Name_____ SN_____

EE 320 – *Electronics I*
Final Exam

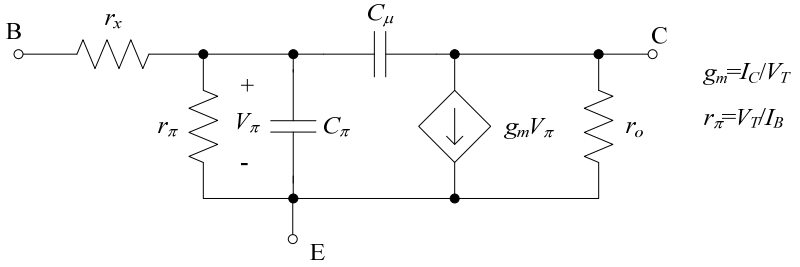
December 8, 2017
2:00-3:30 PM
100 points

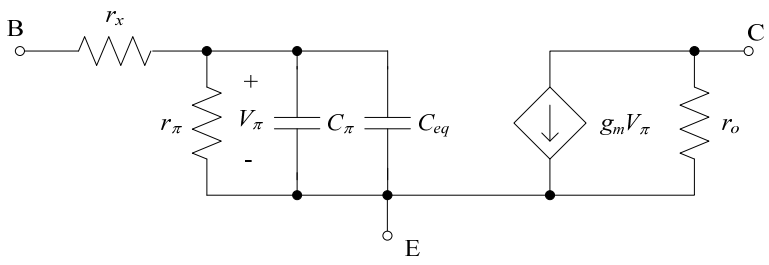
Turn off and store out of sight your mobile telephone, smart watches, and all other electronic devices, other than your calculator. A calculator is the only electronic device you may operate during this exam. Write your name and student number where indicated above. This exam is to be an individual effort and is closed book, closed notes, and no formula sheets. Using pre-programmed equations (symbolic or otherwise) on your calculator is prohibited. Show all of your work on the supplied sheets of paper. **Do not write on the back of any sheet of paper**. This exam will not be returned to you.

Prob. #1	Prob. #2	Prob. #3	Prob. #4	**TOTAL**
25	25	25	25	100 pts.

- Bipolar junction transistors: $I_B = \text{ODF} \cdot I_B\big|_{\text{EOS}}$, $\beta_{\text{forced}} = \dfrac{\beta}{\text{ODF}}$, $V_{BC}\big|_{\text{EOS}} = 0.4\,\text{V}$

- High frequency BJT small-signal models and common emitter amplifiers:
$C_{de} = \tau_F \dfrac{I_C}{V_T}$, $\omega_\beta = \dfrac{1}{\left(C_\pi + C_\mu\right) r_\pi}$, $\omega_T = \beta_0 \omega_\beta$, $f_T = \dfrac{g_m}{2\pi\left(C_\pi + C_\mu\right)}$, $f_H = \dfrac{1}{2\pi C_{\text{in}} R_{\text{sig}}'}$





$g_m = I_C / V_T$

$r_\pi = V_T / I_B$

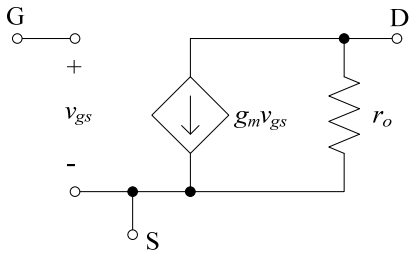
$C_{eq} = C_\mu (1 + g_m R_L')$

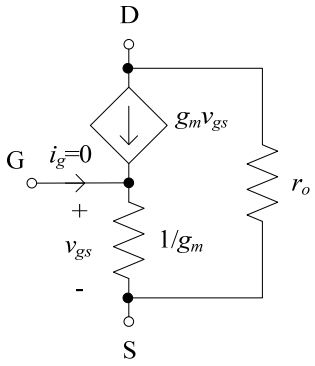
- NMOS: $k_n' = \mu_n C_{ox}$ A/V^2

$$i_D = k_n' \frac{W}{L}\left[(v_{GS} - V_t) v_{DS} - \frac{1}{2} v_{DS}^2 \right] \text{ A} \quad \text{(triode)}$$

$$i_D = \frac{1}{2} k_n' \frac{W}{L} (v_{GS} - V_t)^2 (1 + \lambda v_{DS}) \text{ A} \quad \text{(saturation)}$$

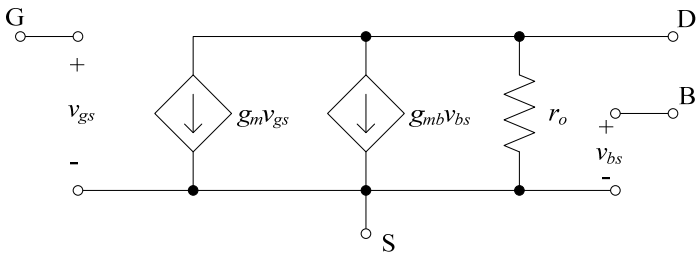
$$r_{DS} = \left[k_n' \frac{W}{L} (V_{GS} - V_t) \right]^{-1} \ \Omega \quad \text{(triode)}$$



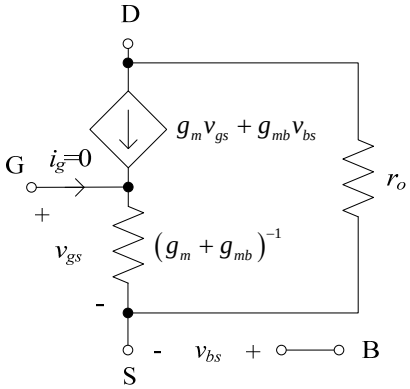


$$r_o = \frac{V_A}{I_D} = \frac{1}{\lambda I_D}$$

$$g_m = k_n' \frac{W}{L}(V_{GS} - V_t) = \sqrt{2 k_n' \frac{W}{L} I_D} = \frac{2 I_D}{V_{GS} - V_t} = \frac{2 I_D}{V_{OV}}$$



$g_{mb} = \chi g_m$



$g_{mb} = \chi g_m$

- CMOS digital logic inverter:

$$r_{DSN} = \left[k_n' \left(\frac{W}{L} \right)_n \left(V_{DD} - V_{tn} \right) \right]^{-1}$$

$$r_{DSP} = \left[k_p' \left(\frac{W}{L} \right)_p \left(V_{DD} - \left| V_{tp} \right| \right) \right]^{-1}$$

$$V_{IL} = \frac{1}{8}\left(3V_{DD} + 2V_t \right)$$

$$V_{IH} = \frac{1}{8}\left(5V_{DD} - 2V_t \right)$$

$$NM_H = V_{OH} - V_{IH} = \frac{1}{8}\left(3V_{DD} + 2V_t \right)$$

$$NM_L = V_{IL} - V_{OL} = \frac{1}{8}\left(3V_{DD} + 2V_t \right)$$

$$V_M = \frac{r\left(V_{DD} - \left| V_{tp} \right| \right) + V_{tn}}{r+1} \quad \text{where} \quad r = \sqrt{\frac{k_p}{k_n}} = \sqrt{\frac{\mu_p W_p}{\mu_n W_n}}$$