 answer b
942 at 1610

943 write Then to control both the A and the B
944 channels, the Y Display should be set to

945 arrow 1750
946 specs bumpshift

947 answer (a) (vs, versus, vs) (b)
948 at 2010

949 write Both the A and the B PREAMPs should
950 be set in the position to deflect
951 the spot.

952 arrow 2124
953 specs bumpshift

954 answer d
955 at 2410

956 write Set the A and B VOLTS FULL SCALE dials to 20 V.
957 ***

958 unit >01s2g

959 back >01m2e

960 next >01m2e

961 at 1310

962 write You incorrectly set the DC SUPPLY. Make
963 sure that a 3 cm deflection is obtained.

964 ***

965 unit >01s2h

966 back >01m2e

967 next >01m2e

968 at 1310

969 write You did not set the A and B PRE AMPs so
970 a positive voltage would cause upward deflection.

971 ***

972 unit >01s2i

973 back >01m2e

974 next >01m2e

975 at 1310

976 write You incorrectly connected the DC SUPPLY to
977 the SCOPE!

part=2, block=b

block 2b, >01s3a

979 unit >01s3a

980 back

981 back >01m3a


```

982 next      x01m3a
983 lab       x01s3b
984 data      x01s3c
985 at        1210
986 write     Press the desired key for the information
987           you want;

988           -LAB- Voltage peak to peak or  $V_{p-p}$ 
989           -DATA- Connections.
990           -NEXT- To return to the task.
991 ***

992 unit       x01s3b
993 back       x01m3a
994 next       x01m3a
995 origin     72,352
996 axes       0,-101,300,100
997 scalex     20
998 scaley     10
999 markx       $\pi, \pi/4$ 
1000 labely    10,2.5
1001 delta     .2
1002 funct     [0sin(v77),v77
1003 at         2510
1004 write     What is the peak to peak voltage of this wave?
1005 arrow      2556
1006 ansy       20,2
1007 no
1008 at         2710
1009 write     The peak to peak voltage is the voltage between
1010            $V_{max}$  and  $V_{min}$ 
1011 hbar       372,10,-
1012 graph      372,10, $V_{max}$ 
1013 hbar       372,-10,-
1014 graph      372,-10, $V_{min}$ 
1015 vector      $9\pi/4,0,9\pi/4,9.6$ 
1016 vector      $9\pi/4,0,9\pi/4,-9.6$ 
1017 at         1054
1018 write      $V_{p-p}$ 
1019 write
1020 end
1021 **

1022 unit       x01s3c
1023 next       x01m3a
1024 at         1210
1025 write     Shown below are the three terminals
1026           of the AUDIO OSCILLATOR. To apply a sine
1027           wave to the A INPUT of the SCOPE,
1028           the A INPUT must be connected to what
1029           terminal of the AUDIO OSCILLATOR. (A, B, or C)
1030 circle     8,160,192
1031 circle     8,192,192
1032 circle     8,224,192
1033 draw       2026;200,178;194,172;157,172;152,177;152,191
1034 skip:167,191;167,183;184,183;184,191
1035 at         157,184

```

```

1036 write A B C
1037 arrow 1740
1038 specs bumpshift
1039 answer c
1040 at 2410
1041 write This is the only connection you need since
1042 the SCOPE and the AUDIO OSCILLATOR are internally
1043 grounded.
1044 wrong (a,b)
1045 at 2410
1046 write No! Terminal B is connected to ground.
1047 Notice the ground strap between A and B.
1048 no
1049 at 2410
1050 write NO!!! Type the letters A, B, or C.
1051 end
1052 ***

```

```

1053 unit >01s3d
1054 next >01s3c
1055 at 1210
1056 write You incorrectly connected the AUDIO OSCILLATOR
1057 to the SCOPE. Press -NEXT- for help.
1058 ***

```

```

1059 unit >01s3e
1060 next >01m3a
1061 at 1010
1062 write You were not to change the dials on the SCOPE!
1063 Reset them in these positions:

```

```

1064 A VOLTS FULL SCALE 20 V
1065 SWEEP MODE OFF
1066 TRIGGER SOURCE OFF
1067 A PRE AMP +DE
1068 Y DISPLAY A vs B
1069 ***

```

```

1070 unit >01s3f
1071 next >01m3a
1072 at 1010
1073 write The output frequency of the AUDIO OSCILLATOR is
1074 incorrectly set. Remember the output frequency
1075 is the product of the RANGE dial and the frequency
1076 dial.

```

-----part=2, block=c-----

block 2c. >01s3g

```

1077 unit >01s3g
1078 base
1079 next >01m3a

```

```

1081 help >01s3b
1082 at 1210
1083 write The AMPLITUDE of the AUDIO OSCILLATOR is
1084 . Incorrectly set.

1085 Press -NEXT- to try again.
1086 Press -HELP- if uncertain about Vp-p.
1087 ***

1088 unit >01s3h
1089 define switch=1
1090 . trmnl=2
1091 ground=3
1092 char trmnl
1093 . 00000016,00000033,00000021,00000033,00000016,00000000,00000000,00000000
1094 char switch
1095 . 00000000,00000340,00000760,00001777,00001777,00000760,00000340,00000000
1096 char ground
1097 . 00000000,01000000,01200000,01240000,01240000,01200000,01000000,00000000
1098 draw 1606;1635;2135;2106;1606
1099 circle 8,160,217
1100 circle 25,160,217
1101 circle 4,184,199
1102 circle 10,224,227
1103 circle 6,224,227
1104 at 256,245
1105 plot trmnl
1106 at 256,235
1107 plot trmnl
1108 at 256,225
1109 plot trmnl
1110 at 256,215
1111 plot trmnl
1112 at 256,205
1113 plot trmnl
1114 at 256,185
1115 plot trmnl
1116 at 240,185
1117 plot trmnl
1118 at 222,185
1119 plot trmnl
1120 circle 5,201,185
1121 circle 8,115,230
1122 circle 8,83,230
1123 at 51,237
1124 plot trmnl
1125 at 51,227
1126 plot trmnl
1127 at 51,217
1128 plot trmnl
1129 at 88,188
1130 plot switch
1131 at 210
1132 write The nonadjustable outputs have fixed voltages.
1133 . There is no way to alter this.
1134 size 5
1135 at 279,208

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```

1136 write )
1137 size 0
1138 at 1839
1139 write Nonadjustable
1140 Outputs
1141 pause
1142 at 610
1143 write The adjustable OUTPUT is controlled by the
1144 ATTENUATOR, the OUTPUT selector, and the DC LEVEL.
1145 / The ATTENUATOR and DC LEVEL controls are interdependent.
1146 draw 224,125;224,181;skip;228,179;224,183;220,179
1147 at 184,108
1148 write Adjustable
1149 OUTPUT
1150 draw 140,121;198,179;skip;198,174;198,179;193,179
1151 at 48,117
1152 write DC LEVEL
1153 draw 222,225;265,268;skip;222,230;222,225;227,225
1154 at 1534
1155 write ATTENUATOR
1156 draw 180,271;215,236;skip;211,235;216,235;216,240
1157 at 1515
1158 write OUTPUT
1159 end

```

----- part=2, block=d -----

block 2d, x01s3ii

```

1161 unit x01s3i
1162 next x01m3c
1163 at 1370
1164 write You incorrectly set the dials. Read the
1165 problem carefully. You are given which dials
1166 you needed to change.
1167 **

1168 unit x01s3j
1169 next x01m3c
1170 at 1310
1171 write It is necessary to again drive the A channel from
1172 the AUDIO OSCILLATOR.
1173 **

1174 unit x01s3k
1175 back x01m3e
1176 next x01m3e
1177 at 705
1178 write The Y DISPLAY FUNCTION should be set to the
1179 position to display the sine wave on the A INPUT.
1180 arrow 749
1181 speed bumpshift
1182 answer a
1183 at 1205

```

1184 write To internally trigger the SCOPE, the TRIGGER
1185 SOURCE should be set at
1186 no
1187 at 1005
1188 write The Y DISPLAY FUNCTION should be set to the A
1189 position to display the sine wave on the A channel.
1190 arrow 1330
1191 specs bumpshift
1192 answer <ac,dc> (int,internal)
1193 at 1310
1194 write The SWEEP MODE should be set to the DRIVEN -
1195 VARIABLE LENGTH position.

1196 Set the TIME at 50 ms (1/frequency), so that one
1197 period (T) of the sine wave appears on the screen.

1198 no
1199 at 1510
1200 write The TRIGGER SOURCE should be set to the INT
1201 position when you internally trigger the SCOPE.
1202 end
1203 ***

1204 unit x01s31
1205 next x01s3k
1206 at 1210
1207 write You have incorrectly set the dials.

1208 Instructions on how to correct these errors
1209 will be given when you press +NEXT-.
1210 ***

1211 unit x01s3m
1212 next x01m3e1
1213 at 1210
1214 write You don't need that wire connected to the B INPUT.

----- part=2, block=e -----

block 2e. x01s4a!

1216 unit x01s4a
1217 next x01s3k
1218 at 505
1219 write To what position must the TRIGGER SOURCE be set
1220 to, permit the SCOPE to be externally triggered?
1221 arrow 653
1222 specs bumpshift
1223 answer <ac,dc> (ext,external)
1224 at 1410
1225 write The only connection needed to externally
1226 trigger the SCOPE from the FUNCTION GENERATOR
1227 is a connection from the _____ terminal of
1228 the SCOPE to the _____ terminal of the
1229 FUNCTION GENERATOR.

```

1230 no
1231 at 1110
1232 write It should be set in an EXT position.
1233 arrow 1634
1234 specs bumpshift
1235 answer <the,terminal>(trig,trigger) (in,input)
1236 no
1237 at 2410
1238 write * The terminal on the SCOPE is the TRIGGER INPUT.
1239 arrow 1726
1240 specs bumpshift
1241 answer <the,terminal>(trig,trigger) (out,output)
1242 jump x01s3h
1243 no
1244 at 2410
1245 write The terminal on the FUNCTION GENERATOR is
1246 the TRIG OUT.

```

part=2, block=f

block 2f, x01s4b1

```

1248 unit x01s4b
1249 define spots=1
1250 char spot
1251 0000014,0000036,0000077,0000077,0000036,0000014,0000000,0000000
1252 join x01s4b1
1253 at 245,320
1254 plot spot
1255 at 2510
1256 write To measure the voltage of this deflection
1257 move the NULL dial until the voltage point is at the
1258 zero base line.

1259 Press -NEXT- to see this done.
1260 pause
1261 mode erase
1262 at 245,320
1263 plot spot
1264 at 2510
1265 write To measure the voltage of this deflection
1266 move the NULL dial until the voltage point is at the
1267 zero base line.

1268 Press -NEXT- to see this done.
1269 mode write
1270 at 245,253
1271 plot spot
1272 pause
1273 erase
1274 join x01s4b1
1275 funct 5sin(v77),v77+2π,2π,.1π
1276 at 2510.
1277 write If you wanted to measure the zero to

```

1278 peak voltage (V_{0-p}), move the trace to the
1279 zero level by adjusting the NULL. Press
1280 -NEXT- to see this done.

1281 pause
1282 mode erase
1283 funct $5\sin(v77), v77 \leftarrow -2\pi, 2\pi, .1\pi$
1284 at 2510

1285 write If you wanted to measure the zero to
1286 peak voltage (V_{0-p}), move the trace to the
1287 zero level by adjusting the NULL. Press
1288 -NEXT- to see this done.

1289 mode write
1290 funct $5\sin(v77) - 5, v77 \leftarrow -2\pi, 2\pi, .1\pi$
1291 end
1292 ***

1293 unit $\times 01s4b*$
1294 origin 1632
1295 axes $-120, 120, 120, 120$
1296 scalex 2π
1297 scaley 10
1298 markx $.4\pi, .4\pi, 2$
1299 marky $2, 2, 2$
1300 markz $.4\pi, .08\pi$
1301 ***

1302 unit $\times 01s4c$
1303 next $\times 01m4a$
1304 back $\times 01m4a$
1305 at 1310
1306 write You did not follow my instructions to leave
1307 the waveform displayed on the screen. Press
1308 -NEXT- to display the waveform again.
1309 ***

1310 unit $\times 01s6a$
1311 next $\times 01m6a$
1312 at 1610
1313 write Set the Y DISPLAY to A vs B.
1314 ***

1315 unit $\times 01s7a$
1316 back $\times 01m7c$
1317 next $\times 01m7c$
1318 at 1310
1319 write You did not set the TRIGGER SOURCE
1320 in the correct position!
1321 end

-----part=2, block=g

block 2g, $\times 01end!$

1323 unit $\times 01end$

```

1324 back x01m7a
1325 join imode
1326 jump n+7,x01end,x
1327 course n2
1328 calcc n2='ee244',
1329 nc (n21+1) + (nc (n21+1) $mask$077777777770000000000) +o4603000000,
1330 nc (n21+1) +nc (n21+1)
1331 output /// student has completed experiment ///
1332 join endunit
1333 join jmpmes
1334 jumpoft ageindex,quest1
1335 entry leave
1336 end lesson
1337 ***

```

```

1338 unit endunit
1339 course n2
1340 jump n,x'ee244',leave,x
1341 calcc n: (n21+7) +nc (n21+7) +ahelp
1342 v0 (n21+6) +v0 (n21+6) +atime/600000
1343 ***Incl. see s.r. @ terms sample, index, imode, comment, slides.
1344 use e0x00,ck1
1345 use ck2
1346 use ck3
1347 use ck4
1348 use ck5
1349 use ck6

```

ck0	not found		120	202	210	330	237	388	271
			580						
ck0w	not found		411	617	696				
ck0i	not found		125	243					
ck1	not found		98	130	138	226	157	270	197
			325	352	385		583	731	658
ck0w	not found		417	631	702				
ck0i	not found		101	133	141	234	207	279	229
			282	285	333				
endunit	x01end	1338	23	1332					
imode	not found		35	393	594		668		1325
jmpmes	not found		1333						
leave	x01end	1335	1340						
x01end	x01end	1323	735	1326					
x01m0a	x01m0a	31	36	54					
x01m1a	x01m1a	51	34	68					
x01m1b	x01m1a	66	55	81					
x01m1c	x01m1a	78	69	105	771		847		848
x01m1d1	x01m1a	96	82						
x01m2a	x01m2a	104	99	145	864	977	865	995	876
			886	914					
x01m2a1	x01m2a	117	106						
x01m2a2	x01m2a	20	121						
x01m2a3	x01m2a	126	121						
x01m2a4	x01m2a	136	126						
x01m2b	x01m2a	144	118	134	142		161		893
x01m2c	x01m2a	154	146	894					
x01m2d	x01m2a	160	158	181					
x01m2e	x01m2d	179	162	214	915				

x01m2d1	x01m2d	195	182					
x01m2d2	x01m2d	200	198					
x01m2d3	x01m2d	205	198					
x01m2e	x01m2d	213	203	211	248	957	924	960 925
			966	967	973		974	
x01m2e1	x01m2d	223	215					
x01m2e2	x01m2d	232	227					
x01m2e3	x01m2d	241	238					
x01m2f	x01m2d	247	224	239	245		259	
x01m3a	x01m3a	256	249	289	981	994	982	1023 993
			1060	1071	1080			
x01m3a1	x01m3a	269	260					
x01m3a2	x01m3a	274	272					
x01m3b	x01m3a	288	277	306				
x01m3c	x01m3a	305	290	339	342		1162	1169
x01m3c1	x01m3c1	323	307					
x01m3c2	x01m3c1	328	326					
x01m3d	x01m3c1	341	337	358	362			
x01m3d1	x01m3c1	350	343					
x01m3e	x01m3c1	360	353	378	1175		1176	
x01m3e1	x01m3c1	367	363	1212				
x01m4a	x01m4a	391	389	394	423		430	1304 1303
x01m4a0	x01m4a	396	394	412	418			
x01m4a1	x01m4a	405	399					
x01m4a2	x01m4a	415	413					
x01m4b	x01m4a	428	422	555	578			
x01m4b0	x01m4a	434	419					
x01m4c	x01m4a	448	431					
x01m4d	x01m4d	486	484	507				
x01m4d1	x01m4d	500	498					
x01m4d2	x01m4d	510	490					
x01m4d3	x01m4d	521	498					
x01m4d4	x01m4d	529	507	504				
x01m4d5	x01m4d	534	502	504				
x01m4d6	x01m4d	539	504					
x01m4e	x01m4d	544	498					
x01m4f	x01m4d	554	545	577	599			
x01m4g	x01m4d	575	556					
x01m5a	x01m5a	580	576	595				
x01m5a0	x01m5a	597	595	618	622			
x01m5a1	x01m5a	615	600					
x01m5b	x01m5a	621	619	639	636			
x01m5b1	x01m5a	629	623					
x01m5c	x01m5a	635	630	643				
x01m5d	x01m5a	642	637	652				
x01m6a	x01m5a	651	644	673	1311			
x01m7a	x01m7a	666	653	669	706		1324	
x01m7a0	x01m7a	671	669	694	700			
x01m7a1	x01m7a	690	674					
x01m7a2	x01m7a	699	697					
x01m7b	x01m7a	705	703	723				
x01m7c	x01m7a	722	707	729	735		1316	1317
x01m7d	x01m7a	728	724					
x01s1a	x01s1a	737	56		752			
x01s1b	x01s1a	751	738					
x01s1c	x01s1a	766	739	753				
x01s1d	x01s1a	790	83					

x01s1e	x01s1a	781	183	681	772	895				
x01s1f	x01s1f	800	182							
x01s1g	x01s1f	809	84	881	882					
x01s1h	x01s1f	836	818							
x01s1i	x01s1f	846	182							
x01s2a	x01s2a	863	187	126						
x01s2a1	x01s2a	875	131	139						
x01s2b	x01s2a	884	134	142						
x01s2c	x01s2a	891	158							
x01s2d	x01s2a	903	184							
x01s2e	x01s2e	913	203	288	211					
x01s2f	x01s2e	923	238							
x01s2g	x01s2e	959	230							
x01s2h	x01s2e	965	239	245						
x01s2i	x01s2e	971	244							
x01s3a	x01s3a	979	261							
x01s3b	x01s3a	987	983	1081						
x01s3c	x01s3a	1007	984	1054						
x01s3d	x01s3a	1053	272							
x01s3e	x01s3a	1059	288							
x01s3f	x01s3a	1070	283							
x01s3g	x01s3e	1078	286							
x01s3h	x01s3e	1088	308	1217	1242					
x01s3i	x01s3i	1161	326							
x01s3j	x01s3i	1168	334							
x01s3k	x01s3i	1174	364	1205						
x01s3l	x01s3i	1204	386							
x01s3m	x01s3i	1211	389							
x01s4a	x01s4a	1216	408							
x01s4b	x01s4b	1248	431							
x01s4c1	x01s4b	1297	1251	1274						
x01s4c	x01s4b	1307	581	584						
x01s4a	x01s4b	1318	659							
x01s4b	x01s4b	1315	732							
ahelp		1341								
atime		1342								
ground		1891	1896							
nc		1319	1329	1338	1338	1341	1341			
next		787								
n2		1327	1328	1339	1340					
n21		1339	1329	1338	1338	1341	1341	1342	1342	
n33		97	188	119	124	129	140	132	156	137
		196	281	286	289	285	236	228	242	233
		278	275	278	281	284	332	324	351	329
		384	387	418	416	579	630	582	657	616
		695	701	738						
n47		36	99	183	121	126	137	131	142	134
		158	198	283	288	217	235	227	238	238
		244	272	277	288	283	337	326	353	331
		386	389	394	412	413	391	418	584	419
		695	618	619	632	659	703	669	732	697
		735	1026							
n78		235	339	245	433	481	494	489	493	489
		496	498	502	504					
sin		1007	1175	1283	1308					
sp:t		1249	1250	1264	1263	1271				
station		118	124							

switch	1089	1094	1130						
trmnl	1090	1090	1105	1107	1109	1111	1117	1113	
	1119	1124	1126	1128					
user	118	224							
vc	1340	1340							
v27	1000	1000	1275	1275	1283	1283	1290	1290	
Vma	1012								
Vm1	1014								
T	997	999	999	1275	1275	1283	1275	1283	1283
	1290	1290	1290	1296	1298	1298	1290	1300	1300

lesson information

lesson name = eex01

starting date = 09/23/72

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by neal of course eece

at site 7, station 12

author name = J P Neal

department = EE

telephone number = 330-4351

discipline = elec. eng. lab

grade level = Freshman

description of lesson = The Operation and Uses of the Oscilloscope, Analab 1120.

block 1a, eex02id

```

2 stop
3 **** For Neal, CGERL, Room 248 EEB.
4 One line description of this lesson, --
5 The Operation and Uses of the Audio Oscillator, HP 200AB.
6 Divisions of this Lesson:      Block      Unit
7 Id for this file                eex02id
8 Experiment eex02:
9 Objectives                      x02m0a   x02m0a
10 Frequency adjustments           x02m0a   x02m1a
11 Amplitude adjustment           x02m0a   x02m2a
12 Compare w/function generator   x02m2a2  x02m3a
13 Floating mode                  x02m4a   x02m4a
14 Superposition of waves         x02m5a   x02m5a
15 Final test                      x02m5j   x02m6a
16 final edit 31 aug 74 neal.
17 *list info
18 *list symbols
19 *list varian,charset,cgeindex,cgechar
20 ****
21 start
22 finish endunit
23 write cat:1010 Loading the CGE Character Set
24 charset,cgeindex,cgechar
25 erase
26 *list
27 *list eex02
28 *list

```

block 1b, x02m0a

```

30 unit x02m0a
31 restart
32 join imode
33 jump h47,x02m0a,x
34 base
35 next x02m1a
36 zero n00
37 zero n51

```

38 at 704
 39 write THE OPERATION AND USES OF THE AUDIO OSCILLATOR, HP 200AB
 40 at 1005
 41 write The purpose of this experiment is to experimentally
 42 study the operation of the Audio Oscillator as a
 43 sine-wave voltage generator, and use it in various modes.

44 The specific tasks of this experiment are to examine:

- 45 1) Frequency adjustments.
- 46 2) Amplitude adjustment and measurement.
- 47 3) Comparisons with the Function Generator.
- 48 4) The floating mode of the Audio Oscillator.
- 49 5) Superposition of waveforms.

50 ***

51 unit x02m1a
 52 restart
 53 base
 54 next x02m1b
 55 back x02m0a
 56 at 807
 57 write The Audio Oscillator produces a sine-wave voltage
 58 over a range of frequencies which nearly coincides
 59 with the range of audible acoustical frequencies.

60 The parameters of the generated sine-wave voltage
 61 are its frequency and its amplitude. These parameters
 62 can be varied by adjustments of the dials on the front
 63 panel of the Audio Oscillator.

64 The output frequency in Hertz is designed to be
 65 within 2 percent of the product of the settings of the
 66 large frequency dial and the RANGE dial.

67 The output amplitude is adjusted by the AMPLITUDE
 68 dial. This dial is not calibrated in volts.

69 ***

70 unit x02m1b
 71 back x02m1a
 72 next x02m1c
 73 at 808
 74 write Adjust the Audio Oscillator to generate a
 75 frequency of approximately 5000 Hertz.
 76 ***

77 unit x02m1c
 78 pack n73, ++++++c(kl)df)+
 79 join ckd
 80 jump n47, x02s01a, x02m2a
 81 ***

82 unit x02m0a
 83 restart

127 Check your measurements!

128 ***

129 unit >02m2c

130 back >02m2b

131 next >02m3a

132 at 607

133 write Good.

134 Without moving the AMPLITUDE control on the

135 Audio Oscillator, observe the amplitude of the

136 output sine wave voltage on the Scope while you

137 vary the frequency of the Audio Oscillator over

138 its entire operating range.

139 pause

140 at 1407

141 write Does the amplitude of the output vary with frequency?

142 arrow 1626

143 answer (y, yes, Y, Yes)

144 at 1707

145 write Right! The amplitude does vary somewhat.

146 wrong (n, no, No)

147 at 1707

148 write Look at it more carefully, while you vary the

149 frequency from the lowest to the highest settings.

150 ***

151 unit >02m3a

152 restart

153 base

154 back >02m2b

155 next >02m3b

156 at 807

157 write The Function Generator is also capable of producing

158 a sinusoidal waveform of adjustable frequency and

159 amplitude.

160 We will now use the Scope to compare the adjustable

161 SINE output of the Function Generator with the output

162 of the Audio Oscillator.

163 ***

164 unit >02m3b

165 back >02m3a

166 next >02m3c

167 at 1507

168 write Connect the adjustable SINE output of the Function

169 Generator to the B channel of the Scope.

170 The Function Generator is grounded by the links

171 between the lower right terminals on its front panel,

172 so only one connection from the Function Generator

173 is necessary.

174 ***

175 unit >02m3c

176 pack n33,+++++*bc++++c+++b+++



```

177 join ckc
178 jump n47,x02s06a,x02m3d
179 ***

180 unit x02m3d
181 restart
182 back x02m3b
183 next x02m3e
184 at -807
185 write Set the Function Generator to produce a sine
186 wave with a frequency of 5000 Hz. and with a
187 maximum amplitude.

188 (If you would like to review the operation
189 of the Function Generator, press -LAB-.)

190 Now, set the Scope to display the A and B
191 channels alternately, with both the A and B VOLTS
192 at 100 volts and with internal triggering.
193 lab x02s07a

```

----- part=1, block=d -----

block 1d, x02m3e

```

195 unit x02m3e
196 pack n39,p+p(bc)d(fg)(bc)db+g(ijk)bv+++++++
197 join ckd
198 jump n47,x02s08a,x02m3f
199 ***

200 unit x02m3f
201 back x02m3d
202 next x02m3g
203 at 807
204 write Use the Scope to compare the output waveshapes
205 of the Function Generator and the Audio Oscillator.

206 As you experiment with various controls, make any
207 observations necessary to answer the following questions.
208 do x02s09a
209 at 1407
210 write Which instrument has the greater maximum output
211 amplitude?
212 arrow 1536
213 answer a
214 at 1607
215 write RIGHT! The Audio Oscillator is capable of
216 producing the largest amplitude sine wave.
217 ***

218 unit x02m3g
219 back x02m3f
220 next x02m3h

```


221 at 807
 222 write Which instrument has the higher maximum frequency?
 223 at 1307
 224 write Which instrument has the lower minimum frequency?
 225 do x02s09a
 226 arrow 930
 227 bump
 228 answer a
 229 wrong b
 230 at 1007
 231 write Look at both the frequency dial and the
 232 MULTIPLIER (range) dial.
 233 arrow 1400
 234 answer b
 235 wrong a
 236 at 1507
 237 write Look at both the frequency dial and
 238 the MULTIPLIER (range) control
 239 ***
 240 unit x02m3h
 241 back x02m3g
 242 next x02m3i
 243 at 707
 244 write With both sine waves at about the same frequency
 245 you may be able to notice that one of the generators
 246 produces a better quality sine wave.
 247 Which generator is it?
 248 arrow 1135
 249 specs n00kr0, bumpshift
 250 match n51, a, b
 251 at 1140
 252 united n51, no, ok, no
 253 enclarrow
 254 at 1308
 255 write The Audio Oscillator produces a pure sine wave
 256 in its internal oscillator circuit.
 257 The Function Generator produces its sine wave
 258 by means of waveshaping circuits.
 259 at 1307
 260 write Thus the Function Generator 'sine wave' is not as
 261 pure a sine wave as that of the Audio Oscillator.
 262 It has noticeable imperfections.
 263 ***
 264 unit x02m3i
 265 back x02m3h
 266 next x02m4a
 267 at 1007
 268 write In experiments which require the use of
 269 a sinusoidal source, it is generally desirable
 270 to use the Audio Oscillator and not the
 271 Function Generator because of the Audio Oscillator's
 272 purer quality output and greater range.

block 1e, x02m4a:

```

274 unit    x02m4a
275 join    1mode
276 jump    n47,x02m4a;x
277 base
278 restart
279 back    x02m3i
280 next    x02m4b
281 at      807

```

282 write As mentioned before, the Audio Oscillator is normally grounded by the ground link at its terminals.

284 As you might suspect, it is also possible to operate the Audio Oscillator in its ungrounded or floating mode.

286 Now prepare the Audio Oscillator for operation in its floating mode by disconnecting its left output terminal from ground.

289 ***

```

290 unit    x02m4b
291 pack    n33,+++++0+++++0+++++0+++++
292 join    ckc
293 jump    n47,x02s10a,x02m4c
294 ***

```

```

295 unit    x02m4c
296 next    x02m4d
297 at      1007

```

298 write With the Audio Oscillator set to operate in its floating mode, it can be connected in series with other generators or the DC SUPPLY. The net output voltage of the series combination would then be the sum of the individual output voltages.

303 ***

```

304 unit    x02m4d
305 back    x02m4c
306 next    x02m4e
307 help    x02s11a
308 at      707

```

309 write Let's use the Function Generator with the Audio Oscillator in its floating mode and add a square wave to a sine wave.

312 Connect the adjustable SQUARE output of the Function Generator to one of the terminals of the Audio Oscillator.

315 Then connect the other terminal of the Audio Oscillator to the 'A INPUT' of the Scope.

316

317 Trigger the Scope from the Function Generator.

318 at 3125

319 write Help is available.

320 ***

321 unit x02m4e

322 pack n33,0000000000000000a0c00000bc000ba00

323 join ckc

324 jump n47,x,x02m4f

325 pack n33,0000000000000000a0c00000bc000ab00

326 join ckc1

327 jump n47,x02s11a,x02m4f

328 ***

329 unit x02m4f

330 back x02m4d

331 next x02m4g

332 at 1007

333 write Good! Now set the frequency of the Function

334 Generator to 5000 Hz and the frequency of the

335 Audio Oscillator to twice that frequency.

336 Display one period of the square wave on the Scope.

337 ***

338 unit x02m4g

339 pack n33,+e++d(de)(cd)a+ag(1jk)d+(abcd)+++<e(pqr)d(klm)>+

340 join ckcw

341 jump n47,x,x02m4h

342 pause

343 jump x02m4f

344 ***

345 unit x02m4h

346 back x02m4f

347 next x02m5a

348 at 1007

349 write Notice how turning up the amplitudes of the Function

350 Generator and the Audio Oscillator voltages influences

351 the display of the sum of the two waveforms.

352 Experiment a bit. Change the frequency of the

353 Audio Oscillator and see what happens.

----- part=1, block=f -----

block 1f, x02m5a

355 unit x02m5a

356 join 1mode

357 jump n47,x02m5a,x

358 base

359 restart

360 back x02m4h
361 next x02m5b
362 zero n95
363 at 707

364 write You have seen how the Audio Oscillator and the
365 Function Generator can be used to add two waveforms.

366 As you should have noticed, in that case it is
367 difficult to obtain a stable display because the
368 two frequencies are not synchronized.

369 Let's try a different method to superpose two
370 waveforms.

----- part=1, block=g

block 1g, x02m5b

372 unit x02m5b
373 back x02m5a
374 next x02m5c
375 at 707

376 write You will need the SUPERPOSITION BOARD,
377 ITEM 38. Please get it from the shelf below.

378 The theory for the method you are about to use
379 is based on Kirchoff's Current law.

380 The theory states that the current leaving a
381 node is the sum of the currents entering the node.

382 Let me demonstrate this with a few diagrams.

383 ***

384 unit x02m5c
385 back x02m5b
386 next x02m5d
387 at 407

388 write Below is a node with three branches.

389 The node is labeled A and the branches are
390 labeled 1 through 3.

391 at 1632

392 write o

393 at 1613

394 write o

395 at 1651

396 write a

397 at 2632

398 write o

399 draw 251,260;251,105;skip;254,262;400,262;skip

400 248,262;102,262

401 at 1532

402 write A

403 at 1552
 404 write 2
 405 at 1512
 406 write 1
 407 at 2732
 408 write 3
 409 pause
 410 mode rewrite
 411 at 607
 412 write Now let's assume a current reference direction
 413 for each branch, and label the diagram accordingly.
 414 pause 1
 415 mode rewrite
 416 at 1515
 417 write i_1
 418 draw 135, 278; 174, 278; 170, 282; skip; 174, 278; 170, 274
 419 at 1548
 420 write i_2
 421 draw 369, 278; 328, 278; 332, 282; skip; 328, 278; 332, 274
 422 draw 1835; 2235; 276, 164; skip; 272, 160; 268, 164
 423 at 2738
 424 write i_3
 425 pause
 426 mode rewrite
 427 at 607
 428 write According to Kirchoff's Current Law, the current
 429 leaving node A is equal to the sum of the currents
 430 entering node A.
 431 pause
 432 mode erase
 433 at 607
 434 write According to Kirchoff's Current Law, the current
 435 leaving node A is equal to the sum of the currents
 436 entering node A.
 437 mode write
 438 at 607
 439 write Therefore i_3 is equal to the sum of i_1 and i_2
 440 or $i_3 = i_1 + i_2$
 441
 442 pause 1
 443 at 2241
 444 write $= i_1 + i_2$
 445 pause
 446 mode erase
 447 at 407
 448 write Below is a node with three branches.
 449 Therefore i_3 is equal to the sum of i_1 and i_2
 450 or $i_3 = i_1 + i_2$
 451
 452 mode / write
 453 at 407
 454 write If the currents, i_1 and i_2 , are two waveforms,
 455 then i_3 will be the sum of the two waveforms.

part=1, block=h

block 1h, x02m5d

457 unit x02m5d
458 back x02m5c
459 next x02m5e
460 at 507
461 write Now that we have reviewed how two currents can be
462 superposed, let's go to the SUPERPOSITION BOARD.
463 ***

464 unit x02m5e
465 back x02m5d
466 erase
467 draw 1314;2514;2552;1352;1314
468 circle 12,132,284
469 circle 11,380,284
470 circle 11,132,131
471 draw 144,283;166,283;166,275
472 draw 153,243;153,210;158,205;148,195;158,185
473 153,180;153,130;skip;143,130;357,130
474 draw 153,243;166,243;166,251
475 draw 357,130;357,180;352,185;362,195;352,205;357,210
476 357,243
477 draw 369,284;347,284;347,276;skip;357,243;347,243
478 347,251
479 draw 288,130;288,134;293,139;283,149;293,159;288,164
480 288,168
481 circle 11,288,179
482 draw 288,189;288,199;skip;283,199;293,199;skip
483 288,199;283,204;293,204;288,199
484 draw 288,204;288,228;skip;278,228;298,228;skip
485 298,233;278,233;skip;288,233;288,286;293,281
486 303,291;313,281;318,286;318,268
487 draw 277,179;259,179;244,204;skip;259,204;279,212
488 288,212
489 draw 259,212;246,240;skip;259,240;259,246;288,246
490 circle 11,245,286
491 draw 288,286;255,286
492 draw 234,286;229,286;224,291;214,281;204,291;199,286
493 199,268
494 draw 166,263;199,263;199,271
495 draw 347,263;318,263;318,268
496 at 1414

497 write 1) R₁ 3 R₂ 5
498 sw1 sw2
499 2 4
500
501 sw4 C
502 7
503 R₄ sw3 Di R₅
504 8
505
506 R₃
507

508 11 SUPERPOSITION BOARD

509 inhibit erase

510 jump n95, x, x02m5f

511 xxx

512 unit x02m5f

513 back x02m5e

514 at 307

515 write This is the board you will be using to
516) to superimpose the wave forms.

517

518 This board contains more components than
519 you will need to use for this experiment

520 pause

521 mode erase

522 at 307

523 write This is the board you will be using to
524 to superimpose the wave forms.

525

526 This board contains more components than
527 you will need to use for this experiment

528 mode write

529 at 307

530 write The components that you will not need are
531 the capacitor and the diode. These must be shorted
532 out by closing switches sw3 and sw4 for this experiment.

533 mode erase

534 draw 259,179;244,204;skip;259,212;246,240

535 mode write

536 draw 259,212;259,240;skip;259,179;259,205

537 inhibit erase

part=1, block=1

block 11, ~~xxxx~~g

539 unit x02m5g

540 next x02m5h

541 mode erase

542 at 307

543 write The components that you will not need are
544 the capacitor and the diode. These must be shorted
545 out by closing switches sw3 and sw4 for this experiment.

546 mode write

547 at 207

548 write Now, make sure the board is connected to the CGE
549 interface by plugging the board's sensor cable into the
550 jack in the center of the panel below the Function
551 Generator. In addition to closing sw3 and sw4:

552 Set sw1 so that terminals 1 and 2 are connected
553 (sw1 in the up position).

554 Set sw2 so that terminals 5 and 4 are connected

555 (sw2 in the up position).

556 inhibit erase

557 ***

558 unit x02m5h

559 pack n13,aadbb0ddd0000c0000000000000000c00.

560 join ckc

561 inhibit erase

562 jump n47,x,x02m5i

563 next x02m5j

564 ***

565 unit x02m5i

566 back x02m5g

567 next x02m5j

568 help x02s13a

569 jump n51,x02m5j,x-1

570 mode erase

571 at 202

572 write Now, make sure the board is connected to the CGE
573 Interface by plugging the board's sensor cable into the
574 jack in the center of the panel below the Function
575 Generator. In addition to closing sw3 and sw4:

576 Set sw1 so that terminals 1 and 2 are connected
577 (sw1 in the up position).

578 Set sw2 so that terminals 5 and 4 are connected
579 (sw2 in the up position).

580 mode write

581 at 107

582 write Connect the non-adjustable SQUARE wave output
583 from the Function Generator to terminal 5 and
584 the non-adjustable sine wave output from the
585 Function Generator to terminal 1.

586 Connect the common input of the board (terminal 11)
587 to Ground.

588 Connect the A INPUT of the Scope to Terminal 8
589 of the SUPERPOSITION BOARD to display the waveform
590 of the total current.

591 Trigger the Scope from the Function Generator.

592 at 2914

593 write Press -HELP- to see a circuit diagram of setup
594 or

595 Press -NEXT- to have your connection checked.

596 inhibit erase

-----part=1, block=j-----

block 1j, x02m5j:

598 unit x02m5j

599 next x02m5i

600 help x02s14a

601 data x02s15a
 602 erase
 603 pack n33,aacdd0cc+0k0k00c0rd0a00r000k00
 604 join ckc
 605 jump n47,x,x02m5k
 606 calc n95*-1
 607 at 1007
 608 write You have some errors in your setup.

 609 Press -NEXT- to try again.

 610 Press -DATA- to see the correct circuit.

 611 Press -HELP- to see a list of your errors.
 612 ***

 613 unit x02m5k
 614 back x02m5i
 615 next x02m5l
 616 at 1007
 617 write Set the frequency of the Function Generator to
 618 5000 Hertz and display two periods of the wave
 619 on the Scope.
 620 ***

 621 unit x02m5l
 622 pack n33,+f++ (cd) (de) +abag (jk) ++ (abcd) ++++++
 623 join ckd
 624 jump n47,x02s16a,x02m5m
 625 ***

 626 unit x02m5m
 627 back x02m5k
 628 next x02m6a
 629 at 1007
 630 write Experiment with the SUPERPOSITION BOARD for
 631 a while if you wish.

 632 When you press -NEXT- you will be taken to
 633 a short review covering the Audio Oscillator.
 634 ***

 635 unit x02m6a
 636 base
 637 restart
 638 join imode
 639 jump n47,x02m6a,x
 640 back x02m5m
 641 next x02m6b
 642 at 607
 643 write You are ready for a short review covering your
 644 experimental examination of the Audio Oscillator.

 645 ***

 646 unit x02m6b
 647 back x02m6a

648 next x02m6c
649 at 607
650 write Set the Audio Oscillator to:

651 Operate at a frequency of about 20,000 Hertz.

652 Be in the nonfloating mode.

653 Generate a peak-to-peak voltage of about 40 volts.

654 ***

655 unit x02m6c
656 calc n51.0n51+1
657 pack n33,+++++<d(pq)c(uv)>+
658 join ckdu
659 jump n47,x,x02m6ca
660 next x02s18a
661 ***

662 unit x02m6ca
663 pack n33,+++++c+a+++++ac++
664 join ckcw
665 jump n47,x,x02m6d
666 next x02s18a
667 ***

668 unit x02m6d
669 back x02m6b
670 next x02end
671 at 707
672 write Great!

673 Experiment on your own for a few minutes if you wish.

674 ***

675 unit x02s01a
676 next x02m1b
677 at 1007
678 write The frequency setting of the Audio Oscillator
679 is not quite right.

680 Recall, that the frequency of the generated output,
681 is the product of the frequency dial setting and
682 the RANGE dial setting.

683 If the frequency dial is set at 40 and the RANGE
684 dial is set at 200, the generated frequency should
685 be _____ Hz.

686 arrow 1911
687 any 8000.,1
688 end

----- part=1, block=k -----

block 1k, x02s02a

690 unit x02s02a
691 next x02s02b
692 at 1007
693 write In order to display a specific waveform on the Scope
694 so the amplitude can be most accurately read:

695 The Y DISPLAY FUNCTION must be set to the pertinent-
696 INPUT channel.

697 Recall that every reading from the CRT screen has
698 a possible error of 0.1 cm. Therefore, the calibrated
699 VOLTS FULL SCALE must be set as low as possible in order
700 to give maximum vertical traverse to the displayed
701 waveform.

702 The TIME FULL SCALE of the Scope must be
703 set to display the desired number of periods of
704 the waveform.

705 Press -BACK- if you are ready to proceed,

706 or -

707 press -NEXT- if you need more help on the Time setting.

708 ***

709 unit x02s02b
710 at 507
711 write Let T represent the time duration in seconds of
712 one period of the waveform.

713 One period of a sine wave is shown below.

714 origin 1616

715 axes 0, -100, 256, 100

716 scaley 1

717 scalex 20

718 labelx 1, .25

719 markx 0, $\pi/4$

720 write / (at, 1731)T/2 (at, 1748)T

721 write sin(v57) .v57 (at, 20, .02 π)

722 at 1507

723 write If the frequency of the sine wave is 4000 Hz,
724 the period T of the wave expressed in milliseconds is
725 $T = 1000 / \text{frequency} = \text{-----} \text{ ms.}$

726 arrow 2739

727 arrow 125

728 mode rewrite

729 write (at, 2910)Right and T/2 = .125 (at, 1730) .125 (at, 1747) .25 (at, 1650) msec

730 mode write

731 no

732 end

733 ***

734 unit x02s03a

735 next x02m3a



736 at 1007
737 write Both the Scope and the Audio Oscillator circuit
738 commons are normally grounded by links on their
739 front panels. Then, in this case, only one connection
740 is required between the ungrounded output of the Audio
741 Oscillator and the INPUT of the Scope.

742 CHECK your connections again.

743 end

744 ***

745 unit x02s04a

746 next x02m2a

747 at 707

748 write Remember that the period (in seconds) of a waveform
749 is the reciprocal of the frequency. $T = 1/f$.

750 To observe only one complete cycle of a waveform,
751 the TIME FULL SCALE of the Scope must be set to
752 one period.

753 Also check the setting of the dials relating to
754 the A channel on the Scope.

----- part=1, block=1 -----

block 11, x02s05a

756 unit x02s05a

757 back x02m2a

758 next x02s05b

759 at 1017

760 write Having problems?

761 Press -BACK- to try again, or,

762 press -NEXT- to see your errors.

763 ***

764 unit x02s05b

765 join ckd2w

766 next n47, x02m2a, x02m2b

767 ***

768 unit x02s06a

769 next x02m3b

770 at 807

771 write Hint!

772 The red adjustable-output jack of the Function
773 Generator is located directly below the red
774 ATTENUATOR knob.

775 Verify that the Audio Oscillator remains
776 connected to the A channel of the Scope.
777 ***

778 unit x02s07a
779 at 807
780 write The frequency of the Function Generator output
781 is the product of the CYCLES/SEC dial setting and
782 the MULTIPLIER dial setting.

783 The black OUTPUT knob selects the shape of
784 the adjustable-output waveform at the red output
785 jack directly below it.

786 The red ATTENUATOR knob controls the amplitude
787 of the waveform at the red output jack. As usual,
788 maximum amplitude is fully clockwise.
789 end
790 ***

791 unit x02s08a
792 next x02m3d
793 at 1007
794 write You had better check your dial settings again.
795 end
796 ***

797 unit x02s09a
798 at 1007
799 write To answer Audio Oscillator, type- a
800 To answer Function Generator, type- b
801 end
802 ***

803 unit x02s10a
804 next x02m4a
805 at 1007
806 write HINT! The left red output terminal of the Audio
807 Oscillator is normally connected to the black ground
808 terminal by a metal ground link.
809 end
810 ***

811 unit x02s11a
812 next x02s12a
813 at 1007
814 write The Function Generator and the Audio Oscillator
815 should be connected in series, that is they should
816 form a single continuous loop to the Scope.
817 circle 32,152,208
818 draw 1924;1936;2236;2242;2142;skip;304,169;1739;1746
819 360,169;304,169;skip;2144;2744;2729;2829;skip
820 2933;2633;2614;2914;2933;skip;2831;240,40;skip
821 250,40;230,40;skip;235,35;246,35;skip;243,31
822 238,31;skip;1916;1912;2012;skip;102,192;74,192
823 skip;80,186;96,186
824 draw ;skip;92,180;85,180

825 at 128,000
826 write 50000
827 at 1940
828 write H.O.
829 at 2818
830 write F.G.
831 circle 3,328,176
832 circle 3,344,176
833 circle 3,314,176
834 circle 3,340,64
835 circle 3,324,64
836 inhibit erase

part=1, block=m

block 1m, x02s12a

838 unit x02s12a
839 next x02m4d
840 mode erase
841 at 1007
842 write The Function Generator and the Audio Oscillator
843 should be connected in series, that is they should
844 form a single continuous loop to the Scope.
845 mode write
846 at 1007
847 write The best source for the external trigger of the
848 Scope is the TRIG OUT of the Function Generator.
849 circle 3,119,64
850 draw 100,344;115,128;155,138;155,176
851 at 2703
852 write TRIG OUT
853 end
854 ***

855 unit x02s10a
856 back x02m5f
857 calc n01421
858 mode erase
859 at 1077
860 write . Connect the non-adjustable SQUARE wave output
861 from the Function Generator to terminal 5 and
862 the non-adjustable sine wave output from the
863 Function Generator to terminal 1.
864 . Connect the common input of the board (terminal 11)
865 to Ground.
866 . Connect the A INPUT of the Scope to Terminal 8
867 of the SUPERPOSITION BOARD to display the waveform
868 of the total current.
869 . Trigger the Scope from the Function Generator.
870 at 2914
871 write Press -HELP- to see a circuit diagram of setup
872 or
873 Press -NEXT- to have your connection checked.

```

874 entry x02s13ae.
875 next x02m5j
876 draw 199,263;166,263;skip;318,263;347,263
877 mode write
878 circle 32,96,448
879 draw 209;228;628;609;209;skip;236;256;656;636;236
880 at 213
881 write SCOPE F. G.
882 draw 199,263;166,275;skip;318,263;347,276
883 circle 3,432,464
884 circle 3,432,441
885 circle 3,166,422
886 circle 3,143,434
887 circle 3,290,461
888 circle 3,383,424
889 draw 207,461;256,461;256,400;166,400;166,419;skip
890 143,431;143,367;47,367;47,160;144,160
891 circle 0,152,160;180,0
892 draw 160,160;272,160;278,174
893 skip;435,463;459,463;459,283;390,283;skip
894 434,440;450,440;450,324;132,324;132,205
895 skip;383,421;383,346;80,346;80,130;121,130
896 at 318
897 write T.O. SQ
898
899 A SIN
900 T.I. GRD
901 at 2910
902 write After you have made your connections, press -NEXT-
903 and

```

-----part=1, block=n-----

.block in, x02s15a

```

905 unit x02s14a
906 join* ch01w
907 next x02m5j
908 help x02s15a
909 at 2907
910 write Press -HELP- to see a circuit diagram of the setup
911
912 or
913 Press -NEXT- to have your connections checked.
914 ***
914 unit x02s15a
915 do x02m5e
916 mode erase
917 draw 259,179;244,204;skip;259,212;246,240
918 mode write
919 draw 259,212;259,240;skip;259,179;259,205

```

```

920 mode erase
921 auto x02s13ae
922 and
923 ***

924 unit x02s16a
925 next x02m5k
926 help x02s17a
927 at 1007
928 write One or more of your dial settings are wrong.
929
930 Press -NEXT- to have your dials rechecked.
931
932 or
933 Press -HELP- for a listing of your dial errors.
934 ***

934 unit x02s17a
935 pack n1, +f++ (cd) (de) +abag (jk) ++ (abcd) ++++++
936 join ckdlw
937 end
938 ***

939 unit x02s18a
940 help x02m4a
941 at 810
942 write You seem to have had difficulty with the review.
943
944 Press the number you want to do:
945
946 1. Repeat the review quiz.
947
948 2. Repeat this experiment.
949
950 3. Review frequency and amplitude.
951
952 4. Review floating or grounded operation.
953
954 arrow 1045
955 long 1
956 store1 n1
957 answer (1,2,3,4)
958 jump n1, x, x, x02m6a, x02m0a, x02m1a, x02m4a
959 ***

954 unit x02end
955 back x02m6b
956 join 1mode
957 jump n47, x02end, x
958 course n2
959 calco n2= 'ee244',
960 no (n21+1) + (no (n21+1) $mask$o777777777700000000000) +o4603000000,
961 no (n21+1) +no (n21+1)
962 erase
963 output /// student has completed experiment ///
964 join endunit
965 join jmpmes

```


966 jumpout cgeindex,quest

967 entry leave

968 end lesson

969 ***

970 unit endunit

971 course n2

972 jump n2='ee244',leave,x

973 calc nc(n2i+7)+nc(n2i+7)+ahelp

974 vc(n2i+6)+vc(n2i+6)+atime/60000

975 ***Incl.cge s.r. & TERMS sample,index,imode,comment,slides.

976 use eex00,ck1

977 use ck2

978 use ck3

979 use ck4

980 use ck5

981 use ck6

ckc	not found		103	177	292	323	684	560
ckcw	not found		664					
ckc1	not found		326					
ckc1w	not found		906					
ckd	not found		79	100	197	623		
ckdw	not found		340	658				
ckd1w	not found		936					
ckd2w	not found		765					
endunit	x02end	970	22	964				
imode	not found		32	275	356	638		956
jmpmes	not found		965					
leave	x02end	967	972					
x02end	x02end	954	670	957				
x02m0a	x02m0a	30	33	55	952			
x02m1a	x02m0a	51	35	71	952			
x02m1b	x02m0a	70	54	85	676			
x02m1c	x02m0a	77	72					
x02m2a	x02m0a	82	80	114	735	746	766	757
x02m2a1	x02m0a	101	86					
x02m2a2	x02m2a2	106	104					
x02m2b	x02m2a2	113	111	130	154	766		
x02m2c	x02m2a2	129	115					
x02m3a	x02m2a2	151	131	165				
x02m3b	x02m2a2	164	155	182	769			
x02m3c	x02m2a2	175	166					
x02m3d	x02m2a2	180	178	201	792			
x02m3e	x02m3e	195	183					
x02m3f	x02m3e	200	198	219				
x02m3g	x02m3e	218	202	241				
x02m3h	x02m3e	240	220	265				
x02m3i	x02m3e	264	242	279				
x02m4a	x02m4a	274	266	276	804	940		952
x02m4b	x02m4a	290	280					
x02m4c	x02m4a	295	293	305				
x02m4d	x02m4a	304	296	330	839			
x02m4e	x02m4a	321	306					
x02m4f	x02m4a	329	324	327	343	346		
x02m4g	x02m4a	338	331					
x02m4h	x02m4a	345	341	360				

x02m5a	x02m5a	355	347	357	373			
x02m5b	x02m5b	382	361	385				
x02m5c	x02m5b	384	374	458				
x02m5d	x02m5d	457	386	465				
x02m5e	x02m5d	464	459	513	915			
x02m5f	x02m5d	512	510	856				
x02m5g	x02m5g	539	566					
x02m5h	x02m5g	558	540					
x02m5i	x02m5g	565	562	599	614			
x02m5j	x02m5j	598	563	567	569	875		907
x02m5k	x02m5j	613	605	627	925			
x02m5l	x02m5j	621	615					
x02m5m	x02m5j	626	624	640				
x02m6a	x02m5j	635	628	639	647	952		
x02m6b	x02m5j	646	641	669	955			
x02m6c	x02m5j	655	648					
x02m6ca	x02m5j	662	659					
x02m6d	x02m5j	668	665					
x02s01a	x02s01j	679	800					
x02s02a	x02s02a	690	87					
x02s02b	x02s02a	709	691					
x02s03a	x02s02a	734	104					
x02s04a	x02s02a	745	110	111				
x02s05a	x02s05a	756	110					
x02s05b	x02s05a	764	110	758				
x02s06a	x02s05a	768	178					
x02s07a	x02s05a	778	193					
x02s08a	x02s05a	791	198					
x02s09a	x02s05a	797	208	225				
x02s10a	x02s05a	803	293					
x02s11a	x02s05a	811	307	327				
x02s12a	x02s12a	838	812					
x02s13a	x02s12a	855	568					
x02s13ae	x02s12a	874	921					
x02s14a	x02end	905	600					
x02s15a	x02end	914	601	908				
x02s16a	x02end	924	624					
x02s17a	x02end	934	926					
x02s18a	x02end	939	660	666				
ahelp		973						
atime		974						
nc		960	960	961	973	973		
n1		950	950					
n2		958	959	971	972			
n21		960	960	961	961	973	973	974
n23		78	102	107	176	196	325	291
		559	603	622	657	663		339
n47		33	80	104	109	111	276	178
		324	327	341	357	562	634	605
		665	766	957				243
n51		37	250	252	569	656		198
n60		36	109	109	109	110		624
n95		362	510	606				
sin		721						
vc		974	974					
x57		721	721					
π		717	719	719	721	721		857

lesson information

lesson name = eex02

starting date = 03/29/73

last edited on 08/21/74 at 11.13.32

by neal of course eecge

at site 7, station 27

author name = J P Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = freshman

description of lesson = The Operation and Uses of the Audio Oscillator, HP 200AB.

block 1a, eex03id

```

2 stop
3 **** For Neal, CGERL, Room 248 EEB.
4 One line description of this lesson --
5 The Operation and Uses of the Function Generator, Exact 251.
6 Divisions of this Lesson:      Block      Unit
7 Id for this file                eex03id
8 Experiment eex03;
9 Objectives                       x03m0a   x03m0a
10 Measure wave parameters         x03mia   x03mia
11 Oper. of function generator     x03m2a   x03m2a
12 Development of equi. circuit    x03m3a   x03m3a
13 final edit 21 aug 74 neal.
14 *list info
15 *list symbols
16 *list varian,charset,cgeindex,cgechar
17 ****
18 start
19 finish endunit
20 write (at,1010) Loading the CGE Character Set
21 charset cgeindex,cgechar
22 erase
23 dataon
24 area eex03
25 ext 0
    
```

block 1b, x03m0a

```

27 unit x03m0a
28 restart
29 join imode
30 jump n47,x03m0a,x
31 at 408
32 write THE OPERATION AND USES OF THE FUNCTION GENERATOR,
33 Exact 251.
34 The learning objectives are:
    
```

35 1) To measure the period, amplitude, and
36 average (DC) characteristics of a waveform.

37 2) To properly drive a two-terminal circuit
38 with any periodic voltage having any adjustable
39 or nonadjustable V_{max} , V_{min} , or V_{avg} , and any
40 frequency within the useful limits of the Function
41 Generator, while triggering the Function Generator
42 internally, externally, or manually.

43 3) To experimentally determine a practical
44 equivalent circuit for the Function Generator
45 as seen looking into its nonadjustable SQUARE
46 wave output terminals.

part=1, block=c

block 1c, x03mia

48 unit x03mia
49 back x03mia
50 calc n51*-1
51 zero n60
52 n61
53 n62
54 n63
55 n64
56 at 1107

57 write Here, you will be given an opportunity to
58 review the physical properties of waveforms (i.e.,
59 V_{p-p} , frequency, period, etc.). You should already be
60 acquainted with these concepts. They will be used
61 extensively in this experiment.
62 ***

63 unit x03mib
64 next x03mic
65 back x03mia
66 at 010

67 write From the waveform displayed below, measure
68 the following quantities:

69 join x03sib
70 at 417

71 write 1) Period _____ sec.
72 2) Frequency _____ Hertz.
73 3) V_{max} _____ volts.
74 4) V_{min} _____ volts.
75 5) V_{p-p} _____ volts.
76 6) V_{g-p} _____ volts.

```

77 ****          doto loop avoids repeat questions
78 calc          n101+233
79 doto          2line,n100+60,64,1
80 calc          n101+n101+200
81 calcs        (n100-61),v102+.05,20,20,-20,40
82 calcs        (n100-61),v103+1.2,2.0
83 at           n101
84 writec       n(n100),(z,v102,v103),,
85 2line.
86 join         n51,x03sia,x03sia1,x03sia2,x,x03sia4,x03sia5
87 ***

88 unit        x03mic
89 next        x03mid
90 back        x03mib.
91 calc        n51+15          $$ for first use of x03s1h
92            n52+15
93            n53+0
94 at          1007
95 write       It is, often desirable, to know other characteristics
96             of a wave in addition to the time- amplitude char-
97             acteristics. One example would be the AVERAGE (DC)
98             value of the wave.
99
100            For now, let us concentrate our efforts on SYMMETRICAL
101            waveforms; a later experiment will present a more
102            mathematical approach for finding the average or dc
            value of any waveform.

```

-----part=1, block=d-----

block 1d, x03mid

```

104 unit        x03mid
105 next        x03mie
106 help        x03s1h
107 back        x03mic
108 at          608
109 write       What is the average (dc) value of the symmetric
110             square wave below ? _____ volts
111
112             -HELP- is available
113 join        x03sfi
114 gdraw       0,15;10,15;10,-15;20,-15;20,15;30,15;30,-15;30,0
115 arrow       732
116 ansy        0
117 ***

118 unit        x03mie
119 help        x03s1j
120 next        x03m2a
121 back        x03mic
122 calc        n51+20          $$ answers for second call to x03s1h.
123            n52+10

```

124 n53*5
125 at 608
126 write Now suppose we were to change the average or dc
127 level such that the waveform is symmetrical about
128 a non-zero value. Observe the effect on the wave-
129 form below; what is the average (dc) value?

130 ----- volts
131
132 -HELP- is available
133 join x03s1i
134 gdraw 0,20;10,20;10,-10;20,-10;20,20;30,20;30,0
135 arrow 1126
136 ansv 5
137 ***

----- part=1, block=e -----

block 1a, x03m2a

139 unit x03m2a
140 restart
141 at 907
142 write The Function Generator produces different signals
143 over a continuous range of frequencies. The para-
144 meters of these outputs are adjusted by three
145 groups of dials:

146 1) OUTPUT
147 2) TIMING
148 3) TRIGGERING

149 If you wish to see what any of these groups does,
150 type in the number of that group. If not, just
151 press -NEXT-.

152 pause
153 keytype n70,1,2,3,back
154 jump n70,x03m2b,x03s2a1,x03s2a2,x03s2a3,x03m1d
155 ***

156 unit x03m2b
157 restart
158 base
159 back x03m2a
160 next x03m2c
161 help x03s2b
162 at 1105
163 write Set up the Function Generator for a nonadjustable
164 RAMP Wave having a period of 2 ms.

165 Display this wave on channel A of the SCOPE, using
166 the Function Generator as the trigger source.

block ff. x03m2c

```

169 unit x03m2c:
170 zero n62
171 n63
172 n64
173 p65
174 n66
175 n67
176 pack n33,++(op)+(acd)(de)(abcd)a+af(ijk)+++++++
177 join ckd
178 calc n55+n47 $$ n55=-1. if dials wrong
179 jump n47,x,x03m2c1
180 pack n33,+++++++f(ijk)+++++++
181 join ckd1
182 calc n62+n47 $$ n62=-1 if freq. wrong
183 pack n33,++++(de)+++a+++++++
184 join ckd1
185 calc n63+n47 $$ checks trigger
186 pack n33,++++(acd)+(abcd)a+++++++
187 join ckd1 $$ checks dials 5,7,8
188 calc n67+n47
189 pack n33,++(op)+++++++
190 join ckd1
191 calc n64+n47 $$ n64=-1 if a-volts wrong

192 entry x03m2c1
193 pack n33,0000000000000000n0a000n0a000+00
194 join ckc
195 jump n55,x03s2c,x $$ falls thru if dials ok
196 jump n47,x03s2c,x03m2d. $$ x03s2c jumps to helps
197 ***

```

```

198 unit x03m2d
199 restart
200 base
201 back x03m2b
202 next x03m2d1
203 help x03s2i
204 at 1407
205 write Now set up the Function Generator for a sine wave
206 with a  $V_{p-p} = 10$  V and having a frequency of 1
207 kHz. Trigger the Scope from the Function Generator
208 and display the waveform on channel A of the Scope.
209
210 -HELP- is available

```



block 1g, x03m2d1

212 unit x03m2d1
213 zero n60 \$\$ pre-set for use in x03s2j
214 n61
215 n62
216 n63
217 pack n33, ++ (mno) ++ (de) +a+a<f (tuv) g (ab) >b (cdef) +++++++
218 join ckd
219 calc n55+n47
220 jump n47, x, x03m2d1e
221 pack n33, ++ (mno) ++++a++++b (cdef) +++++++
222 join ckd1
223 calc n60+n47
224 pack n33, +++++ (de) +++a+++++
225 join ckd1
226 calc n61+n47
227 pack n33, ++++++<f (tuv) g (ab) >+++++
228 * dial 11 on f and 12 on t, u, v
229 * or dial 11 on g and 12 on a or b

230 join ckd1
231 calc n62+n47
232 entry x03m2d1e
233 pack n33, 0000000000000000n0a0000na0000+00
234 join ckd
235 jump n55, x03s2j, x
236 jump n47, x03s2j, x03m2e
237 **
238 unit x03m2e
239 base
240 help x03s2q
241 back x03m2d
242 restart
243 at 1406
244 write Next set up the system for an adjustable square wave
245 having a period of 1 ms. with a V_{p-p} of 10 volts. Set
246 up the Function Generator to be manually triggered
247 and display the waveform on channel A.
248
249 -HELP- is available
250 ***

251 unit x03m2g
252 zero n60 \$\$ pre-set for x03s2r
253 n61
254 pack n33, ++ (mnop) ++ (defg) + (ae) +v<f (tuv) g (ab) >d (abc) +++++++
255 join ckd
256 calc n55+n47
257 jump n47, x, x03m2g1
258 pack n33, ++++++<f (tuv) g (ab) >+++++
259 join ckd1
260 calc n60+n47

```

261 pack n33, ++ (mnop) +++++ (ae) +++++d (abc) ++++++
262 join ckd1
263 calc n61+n47

264 entry x03m2g1
265 pack n33, 0000000000000000n0+0000n+000+00
266 join ckc
267 jump n55, x03s2r, x
268 jump n47, x03s2t, x03m2h
269 ***

270 unit x03m2h
271 restart
272 base
273 help x03s2w
274 back x03m2e
275 at 1206
276 write Finally, set up a 20 Vpp triangle wave at a frequency
277 of 500 Hz. and a DC LEVEL of -5 volts. Display this
278 waveform on channel A of the scope, which should be
279 triggered from the Function Generator.
280
281 -HELP- is available
282 ***

283 unit x03m2i
284 base
285 zero n60 $$ pre-set for x03s2x
286 n61
287 n62
288 pack n33, ++ (nop) ++ (de) c (acd) +af (ijk) c (ode) (st) ++++++
289 join ckd1
290 calc n55+n47
291 jump n47, x, x03m2i1
292 pack n33, ++++++f (ijk) ++++++
293 join ckd1
294 calc n60+n47
295 pack n33, +++++ (de) +a+++++
296 join ckd1
297 calc n61+n47

298 entry x03m2i1
299 pack n33, 0000000000000000n0a0000na000+00
300 join ckc
301 jump n55, x03s2x, x
302 jump n47, x03s2x, x03m3a

```

----- part=1, block=h -----

block 1h, x03m3a

```

304 unit x03m3a
305 base
306 term equiv

```



307 restart
 308 join imode
 309 jump n47,x03m3a,x
 310 back x03m2h
 311 at 1205
 312 write When you finish this section you should be able to:
 313
 314 1) Describe and characterize the circuit model of the
 315 Function Generator that has been developed.
 316
 317 2) Establish the applicability of this model to the
 318 Function Generator for any given circuit conditions.
 319 ***

320 unit x03m3b
 321 back x03m3a
 322 at 306
 323 write The Function Generator must be represented by a model
 324 consisting of voltage sources, resistors, and other
 325 circuit elements useful in circuit theory calculations.
 326 A logical first choice would be an IDEAL voltage source
 327 as illustrated below.
 328 join x03s3a
 329 draw 937;1237;284,305;274,301;256,302;261,306;256,301
 330 261,296
 331 at 1130
 332 write $i_L(t)$
 333 at 1806
 334 write An ideal voltage source, $v_S(t)$ is defined as a circuit
 335 element whose circuit voltage is a prescribed function
 336 of time and is independent of the circuit current. In
 337 other words, in the suggested equivalent circuit, $v_S(t)$
 338 is independent of $i_L(t)$.
 339 ***

340 unit x03m3c
 341 back x03m3b
 342 join x03s3a
 343 at 1707
 344 write $v_S(t)$ is the open circuit voltage of the Function
 345 Generator. If this were the correct model, would
 346 you expect the amplitude or waveshape of the volt-
 347 age between points A and B to vary when a resistor
 348 is placed across the output? (yes/no)
 349 arrow 2410
 350 specs nookno,bumpshift
 351 match n51,yes,no
 352 at 2417
 353 writec n51,no,no,ok
 354 at 2607
 355 write The output voltage will not be affected when a
 356 resistance is placed across the outputs; it should
 357 be independent of the load, as specified.
 358 ***

359 unit x03m3d
 360 back x03m3c

361 at 1006
362 write We now have a model of the Function Generator to help
363 us predict its performance in a given circuit applica-
364 tion. Let us now consider a specific case and see how
365 accurately this first model predicts the behavior of
366 the Function Generator.

----- part=i, block=i -----

block ii, x03m3e

368 unit x03m3e
369 next x03s3b
370 back x03m3d
371 at 405
372 write According to Kirchoff's Voltage Law, $V_L = V_S$ on
373 open circuit. Since our model is an ideal voltage
374 source, V_S should not change when a resistor is
375 placed across the output. Let's see if this is
376 the case.
377 join x03s3a
378 draw 841;845;843;942;843;944;843;1043;skip;1243;1443
379 1441;1445
380 at 328,330
381 write V_L
382 at 2107
383 write Set up the Function Generator to produce a non -
384 adjustable square wave at a frequency of 8000 hz.
385 Display this waveform on channel A of the Scope
386 and trigger the Scope from the Function Generator.

----- part=1, block=j -----

block ij, x03m3f

388 unit x03m3f
389 back x03m3e
390 help x03s3d
391 next x03s3g
392 at 308
393 write Our model predicts that the voltage will not be
394 affected when a resistor is placed across the
395 output.
396 join x03s3a
397 draw 838;296,360;285,353;296,346;285,339;296,332
398 285,325;296,318;296,288
399 at 1708
400 write Using the RESISTOR BOARD, ITEM 32, place a 500 ohm
401 resistor across the output of the Function Generator
402 (nodes A and B) as shown above.

403 Press -NEXT- when you have done so.

404 at 2300

405 write **NOTE: You should still be displaying a non-adjustable square wave at a frequency of 800 Hz.

406

407

408

409 -HELP- is available

410 ***

411 unit x03m3g

412 back x03m3f

413 at 1009

414 write Our ideal voltage source model predicted that the voltage would not be affected when a resistor is placed across the output. Can the Function Generator be represented as an ideal voltage source?

415

416

417

418 _____ (yes/no)

419 arrow 1422

420 specs nookno,bumpshift

421 match n51,yes,no

422 at 1431

423 writec n51,no,no,ok

424 at 1709

425 write An ideal voltage source implies that the voltage will not be affected when a resistor is placed across the output. Hence, the Function Generator cannot be represented by a model consisting only of an ideal voltage source.

426

427

428

429

430 ***

431 unit x03m3h

432 base

433 next x03m3i

434 back x03m3g

435 at 206

436 write It would appear that the ideal voltage source model for the Function Generator is not adequate. Consider the following model.

437

438

439 join x03s3e

440 at 2109

441 write This model consists of an ideal source and an unknown R,L, or C element in series with it. If a resistor were now connected between nodes A and B, V_{AB} would... (increase,decrease,not change)

442

443

444

445 at 2523

446 write _____

447 arrow 2524

448 specs bumpshift,okextra

449 wrong (increase,not change,notchange)

450 draw 2605;2660

451 at 2709

452 write No. The output would decrease because $R_L (=500\Omega)$ and the unknown R,L, or C element would form a voltage divider. Therefore, V_{AB} would be only a fraction of V_S .

453

454

455

456 answer decrease

457 at 2808

458 write Yes, and our earlier observation (V_{AB} decreased)
459 would tend to support this model.
460 endarrow
461 at 3109
462 write ----Hereafter, let us refer to V_{AB} as V_L ----
463 press -NEXT-
464 pause
465 join x03s3k1.

-----part=1, block=k-----

block 1k, x03m3i

467 unit x03m3i
468 back x03m3h
469 at 1007
470 write We remember that the open circuit voltage of the
471 Function Generator was a square wave. With an R_L of
472 500 ohms connected, is the output still a square
473 wave?
474 _____ (yes/no)
475 arrow 1420
476 specs bumpshift
477 answer yes
478 wrong no
479 at 1607
480 write If the output of the generator doesn't look like
481 a square wave, no conclusions can be made about the
482 unknown elements at this time. However, you should
483 have found that the resistive load did not alter the
484 waveshape and answered, "yes" instead of "no".
485 ***
486 unit x03m3j
487 back x03m3i
488 at 1207
489 write The output of the generator with R_L connected is
490 exactly proportional to V_G and would appear to be
491 independent of time. This would lead to the con-
492 clusion that the unknown element has a V/I relation
493 that is independent of time. The only element that
494 satisfies this condition is a _____.
495 arrow 1738
496 specs bumpshift,okspell
497 answer (resistor,resistance)
498 ***
499 unit x03m3k
500 back x03m3j
501 at 407
502 write Can the Function Generator be represented by an ideal
503 source and a resistor if the open circuit voltage is
504 a square wave with a resistor across the output, and
505 the following waveform results? _____ (yes/no)

506 at 1649
 507 write time
 508 draw 1648;1689;1209;1418;2018;1827;1227;1436;2036;1845
 509 1645
 510 arrow 740
 511 specs nookno,bumpshift
 512 match n51,yes,no
 513 at 748
 514 writec n51,no,no,ok
 515 at 2208
 516 write Since the output is not a square wave, the relation
 517 between V and I is not constant.
 518 ***

519 unit x03m3l
 520 back x03m3k
 521 calc n51e-2 \$\$pre-set for x03m3m
 522 at 307
 523 write A simple equivalent circuit for an actual
 524 controlled - source driving a resistive load may
 525 be assumed as shown below, where $v_s(t)$ is the
 526 voltage of an ideal voltage source and R_g is an
 527 internal resistance.
 528 join x03s3e1
 529 join x03s3k
 530 join x03s3f
 531 at 2010
 532 write where $v_s(t) = v_g(t) + v_L(t) = R_g i_L(t) + R_L i_L(t)$
 533
 534 or
 535
 536 $v_s(t) - R_g i_L(t) = R_L i_L(t)$
 537 at 2403
 538 write Eq. (1)
 539 at 2707
 540 write We will limit this task to determining experiment-
 541 ally whether an equivalent circuit of this type is
 542 applicable, and, if so, evaluating R_g .

----- part=1, block=1 -----

block 11, x03m3m

544 unit x03m3m
 545 back x03m3l
 546 addl n51 \$\$writec in x03s3l and x03s3n
 547 join x03s3e1
 548 join x03s3k
 549 join x03s3f
 550 at 2111
 551 write In our setup only R_L and V_L are known
 552 Noting the given reference direction,
 553 write an equation for I_L .
 554



555 $I_L = 1$ -----
 556 arrow 2524
 557 specs bumpshi ft, nookno
 558 put +=/
 559 $I_L = 1$
 560 $I_L = 5$
 561 $I_L = 5$
 562 storea n60, 30
 563 ok
 564 search 'vs', 2, n60, 30, 1, n61
 565 jump n61, x, x03s3l
 566 search 'ng', 2, n60, 30, 1, n61
 567 jump n61, x, x03s3l
 568 search 'vl/r1', 5, n60, 30, 1, n61
 569 jump n61, x03s3n, x03s3m
 570 ***

571 unit x03m3n
 572 base
 573 back x03m3m
 574 calc n58+1 \$\$used in x03m3p
 575 n51*-1
 576 at 500

577 write In order to experimentally measure a current, I_L ,
 578 with the scope, we measure the voltage, V_L , produced
 579 across a known resistance, R_L , by that current and
 580 calculate

$$I_L = \frac{V_L}{R_L}$$

581
 582
 583
 584
 585
 586 Observe I_L with $R_L = 500$ ohms. Is the waveshape of
 587 I_L identical to the waveform you observed for V_s ?
 588 ----- (yes/no)

589 at 2000
 590 write Is the point at which I_L crosses zero and is positive
 591 going at the same point on the display as it was for
 592 V_s ?
 593 ----- (yes/no)

594 specs bumpshift
 595 arrow 1616
 596 answer yes
 597 wrong no
 598 at 1800
 599 write Once again the waveform is a square wave
 600 draw 1800;1848
 601 specs bumpshift
 602 arrow 2616
 603 answer yes
 604 ***

605 unit x03m3o
 606 base
 607 back x03m3n
 608 next x03m3p
 609 erase


```

610 catchup
611 at 505
612 write Eq(1)  $v_s(t) - R_g i_L(t) = R_L i_L(t)$ 
613 at 1007
614 write Excellent, you have now shown that Eq. (1) for the
615 proposed circuit is not violated for the value
616  $R_L = 500$  ohms; in that
617
618  $v_s(t) = 500 i_L(t) + R_g i_L(t) = (500 + R_g) i_L(t)$ 
619
620 where  $R_g$  may be a positive real number.
621 at 1405
622 write Eq(2)
623 at 2207
624 write The above equation could not apply with  $R_g$  being a
625 positive real number if the waveshapes of  $v_s(t)$  and
626  $i_L(t)$  differed, particularly, if  $i_L(t) \neq 0$  when
627  $v_s(t) = 0$ .

```

----- part=1, block=m -----

block 1m, x03m3p

```

629 unit x03m3p
630 inhibit erase
631 lab x03s2e2
632 back x03m3o
633 help x03s3o
634 data x03s3q
635 next x03m3p2
636 at 207
637 write You have not shown that Eq(1) applies for all
638 values of  $R_L$  with a specific value of  $R_g$ . To do so
639 tabulate  $V_L$  p-p and  $I_L$  p-p for the specified values
640 of  $R_L$ .
641 When you have satisfactorily tabulated values
642 for five different resistive loads, PLATO will plot
643  $V_L$  p-p versus  $I_L$  p-p.
644
645 REMEMBER:  $I_L = V_L / R_L$ 
646 size 2
647 at 1213
648 write Data point no:
649 calc n57+n58-5
650 at 1240
651 showt n58,3
652 size 0
653 at 1412
654 write Choose  $R_L =$  _____ (ohms)
655
656 Enter  $V_L =$  _____ (Volts) (measured)
657
658 Enter  $I_L =$  _____ (Amps) (calculated)
659 at 3222

```

```

660 write -HELP- is available
661 at 1426
662 write n51,500,1000,250,100,50 $$resistor
663 calca n51,v130+500,1000,250,100,50
664 calcs n51,v52+17.6,24.5,10.4,4.65,2.55 $$voltage
665 arrow 1623
666 store v131
667 ansv v52,10%
668 no
669 at 2707
670 write Your readings for  $V_L$  must be as accurate as possible.
671 Be sure you are displaying the largest possible
672 waveform on the Scope. Press -LAB- for an explanation.
673 endarrow
674 calc v132+(v131/v130)
675 join x03s3p
676 pause
677 join key=data,x03s3q,x

678 entry x03m3p1
679 next x03m3p2
680 at 1824
681 erase 10
682 catchup
683 at 1822
684 write _____
685 inhibit erase
686 data x03s3q
687 arrow 1822
688 store v56
689 ansv v132
690 no
691 draw 2803;2862
692 at 2913
693 write Thought I wasn't looking, didn't you? Let's
694 try that division again.  $I_L (=V_L/R_L)=?$ 
695 endarrow
696 ***

697 unit x03m3p2
698 erase
699 join n50,x,x,x03s3t,x03s3r1
700 add1 n58
701 n51
702 at 1521
703 write Press -NEXT-
704 next n57,x03m3p,x03m3q

```

----- part=1, block=n

block=n, x03m3q

```

706 unit x03m3q
707 base

```

```

708 next      x03m3r
709 back      x03m3n
710 at        310
711 write     For any range of  $I_L$  where the graph is a straight
712           line, the negative of the value of the slope can
713           be used as the value of  $R_g$  and for that range the
714           assumed equivalent circuit is applicable.
715 origin     100,100
716 axes      300,240
717 scalex     .08
718 scaley     30
719 labelx     .02,.01
720 labely     10,2
721 size       2
722 graph      -.02,20,VL
723 locate     .02,-7
724 write     IL (amps)
725 size       0
726 gdraw      v142,v143;v140,v141;v144,v145;v146,v147;v148,v149
727 dots       1line,n100+140,148,2
728 locate     v(n100),v(n100+1)
729 write     (n100-142)/2,5000,10000,2500,1000,500
730 iline
731 locate     .045,25
732 write     slope = -Rg
733 ***
734 unit      x03m3r
735 next      x03end
736 back      x03m3n
737 at        400
738 write     Thus you have experimentally shown that this
739           circuit is an acceptable equivalent circuit
740           model for the function generator for a range
741           of  $0 < R_L < (\approx 10000)$  ohms.
742 join      v03s3e1
743 at        1624
744 write     Rg
745 at        2100
746 write     where Rg is the assumed internal resistance of
747           the function generator and Vg a voltage source.
748           Beyond this range however, the model is not
749           applicable and other circuit elements must be
750           included to account for variations in the slope
751           of VL/IL.

```

part=2, block=a

block 2a, x03s1a

```

753 unit      x03s1a
754 arrow     431
755 store     v52
756 ansv      .05

```

```

757 calc      n51+0
758          n60+1
759 no
760 jump     x03sic

761 entry    x03sia1
762 arrow    631
763 ansv     20
764 calc     n51+1
765          n61+1
766 no
767 jump     x03sid

768 entry    x03sia2
769 arrow    831
770 store    n54
771 ansv     20
772 calc     n51+2
773          n62+1
774 no
775 jump     x03sie

776 entry    x03sia3
777 arrow    1031
778 ansv     -20
779 calc     n51+3
780          n63+1

781 entry    x03sia4
782 arrow    1231
783 ansv     40
784 calc     n51+4
785          n64+1
786 no
787 jump     x03sif

788 entry    x03sia5
789 arrow    1431
790 ansv     20
791 no
792 jump     x03sig
793 ***

794 unit     x03sib
795 origin   75,130
796 axes     0,-100,300,100
797 scalex   100
798 scaley   20
799 labelx   25,5
800 labely   10,5
801 gdraw    0,0;12.5,20;37.5,-20;62.5,20;87.5,-20;100,0
802 graph    106,-3,msecs
803 graph    -5,23,volts
804 frame    -40,-130,375,140
805 ***

806 unit     x03sic

```

807 next x03mlb
 808 back x03mlb
 809 at 505
 810 write No, the period of this waveform is not (s,v52) secs.
 811 Observe the waveform below and, remembering that the
 812 period is the time required for the waveform to begin
 813 repeating itself, determine the period.
 814
 815 Note that your answer should be in units of seconds.
 816 (1 msec = .001 sec.)
 817 join x03slb
 818 ***

819 unit x03sld
 820 next x03mlb
 821 at 1005
 822 write No, frequency (f) is the reciprocal of the period (T).
 823 You have determined that the period of this waveform
 824 is .05 secs. Thus, since $f = 1/T$ and $T = .05$ secs.:

$$f = \frac{1}{.05} = 20 \text{ hz}$$

828 Press -NEXT- to enter your answer
 829 ***

830 unit x03sle
 831 next x03mlb
 832 at 806
 833 write You incorrectly specified V_{max} as being (z,n54) volts.
 834 Observe how V_{max} is noted on the waveform below, then
 835 press -NEXT- to enter the correct answer.
 836 join x03slb
 837 graph 00,10,V_{max}



838 entry x03sle1
 839 edraw 21,0;40,20
 840 edraw 31,0;31,7
 841 edraw 31,15;31,20
 842 ***

843 unit x03slf
 844 next x03mlb
 845 at 806
 846 write The peak-to-peak value is $V_{max} - V_{min}$. Observe this
 847 on the waveform below, then press -NEXT- to enter
 848 the correct answer.

849 join x03slb
 850 join x03sle1
 851 edraw 31,0;31,-20
 852 edraw 31,-20;40,-20
 853 graph 00,10,V(p-p)
 854 ***



855 unit x03sig
 856 next x03mlb
 857 at 907

```

858 write For this waveform  $V(t-p)$  is  $V_{max}$ . Observe this on
859 the figure below, then press -NEXT- to enter the
860 correct answer.
861 join x03s1b
862 join x03s1e1
863 graph 20,10,V(t-p)

```

----- part=2, block=b -----

Block 2b, x03s1h

```

865 unit x03s1h
866 join x03s1i
867 gdraw 0,15;10,15;10,-15;20,-15;20,15;30,15;30,-15;30,0
868 entry x03s1h1
869 at 214
870 write Since this is a symmetrical waveform,
871 the average value is the line about which
872 the waveform is symmetrical.
873 -OR-
874 ...taking a different approach...
875
876 
$$\frac{V_{max}+V_{min}}{2} = \text{AVERAGE VALUE}$$

877
878 Enter  $V_{max} =$  _____ volts
879
880 Enter  $V_{min} =$  _____ volts
881
882 The average value is then= _____ volts
883 arrow 1028
884 ansy n51
885 arrow 1030
886 ansy n50
887 arrow 1442
888 ansy n53
889 no
890 at 1536
891 write  $\frac{(42,n51) + (42,n52)}{2} = ???$ 
892
893 end
894 ***

895 unit x03s1i
896 origin 75,150
897 axes 0,-100,300,100
898 scalex 35
899 scaley 20
900 labely 10,5
901 graph -2,20,Volts
902 graph 30,0,Time
903

904 unit x03s1j

```

```

905 join      x03s1i
906 gdraw    0,20;10,20;10,-10;20,-10;20;20;30,20;30,0
907 join      x03s1hi
908 end
909 ***

910 unit      x03s2a1
911 next      x03m2a
912 output    //output help reviewed//
913 at        700
914 write     The adjustable output of the Function Generator
915            is affected by:
916
917            1) The Attenuator- The red dial of the OUTPUT
918               group. This dial varies the voltage of the output
919               waveform.
920
921            2) Output Selector- This is the dial behind the
922               attenuator. It is used to select the periodic
923               signal to be controlled.
924
925            3)  $\pm$  DC Level - This dial changes the  $V_{av}$ 
926               of the adjustable output.
927
928            4) Terminals- The only terminal affected by the
929               above dials is the one directly below the
930               attenuator. The terminals to the right of the
931               attenuator have a constant magnitude and DC level.
932 end
933 ***

934 unit      x03s2a2
935 next      x03m2a
936 output    //timing help reviewed//
937 at        1000
938 write     The time it takes a periodic signal to complete
939            one cycle is known as the period of the waveform.
940            The number of these periods that occur in one second
941            is known as the frequency of the signal. The Timing
942            section of the Function Generator allows the
943            variation of the signal's frequency. The output
944            frequency is the product of the MULTIPLIER and the
945            CYCLES/SEC dials.
946 end

```

----- part=2, block=c -----

block 2c, x03s2a3

```

948 unit      x03s2a3
949 output    //trigger reviewed//
950 next      x03m2a
951 at        800
952 write     To trigger means to initiate or start a cycle.

```

953 This Function Generator has two ways of being
954 triggered. The INT setting causes the generator
955 to be on continuously. The EXT setting allows
956 the Function Generator to be triggered by an
957 external voltage or event. This station is not
958 equipped to externally trigger the Function
959 Generator (other than manual triggering); thus
960 you should use the INT setting unless you are
961 instructed to do otherwise.

962 The TRIG OUT terminal is used to trigger
963 other instruments synchronously with the
964 Function Generator.

965 end
966 ***

967 unit >03s2b
968 back >03m2b
969 at 1107
970 write Remember that $F = 1/T$ where:

971
972 $F =$ frequency in Hertz
973 $T =$ period in seconds

974 Also, use the output terminal to the right of the
975 attenuator.
976
977 end
978 ***

979 unit >03s2c
980 pack n33,0000000000000000n0+000n0+000+00
981 join ckc1
982 calc n65en47
983 jump n67,<03s2e,x
984 jump n65,<03s2h,x
985 jump n62,<03s2d,x
986 jump n63,<03s2g,x
987 jump n64,<03s2el,x03s2g
988 ***

989 unit >03s2d
990 next >03m2c
991 help >03s2f
992 back >03m2b
993 at 1105
994 write No, you seem to be having a problem with the timing
995 aspect: You were asked to set it for a period of 2.ms.

996 Press -NEXT- if you understand your error and
997 have corrected it.

998 Press -HELP- if you would like some assistance.

999 Press -BACK- to reread the problem statement.

1000 ***

1001 unit x03s2e
1002 next x03m2c
1003 back x03m2b
1004 at 705
1005 write Unless you properly set the SWEEP MODE and A
1006 PRE AMP dials, you cannot display this waveform
1007 on the SCOPE. You should have mastered the use
1008 of these dials in the first experiment.

1009 If you need assistance, it would be best for
1010 you to review Experiment 1 (Operation and Use
1011 of the Oscilloscope) before continuing this
1012 experiment.

1013 -OTHERWISE-

1014 Press -NEXT- if you understand your error and
1015 have corrected it.

1016 Press -BACK- to reread the problem statement.

----- part=2, block=d -----

block=2d, x03s2e1

1018 unit x03s2e1
1019 back x03m2b
1020 next x03m2c
1021 help x03s2e3
1022 at 805
1023 write The waveform which you are displaying is not acceptable.

1024 Reset the A VOLTS dial so that the waveform is as
1025 large as possible without exceeding the boundaries
1026 of the Oscilloscope screen.

1027 Press -NEXT- when you have correctly set the
1028 A VOLTS dial.

1029 Press -BACK- if you would like to reread the
1030 problem statement.

1031 Press -HELP- for further assistance.

1032 ***

1033 unit x03s2e2
1034 erase \$\$ x03m3p has inhibit erase
1035 catchup
1036 at 1008
1037 goto x03s2e3 \$\$ x03m3p avoids first paragraph

1038 entry x03s2e3
1039 at 605
1040 write At this point of the experiment the size of the

1041 waveform is somewhat of a triviality. However,
1042 the final task of this experiment requires that
1043 you be able to accurately read the peak-to-peak
1044 voltage of the displayed waveform. As you increase
1045 the size of the displayed waveform, your accuracy
1046 improves. The reason for this is as follows:
1047 at 1405

1048 entry: x03s2e4
1049 write The normally specified tolerance is $\approx \pm 3\%$
1050 of the FULL SCALE voltage setting. Thus if you are
1051 displaying a 10 volt peak-to-peak signal on a
1052 FULL SCALE setting of 10 volts, you are reading
1053 10 volts $\pm 3\%$, or 10 volts ± 0.3 volts.

1054 Now, suppose you were to decrease the size of
1055 the waveform by changing A VOLTS to 100 VOLTS FULL
1056 SCALE. Once again the tolerance is $\pm 3\%$ or
1057 ± 3 volts. Thus, attempting to read a 10 volt peak-
1058 to-peak signal on a 100 volt FULL SCALE would
1059 produce an answer of 10 volts ± 3 volts, an
1060 unacceptable reading.
1061 end
1062 ***

1063 unit | x03s2f
1064 next | x03m2c
1065 help | x03s2a2
1066 back | x03m2b
1067 base
1068 at 605
1069 write You were asked to set the timing dials so as to
1070 obtain a period T of 2 ms.

1071 1 ms (millisecond) = .001 second = 10^{-3} second.
1072 Therefore, T (= 2 ms) = 2×10^{-3} sec.

1073 Frequency f is the reciprocal of the period; i.e.,
1074 $f = 1/T$

1075 Thus the frequency when T = 2 ms. is
1076
$$f = \frac{1}{2 \times 10^{-3}} = 500 \text{ Hz}$$
1077
1078
1079 at 2205
1080 write Press -HELP- if you would like further assistance.

1081 Press -NEXT- when you have set the timing dials to
1082 500 Hz.

1083 Press -BACK- to reread the problem statement.

----- part=2, block=e -----

block 2e, x03s2g)

1085 unit x03s2g
1086 next x03s2g1
1087 at 205
1088 write No, the system is not triggered as requested. Let's
1089 try a different approach.

1090 Beginning with the SCOPE.

1091 Suppose you wish to trigger the SCOPE from another
1092 source, such as the Function Generator, where would
1093 you position the SCOPE's TRIGGER SOURCE dial?

1094 _____ (ext/int)

1095 Now, in order to obtain that external triggering signal,
1096 from the Function Generator which output of the
1097 Function Generator would you connect to the SCOPE's
1098 TRIGGER INPUT ?

1099 _____ (Trig out/ Ext)

1100 arrow 1118
1101 specs bumpshift
1102 answer (ext,external)
1103 wrong (int,internal)
1104 draw 2060;2005;2505;2560;2060
1105 at 2107
1106 write No...

1107 the INT setting triggers the SCOPE internally
1108 internally. You want to trigger the SCOPE externally.

1109 arrow 1618
1110 specs bumpshift,okextra
1111 answer (trig out,trigout)
1112 draw 2060;2005;2505;2560;2060
1113 at 2107

1114 write Great... Once you have made the connection and/or
1115 dial setting adjustments as specified above you will
1116 have the SCOPE properly triggered. Press -NEXT- when
1117 you have done so.

1118 wrong (ext,external)
1119 draw 2060;2005;2505;2560;2060
1120 at 2108
1121 write No...

1122 The EXT TRIGGER is for externally triggering
1123 the FUNCTION GENERATOR. You want to externally
1124 trigger the SCOPE from the FUNCTION GENERATOR.

1125 ***

1126 unit x03s2g1
1127 back x03m2b
1128 next x03m2c
1129 help x03s2a3
1130 at 508

1131 write Now that you know how to properly trigger the
1132 SCOPE, let's turn our attention to the Function

1133 Generator...
1134
1135 You have already noted that a connection should,
1136 be made between the SCOPE's TRIGGER INPUT and
1137 the Function Generator's TRIG OUT. As noted,
1138 this connection allowed the Scope to be triggered
1139 externally. Thus far we have not stabilized the
1140 FUNCTION GENERATOR.
1141 at 1808
1142 write Press -HELP- for a description of how to trigger
1143 the Function Generator.
1144
1145 Press -NEXT- if you know how to properly trigger
1146 the Function Generator and have set
1147 the dials accordingly.
1148
1149 Press -BACK- to reread the problem statement.

----- part=2, block=f -----

block 2f, x03s2h:

1151 unit x03s2h
1152 zero n55 \$\$ avoids first jump in x03m2d1
1153 next x03m2c1
1154 back x03m2b
1155 help x03s2h1
1156 at 805
1157 write You are not displaying a nonadjustable RAMP
1158 wave as requested.
1159
1160 Press -NEXT- if you understand your error and
1161 have corrected it.
1162
1163 Press -HELP- for assistance.
1164
1165 Press -BACK- to reread the problem statement.
1166 ***

1167 unit x03s2h1
1168 base
1169 next x03m2c1
1170 lab x03s2a1
1171 at 605
1172 write The nonadjustable RAMP wave output is
1173 located to the right of the OUTPUT dial.

1174 Before changing your set-up, vary the
1175 setting of the ATTENUATOR. You should find
1176 that doing so changes the peak-to-peak value
1177 of the displayed waveform.

1178
1179 Now connect the nonadjustable RAMP wave
1180 output terminal to the SCOPE's a INPUT. You

1181 should now find that varying the ATTENUATOR
 1182 setting does not change the peak-to-peak
 1183 value of the waveform.
 1184
 1185 Press -NEXT- when you have connected the
 1186 nonadjustable RAMP output to the SCOPE's A INPUT.
 1187
 1188 Press -LAB- for a further discussion of the
 1189 Function Generator's features output features.

1190 unit x03s2i
 1191 back x03m2d
 1192 at 1010
 1193 write Make sure that the OUTPUT selector is
 1194 in the SINE wave position. Also be sure the
 1195 adjustable OUTPUT terminal is connected to
 1196 the SCOPE.
 1197 end
 1198 ***

1199 unit x03s2j
 1200 pack n33,0000000000000000n0+0000n+000+00
 1201 join ckc1
 1202 calc n63en47
 1203 jump n60,x03s2k,x
 1204 jump n61,x03s2m,x
 1205 jump n62,x03s2l,x
 1206 jump n63,x03s2k,x03s2m
 1207 ***

1208 unit x03s2k
 1209 next x03m2d1
 1210 help x03s2n
 1211 back x03m2d
 1212 at 1009
 1213 write You are not properly displaying an adjustable
 1214 SINE wave with a peak-to-peak voltage of 10 volts.

1215 Press -NEXT- if you understand your error and
 1216 have corrected it.
 1217
 1218 Press -HELP- for assistance.
 1219
 1220 Press -BACK- to reread the problem statement.
 1221 ***

1222 unit x03s2l
 1223 next x03m2d1
 1224 help x03s2p
 1225 back x03m2d
 1226 at 705
 1227 write Caught you day-dreaming a little, right?
 1228 Let's set that timing dial at 1000 Hz.
 1229
 1230

1231 Press -NEXT- when you have done so.
1232
1233 Press -HELP- if you need assistance.
1234 Press -BACK- to reread the problem statement.

----- part-2, block-g -----

block 2g, x03s2m:

1236 unit x03s2m
1237 next x03m2e
1238 back x03m2d
1239 at 1005
1240 write You should still be triggering the SCOPE from the
1241 Function Generator just as you did in the previous
1242 exercise.
1243

1244 Press -NEXT- when you have triggered the SCOPE
1245 from the Function Generator.
1246

1247 Press -BACK- to reread the problem statement.
1248 ***

1249 unit x03s2n
1250 base
1251 next x03s2n1
1252 lab x03s2a1
1253 at 811

1254 write The adjustable output terminal is located
1255 directly below the ATTENUATOR dial. Find this
1256 terminal now and connect it to A INPUT on the SCOPE!

1257 Press -NEXT- when you have done so.

1258 Press -LAB- for a further discussion of the
1259 Function Generator's features.
1260 ***

1261 unit x03s2n1
1262 pack n33,000000000000+00n0+0000n+000+00
1263 join ckc
1264 jump n47,x,x03s2o
1265 pack n33,000000000000+00n0+0000n+000+00
1266 join ckclw
1267 pause
1268 jump x03s2n
1269 ***

1270 unit x03s2o
1271 next x03s2o1
1272 back x03m2d
1273 at 1005
1274 write Good, now set the OUTPUT selector to the SINE

1275 wave position. Adjust the ATTENUATOR setting until
1276 the peak-to-peak voltage is 10 volts. Of course the
1277 SCOPE's dials should be set so that you can properly
1278 display this waveform on channel A.
1279
1280 Press -NEXT- when you have set these dials correctly.

1281 Press -BACK- to reread the problem statement.

1282 ***

1283 unit x03s2o1
1284 pack n33, ++ (mno) +++++a++++b (odef) ++++++
1285 join ckd
1286 jump n47, x, x03m2d1
1287 pack n33, ++ (mno) +++++a++++b (odef) ++++++
1288 join ckdlw
1289 pause
1290 jump x03s2o
1291 ***

1292 unit x03s2p
1293 next x03m2d1
1294 base
1295 at 1100
1296 write ✓ The frequency of the waveform to be displayed is
1297 the product of the settings of the CYCLES/SEC dial
1298 and the MULTIPLIER dial.

1299 Since you want a frequency of 1000 Hz, you should
1300 set the MULTIPLIER dial on 1000 and the CYCLES/SEC
1301 dial on -----

1302
1303 arrow 1716
1304 specs bumpshift
1305 answer (1, one)
1306 at 1000
1307 write or.....

1308 You could set the MULTIPLIER dial on 100 and the
1309 CYCLES/SEC dial on -----

1310 arrow 2927
1311 specs bumpshift
1312 answer (10, ten)
1313 at 2709
1314 write Press -NEXT- when you have properly set the
1315 CYCLES/SEC and MULTIPLIER dials at 1000 Hz.

----- part=2, block=h -----

block 2h, x03s2q

1317 unit x03s2q
1318 help x03s2v
1319 back x03m2e

1320 at 1005
1321 write Don't forget to put the Function Generator's
1322 TRIGGER dial to the MANUAL position.

1323 Also, $f=1/T$ (The frequency of the Function Generator
1324 is the product of the MULTIPLIER and the CYCLES/SEC dials.
1325 at 2005
1326 write If you would like more information on the MANUAL
1327 TRIGGER, press -HELP-. Otherwise, press -NEXT- to
1328 continue.
1329 end
1330 ***

1331 unit x03s2r
1332 jump n60,x03s2s,x
1333 jump n61,x03s2t,x03s2u
1334 ***

1335 unit x03s2s
1336 next x03m2g
1337 at 905
1338 write As in the last exercise, you should have a frequency
1339 of 1000 Hz. Set the frequency dials at 1000 Hertz.

1340 Then...

1341 Press -NEXT-

1342 Press -BACK- to reread the problem statement
1343 ***

1344 unit x03s2t
1345 next x03m2g
1346 back x03m2e
1347 at 905
1348 write Once again you are displaying an adjustable wave-
1349 form, this time a 10 V_{p-p} square wave. Carefully,
1350 adjust the ATTENUATOR and check the SCOPE's dial
1351 settings (such as A VOLTS, Y DISPLAY, etc.).
1352
1353 Press -NEXT- when you are properly displaying the
1354 waveform.

1355 Press -BACK- to reread the problem statement.
1356 ***

1357 unit x03s2u
1358 next x03m2g
1359 help x03s2v
1360 back x03m2e
1361 at 811
1362 write You appear to be having trouble with the
1363 manual trigger. Before we go further, you
1364 should be aware that PLATO does not sense when
1365 the MANUAL button is being pressed; thus, it
1366 is not necessary that you be pressing the
1367 MANUAL button when the dial check is in

1368 progress. You only need to have the system
 1369 set up to be manually triggered, press the
 1370 MANUAL button once or twice to assure your-
 1371 self that you have the proper set-up, then:

1372 Press -NEXT- for PLATO to check.

1373 Press -HELP- for further assistance.

1374 Press -BACK- to reread the problem statement.

1375 ***

1376 unit x03s2v
 1377 at 605
 1378 write When the Function Generator's TRIGGER selection
 1379 dial is set to the EXT position, the Function
 1380 Generator may be triggered by an external voltage
 1381 or event. Pressing the MANUAL button may be
 1382 considered an external event.

1383 You may trigger the SCOPE either internally or
 1384 from the Function Generator.

1385 end

----- part=2, block=i -----

block 2i, x03s2w

1387 unit x03s2w
 1388 at 1105
 1389 write The DC LEVEL control is below the ATTENUATOR.

1390 Carefully set this dial. Also, since this dial
 1391 interacts with the ATTENUATOR dial, you may find it
 1392 necessary to re-adjust the ATTENUATOR setting.

1393 (Since you are putting a dc component into the
 1394 waveform, to what position should the A PRE AMP be set?)

1395 end
 1396 ***

1397 unit x03s2x
 1398 pack n33,0000000000000000+0a0000+a000+00
 1399 join ckc1
 1400 call n62+n47
 1401 jump n60,x03s2y,x
 1402 jump n61,x03s2z,x
 1403 jump n62,x03s2z,x03s2z1
 1404 ***

1405 unit x03s2y
 1406 next x03m21
 1407 back x03m2h
 1408 at 905

1409 write If you've gotten this far, the timing dials should
1410 be causing you problems now. However, the Function
1411 Generator's CYCLES/SEC and MULTIPLIER dials, which
1412 should be set at a frequency of 500 Hz, are not set
1413 properly.

1414 Press -NEXT- when you have set these dials properly.

1415 Press -BACK- to reread the problem statement.

1416 ***

1417 unit x03s2z
1418 next x03m2i
1419 back x03m2h
1420 at 805

1421 write You are not triggering the SCOPE from the Function
1422 Generator.

1423 Press -NEXT- when you have made the necessary dial
1424 and/or connection corrections.

1425 Press -BACK- to reread the problem statement.

1426 ***

1427 unit x03s2z1
1428 next x03m2i
1429 help x03s2z2
1430 back x03m2h
1431 at 905

1432 write You are not displaying a triangle wave with a peak-to-
1433 voltage of 20 volts and a dc level of -5 volts.

1434 Press -NEXT- if the understand your error and
1435 have corrected it.

1436 Press -HELP- for assistance with the DC LEVEL.

1437 Press -BACK- to reread the problem statement.

1438 ***

1439 unit x03s2z2
1440 next x03m2i
1441 at 505

1442 write Before attempting to set the DC LEVEL at -5 Volts,
1443 you must set the 0 Volts level on the SCOPE. To do so,
1444 turn the A PRE AMP to OFF, and position the trace on
1445 the center horizontally by means of the Y POSITION knob.

1446 pause

1447 write Now that you have positioned the zero voltage level
1448 on the SCOPE, do not move the Y POSITION knob. Doing
1449 so will dislocate the zero voltage level on the screen.

1450 Return the A PRE AMP from OFF to its previous setting.

1451 Adjust the Function Generator's DC LEVEL until the
 1452 wave is centered about -5 V. Then readjust the
 1453 ATTENUATOR and the DC LEVEL as necessary to obtain the
 1454 20 V_{p-p} waveform with a dc level of -5 volts.

----- part=2, block=j -----

block 2j, x03s3a

```
1456 unit x03s3a
1457 draw 037;024;1024;1026;1226;1222;1022;1024;skip;1224
1458 1424;1437
1459 at 200,202
1460 write c B
1461 at 200,376
1462 write c A
1463 at 1120
1464 write +
1465 vs(t)
1466 ***
```

```
1467 unit x03s3b
1468 pack n33,++(op)++(de)+a+af(pqr)+++++++
1469 join ckd
1470 jump n47,x,x03s3c
1471 join ckd1w /
1472 pause
1473 jump x03m3e
1474 ***
```

```
1475 unit x03s3c
1476 pack n33,0000000000000+00n0an0000a0000+00
1477 join ckc
1478 jump n47,x,x03m3f /
1479 join ckc1w /
1480 pause
1481 jump x03m3e
1482 ***
```

```
1483 unit x03s3d
1484 at 1207
1485 write Connect the (+) output terminal of the Function
1486 Generator to terminal 7 on the RESISTOR BOARD. Also,
1487 connect terminal 7 to (+) A-input of the Scope.
```

```
1488
1489 Now connect the (-) output terminal of the
1490 Function Generator to terminal 8 on the resistor
1491 board. Terminal 8 should also be connected to the
1492 A INPUT of the Scope.
```

```
1493 end
1494 ***
```

```
1495 unit x03s3g
1496 pack n33,++(no)++(de)+a+af(pqr)+++++++
```

```

1497 join      ckd
1498 jump      n47,x,x03s3j
1499 pack      n33,++(no)+++++
1500 join      ckd1
1501 jump      n47,x03s3h,x03s3i
1502 ***

1503 unit      x03s3h
1504 help      x03s2e3
1505 next      x03s3g
1506 back      x03m3f
1507 at        905
1508 write     The waveform you are displaying is too small. You
1509            cannot measure it very accurately.

1510
1511            Press -NEXT- when you have reset A VOLTS so that the
1512            waveform is as large as possible without exceeding
            the boundaries of the screen.

1513            Press -HELP- for a further explanation.

1514            Press -BACK- to reread the problem statement.
1515 ***

1516 unit      x03s3i
1517 next      x03s3g
1518 pack      n33,++(no)++(de)+a+af(pqr)+++++
1519 join      ckd1w
1520 ***

1521 unit      x03s3j
1522 pack      n33,000000ab0000a00b0cb0000c000+00
1523 join      ckc
1524 jump      n47,x,x03m3g
1525 pack      n33,000000ab0000b00a0ca0000c000+00
1526 join      ckd1
1527 jump      n47,x,x03m3g
1528 join      ckd1w
1529 pause
1530 jump      x03m3f
1531 ***

1532 unit      x03s3l
1533 next      x03m3m
1534 at        1315
1535 write      $v_g(t)$  and  $R_g$  are unknowns. Write your
1536            equation in terms of known parameters
1537            only.

1538
1539            press -NEXT- to try again
1540 at        2111
1541 write     n51,..ASK YOUR INSTRUCTOR FOR ASSISTANCE.....
1542 ***

1543 unit      x03s3m
1544 next      x03m3n
1545 at        1416

```

1546 write Your equation will work!!
1547
1548 press -NEXT-
1549 ***
1550 unit x03s3n
1551 next x03m3m
1552 at 1615
1553 write No, your equation will not work
1554
1555 press -NEXT- to try again. i
1556 at 2411
1557 writec "n51,,ASK YOUR INSTRUCTOR FOR ASSISTANCE....."

part=2, block=k

block 2k, x03s3e

1559 unit x03s3e
1560 at 1524
1561 write Unknown
1562 R,L,or C
1563 element
1564 at 304,360
1565 write o A
1566 at 304,218
1567 write o B
1568 entry x03s3e1
1569 at 304,360
1570 write o
1571 at 304,218
1572 write o
1573 draw 939;921;1121;1120;1220;1222;1122;1121;skip;1221
1574 1421;1420;1620;1622;1422;1421;skip;1621;1821;1839
1575 at 192,336
1576 write +
1577 at 184,318
1578 write $v_s(t)$
1579 ***
1580 unit x03s3f
1581 draw 940;1140;320,328;312,320;320,312;312,304;320,296
1582 312,288;320,280;312,272;320,264;312,256;1840
1583 at 1342
1584 write R_L
1585 draw 1235;1535;1733;1730;238,246;232,240;238,234
1586 at 1436
1587 write I_L
1588 ***
1589 unit x03s3k
1590 at 1416
1591 write -

```

1592          Ve
1593          +
1594 at      1624
1595 write   Re

1596 entry   x03s3ki
1597 at      308,360
1598 erase    7
1599 at      308,218
1600 erase    7
1601 draw    945;950;skip;947;1046;947;1048;947;1247;skip
1602        1447;1847;1845;1850
1603 at      353,299
1604 write   VL
1605 ***

1606 unit    x03s3o
1607 back    x03m3p
1608 erase
1609 catchup
1610 at      1010
1611 write   For each of the five data points place the
1612         specified value of RL across the output of
1613         the Function Generator (just as you have
1614         done previously). The peak-to-peak voltage
1615         which you read from the SCOPE is VL. You
1616         have already determined that IL = VL/RL.
1617         Since you know VL and RL, the calculation
1618         of IL is simple division; a calculator has
1619         been provided for your convenience.
1620 end
1621 ***

1622 unit    x03s3p
1623 draw    2111;2154;2754;2711;2111
1624 at      2317
1625 write   PLATO CALCULATOR
1626 at      2312
1627 write   Enter expression such as 5/7, 4.3/75, etc.
1628         EXPRESSION:
1629         PLATO CALCULATES:
1630 at      1904
1631 write   Press -DATA- if you would like to use the calculator to
1632         calculate IL. Otherwise press -NEXT- to enter IL directly.
1633 ***

1634 unit    x03s3q
1635 at      1822
1636 erase    2
1637 at      2432
1638 erase    12
1639 at      2539
1640 erase    6
1641 catchup
1642 inhibit erase
1643 arrow    2432
1644 store    y70

```

```

1645 ok
1646 endarrow
1647 calc v71+v70
1648 at 2539
1649 show v71
1650 at 2612
1651 write Press -NEXT- to enter IL above
1652 pause
1653 jump x03m3p1
1654 ***

1655 unit x03s3r
1656 calc n100+140

1657 entry x03s3r1
1658 calc v(n100)+v56
1659 add1 n100
1660 calc v(n100)+v131
1661 add1 n100

```

----- part=2, block=1 -----

block 21, x03end:

```

1663 unit x03end
1664 back x03m3r
1665 join imode
1666 jump n47,x03end,x
1667 course n2
1668 calcc n2='ee244'
1669 nc(n21+1)+(nc(n21+1)$mask$077777777770000000000)+o4603000000
1670 nc(n21+1)enc(n21+1)
1671 erase
1672 output /// student has completed experiment ///
1673 join endunit
1674 join jmpmes
1675 jumpout cgeindex,quest1

1676 entry leave
1677 end lesson
1678 ***

1679 unit endunit
1680 course n2
1681 jump n2='ee244',leave,x
1682 calc nc(n21+7)enc(n21+7)+ahelp
1683 vc(n21+6)+vc(n21+6)+atime/60000
1684 ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
1685 use ee=00,ck1
1686 use ck2
1687 use ck3
1688 use ck4
1689 use ck5
1690 use ck6

```

ckc	not found		194	234	266	1477	300	1523	1263
ckc1	not found		981	1201	1399		1526		
ckc1w	not found		1266	1479	1528				
ckd	not found		177	218	255	1469	289	1477	1285
ckd1	not found		181	184	187	225	190	230	222
			259	262	293		296		1500
ckdlw	not found		1288	1471	1519				
endunit	x03end	1679	19	1673					
imede	not found		29	308	1665				
jmpmes	not found		1674						
leave	x03end	1676	1681						
x03end	x03end	1663	735	1666					
x03m0a	x03m0a	77	30	49					
x03m1a	x03m1a	40	65						
x03m1b	x03m1a	63	90	807	808	944	820	956	831
x03m1c	x03m1a	86	64	107	121				
x03m1d	x03m1d	104	89	154					
x03m1e	x03m1d	118	105						
x03m2a	x03m2a	133	120	159	911		935		950
x03m2b	x03m2a	156	154	201	968	1019	992	1066	1003
			1127	1154					
x03m2c	x03m2c	169	160	990	1002		1020	1128	1064
x03m2d	x03m2c	191	179	1153	1169				
x03m2e	x03m2c	198	196	241	1191	1236	1211	1272	1225
x03m2f	x03m2d	211	202	1209	1223		1286		1293
x03m2g	x03m2d	232	220						
x03m2h	x03m2d	238	236	274	1237		1319	1364	1346
x03m2i	x03m2d	251	1336	1345	1358				
x03m2j	x03m2d	264	257						
x03m2k	x03m2d	270	268	310	1407		1419		1430
x03m2l	x03m2d	283	1406	1418	1428		1440		
x03m2m	x03m2d	291	291						
x03m2n	x03m2a	307	302	309	321				
x03m2o	x03m2a	314	341						
x03m2p	x03m2a	316	360						
x03m2q	x03m2a	320	370						
x03m2r	x03m2a	367	389	1473	1481				
x03m2s	x03m2a	387	412	1478	1506		1530		
x03m2t	x03m2f	411	434	1524	1527				
x03m2u	x03m2f	431	466						
x03m2v	x03m2f	467	433	487					
x03m2w	x03m2f	486	500						
x03m2x	x03m2f	499	520						
x03m2y	x03m2f	519	545						
x03m2z	x03m2f	544	573	1533	1551				
x03m3a	x03m3m	571	607	709	1544				
x03m3b	x03m3m	605	632						
x03m3c	x03m3m	629	608	704	1607				
x03m3d	x03m3p	636	1653						
x03m3e	x03m3p	641	635	679					
x03m3f	x03m3p	706	704	736					
x03m3g	x03m3q	734	708	1664					
x03s1a	x03s1a	753	86						
x03s1a1	x03s1a	761	86						
x03s1a2	x03s1a	766	86						
x03s1a3	x03s1a	770							
x03s1a4	x03s1b	781	86						

x03s1a5	x03s1a	788	86				
x03s1b	x03s1a	794	69	817	836	849	861
x03s1c	x03s1a	806	760				
x03s1d	x03s1a	819	767				
x03s1e	x03s1a	830	775				
x03s1e1	x03s1a	838	850	862			
x03s1f	x03s1a	843	787				
x03s1g	x03s1a	855	792				
x03s1h	x03s1h	865	106				
x03s1h1	x03s1h	868	907				
x03s1i	x03s1h	895	113	133	866	905	
x03s1j	x03s1h	904	119				
x03s2a1	x03s1h	910	154	1170	1252		
x03s2a2	x03s1h	934	154	1065			
x03s2a3	x03s2a3	948	154	1129			
x03s2b	x03s2a3	967	161				
x03s2c	x03s2a3	979	195	196			
x03s2d	x03s2a3	989	985				
x03s2e	x03s2a3	1001	983				
x03s2e1	x03s2e1	1018	987				
x03s2e2	x03s2e1	1033	631				
x03s2e3	x03s2e1	1038	1021	1037	1504		
x03s2e4	x03s2e1	1048					
x03s2f	x03s2e1	1063	991				
x03s2g	x03s2g	1085	986	987			
x03s2g1	x03s2g	1126	1086				
x03s2h	x03s2h	1151	984				
x03s2h1	x03s2h	1167	1155				
x03s2i	x03s2h	1190	203				
x03s2j	x03s2h	1199	235	236			
x03s2k	x03s2h	1208	1203	1206			
x03s2l	x03s2h	1222	1205				
x03s2m	x03s2m	1236	1204	1206			
x03s2n	x03s2m	1249	1210	2268			
x03s2n1	x03s2m	1261	1251				
x03s2o	x03s2m	1270	1264	1290			
x03s2o1	x03s2m	1283	1271				
x03s2p	x03s2m	1292	1224				
x03s2q	x03s2q	1317	240				
x03s2r	x03s2q	1331	267				
x03s2s	x03s2q	1335	1332				
x03s2t	x03s2q	1344	268	1333			
x03s2u	x03s2q	1357	1333				
x03s2v	x03s2q	1376	1318	1359			
x03s2w	x03s2w	1387	273				
x03s2x	x03s2w	1397	301	302			
x03s2y	x03s2w	1405	1401				
x03s2z	x03s2w	1417	1402	1403			
x03s2z1	x03s2w	1427	1403				
x03s2z2	x03s2w	1439	1429				
x03s3a	x03s3a	1456	328	342	377	396	
x03s3b	x03s3a	1467	369				
x03s3c	x03s3a	1475	1470				
x03s3d	x03s3a	1483	390				
x03s3e	x03s3e	1559	439				
x03s3e1	x03s3e	1568	528	547	742		
x03s3f	x03s3e	1580	530	549			

x03s3g	x03s3a	1495		391	1505	1517			
x03s3h	x03s3a	1503		1501					
x03s3i	x03s3a	1516		1501					
x03s3j	x03s3a	1521		1498					
x03s3k	x03s3e	1589		529	548				
x03s3k1	x03s3e	1596		465					
x03s3l	x03s3a	1532		565	567				
x03s3m	x03s3a	1543		569					
x03s3n	x03s3a	1550		569					
x03s3o	x03s3e	1606		633					
x03s3p	x03s3e	1622		675					
x03s3q	x03s3e	1634		634	677	686			
x03s3r	x03s3e	1655		699					
x03s3rd	x03s3e	1657		699					
ahelp		1682							
atime		1683							
data		677							
key		677							
msecs		802							
n		84							
nc		1669	1669	1670	1670	1682	1682		
n100		79	81	82	84	727	729	728	1656 728
		1658	1659	1660	1661				
n101		78	80	80	83				
n2		1667	1668	1680	1681				
n21		1669	1669	1670	1670	1682	1682	1683	1683
n33		176	180	183	186	189	221	193	224 217
		227	233	254	258	261	292	265	295 288
		299	980	1200	1262	1265	1398	1284	1468 1287
		1476	1496	1499	1518	1522		1525	
n47		30	178	179	182	185	196	188	219 191
		220	223	226	231	236	260	256	263 257
		268	290	291	294	297	982	302	1202 309
		1264	1286	1400	1470	1478	1524	1498	1527 1501
		1666							
n51		500	86	91	122	351	429	353	512 421
		514	521	546	575	662	701	662	757 664
		764	772	779	784	884		891	1557 1541
n52		92	123	886	891				
n53		93	124	888					
n54		770	833						
n55		178	195	219	235	256	301	267	1152 290
n57		649	704						
n58		574	649	651	699	700			
n60		51	213	223	252	260	562	285	564 294
		566	568	758	1203	1332		1401	
n61		52	214	226	253	263	564	286	565 297
		566	567	568	569	765		1204	1402 1333
n62		53	170	182	215	231	985	287	1205 773
		1400	1403						
n63		54	171	185	216	780		986	1206 1202
n64		55	172	191	785	987			
n65		173	982	984					
n66		174							
n67		175	188	983					
n70		153	154						
		853	853	863					

v	728	728	1658	1660
vc	1683	1683		
volts	803			
v102	81	84		
v103	82	84		
v130	680	674		
v131	666	674	1660	
v132	674	689		
v140	726			
v141	726			
v142	726			
v143	726			
v144	726			
v145	726			
v146	726			
v147	726			
v148	726			
v149	726			
v52	664	667	755	810
v56	608	1658		
v70	1644	1647		
v71	1647	1649		
%	667			
Time	902			
V	853	863		
Volts	901			
V _{ma}	837			
V _L	722			

Lesson information

lesson name = ^eex03
 starting date = 05/18/73
 last edited on 08/21/74 at 11.18.26
 by neal of course cece
 at site 7, station 27
 author name = J.P. Neal
 department = EE
 telephone number = 333-4351
 discipline = EE
 grade level = Freshman
 description of lesson = The Operation and Uses of the Function Generator, Exact 251.

block 1a, eex04id.

2 stop
 3 **** For Neal, CGERL, Room 248, EEB.
 4 One line description of this lesson --
 5 The Operation and Uses of the DC Supply, Harrison 065B.

6	Divisions of this Lesson:	Block	Unit
7	Id for this file	eex04id	
8	Experiment eex04;		
9	Objectives	x04m0a	x04m0a
10	Uses of dc supply	x04m0a	x04m1a
11	Constant v / constant i opn.	x04m2a	x04m2a
12	Operation in floating mode	x04m3a	x04m3a
13	Practical applications	x04m3h	x04m4a
14	Optional studies	x04m4d	x04m5a

15 Final edit 21 aug 74 neal.

16 *list info
 17 *list symbols
 18 *list varian, charset, cgeindex, cgechar
 19 ****
 20 start
 21 finish endunit
 22 write (at, 1010) Loading the CGE Character Set
 23 charset cgeindex, cgechar
 24 erase
 25 dataon
 26 area eex04
 27 ext 0

block 1b, x04m0a

29 unit x04m0a
 30 restart
 31 join imode
 32 jump n47, x04m0a, x
 33 base
 34 next x04m0b
 35 calc n59+ (-1)
 36 at 505
 37 write The Operation and Uses of the Constant Voltage Constant

38 Current Supply, Harrison Laboratories 865B
39 at 1010
40 write When you have completed this experiment
41 you should be able to:

- 42 1) Determine the cases in which the DC SUPPLY
43 can be used.
- 44 2) Adjust the DC SUPPLY for constant current/
45 voltage operation.
- 46 3) Connect the DC SUPPLY in either a floating
47 or a grounded mode, as the particular application
48 may require.
- 49 4) Use the DC SUPPLY in practical applications.

50 ***

51 unit x04m0b
52 back x04m0a
53 next x04m1a
54 lab x04m4a
55 data x04m5a
56 at 1210
57 write Press -NEXT- for a CGE learning experience,
58 -LAB- if you know all about this device,
59 -DATA- for a do-it-yourself CGE sequence.
60 ***

61 unit x04m1a
62 back n59, x04m0b, x04m3h, x04m5b
63 next n59, x04m1b, x04m3h, x04m5b
64 join n59-3, x04s1a, x
65 goto n59, x, x04s0a, x04s0a, x
66 at 1611
67 write Do you think that this device could be used
68 to generate the 60 Hz. alternating current
69 that is available from wall outlets?
70 arrow 1849
71 answer (n, no, nope, NO, No)
72 at 2211
73 write Right! 60 Hz. current is a periodic function of
74 time.
75 wrong (y, yes, YES, Yes)
76 at 2211
77 write 60 Hz current is not constant, it's a periodic
78 function of time.
79 wrong
80 at 2211
81 write y or n will suffice as an answer.

----- part=1, block=c -----

block 1c, x04m1b

83 unit x04m1b
 84 back n59, x04m1a, x04m3h, x04m5b
 85 next n59, x04m1c, x04m3h, x04m5b
 86 join n59-3, x04s1b, x
 87 goto n59, x, x04s0a, x04s0a, x
 88 at 1611
 89 write Can this supply be used to ...
 90 at '811
 91 write Generate a constant (dc) voltage of 15 V ?
 92 Produce 10 volts across a 15 ohm resistor?
 93 Generate a constant current of 0.01 amp?
 94 arrow 1854
 95 answer (YES, Yes, yes, y)
 96 wrong (NO, No, no, n, nope)
 97 at 2211
 98 write Nope, it'll work. Try it!
 99 arrow 1954
 100 answer (NO, no, No, n)
 101 wrong (YES, Yes, yes, y)
 102 at 2211
 103 write 10 volts = 15 ohms = 0.667 amp. That's too much!
 104 arrow 2054
 105 answer (no, NO, No, n)
 106 wrong (YES, Yes, yes, y)
 107 at 2211
 108 write 0.01 amp is below the minimum current of 0.1 amp
 109 ***
 110 unit x04m1c
 111 back n59, x04m1b, x04m3h, x04m5b.
 112 next n59, x04m2a, x04m3h, x04m5b
 113 join n59-3, x04s1c, x
 114 goto n59, x, x04s0a, x04s0a, x
 115 at 1211
 116 write The DC SUPPLY should be "ON".
 117 Is the pilot light glowing?
 118 arrow 1339
 119 answer (yes, y, Yes, YES)
 120 wrong (no, NO, No, n)
 121 at 1511
 122 write Call the lab assistant to check your supply.

-----part=1, block=d-----

block 1d, x04m2a

124 unit x04m2a
 125 back n59, x04m1c, x04m3g, x04m5b
 126 next x04m2b
 127 jump n59=3, x04m2b, x

128 at 611
 129 write The DC SUPPLY will operate as a constant voltage
 130 source if the load current remains less than the
 131 setting of the CURRENT dial.
 132 at 1011
 133 write Or the DC SUPPLY will operate as a constant current
 134 source so long as the load voltage is less than the
 135 setting of the VOLTAGE dial.
 136 at 1411
 137 write In any case, the load current (I_L) will never be
 138 greater than the CURRENT dial setting; and,
 139 the load voltage, V_L , will never be greater than
 140 the VOLTAGE dial setting. The mode of operation
 141 of the DC SUPPLY is determined by the setting
 142 of these dials and the load resistor only!!
 143 The setting of the DELIVER switch has no effect on
 144 this operation!!!

----- parts1, block=e

block 1e. x04m2b

146 unit x04m2b
 147 back x04m2a
 148 next 159, x04m2c, x04m2h, x04m5b, x04m2c
 149 goto 159, 159, 159, x
 150 xdb 159, 159, 159, 159, x
 151 at 1411
 152 write If the DC SUPPLY is set at 20 volts and
 153 2.15 amp, and then a 100 ohm load is placed
 154 on the output, what will be the resultant load
 155 current and voltage?
 156 at 1011
 157 write _____ amp. $V_L =$ _____ volts.
 158 answer 2.15
 159 ans 100 ohms
 160 copy 0.15, 13
 161 at 1011
 162 write Right! The DC SUPPLY will not allow the load
 163 current to become greater than the dial setting.
 164 store 155
 165 no.
 166 join v05=0.15, x04s2b, x04s2c
 167 answer 155
 168 copy 155, 1
 169 at 1011
 170 write Right! The DC SUPPLY is in constant current mode!
 171 store 155
 172 no.
 173 at 1011
 174 write You got I_L right; now just use Ohm's law!
 175 x
 176 unit x04m2c

```
177 help x04s2d
178 next. x04m2d
179 goto n59, x, x04s0a, x04s0a, x
180 at 810
181 write Let's try to show this by experimentation.
182 at 1210
183 write Set up the DC SUPPLY for 20 volts and 0.15 amperes.
184 at 3110
185 write -HELP- is available.
186 ***

187 unit x04m2d
188 pack n00, ++++++ (hi) (fghijk) +++++
189 join cl d
190 jump n47, x04s2e, x
191 goto n59-10, x04m3a, x04m3h, x04m5b, x04m5b, x04m5b, x04s2f
```

part=1, block=f

block 1f, x04m3a

```
193 unit x04m3a
194 back n59, x, x04m3h, x04m5b
195 next n59, x04m3b, x04m3h, x04m5b, x04m3b
196 join n00-3, x04s3a, x
197 goto n59, x, x04s0a, x04s0a, x
198 at 1511
199 write Connect the sensor cable of the RESISTOR BOARD,
200 and then drive the 100 ohm resistor from the
201 DC SUPPLY in the following fashion:

202 Connect the (+) output to Terminal 3.
203 Connect the (-) output to GROUND.
204 Connect the (-) output to Terminal 4.
205 ***

206 unit x04m3b
207 pack n00, 001200000000000000000000000000120+00
208 join cl c
209 jump n47, x04m3a, x04m3c
210 ***

211 unit x04m3c
212 back n59, x04m3a, x04m3h, x04m3a
213 next n59, x04m3d, x04m3h, x04m5b
214 at 811
215 write With the 100 ohm resistor connected the current
216 will not exceed 0.15 amp, at any voltage setting.
217 Also, the voltage will never exceed the 20 volts
218 despite the current setting.

219 Experiment with this until you can verify these
```


220 statements.
 221 Can you verify the above ?
 222 arrow 1642
 223 answer (E, res, yes, y)
 224 write no.
 225 write Call the lab instructor:
 226 join mode
 227 jump n59-4*n47, x04m3d, x04m3h, x04m5b, x04m3c

part=1, block=g

block 1g. x04m3d

229 unit x04m3d
 230 back n59, x04m3c, x04m3h, x04m5b
 231 next n59, x04m3e, x04m3h, x04m5b
 232 join n59-1, x04s3b, x
 233 goto n59, x, x04s0a, x04s0a, x
 234 at 2311
 235 write If you had as many power supplies of this type
 236 as you wanted could you generate a 1.5 ampere
 237 current ?

238 arrow 2421
 239 answer (N, n, no, n)
 240 ***

241 unit x04m3e
 242 back n59, x04m3d, x04m3h, x04m5b
 243 next n59, x04m3f, x04m3h, x04m5b, x04m3f
 244 join n59-1, x04s3c, x
 245 goto n59, x, x04s0a, x04s0a, x
 246 jump n59-1, x04m3f, x
 247 ***

248 unit x04m3f
 249 back x04m3e
 250 at 209
 251 write Set the METER dial to display the load current.
 252 pause
 253 pack n00, ++++++v+++++
 254 join did
 255 jump n59-10*n47, x04m3g, x04m3h, x04m5b, x04m5b, x04m5b, x04m3f
 256 ***

257 unit x04m3g
 258 term test
 259 zero n59
 260 jump x04m3h

part=1, block=h

block 1h, x04m3h

262 unit x04m3h
263 at 11
264 write To review any of these topics press the
265 following keys:
266 a) Definitions of direct current (dc).
267 b) Power supplies and glowing lights.
268 c) Constant voltage and constant current mode.
269 d) Power supply load connections.
270 e) Multiple power supply operations.
271 f) Functions of the METER dial.
272 g) Voltage and current limitations.
273 h) Operation of the VOLTAGE and CURRENT controls.
274
275 You will be automatically returned to this
page after each review unit.
276
277 Topic 2
278 When you are finished press -DATA- for the final test.
279 data x04m4a
280 goto n69, x, y, x04=0a
281 base
282 arrow 2310 +
283 long 1
284 match n60, a, b, c, d, e, f, g, h
285 jump n60, x, x04m1a, x04m1c, x04m2a, x04m3a, x04m3d, x04m3e, x04m1b, x04s2d
286 at 2511
287 write Just type the letter.
288 * * *
289 unit x04m4a
290 base
291 join 1mode
292 jump n47, x04m4a, x
293 call n60+2
294 jump x04m4b
295 * * *
295 unit x04m4b
296 back x04m10a
297 at 810
298 write Set the DC SUPPLY to produce the following output:
299
300 A 15V dc signal across the 500 ohm resistor
on the resistor circuit board.
301 The DC voltage generated should be negative
302 (-) with respect to ground.
303 The resistor itself should be connected
304 such that terminal 7 is connected to ground.
305
305 Set the meter on the DC supply to monitor the

306 load voltage.
 307 pause
 308 pack n30,000000ab00000a000000000000ab0+00
 309 join ckdv
 310 jump n47, x04m4b1
 311 next x04m4b
 312 ***

313 unit >04m4b1
 314 pack n13,+++++ (fg) +++++
 315 join ckd
 316 jump n47, x04s4a, x
 317 jump x04m4c
 318 ***

319 unit >04m4c
 320 join 10000
 321 jump n47, x04m4c, x
 322 at 511

323 write Can the power supply be used to generate:

- 324 1) A 48 volt dc signal ? (yes/no)
 325 2) How about 17 volts ac ?
 326 3) A constant current of 0.4 amperes ?

327 arrow 10039
 328 answer (NO, No, no, n)
 329 wrong (YES, yes, y, Yes)
 330 edit n60
 331 arrow 1041
 332 answer (NO, No, no, n)
 333 wrong (YES, yes, yes, y)
 334 edit n60
 335 arrow 10000
 336 answer (YES, yes, yes, y)
 337 next n60, y, y, x04s4d
 338 wrong (NO, No, no, n)
 339 edit x60

----- part=i, block=i -----

block ii, x04m4d

341 unit x04m4d
 342 at 810
 343 write (Set the DC SUPPLY to generate 20 V dc
 344 with the current limited to 0.3 A.)

345 (Set the METER to measure output voltage.

346 pause
 347 pack n33,+++++a(hi) (Imn) +++++
 348 join ckd
 349 jump n47, x04s4b, x

350 jump n47,x04s4c,x
351 jump x04m4e
352 ***

353 unit x04m4e
354 join mode
355 jump n47,x04m4e,x
356 at 411

357 write If you were to set the dials of the supply to
358 the following positions-

359 1) METER - volts
360 2) VOLTAGE - 20 volts
361 3) CURRENT - 0.1 amperes

362 Would the supply be in constant voltage or
363 constant current operation with a load of
364 100 ohms? (type letter)

365 a) Constant current
366 b) Constant voltage

367 arrow 1332
368 answer (F),a)
369 wrong (F),b)
370 add1 no
371 ***

372 unit x04m4f
373 at 410

374 write If you required more current than the DC SUPPLY
375 could furnish, could you connect two DC SUPPLIES
376 in parallel?

377 If you required more voltage than the DC SUPPLY
378 could furnish, could you connect two DC SUPPLIES
379 in series?

380 next n00,x04end,x04end,x04s4d
381 arrow 1034
382 answer (N),No,no,n)
383 wrong (Y),S, yes, Yes, y)
384 add1 no
385 arrow 1434
386 answer (Y),S, Yes, yes, y)
387 wrong (N),No,no,n)
388 add1 no
389 ***

390 unit x04m5a
391 back x04m0a
392 face
393 at 620

394 write Do it your self study
395 at 411
396 write Choose any method of study you wish!

397 Enter i for only information
398 q for only questions, or

399 b for both information and questions

400 arrow 1411

401 long 1

402 answer (I, i)

403 calc n59+1

404 answer (Q, q)

405 calc n59+3

406 answer IB, b

407 calc n59+2

408 ***

409 unit x04m5b

410 back x04m5a

411 base

412 at 611

413 write (Press -BACK- to change study mode.)

414 join x04m3h

415 arrow 0019

416 long

417 match n00, a, b, c, d, e, f, g, h,

418 next n00, x04m1a, x04m1c, x04m2a, x04m3a, x04m3d, x04m3e, x04m1b

part=i, block=j

block 1j. x04s0a

420 unit x04s0a

421 * dummy unit to end goto's

422 ***

423 unit x04s1a

424 at 711

425 write The DC SUPPLY is used to generate direct

426 current; that is, the current (or voltage)

427 generated is constant for a given load, i.e.

428 it is not a periodic function of time.

429

430 Of course the output of the device is

431 adjustable, but for any setting it will not

432 generate anything but a constant voltage and

433 current, if the load is constant.

433 ***

434 unit x04s1b

435 at 711

436 write Note that this supply can only generate voltages

437 up to 40 volts dc. Also, the maximum current

438 capacity of this supply is 0.5 amperes.

439 Voltages or currents greater than these limits

440 cannot be produced.

441

442 However, the supply will not operate at all if

443 the CURRENT dial is set less than about 0.1 amp.

444 ***

445 unit x04s1c
446 at 811
447 write * Turn on the DC SUPPLY by throwing the
448 small toggle switch on the left of the supply.
449 The small, red pilot light should glow.
450 ***

451 unit x04s2a
452 at 811
453 write Calculating I_L and V_L is easy. Just assume that
454 the supply is in either constant voltage or
455 constant current operation. Then, use R_L to
456 calculate the remaining V_L or I_L . If the V or
457 I is not greater than it's limit, you have the
458 solution. If not, the supply is operating in
459 the other mode.
460 ***

461 unit x04s2b
462 at 811
463 write I_L cannot be greater than the current limit.
464 ***

465 unit x04s2c
466 at 811
467 write No, if I_L were really that, what would V_L be?
468 Find which parameter (I or V) would be limiting?

part=1, block=k

block 1k, x04s2d

470 unit x04s2d
471 back n59, x04m2c, x04m3h, x04m5b
472 next n59, x04s2d2, x04m3h, x04m5b, x04s2d2, x04m5b
473 join n59-3, x04s2d1, x
474 goto n59, x, x04s0a, x04s0a, x
475 jump n59-3, x04s2d2, x
476 ***

477 unit x04s2d1
478 at 811
479 write To set the power supply to a given voltage and
480 current limit output, first short the + (red)
481 and - (black) terminals of the DC SUPPLY
482 with a test lead.

483 -With the METER switch on AMPS, adjust the
484 CURRENT control to the desired current limit.

485 Remove the test lead from the DC SUPPLY
486 terminals and turn the METER switch to VOLTS.
487 Then adjust the VOLTAGE control to the desired

488 output voltage limit.

489 One additional note: Be sure you are reading
490 the correct meter scale when setting the
491 current and voltage limits.

492 ***

493 unit x04s2d2
494 back n59-3, x04s2d, x04m5b
495 next n59, x04m2c, x04m3h, x04m5b
496 at 410

497 write To set the output current limit of the DC SUPPLY,--
498 which of the following is necessary?

499 a) The + output terminal of the supply should
500 be grounded.

501 b) The + and - terminals of the supply should
502 be shorted together.

503 c) The + and - terminals of the supply should
504 be left open circuited.

505 arrow 1520

506 specs nookno

507 answer (b,B)

508 at 1705

509 write Right! But remember to disconnect the short when
510 setting the output voltage limit.

511 wrong (a,A)

512 at 1705

513 write No! The DC SUPPLY is a floating supply and hence
514 neither the + or - terminals are internally
515 connected to ground.

516 wrong (c,C)

517 at 1705

518 write No! Only when you are setting the voltage limit
519 is it necessary that the output terminals be
520 open circuited.

521 no

522 at 1705

523 write Just type the letter of your response.

524 ***

525 unit x04s2e

526 next x04m2c

527 pack n88, ++++++ij++++

528 join ckd1

529 jump n47, x04s2f, x

530 at 1116

531 write You are reading the wrong meter scale!!

532 ***

533 unit x04s2f

534 next x04s2d

535 at 1005

536 write You have incorrectly set the VOLTAGE and/or
537 CURRENT dials. You will receive help when you

block 11, x04s3a

540 unit x04s3a

541 at 811

542 write The output of the DC SUPPLY is available
543 at the red and black jacks in the lower right
544 area of the panel. The silver jack at the far
545 right is a chassis ground and may be connected
546 to either the red or black jack as required.

547 ***

548 unit x04s3b

549 at 809

550 write Note carefully that two DC SUPPLIES cannot
551 be connected in parallel to achieve a greater
552 current capability. The reason for this is
553 simple but important:

554 If two DC SUPPLIES are connected in parallel,
555 one supply will try to drive the other and a
556 large current will flow along the low resistance
557 wires between the supplies. This does not
558 happen when two DC SUPPLIES are connected in series
559 with a current limiting load; thus, they can be
560 connected in series to generate larger voltages
561 than either supply acting alone.

562 ***

563 unit x04s3c

564 at 811

565 write Note the METER switch located just right of
566 the panel meter. This switch controls the
567 indications of the meter. The meter will
568 measure either load current or load voltage,
569 depending upon the position of the switch.

570 Note that this switch has NO EFFECT on the
571 operation of the supply, it simply indicates the
572 actual terminal voltage or current.

573 ***

574 unit x04s4a

575 at 1011

576 write Remember...

577 Set the output voltage to 15 V dc.

578 (It will be necessary for you to increase
579 the output current limit until the voltage
580 across the 500 ohm resistor is 15 V dc.)


```

581          Monitor the output voltage!
582 next      x04m4a
583 ***

584 unit      x04s4b
585 pack      n33,+++++a(ijk)q++++
586 join      ckd1
587 jump      n47,x04s4c,x
588 at        1116
589 write     You are reading the wrong meter scale!!
590 next      x04m4d
591 ***

592 unit      x04s4c
593 join      x04s2f
594 pause
595 erase
596 join      x04s2d1
597 pause
598 jump      x04m4d

```

----- part=1, block=m -----

block 1m, x04end

```

600 unit      x04s4d
601 at        1211
602 write     You appear to be having some trouble.

603          .Press -NEXT- for a chance to review.
604 c        A student failing the prof. test has(n59*-1).
605 next      n59,x04m5a,x04m3h,x04m5a
606 ***

607 unit      x04end
608 back      x04m5a
609 join      imode
610 jump      n47,x04end,x
611 course    n2
612 calcc     n2='ee244',
613           nc(n21+1) + (nc(n21+1) $mask$077777777770000000000) +o4603000000,
614           nc(n21+1) eng (n21+1)
615 erase
616 output    /// student has completed experiment ///
617 join      endunit
618 join      jmpmes
619 jumpout   cgeindex,quest1

620 entry     leave
621 end       lesson
622 ***

623 unit      endunit

```

624	course	n2																		
625	jump	n2='ee244',leave,x																		
626	calc	nc(n21+7)+nc(n21+7)+ahelp																		
627		vc(n21+6)+vc(n21+6)+atime/60000																		
628	***Incl.	cge s.r. & terms sample, index, imode, comment, slides.																		
629	use	eex00,ck1																		
630	use	ck2																		
631	use	ck3																		
632	use	ck4																		
633	use	ck5																		
634	use	ck6																		
	cko	not found					208													
	ckcw	not found					309													
	ckd	not found					189	254			315									348
	ckd1	not found					528	586												
	endunit	x04end	623				21	617												
	imode	not found					31	226			290								320	609 354
	jmpies	not found					618													
	leave	x04end	620				625													
	x04end	x04end	607				380	380			610									
	x04m0a	x04m0a	29				32	52			296									391
	x04m0b	x04m0a	51				34	62												
	x04m1a	x04m0a	61				53	84			284									418
	x04m1b	x04m1b	83				63	111			284									418
	x04m1c	x04m1b	110				85	125			284									418
	x04m2a	x04m2a	124				112	147			284									418
	x04m2b	x04m2b	146				126	127												
	x04m2c	x04m2b	176				148	148			471									495 526
	x04m2d	x04m2b	187				178													
	x04m3a	x04m3a	193				191	209			212									212 418 284
	x04m3b	x04m3a	206				195	195												
	x04m3c	x04m3a	211				209	227			230									
	x04m3d	x04m3d	229				213	227			242									284 418
	x04m3e	x04m3d	241				231	249			284									418
	x04m3f	x04m3d	248				243	243			246									255
	x04m3g	x04m3d	257				125	255												
	x04m3h	x04m3h	262				62	63			84	112								85 148 111
							191	194			195	227								212 234 213
							231	242			243	414								255 471 260
							472	495			605									
	x04m4a	x04m3h	288				54	278			291									582
	x04m4b	x04m3h	295				243	311												
	x04m4b1	x04m3h	313				310													
	x04m4c	x04m3h	319				317	321												
	x04m4d	x04m4d	341				590	598												
	x04m4e	x04m4d	353				351	355												
	x04m4f	x04m4d	372																	
	x04m5a	x04m4d	390				55	410			605									605 608
	x04m5b	x04m4d	409				62	63			84	110								85 125 111
							148	191			191	125								191 194
							227	230			231	255								242 235 243
							255	471			472									472 495 494
	x04s0a	x04s0a	420				65	65			87	114								87 134 114
							150	179			179	203								197 233 197
							245	245			279									474 474
	x04s1a	x04s0a	423				64													
	x04s1b	x04s0a	434				86													

x04s1c	x04s0a	445		113					
x04s2a	x04s0a	451		149					
x04s2b	x04s0a	461		166					
x04s2c	x04s0a	465		166					
x04s2d	x04s2d	470		177	284	494		534	
x04s2d1	x04s2d	477		473	596				
x04s2d2	x04s2d	493		472	472	475			
x04s2e	x04s2d	525		190					
x04s2f	x04s2d	533		191	529	593			
x04s3a	x04s3a	540		196					
x04s3b	x04s3a	548		232					
x04s3c	x04s3a	563		244					
x04s4a	x04s3a	574		316					
x04s4b	x04s3a	584		349					
x04s4c	x04s3a	592		350	587				
x04s4d	x04end	600		337	380				
ahelp		626							
atime		627							
nc		613	613	614	614	626		626	
n2		611	612	624	625				
n21		613	613	614	614	626		626	627
n33		186	207	253	300	314		347	585
n47		32	190	191	209	227	310	255	316
		321	349	350	355	529		587	610
n59		35	62	63	64	65	86	84	87
		111	112	113	114	125	149	127	150
		179	191	194	195	196	213	197	227
		230	231	232	233	242	245	243	246
		255	259	279	403	405	470	407	473
		474	475	494	495	605			471
n60		283	284	292	330	334	370	337	380
		384	388	417	418				339
vc		627	627						
v55		164	166	171					
%		160							

lesson information

lesson name = eex04
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by neal of course eecge
at site 7, station 27
author name = J.P. Neal
department = EE
telephone number = 333-4351
discipline = EE

grade level = Freshman

description of lesson = The Operation and Uses of the DC Supply, Harrison 865B.

block 1a, eex05id

2) stop
 3) *** For Neal, CGERL, Room 248, EEB.

4 One line description of this lesson --

5 The Operation and Uses of the Vacuum Tube Voltmeter, HP400D.

6	Divisions of this Lesson:	Block	Unit
7	Id for this file	eex05id	
8	Experiment eex05;		
9	Objectives	eex05id	x05m0a
10	Properly set range dial	x05m1a	x05m1a
11	Properly connect vtvm	x05m1a	x05m2a
12	Determine uses of vtvm	x05m2d	x05m3a
13	Convert rms to p-p	x05m2d	x05m4a
14	Predict vtvm indications	x05m4h	x05m5a
15	Final test	x05m5n	x05m6a

16 Final edit 21 aug 74 neal,

17 *list info
 18 *list symbols
 19 *list varian,charset,cgeindex,cgechar

20 ****
 21 start
 22 finish endunit.
 23 write {at,1010} Loading the CGE Character Set
 24 charset cgeindex,cgechar
 25 erase
 26 dataon
 27 area eex05
 28 ext 0
 29 ***

30 unit x05m0a
 31 base
 32 restart
 33 next x05m1a
 34 join imode
 35 jump n47,x05m0a,x
 36 at 507
 37 write THE OPERATION AND USES OF THE VACUUM TUBE VOLTMETER,
 38 Hewlett Packard Model 400D

39 In this experiment, you should learn to:

40 1) Adjust the RANGE dial of the VTVM to measure
 41 voltages accurately.

- 42 2) Properly connect the VTVM to the terminal
 43 whose voltage-to-ground is to be measured.
- 44 3) Determine those voltages which can and cannot
 45 be accurately measured on the VTVM.
- 46 4) Convert V_{rms} to V_{pp} , and understand the
 47 relationship between the two for sinusoidal waveforms.
- 48 5) Predict the VTVM indication for simple
 49 non-sinusoidal periodic waveforms.

----- part=1, block=b -----

block 1b, x05mia

51 unit x05mia
 52 back x05m0a
 53 next x05m1b
 54 at 510

55 write Voltage measurements are displayed on the
 56 large panel meter. The RANGE switch (below the
 57 meter) is used to scale the input voltage to
 58 allow more accurate readings.

59 The setting of the RANGE switch determines the
 60 largest rms voltage voltage that can be measured
 61 at that setting. For most accurate measurements,
 62 the pointer should indicate in the range between
 63 30 to 100% of full scale.

64 ***

65 unit x05m1b
 66 back x05mia
 67 next x05m1b1
 68 help x05s1a
 69 at 1010

70 write Set the RANGE dial to accurately measure a
 71 45 rms volt signal.

72 -HELP- is available.

73 ***

74 unit x05m1b1
 75 help x05s1a
 76 pack n33,+++++k+
 77 join ckdu
 78 jump n47;x,x05m2a
 79 next x05m1b
 80 ***

81 unit x05m2a

82 back x05m1b
83 next x05m2b
84 at 510
85 write The voltage applied between the RED and BLACK
86 jacks on the left side of the voltmeter marked
87 INPUT is the voltage that will be measured by
88 the voltmeter. The BLACK jack is internally
89 connected to ground. The RED jack is connected
90 to the point of interest. Note that the
91 resultant voltage is always measured with
92 respect to ground, because the BLACK jack is
93 internally grounded.
94 ***

95 unit x05m2b
96 back x05m2a
97 next x05m2c
98 at 1010
99 write If you were to measure a voltage with respect
100 to ground at some point "X", which color terminal
101 on the VTVM would you connect to "X" ?
102 arrow 1010
103 specs bumpshift
104 answer red
105 at 2010
106 write RIGHT ! And that's the only connection required.

107 However, if you were to measure a voltage in an
108 UNGROUNDED circuit you would have to connect the
109 black terminal of the VTVM to the circuit also.
110 wrong black
111 at 1010
112 write The black jack is already connected to ground.
113 no
114 at 1010
115 write You only need to write the color of the jack.
116 ***

117 unit x05m2c
118 back x05m2b
119 next x05m2d
120 at 510
121 write Connect the VTVM to display an indication for
122 the 0.1V P-P. CAL OUT jack on the SCOPE.

----- part=1, block=c -----

block 1c, x05

124 unit x05m2d
125 back x05m2c
126 next x05m3a
127 help x05s1a
128 at 510

129 write Adjust the RANGE switch to accurately measure
130 the output from the 0.1V P-P CAL OUT jack.

131 What indication do you read ?
132 at 1429
133 write -HELP- is available
134 arrow 843
135 specs nookno
136 ansy 0.056,.002
137 at 1015
138 write Excellent ! A very close reading:
139 ansy 0.056,.01
140 at 1015
141 write That's a good reading.
142 wrongy 0.056,.04
143 at 1015
144 write Try to get a little closer reading.
145 wrongy 0.0056,.001
146 at 1015
147 write You've got the wrong jack !
148 no
149 at 1015
150 write You're way off, better try again.
151 ***

152 unit x05m3a
153 back x05m3d
154 next x05m4a
155 at 005
156 write The nonsinusoidal voltage from the SCOPE that you just
157 measured was at a frequency of 1000 Hz. Furthermore, the
158 scale reading was equal to or less than the voltage label.

159 Only frequencies greater than 10 Hz but less than
160 4 MHz (4×10^6) can be measured accurately.

161 Also, only indications larger than about 0.001 and
162 less than 300 can be read accurately.
163 at 1500
164 write Can the VTVM be used to measure:

165 1) A 17 V p-p 1000 Hz signal ? (yes/no)
166 2) The 115 volt ac output of a wall receptacle ?
167 3) A 43 volt dc signal ?
168 arrow 1739
169 specs bumpshift
170 answer yes
171 arrow 1957
172 specs bumpshift
173 answer yes
174 arrow 2133
175 specs bumpshift
176 answer no
177 no
178 at -2422

179 write REMEMBER: do is 0 Hz.

180 ***

181 unit x05m4a

182 restart

183 base

184 join imode

185 jump n47,x05m4a,x

186 at 507

187 write This task will examine the relationship between
188 the peak-to-peak voltage measurement on the SCOPE,
189 and the R.M.S. SINE indication on the VTVM, for the
190 same ac signal.

191 In electrical engineering, the term ac for
192 alternating current usually refers to a sinusoidal
193 current with a zero average value.

194 To begin our experiment, we need an ac source.
195 Hence, set the AUDIO OSCILLATOR to an output frequency
196 of 2000 Hz.

197 pause

198 jump key=back,x05m3a,x

199 entry x05m4a1

200 pack n33,+++++++<b (uv) c (bc) >+

201 join ckd

202 jump n47,x05s4a,x05m4b

203 ***

204 unit x05m4b

205 at 1007

206 write Measure this signal with the VTVM, as follows:

207 First, set the VTVM range to allow the most accurate
208 measurement of a 25 rms volt sinusoidal signal.

209 pause

210 jump key=back,x05m4a,x

211 pack n33,+++++++]

212 join ckd

213 jump n47,x05s4b,x05m4c

----- part=1, block=d -----

block 1d, x05m4c

215 unit x05m4c

216 at 510

217 write Connect the output of the AUDIO OSCILLATOR
218 to the VTVM.

219 The VTVM is internally grounded and only
220 requires one connection.

Be sure that the AUDIO OSCILLATOR ground link is connected and tightened.

```
221
222
223 pause
224 jump key-back,x05m4b,x
225 pack n33,000000000000b00000000000000000aba
226 join ckcw
227 jump n47,x,x05m4d
228 next x05m4c
229 ***

230 unit x05m4d
231 back x05m4c
232 next x05m4d1
233 at 510
234 write Carefully adjust the output AMPLITUDE of the
235 AUDIO OSCILLATOR to cause a 25 rms volt indication
236 on the VTVM.
237 ***

238 unit x05m4d1
239 pack n33,+++++ (rs) (bc) (bcuv) j
240 join ckd
241 jump n47,x,x05m4e
242 pack n33,+++++ (tu) (bc) (bcuv) j
243 join ckd1
244 goto n47,x,x05s4c
245 pack n33,+++++ (pq) (bc) (bcuv) j
246 join ckd1
247 goto n47,x,x05s4d
248 at 510
249 write You're way off! The frequency should still
250 be 2000 Hz. The VTVM should be set to measure
251 25 RMS volts. The Audio Oscillator AMPLITUDE
252 should be adjusted to cause an indication of
253 25 rms volts on the VTVM.
254 pause
255 jump x05m4d1
256 ***

257 unit x05m4e
258 back x05m4d
259 next x05m4f
260 erase
261 catchup
262 at 1510
263 write Now that you have set the AUDIO OSCILLATOR
264 correctly, do not change any of its controls unless
265 specifically directed.
266 ***

267 unit x05m4f
268 back x05m4e
269 next x05m4g
270 at 510
271 write The ac voltage you have set is measured
272 on the VTVM in rms (root-mean-square) volts.
```

273 Root-mean-square volts are defined as follows:

274 at 1019
275 write $V_{rms} = \left[(1/T) \int_0^T (v(t))^2 dt \right]^{1/2}$

276 at 1210
277 write where T = the period, of v(t), and v(t) is in volts.

278 pause
279 at 1410
280 write Note that root-mean-square is descriptive
281 of the above formula, as follows:

282 ROOT = square root of the bracketed expression

283 MEAN = $1/T \times \int_0^T () dt$ of the following integrand

284 SQUARE = squared time function = $(v(t))^2$

285 ***

286 unit x05m4g
287 back x05m4f
288 at 700

289 write Set the SCOPE to measure an ac voltage on the A
290 channel with A VOLTS at 100 V FULL SCALE.

291 Of course, the A PREAMP should be AC coupled and
292 the SWEEP should be internally triggered by AC signals.

293 RECALL: DO NOT TOUCH THE AUDIO OSCILLATOR DIALS!

294 pause
295 pack n33, *p++f+ab+++++
296 join ckd
297 jump n47, x05s4e, x05m4h

part=1, block=e

block 1e. x05m4h

299 unit x05m4h
300 at 710

301 write Connect the output of the AUDIO OSCILLATOR
302 to the A INPUT of the SCOPE.

303 The SCOPE is grounded by ground links and also
304 requires only one connection.

305 pause
306 pack n33, 0000000000000000a000b00000000000ba+0
307 join ckcw
308 jump n47, x, x05m4i
309 next x05m4h
310 ***

311 unit x05m4i
312 base
313 back x05m4e

```

314 next      x05m5a
315 calc      n120*-1
316 at        510
317 write     What is Vpp (from the SCOPE)? _____ volts
318 arrow     540
319 store     v55
320 ansv      70,4
321 endarrow
322 calc      v56*25.0/v55
323 at        710
324 write     On the basis of your measurements:

325          Vrms = _____ * Vpp
326 join      x05s4f

327 entry     x05m411
328 inhibit   erase
329 data      x05s4f
330 back      x05m4e
331 arrow     920
332 ansv      v56,10%
333 no
334 at        1110
335 write     Vrms = VTVM indication = 25
336
337          Vpp = Scope Reading = (s,v55) volts
338
339          Vrms = .707 * Vpp
340
341          Press -NEXT- to clear your answer; then...
342          ...Press -DATA- to re-use the calculator.
343 endarrow
344 calc      n120*0
345 at        1110
346 write     And Vpp = _____ * Vrms
347 join      x05s4f

348 entry     x05m412
349 inhibit   erase
350 data      x05s4f
351 back      x05m4e
352 arrow     1120
353 ansv      v55*25,2%
354 no
355 at        1315
356 write     Press -NEXT- to clear your answer then ...
357          ... press -DATA- to re-use the calculator
358 endarrow
359 at        1310
360 write     NOTE: These conversion factors are only valid
361          for a sinusoidal wave symmetric about 0 volts.
362
363          Let's take a look at what the theoretical values
364          are for these conversion factors.
365 ***

366 unit      x05m5a

```

```

367 term rms
368 back x05m4i
369 next x05m5b
370 erase
371 catchup
372 at 210
373 write NOTE: Study this sequence carefully.
374 You'll be asked a problem based on this method.
375 at 715
376 write Consider an ac or simple sine wave:

```

```

377 v(t) = sin(wt)
378 join x05s5b
379 delta .1
380 funct (sin(v55)),v55
381 ***

```

```

382 unit x05m5b
383 back x05m5a
384 next x05m5c
385 at 305
386 write Now let's square v(t):

```

```

387 (v(t))^2 = (sin(wt))^2
388 join x05s5b
389 delta .1
390 funct (sin(v55))^2,v55

```

```

391 pause
392 join x05s5b1
393 pause
394 calc v60+sqrt(v59)
395 at 2219
396 write  $V_{rms} = \sqrt{V_1} = (2, v60, 3.3)$ 
397 hpar 2π, .707, -
398 graph 2.1π, .707, V_rms
399 pause
400 at 2505

```

```

401 write The average of the squared wave is 0.5

```

```

402 The square root of 0.5 is 0.707

```

```

403 The value of  $V_{rms} = 0.707$  for  $v(t) = \sin wt$  compares
404 with  $V_{pp} = 2.0$  which is read on the Scope for  $v(t)$ .

```

----- part=1, block=f -----

block 1f, x05m5c

```

406 unit x05m5c
407 back x05m5b
408 next x05m5d
409 at 709
410 write Generally, as applies for any simple sine wave,
411 the following ratios are established:

```

412 $V_{pp} / V_{rms} = 2\sqrt{2} = 2.828$
 413 $V_{\theta p} / V_{rms} = 2\sqrt{2} / 2 = \sqrt{2} = 1.414$
 414 Or, inversely:
 415 $V_{rms} / V_{pp} = \sqrt{2} / 4 = 0.354$
 416 $V_{rms} / V_{\theta p} = 1/\sqrt{2} = \sqrt{2}/2 = 0.707$
 417 ***

418 unit x05m5d
 419 back x05m5a
 420 next x05m5e
 421 at 205

422 write The rms value of a periodic voltage is the square
 423 root of the average of the squared voltage.

424 Calculate V_{rms} for the following wave:

425 $V_{rms} =$ rms volts (Press -BACK- to review)
 426 at 1235
 427 write $v(t) = 1 \quad 0 < t < T/2$
 428 $= -1 \quad T/2 < t < T$
 429 join x05s5b
 430 gdraw 0,1;π,1
 431 gdraw ;π,-1
 432 gdraw ;2π,-1
 433 gdraw ;2π,0
 434 arrow 712
 435 ansv 1.0

436 no
 437 at 2505
 438 write 1^2 is the same as $(-1)^2$, the average over one
 439 period of the constant 1.0 volt is 1.0 volt, and
 440 the square root of 1. is 1.
 441 ***

442 unit x05m5e
 443 restart
 444 back x05m5d
 445 next x05m5e1
 446 join imode
 447 jump n47,x05m5e,x
 448 at 505

449 write * Although the VTVM scales are calibrated in the unit
 450 R.M.S. VOLTS, for a simple SINE wave, the VTVM does not
 451 indicate the root-mean-square voltage for any signal.

452 The actual indication on the VTVM is related to the
 453 input signal by the following formulae:

454 at 1207
 455 join x05s5a
 456 ***

457 unit x05m5e1

458 back x05m5e
 459 next. x05m5e2,
 460 at 707
 461 write As noted, the VTVM indication for a pure sine wave
 462 is its rms voltage, and this is not true generally
 463 for every non-sinusoidal waveshape.

464 The relation between the waveshape of a periodic
 465 voltage applied at the INPUT of the VTVM, the responsive
 466 position of the pointer of the VTVM, and the scale
 467 reading indicated by the pointer can be understood
 468 more clearly by tracing the effects of the INPUT voltage
 469 through a schematic diagram of the VTVM.

-----part-1, block=g-----

block 1g, x05m5e2

471 unit x05m5e2
 472 back x05m5e1
 473 next x05m5e3
 474 join x05m5e2
 475 at 1605
 476 write The signal at the INPUT terminals of the VTVM is:

477 $V_{AA}' = v(t)$

478 pause
 479 mode erase

480 at 1605

481 write The signal at the INPUT terminals of the VTVM is:

482 $V_{AA}' = v(t)$

483 mode write

484 at 1605

485 write $V_{AA}' = v(t)$

486 The capacitor blocks the average value so at BB'
 487 only the ripple remains:

488 $V_{BB}' = v(t) - V_{av}$, where $V_{av} = 1/T \int_0^T v(t) dt$

489 at 190,456

490 write B

491 at 190,344

492 write B'

493 pause

494 mode erase

495 at 1805

496 write The capacitor blocks the average value so at BB'
 497 only the ripple remains:

498 $V_{BB}' = v(t) - V_{av}$, where $V_{av} = 1/T \int_0^T v(t) dt$

499 mode write

500 at 1805

501 write $V_{BB}' = v(t) - V_{av}$, where $V_{av} = 1/T \int_0^T v(t) dt$

502 The full-wave rectifier converts all negative values
503 to positive values, so the fully-rectified ripple
504 at CC' is:

505 $V_{CC'} = |v(t) - V_{av}|$

506 size 7
507 at 352,382

508 write }

509 size 0
510 at 384,400

511 write Full-wave
512 Rectifier

513 at 235,321

514 write C
515 at 333,321

516 write C

517 pause
518 mode erase

519 at 2005

520 write The full-wave rectifier converts all negative values
521 to positive values, so the fully-rectified ripple
522 at CC' is:

523 $V_{CC'} = |v(t) - V_{av}|$

524 mode write
525 at 292,319

526 write M
527 at 2005

528 write $V_{CC'} = |v(t) - V_{av}|$

529 The d'Arsonval mechanism (M), because of its inertia,
530 cannot respond to a frequency greater than 3 Hz, so
531 the pointer responds to the average value of $V_{CC'}$...

532 VTVM response = $1/T \int_0^T |v(t) - V_{av}| dt$

533 pause
534 mode erase

535 at 2205

536 write The d'Arsonval mechanism (M), because of its inertia,
537 cannot respond to a frequency greater than 3 Hz, so
538 the pointer responds to the average value of $V_{CC'}$:

539 VTVM response = $1/T \int_0^T |v(t) - V_{av}| dt$

540 mode write
541 at 2205

542 write VTVM response = $1/T \int_0^T |v(t) - V_{av}| dt$

543 The manufacturer marked this VTVM meter scale to
544 indicate R.M.S. volts when a simple sine wave is
545 applied to the INPUT. Therefore, the VTVM indication is:

546 VTVM indication = $1.11/T \int_0^T |v(t) - V_{av}| dt$

block 1h, x05m5e3

```

548 unit x05m5e3
549 back x05m5e2
550 next x05m5f
551 at 505
552 write In general, the value indicated by the VTVM pointer
553 is 1.11 times the average of the fully-rectified
554 ripple of the INPUT voltage. This is mathematically
555 expressed by the following previously-mentioned formula:
556 at 1207
557 join x05s5a
558 ***

```

```

559 unit x05m5f
560 back x05m5e
561 next x05s5b
562 calc nr20+1
563 erase
564 catchup
565 at 505
566 write Let's look at some non-sinusoidal waveforms from
567 the Function Generator and see how this applies:

```

568 Accomplish this task:

569 On the A channel of the oscilloscope:

570 Display two cycles of a square wave with $V_{pp} = 20$ V,
571 and $V_{av} = 0$.

572 Set the A BREAMP at +DC.

573 Use a generator frequency of 1 kHz.

574 Connect the VTVM to measure this same signal, starting
575 with the 300 RANGE and reducing the RANGE until you
576 display the reading most accurately.

577 ***

```

578 unit x05m5g
579 base
580 back x05m5f
581 at 310
582 write What is the reading on the VTVM ?
583 V indicated =
584 at 535
585 writec n120, ..., (s, v51)
586 goto n120, x, x, x, x05m5g0
587 arrow 533
588 store v51

```

```

589 ansv 11.0,1
598 endarrow

591 entry x05m5g0
592 at 810
593 write On the basis of your measurement:
594 at 1105
595 write Vindicated = _____ Vpp for a symmetrical square wave.
596 calc v56+v51/20
597 at 1125
598 write n120,,, (s,v56)
599 goto n120,x,x,x,x05m5g0a
600 join x05s4f

601 entry x05m5g1
602 inhibit erase
603 back x05m5f
604 data x05s4f
605 arrow 1119
606 ansv v56,10%
607 no
608 at 1308
609 write Vpp = 20 V.
610
611 Vindicated = (s,v51)
612
613 thus, Vindicated = ?? * Vpp
614
615 Press -NEXT- to clear your answer then...
616 ... press -DATA- to re-use the calculator
617 endarrow

618 entry x05m5g0a
619 calc n120+2
620 at 1307
621 write For a square wave symmetrical about 0 V:

622 Vpp = 2 V0p = 2 Vrms
623 therefore your conversion factor is:

624 Vrms = V0p = _____ * the VTVM indication.
625 at 3204
626 write -HELP- is available
627 help x05s5f
628 join x05s4f

629 entry x05m5g2
630 inhibit erase
631 back x05m5f
632 data x05s4f
633 help x05s5f
634 arrow 2025
635 ansv .9091,..1
636 no
637 at 2210
638 write Press -NEXT- to erase your answer,

```

639 then, press -DATA- to re-use the calculator.
640 endarrow

----- part=1, block=i -----

block ii, x05m5h

642 unit x05m5h
643 back x05m5g
644 next x05m5h1
645 erase
646 watchup
647 at 1010
648 write Now adjust the \pm dc level adjust on the func-
649 tion generator to produce a sq. wave such that:

650 $V_{+pk} = 20$ volts and $V_{-pk} = 0$ volts as measured

651 on the scope. The frequency is left at 1 kHz.

652 NOTE: the dc level adjust interacts with the
653 amplitude, therefore, you must adjust them both
654 to obtain the desired signal.

655 at 3007

656 write Press -NEXT- when ready.

657 unit x05m5h1
658 pack x33,+ (ghi) (no) + (cd) (defg) caba x f (tuv) g (ab) x d (defghi) (stu) ++++++ j
659 join cldu
660 jump r47, x, x05m51
661 next x05m5h
662 ***

663 unit x05m5i
664 back x05m5h
665 next x05m5j
666 at 1010
667 write What is the VTVM indication ?

668
669 _____ volts

670 arrow 1210

671 ansy 11.074

672 at 1410

673 write That's correct! Note that changing V_{av}
674 changes V_{rms} as well as V_{g-p} , however,
675 V_{pp} and the indication on the VTVM are
676 the same.

677 ***

678 unit x05m5j
679 back x05m5i
680 at 1010

681 write you could therefore conclude that the

682 . VTVM indication for a given waveform
 683 is directly proportional to the
 684 voltage of that waveform. (A,B,C,D)
 685 at 2118
 686 write A) RMS
 687 B) AVERAGE
 688 C) 8-PEAK
 689 D) PEAK-PEAK
 690 arrow 1318
 691 answer (D,d)
 692

693 unit x05m5k
 694 back x05m5j
 695 at 218
 696 write NOTE: Study this sequence carefully. You'll
 697 be asked a problem based on this method.

698 at 522
 699 write Consider this waveform:

700 at 722
 701 size 2
 702 write v(t)
 703 size 8
 704 join x05s5e.
 705 gdraw 0,1;2,2;6,0;8,1
 706 pause

707 at 3018
 708 write $V_{av} = \frac{1}{T} \int_0^T v(t) dt$
 709 pause
 710 hbar 8,1,-
 711 at 1148

712 write $V_{av} = 1$
 713

714 unit x05m5l
 715 back x05m5l
 716 at 522
 717 write Performing the operation:

718
 719 v(t) - V_{av}
 720 join x05s5e
 721 gdraw 0,0;2,1;6,-1;8,0
 722

723 unit x05m5m
 724 back x05m5l
 725 at 522
 726 write Next finding the magnitude:

727
 728 $|v(t) - V_{av}|$
 729 join x05s5e
 730 gdraw 0,0;2,1;4,0;6,1;8,0
 731 pause
 732 at 1818
 733 write calculating: $V_1 = \frac{1}{T} \int_0^T |v(t) - V_{av}| dt$
 734 pause
 735 hbar 8,.5,-

```

736 at      1348
737 write   ← V1 = .5
738 pause
739 at      2110
740 write   The VTVM should therefore indicate :
741
742        1.11072 × V1 or approximately .555 volts

```

----- part=i, block=j -----

block ij, x05m5n

```

744 unit    x05m5n
745 term    test
746 back    x05m5k
747 at      1010
748 write   If you would like to repeat the last graphical
749         sequence explaining the VTVM response.....
750
751         press -BACK-. Otherwise press -NEXT-.
752 ***

```

```

753 unit    x05m5o
754 back    x05m5n
755 erase
756 catchup
757 at      1010
758 write   At this time you might want to experiment
759         with some waveforms other than the square
760         wave from the function generator. See if
761         you can predict what they should indicate
762         on the VTVM for a given amplitude, then
763         verify this by measuring it with the VTVM.
764
765
766         When you are ready for a challenge to your
767         prowess.....PRESS -NEXT-.

```

```

768 at      2110
769 write   REMEMBER
770 at      2310
771 join    x05s5a
772 ***

```

```

773 unit    x05m6a
774 calc    n12043
775 next    x05end
776 back    x05m5o
777 base
778 help    x05s6a
779 at      3210
780 write   HELP is available.....
781 join    x05s5e
782 draw    0.0, .5; 2, 1.5; 4, 1.5; 4, 0.5; 6, -.5; 8, -.5; 8, .5
783 at      4100

```

784 write On the basis of what you have learned in this
 785 experiment, what would the VTVM indicate for
 786 this waveform? ----- volts
 787 at 1918
 788 join x05s5a
 789 join x05s4f

 790 entry x05m6a1
 791 inhibit enase
 792 data x05s4f
 793 help x05s6a
 794 next x05end
 795 back x05m5o
 796 arrow 625
 797 ansv /833,.01
 798 no
 799 at 718
 800 write Press -NEXT- to clear your answer then...
 801 ...press -DATA- to re-use the calculator
 802 ***

 803 unit x05s1a
 804 at 505
 805 write The RANGE setting indicates the largest rms volt
 806 signal that the voltmeter can measure. Thus, if
 807 you wanted to measure a signal of approximately
 808 .15 rms volts, you would not set the RANGE dial to
 809 10.0, but rather, to 30.0 to obtain a readable
 810 indication.
 811 end
 812 ***

 813 unit x05s4a
 814 next x05m4a1
 815 back x05m4a
 816 at 510
 817 write I caught you daydreaming, didn't I!
 818 at 710
 819 write Come on now, you can do better than that
 820 I asked for 2000 Hz. In case it slipped your
 821 mind....
 822
 823
$$\text{Freq. out} = \text{Freq. setting} * \text{Multiplier.}$$

 824
 825 Let's set it carefully and continue on.
 826 Press -NEXT- when ready.
 827 ***

 828 unit x05s4b
 829 at 510
 830 write Surely you're not nervous!
 831 Let's try that again.
 832
 833 Just set the range switch to 30 and then ...
 834
 835 Press -NEXT-
 836 pause

837 pack n33,+++++*****j
838 join ckd
839 jump n47,x05s4b,x05m4c

-----part=1, block=k-----

block 1k, x05s4c

841 unit x05s4c
842 at 510
843 write Not bad. You're just a little high.
844 In order to get good results we need
845 to be a little more precise.
846
847 I want that needle right on 25 VRMS.
848 When you've got it, press -NEXT-.
849 pause
850 jump x05m4d1
851 ***

852 unit x05s4d
853 at 510
854 write You're just a little low. To get good
855 results we must be precise as possible.
856
857 Set the amplitude as close to 25 VRMS
858 as you can and then press - NEXT -
859 pause
860 jump x05m4d1
861 ***

862 unit x05s4e
863 at 640
864 write Are you sure that you know all that ?
865
866 The A channel should be
867 AC coupled at 100 volts
868 full scale. Internally
869 trigger the sweep from
870 AC levels in the AUTO mode.
871 Display only the A channel,
872 and sweep it normally (not
873 times 5).
874
875 Then, press -NEXT-.
876 pause
877 pack n33,++p++f+ab+++++*****
878 join ckdw
879 jump n47,x,x05m4h
880 next x05s4e
881 ***

882 unit x05s4f
883 inhibit erase

884 calcs n120,n121+922,1122,1123,2025,625
 885 mode erase
 886 at 3019
 887 write Press -NEXT- to enter your answer above
 888 Press -BACK- to recalculate
 889 at n121
 890 write
 891 mode write
 892 at 2737
 893 erase 20
 894 at 2838
 895 erase 15
 896 gatchup
 897 draw 2617;2657;2957;2917;2617
 898 at 2719
 899 write CGE Calculator
 900 Enter Expression:
 901
 902 arrow 2837
 903 store v100
 904 ok
 905 endarrow
 906 at 2938
 907 show v100
 908 at 3019
 909 write Press -NEXT- to enter your answer above
 910 Press -BACK- to recalculate
 911 pause
 912 goto key=back,x05s4f,x
 913 jump n120,x05m4i1,x05m4i2,x05m5g1,x05m5g2,x05m6a1
 914 ***

915 unit x05s5a
 916 write $V_{\text{indicated}} = \frac{\pi \sqrt{2}}{4} \cdot \frac{1}{T} \int_0^T |v(t) - V_{\text{av}}| dt$
 917

918 where $V_{\text{av}} = \frac{1}{T} \int_0^T v(t) dt.$

919 Here: $\frac{\pi \sqrt{2}}{4} = \frac{\sqrt{2} / 2}{2 / \pi} = 1.11$ for a sine.
 920 ***

921 unit x05s5b
 922 origin 1510
 923 axes 0,-100,300,100
 924 scalex 2π
 925 scaley 1
 926 markx π,π/4
 927 labely 1,.25

----- part=1, block=1 -----

block 11, x05s5b1


```

929 unit x05s5b1
930 at 705
931 write and calculate the average of the squared wave as Y1:
932 at 2019
933 write  $Y_1 = \frac{1}{T} \int_0^T (v(t))^2 dt =$ 
934 mode rewrite
935 at 1828
936 write Plato is computing Y1 by increments.
937 calc v5940
938 doto 2line,v70+1,50
939 calc v57+(sin(2πv70/50))2
940 v58+(sin(2π(v70-1)/50))2
941 v59+v59+(v57+v58)/100
942 v71+πv70/25
943 gdraw v71,0;v71,v57
944 at 2044
945 showt v59
946 2line
947 mode erase
948 at 1828
949 write Plato is computing Y1 by increments.
950 mode write
951 hbar 2π,.5,-
952 graph 2.1π,.5,Y1
953 end
954 ***

955 unit x05s5c
956 pack n33,000000000000a00p0++++b+000ab0
957 join ckdw
958 jump n47,x,x05s5d
959 next x05m5f
960 ***

961 unit x05s5d
962 pack n33,+(ghi)(nop)+(cd)(defg)(bc)aba<f(tuv)g(ab)>d(efghi)(abcd)+++++j
963 join ckdw
964 jump n47,x,x05m5g
965 next x05m5f
966 ***

967 unit x05s5e
968 origin 1515
969 axes 0,-128,256,128
970 scalex 8
971 scaley 2
972 markx 4,1
973 labely 1,.25
974 at 1730
975 write T/2
976 at 1747
977 write T
978 ***

979 unit x05s5e2
980 at 17
981 write HP 400D VACUUM TUBE VOLTMETER

```

```

982 draw 117;146
983 at 1413
984 write Internal Schematic Diagram of the VTVM
985 draw 1413;1451
986 at 70,431
987 write +

988 v(t)

989
990 draw 88,448;138,448;skip;138,453;138,443
991 circle 7,150,448,135,225
992 draw 143,448;193,448;193,428;197,424;189,416;197,408
993 189,400;197,392;193,388;193,368;88,368;skip;193,448;293,448;skip;193,368;293,368
994 draw 293,448;276,431;skip;271;426;254,409;271,392
995 skip;276,387;295,368;314,387;skip;319,392
996 336,409;319,426;skip;314,431;297,448
997 draw 276,431;276,424;269,431;276,431;skip;280,427
998 272,435
999 draw 276,387;276,394;269,387;276,387;skip;280,391
1000 272,383
1001 draw 319,391;319,384;312,391;319,391;skip;315,395
1002 323,387;skip;319,426;319,433;312,426;319,426
1003 skip;323,430;315,422
1004 draw 254,409;254,374
1005 circle 6,254,368,90,270
1006 draw 254,361;254,329;280,329
1007 circle 15,295,329
1008 draw 309,329;336,329;336,409
1009 at 85,456
1010 write A
1011 *
1012 at 85,360
1013 write *
1014 A
1015 at 190,440
1016 write *
1017 at 190,360
1018 write *
1019 at 292,440
1020 write *
1021 at 251,401
1022 write *
1023 at 333,401
1024 write *
1025 at 292,360
1026 write *
1027 at 251,321
1028 write *
1029 at 333,321
1030 write *
1031 end

```

----- part=1, block=m -----

block 1m, x05s5f

```
1033 unit x05s5f
1034 erase
1035 catchup
1036 at 811
1037 write  $V_{pp} = 2 V_{\theta p} = 2 V_{rms}$ 
1038  $V_{indicated} = \frac{\langle s, v51 \rangle}{2\theta} \times V_{pp}$ 
1039
1040  $V_{pp} = \frac{2\theta}{\langle s, v51 \rangle} V_{indicated}$ 
1041
1042 thus,  $V_{rms} = \frac{V_{pp}}{2} = \frac{2\theta}{\langle s, v51 \rangle \times 2} \times V_{indicated}$ 
1043
1044 pause
1045 jump x05m5g
1046 ***

1047 unit x05s6a
1048 back x05m6a
1049 erase
1050 catchup
1051 join x05s5e
1052 gdraw 0,0.5;2,1.5;4,1.5;4,0.5;6,-0.5;8,-0.5;8,0.5
1053 hbar 8.25,.5,-
1054 at 525
1055 write  $V_{av} = \int_0^T v(t) dt$ 
1056 locate 8.5,.4
1057 write  $+ V_{av} = 172$ 
1058 ***

1059 unit x05s6b
1060 back x05s6a
1061 at 525
1062 write Performing the operation:
1063  $v(t) - V_{av}$ 
1064 join x05s5e
1065 gdraw 0,0;2,1;4,1;4,0;6,-1;8,-1;8,0
1066 ***

1067 unit x05s6c
1068 back x05s6b
1069 at 525
1070 write Next, finding the magnitude
1071  $|v(t) - V_{av}|$ 
1072 join x05s5e
1073 gdraw 0,0;2,1;4,1;4,0;6,1;8,1;8,0
1074 ***

1075 unit x05s6d
1076 back x05s6c
1077 help x05s6e
1078 next x05m6a
1079 join x05s5e
```

1080 gdraw 0,0;2,1;4,1;4,0;6,1;8,1;8,0
 1081 at 321
 1082 write Recalling the formula:
 1083
$$V_{\text{indicated}} = \frac{\pi\sqrt{2}}{4} \cdot \frac{1}{T} \int_0^T |v(t) - v_{\text{av}}| dt$$

 1084 where $\frac{\pi\sqrt{2}}{4} = 1.11$,
 1085 at 2005
 1086 write Note that the area to the left of $t=T/2$ is identical
 1087 to the area to the right.

1088 Thus, you only need to integrate from $t = 0$ to
 1089 $t = T/2$ and multiply by two.

1090 Press -NEXT- to enter your answer.

1091 Press -HELP- for further assistance.

1092 ***

1093 unit x05s6e

1094 back >05s6d

1095 next x05s6f

1096 help x05s6g

1097 at 709

1098 write To find the area under the curve $|v(t) - v_{\text{av}}|$:

1099 Press -NEXT- for a geometric approach.

1100 Press -HELP- to solve the integral directly.

1101 ***

1102 unit x05s6f

1103 help x05s6g

1104 back x05s6a

1105 next >05m6a

1106 join x05s5e

1107 gdraw 0,0;2,1;4,1;4,0;6,1;8,1;8,0

1108 at 208

1109 write Note that the figure to the left of $t=T/2$ is:

1110 (rectangle of area $1/2$)

1111 doto 3line,r101e1,8,1

1112 calc v102e101 * 0.25

1113 calc v103e101 * 0.125

1114 hbar v102,v103,-

1115 3line

1116 at 432

1117 write - (shaded triangle $\frac{1}{2} \times \frac{1}{4} \times 1$)

1118 at 622

1119 write $= \frac{1}{8} - \frac{1}{8} = \frac{3}{8}$

1120 at 1924

1121 write. Recall that the total area is twice
 1122 as large ($= 2 \times 3/8 = 3/4$)

1123 and $V_{\text{indicated}} = 1.11072 \times 3/4$

1124 write 4at,2608) Press -NEXT- to enter your answer

1125

-BACK- to review this sequence

1126

-HELP- to see the integral approach

-----part=1, block=n-----

block in, x05end:

1128 unit. x05s6g

1129 help. x05s6f

1130 back x05s6a

1131 next x05m6a

1132 join x05s5e

1133 gdraw 0,0;2,1;4,1;4,0;6,1;8,1;8,0

1134 at 321

1135 write $V_{indicated} = \frac{\sqrt{2}}{4} \frac{1}{T} \int_0^T |v(t) - V_{av}| dt$

1136 pause

1137 at 621

1138 write $= 1.11072 \times \frac{1}{T} \times 2 \times \int_0^{T/4} 4/T t dt + \int_{T/4}^{T/2} dt$

1139 at 541

1140 write

1141 $\left[\dots \right]$

1142 pause

1143 at 921

1144 write $= 1.11072 \times \frac{1}{T} \times 2 \times \left[\frac{4}{T} \frac{t^2}{2} \Big|_0^{T/4} + \left(\frac{T}{2} - \frac{T}{4} \right) \right]$

1145 at 841

1146 write

1147 $\left[\dots \right]$

1148 pause

1149 at 2021

1150 write $= 1.11072 \times \left[2 \times \dots \right]$

1151 calc v61+.1

1152 zero v62.

1153 mode rewrite

1154 at 1821

1155 write Platq Computing Integral

1156 doto lline,v60+0,20

1157 calcs v60-11,v61+v61+0.1,1

1158 gdraw 0.2*v60,0;0.2*v60,v61

1159 gdraw (0.2*v60)+4,0;(0.2*v60)+4,v61

1160 calcc v60-11,v63+0.0125*v60*v61,v62+v63+(0.025*v60*v61)-0.25

1161 at 2038

1162 wripec v60-11,(t,v63),(t,v62)

1163 lline

1164 at 1821

1165 write

1166 mode write

1167 at 2600

1168 write Press.-NEXT- to enter your answer

1169 -BACK- to review this sequence

1170 -HELP- for the geometrical approach.

1171 ***



```

1172 unit : x05end
1173 back : x05m6a
1174 join imode
1175 jump n47,x05end,x
1176 course n2
1177 calcc n2='ee244',
1178 nc(n21+1) + (nc(n21+1) $mask$07777777770000000000) +04603000000,
1179 nc(n21+1) +nc(n21+1)
1180 erase
1181 output /// student has completed experiment ///
1182 join endunit
1183 join jmpmes
1184 jumpout cgeindex,quest1

```

```

1185 entry leave
1186 end lesson
1187 ***

1188 unit endunit
1189 course n2
1190 jump n2='ee244',leave,x
1191 calc nc(n21+7) +nc(n21+7) +ahelp
1192 vc(n21+6) +vc(n21+6) +atime/60000
1193 ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
1194 use eex00,ck1
1195 use ck2
1196 use ck3
1197 use ck4
1198 use ck5
1199 use ck6

```

ckaw	not found		226	307	957		
ckd	not found		201	212	240	296	838
ckdw	not found		77	659	878	963	
ckd1	not found		243	246			
endunit	x05end	1188	22	1182			
imode	not found		34	184	446	1174	
jmpmes	not found		1183				
leave	x05end	1185	1190				
x05end	x05end	1172	775	794	1175		
x05m0a	eex05id	30	35	52			
x05m1a	x05m1a	51	33	66			
x05m1b	x05m1a	65	53	79	82		
x05m1b1	x05m1a	74	67				
x05m2a	x05m1a	81	78	96			
x05m2b	x05m1a	95	83	118			
x05m2c	x05m1a	117	97	125			
x05m2d	x05m2d	124	119	153			
x05m3a	x05m2d	152	126	198			
x05m4a	x05m2d	181	154	185	210	815	
x05m4a1	x05m2d	199	814				
x05m4b	x05m2d	204	202	224			
x05m4c	x05m4c	215	213	228	231	839	
x05m4d	x05m4c	230	227	258			
x05m4d1	x05m4c	238	232	255	850	860	
x05m4e	x05m4c	257	241	268	313	330	351
x05m4f	x05m4c	267	259	287			

x05m4g	x05m4c	286	269						
x05m4h	x05m4h	299	297	309		879			
x05m4i	x05m4h	311	308	368					
x05m4i1	x05m4h	327	913						
x05m4i2	x05m4h	348	913						
x05m5a	x05m4h	366	314	383		419			
x05m5b	x05m4h	382	369	407					
x05m5c	x05m5c	406	384						
x05m5d	x05m5c	418	408	444					
x05m5e	x05m5c	442	420	447		458		568	
x05m5e1	x05m5c	457	445	472					
x05m5e2	x05m5e2	471	459	549					
x05m5e3	x05m5e3	548	473						
x05m5f	x05m5e3	559	550	580		603		631	765
x05m5g	x05m5e3	578	643	964		1045			959
x05m5g0	x05m5e3	591	586						
x05m5g0a	x05m5e3	618	599						
x05m5g1	x05m5e3	601	913						
x05m5g2	x05m5e3	629	913						
x05m5h	x05m5h	642	661	664					
x05m5h1	x05m5h	657	644						
x05m5i	x05m5h	663	660	679					
x05m5j	x05m5h	678	665	694					
x05m5k	x05m5h	693	715	746					
x05m5l	x05m5h	714	724						
x05m5m	x05m5h	723							
x05m5n	x05m5n	744	754						
x05m5o	x05m5n	753	776	795					
x05m6a	x05m5n	773	1048	1078		1105		1131	1179
x05m6a1	x05m5n	790	913						
x05s1a	x05m5n	803	68	75		127			
x05s4a	x05m5n	813	202						
x05s4b	x05m5n	828	213	839					
x05s4c	x05s4c	841	244						
x05s4d	x05s4c	852	247						
x05s4e	x05s4c	862	297	880					
x05s4f	x05s4c	882	326	329		347	604	350	620
			632	789		792		912	600
x05s5a	x05s4c	915	455	557		771		788	
x05s5b	x05s4c	921	378	388		429			
x05s5b1	x05s5b1	929	392						
x05s5c	x05s5b1	955	561						
x05s5d	x05s5b1	961	958						
x05s5e	x05s5b1	967	704	720		729	1064	781	1072
			1079	1106		1132			1051
x05s5e2	x05s5b1	979	474						
x05s5f	x05s5f	1033	627	633					
x05s6a	x05s5f	1047	778	793		1060		1104	1130
x05s6b	x05s5f	1059	1068						
x05s6c	x05s5f	1067	1076						
x05s6d	x05s5f	1075	1094						
x05s6e	x05s5f	1093	1077						
x05s6f	x05s5f	1102	1095	1129					
x05s6g	x05s5f	1128	1096	1103					
ahelp		1191							
atime		1192							
back		198							
			210	224		912			



key	198	218	224	912				
nc	1170	1170	1179	1179	1191	1191		
n101	1111	1112	1113					
n120	315	344	562	585	586	619	598	774 599
	004	913						
n121	004	809						
n2	1176	1177	1189	1190				
n21	1170	1170	1179	1179	1191	1191	1192	1192
n33	76	200	211	225	209	245	242	306 245
	650	837	877	956	962			
n47	35	78	185	1202	213	244	227	247 241
	297	300	447	660	039	964	079	1175 958
sin	300	390	939	940				
sqrt	394							
vc	1192	1192						
v100	903	907						
v102	1112	1114						
v103	1113	1114						
v51	585	500	596	611	1030	1041	1043	1043
v55	319	322	337	353	300	300	344	390
v56	322	332	596	590	606			
v57	939	941	943					
v58	940	941						
v59	394	937	941	941	945			
v60	394	396	1156	1157	1150	1159	1150	1160 1159
	1160	1160	1162					
v61	1151	1157	1157	1150	1159	1160		1160
v62	1152	1160	1162					
v63	1160	1160	1162					
v70	938	940						
v71	942	943	943					
%	332	353	606					
Vrms	398							
Y1	952							
	397	710	736	451	1053	1114		
π	397	398	430	431	432	433	433	433 924
	940	951	952					
πv70	939	942						

lesson information

lesson name = eex05
 starting date = 06/01/73
 last edited on 08/21/74 at 11.23.41
 by neal of course eece
 at site 7, station 27
 author name = J. P. Neal
 department = EE
 telephone number = 333-4351

discipline = EE

grade level = Freshman

description of lesson = The Operation and Uses of the Vacuum Tube Voltmeter, HP 455D.

block 1a, eex06id

```
2 stop
3 **** For Neal, CGERL, Room 248, EEB.
4 One line description of this lesson
5 Measurements of Transients.
6 Divisions of this Lesson:      Block      Unit
7 Id for this file                eex06id
8 Experiment eex06;
9 Objectives                       x06m0a    x06m0a
10 Measure transient waveshapes    x06m0a    x06m1a
11 Measure and calc. time const.   x06m1q0   x06m2a
12 Final edit 21 aug 74 neal.
13 *list info
14 vlist symbols
15 *list varían,charset,cgeindex,cgechar
16 ****
17 start
18 finish endunit
19 write (at,1010) Loading the CGE Character Set
20 charset cgeindex,cgechar
21 erase
22 datacn
23 area eex06
24 ext 0
25 calc n99+1          $$ used for restart skipping
```

block 1b, x06m0a

```
27 unit x06m0a
28 restart
29 join imode
30 jump n47,x06m0a,x
31 next x06m0b
32 calc n99+0
33 at 407
34 write MEASUREMENTS OF TRANSIENTS
```

35 This is an experimental study of transients in a

36 series circuit which contains resistors and a single
37 energy-storage element, such as a capacitor or an
38 inductor.

39 The principal objectives of this experiment are:

40 1. To measure and compare the waveshapes of the input
41 and element voltages, currents, powers, and energies
42 in a series RC circuit, when the source voltage is
43 constant.

44 2. To measure the time constant of the current of a
45 series RC circuit and compare it with the value
46 calculated from the nominal parameters of the circuit
47 devices.

48 ***

49 unit x00m0b
50 back x06m0a
51 next x06m1a
52 at 707

53 write A square-wave voltage is constant during each
54 half-period. Consequently, when a square-wave
55 voltage drives a series RC or RL circuit, the
56 circuit's response to a constant voltage can be
57 studied by examining its response to the square-
58 wave voltage during any half-period. Furthermore,
59 being repetitive, the input and element voltages
60 can be displayed on the Scope.

61 pause
62 at 1907

63 write Hence, the response of an RC circuit to a constant
64 voltage applied when the capacitor is INITIALLY
65 DISCHARGED can be studied experimentally by driving
66 the RC circuit with a square-wave voltage having a
67 zero value during each alternate half-period, and
68 a frequency sufficiently low for the transients to
69 decay practically to zero during each half-period.

70 ***

71 unit x06m1a
72 back x06m0b
73 next x06m1a
74 help x06s1a
75 at 707

76 write Display one period of the adjustable SQUARE OUTPUT
77 of the Function Generator on channel A of the Scope.

78 Trigger the Scope from the Function Generator.

79 Accurately adjust the open-circuit SQUARE-wave
80 OUTPUT of the Function Generator to:

81 $V_{\max} = 20 \text{ V}$, $V_{\min} = 0$, and $f = 1000 \text{ Hz}$.

82 Use A VOLTS FULL SCALE at 20 V for greatest accuracy,
83 and lower the zero volts base line of the display

84 to the bottom line, 5 cm below the center of the
85 CRT screen.

86 Disregard any small peak at the start of the trace.

87 Recall that the possible error with the Scope is
88 $\pm 3\%$ of the VOLTS FULL SCALE setting, so you should
89 avoid introducing further errors due to inaccuracies
90 in your settings, readings, or calculations.

----- part=1, block=c -----

block 1c, x06mia1-

92 unit x06mia1
93 pack n33,000000000000a000b0c0000bc0000a000
94 join ckcw
95 next n47,x06mia,x
96 jump n47,x,x06mia2
97 ***

98 unit x06mia2
99 pack n33,+gne (cd) (de) caba< f (rstuv) g (ab) >d (ef) (tu) +aaa++1
100 join ckdw
101 next n47,x06mia,x
102 jump n47,x,x06m1b
103 ***

104 unit x06m1b
105 at 1007
106 write The Scope is the most accurate of the rack-
107 mounted instruments. Consequently, please readjust
108 the frequency of the Function Generator, so the
109 swept length of one period, as observed on the Scope,
110 is exactly 10 cm, for the period of 1 ms and the
111 frequency of 1000 Hz.
112 ***

113 unit x06m1b1
114 pack n33,000000000000a000b0c0000bc0000a000
115 join ckcw
116 next n47,x06mia,x
117 jump n47,x,x06m1b2
118 ***

119 unit x06m1b2
120 pack n33,+gne (cd) (de) caba< f (stu) g (ab) >d (ef) (tu) +aaa++1
121 join ckdw
122 next n47,x06mia,x
123 jump n47,x,x06mic
124 ***

125 unit x06mic
126 back x06mia

127 next x06m1d
 128 jump n99,x,x,x06m1i1,x06m1q8a \$\$ units added for retarts
 129 at 807

130 write DO NOT readjust any dial or knob on the Function
 131 Generator during the remainder of this task. You
 132 have correctly set the open-circuit voltage v_o of the
 133 Function Generator and it will automatically try
 134 to maintain the terminal voltage constant.

135 However, the terminal voltage will still vary with the
 136 load current, as was observed in a previous experiment
 137 where it was found that the Function Generator with
 138 the controls at a fixed setting could be approximately
 139 represented theoretically by an ideal voltage source
 140 v_g in series with an internal resistance R_g .

141 ***

142 unit x06m1d
 143 back x06m1c
 144 next x06m1d1
 145 help x06s1a
 146 at 707

147 write, Connect the sensor cable of the RC BOARD, ITEM 33,
 148 to the CGE Interface.

149 Ground Terminal 4 of the RC BOARD.

150 Drive Terminal 1 of the series resistor-capacitor
 151 circuit with the adjusted SQUARE-wave OUTPUT of the
 152 Function Generator. Note how the display of v_{in} changes !

153 Observe the input voltage v_{in} on channel A with
 154 A VOLTS FULL SCALE at 50 V, and observe the input
 155 current i on channel B with B VOLTS FULL SCALE at
 156 2 V. Return the zero base line to the center of
 157 the screen.

158 -HELP- is available.

159 ***

160 unit x06m1d1
 161 pack n33, a0bc0000000000c00abd00000ad000c00
 162 join ckew
 163 next n47,x06m1d,x
 164 jump n47,x,x06m1d2
 165 ***

166 unit x06m1d2
 167 pack n33,kgoc(od) (de) cdba<f(stu)g(ab)>d(ef)(tu)+aaa++1
 168 join ckdw
 169 next n47,x06m1d,x
 170 jump n47,x,x06m1e

----- part=1, block=d -----

block id, x06mie

```
172 unit x06mie
173 base
174 back x06mid
175 next x06mif
176 define x+n120
177 y+n121
178 Xmax+n122
179 Ymax+n123
180 calc x+398
181 y+425
182 Ymax+20
183 Xmax+10
184 join x06s1b
185 gdraw -10,0;-10,16;0,16;0,0;10,0
186 graph 2,20,vg(t)
187 at 66f
188 write t
189 at 405
190 write The voltage source of the
191 RC circuit is a square wave
192 having:
```

193 $V_{max} =$ volt.

194 $V_{min} =$ volt.

195 arrow 818

196 long 2

197 answer 20

198 no

199 at 1205

200 write If you have not change the Function Generator
201 controls, V_{max} of v_g should be 20 volt. The Scope
202 is displaying the input voltage of the RC circuit.

203 The source voltage is theoretically internal to
204 Function Generator and cannot be displayed under load.

205 arrow 1018

206 answer 0

207 long 1

208 inhibit erase

209 no

210 at 1205

211 write If you have not changed the generator controls,
212 V_{min} of v_g should be 0 volt.

213 endarrow

214 ***

215 unit x06mif

216 back x06mie

217 next x06mig

218 calc y+255

219 join x06s1b

```
220 calc n95+1
221 doto @6mif1,n94+10,5,10
222 @draw n94,0;n94,n95(20)
223 graph 2,10,i(t)
224 at 1561
225 write t
226 funct n95(20)exp(-.5(v100-n94)),v100+n94,n94+10,.5
227 calc n95+n95*-1
228 @6mif1
229 at 1305
```

```
230 write Without changing any
231 connections, turn the A PRE AMP
232 to OFF and by adjusting the
233 A*B SEPARATION knob, use the
234 undeflected channel A trace
235 for a zero baseline of the
236 current display.
```

```
237 pause
238 mode erase
239 at 1305
```

```
240 write Without changing any
241 connections, turn the A PRE AMP
242 to OFF and by adjusting the
243 A*B SEPARATION knob, use the
244 undeflected channel A trace
245 for a zero baseline of the
246 current display.
```

```
247 inhibit erase
248 jump x@6mif1
249 ***
```

```
250 unit x@6mif1
251 pack n33,abc000000000c000abd0000ad000c00
252 join ckd
253 inhibit erase
254 jump n47,x@6s1c,x@6mif2
255 ***
```

```
256 unit x@6mif2
257 pack n33,kgoc(od)(de)edba<f(rstu)g(ab)>d(ef)(tu)7aaa++1
258 join ckd
259 inhibit erase
260 jump n47,x@6s1c,x@6mig
```

part=1, block=e

block 1e, x@6mig

```
262 unit x@6mig
263 back x@6mie
264 next x@6mih
265 at 1305
266 write The exponential current
267 of the RC circuit, read
```

268 experimentally has:

269 $I_{max} =$ mA

270 $I_{min} =$ mA

271 arrow 1718

272 ansv 8.4,1

273 no

274 at 2205

275 write You can read the amplitude
276 more accurately by momentarily
277 going to a smaller FULL SCALE
278 setting on B VOLTS.

279 arrow 1918

280 ansv -8.0,1

281 inhibit erase

282 no

283 at 2205

284 write You can read the amplitude
285 more accurately by momentarily
286 going to a smaller FULL SCALE
287 setting on B VOLTS.

288 endarrow

289 inhibit erase

290 ***

291 unit x06m1h

292 back x06m1e

293 next x06m1h1

294 calc y+85

295 $V_{max} = 200$

296 join x06s1b

297 graph 2,200,p₀(t)

298 graph 10,-20,t

299 doto 06m1h1,n94+-10,-2,10

300 gdraw n94,0;n94,20(8.8)

301 funct 20(8.8) exp(-1.(v100-n94)),v100+n94,n94+10,.5

302 06m1h1

303 at 2505

304 write The power delivered by the
305 source can be calculated
306 by simply multiplying the
307 source voltage (20 or 0 V) by
308 the current for each point in
309 time.

310 ***

311 unit x06m1h1

312 next x06m1h1

313 at 1007

314 write Now, in order to read i(t) versus t more accurately
315 for the next tabulation, please set the Scope TIME
316 at 500 μ s and B VOLTS at 1 V.
317 Turn the A PRE-AMP to +DC.

318 pause

319 pack n33,abc0000000000000abcd0000ad0000c00

320 join ckaw


```

321 jump n47,x,x06m1h2
322 ***
323 unit x06m1h2
324 next x06m1h1
325 pack n33,j foc (cd) (de) (cd) dba<f (rtu)g (sb) >d (ef) (tu) +aaa++l
326 join ckdw
327 jump n47,x,x06m1i

```

part=1, block=f

block 1f, x06m1i

```

329 unit x06m1i
330 base
331 help x06s1f
332 back x06m1e
333 at 207
334 write Enter the values of the source voltage  $v_g$ , and
335 measure on the Scope display and enter the values of
336 of the circuit current  $i$ , in the table below. As you
337 properly enter each pair of values, I will then
338 calculate and enter  $p_g = v_g \times i$  within 6%.

```

	t	v_g	i	p_g
	(ms)	(V)	(mA)	(mW)
341	0.02			
342	0.1+			
343	0.2+			
344	0.3+			
345	0.4+			
346	0.5+			
347	0.6+			
348	0.7+			
349	0.8+			
350	0.9+			

Help is available

```

351 goto key=back, replot,x
352 calc n100+1224
353 calc n1+104
354 calc v101+20
355 calc v102+8.4
356

```

```

357 join/ x06s1d
358 calc v102+3.3
359 join x06s1d
360 calc v102+1.2
361 join x06s1d
362 calc v102+.5
363 join x06s1d
364 calc v102+.2
365 join x06s1d
366 calc v102+-7.6
367 v101+0
368 join x06s1d
369 calc v102+-3.6
370 join x06s1d
371 calc v102+-1.2
372 join x06s1d
373 calc v102+-.5
374 join x06s1d
375 calc v102+--.2
376 join x06s1d
377 pause

378 entry replot
379 next x06m1i0
380 jump key=back,x,x06m1i0
381 at 1223
382 write 20 <s,v80> <s,v105>
383 20 <s,v81> <s,v106>
384 20 <s,v82> <s,v107>
385 20 <s,v83> <s,v108>
386 20 <s,v84> <s,v109>
387 0 <s,v85> 0
388 0 <s,v86> 0
389 0 <s,v87> 0
390 0 <s,v88> 0
391 0 <s,v89> 0
392 ***

393 unit x06m1i0 $$ this is a dummy unit for restart
394 restart
395 jump n99,x,x,x06m1a

396 entry x06m1i1
397 zero n99
398 jump x06m1j
399 ***

400 unit x06m1j

```

```

401 back x06m1i
402 next x06m1k
403 at 007
404 write The input power  $p_g$ , calculated above,
405 will be plotted versus time  $t$ , when you press -NEXT-.
406 calc Ymax=200
407 Xmax=10
408 x=248
409 y=160
410 pause

411 entry power
412 join x06s1b
413 gdraw -10,0;-10,v105;-8,v106;-6,v107;-4,v108;-2,v109;0,0
414 graph 2,200,pg(t)
415 graph 10,-20,t
416 exit
417 calc n149=104
418 doto 06m1j1,n150=1,5,1
419 graph -12+2(n150),v(n149+n150),
420 06m1j1
421 doto 06m1j2,n150=1,6,1
422 graph 2(n150-1),0,
423 06m1j2

```

part=1, block=g

block ig, x06m1k

```

425 unit x06m1k
426 base
427 term work
428 back x06m1i
429 next x06m1l
430 at 405
431 write The energy  $w_g(t)$  supplied to the circuit by the
432 voltage source  $v_{10}$  is
433

$$w_g(t) = \int_0^t p_g(t) dt.$$

434
435 When you press -DATA-, I will calculate and
plot  $w_g(t)$  versus  $t$  for one period, using your data.

436 calc Ymax=50
437 x=248
438 y=160
439 Xmax=10
440 pause

441 entry work
442 join x06s1b
443 graph 2,50,wg(t)
444 graph 10,-5,t

```

```

445 calc n11+104
446 v112+v134
447 n130+1
448 n132+10

449 entry x06mik1
450 calc v131*(v(n111+n130)-v(n111+n130+1))/4
451 dot0 06mik2,v140+.25,1,.25
452 calc v133*(v(n111+n130+1)+(1-v140+.25)*4(v131))
453 calc v112+v112+.025*v133
454 gdraw 2(v140-.25)+n132,v134;2(v140)+n132,v112
455 calc v134+v112
456 06mik2
457 calc n130+n130+1
458 n132+n132+2
459 goto n132-2,x06mik1,x
460 gdraw 0,v112;10,v112
461 exit
462 at 2912
463 write w_g(t) = \int_0^T p_g(t) dt. = (z,v112) \mu J (within 9%)
464 ***

```

```

465 unit x06m11
466 base
467 term resis
468 back x06mik
469 next x06m1m
470 at 305

```

471 write While the energy was being supplied to the RC
472 circuit by the source, energy was being dissipated in
473 the resistances of the circuit. The total resistance
474 of the RC circuit includes the generator internal
475 resistance well as the resistances of the various
476 circuit elements on the RC BOARD. Hence, in the
477 equivalent circuit below;

$$478 \quad R = R_g + R_1 + R_2$$

```

479 draw 2023;2030;1931;2133;1935;2035;2044;2344;skip
480 2341;2247;skip;344,136;2044;2744;2723;2523
481 circle 36,343,101,132,48
482 draw 2523;176,122
483 draw 176,149;2023
484 circle 14,176,136
485 at 1933
486 write R
487 at 2449
488 write C
489 at 2229
490 write i
491 draw 235,164;271,164
492 at 2318
493 write +
494 v_g
495 -
496 pause
497 at 1305

```



498 write
499
500
501

As you may verify, the manufacturer's rated equivalent resistance values for the Function Generator and the circuit board resistors give $R = 200 + 2000 + 100 = 2300$ ohms. 1

----- part=1, block=h -----

block 1h, x05min.

503 unit x06min
504 back x06min
505 next x06min
506 at 507

507 write Let's check this with your experimental
508 measurements.

509 As we mentioned previously, the
510 capacitor voltage is zero when v_c jumps from 0 to
511 20 volts at the beginning of each period. Therefore,
512 at that instant the only opposition to the flow of
513 current is the resistance voltage $v_R = iR$. Using
514 this relation and your previously-measured current
515 in milliamperes:

516 $R = 20 / (.001 * \langle s, v80 \rangle) = \langle s, 20 / (v80 * .001) \rangle$ ohms (within 6%)

517 When you press -NEXT-, I will use your value of R
518 with the values you read for i to calculate and
519 display the power dissipation $p_R = i^2 R$ versus t.

520 pause
521 erase
522 at 210

523 write An estimate of the power being dissipated at any
524 instant t in the circuit resistance R is

$$p_R(t) = i^2(t) R$$

525
526 calc y0350
527 x0248
528 ymax0200
529 xmax010

530 entry resisp

531 join x0651b

532 graph 1.5, 200, $p_R(t)$

533 graph 10, -20, t

534 calc v1020/v80

535 gdraw -10,0;-10,v1(v80)²;-8,v1(v81)²;-6,v1(v82)²;-4,v1(v83)²;-2,v1(v84)²;0,0

536 gdraw 0,0;0,v1(v85)²;2,v1(v86)²;4,v1(v87)²;6,v1(v88)²;8,v1(v89)²;10,0

537 exit

538 pause

539 at 1610

540 write An estimate of the energy $w_R(t)$ dissipated in R
541 during the interval $t = 0$ to $t = t$ is

542 $w_R(t) = \int_0^t p_R(t) dt.$

```

543 calc      v115
544          ymax*58
545 entry    resiw
546 join     x86s1b
547 graph    1.5,58,wr(t)
548 graph    18,-5,t
549 calc     n111*79
550         v112+v134*8
551         n138*1
552         n132*-18
553 entry    x86m1m1
554 calc     v131*(v(n111+n138)-v(n111+n138+1))/4
555 doto     86m1m2,v148*.25,1,.25
556 calc     v133*v(n111+n138+1)+(1-v148*.25)4(v131)
557 calc     v112+v112+.025(v133)2v1
558 gdraw    2(v148-.25)+n132,v134;2(v148)+n132,v112
559 calc     v134+v112
560 86m1m2
561 calc     n138+n138+1
562         n132+n132+2
563 goto     n132$-4,x86m1m1,x
564 gdraw    -2,v112;8,v112
565 calc     n111*84
566         n138*1
567         n132*8
568 entry    x86m1m3
569 calc     v131*(v(n111+n138)-v(n111+n138+1))/4
570 doto     86m1m4,v148*.25,1,.25
571 calc     v133*v(n111+n138+1)+(1-v148*.25)4(v131)
572 calc     v112+v112+.025(v133)22.353
573 gdraw    2(v148-.25)+n132,v134;2(v148)+n132,v112
574 calc     v134+v112
575 86m1m4
576 calc     n138+n138+1
577         n132+n132+2
578 goto     n132$6,x86m1m3,x
579 gdraw    8,v112;18,v112
580 exit
581 at      3112
582 write   wr(t) = ∫0T pr(t) dt. = (z,v112) μJ

```

part=1, block=1

block 11, x86m1n

```

584 unit    x86m1n
585 base
586 back    x86m1m
587 next    x86m1n1
588 at      785
589 write   Let's examine the voltage across the capacitor

```

598 in the experimental RC circuit, and relate it to the
599 current i .

592 For this purpose, please return the Scope TIME to
593 1 ms, B $\times 5$ to 2 V, and A VOLTS to 50 V, and
594 raise the base line to the center of the screen.

595 Since v_{34} across the current-sensing resistor is
596 insignificant in comparison, v_{24} is like v_C .

597 Therefore, monitor Terminal 2 on the A channel to
598 display $v_C(t)$.

599 ***

600 unit $\times 06min1$
601 next $\times 06min$
602 pack $n33, aebc00000000c00ebd0000ad000c00$
603 do $ckcw$
604 jump $n47, x, \times 06min2$
605 ***

606 unit $\times 06min2$
607 next $\times 06min$
608 pack $n33, kgoc (cd) (de) (cd) dbac f (rtu) g (ab) \times d (e) (tu) + aea + 1$
609 do $ckdw$
610 jump $n47, x, \times 06mio$
611 ***

612 unit $\times 06mio$
613 back $\times 06min$
614 next $\times 06mip$
615 jump $n99, x, x, x, \times 06miqb$
616 calc $\times e356$
617 $\times e425$
618 $\times max + 20$
619 $\times max + 10$
620 join $\times 06sib$
621 graph $8, 20, v_C(t)$
622 graph $10, -2, t$
623 calc $n95 + 1$
624 doto $11lasta, n94 + 10, 5, 10$
625 funct $n95 (20 - 20 \exp(-.5 (v100 - n94))) + (n95 - 1)^2 (20 \exp(-.5 (v100 - n94))), v100 + n94, n94 + 10, .5$
626 calcc $n95 = 1, n95 + 0, n95 + 1$
627 11lasta
628 at 505

629 write The voltage v_C across the
630 capacitor is exponentially
631 increasing towards 20 when
632 $v_g = 20$, and is exponentially
633 decreasing towards 0 when $v_g = 0$.
634 ***

635 unit $\times 06mip$
636 back $\times 06mio$
637 term try
638 next $\times 06miqb$
639 at 105

648 write For this analysis, please read from the Scope and
 641 properly enter each value of $v_C(t)$, I will then
 642 calculate and enter $P_C = v_C \cdot i$.

	t	v_C	i	P_C
	(ms)	(V)	(mA)	(mW)
643				
644	0.0-			
645	0.1-			
646	0.2-			
647	0.3-			
648	0.4-			
649	0.5-			
650	0.6-			
651	0.7-			
652	0.8-			
653	0.9-			

```

654      0.9-
655 goto  key=back, replotv, x
656 calc  n100+922
657      n1+80
658      v102+0
659 join  x06s1e
660 calc  v102+12
661 join  x06s1e
662 calc  v102+16
663 join  x06s1e
664 calc  v102+18
665 join  x06s1e
666 calc  v102+19
667 join  x06s1e
668 calc  v102+20
669 join  x06s1e
670 calc  v102+8
671 join  x06s1e
672 calc  v102+3
673 join  x06s1e
674 calc  v102+1.8
675 join  x06s1e
676 calc  v102+.4
677 join  x06s1e
678 pause
  
```

```

679 entry replotv
680 next  x06m1q0
681 jump  key=back, x, x06m1q0
682 calc  n100+922
683      n1+80
  
```




```

684. dot   lplot, n158+8, 9, 1
685. at    n188+2
686. show  v(n1+n158-38)
687. at    n188+18
688. show  v(n1+n158)
689. at    n188+21
690. show  v(n1+n158-28)
691. calc  n188+n188+288
692. lplot

```

----- part=1, block=j -----

block 1j. x86m1q8

```

694. unit  x86m1q8
695. restart
696. calc  n99=1, n99+2, n99+8
697. jump  n99, x, x, x, x86m1a

```

```

698. entry  x86m1q8a
699. jump  n99, x, x, x, x86m1n
700. jump  x86m1q
701. ***

```

```

702. unit  x86m1q
703. next  x86m2a
704. at    585

```

```

705. write  At any instant,  $p_g(t) = p_R(t) + p_C(t)$ .

```

```

706. Over any period  $0 < t < T$ :
707.  $w_g(t) = w_P(t) + w_C(t)$ 

```

```

708. Graphs of  $p_C(t)$ ,  $w_C(t)$ ,  $p_g(t)$ ,  $w_g(t)$ ,  $p_R(t)$ , and
709.  $w_P(t)$  will be shown when you press -NEXT-.

```

```

710. pause
711. erase

```

```

712. calc  y+85
713.      x+128

```

```

714.      v_max+18
715.      v_max+288

```

```

716. join  x86s1b
717. graph 1.5, 288, p_C(t)

```

```

718. graph 18, -28, t

```

```

719. gdraw -18, 8; -18, v68; -8, v61; -6, v62; -4, v63; -2, v64; 8, 8; 8, v65; 2, v66; 4, v67; 6, v68; 8, v69; 18, 8

```

```

720. calc  y+85
721.      x+398

```

```

722.      v_max+58
723. join  x86s1b

```

```

724. graph 1.5, 58, w_C(t)

```

```

725. graph 18, -5, t

```

```

726. calc  n111+68

```

```

727.      v112+v134+8

```

```

728.      n138+1

```

```

729.      n132+-8

```

```

730 calc v131=(v(60)-v(61))/4
731 goto 06m1q1a,v140+.25,1,.25
732 calc v133=v(61)+(1-v140)/4(v131)
733 calc v112=v112+.025v133
734 gdraw 2(v140-.25)-10,v134;2(v140)-10,v112
735 calc v134=v112
736 06m1q1a

737 entry x06m1q1
738 calc v131=(v(n111+n130)-v(n111+n130+1))/4
739 goto 06m1q2,v140+.25,1,.25
740 calc v133=v(n111+n130+1)+(1-v140+.25)/4(v131)
741 calc v112=v112+.025v133
742 gdraw 2(v140-.25)+n132,v134;2(v140)+n132,v112
743 calc v134=v112
744 06m1q2
745 calc n130=n130+1
746 n132=n132+2
747 goto n130+8,x06m1q1,x
748 gdraw 0,v112;10,v112

749 entry x06m1q3
750 calc x=120
751 u=355
752 v_max=200
753 join resistp
754 calc x=398
755 v_max=50
756 join resistw
757 calc x=120
758 v_max=200
759 u=425
760 join power
761 calc v_max=50
762 x=398
763 join work

764 unit x06m2a
765 back x06m1p
766 next x06m1b
767 at 507
768 write

```

Transients occur whenever a stable system is disturbed, so it behooves us to relate the wave-shapes you have just observed to the values of R and C in the equivalent circuit.

As with any dissipative system containing a single type of storage element, the differential equation which applies during any half-period in which the source voltage v_g is constant is

$$v_g(t) = R i(t) + \frac{1}{C} \int_0^t i(t) dt + V_{C0}$$

where V_{C0} is the capacitance voltage at $t = 0$, the beginning of that half-period.

Differentiating with respect to t gives the

782 first-order differential equation:

783

784

785

786

787

788

789

$$R \frac{di}{dt} + \frac{1}{C} i = 0$$

or

$$\frac{di}{dt} = - \frac{1}{RC} i$$

----- part=1, block=k -----

block 1k, x06m2b:

791 unit : x06m2b

792 back x06m2a

793 next x06m2c

794 at 507

795 write The differential equation i

796

797

798

799

800

801

802

803

$$R \frac{di}{dt} + \frac{1}{C} i = 0$$

or

$$\frac{di}{dt} = - \frac{1}{RC} i$$

Solves to

804

805

806

$$i = I_g e^{-\frac{t}{RC}}$$

807

808

where I_g is the current at $t = 0$ and $e = 2.71828$,
the base of natural logarithms.

809

810

811

812

Any variable, whose rate of change at any instant
is proportional to the value of that variable at that
instant is of the natural exponential form, like i.

813 unit : x06m2c

814 back x06m2b

815 next x06m2d

816 at 507

817 write Consider the term

818

$$e^{-t/RC}$$

819

RC is called the time constant $\tau = RC$.

820

When $t = 0$, $e^{-t/RC} = e^{-0/\tau} = e^0 = 1.00$

821

When $t = \tau$, $e^{-t/RC} = e^{-\tau/\tau} = e^{-1} = 0.37$

822 When $t = 2\tau$, $e^{-t/RC} = e^{-2\tau/\tau} = e^{-2} = 0.14$

823 When $t = 3\tau$, $e^{-t/RC} = e^{-3\tau/\tau} = e^{-3} = 0.05$

824 When $t = 4\tau$, $e^{-t/RC} = e^{-4\tau/\tau} = e^{-4} = 0.02$

825 When $t = 5\tau$, $e^{-t/RC} = e^{-5\tau/\tau} = e^{-5} = 0.01$

826 Note that for any time $t_2 = t_1 + \tau$,

827
$$e^{-t_2/RC} = e^{-1} \times e^{-t_1/RC} = 0.37 e^{-t_1/RC}$$

828 In other words, during any time interval $\Delta t = \tau$
829 the exponential function concerned will decrease to
830 37 % of its value at the beginning of that interval.
831 ***

```
832 unit x06m2d
833 term test2
834 back x06m2c
835 next x06m2d1
836 at 1005
```

837 write Let's apply the above theory to measure the time
838 constant τ for the experimental RC circuit.

839 Turn the A PRE AMP to OFF, to provide a baseline
840 as we did before. Also, set TIME at 500 μ s and
841 B VOLTS at 1 V, so you display one half-period of
842 the current i .

843 ***

```
844 unit x06m2d1
845 pack n33,a0bc0000000000c00+bd0000ad000c00
846 join ckc
847 goto n47,x06s1c1,x06m2d2
848 ***
```

```
849 unit x06m2d2
850 pack n33,jfoc(cd)(de)edba<f(rtu)g(ab)>d(ef)(tu)+aaa++l
851 join ckd
852 jump n47,x06s1c1,x06m2e
```

-----part=1, block=1-----

block 11, x06m2e:

```
854 unit x06m2e
855 back x06m2d
856 next x06m2f
857 at 1007
```

858 write Recall that 1 cm horizontally on this display
859 is now equivalent to 50 microseconds, and, beginning
860 at any point on the exponential curve, measure the
861 time interval in which the current i decreases



862 to 37 % of its initial value.

863 Time constant = $\tau =$ μs

864 arrow 1642

865 long 2

866 ansv 92,10

867 no

868 at 1705

869 write If the period of the current
870 is still 1 ms, your measurement
871 of τ should be in the range of,
872 80 to 100 μs .

873 Try again, perhaps starting from some
874 other initial time on the smooth curve.

875 ***

876 unit x06m2f,

877 back x06m2e

878 next x06m2g

879 at 505

880 write Another feature is significant for any first-order
881 exponential curve. Recall that

882

883

884

885

$$\frac{di}{dt} = -\frac{1}{RC} i = +\frac{1}{\tau} I_0 e^{-\frac{t}{\tau}}$$

886 At any time t_1 , the tangent to the current curve is

887

888

889

890

891

892

$$\frac{\Delta i}{\Delta t} = -\frac{i}{\tau}$$

Consequently, if a tangent to the current curve is
extend from time $t = t_1$ to $t = t_1 + \tau$, the tangent
line should end at $i = 0$.

893 Since this should apply at any point on the
894 decreasing curve, you now have another method of
895 graphically checking whether the curve represents a
896 first-order decreasing exponential function.

897 ***

898 unit x06m2g

899 back x06m2f

900 term test

901 at 205

902 write You should now be able to answer the following
903 questions pertinent to this experiment.

904 1. What element supplies the energy dissipated in R
905 during the second half-period when $v_g = 0$?

906 2. During the second half-period, $i = I_0 e^{-t/\tau}$
907 wherein $I_0 =$ mA

908 arrow 650

909 specs bumpshift

```

910 answer (c, cap, capacitor)
911 wrong (vg, generator, source)
912 arrow 918
913 ansv -7.8, .5
914 inhibit erase
915 jump x06m2g1
916 ***

917 unit x06m2g1
918 next x06end
919 at 1405
920 write 3. During any half-period, the curve of pr(t)
921 versus t is a first-order exponential function.

922 What is the time constant of pr(t)?
923 calc x0248
924 y0205
925 ymax020
926 xmax010
927 join x06s1b
928 graph 1.5, 20, pr(t)
929 graph 1.5, -2, 40
930 graph 9, -2, 200 μsec.
931 funct (20) exp(-.5(v100)), v1000, 10, .5.
932 at 1451
933 write μsec
934 arrow 1444
935 ansv 40, 5
936 wrong
937 join x06s2c

```

----- part=1, block=m -----

block 1m, x06s1a:

```

939 unit x06s1a
940 at 1010
941 write The output voltage is displayed as it was in
942 earlier experiments. Just connect the adjustable
943 SQUARE OUTPUT of the Function Generator to A INPUT.

944 The circuit current is not as easy to measure.
945 The Scope is only capable of displaying a voltage
946 not a current. Using the basic equation v=iR,
947 the current can be measured by interpreting each
948 volt across the 100 ohm sampling resistor as
949 10 milliamperes. Therefore, monitor the voltage
950 at Terminal 3 and multiply it by 10 to read the
951 current in mA.
952 end
953 ***

954 unit x06s1b
955 origin x,y

```

```

956 axes      -75,-75,75,75
957 scalex    xmax
958 scaley    ymax
959 markx     2xmax,xmax/5
960 marky     2ymax,ymax/5
961 end
962 ***

963 unit      x06s1c
964 next      x06m1e
965 erase
966 at        1007
967 write     You have not followed my suggestions carefully.

968          Try again please..
969 ***

970 unit      x06s1c1
971 next      x06m2d
972 erase
973 at        1007
974 write     You have not followed my suggestions carefully.

975          Try again please..
976 ***

977 unit      x06s1d
978 back      x06m1e
979 arrow     n100
980 store     v103
981 ansv      v101
982 arrow     n100+13
983 store     v(n1-24)
984 ansv      v102,.5
985 at        n100+26
986 showt     v103*v(n1-24)
987 calc      n1←n1+1
988          v(n1)←v103*v(n1-25)
989          n100←n100+200
990 ***

991 unit      x06s1e
992 arrow     n100
993 store     v(n1-30)
994 ansv      v102,2
995 at        n100+10
996 showt     v(n1)
997 at        n100+21
998 showt     v(n1-30)*v(n1)
999 calc      v(n1-20)←v(n1+30)*v(n1)
1000        n1←n1+1
1001        n100←n100+200
1002 ***

1003 unit     x06s1f
1004 next     x06s1g
1005 at      510

```

1006 write The graph you see below should look similar
1007 to the traces, displayed on the oscilloscope.
1008 If it doesn't ask your instructor for assistance.

1009 entry graph
1010 origin 248,150
1011 axes -140,-140,140,140
1012 scalex 10
1013 scaley 10
1014 markx 2
1015 marky 2
1016 exit
1017 funct $10 \exp(-.25(10+v150))$, v150 ← -10; 10, .5
1018 gdraw -10,0;-10,10;10,10;10,0
1019 pause
1020 mode erase
1021 at 510

1022 write The graph you see below should look similar
1023 to the traces displayed on the oscilloscope.
1024 If it doesn't ask your instructor for assistance.

1025 mode write
1026 at 510

1027 write You can obtain five of the needed data points
1028 from this display read the voltage values at
1029 the • on the horizontal axis. Each data point
1030 has a current and a voltage reading.

1031 Slide the base line up or down to read any
1032 value that is off the screen. When you read
1033 that value do not forget that the voltage is
1034 from the new base line.

----- part=1, block=n -----

block in, x06end:

1036 entry points
1037 graph -9,0,♦
1038 graph -6,0,♦
1039 graph -2,0,♦
1040 graph 2,0,♦
1041 graph 6,0,♦
1042 exit
1043 ***

1044 unit x06sig
1045 at 510

1046 write For the other 5 data points the Trigger
1047 Slope slide switch is used. Switch the
1048 Trigger Slope to trigger on the negative
1049 side of the wave. This will give you the
1050 second cycle of the wave. The traces seen
1051 on the scope should resemble the below graph.

1052 join graph
1053 gdraw -10,0;-10,-10,


```

1054 funct -10exp(-.25(10+v150)),v150e-10,10,.5
1055 pause
1056 mode erase
1057 at 510
1058 write For the other 5 data points the Trigger
1059 Slope slide switch is used. Switch the
1060 Trigger Slope to trigger on the negative
1061 side of the wave. This will give you the
1062 second cycle of the wave. The traces seen
1063 on the scope should resemble the below graph.
1064 mode write
1065 at 510
1066 write You can obtain the final five data points
1067 from this display read the voltage and current
1068 values at the * on the horizontal axis.
1069 ( As before the base line can be moved up or
1070 down to read values off the screen.
1071 join points
1072 end
1073 ***

1074 unit x06s2c
1075 at 2105
1076 write Known equations:
1077 
$$p_r(t) = R_t \times [i_c(t)]^2$$

1078 
$$i_c(t) = I_{max} \times \exp[-t/\tau_1]$$

1079 at 2505
1080 write Rearranging the equations: 
$$p_r(t) = R_t \times I_{max}^2 \times \exp[-2t/\tau_1]$$

1081
1082 Now a different time constant,  $\tau_2$ , can be defined as  $\tau_1/2$ 
1083 This new time constant is the time constant for  $p_r(t)$ .

1084 
$$p_r(t) = R_t \times I_{max}^2 \times \exp[-t/\tau_2]$$

1085 gdraw 0,20;2.2,0
1086 end
1087 ***

1088 unit x06end
1089 back x06m2g
1090 join imode
1091 jump n47,x06end,x
1092 course n2
1093 calcc n2='ee244',
1094 nc(n21+1) * (nc(n21+1) $mask$07777777770000000000) + 04603000000,
1095 nc(n21+1) enc(n21+1)
1096 erase
1097 output /// student has completed experiment ///
1098 join endunit
1099 join jmpmes
1100 jumpout cgeindex,quest1

1101 entry leave
1102 end lesson
1103 ***

1104 unit endunit
1105 course n2

```

```

1106 jump      n2='ee244',leave,x
1107 calc      nc(n21+7)+nc(n21+7)+ahelp
1108          vc(n21+6)+vc(n21+6)+atime/68888
1109 ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
1110 use       eex00,ck1
1111 use       ck2
1112 use       ck3
1113 use       ck4
1114 use       ck5
1115 use       ck6

ckc          not found          252          846
ckcw         not found          94           115          162          328          689
ckd          not found          258          851
ckdw         not found          100          121          188          326          689
endunit     x06end          1104          18          1098
graph       x06sia          1009          1052
imode       not found          29           1098
jmpmes      not found          1099
leave       x06end          1101          1106
points      x06end          1036          1071
power       x06mli          411          760
replot      x06mli          378          352
replotv     x06min          679          655
resisp      x06mim          530          753
resisw      x06mim          545          756
work        x06mik          441          763
x06end      x06end          1088          918          1091
x06m0a      x06m0a          27           30           50
x06m0b      x06m0a          49           31           72
x06m1a      x06m0a          71           51           95          101 126 116 395 122
          697
x06m1a1     x06m1a1          92           73
x06m1a2     x06m1a1          98           96
x06m1b      x06m1a1          104          102
x06m1b1     x06m1a1          113
x06m1b2     x06m1af          119          117
x06m1c      x06m1af          125          123          143
x06m1d      x06m1a1          142          127          163          169          174
x06m1d1     x06m1a1          160          144
x06m1d2     x06m1a1          166          164
x06m1e      x06m1e          172          170          216          263 964 292 978 332
x06m1f      x06m1e          215          175
x06m1f1     x06m1e          250          248
x06m1f2     x06m1e          256          254
x06m1g      x06m1g          262          217          260
x06m1h      x06m1g          291          264
x06m1h1     x06m1g          311          293          312          324
x06m1h2     x06m1g          323          321
x06m1i      x06m1i          329          327          401          428
x06m1i0     x06m1i          393          379          380
x06m1i1     x06m1i          396          128
x06m1j      x06m1i          400          398
x06m1k      x06m1k          425          402          468
x06m1k1     x06m1k          449          459
x06m1l      x06m1k          465          429          504
x06m1m      x06m1m          503          469          586
x06m1m1     x06m1m          553          563

```

x06m1m3	x06m1m	568		578					
x06min	x06min	584		585		681	687	613	699
x06min1	x06min	600		587					
x06min2	x06min	606		604					
x06mio	x06min	612		610		636			
x06mip	x06min	635		614		765			
x06miq	x06miq0	702		700					
x06miq0	x06miq0	694		615		638	688	681	
x06miq0a	x06miq0	698		128					
x06miq1	x06miq0	737		747					
x06miq3	x06miq0	749							
x06m2a	x06miq0	764		703		792			
x06m2b	x06m2b	791		766		814			
x06m2c	x06m2b	813		793		834			
x06m2d	x06m2b	832		815		855	971		
x06m2d1	x06m2b	844		835					
x06m2d2	x06m2b	849		847					
x06m2e	x06m2e	854		852		877			
x06m2f	x06m2e	876		856		899			
x06m2g	x06m2e	898		878		1089			
x06m2g1	x06m2e	917		915					
x06s1a	x06s1a	939		74		145			
x06s1b	x06s1a	954		184		219	296	531	412
				620		716	723		546
				254		260			442
				847		852			
				357		359	361	363	365
				372		374	376		
				659		661	663	669	665
				673		675	677	671	667
				331					
x06s1c	x06s1a	963		1003					
x06s1c1	x06s1a	970		1044					
x06s1d	x06s1a	977		1004					
				937					
x06s1e	x06s1a	991							
x06s1f	x06s1a	1003							
x06s1g	x06end	1044							
x06s2c	x06end	1074							
ahelp		1107							
atime		1108							
back		352	380	655	681				
exp		226	301	625	625	931	1017		1054
i		223							
key		352	380	655	681				
nc		1094	1094	1095	1095	1107	1107		
nl		354	657	683	686	688	986	690	987
		987	988	988	993	996	999	998	999
		999	1000	1000					
n100		353	656	682	685	687	691	689	979
		982	985	989	989	992	1001	995	1001
n111		445	450	450	452	549	556	554	565
		569	569	571	726	738		738	740
n120		176							
n121		177							
n122		178							
n123		179							
n130		447	450	450	452	457	554	457	554
		556	561	561	566	569	576	569	576
		728	738	738	740	745		745	571
n132		448	454	454	458	458	558	459	558
		562	562	563	567	573	577	573	578
		729	742	742	746	746		747	577

n149	417	419								
n158	418	419	419	421	422	430	604	690	686	
n2	1892	1893	1185	1186						
n21	1894	1894	1895	1895	1187		1187	1100	1180	
n39	93	99	114	128	161	257	167	319	251	
	325	602	688	845	858					
n47	38	95	96	181	182	122	116	123	117	
	163	164	169	178	254	327	268	604	321	
	618	847	852	1891						
n94	221	222	222	226	226	300	226	300	299	
	381	381	381	624	625		625	625	625	
n95	228	222	226	227	227	625	628	626	625	
	626	626								
n99	25	32	128	395	397	696	615	696	696	
	697	699								
Pc	717									
Pg	297	414								
Rr	532	928								
t	186	223	297	298	414	444	415	532	443	
	533	547	548	621	622	724	717	725	718	
	928									
v	419	458	458	452	554	589	554	562	556	
	571	686	688	698	738	739	738	738	732	
	748	983	986	988	988	998	993	998	996	
	999	999	999							
vc	1188	1188								
v1	534	535	535	535	535	536	535	536	536	
	536	536	557							
v100	226	226	201	381	625	921	625	931	625	
v101	355	367	981							
v102	356	358	368	362	364	371	366	373	369	
	375	658	668	662	664	670	666	672	668	
	674	676	984	994						
v103	988	986	988							
v105	382	413								
v106	383	413								
v107	384	413								
v108	385	413								
v109	386	413								
v112	446	453	453	454	455	463	468	530	468	
	557	557	558	559	564	572	564	583	572	
	574	579	579	582	727	734	733	735	733	
	741	741	742	743	748		748			
v131	458	452	554	556	569	732	571	738	738	
	748									
v133	452	453	556	557	571	733	572	744	732	
	741									
v134	446	454	455	558	558	574	559	727	573	
	734	735	742	743						
v140	451	452	454	454	555	558	556	570	558	
	571	573	573	731	732	739	734	740	734	
	742	742								
v150	1817	1817	1854	1854						
v60	719									
v61	719									
v62	719									
v63	719									

v64	719								
v65	719								
v66	719								
v67	719								
v68	719								
v69	719								
v80	382	516	516	534	535				
v81	383	535							
v82	384	535							
v83	385	535							
v84	386	535							
v85	387	536							
v86	388	536							
v87	389	536							
v88	390	536							
v89	391	536							
v	186								
vC	621								
vE	724								
vR	443								
vT	547								
x	176	188	488	437	527	721	616	754	713
	754	757	762	923	955				
xmax	178	189	487	439	529	926	619	957	714
	959	959							
y	177	181	218	294	489	543	438	617	526
	712	728	751	759	924		955		
ymax	179	182	295	486	436	618	528	715	544
	722	752	755	758	761	960	925	960	958
	419	422	1037	1038	1039		1040		1041
μsec	938								

lesson information

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by neal, of course eece

at site 7, station 27

author name = J. P. Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

description of lesson = Measurements of Transients.

block 1a, eex07id

2 stop
3 *** For Neal, CGERL, Room 248, EEB.

4 One line description of this lesson --

5 Measurements of Impedance.

6	Divisions of this Lesson:	Block	Unit
7	Id for this file	eex07id	
8	Experiment eex07;		
9	Objectives	eex07id	x07m0a
10	Measure impedance magnitude	x07m1a	x07m1a
11	Time displacement method	x07m1d	x07m2a
12	Lissajous figure method	x07m2e	x07m3a
13	Calc. impedance from components	x07m4a	x07m4a

14 final edit 21 aug 74 neal.

```

15 *list info
16 *list symbols
17 *list varian,charset,cgeindex,cgechar
18 ****
19 start
20 finish endunit
21 write (at,1010) Loading the CGE Character Set
22 charset,cgeindex,cgechar
23 erase
24 zero n99          $$ used for restart skipping
25 dataon
26 area eex07
27 ext 0
28 ***
    
```

```

29 unit x07m0a
30 restart
31 join imode
32 jump n47,x07m0a,x
33 calc n55*-1      $$ used in review seq.
34 calc n99*-1     $$ n99 = 0 if restart
35 at 509
    
```

36 write MEASUREMENTS OF IMPEDANCE

37 When you have completed this experiment, you
38 should be able to:

39 1) Experimentally measure the magnitude of an
40 impedance.

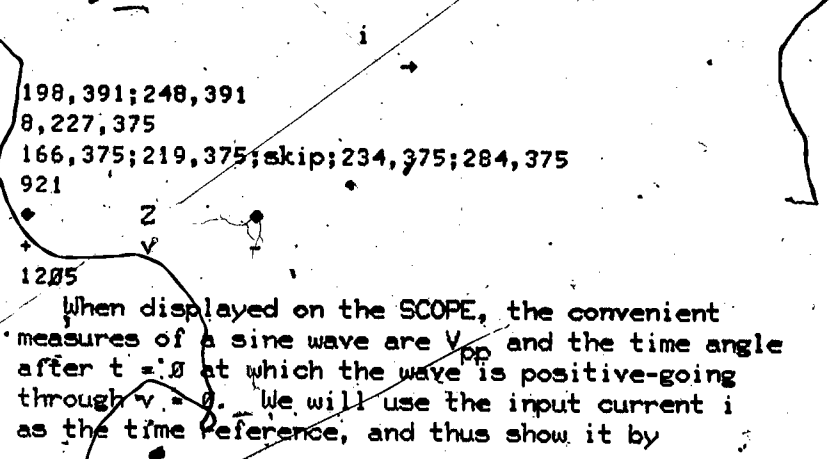
- 41 2) Measure the time-phase relation between two
 42 waveforms by the time-displacement method.
- 43 3) Measure the time-phase relation between two
 44 waveforms by the Lissajous-figure method.
- 45 4) Calculate the theoretical impedance of a
 46 series circuit and compare this value with the
 47 actual laboratory measurement.

----- part-1, block-b -----

block 1b, x07mia

49 unit x07mia
 50 base
 51 back x07mba
 52 next n55,x07m1b,x07m3e
 53 at 307

54 write Consider a two-terminal electrical device driven
 55 by a single-frequency sinusoidal power source and
 56 having an input voltage v and input current i :

57
 58
 59 draw 198,391;248,391
 60 circle 8,227,375
 61 draw 166,375;219,375;skip;234,375;284,375
 62 at 921
 63 write 
 64
 65 at 1205

66 write When displayed on the SCOPE, the convenient
 67 measures of a sine wave are V_{pp} and the time angle
 68 after $t = 0$ at which the wave is positive-going
 69 through $v = 0$. We will use the input current i
 70 as the time reference, and thus show it by

71
$$i = I_{pp} \sin \omega t = 0.5 I_{pp} \sin \omega t$$

72 Now, the input voltage leads or lags the input
 73 current by a time-angle equal to or less than $\pi/2$
 74 or 90° . Hence, the expression for the input voltage
 75 can be shown by

76
$$v(t) = V_{pp} \sin(\omega t + \theta) = 0.5 V_{pp} \sin(\omega t + \theta)$$

77 where $-90^\circ \leq \theta \leq 90^\circ$.

78 unit x07m1b
 79 back x07mia
 80 next x07m1b1
 81 at 505
 82 write

In terms of the input voltage and current of a

83 two-terminal circuit element, we will define the
84 impedance of that element by

85 $Z = |Z| \angle \theta$

86 where $|Z| = V_{pp} / I_{pp}$

87 θ = the angle by which the voltage
88 leads the current, as shown in the equations on the
89 preceding display.

90 Our present task is to measure $|Z|$, the magnitude
91 of the impedance of an inductive two-terminal circuit.

92 Select the IMPEDANCE BOARD, ITEM 35 from the
93 shelf below, and connect the sensor cable securely
94 in the panel connector below the Function Generator.

95 When you have connected the circuit-board sensor cable,
96 connect the circuit diagrammed on the next display.

97 ***

98 unit x07m1b1
99 back x07m1b
100 next x07m1b
101 join x07s1a
102 pause
103 pack n33,a0a0000000b0c0caba000000+00ba00
104 join ckc
105 jump n47,x,x07m1c
106 pack n33,a0a0000000b0c0caba000000+00ba00
107 join ckc2w
108 ***

109 unit x07m1c
110 back x07m1b
111 join x07s1b
112 at 2007

113 write The connection diagram requires the display of
114 the voltage across the switch-selected impedance
115 on A channel of the SCOPE, and the voltage of the
116 current-sensing resistor on B channel, so

117 $|v_B| = |i_Z| \times 100$

118 Therefore : $|i_Z| = 10 \times |v_B|$ (milliamperes)
119 As connected, $v_B = -i_Z \times 100$. In order to display
120 $+i_Z$, set the B PRE AMP at AC.

----- part=1, block=c -----

block 1c, x07mid

122 unit, x07mid


```

123 back    x87mic
124 next    x87mid1
125 at      787
126 write   Set the equipment so that:

127         Two periods of a 2 kHz sine wave with  $V_{pp} = 28\text{ V}$ 
128         are displayed on channel A of the SCOPE.

129         Externally trigger the SCOPE from the A INPUT
130         for a stable display and use the AC EXT setting.

131         Set the A PRE AMP at DC+, and the B PRE AMP at -DC.
132 ***

133 unit     x87mid1
134 next     x87mid
135 pack     n33,+ (gh) (nop) d (cd) dc (ad) b+++++ (fg) <c (bc) b (uv) >+
136 join     ckdw
137 jump     n47,x,x87mie
138 ***

139 unit     x87mie
140 back     x87mid
141 at       788
142 write    What is the value of  $I_{pp}$  ?

143         milliamperes (mA)

144 arrow    988
145 ansv     2.9,.15
146 wrongv   .29,.15
147 at       1518
148 write    For the current-sensing resistor

149          $|I_{pp}|$  (milliamperes) =  $|V_B pp| \times 18$ 
150 wrongv   -2.9,.15
151 at       1518
152 write    A peak-to-peak value cannot be a negative number.
153 no
154 at       1587
155 write    You should recall that  $i_z = -18 \times v_B$ , where
156          $i_z$  is in milliamp and  $v_B$  is the voltage displayed
157         on channel B. Be sure to set B VOLTS so that a
158         large-size waveform is displayed on the CRT.
159 endarrow
160 at       1387
161 write    Recalling that  $Z = \frac{V}{I}$ , what is the magnitude
162         of the impedance?

163          $|Z| =$  . k $\Omega$ 
164 at       1986
165 write    NOTE: As this experiment requires numerous calculations,
166         a calculator is provided for your convenience.

167         Simply enter the expression you need to evaluate.
168 join     x87s4e
169 arrow    1713

```

170 ansv 7,14,.7

171 ***

172 unit x07m2a

173 back x07mie

174 at 505

175 write Now that you have seen how to measure the magnitude
176 of an impedance, we will next measure the angle of
177 that impedance.

178 As stated earlier v and i have certain time angles
179 with respect to $t = 0$. We selected the time-reference
180 angle of the current as 0 . Consequently, the time-
181 reference angle of the voltage is θ , the angle by which
182 the voltage leads or lags the current, that is, the
183 angle of the impedance.

----- part=1, block=d -----

block 1d, x07m2b.

185 unit x07m2b

186 back x07m2a

187 next n56, x07m2c, x07s2b

188 at 505

189 write We will now measure θ for the selected impedance
190 on the circuit board, by the time-displacement method.

191 If Δt is the time interval by which the voltage leads
192 the current, or the current lags the voltage, on the SCOPE
193 display, we can calculate θ using the following relations

194
$$i(t) = I_{gp} \sin \omega t$$

195
$$v(t) = V_{gp} \sin \omega(t + \Delta t) = V_{gp} \sin (\omega t + \theta)$$

196 where $\theta = \omega \Delta t = 2\pi f \Delta t = 2\pi (\Delta t/T)$

197 In the sinusoidal expressions; angles are in radians
198 and $\omega T = 2\pi$. However, in circuit calculations it is most
199 convenient to use angles in degrees, where 2π radians
200 is equivalent to 360° . Hence, to measure θ on the SCOPE
201 simply determine the fraction of the period T by which
202 the voltage leads the current and multiply that fraction
203 by 360° to evaluate θ . Incidentally, to type the
204 degree sign, simply press -MICRO- and type o.

205 ***

206 unit x07m2c

207 next x07s2a

208 back x07m2b

209 at 405

210 write Set the equipment so that:

211 The SCOPE is triggered externally by the A INPUT.
 212 Both the A and B INPUTS are displayed in the Alternat
 213 mode, with the A PRE AMP at DC and the B PRE AMP at -DC.
 214 With the B PRE AMP set in this manner, $i(t)$ will be
 215 displayed rather than $-i(t)$.

216 The AUDIO OSCILLATOR should still supply $V_{pp} = 20\text{ V}$
 217 at a frequency of 2 kHz to the A channel of the SCOPE.

218 It is not necessary to change any connections.

219 ***

220 unit x07m2d

221 base

222 jump n99,x,x07m3a

223 back x07m2c

224 next x07m2e

225 help x07s2b

226 at 2410

227 write -HELP- is available.

228 at 505

229 write By what time interval does the current lag the voltage.

230 milliseconds.

231 arrow 705

232 store v60

233 ansv 0-00,0.02

234 at 905

235 write What is the period T of the sine waves, as

236 displayed on the SCOPE ?

237 milliseconds.

238 arrow 1205

239 store v61

240 ansv .5,.02

241 endarrow

242 at 1305

243 write Recalling that $\theta = (\Delta t/T) \times 360^\circ$, what is θ ?

244 join x07s4e

245 arrow 1710

246 ansy (v60/v61) *360,2

----- part=1, block=e -----

block 1e, x07m2e

248 unit x07m2e

249 calc n51e-1

\$\$ used in x07m2f goto and writc

250 base

251 back x07m2d

252 next x07m2f

253 join x07s2c

254 join x07s2d

```

255 at 1126
256 write * LEADING waveform
257 at 1531
258 write * LAGGING waveform
259 pause
260 mode erase
261 join x07s2d
262 mode write
263 join x07s2e
264 pause
265 mode erase
266 join x07s2e
267 mode write
268 join x07s2f
269 ***

270 unit x07m2f
271 base
272 back x07m2e
273 lab x07s2d
274 help x07s2e
275 at 805
276 write Set the impedance-selector switch to position 5.
277 Is v(t) for this circuit leading or lagging?
278 -----
279 at 1011
280 writec n51,,lagging $$ inserts previous response
281 goto n51,x,x07m2f1
282 arrow 1010
283 answer lagging
284 no
285 at 1205
286 write Remember, v(t) is display on channel A; i(t)
287 on channel B. Press -LAB- to review the
288 definitions of leading and lagging.
289 endarrow
290 addl n51 ^

291 entry x07m2f1
292 at 1410
293 write Is  $\theta$  positive or negative? -----
294 at 1438
295 writec n51,,negative
296 goto n51,x,x,x07m2f2
297 arrow 1438
298 answer negative
299 no
300 at 1610
301 write  $\theta$  for a a lagging v(t) is negative
302 endarrow
303 addl n51

304 entry x07m2f2
305 at 1710
306 write Thus, this circuit is: _____ (type a,b, or c)
307
308 a) inductive

```

309 b) capacitive
310 c) resistive
311 arrow 1733
312 answer b
313 no
314 at 2309
315 write Press -HELP- for assistance and/or an explanation.
316 endarrow
317 at 2409
318 write Return the impedance selector switch to position
319 3 before proceeding.
320 ***

321 unit x07m3a
322 restart
323 base
324 back x07m2e
325 next x07m3b
326 help n99,x,x07s1a
327 data n99,x,x07m2c
328 at 1005
329 write The next method for measuring phase angles is
330 the Lissajous figure method. Before continuing,
331 however, recheck the balance of both SCOPE
332 channels and the positioning of the 0,0 point
333 on the SCOPE grid.
334 at 2010
335 writec n99* Press -HELP- to see the circuit diagram

Press -DATA- for dial settings.

----- part=1, block=f -----

block_1f, x07m3b

337 unit x07m3b
338 zero n52 \$\$ needed for proper use of x07s3a
339 back x07m3a
340 next x07s3c
341 at 305
342 write To obtain a Lissajous figure from your
343 present circuit, set the Y DISPLAY FUNCTION
344 to A vs B and turn OFF the SWEEP MODE.
345 Press -NEXT- when you have finished.
346 Press -DATA- to see a typical Lissajous figure.
347 pause
348 keytype n51,data,next,back
349 goto n51,x,x07s3a,x
350 jump n51,x,x,x07s3c,x07m3a
351 ***
352 unit x07m3c

```

353 next      n55, x07m3d, x07m3e
354 back     x07m3b
355 at       205
356 write    The Lissajous figure on display is a plot of
357           $y = V_m \sin(\omega t + \theta)$  versus  $x = I_m \sin \omega t$ .
358           $\theta$  can be evaluated from the ratio of  $M = 2V(t)$  at  $t = 0$ ,
359          to  $N = V_{pp}$ . Thus:

```

```

360 entry    x07m3c1
361 at       1007
362 write     $\frac{2V_m \sin(\omega t + \theta) |_{\omega t = 0}}{2V_m \sin \omega t |_{\omega t = \pi/2}} = \frac{2V_m \sin(\theta + \theta)}{2V_m \sin 90^\circ} = \sin \theta = \frac{M}{N}$ 
363
364
365 join     x07s3a
366 join     x07s3b
367 ***

```

```

368 unit     x07m3d
369 base
370 next     x07m3e
371 back     x07m3c
372 help     x07m3c1
373 calc     n52+-1          $$ needed for x07s3a
374 at       305
375 write    From the Lissajous pattern displayed on the SCOPE,
376          measure:

```

```

377          M (t = 0) _____ Volts
378          N (at  $V_{max}$ ) _____ Volts
379           $\theta = \arcsin M/N$  _____ °

```

```

380          -HELP- is available
381 arrow    630
382 store    v120
383 ansv     8.4,.6
384 arrow    630
385 store    v121
386 ansv     10.1,1
387 no
388 at       1605
389 write    A convenient method for measuring N is to turn
390          the B PRE AMP to OFF.

```

```

391 endarrow
392 join     x07s3f
393 arrow    1030
394 ansv     v102,5%
395 ***

```

```

396 unit     x07m3e
397 base
398 at       405

```

399 write Recall our definition of impedance Z:

400
$$Z = |Z| \angle \theta$$

401 You should now be able to calculate the
402 magnitude, $|Z|$, and its phase angle θ .

403 Press -HELP- to review measurements of magnitude.

404 Press -DATA- to review the use of the time displacement
405 method in calculating θ .

406 Press -LAB- to review the use of the Lissajous
407 figure in determining θ .

408 Press -NEXT- to continue.

409 pause

410 keytype n55,next,back,help,data,lab

411 jump n55,x07m4a,x07m4a,x07m3c,x07m1a,x07m2b,x07m3c

----- part=1, block=g -----

block 1g, x07m4a

413 unit x07m4a

414 imain x07s4g

415 at 405

416 write Thus far we have expressed impedance in the
417 polar form, $Z \approx |Z| \angle \theta$. Another representation is
418 the rectangular or complex form:

419
$$Z = R + jX \quad \text{where } j = \sqrt{-1}$$

420 in this expression, R is termed the resistive component
421 and X is called the reactive component.

422 For converting from the polar form to the rectangular
423 form, use of Euler's identity gives:

424
$$R = |Z| \cos \theta \quad \text{and} \quad X = |Z| \sin \theta$$

425 Similarly, to convert from the rectangular form
426 to the polar form, use the identities:

427
$$|Z| = \sqrt{R^2 + X^2} \quad \text{and} \quad \theta = \arctan (X/R)$$

428 Since these identities will be useful in the
429 remainder of this experiment, you may obtain
430 this display hereafter by pressing -SHIFT-DATA-.

431 Press -NEXT- to continue.

432 end

433 next x07m4b

434 ***

260

435 unit x07m4b
 436 back x07m4a
 437 at 505
 438 write
 439
 440

For a SERIES circuit, R is the sum of the resistances in the circuit. (Caution: this is not true for a parallel circuit).

441 Individual series-element reactances are related
 442 to the element parameters, i.e., capacitance and
 443 inductance, and the frequency by the formulas:

$$X_L = \omega L = 2\pi fL \quad (\text{recall } \omega = 2\pi f)$$

$$X_C = -\frac{1}{\omega C} = -\frac{1}{2\pi fC}$$

$$X = X_L + X_C$$

448 These formulas will also be useful in the
 449 remainder of this experiment; you may obtain this
 450 display hereafter by pressing -SHIFT-LAB-.

451 end/
 452 next x07m4c
 453 ***

454 unit x07m4c
 455 base
 456 back x07m4c
 457 next x07m4c1
 458 at 605

459 write In a given circuit, one may measure either
 460 R and X , or $|Z|$ and θ_z , and expect the results
 461 to be in agreement with one another.

Set the Impedance Selector Switch to position 2.

462
 463 ***

464 unit x07m4c1
 465 pack n33,aa0000000000b0c0caba00000+00ba000
 466 join ckc
 467 jump n47,x07m4c,x07m4d
 468 pack n33,aa0000000000b0c0caba00000+00ba000
 469 join ckc2w
 470 ***

471 unit x07m4d
 472 zero n59 \$\$\$ used in next goto and writec
 473 base
 474 back x07m4c
 475 next x07m4e
 476 help x07s4b
 477 at 705

478 write Using the same 20 V p-p, 2 kHz signal from the
 479 AUDIO OSCILLATOR, determine the magnitude of this
 480 new impedance, Z .

Q




```

481 |Z| = _____ kΩ
482 -HELP- is available
483 join x07s4e
484 arrow 1118
485 store v50
486 ansv 3.5, 10%

```

----- part=1, block=h -----

block 1h, x07m4e

```

488 unit x07m4e
489 base
490 back x07m4d
491 next x07m4f
492 help x07s4d
493 lab x07s2e
494 at - 705
495 write To complete this calculation of Z in the polar
496 form,  $Z = |Z| \angle \theta$ , determine  $\theta$  by the time-
497 displacement method.

```

```

498 Recall that  $\theta = \frac{\Delta t}{T}$ 
499 enter T = _____ milliseconds

```

```

500 enter  $\Delta t$  = _____ milliseconds

```

```

501 at 2420
502 write -HELP- is available
503 at 1318
504 writec n59,(s,v61),,
505 at 1518
506 writec n59,(s,v60),,
507 goto n59,x07m4e1,x
508 arrow 1316
509 store v61
510 ansv .5
511 no
512 at 1722
513 write Set the frequency so T = .5 ms.
514 endarrow
515 arrow 1516
516 store v60
517 ansv .04,.05
518 endarrow
519 calc n59*-1

```

```

520 entry x07m4e1
521 at 1910
522 write enter  $\theta$  = _____
523 join x07s4e
524 arrow 1922
525 store v51

```

```

525 ansy      -(v60/v61)*360,1
527 wrongv   (v60/v61)*360,1
528 at       2105
529 write    Recall that  $\theta$  for a capacitive circuit is negative.
530          Press -LAB- for an explanation.
531 ***

```

```

532 unit     x07m4f
533 base
534 back     x07m4e
535 next     x07m4e
536 calc     v52+sin(v51°)
537 calc     v53+cos(v51°)
538 at       410
539 write    You have calculated Z in the polar form as

```

$$Z = |(s, v50) k\Omega| \angle (s, v51)^\circ$$

```

541          Using the identities available by pressing
542          -SHIFT-DATA-, express Z in the rectangular
543          form as  $Z = R + jX$ :

```

$$R = \frac{v50}{v51} k\Omega$$

```

546 at       1616
547 write    sin((s, v51)°) = (s, v52)

```

```

548
549          cos((s, v51)°) = (s, v53)

```

```

550 at       1213
551 writec   n59, (s, v54)
552 goto     n59, x, x07m4f1
553 join     x07s4e

```

```

554 arrow    1221
555 store    v54
556 ansy     v50/v50, 10%
557 no
558 at       1237
559 write    Units of Z and R are k $\Omega$ .
560 endarrow
561 zero     n59

```

```

562 entry    x07m4f1
563 at       1416
564 write    X = _____ k $\Omega$ 
565 join     x07s4e
566 arrow    1421
567 store    v55
568 ansy     v52/v55, 10%
569 wrongv   -(v52/v55), 10%
570 at       1437
571 write    You need a minus sign.
572 no
573 at       1437
574 write    Units of Z and X are k $\Omega$ .

```

part=1, block=1

block 11, x07m4g

576 unit x07m4g
577 base
578 back x07m4f
579 next x07m4h
580 help x07s4f
581 join x07s1b
582 at 144,428
583 erase 4
584 at 144,428
585 write
586 at 100
587 write
588 catchup
589 at 1005
590 write Using the reactance equations which are available
591 by pressing -SHIFT-LAB-, calculate the theoretical
592 value of the impedance of circuit 2, and express
593 Z in rectangular form, $R + jX$
594
595 $R = \text{-----} \text{ k}\Omega$
596 at 2514
597 writec n59,,, (s,v56)
598 goto n59,x,x,x07m4g1
599 arrow 2511
600 store v56
601 ansy 3.3
602 wrongy 3.4
603 at 2705
604 write Voltage is measured between Terminal 15 and ground
605 Note that the 1000 resistor is not included in
606 this measurement. It is used only for sensing the
607 impedance current.
608 no
609 at 2700
610 write For a series circuit, R is the sum of resistors.
611 endarrow
612 calc n59e1 \$\$ avoids rewriting after branching key hit

613 entry x07m4g1
614 at 1003
615 write -HELP- is available
616 at 2532
617 write $X = \text{-----} \text{ k}\Omega$
618 join x07s4e
619 arrow 2536
620 store v57
621 ansy -1.6,10%
622 wrongy -1600,10%
623 at 2631
624 write Check your units.
625 wrongy 1.6,10%
626 at 2631
627 write Almost! You forgot the minus sign ..

628 ***

629 unit x07m4h
630 base
631 back x07m4g
632 next x07en-1
633 at 509

634 write " You have measured the impedance of circuit
635 2 and expressed it in polar form as:

636
$$Z = |(s,v50) k\Omega| \angle (s,v51)^\circ$$

637 You converted Z to the rectangular form and expressed
638 Z as:

639
$$1) \quad Z = (s,v54) k\Omega + j (s,v55) k\Omega$$

640 Finally, you calculated the theoretical value of
641 Z in rectangular form and found:

642
$$2) \quad Z = (s,v56) k\Omega + j (s,v57) k\Omega$$

643 If the measured value of Z , equation 1, differs
644 greatly from the theoretical value, equation 2,
645 you may wish to discuss the discrepancy with your
646 instructor. Bear in mind, however, that the values
647 of the components used to obtain equation 2 are rated
648 at $\pm 10\%$. Also, recall the inherent $\pm 3\%$ error en-
649 countered when reading oscilloscope measurements.

----- part=1, block=j -----

block 1j. x07s1a

651 unit x07s1a
652 draw 313;337;737;713;313
653 circle 29.152,400
654 draw 241;349;849;841;241
655 circle 29.352,400
656 circle 3.350,400
657 circle 2.352,390
658 circle 3.340,390
659 circle 2.363,390
660 at 336,370
661 write 1
662 circle 3.200,416
663 circle 3.264,416
664 draw 1719;1741;2341;2319;1719
665 circle 3.160,208
666 circle 3.160,160
667 circle 3.304,176
668 circle 3.208,406
669 circle 3.264,406
670 at 261,380

671 write ↓
 672 at 205,308
 673 write ↓
 674 draw 1921;1221;1224;624;627;skip;208,406;224,406
 675 224,319;352;319;352,176;304,176;skip;352,390
 676 352,353;104,353
 677 at 101,349
 678 write ◆
 679 draw 2221;2421;skip;363,389;363,128;2421;skip;634;639
 600 1139;363,336
 601 at 360,332
 602 write ◆
 603 at 2322
 604 write IMPEDANCE BOARD
 605 at 2137
 606 write 15
 607 at 2221
 608 write 11
 609 at 1922
 690 write 1
 691 at 506
 692 write
 693 at 833
 694 write
 695 draw 2221;2233
 696 at 256,156
 697 write
 698 draw 2237;2239;2139
 699 at 248,163
 700 write 1000Ω
 701 at 1623
 702 write current-sensing
 703 resistor
 704 at 260,228
 705 write
 706
 707
 708
 709 draw 1921;1924;1824;1830;2030;2024;1924;skip;1930;1939
 710 2139
 711 at 1905
 712 write set switch to
 713 connect
 714 Term. 1 to 3
 715 draw 109,197;160,197
 716 at 159,193
 717 write
 718 at 950
 719 write NOTE:
 720 AUDIO OSC.
 721 ground strap
 722 should be dis-
 723 connected.
 724 draw 349;345,368
 725 at 342,368
 726 write
 727 draw 123,432;187,432;skip;520;152,460;152,403

```

728 at 1016
729 write VA →
730 at 929
731 write VB →
732 circle 3,232,406
733 draw 232,406;630;627
734 at 427
735 write trigger
736 input
737 ↓
738 at 221
739 write SET UP THIS CIRCUIT
740 at 2819
741 write Press -NEXT- when finished
742 end

```

----- part=1, block=k -----

block k, x07s1b

```

744 unit x07s1b
745 circle 8,104,432
746 draw 515;519
747 at 144,428
748 write →
749 at 176,428
750 write ●
751 at 170,444
752 write ●
753 at 173,412
754 write ●
755 at 161,400
756 write ●
757 at 144,396
758 write ●
759 at 419
760 write
761 draw 147,397;147,368
762 at 1019
763 write
764
765
766 at 1013
767 write 3.3kΩ
768 at 1021
769 write 0.05μF
770 draw 160,404;216,404;928
771 at 213,352
772 write ↑
773
774
775 at 0.30
776 write .5H
777 draw 630;635;835

```

778 at 269,368
779 write
780
781
782
783 draw 524;530
784 at 232,428
785 write
786 draw 534;543;943
787 at 393,352
788 write
789
790
791 at 1037
792 write 3.3k Ω
793 at 630
794 write .5H
795 draw 423;325;334
796 at 264,460
797 write -H
798 draw 336;351;951
799 at 397,352
800 write
801
802
803 at 1045
804 write 3.3k Ω
805 at 256,444
806 write .05 μ F
807 circle 8,400,304
808 draw 1251;400,311
809 draw 1350;147,304;147,321
810 at 213,304
811 write
812 at 269,304
813 write
814 at 333,304
815 write
816 draw 400,296;1551;1545
817 at 320,268
818 write
819 draw 1541;1515
820 circle 8,104,272
821 at 320,276
822 write 100 Ω
823 at 1352
824 write 15
825 at 1413
826 write 11
827 at 413
828 write 1
829 at 425
830 write 2
831 at 525
832 write 3
833 at 625
834 write 4


```

883 hbar  $\pi/2, 1, -$ 
884 hbar  $3\pi/2, -1, -$ 
885 hbar  $3\pi/4, .5, -$ 
886 hbar  $7\pi/4, -.5, -$ 
887 locate 0,.8
888 write + $\Delta t$ +
889 end
890 ***

```

```

891 unit x07s2c
892 origin 1815
893 axes 0, -128, 256, 128
894 scalex 2 $\pi$ 
895 scaley 1
896 labely 1,.25
897 markx  $\pi, .25\pi$ 
898 funct sin(v70), v70+0, 2 $\pi$ , .02 $\pi$ 
899 funct sin(v70-.25 $\pi$ )*.5, v70+0, 2 $\pi$ , .02 $\pi$ 
900 ***

```

```

901 unit x07s2d
902 at 305
903 write The following convention has been adopted
904 regarding the sign of  $\theta$ . Consider the
905 positive going slopes of the two waveforms.
906 The waveform whose peak appears on the left
907 is said to LEAD the other. Correspondingly,
908 the sinusoid whose peak appears on the right
909 is said to LAG the other.
910 end
911 ***

```

```

912 unit x07s2e
913 at 305
914 write The impedance angle  $\theta$  is defined as the
915 angle of the voltage wave with respect to
916 the current wave. Thus, if  $v(t)$  is leading,
917  $\theta$  is positive (inductive circuit); if  $v(t)$  is
918 lagging,  $\theta$  is negative (capacitive circuit);
919 if  $v(t)$  is neither leading nor lagging,  $\theta$ 
920 is zero (resistive circuit).
921 end
922 ***

```

```

923 unit x07s2f
924 at 305
925 write Note that the voltage waveform (displayed
926 on channel A) for this circuit leads the
927 current waveform; thus,  $\theta$  is positive, i.e.,
928 an inductive circuit.
929 ***

```

```

930 unit x07s3a
931 calc v141+50
932 calc v141+(v141) $^\circ$ 
933 calc v141+abs(v141)*.000001 $^\circ$ 
934 calc |v141+cos(v141)/sin(v141)

```

```

935 origin 2132
936 axes -120,-120,120,120
937 scalex 5
938 scaley 5
939 markx 1,.5
940 marky 1,.5
941 calc v1424/(sqrt(16-16(v1412/(v1412+1))))+4v141sqrt(v1412/(v1412+1))
942 funct v142*(sqrt(16-v1402)+v141*(v140)),v140e-4,+4,.1
943 funct -v142*(sqrt(16-v1402)-v141*(v140)),v140e+4,+4,.1
944 goto n52,x07s3b,x
945 end

```

----- part=1, block=m -----

block 1m, x07s3b

```

947 unit x07s3b
948 gdraw -8,-3;0,-3
949 gdraw -7.25,-2.75;-7.25,0.75
950 gdraw -7.25,2;-7.25,2.75
951 gdraw -8,3;0,3
952 gdraw -2,-4;8,-4
953 gdraw 3,4;8,4
954 gdraw 7.25,-3.75;7.25,0.75
955 gdraw 7.25,2;7.25,3.75
956 size 2
957 graph -9,1.2,2 A
958 size 5:7,1.2,2 B
959 size 0
960 end
961 ***

```

```

962 unit x07s3c
963 pack n33,(ij)+(no)d+(de)ce+++++++ (fg)<c(bcd)b(uv)>+
964 join ckd
965 jump n47,x07s3d,x
966 pack n33,a0a00000000b0c0gaba00000+00ba00,
967 join ckw
968 jump n47,x,x07m3c
969 pause
970 jump x07m3b
971 ***

```

```

972 unit x07s3d
973 base
974 next x07m3b
975 help x07s3e
976 at 309
977 write You have incorrectly set the dials.
978 Press -NEXT- to try again
979 Press -HELP- for a listing of your errors

```



```

980      Press -DATA- to see a typical Lissajous figure.
981  pause
982  keytype n51,data,next,help
983  goto   n51,x,x07s3a,x
984  jump   n51,x,x,x07m3b,x07s3e
985  ***

986  unit   x07s3e
987  pack   n33,(ij)+(no)d+(de)ce+++++++ (fg) <c (bcd) b (uv) >+
988  join   ckd1w
989  pause
990  jump   x07m3b
991  ***

992  unit   x07s3f
993  at     2510
994  write  ARCSIN CALCULATOR ( enter M/N )
995  arrow  2720
996  store  v109
997  ansy   v120/v121,5%
998  endarrow
999  calc   v102+45°
1000 calc   v101+0°
1001 calc   v103+90°
1002 entry  x07m3d1
1003 calc   v110+v109-sin(v102)
1004 goto   .0000001>abs(v110),x07m3d2,x
1005 calc   0>v110,v103+v102,v101+v102
1006 calc   v102+(v101+v103)/2
1007 goto   x07m3d1

1008 entry  x07m3d2
1009 calc   v102+(160/π)*v102
1010 at     2920
1011 write  θ = (t,v102)
1012 at     3110
1013 write  Press -NEXT- to enter θ above
1014 pause
1015 ***

1016 unit   x07s4b
1017 base
1018 at     705
1019 write  Recall that the Y Display Function must be

1020      set to A & B ALT. Also,  $|Z| = \frac{|V_{pp}|}{|I_{pp}|}$ , where
1021

1022      v is displayed on channel A, and channel B
1023      displays .1|i| where i is in milliamps.
1024 at     1610
1025 write  Press -NEXT- when you have correctly set then dials.
1026 pause
1027 pack   n33,(ij)(fgh)(no)d(ode)(de)cdb+++++++ (fg) <b (uv) c (bcd) >+
1028 join   ckdw
1029 next   n47,x07s4b,x

```

```

1030 jump n47,x,x07s4c
1031 ***

1032 unit x07s4c
1033 next x07m4e
1034 at 707
1035 write |Ipp| = _____ milliamps
1036 arrow 715
1037 ansv 5.7,10%
1038 no
1039 at 907
1040 write Recall that |i| = 10 |vB|, where i is in milliamps.
1041 endarrow
1042 at 1011
1043 write |Z| = _____ kΩ
1044 join x07s4e
1045 arrow 1018
1046 store v50
1047 ansv 3.5,10%

```

----- part=1, block=n -----

block in, x07end

```

1049 unit x07s4d
1050 next x07m4e
1051 help x07s4d1
1052 data x07s2b
1053 at 1108
1054 write Press -HELP- for explanations on setting the dials.
1055 Press -DATA- for assistance in determining θ.
1056 ***

1057 unit x07s4d1
1058 base
1059 next x07s4d
1060 join x07m2c
1061 pause
1062 pack n33.(ij)(fgh)(nq)w(tcde)(de)cdb+++++++ (fg) <b (uv) c (bcd) >+
1063 join chdw
1064 jump n47,x,x07m4e
1065 ***

1066 unit x07s4e
1067 mode erase
1068 at 3219
1069 write Press -NEXT- to enter your answer above
1070 mode write
1071 at 3337
1072 erase 20
1073 at 2938
1074 erase 15
1075 catchup

```



```

1076 draw      2717;2757;3057;3017;2717
1077 at        2819
1078 write    CGE Calculator.
1079          Enter Expression:
1080
1081 arrow     2837
1082 store    v100
1083 ok
1084 endarrow
1085 at        3038
1086 show     v100
1087 at        3219
1088 write    Press -NEXT- to enter your answer above
1089 pause
1090 ***

```

```

1091 unit      x07s4f
1092 at        511.
1093 write     The important equation for use in calculating
1094 the reactance, X, is:

```

$$jX_C = \frac{1}{j\omega C} = j \left(-\frac{1}{2\pi f C} \right)$$

```

1098 where f = 2,000 Hz.

```

```

1099 'π', if you would prefer to use the symbol,
1100 is obtained by pressing -MICRO- then pressing -p-.

```

```

1101 Note that your answer is requested in units
1102 of kΩ, where k = 103. The capacitance shown on
1103 the diagram is rated in units of μF, where μ = 10-6.

```

```

1104 end
1105 ***

```

```

1106 unit      x07s4g
1107 data1     x07m4a
1108 lab1      x07m4b
1109 ***

```

```

1110 unit      x07end
1111 back      x07m4a
1112 join      imode
1113 jump      n47,x07end;x
1114 course    n2
1115 calcc     n2='ee244',
1116           nc(n21+1) ← (nc(n21+1)$mask$0777777777700000000000) + 04603000000,
1117           nc(n21+1) ← nc(n21+1)
1118 erase
1119 output    /// student has completed experiment ///
1120 join      endunit
1121 join      jmpries
1122 jumpout   cgeindex,quest1

1123 entry    leave
1124 end      lesson
1125 ***

```

```

1126 unit      endunit
1127 course    n2
1128 jump      n2='ee?44',leave,x
1129 calc      nc(n21+7)←nc(n21+7)+ahelp
1130           vc(n21+6)←vc(n21+6)+atime/600000
1131 ***Incl.oge s.r. & terms sample,index,imode,comment,slides.
1132 use        eex00,ck1
1133 use        ck2
1134 use        ck3
1135 use        ck4
1136 use        ck5
1137 use        ck6

```

ckc	not found		104	466		
ckcw	not found		866	967		
ckc2w	not found		107	469		
ckd	not found		858	964		
ckdw	not found		136	1028	1063	
ckdiw	not found		861	988		
endunit	x07end	1126	20	1120		
imode	not found		31	1112		
jmpmes	not found		1121			
leave	x07end	1123	1128			
x07end	x07end	1110	632	1113		
x07m0a	eex07id	29	32	51		
x07m1a	x07m1a	49	79	411		
x07m1b	x07m1a	78	52	99	100	110
x07m1b1	x07m1a	98	80			
x07m1c	x07m1a	109	105	123		
x07m1d	x07m1d	122	134	140		
x07m1d1	x07m1d	133	134			
x07m1e	x07m1d	139	137	173		
x07m2a	x07m1d	172	186			
x07m2b	x07m2b	185	208	411		
x07m2c	x07m2b	206	187	223	327	856 100 864
x07m2d	x07m2b	200	251	867		
x07m2e	x07m2e	248	224	272	324	
x07m2f	x07m2e	270	252			
x07m2f1	x07m2e	294	281			
x07m2f2	x07m2e	304	296			
x07m2a	x07m2e	321	222	339	350	
x07m3b	x07m3b	337	325	354	970	974 990 984
x07m3c	x07m3b	352	371	411	968	
x07m3c1	x07m3b	360	372			
x07m3d	x07m3b	368	350	411		
x07m3d1	x07m3b	1002	1007			
x07m3d2	x07m3b	1000	1004			
x07m3e	x07m3b	396	52	353	370	870
x07m4a	x07m4a	413	411	411	436	1107 1111
x07m4b	x07m4a	435	433	1108		
x07m4c	x07m4a	454	452	456	467	474
x07m4c1	x07m4a	464	457			
x07m4d	x07m4a	471	467	490		
x07m4e	x07m4e	488	475	534	1033	1050 1064
x07m4e1	x07m4e	520	507			
x07m4f	x07m4e	532	491	578		
x07m4f1	x07m4e	562	552			

x07m4g	x07m4g	576		535	631																	
x07m4g1	x07m4g	613		598																		
x07m4h	x07m4g	629		579																		
x07s1a	x07s1a	651		101	326																	
x07s1b	x07s1b	744		111	581																	
x07s2a	x07s2a	855		207																		
x07s2a1	x07s2a	863		859																		
x07s2b	x07s2a	869		187	225	1852																
x07s2c	x07s2a	891		253	888																	
x07s2d	x07s2a	901		254	261	273																
x07s2e	x07s2a	912		263	266	274	493															
x07s2f	x07s2a	923		268																		
x07s3a	x07s3a	938		349	365	983																
x07s3b	x07s3b	947		366	948																	
x07s3c	x07s3b	962		348	358																	
x07s3d	x07s3b	972		965																		
x07s3e	x07s3b	986		975	984																	
x07s3f	x07s3b	992		392																		
x07s4b	x07s3b	1016		476	1029																	
x07s4c	x07s3b	1032		1038																		
x07s4d	x07end	1049		402	1059																	
x07s4d1	x07end	1057		1051																		
x07s4e	x07end	1066		168	244	483	565	523	610	553												
				1044																		
x07s4f	x07end	1091		588																		
x07s4g	x07end	1106																				
abs		933	1004																			
ahelp		1130																				
etime		1130																				
cos		537	934																			
n0		1116	1116	1117	1117	1129	1129															
n2		1114	1115	1127	1128																	
n3		1116	1116	1117	1117	1129	1129	1130	1130													
n3d		103	106	135	465	468	865	857	963	868												
		966	967	1027	1062																	
n47		34	105	137	467	859	968	867	1029	965												
		1000	1004	1143																		
n51		299	290	281	298	295	348	296	349	303												
		357	962	983	984																	
n52		337	373	944																		
n55		35	52	187	353	410		411		870												
n59		472	584	586	587	519	561	551	597	552												
		530	612																			
n99		4	34	202	326	327		335														
sirr		536	899	899	934	1003																
sqrt		941	942	943																		
vc		1130	1130																			
v100		1082	1080																			
v101		1000	1005	1006																		
v102		394	999	1002	1005	1005	1007	1008	1011	1009												
v103		1001	1005	1006																		
v109		996	1003																			
v110		1003	1004	1005																		
v120		382	997																			
v121		385	997																			
v140		942	942	942	943	943		943														
v141		931	932	932	933	933	934	934	941	934												

	941	941	941	942	943				
v141sq	941	942	943						
v142	941	942	943						
v58	485	548	556	568	569	636	1846		
v51	525	548	547	549	636				
v51°	536	537							
v52	536	547	568	569					
v53	537	549	556						
v54	551	555	539						
v55	567	639							
v56	547	600	642						
v57	600	642							
v60	212	246	506	516	526	527			
v61	239	246	504	509	526	527			
v70	308	898	899	899					
	394	486	556	568	569	625	621	797	622
	1037	1047							
A	957								
B	958								
-	883	884	885	886					
I	882								
2	902	903	900	1000	1001				
T	883	883	884	885	886	897	894	898	897
	898	849	899	899	1009				

lesson information

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 at site 17, station 18
 author name = J P Neal
 department = EE
 telephone number = 333-4351
 discipline = EE
 grade level = Freshman
 description of lesson = Measurements of Impedance.



----- part=1, block=a -----

block 1a, cex08id

2 stop
3 0000 For Neal, CGERL, Room 240, EEB.

4 One line description of this lesson --

5 Measurements of Two-Port Networks.

6	Divisions of this Lesson:	Block	Unit
7	Id for this file	cex08id	
8	Experiment cex08		
9	Objectives,	x08m0a	x08m0a
10	Definition of two-port network	x08m1a	x08m1a
11	Voltage gain of a two-port	x08m2a	x08m2a
12	Frequency response of two-port	x08m3a	x08m3a
13	Final test	x08m4a	x08m4a

14 final.edit 21 aug 74 neal.

15 *list info

16 *list symbols

17 *list varian,charset,cgeindex,cgechar

18 ****

19 start

20 finish endunit

21 write igt,1010 Loading the CGE Character Set

22 charset cgeindex,cgechar

23 erase

24 dataon

25 area cex08

26 ext 0

----- part=1, block=b -----

block 1b, x08m0a

28 unit x08m0a

29 next x08m1a

30 define x08def

31 err=n50

32 errmess=n51

33 it=n52 \$\$ specifies input terminal of two port

34 ot=n53 \$\$ specifies output terminal of two port

35 f₀=v54

36 f₀=v56

37 zero err



```

38 restart
39 join imode
40 jump n47, x88m0a, x
41 at 417
42 write MEASUREMENTS OF TWO-PORT NETWORKS
43 at 385
44 write When you have completed this experiment, you should
45 be able to:
46
47 1. Understand the definition of a two-port network.
48
49 2. Measure the voltage-gain transfer function of a
50 two-port network.
51
52 3. Measure the frequency response of the voltage
53 gain of a two-port network.
54
55 4. As a final test, measure the frequency response
56 of the voltage gain of a band-pass filter.

```

----- part=1, block=c -----

block 1c, x88mia

```

54 unit x88mia
55 back x88m0a
56 next x88m1b
57 at 387
58 write Throughout this lesson we will represent a network
59 by a box which may be thought of as containing the
60 network.

```

```

61 Leads brought out of the box indicate that
62 certain terminals or nodes of the network are
63 externally accessible. That is, we can connect to
64 or measure between these terminals or nodes.
65 draw 1723;1742;2342;2333;1725;2123;2117;skip;1923;1917
66 skip;1942;1948;skip;2142;2148;skip;2335;2735
67 skip;2730;2330

```

```

68 at 219,187
69 write NETWORK
70 circle 3,128,208
71 circle 3,128,176
72 circle 3,376,176
73 circle 3,376,208
74 circle 3,232,80
75 circle 3,272,80
76 vector 252,41;272,80
77 vector 252,41;232,80
78 at 208,21
79 write TERMINALS
80 ***

```

```

81 unit x88m1b

```

82 term mib
 83 back x08mia
 84 next x08mic
 85 at 307
 86 write A pair of terminals is called a port. A two-port
 87 network is, therefore, a network with two pairs of
 88 external terminals.

89 In a two-port network, one of the ports is usually
 90 connected to a source, and the other port is usually
 91 connected to a load.

92 For the arrangement shown below, the following
 93 four electrical quantities can be measured:

$$I_1, V_1, I_2, \text{ \& } V_2.$$

94
 95 join x08sia
 96 join x08sib
 97 join x08sic
 98 at 2705

99 write Throughout this experiment, we will assume that the
 100 impedance Z_L is a very high impedance, i.e., that the
 101 magnitude of I_2 is small compared to the magnitude of I_1 .

----- part=1, block=d -----

block 1d, x08mic

103 unit x08mic
 104 back x08mib
 105 next x08mid
 106 at 307

107 write Consider any port, or pair of terminals, in a network
 108 driven by a single-frequency sinusoidal power source.
 109 Conventions used here for the voltage and current are:



115 When displayed on the SCOPE, the convenient measures
 116 of a voltage are V_{pp} and the time angle ϕ_V after $t = 0$,
 117 where the voltage is positive-going through $v = 0$.

118 Then, the voltage is expressed mathematically by:

119
$$v(t) = 0.5V_{pp} \sin(\omega t + \phi_V) = V_{pp} \sin(\omega t + \phi_V)$$

120 Here, this voltage is expressed as a phasor by:

121
$$V = |V| \angle \phi_V \text{ where } |V| = 0.707 V_{pp}$$

122 Similarly, the current representations are:

123 $i(t) = I_{pp} \sin(\omega t + \phi_1)$, $I = |I| \angle \phi_1$, $|I| = 0.707 I_{pp}$
124 ***

125 unit x08m1d
126 back x08m1c
127 next x08m2a
128 at 505

129 write A transfer function is a relation between two
130 activities at two different ports in a network. This
131 contrasts with an impedance function which is a relation
132 between two activities at the same port in a network.

133 The transfer function called the voltage gain is
134 of interest in this experiment. We will refer to it
135 hereafter simply as the gain G and define it by:

136 $G = |G| \angle \phi_G = V_2 / V_1 = (|V_2| / |V_1|) \angle (\phi_{V_2} - \phi_{V_1})$

137 The gain is a complex quantity and can also be
138 written in complex form, like we did for impedances
139 in the impedance experiment, as:

140 $G = G_{re} + j G_{im}$

part=1, block=e

block 1e, x08m2a

142 unit x08m2a
143 back x08m1d
144 next x08m2b
145 at 405

146 write Now consider the two-port shown below, where port 1
147 is the driven port, and port 2 is the load port.

148 If $V_1 = 15$ V dc and $V_2 = 3$ V dc,; what is the gain G?

149 join x08s1a
150 join x08s1c
151 join x08s1b
152 arrow 926
153 at 926

154 write
155 ansv .20,.05
156 wrong 3
157 at 1111

158 write No, the gain of the two port is defined as the
159 ratio V_2/V_1 .

160 ***

161 unit x08m2b
162 back x08m2a
163 next x08m2c

164 help x08s2a
165 at 405
166 write Now suppose you are given another two-port network.

167 $V_{1pp} = 10 \angle 0^\circ$ V drives port 1.

168 V_2 is then measured as $V_{2pp} = 5 \angle +31^\circ$.

169 What is the voltage gain G of the two-port in polar form,
170 i.e., in the form $|G| \angle \alpha^\circ$? (Press -MICRO- then o for °.)

171 join x08s1a
172 join x08s1c
173 join x08s1b
174 at 1210
175 write Magnitude _____ Phase angle _____
176 at 3132
177 write -HELP- is available.
178 arrow 1220
179 ansy 5
180 arrow 1240
181 answer degrees, deg. ° 31
182 wrong degrees, deg. ° -31
183 434

184 unit x08m2c
185 back x08m2b
186 next x08m2d
187 help x08s2b
188 at 405

189 write Consider the resistive two port network shown below.

190 If $V_1 = 10$ V dc, what is V_2 and G .

191 $V_2 =$
192 at 817
193 write 830 V dc.
194 at 830
195 write $G =$
196 join x08s1d
197 join x08s1a
198 join x08s1c
199 at 3132

200 write HELP is available
201 arrow 817
202 ansy 5
203 no
204 at 1005

205 write Hint: Think of the two-port network as a simple
206 voltage divider. Note also that -HELP- is available.

207 arrow 833
208 ansy 5
209 no
210 at 1011
211 write You got V_2 correct, now simply use the formula
212 $G = V_2 / V_1$ to find the voltage gain.

part=1, block=f

block lf. x08m2d

214 unit x08m2d
215 back x08m2c
216 next x08m2e
217 calc ite1
218 at ct+3
219 at +05

220 write- Let's try to verify this last result experimentally.
221 The resistive two-port just studied is part of the
222 the superposition circuit. Plug in the sensor cable
223 of the SUPERPOSITION BOARD, ITEM 38, and place all
224 the switches on the board (SW1 through SW4) in the
225 up position.

226 You should now have the following two-port network:

227 join x08m1
228 join x08m1a
229 join x08m1c
230 at 1017
231 write 1
232 at 1043
233 write
234 at 2316
235 write 11
236 at 2347
237 write 11
238 pause
239 at 2320
240 write
241 at 1005

242 write- In this experiment, terminal 1 is used as the
243 common grounded terminal.

244 ***

245 unit x08m2e
246 back x08m2d
247 next x08m2f
248 calc enrress+0
249 zero enr
250 join x08s2h
251 end
252 ***

253 unit x08m2f
254 pack n33,+++efhe++a++a(abcd)+aaa++l
255 join ckd
256 jump n47,x08s2c,x

257 entry x08m2g
258 pack n33,aacdd0cc00k0k00ac0000000000akc0
259 join chc
260 calc enrress+0

```
261 errren47
262 jump n47,x08s2d,x08m2h
263 ***
```

```
264 unit x08m2h
265 erase
266 catchup
267 back x08m2d
268 next x08m2j
269 zero err
270 at 405
```

```
271 write Measure the gain of the two-port by setting the
272 following dials:
```

```
273 1) Set the OSCILLOSCOPE to display a 1 kHz sine
274 wave with an amplitude in the range  $5 \leq V_{pp} \leq 10$  V.
275 Set the Y DISPLAY to A, the A PRE AMP to AC,
276 the TRIGGER SOURCE to AC INT, and the SWEEP MODE to
277 AUTO.
```

```
278 2) Set the RANGE control of the VACUUM TUBE VOLTMETER
279 to 3 RMS VOLTS.
```

```
280 3) Adjust the frequency controls of the AUDIO
281 OSCILLATOR to produce a 1 kHz sine wave output.
282 Temporarily connect the VTVM INPUT to terminal
283 (z, it) of the two-port network and then
284 adjust the AMPLITUDE dial of the AUDIO
285 OSCILLATOR to give a 2 rms V reading on the VTVM.
```

```
286 4) Now reconnect the VTVM INPUT to terminal (z, ot) of
287 the two-port network.
```

```
288 end
289 join x08m2i
290 ***
```

```
291 unit x08m2i
292 at 2005
293 write After setting these dials, press -NEXT-.
294 ***
```

```
295 unit x08m2j
296 pack n33,+(gh)mecfbab+++++++ (bc) b (pq) h
297 join ckd
298 calc errmess+0
299 errren47
300 jump n47,x08s2f,x08m2k
```

part=1, block=g

block 1g, x08m2k.

```
302 unit x08m2k
303 back x08m2h
```

304 next x08m2l
305 at 405
306 write You have now correctly set up the two-port network
307 for gain measurements. Without changing the
308 AMPLITUDE dial of the AUDIO OSCILLATOR at all;
309 measure the output port voltage (terminal 3) on the VTVM.

310 What is value that you read on the VTVM?

311 arrow 1110
312 at 1110
313 write rms V

314 store v52
315 ansy 1.5%
316 at 1605

317 write The input voltage V_1 to the two-port network was
318 set above to 2 rms V.

319 The output voltage, V_2 that you obtained was
320 (2. v52) rms V.

321 What is the voltage gain of the two port?

322 arrow 2417
323 ansy v52=2.5%
324 wrongy 1.5%
325 at 1605

326 write Remember the voltage gain of a two-port is defined
327 as V_2/V_1 , not V_1/V_2 !!!

328 no
329 at 1605

330 write You have miscalculated the voltage gain G.
331 Check again to make sure that V_1 is 2 rms V,
332 and remeasure the output port voltage, V_2 .

333 write x08m2l

334 write
335 set up

336 back x08m2k
337 next x08m2n
338 at 805

339 write Now vary the frequency of the AUDIO OSCILLATOR, making
340 sure to keep the input voltage V_1 constant as you do this.
341

342 entry x08m2m

343 at 1005

344 write It may be helpful to first set V_1 to 2 rms V, at a
345 particular frequency (e.g. 1 kHz). Then, with A VOLTS
346 FULL SCALE set to 5 V, take the A PRE AMP. off of
347 calibration. This is done by rotating the red knob
348 marked VARIABLE GAIN counter-clockwise.

349 By adjusting the VARIABLE GAIN, set the peak-to-peak
350 deflection on the SCOPE to exactly 10 divisions and leave
351 it there.

352 Thereafter, as you rotate the frequency dial of the
353 AUDIO OSCILLATOR, readjust only the AUDIO OSCILLATOR
354 AMPLITUDE control to maintain a constant peak-to-peak
355 deflection on the SCOPE.
356 end.

----- part=1, block=h -----

block 1h, x08m2n

358 unit x08m2n
359 back x08m21
360 next x08m2o
361 lab x08m2m
362 at 805
363 write Do you notice any change in the amplitude of the
364 output voltage on the VTVM, as the input frequency
365 to the two-port is varied?
366 arrow 1220
367 answer (n, no, N, No)
368 at 1405
369 write Right! As long as the input amplitude to a resistive
370 two-port is held constant, the output voltage
371 amplitude will not vary as a function of frequency.
372 This is because the impedance of a resistor is
373 independent of frequency and hence the voltage
374 gain of a resistive two-port is independent of
375 frequency.
376 wrong (y, yes, Y, Yes, some)
377 at 1405
378 write Make sure that you keep the input voltage
379 to the two-port constant as you vary the frequency.
380 Press LAB- if you need a hint on how to do this.
381 ***

382 unit x08m2o
383 at 805
384 write If you have taken the A VOLTS off of calibration
385 by adjusting the red VARIABLE GAIN knob, place
386 the A VOLTS back into calibration by rotating
387 the red VARIABLE GAIN dial fully clockwise until
388 it clicks.

389 * When the A channel is in its calibrated mode,
390 the A VOLTS window will be lit.
391 pause

392 entry x08m2p
393 join imode
394 jump n47, x08m2p, x08m3a

----- part=1, block=i -----

436 . Press -NEXT- after you have properly set the dials.

437 ***

438 unit x08m3e
439 pack n33,++m+cfbab+ii+++++bb (pq) h
440 join ckd
441 calc errmess+1
442 enr+n47
443 jump n47,x08s2f,x08m3f
444 ***

445 unit x08m3f
446 back x08m3d
447 next x08m3g
448 data x08m2m
449 at 405

450 write Now, monitoring the output port with the VTVM,
451 vary the AUDIO OSCILLATOR frequency over the range
452 of 20 Hz to 100 Hz, while keeping the voltage
453 amplitude at the input port constant.

454 at 905

455 write Press -DATA- for a hint on keeping the input
456 port voltage amplitude constant.

457 at 1405

458 write Does the output voltage vary as a function of
459 frequency?

460 arrow 1524

461 answer (y, Y, yes, Yes)

462 at 1705

463 write Right! If the input port voltage V_1 is held
464 constant, the output port voltage V_2 will vary as
465 a function of frequency.

466 Our next goal will be to predict the frequency response
467 of the gain of a simple two-port RC network.

468 Leave your equipment setup alone, as it will be
469 used later.

470 wrong (n, N, no, No)

471 at 1710

472 write Make sure that you are keeping the input
473 port voltage constant and that you are varying
474 the AUDIO OSCILLATOR over the correct frequency
475 range.

476 ***

477 unit x08m3g
478 back x08m3f
479 next x08m3h
480 lab x08s2b
481 at 405

482 write The gain G of the two port you have just connected
483 may be analyzed easily by using the voltage divider
484 concept, where impedances are used instead of resistances.

485 When I_2 is negligible with respect to I_1 , the gain
486 of the two-port under study, is approximated by:

487
488

$$G(j\omega) = \frac{V_1}{V_2} = \frac{j\omega RC}{1 + j\omega RC}$$

489

where $R = 2 \text{ k}\Omega$, $C = .1 \text{ }\mu\text{F}$, and $\omega = 2\pi f$.

490
491

Note that the gain is now a function of frequency, and may be designated by $G(j\omega)$.

492

To review the voltage divider concept, press -LAB-.

493

We will now measure $G(j\omega)$ as a function of frequency.

part=1, block=k

block {k, x08m3h

495 unit x08m3h
496 back x08m3g
497 next x08m3i
498 at 405

499 write
500

The magnitude of $G(j\omega)$ in decibels (abbreviated dB) is defined by $|G(j\omega)|_{dB} = 20 \times \log_{10} |G(j\omega)|$ dB

501
502
503
504

The advantage of using the decibel or logarithmic notation is that it permits the easy computation of the magnitude of a product of gain functions, by simply adding the individual decibel values, i.e.:

505

$$|G_1(j\omega)G_2(j\omega)|_{dB} = |G_1(j\omega)|_{dB} + |G_2(j\omega)|_{dB}$$

506
507

It may also be noted that the phase angle of the product of two gains is simply the sum of their angles:

508

$$\angle G_1(j\omega)G_2(j\omega) = \angle G_1(j\omega) + \angle G_2(j\omega)$$

509
510
511
512 ***

The measurement of $|G|_{dB}$ is facilitated by the use of the VTVM's dB scale. The use of this scale in measuring $|G|_{dB}$ will be covered next.

513 unit x08m3i
514 back x08m3h
515 next x08m3j
516 at 204

517 write

USE OF THE dB SCALE ON THE HP400D VTVM

518
519

A decibel is defined as $20 \log_{10} a/b$, i.e., 20 times the log to the base 10 of the ratio of two numbers.

520
521

For our use (finding the gain of a two-port), the dB scale on the VTVM makes gain measurements easy.

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562

The dB scale on the VTVM is calibrated in terms of the ratio of the measured voltage V_2 to the reference voltage. The reference voltage used on the VTVM is $V_r = 0.775$ rms V. Hence, the dB reading on the VTVM of any voltage is

$$|V_x|_{dB} = 20 \log_{10} |V_x/V_r| = 20 \log_{10} |V_x| + 20 \log_{10} |0.775|$$

In making a gain measurement, it is convenient to set the VTVM to the proper voltage scale to read $|V_2|$, but before reading it, readjust V_r so the pointer indicates 0 dB on the dB scale. Then the value of $|V_2|_{dB}$ is that value, 0 dB, plus the label on the RANGE dial setting.

Next, without further adjusting V_r , measure V_1 on the dB scale, adjusting the RANGE switch so as to give the most accurate reading. Then, $|V_1|_{dB}$ is the sum of the dB reading and the dB RANGE label. Finally

$$|V_2/V_1|_{dB} = |V_2|_{dB} - |V_1|_{dB}$$

end

part=1, block=1

block 11, x08m3j

538 unit x08m3j
540 base
541 back x08m3i
542 next x08m7ik
543 lab x08m m
544 al 405

Now measure the frequency response of $|G|_{dB}$:

1) At 5 kHz, adjust the A.O. AMPLITUDE dial so that the VTVM, which is currently displaying V_2 , reads 0 dB, when the RANGE dial is set to +10 dB.

2) Now keeping V_1 constant, decrease the frequency of the A.O. until the gain is down 3 dB from its 5 kHz value.

Press <LAB> for a suggestion on keeping V_1 constant.

At what frequency is the gain down 3 dB? Hz.

554 arrow 1640
555 store f
556 ansv 66.5.5%
557 wrong
558 at 1805

The frequency at which $|G|_{dB}$ is down 3 dB from its high frequency value is known as the corner frequency, f_c , of the two port.

563 unit x08m3k
 564 back x08m3j
 565 at 410
 566 write Measure $|G|_{dB}$ at .5,.7,1,2,3,5,& 10 times f_0 .

567 FREQUENCY (Hz) $|G|_{dB}$
 568 .5 $\times f_0$ = (<e,.5 $\times f_0$ > Hz
 569 .7 $\times f_0$ = (<e,.7 $\times f_0$ > Hz
 570 1 $\times f_0$ = (<e,1 $\times f_0$ > Hz
 571 3 $\times f_0$ = (<e,3 $\times f_0$ > Hz
 572 5 $\times f_0$ = (<e,5 $\times f_0$ > Hz
 573 10 $\times f_0$ = (<e,10 $\times f_0$ > Hz
 574 calc n610640
 575 n61061

576 entry x00m3l
 577 calc n610n61+1
 578 scales (n61-63),v70e-6,5,-4.7,-3,-.5,-.3,0
 579 arrow (n60+n60+200)
 580 store v(n61)
 581 ansy v70,.3
 582 order row
 583 inhibit erase
 584 goto (n61>66),x08m3m,x08m3l
 585 ***

586 unit x08m3m
 587 next x08m3n
 588 back x08m3k
 589 at 2105
 590 write To make evaluation of your data more meaningful,
 591 the data above will be plotted when you press -NEXT-.
 592 ***

593 unit x08m3n
 594 back x08m3k
 595 erase
 596. origin 100,100
 597 axes 300,300
 598 lscalex 10000,10
 599 scaley 0,-10
 600 markx 20,10,2
 601 labely 2,1,0
 602 gdraw (.5 $\times f_0$),v62;(0.7 $\times f_0$),v63; f_0 ,v64;(2 $\times f_0$),v65;(3 $\times f_0$),v66;(5 $\times f_0$),v67;(10 $\times f_0$),v68
 603 write (<at,2713>10¹ 10² Hz 10³ 10⁴
 604 write (<at,1606>)dB
 605 at 205

606 write The graph below is known as a Bode plot of the
 607 gain. Note that the vertical scale is a linear plot
 608 of logarithmic values, and the horizontal scale is
 609 a logarithmic plot of frequency values.

block in, x08m3r

655 unit x08m3r
 656 back x08m3p
 657 next x08m3s
 658 data x08m2h
 659 calc it+4
 660 et+5
 661 at 405
 662 write Set the dials on the equipment to measure $|G|_{dB}$
 663 of this two port network. Use the same dial settings
 664 that you used to measure $|G|_{dB}$ of the high pass filter.
 665 Press -DATA- to review the needed dial settings.
 666 ***
 667 unit x08m3s
 668 pack n33,++m+cfbab+++++++bb (pq) h
 669 join ckd
 670 calc errmess+2
 671 err+n47
 672 jump n47,x08s2f,x08m3t
 673 ***
 674 unit x08m3t
 675 back x08m3r
 676 next x08m3u
 677 lab x08m2l
 678 at 405
 679 write Now measure the frequency response of $|G|_{dB}$ as follows:
 680 1) At 100 Hz, adjust the A.O. AMPLITUDE dial so that
 681 the VTVM (which is currently displaying V_2) reads 0 dB,
 682 when the RANGE dial is set to the +10 dB scale.
 683 2) Now keeping V_1 constant, increase the frequency of the
 684 A.O. until the gain is down 3 dB from its 100 Hz value.
 685 Press -LAB- for a suggestion on keeping V_1 constant.
 686 At what frequency is the gain down 3 dB? Hz.
 687 arrow 1549.
 688 store f₀
 689 ansy 1820.3%
 690 wrong
 691 at f805
 692 write The frequency at which $|G|_{dB}$ is down 3 dB from its
 693 low frequency value is known as the corner frequency
 694 f₀ of this network.

block 2a, x00m3u.

696 unit x00m3u
697 back x00m3t
698 lab x00m31
699 base
700 at 400
701 write

Measure $|G|_{dB}$ of this two port as indicated below.

702 Press -LAB- to review the measurement procedure.

703 at 810

704 write FREQUENCY $|G|_{dB}$

705 $.1 \times f_0 = (e, .1 \times f_0)$ Hz

706 $.2 \times f_0 = (e, .2 \times f_0)$ Hz

707 $.5 \times f_0 = (e, .5 \times f_0)$ Hz

708 $.7 \times f_0 = (e, .7 \times f_0)$ Hz

709 $1 \times f_0 = (e, 1 \times f_0)$ Hz

710 $2 \times f_0 = (e, 2 \times f_0)$ Hz

711 $3 \times f_0 = (e, 3 \times f_0)$ Hz

712 $5 \times f_0 = (e, 5 \times f_0)$ Hz

713 $10 \times f_0 = (e, 10 \times f_0)$ Hz

714 calc n00e040

715 n01e09

716 entry x00m3v

717 calc n61en61+1

718 calcs (n61-101), v70e0, -.2, -1, -1.9, -3, -7.2, -10:1, -14, -20

719 arrow (n60en60+200)

720 store v(n61)

721 ansy v70, .3

722 no

723 endarrow

724 inhibit erase

725 goto (n61>107), x00m3w, x00m3v

726 ***

727 unit x00m3w

728 back x00m3u

729 next x00m3x

730 at 2005

731 write To make evaluation of your data more meaningful,
732 the data above will be plotted when you press -NEXT-.

733 ***

```

734 unit    x08m3x
735 back    x08m3u
736 next    x08m4a
737 erase
738 origin  100,100
739 axes    300,300
740 lscalex 100000,100
741 scaley  0,-25
742 markx   20,10,2
743 labely  5,1,0
744 gdraw   (.1*f0),v100; (.2*f0),v101; (.5*f0),v102; (.7*f0),v103; f0,v104
745 gdraw   f0,v104; (2*f0),v105; (3*f0),v106; (5*f0),v107; (10*f0),v108
746 write   (at,2713)102 Hz 103 Hz 104 Hz 105 Hz
747 write   (at,1606)dB
748 at      205
749 write   The graph below is the Bode plot of |G|dB for the two
750         port network you currently have set up.

```

```

751         Note that the plot differs from the Bode plot of the
752         high-pass filter previously studied.
753 at      2805
754 write   Since low frequencies are passed and high frequencies
755         are attenuated, this two port network is known as
756         a low-pass filter.

```

----- part=2, block=b -----

block 2b, x08m4a

```

758 unit    x08m4a
759 restart
760 base
761 back    x08m3x
762 next    x08m4b
763 erase
764 catchup
765 at      405
766 write   The great utility of the Bode-plot method of
767         recording G vs f is easily demonstrated.

```

```

768         Consider the two gains you have evaluated experimentally
769         for the high-pass and low-pass filters. The gain for
770         a filter consisting of those two filters cascaded is
771         simply the product of the gains of the individual filters.

```

```

772         The 2 two-ports are cascaded simply by connecting
773         Terminal 3 to Terminal 4. The input port is then Terminals
774         1 & 2, and the output port is Terminals 5 & 2. Note
775         that Terminal 2 is the common ground terminal.

```

```

776         The gain |G|dB of this composite filter, using
777         your calculated values, is shown in the next display.
778 ***

```

```

779 unit x08m4b
780 origin 75,100
781 axes 350,300
782 scalex 1000000,10
783 scaley 0,-25
784 markx 20,10,2
785 labely 5,1,0
786 write (at,2700)101 102 103 104 105
787 write (at,28,241)|G|dB
788 write (at,2831)f (Hz)
789 gdraw (.5xf0),v62; (.7xf0),v63; f0,v64; (2xf0),v65; (3xf0), (v66+v100);
790 gdraw (3xf0), (v66+v100); (5xf0), (v67+v101); (10xf0),v68
791 gdraw (10xf0),v68; (.5xf0),v102; (.7xf0),v103; f0,v104; (2xf0),v105; (3xf0),v106;
792 gdraw (3xf0),v106; (5xf0),v107; (10xf0),v108

```

----- part=2, block=c -----

block 2c, x08m4c

```

794 unit x08m4c
795 base
796 back x08m4a
797 data x08m2h
798 lab x08s2i
799 help x08m2l
800 calc it+1
801 ct+5
802 at 405

```

803 write Check the preceding display experimentally, by measuring
804 and entering |G|_{dB} in the table below:

	FREQUENCY	G _{dB}
805		
806	50 Hz	
807	100 Hz	
808	200 Hz	
809	500 Hz	
810	1 kHz	
811	2 kHz	
812	5 kHz	
813	10 kHz	
814	15 kHz	
815	at 2000	
816	write Press -DATA- to review the dial settings.	
817	-LAB- to review the connections.	

```

818          -BACK- for the terminal numbers of the two-port.
819          -HELP- for a hint on keeping  $V_1$  constant.
820 calc      n60+839
821          n61+110

822 entry    x08m4d
823 calc     n61+n61+1
824 calcs    (n61-112),v70+-.4.3,-.1.8,-.75,-.6,-1.3,-2.8,-9.5,-15,-18.2
825 arrow    (n60+n60+200)
826 store    v(n61)
827 ansv     v70,.5
828 no
829 endarrow
830 inhibit  erase
831 goto     (n61>110);x08m4e,x08m4d
832 ***

833 unit     x08m4e
834 next     x08m4f
835 mode     rewrite
836 at       2005          $$ blank lines needed for rewrite
837 write    Press -NEXT- to see your experimental values
838          superimposed as *'s on the calculated Bode plot.
839
840
841 ***

842 unit     x08m4f
843 erase
844 origin   75,100
845 axes     350,300
846 lscalex  1000000,10
847 scaley   0,-25
848 markx    20,10,3
849 labely   5,1,0
850 write    (at,2709)101      102      103      104      105
851 write    (at,28,241)|G|dB
852 write    (at,2831)f (Hz)
853 gdraw    (.5*f0),v62;(1.7*f0),v63;f0,v64;(2*f0),v65;(3*f0),v66+v100;
854 gdraw    (3*f0),v66+v100;(5*f0),v67+v101;(10*f0),v68
855 gdraw    (10*f0),v68;(1.5*f0),v102;(1.7*f0),v103;f0,v104
856 gdraw    f0,v104;(2*f0),v105;(3*f0),v106;(5*f0),v107
857 gdraw    (5*f0),v107;(10*f0),v108
858 graph    50,v111,*
859 graph    100,v112,*
860 graph    200,v113,*
861 graph    500,v114,*
862 graph    1000,v115,*
863 graph    2000,v116,*
864 graph    5000,v117,*
865 graph    10000,v118,*
866 graph    15000,v119,*
867 at       2005
868 write    Note that this two port network attenuates frequencies
869          greater than 600 Hz and less than 200 Hz. Because of this
870          characteristic, this network is known as a band-pass filter.
871 pause

```

block 2d, x08sia

```

874 unit x08sia
875 draw 1723;1742;2342;2323;1723
876 draw 1823;1817;skip;2223;2223;2217
877 circle 3,128,160
878 circle 3,128,224
879 at 1817
880 write +
881 at 128,168
882 write -
883 at 128,188
884 write V1
885 at 1719
886 write I1
887 at 1819
888 write →
889 draw 1842;1848
890 circle 3,376,224
891 at 373,207
892 write +
893 draw 2242;2248
894 circle 3,376,160
895 at 375,171
896 write -
897 at 372,184
898 write V2
899 at 348,224
900 write →
901 at 348,240
902 write I2
903 ***

904 unit x08sib
905 draw 1848;426,224
906 at 423,208
907 write
908
909
910
911 draw 426,160;2248
912 at 440,188
913 write ZL
914 ***

915 unit x08sic
916 draw 1817;1811
917 circle 16,80,192
918 draw 1911;1811;skip;2111;2211;2217
919 at 76,192

```

```

920 write +
921
922 ***

923 unit x08s1d
924 at 200,220
925 write
926 draw 1830;1834
927 at 261,208
928 write
929
930
931 draw 2223;2242;2234;2134;skip;1834;1834;1842;skip;1826;1823
932 at 192,203
933 write 33000
934 at 272,188
935 write 33000
936 ***

```

```

937 unit x08s2a
938 at 505
939 write Complex numbers may be written in two forms;
940 rectangular form (A+jB) and polar form (|C|∠α°).

```

```

941 The two forms are interrelated by the following
942 equations:

```

```

943 at 1010
944 write
945  $|C| = \sqrt{A^2 + B^2}$ 
946  $\alpha = \tan^{-1}(B/A)$ 

```

```

947 at 1135
948 write  $A = |C| \cos \alpha$ 
949
950  $B = |C| \sin \alpha$ 
951 at 1605

```

```

952 write To divide two complex numbers, first put both
953 numbers into polar form. Then divide the magnitudes
954 and subtract the phase angles.

```

```

955 For example:  $\frac{A \angle \alpha}{B \angle \beta} = \frac{A}{B} \angle (\alpha - \beta)$ 
956
957 end

```

----- part=2, block=

block 2e, x08s2b

```

959 unit x08s2b
960 at 405
961 write The network below is known as a voltage divider network,
962 when I2 is negligible with respect to I1:

```

```

963 at 192,380
964 write ~~~~~
965 R1
966 at 735
967 write I2
968
969 at 1034
970 write ~~~~~
971
972 draw 820;825;skip;829;267,384;267,368;skip;267,384
973 842;skip;1220;1242;skip;267,335;267,320
974 at 280,348
975 write R2
976 at 152,346
977 write V1
978 at 320,346
979 write V2
980 at 920
981 write +
982 at 152,326
983 write -
984 at 318,327
985 write -
986 at 318,368
987 write +
988 draw 1023;1031;1131;1126;204,340;skip;204,332;200,336
989 at 1124
990 write I1
991 at 1405
992 write
993
994 at 1626
995 write 1)  $V_2 = R_2 I_1$ 

```

From the above network, the following equations can be derived:

2) $I_1 = V_1 / (R_1 + R_2)$

Substituting eq. 1) into eq. 2), the following equation is obtained:

$$V_2 = \frac{R_2 V_1}{R_1 + R_2}$$

The output voltage V_2 is just that part of the input voltage V_1 appearing across R_2 . Hence the name 'voltage divider'.

It can be shown that this voltage divider idea holds in general for impedances Z_1 and Z_2 in place of R_1 and R_2 , and also holds for ac voltages.

```

1007 end
1008 ***

```

```

1009 unit x08s2c
1010 next x08m2f
1011 at 405
1012 write
1013
1014
1015 ***

```

At this point, you have not yet been asked to set any dials. Set all dials back to their initial mode positions, and then press -NEXT- to proceed.



1016 unit. x08s2d
1017 help errmess,x,x08m2e,x08m3b,x08m3p
1018 next errmess,x,x08m2g,x08m3c,x08m3q
1019 join (err<0),x08s2e,x
1020 at 605
1021 write Press -NEXT- if you know and have corrected your error.
1022 or, press -HELP- to review the needed connections.
1023 ***
1024 unit x08s2e
1025 at 408
1026 write There is something wrong with your connections.

----- part=2, block=f -----

block 2f, x08s2f

1028 unit x08s2f
1029 next errmess,x,x08m2i,x08m3e,x08m3s
1030 help x08m2h
1031 join (err<0),x08s2g,x
1032 at 1005
1033 write Press -NEXT- if you know and have corrected your
1034 errors.
1035 Press -HELP- if you wish to review the needed dial
1036 settings.
1037 ***
1038 unit x08s2g
1039 at 810
1040 write You have incorrectly set (z,-n47) dials(s).
1041 ***
1042 unit x08s2h
1043 at 405
1044 write Now make the following connections:
1045 1) Connect the input port of the two port network to
1046 the AUDIO OSCILLATOR.
1047 2) Also connect the input port to the A INPUT of the
1048 OSCILLOSCOPE.
1049 3) Connect the output port of the two port network
1050 to the INPUT of the VACUUM TUBE VOLTMETER.
1051 4) Finally, connect the output port of the two port
1052 network to the B INPUT of the OSCILLOSCOPE.
1053 at 2105
1054 write Did you remember to correctly connect all grounds.

1055 Press -BACK- to review the terminal numbers of the
1056 two port under study.
1057 at 2605
1058 write When you are through making the above connections,
1059 press -NEXT-.
1060 end.

1061 unit x08s2i
1062 erase
1063 catchup
1064 at 405
1065 write Now make the following connections:

1066 1) Connect the input port of the two port network
1067 to the AUDIO OSCILLATOR.

1068 2) Also connect the input port to the A INPUT of the
1069 OSCILLOSCOPE.

1070 3) Connect the output port of the two port network
1071 to the INPUT of the VACUUM TUBE VOLTMETER.

1072 4) Finally, connect the output port of the two port
1073 network to the B INPUT of the OSCILLOSCOPE.

1074 at 2105
1075 write Did you remember to correctly connect all grounds.
1076 end

part=2, block=g

block 2g, x08end

1078 unit x08end
1079 back x08m3a
1080 join imode
1081 jump n47, x08end, x
1082 course n2
1083 calcc n2='ee244',
1084 nc(n21+1) ← (nc(n21+1) \$mask\$077777777770000000000) + 04603000000,
1085 nc(n21+1) ← nc(n21+1)
1086 erase
1087 output /// student has completed experiment ///
1088 join endunit
1089 join jmpmes
1090 jumpout cgeindex, quest1
1091 entry leave
1092 end lesson
1093 ***
1094 unit endunit
1095 course n2
1096 jump n2='ee244', leave, x
1097 calc nc(n21+7) ← nc(n21+7) + ahelp

1098	vc(n21+6)+vc(n21+6)+atime/60000						
1099	***Incl. cge, p.r. & terms sample, index, imode, comment, slides.						
1100	use	eex00, ck1					
1101	use	ck2					
1102	use	ck3					
1103	use	ck4					
1104	use	ck5					
1105	use	ck6					
ckc		not found		259	419	627	658
ckd		not found		255	297	448	669
endunit	x08end	1094		20	1000		
imode		not found		39	393	1000	
jmpmes		not found		1009			
leave	x08end	1091		1096			
x08end	x08end	1078		872	1081		
x08m0a	x08m0a	28		40	55		
x08m1a	x08m1a	54		29	83		
x08m1b	x08m1a	81		56	104		
x08m1c	x08m1c	103		84	126		
x08m1d	x08m1c	125		105	143		
x08m2a	x08m2a	142		127	162		
x08m2b	x08m2a	161		144	185		
x08m2c	x08m2a	184		163	215		
x08m2d	x08m2d	214		186	246	267	
x08m2e	x08m2d	245		216	1017		
x08m2f	x08m2d	253		247	1010		
x08m2g	x08m2d	257		1018			
x08m2h	x08m2d	264		262	303	427	658 030 797
x08m2i	x08m2d	291		289	1029		
x08m2j	x08m2d	295		268			
x08m2k	x08m2k	302		300	337		
x08m2l	x08m2k	334		304	359	677	799
x08m2m	x08m2k	342		361	448	543	
x08m2n	x08m2h	358		338	397		
x08m2o	x08m2n	382		360			
x08m2p	x08m2n	392		394			
x08m3a	x08m3a	396		394	412	425	1079
x08m3b	x08m3a	410		398	1017		
x08m3c	x08m3c	417		413	1018		
x08m3d	x08m3c	424		422	446		
x08m3e	x08m3c	438		426	1029		
x08m3f	x08m3c	445		443	478		
x08m3g	x08m3c	477		447	496		
x08m3h	x08m3h	495		479	514		
x08m3i	x08m3h	513		497	541	698	
x08m3j	x08m3j	539		515	564		
x08m3k	x08m3j	563		542	588	594	617
x08m3l	x08m3j	576		584			
x08m3m	x08m3j	586		584			
x08m3n	x08m3j	593		587			
x08m3o	x08m3o	616		628	631		
x08m3p	x08m3o	630		618	628	656	1017
x08m3q	x08m3o	648		632	1018		
x08m3r	x08m3r	655		653	675		
x08m3s	x08m3r	667		657	1029		
x08m3t	x08m3r	674		672	697		
x08m3u	x08m3u	696		676	728	735	

x00m3v	x00m3u	716		725						
x00m3w	x00m3u	727		725						
x00m3x	x00m3u	734		729	761					
x00m4a	x00m4a	750		736	796					
x00m4b	x00m4a	779		762						
x00m4c	x00m4c	794								
x00m4d	x00m4c	822		831						
x00m4e	x00m4c	833		831						
x00m4f	x00m4c	842		834						
x00s1a	x00s1a	874		95	149	171	197	220		
x00s1b	x00s1a	904		96	151	173				
x00s1c	x00s1a	915		97	150	172	198	229		
x00s1d	x00s1a	923		196	227					
x00s2a	x00s1a	937		164						
x00s2b	x00s2b	959		187	480					
x00s2c	x00s2b	1009		256						
x00s2d	x00s2b	1016		262	422	653				
x00s2e	x00s2b	1024		1019						
x00s2f	x00s2f	1028		300	443	672				
x00s2g	x00s2f	1038		1031						
x00s2h	x00s2f	1042		250	414	633				
x00s2i	x00s2f	1061		798						
ahelp	x00def	1097								
atime	x00def	1098								
err	x00def	31	37	249	261	269	421	299	442	411
		634	652	671	1019	1031				
errmess	x00def	32	248	260	298	420	670	441	1017	651
		1018	1029							
f_c	x00def	35	555	568	569	570	573	571	602	572
		602	602	602	602	602	784	602	784	789
		789	789	790	790	790	853	791	853	853
		853	853	854	854	854		855		
f_o	x00def	36	688	705	706	707	710	708	711	709
		712	713	744	744	744	745	744	745	744
		745	745	745	791	791	791	791	792	791
		792	792	855	855	855	856	856	856	856
		857	857							
it	x00def	33	217	283	428	659		800		
nc	x00def	1004	1004	1005	1005	1097		1097		
n2	x00def	1002	1003	1095	1096					
n21	x00def	1004	1004	1005	1005	1097		1097	1098	1090
n33	x00def	254	258	296	418	439		626	603	649
n47	x00def	40	256	261	262	299	421	300	422	394
		442	443	628	652	653	640	671	1081	672
n50	x00def	31								
n51	x00def	32								
n52	x00def	33								
n53	x00def	34								
no	x00def	574	579	579	714	719	825	719	825	820
no	x00def	575	577	577	578	580	717	584	717	715
		718	720	725	821	823	826	823	831	824
ot	x00def	34	218	286	429	660		801		
v	x00def	580	720	826						
vc	x00def	1098	1098							
v100	x00def	744	789	790	853	854				
v101	x00def	744	790	854						
v102	x00def	744	791	855						

v103	x08def	744	791	855		
v104	x08def	744	745	791	855	856
v105	x08def	745	791	856		
v106	x08def	745	791	792	856	
v107	x08def	745	792	856	857	
v108	x08def	745	792	857		
v111	x08def	858				
v112	x08def	859				
v113	x08def	860				
v114	x08def	861				
v115	x08def	862				
v116	x08def	863				
v117	x08def	864				
v118	x08def	865				
v119	x08def	866				
v52	x08def	314	320	323	324	
v55	x08def	35				
v56	x08def	36				
v62	x08def	602	789	853		
v63	x08def	602	789	853		
v64	x08def	602	789	853		
v65	x08def	602	789	853		
v66	x08def	602	789	790	853	854
v67	x08def	602	790	854		
v68	x08def	602	790	791	854	855
v70	x08def	578	581	718	721	824
%	x08def	315	323	324	556	689

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