EE 105 Discussion 4

1) Circuit Techniques:
   voltage/current division
   
   - Draw transconductance amplifier circuit (figure 8.5 page 467) Derive formula for voltage division
     o I = Vs/(Rin+Rs) so Vin = IRin = VRin/(Rin+Rs)
   - Do the same for current division circuit.
     o Iout = I(Rl/(Rout+Rl))
     o Il = I(Rout/(Rout+Rl))

2) Nmos/Pmos Equations
   a) Linear Region
      - From definition of current: Ids = -WvyQn (1)
      - Using the result for the inversion charge under a MOS capacitor:
        Qn = -Cox(Vgb-Vtn)
      - Replacing the value of Qn in (1), we get Ids = WvyCox(Vgs-Vtn) (2)
        where Vgs > Vtn and Vds < 0.1V
      - When Vds is small, the channel has uniform density, (so it looks like a resistor) which means the voltage in the channel must vary linearly from source to drain with a constant electric field in the channel.
        so vy = -µn*Ey and Ey = -Vds/L
      - Using this value of vy and substituting it into (2), we get:
        \[ Id = \frac{W}{L} \mu n C_{ox} (V_{gs} - V_{tn}) V_{ds} \]
   b) Improved linear approximation
      - Inversion Charge at Source/Drain
        Qn(y) ≈ ½ (Qn(y=0) + Qn(y=L))
        With: Qn(y=0) = -Cox(Vgs-Vtn)
        Qn(y=L) = -Cox(Vgd-Vtn) and Vgd=Vgs-Vds
        This gives:
        \[ Qn(y) \approx -C_{ox}(V_{gs} - V_{tn} - V_{ds}/2) \]
      - Using this result, we get:
        \[ Id = (W/L)\mu n C_{ox} (V_{gs} - V_{tn} - V_{ds}/2)V_{ds} \] (3)
   c) Saturation Region
      - Current stops increasing when Vds = Vds_sat = Vgs-Vtn
      - Replace this in (3) and get:
        \[ Id_{sat} = (W/L)(\mu n C_{ox}/2)(V_{gs} - V_{tn})^2 \]
      - Note: for pmos, µp, Vtp, Vgs and Vds are negative.

3) Track and hold circuit
Ask students reason for which improved sample and hold circuit (with pmos and nmos) is better:
- draw circuit from lecture 8 slide 27
- allows C1 to fully charge to input voltage, go over why.