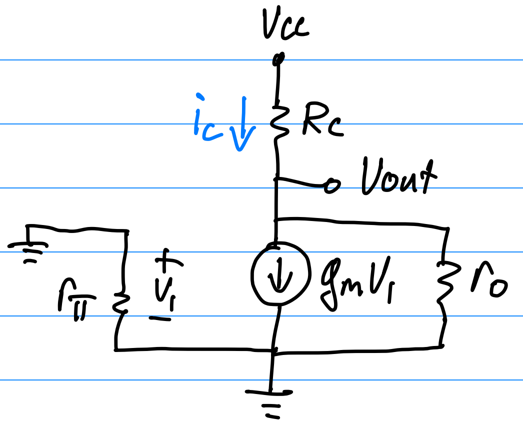
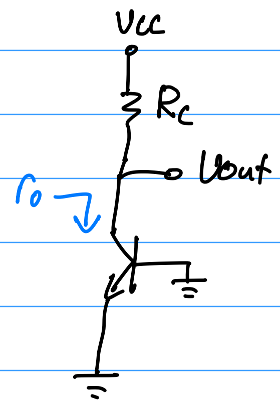
10.3 (a) If the "input" is V_{cc} then V_{in} is an independent source, so is turned off ($V_{in} = 0$).



or simply

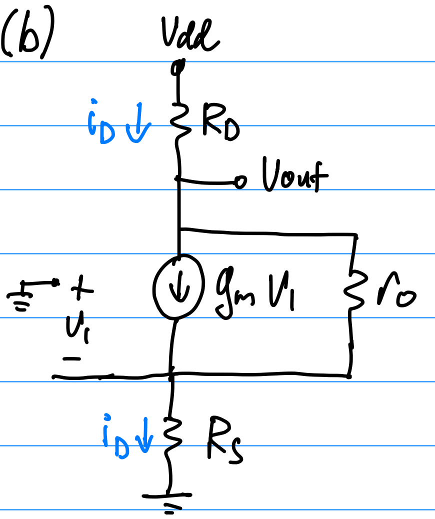


$$\therefore \frac{V_{out}}{V_{cc}} = \frac{r_o}{R_c + r_o}$$ by voltage divider formula.

Could also subst $r_o = \frac{V_A}{I_c}$ to obtain

$$\frac{V_{out}}{V_{cc}} = \frac{V_A}{R_c I_{EE} + V_A}.$$

(b)



KCL at the source:

$$\frac{(-V_1)}{R_S} + \frac{(-V_1) - V_{out}}{r_o} = g_m V_1$$

$$\frac{-V_{out}}{r_o} = g_m V_1 + \frac{V_1}{R_S} + \frac{V_1}{r_o}$$

$$V_1 = \frac{-V_{out}}{r_o\left(g_m + \frac{1}{R_S} + \frac{1}{r_o}\right)}$$

$$i_D = \frac{(-V_1)}{R_S} = \frac{V_{out}}{g_m r_o R_S + r_o + R_S}$$

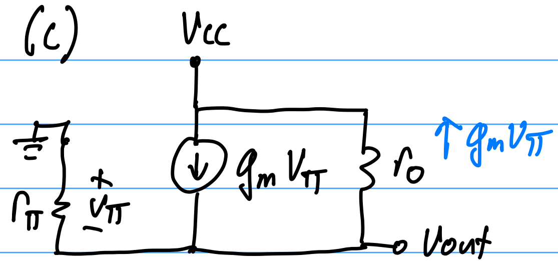
$$V_{out} = V_{dd} - i_D R_D = V_{dd} - \frac{V_{out} R_D}{g_m r_o R_S + r_o + R_S}$$

$$V_{out} + \frac{V_{out} R_D}{g_m r_o R_s + r_o + R_s} = V_{dd}.$$

$$V_{out}\left(\frac{g_m r_o R_s + r_o + R_s + R_D}{g_m r_o R_s + r_o + R_s}\right) = V_{dd}$$

$$\frac{V_{out}}{V_{dd}} = \frac{g_m r_o R_s + r_o + R_s}{g_m r_o R_s + r_o + R_s + R_D}.$$

(c)



KCL at Vout:

$$\frac{V_{out}}{r_\pi} + \frac{V_{out} - V_{cc}}{r_o} = g_m V_\pi$$

Notice $V_\pi = -V_{out}$

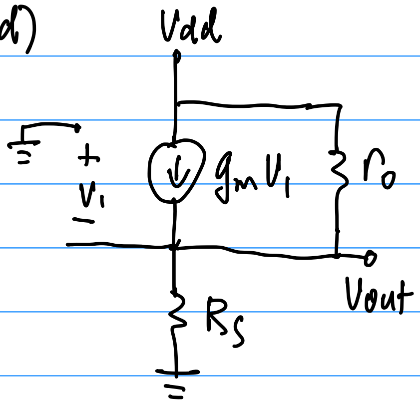
$$\therefore \frac{V_{out}}{r_\pi} + \frac{V_{out}}{r_o} - \frac{V_{cc}}{r_o} = -g_m V_{out}$$

$$(r_o + r_\pi + g_m r_o r_\pi) V_{out} = V_{cc} r_\pi$$

$$\frac{V_{out}}{V_{cc}} = \frac{r_\pi}{r_o + r_\pi + g_m r_o r_\pi} = \frac{r_\pi}{r_o + r_\pi + \beta r_o}$$

$\because r_\pi = \frac{\beta}{g_m}$.

(d)



$V_1 = -V_{out}$. Write KCL:

$$\frac{V_{out}}{R_s} + \frac{V_{out} - V_{dd}}{r_o} = -g_m V_{out}$$

$$(r_o + R_s + g_m r_o R_s) V_{out} = V_{dd} R_s$$

$$\frac{V_{out}}{V_{dd}} = \frac{R_s}{r_o + R_s + g_m r_o R_s}.$$