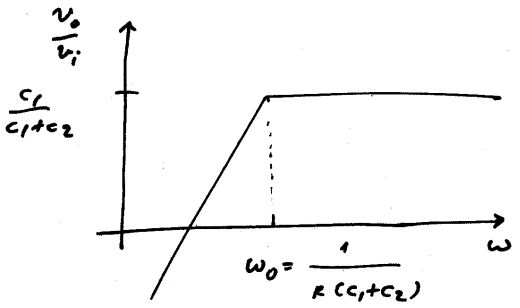
EL2 FP5

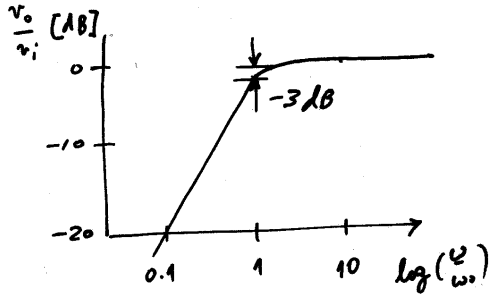
E.1

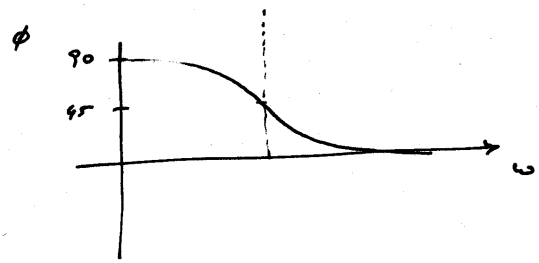
$$Z_c = \frac{1}{j\omega c} = \frac{1}{sc}$$

$$\frac{v_o}{v_{in}} = \frac{R \| C_2}{(R \| C_2) + C_1} = \frac{\frac{\frac{1}{sC_2} \times R}{\frac{1}{sC_2} + R}}{\frac{\frac{1}{sC_2} \times R}{\frac{1}{sC_2} + R} + \frac{1}{sC_1}} = \frac{\frac{R}{sC_2}}{\frac{R}{sC_2} + \frac{R}{sC_1} + \frac{1}{s^2 C_2 C_1}}$$

$$= \frac{\frac{R}{sC_2} s^2 C_2 C_1}{1 + \frac{s^2 C_2 C_1 R}{sC_2} + \frac{s^2 C_2 C_1 R}{sC_1}} = \frac{sRC_1}{1 + sR(C_1 + C_2)}$$







E.2

$\omega \to \infty \qquad \frac{v_o}{v_s} = \frac{R_L}{R_L + R_S}$

$$\frac{v_o}{v_s} = \frac{j\omega R_L C}{1 + j\omega (R_L + R_S) C}$$

$$\frac{v_o}{v_s} = \frac{R_L}{R_L + R_S + \frac{1}{j\omega C}} = \frac{j\omega C R_L}{1 + j\omega C (R_L + R_S)}$$

$$\frac{v_o}{v_s} = \frac{\omega C R_L}{\sqrt{1 + \omega^2 C^2 (R_L + R_S)^2}} \; e^{j\left(\frac{\pi}{2} - \text{arctg}\, \omega/\omega_0\right)} \; ; \quad \omega_0 = \frac{1}{(R_L + R_S) C}$$

(i) (ii) $\qquad \frac{v_o}{v_s} = \frac{R_L}{R_L + R_S} \qquad 0.7 = \frac{R_L}{R_L + 10 \times 10^3}$

$$0.7 \times 10 \times 10^3 = R_L (1 - 0.7)$$

$$R_L = \frac{0.7 \times 10 \times 10^3}{0.3}$$

$$R_L \geq 23 \text{ k}\Omega$$

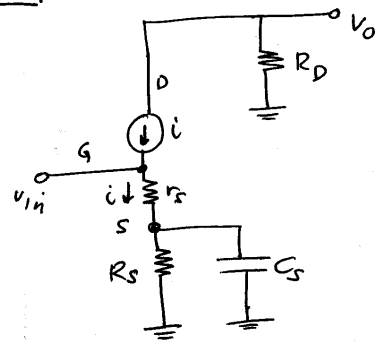
(iii)

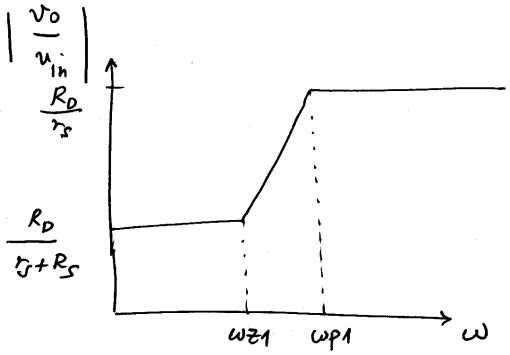
$$0.1^2 = \frac{\omega^2 C^2 R_L^2}{1 + \omega^2 C^2 (R_L + R_S)^2} \iff 0.1^2 = C^2 \left(\omega^2 R_L^2 - 0.1^2 \omega^2 (R_L + R_S)^2\right)$$

$$C^2 = \frac{0.1^2}{2^2 \pi^2 \cdot 10^2 \cdot 23^2 \cdot 10^6 - 0.1^2 \cdot 2^2 \cdot \pi^2 \cdot 10^2 \times (33^2 \cdot 10^6)}$$

$\therefore \quad C = 70 \text{ nF}$

9.1





$v_o = - R_D\, i$

(i) $v_{in} = r_s\, i \quad \Rightarrow \quad \frac{v_o}{v_{in}} = - \frac{R_D}{r_s}$

(ii) $v_{in} = (r_s + R_S)\, i \quad \Rightarrow \quad \frac{v_o}{v_{in}} = - \frac{R_D}{r_s + R_S}$

$$v_{in} = i\left(r_s + (R_S \| C_S)\right) = i\left(r_s + \frac{R_s \times \frac{1}{j\omega C}}{R_s + \frac{1}{j\omega C}}\right) = i\left(r_s + \frac{R_S}{1 + j\omega R_S C}\right)$$

$$= i\left(\frac{(r_s + R_S) + j\omega R_S r_s C}{1 + j\omega R_S C}\right)$$

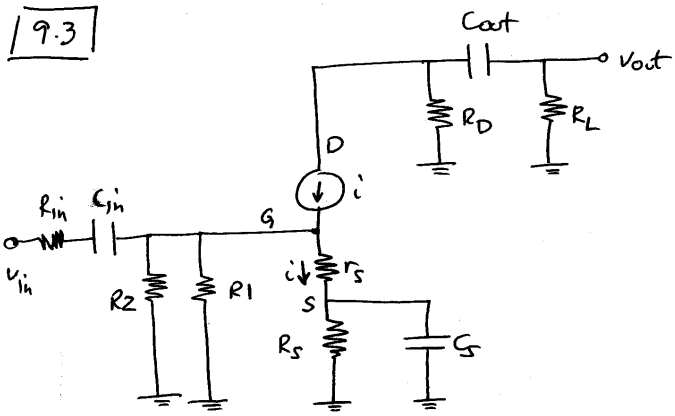
$$\frac{v_o}{v_{in}} = - \frac{R_D\,(1 + j\omega R_s C)}{(r_s + R_s) + j\omega R_s r_s C} = - \frac{R_D}{r_s + R_S} \cdot \frac{1 + j\omega R_S C}{1 + j\omega (R_S \| r_s) C}$$

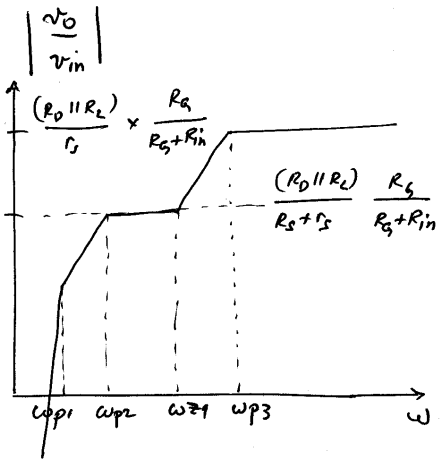
$$\omega_{p1} = 2\pi f_L = \frac{1}{(R_S \| r_s) C} \quad \Rightarrow \quad C = \frac{1}{2\pi f_L (R_S \| r_s)}$$

$$C = \frac{1}{2 \times 3.14 \times 20 \times \frac{6\times10^3 \times 1\times10^3}{6\times10^3 + 1\times10^3}} = 9.3\,\mu F$$

$$f_{z1} = \frac{1}{2\pi} \frac{1}{R_S C} = \frac{1}{2 \times 3.14 \times 6\times10^3 \times 9.3 \times 10^{-6}} = 2.85\,Hz$$

9.3





$$\omega_{z1} = \frac{1}{R_S C_S} \Rightarrow f = \frac{1}{2\pi \times 2\times10^{7} \times 10\times10^{-6}} = 8\,Hz$$

$$\omega_{p2} = \frac{1}{(R_S \| r_s) C_S} \Rightarrow f = \frac{1}{2\pi \frac{200 \times 2\times10^{3}}{200 + 2\times10^{3}} \times 10\times10^{-6}} = 87\,Hz$$

$$g_m = \frac{1}{r_s}$$

$$\omega_{p1} = \frac{1}{(R_{in} + R_G) C_{in}} \Rightarrow f = \frac{1}{2\pi (100\times10^{3} + 9.2\times10^{6}) \times 0.01\times10^{-6}} = 1.9\,Hz$$

$$\omega_{p3} = \frac{1}{(R_D + R_L) C_{out}} \Rightarrow f = \frac{1}{2\pi (10\times10^{3} + 4.7\times10^{3}) \times 0.1\times10^{-6}} = 108\,Hz$$