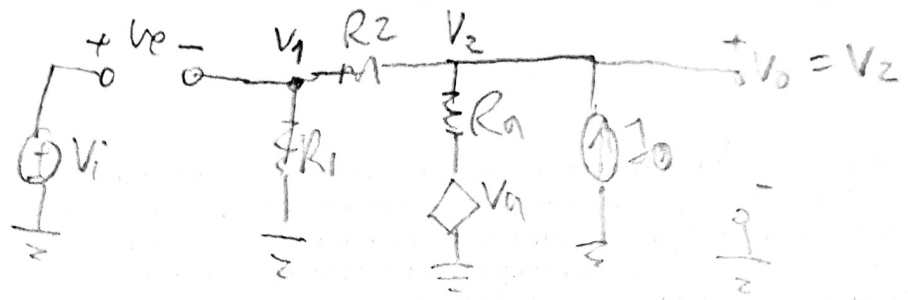
19.



Definition: $V_a = AV_e \rightarrow V_e = V_a/A$

Definition: $V_e = V_i - V_1 \rightarrow V_1 = V_i - V_e = V_i - V_a/A$

Current sum at V_2: $0 = \frac{V_2 - V_1}{R_2} + \frac{V_2 - V_a}{R_a} - I_o$

$$V_2\left(\frac{R_2+R_a}{R_2R_a}\right) = \left(\frac{V_1}{R_2} + \frac{V_a}{R_a} + I_o\right)$$

Current sum at V_1: $0 = \frac{V_1 - 0}{R_1} + \frac{V_1 - V_2}{R_2}$

$$V_1 = \frac{V_2}{R_2}\left(\frac{R_1R_2}{R_1+R_2}\right) = \left(\frac{R_1}{R_1+R_2}\right)V_2$$

Substitute: $V_2\left(\frac{R_2+R_a}{R_2R_a}\right) = \left(\frac{R_1}{R_2(R_1+R_2)}V_2 + \frac{V_a}{R_a} + I_o\right)$

$$V_2\left(\frac{R_2+R_a}{R_2R_a} - \frac{R_1}{R_2(R_1+R_2)}\right) = \frac{V_a}{R_a} + I_o$$

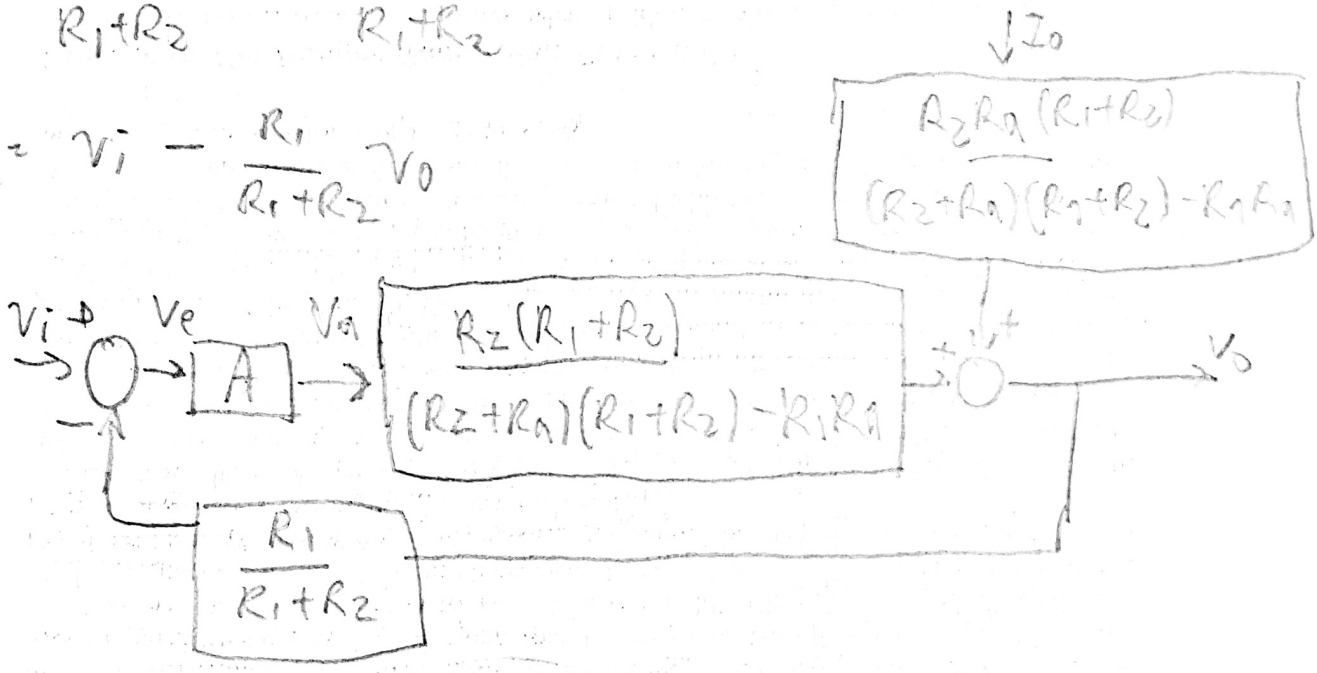
$$V_o = V_2 = \underbrace{\left(\frac{R_2R_a(R_1+R_2)}{(R_2+R_a)(R_1+R_2) - R_1R_a}\right)}_{B}\left(\frac{V_a}{R_a} + I_o\right)$$

1b. $v_e = v_i - v_1$

$$v_1 = \frac{R_1}{R_1+R_2} v_2 = \frac{R_1}{R_1+R_2} v_o$$

$$v_e = v_i - \frac{R_1}{R_1+R_2} v_o$$

1c.



2. $$v_a = Av_e = A\left(v_i - \frac{R_1}{R_1+R_2} v_o\right)$$

$$v_o = \left(\ B\ \right)\left[\frac{A\left(v_i - \frac{R_1}{R_1+R_2} v_o\right)}{R_a} + I_o\right]$$

$$v_o\left(1 + \frac{BR_1}{R_a(R_1+R_2)}\right) = \frac{BA}{R_a} v_i + BI_o$$

2a $$\frac{v_o}{v_i} = \frac{BA/R_a}{1+\frac{BR_1}{R_a(R_1+R_2)}} = \frac{AR_2(R_1+R_2)}{(R_2+R_a)(R_1+R_2)-R_1R_a}$$

$$\frac{(R_2+R_a)(R_1+R_2)-R_1R_a)R_a(R_1+R_2) + R_2R_aR_1(R_1+R_2)}{R_a(R_1+R_2)((R_2+R_a)(R_1+R_2)-R_1R_a)}$$

$$= \frac{AR_2(R_1+R_2)}{(R_2+R_a)(R_1+R_2)-R_1R_a+R_1R_2}$$

$$\frac{v_o}{v_i} = \frac{10^5 (9k)(10k)}{(9050)(10k) - 50k + (9\times10^6)}$$

$$= 90497$$

26. $\frac{v_o}{v_i} = \infty$

39. $\frac{v_o}{I_o} = \frac{B}{1 + \frac{BR_1}{R_a(R_1+R_2)}} = \frac{R_2 R_a (R_1+R_2)}{(R_2+R_a)(R_1+R_2) - R_1 R_2}$

$$= \frac{R_2 R_a (R_1+R_2)}{((R_2+R_a)(R_1+R_2) - R_1 R_2) + R_a(R_1+R_2)}$$

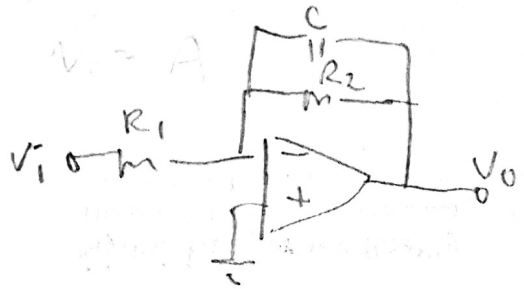
$$= \frac{R_2 R_a (R_1+R_2)}{((R_2+R_a)(R_1+R_2) - R_1 R_a + R_1 R_2)}$$

$$\frac{v_o}{I_o} = \frac{9k(50)(10k)}{9050(10k) - 50k + (9\times10^6)}$$

$$= 45.24$$

36. $\frac{v_o}{I_o} = 45.24$

4a.



$$\frac{V_i}{R_1} + \frac{V_o}{R_2} + C\frac{dV_o}{dt} = 0$$

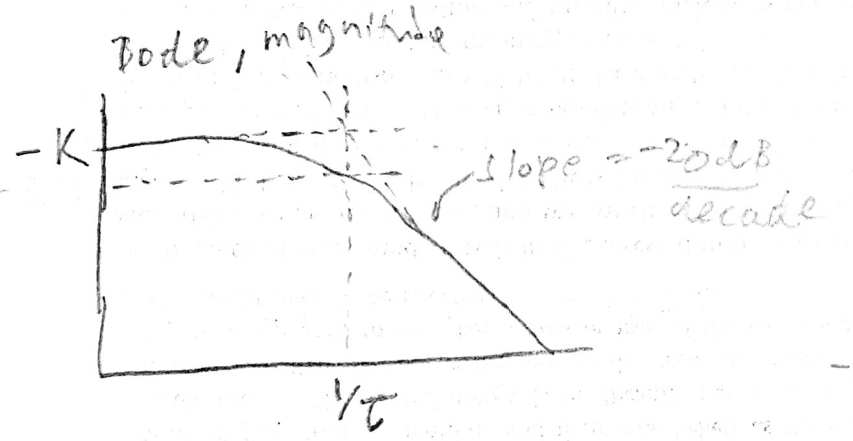
$$\therefore \frac{dV_o}{dt} + V_o = -kV_i$$

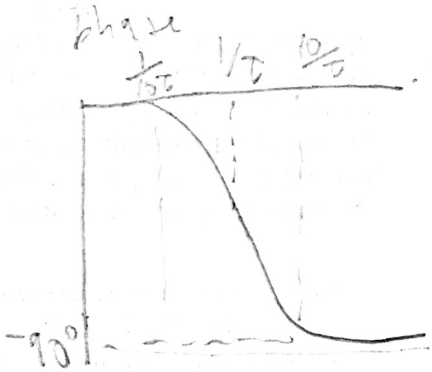
$$\frac{V_o}{V_i} = \frac{-k}{\tau s + 1} \quad \text{where}$$

$$\tau = R_2 C = 10k(.01)10^{-6} = 10^{-4}\ s^{-1}$$

$$k = R_2/R_1 = 10k/1k = 10$$

4b.





$$\text{step } y(t) = \frac{-K}{s(\tau s+1)} = \frac{-k}{s} + \frac{k\tau}{\tau s+1} = \frac{-k}{s} + \frac{k}{s-(-\frac{1}{\tau})}$$

$$\therefore y(t) = -k + Ke^{-t/\tau}$$