1. For the cascade amplifier calculate the dc bias voltages currents of each stage.

From graph $V_{GS_Q} = -0.95\text{ V}$, $I_{D_Q} = \mathbf{2.9\text{ mA}}$

$$V_D = 10\text{ V} - I_D(1.8\text{ k}\Omega) = 10\text{ V} - (2.9\text{ mA})(1.8\text{ k}\Omega) = 10\text{ V} - 5.22\text{ V}$$
$$= \mathbf{4.78\text{ V}}$$
$$V_S = I_D R_S = (2.9\text{ mA})(330\ \Omega) = \mathbf{0.957\text{ V}}$$
$$V_{DS} = V_D - V_S = 4.78\text{ V} - 0.957\text{ V} = \mathbf{3.82\text{ V}}$$
$$V_G = \mathbf{0\text{ V}}$$
$$I_D = I_S = \mathbf{2.9\text{ mA}}$$
$$I_G = \mathbf{0\text{ A}}$$

$$B_{RE} \geq 10R_2$$
$$(150)(2.2\text{ k}\Omega) \geq 10(8.2\text{ k}\Omega)$$
$$330\text{ k}\Omega \geq 82\text{ k}\Omega \quad \text{checks}$$

$$V_B = \frac{8.2\text{ k}\Omega(10\text{ V})}{8.2\text{ k}\Omega + 24\text{ k}\Omega} = \mathbf{2.55\text{ V}}$$
$$V_E = V_B - V_{BE} = 2.55\text{ V} - 0.7\text{ V} = \mathbf{1.85\text{ V}}$$
$$I_E \cong I_C = \frac{V_E}{R_E} = \frac{1.85\text{ V}}{2.2\text{ k}\Omega} = \mathbf{0.84\text{ mA}}$$
$$V_C = 10\text{ V} - I_C 2.7\text{ k}\Omega = 10\text{ V} - (0.84\text{ mA})(2.7\text{ k}\Omega)$$
$$= 10\text{ V} - 2.27\text{ V} = \mathbf{7.73\text{ V}}$$
$$V_{CE} = V_C - V_E = 7.73\text{ V} - 1.85\text{ V} = \mathbf{5.88\text{ V}}$$
$$I_B = \frac{I_C}{\beta} = \frac{0.84\text{ mA}}{150} = \mathbf{5.6\ \mu A}$$

2. For the amplifier circuit calculate the voltage gain of each stage and the overall amplifier voltage gain. Include the dynamic model.

$$Z_{i_2} = 8.2\ \text{k}\Omega \,||\, 24\ \text{k}\Omega \,||\, \beta(2.2\ \text{k}\Omega)$$
$$= 6.11\ \text{k}\Omega \,||\, 330\ \text{k}\Omega \cong 6\ \text{k}\Omega$$
$$A_{v_1} = -g_m(R_D \,||\, Z_{i_2})$$

$$g_m = \frac{2I_{DSS}}{|V_P|}\; 1 - \frac{V_{GS}}{V_P} = \frac{2(6\ \text{mA})}{3}\; 1 - \frac{0.95\ \text{V}}{3\ \text{V}}$$
$$= 2.73\ \text{mS}$$

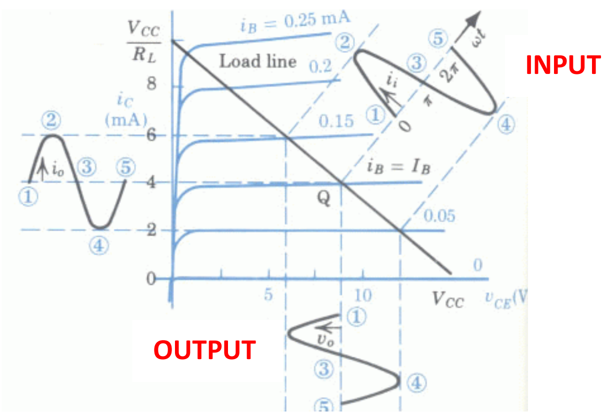
$$A_{v_1} = -(2.73\ \text{mS})(1.8\ \text{k}\Omega \,||\, 6\ \text{k}\Omega)$$
$$= \mathbf{-3.77}$$
$$A_{v_2} = -\frac{R_C}{r_e}$$
$$r_e = \frac{26\ \text{mV}}{I_E} = \frac{26\ \text{mV}}{0.84\ \text{mA}} = 30.95\ \Omega$$
$$A_{v_2} = -\frac{2.7\ \text{k}\Omega}{30.95\ \Omega} = \mathbf{-87.2}$$

$$A_{v_T} = A_{v_1} \cdot A_{v_2} = (-3.77)(-87.2) = \mathbf{328.74}$$

3. Calculate the input impedance (Z_i) and output impedance (Z_o) for the amplifier circuit

$$Z_i = \mathbf{10\ M\Omega}$$
$$Z_o \cong R_C = \mathbf{2.7\ k\Omega}$$

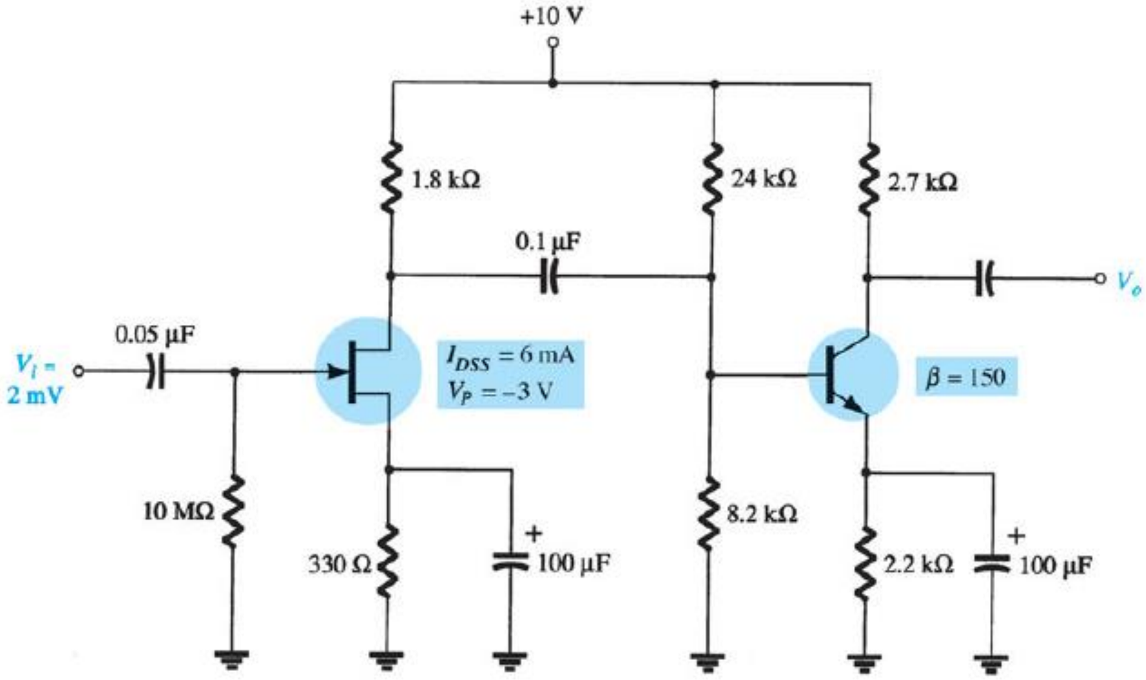
4. What is the maximum input voltage (Vpp) allowed to prevent distortion.
For no distortion the output must be less than the supply voltage Vcc, this is 10 Volts, allowing for the saturation and cutoff areas of the BJT response curve the output should be no greater than 8 Vpp



$$Av = \frac{Vo}{Vi}$$

$$\therefore 328.74 = \frac{8}{Vi}$$

$$Vi < 24mV$$



5. Design the self-bias network below to have a gain of 10. The device should be biased at $V_{GS_Q} = 1/3 V_P$.

$$V_{GS_Q} = \frac{1}{3}V_P = \frac{1}{3}(-3\text{ V}) = -1\text{ V}$$

$$I_{D_Q} = I_{DSS}\left(1-\frac{V_{GS_Q}}{V_P}\right)^2 = 12\text{ mA}\left(1-\frac{-1\text{ V}}{-3\text{ V}}\right)^2 = 5.33\text{ mA}$$

$$R_S = \frac{V_S}{I_{D_Q}} = \frac{1\text{ V}}{5.33\text{ mA}} = 187.62\ \Omega \ \therefore \text{Use } R_S = \mathbf{180\ \Omega}$$

$$g_m = \frac{2I_{DSS}}{V_P}\left(1-\frac{V_{GS_Q}}{V_P}\right) = \frac{2(12\text{ mA})}{3\text{ V}}\left(1-\frac{-1\text{ V}}{-3\text{ V}}\right) = 5.33\text{ mS}$$

$$A_v = -g_m(R_D \parallel r_d) = -10$$

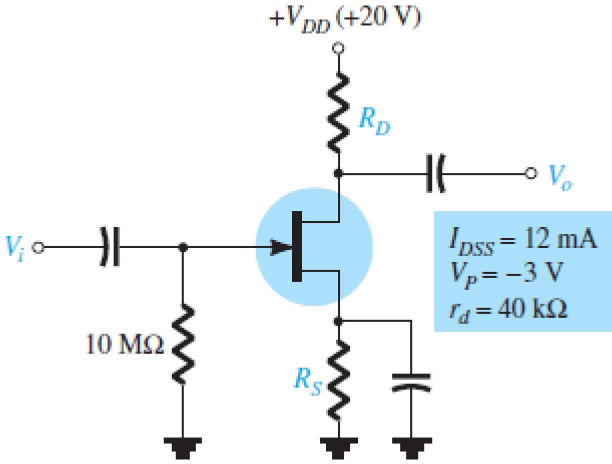
$$\text{or } R_D \parallel 40\text{ k}\Omega = \frac{-10}{5.33\text{ mS}} = 1.876\text{ k}\Omega$$

$$= 1.876\text{ k}\Omega$$

$$40\text{ k}\Omega R_D = 1.876\text{ k}\Omega R_D + 75.04\text{ k}\Omega^2$$

$$38.124 R_D = 75.04\text{ k}\Omega$$

$$R_D = 1.97\text{ k}\Omega \Rightarrow R_D = \mathbf{2\ k\Omega}$$



+VDD (+20 V)
RD
Vo
Vi
IDSS = 12 mA
VP = −3 V
rd = 40 kΩ
10 MΩ
RS