File: 302f0_01 RWN 09/05/00
ENEE 302 Possible to do items.

1. Make Spice DC plots for the following (in order of increasing complexity)
   a) Diode, I versus V - use the spice default values given in [text, p. 201].
   b) npn BJT, IC versus VCE with IB as a parameter, using the Ebers-Moll equivalent circuit of [text, Fig. 4.55] with the diode of a) and betas of the Spice model of p. 327.
   Skip to part c) and then return to repeat using the full Spice model of [text, p. 327]. Repeat again using any MOSIS transistor model {available from MOSIS or http://www.ece.umd.edu/newcomb/bicmosis.htm}.
   Make a diode as in [text, Fig. E4.39, p. 306] and run its curves.
   c) NMOS, ID versus VDS with VGS as a parameter, using the default values given in [text, p. 459]. Repeat with MOSIS 2 micron transistor parameters {available in http://www.ece.umd.edu/newcomb/bicmosis.htm}. Repeat for a PMOS transistor. Compare magnitudes with the same W/L NMOS - Calculate the W/L needed on the PMOS to bring its currents in line with the NMOS.
   Make a diode, as in [text, Fig. 5.51, p. 421] with both NMOS and PMOS and run curves for them.
2. Make 3D plots of the NMOS curves of #1.1c), above, in either MathCad or Matlab, i.e. plot ID as a surface over the (VGS,VDS)-plane.
   Here are the starting lines for MathCad where $\Phi(.)$ is the unit step function.

MOSIS 2u NMOS parameters

$KP := 5.048 \cdot 10^{-5}$ $VTO := 0.8582$ $\lambda := 1.8434 \cdot 10^{-2}$

$W := 10 \cdot 10^{-6}$ $L := 10 \cdot 10^{-6}$ $Vdd := 5$

Cutoff region:

$IDco(VGS, VDS) := 0$

Saturation region:

$$IDs(VGS, VDS) := \left(\frac{KP}{2}\right) \cdot \left(\frac{W}{L}\right) \cdot (VGS - VTO)^2 \cdot (1 + \lambda \cdot VDS) \cdot \Phi(VDS - VGS + VTO)$$

Ohmic region:

$$IDo(VGS, VDS) := \left(\frac{KP}{2}\right) \cdot \left(\frac{W}{L}\right) \cdot \left[\left[2 \cdot (VGS - VTO) \cdot VDS - VDS^2\right] \cdot (1 + \lambda \cdot VDS)\right] \cdot \Phi((VGS - VTO - VDS))$$

Total drain current:

$$ID(VGS, VDS) := IDco(VGS, VDS) + (IDs(VGS, VDS) + IDo(VGS, VDS)) \cdot \Phi(VGS - VTO)$$

Discretization to form 3D plots of ID versus VDS, VGS

$M := 10$ $N := 10$ $VGSmax := Vdd$ $VDSmax := Vdd$

$i := 1, 2 .. M$ $j := 1, 2 .. N$

$$VGS_i := i \cdot \frac{VGSmax}{M} \qquad VDS_j := j \cdot \frac{VDSmax}{N}$$

$$ID_{i,j} := ID\left(VGS_i, VDS_j\right)$$