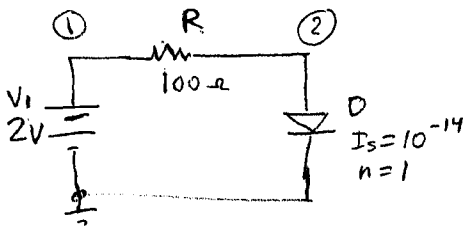
Today: Load Line Analysis
Some diode circuits (ideal)

Solving diode circuits

or --- how to solve a nonlinear circuit graphically.

Consider this circuit:



Sec 3.2
9, 10, 11, 12

Try nodal analysis:

$$I_D + I_R = 0$$

$$I_S\left[e^{\frac{V_2}{V_T}} - 1\right] + \frac{V_2 - V_1}{R} = 0$$ ← Node equation at node 2

Too much work to solve formally.

Try iteration.
Solve the node equation for 2
Try values of V_2 until it is close enough.

Iterative solution:

Guess the answer.
Try it
Based on the result, guess again and repeat

	V_2	sum of currents = 0	
known too low →	0	−.02	− means V_2 too low
known too high →	2	2×10^{19}	+ means V_2 too high
	1	505	
	.5	−.014998	
	.75	.021207	
	.625	−.013475	
	.7	−.0080734	
	.72	−.0021680	
	.73	.0029190	
	.725	.0013649	
	.723	-8.3761×10^{-4}	
	.724	-3.5974×10^{-4}	
	.7245	-1.396×10^{-4}	
	.7247	-1.4347×10^{-5}	
	.7248	$+3.5742 \times 10^{-5}$	

This is "bisection method"
Keep dividing the interval in half

between these. about in the middle
Just say ".725" is close enough

Approaches 0
Continue until "close enough"

between these. — closer to .7247

$V_R = 2 - .7247 = 1.275$ V
$I = .01275$ A

Load line method

Make 2 plots on the same graph;

1. I_D vs. V_2 ← $I_s\left(e^{\frac{V_2}{V_T}}-1\right)$ ← usually from data sheet.

2. I_R vs. V_2

   ↑ same voltage as #1.

$$V_2 = V_1 - V_R$$

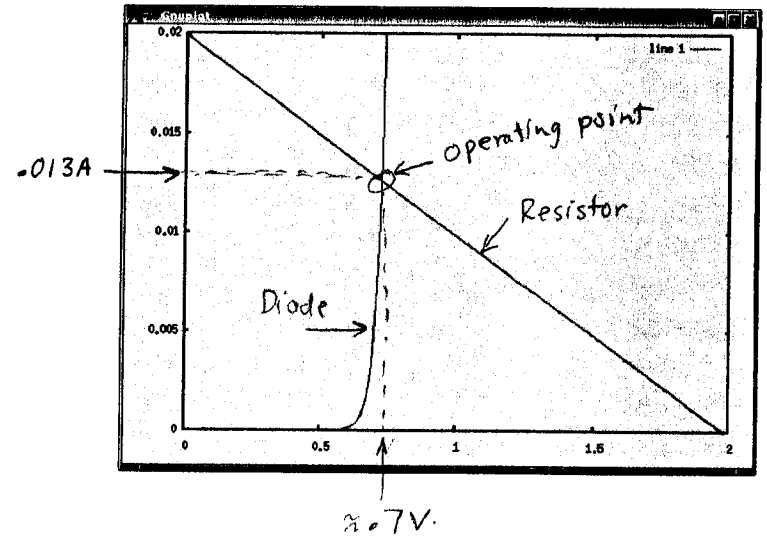
Try 2 points:

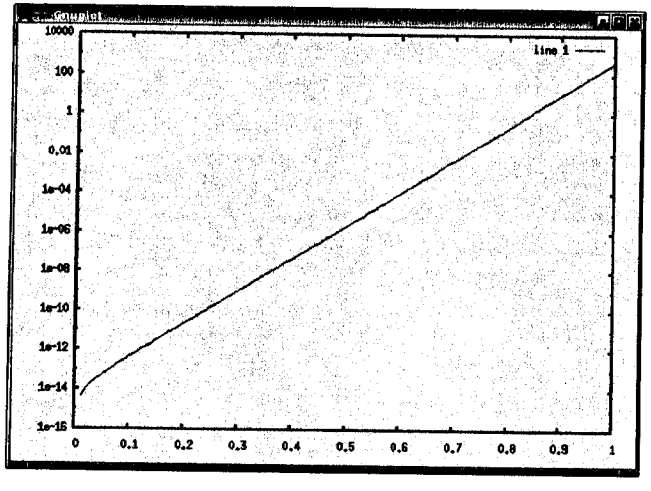
$$V_R = 0 \Rightarrow V_2 = V_1 \Rightarrow I = 0$$

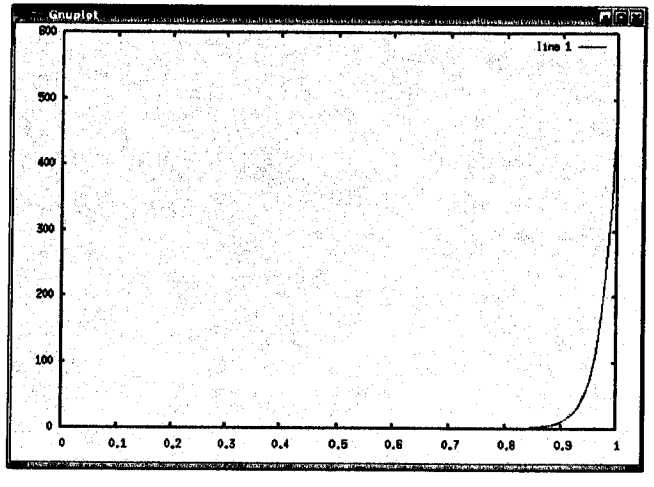
(Diode is open)

$$V_D = 0 \Rightarrow V_R = V_1 \Rightarrow I = \frac{V}{R} = \frac{2}{100} = .02$$

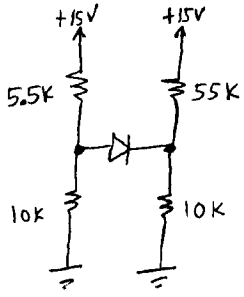
Connect with a line




Gnuplot
line 1
10000
100
1
0.01
1e-04
1e-06
1e-08
1e-10
1e-12
1e-14
1e-16
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Gnuplot
line 1
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

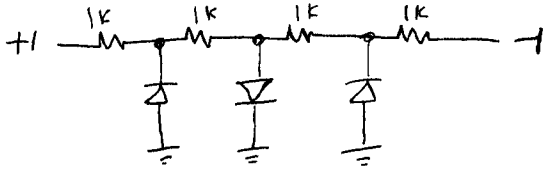
Simple diode circuits

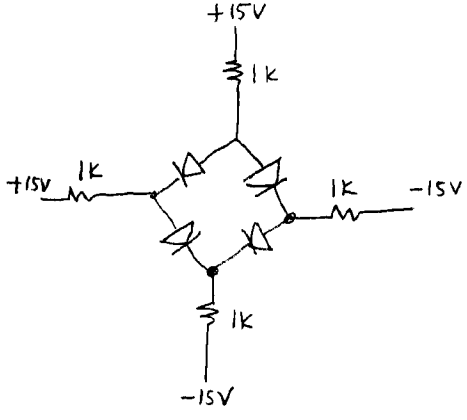


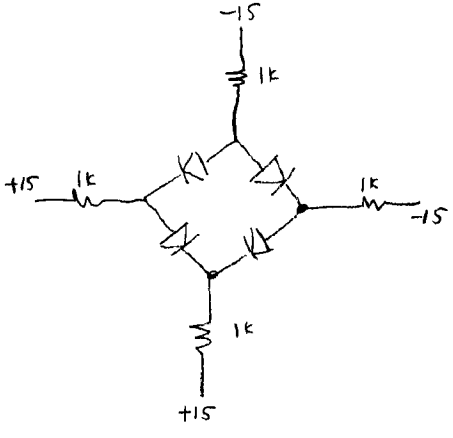
Do twice:

① for ideal diodes

② forward voltage = .7







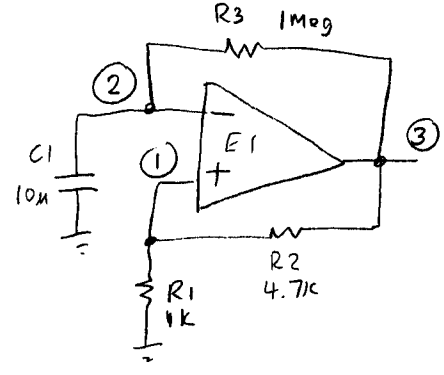
Sec 3.2
13, 14, 15, 16,
17, 18

```
.
R1 ( 1 0 )  1.K
R2 ( 1 3 )  4.7K
R3 ( 2 3 )  1.Meg
C1 ( 2 0 )  10.u [redacted] ic= 1.
E1 ( 3 0 1 2 ) TANH gain= 10.K limit= 14.
```

Netlist for oscillator, with 10uf capacitor

specifies a gain of 10000 (10k) that clips at ±14 V. with "soft clipping"

There are many ways to specify a nonlinear source.



```
gnucap> get oscillator.ckt

gnucap> list
R1  ( 1 0 )  1.K
R2  ( 1 3 )  4.7K
R3  ( 2 3 )  1.Meg
C1  ( 2 0 )  10.u ic= 1.
E1  ( 3 0 1 2 ) TANH gain= 10.K limit= 14.
gnucap> print tran v(nodes)
gnucap> tran 0 20 .1
#Time       v(1)        v(2)        v(3)
 0.         0.          0.          0.
 0.1        0.          0.          0.
 0.2        0.          0.          0.
 0.3        0.          0.          0.
 0.4        0.          0.          0.
 0.5        0.          0.          0.
 0.6        0.          0.          0.
...............
...............
 19.2       0.          0.          0.
 19.3       0.          0.          0.
 19.4       0.          0.          0.
 19.5       0.          0.          0.
 19.6       0.          0.          0.
 19.7       0.          0.          0.
 19.8       0.          0.          0.
 19.9       0.          0.          0.
 20.        0.          0.          0.
gnucap> tran 0 20 .1 uic
#Time       v(1)        v(2)        v(3)
 0.         0.          0.          0.
 0.1        1.0488      1.0482      5.9781
 0.2        1.0993      1.0986      6.2661
 0.3        1.1523      1.1516      6.5679
 0.4        1.2078      1.207       6.8844
 0.5        1.266       1.2652      7.216
 0.6        1.327       1.3261      7.5636
 0.7        1.3909      1.39        7.9281
 0.8        1.4579      1.4569      8.31
 0.9        1.5281      1.5271      8.7104
 1.         1.6018      1.6007      9.1301
 1.1        1.679       1.6778      9.5701
 1.2        1.7599      1.7586      10.031
 1.3        1.8447      1.8433      10.515
 1.4        1.9336      1.9321      11.022
 1.5        2.0269      2.0252      11.553
 1.6        2.1247      2.1228      12.111
 1.7        2.2272      2.2251      12.695
 1.8        2.3349      2.3323      13.309
 1.9        2.4494      2.4448      13.962
 2.        -2.4561      2.4202     -14.
 2.1       -2.4561      2.2569     -14.
 2.2       -2.4561      2.0951     -14.
 2.3       -2.4561      1.9349     -14.
 2.4       -2.4561      1.7764     -14.
...............
 4.6       -2.4561     -1.3392     -14.
 4.7       -2.4561     -1.4652     -14.
 4.8       -2.4561     -1.5899     -14.
 4.9       -2.4561     -1.7134     -14.
 5.        -2.4561     -1.8356     -14.
 5.1       -2.4561     -1.9567     -14.
 5.2       -2.4561     -2.0765     -14.
 5.3       -2.4561     -2.1951     -14.
 5.4       -2.4561     -2.3126     -14.
 5.5       -2.4561     -2.4289     -14.
 5.6        2.4561     -2.4047      14.
 5.7        2.4561     -2.2415      14.
 5.8        2.4561     -2.0799      14.
 5.9        2.4561     -1.9199      14.
 6.         2.4561     -1.7615      14.
 6.1        2.4561     -1.6046      14.
...............
...............
 19.3      -2.4561     -1.7186     -14.
 19.4      -2.4561     -1.8408     -14.
 19.5      -2.4561     -1.9618     -14.
 19.6      -2.4561     -2.0816     -14.
 19.7      -2.4561     -2.2001     -14.
 19.8      -2.4561     -2.3176     -14.
 19.9      -2.4561     -2.4338     -14.
 20.        2.4561     -2.4096      14.
gnucap> tran 0 20 .1 uic >oscillator.dat
gnucap> quit
```

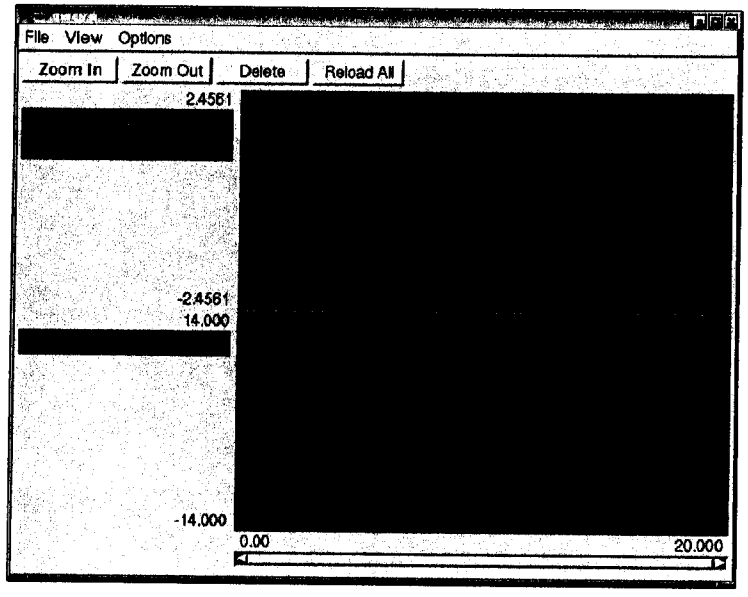
Initial condition necessary to start oscillator.

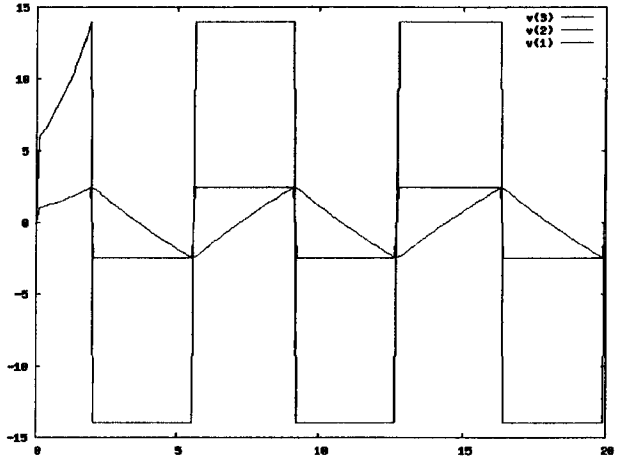
Output is 0

Need to "UIC" (use initial conditions)

Now it works.

on screen





right click on plot → menu

Choose plot

click "GNU Plot"

select file type – "postscript"

Type in file name to save as "n12.ps"

click "plot"

n12.eps

or PNG

choose "postscript EPS" to include in other document