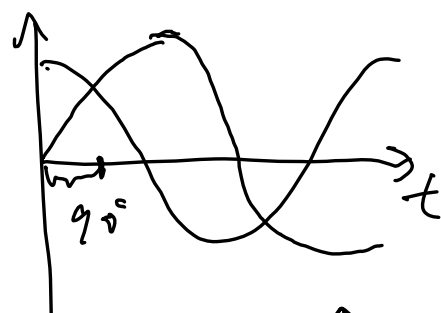
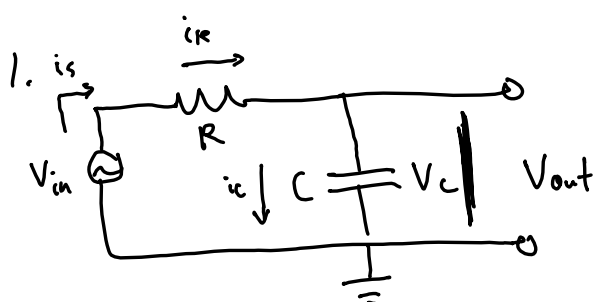


HW #5



a) $V_{out} = V_c$

b) $\tan \theta = \frac{X_c}{R}$

$$i_c = C \cdot \frac{dV_c}{dt}$$

$$i_R = \frac{V_R}{R}$$

$$i_R = i_c = i_s$$

$$\frac{V_R}{R} = C \cdot \frac{dV_c}{dt}$$

$$\theta = \tan^{-1}\left(\frac{X_c}{R}\right)$$

$$V_R \propto \frac{dV_c}{dt}$$

$R \rightarrow 0$
 $\theta = \tan^{-1}(\infty)$

$$= 90^\circ$$

ex) $V_c = V_0 \sin(\omega t)$

$$V_R = k \cdot \cos(\omega t)$$

$X_c \rightarrow 0$

$$\theta = \tan^{-1}\left(\frac{0}{R}\right) = \tan^{-1}(0) = 0$$

c) $R = 1k\Omega$, $C = 0.01\mu F$

i) $f = 1000 Hz$

$$X_c = \frac{1}{2\pi f C} = \frac{1}{2\pi \cdot 1000 \cdot 0.01\mu F} = 1591 \Omega$$

$$Z = \sqrt{X_c^2 + R^2} = \sqrt{(1591)^2 + (1000)^2} = 1880 \Omega$$

$$\theta = \tan^{-1}\left(\frac{1591}{1000}\right) = 57.9^\circ$$

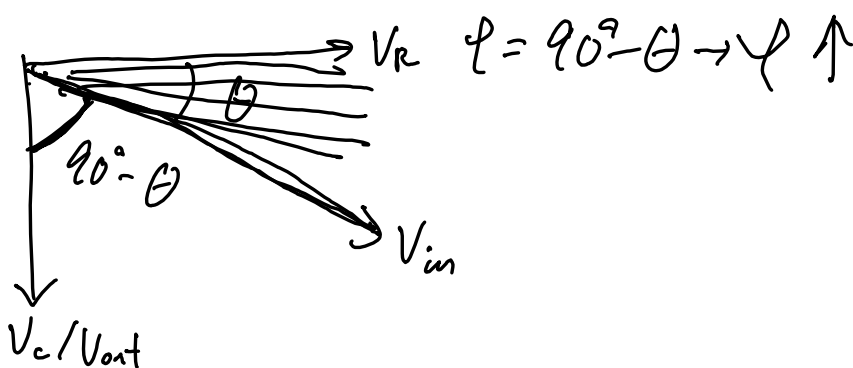
d) V_{out} , V_{in} , R , X_c

$$V_{out} = V_{in} \cdot \frac{X_c}{Z} = V_{in} \cdot \frac{X_c}{\sqrt{X_c^2 + R^2}}$$

e) $f \uparrow \rightarrow X_c \propto \frac{1}{f} \rightarrow X_c \downarrow$

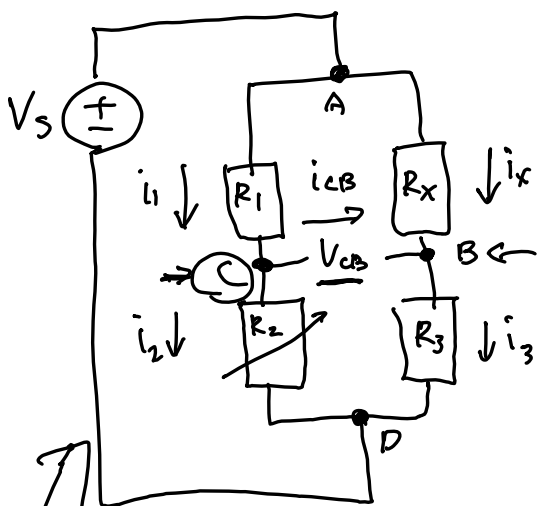
$$V_{out} = \frac{X_c}{Z} \rightarrow V_{out} \downarrow$$

f) $f \uparrow \rightarrow X_c \downarrow \rightarrow \theta = \tan^{-1}\left(\frac{X_c}{R}\right) \rightarrow \theta \downarrow$



g) $f \uparrow \rightarrow T \propto \frac{1}{f} \rightarrow T \downarrow \rightarrow t_{delay} \downarrow$

2.



balanced:

$$V_{CB} = 0$$

$$i_{CB} = 0$$

$$R_x = \frac{R_1 \cdot R_3}{R_2}$$

a) $R_1 = R_3 = 100 \Omega$, $R_2 = 40 \Omega$, $V_s = 15V$

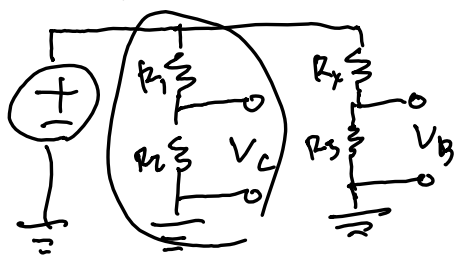
$$R_x = \frac{R_1 \cdot R_3}{R_2} = \frac{(100 \Omega)(100 \Omega)}{40 \Omega} = \boxed{250 \Omega}$$

b) V_{CB} if V_s doubles?

$$V_{CB} = 0 \text{ b/c balanced}$$

c) Double R_1, R_2, R_3

$$V_{CB} = V_C - V_B = V_s \cdot \frac{R_1}{R_1 + R_2} - V_s \cdot \frac{R_x}{R_x + R_3}$$



2x voltage dividers!

$$= 15V \left(\frac{80 \Omega}{280 \Omega} - \frac{200 \Omega}{450 \Omega} \right)$$

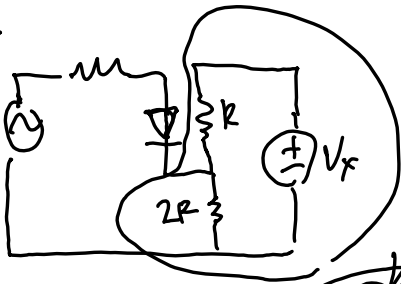
$$= \boxed{-2.38V}$$

↑
unbalanced

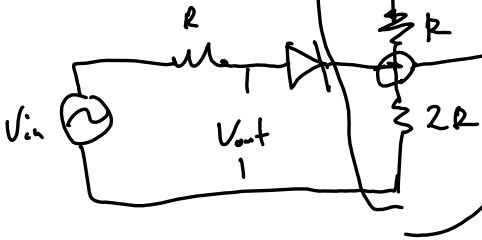
$$R_x = \frac{R_1 \cdot R_3}{R_2}$$

$$R_2 = \frac{R_1 \cdot R_3}{R_x} = \frac{(200 \Omega)^2}{250 \Omega} = \boxed{160 \Omega}$$

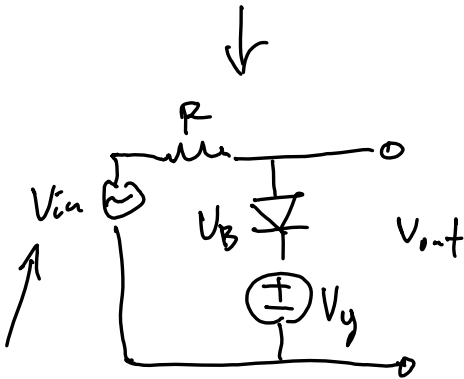
3.



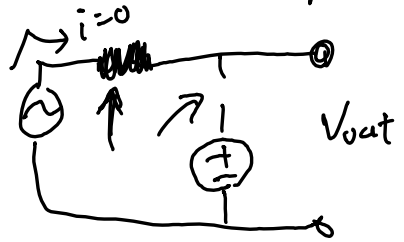
Voltage divider



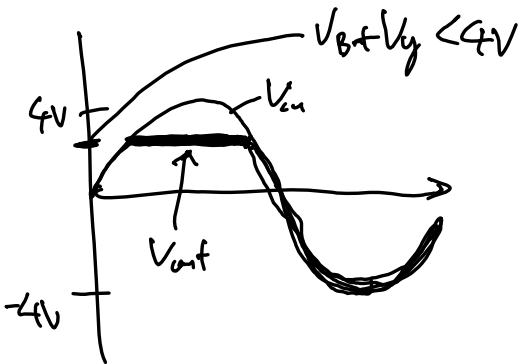
$$V_y = V_x \cdot \frac{2R}{R+2R} = \frac{2}{3} V_x$$



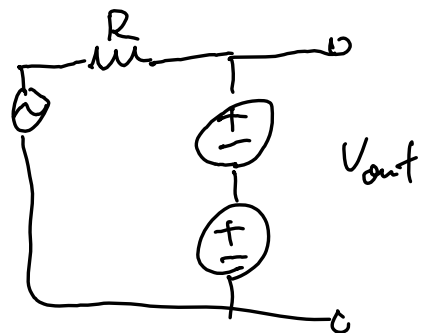
$$V_{in} < V_B + V_y :$$



$$V_{out} = V_{in}$$

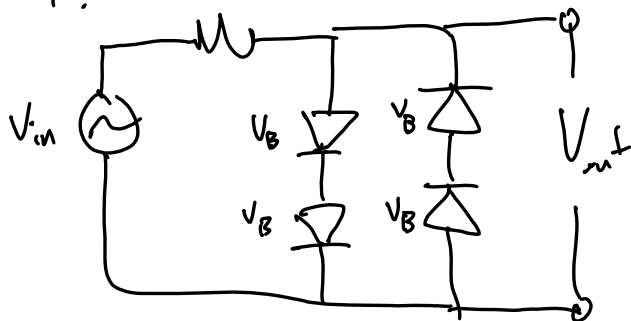


$$V_{in} \geq V_B + V_y :$$

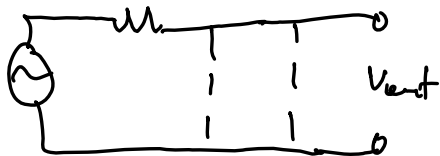


$$V_{out} = V_y + V_B$$

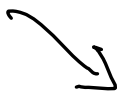
4.



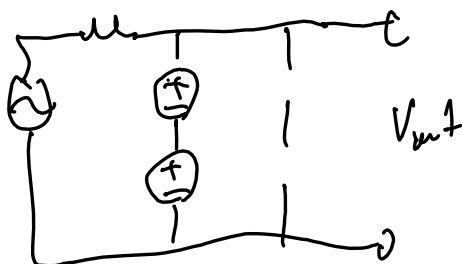
$$0 < V_{in} < 2V_B$$



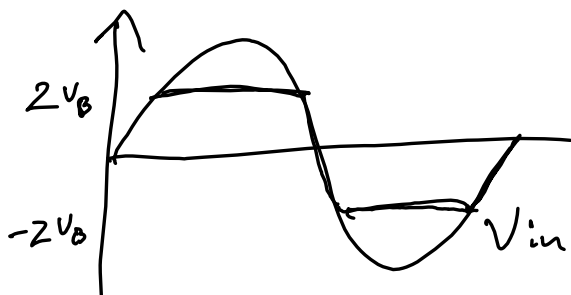
$$V_{out} = V_{in}$$

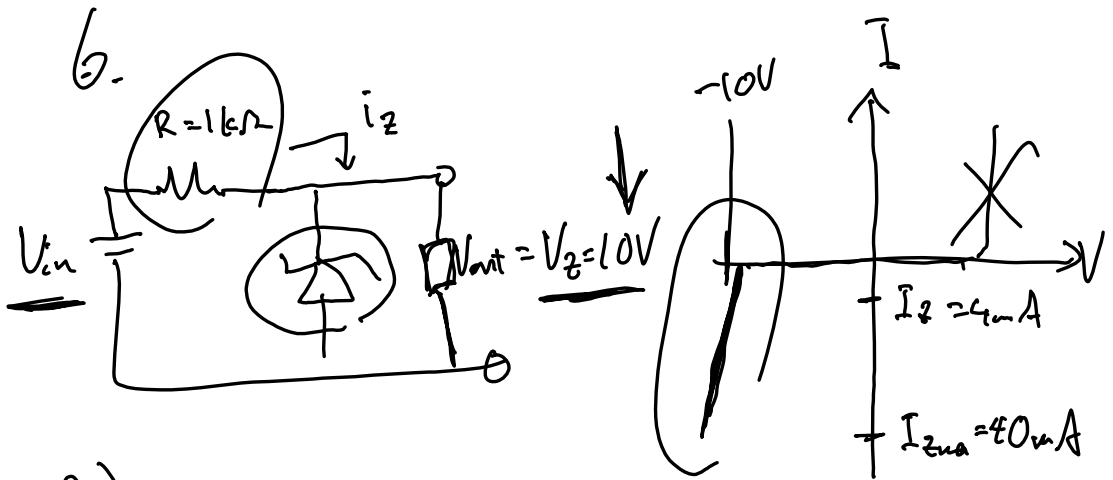


$$V_{in} \geq 2V_B :$$



$$V_{out} = 2V_B$$





a) $V_{R_{min}} = I_{Z_{min}} \cdot R = 4\text{ mA} \cdot 1\text{ k}\Omega = \underline{4\text{ V}}$

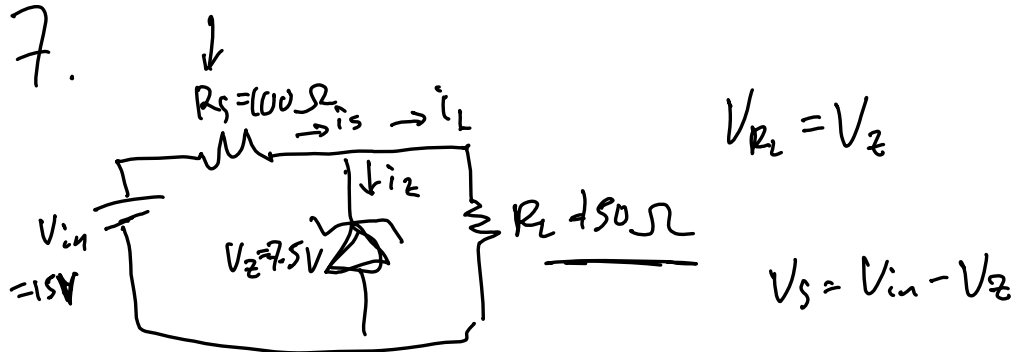
$V_{R_{max}} = I_{Z_{max}} \cdot R = 40\text{ mA} \cdot 1\text{ k}\Omega = \underline{40\text{ V}}$

$V_{in_{min}} = V_{R_{min}} + V_Z = 4\text{ V} + 10\text{ V} = \boxed{14\text{ V}}$

$V_{in_{max}} = V_{R_{max}} + V_Z = 40\text{ V} + 10\text{ V} = \boxed{50\text{ V}}$

b) Same as a)

7.



$$a) i_L = \frac{V_Z}{R_L} = \frac{7.5V}{150\Omega} = \boxed{50mA}$$

$$b) i_S = \frac{V_{in} - V_Z}{R_S} = \frac{7.5V}{100\Omega} = \boxed{75mA}$$

$$c) KCL: i_Z = i_S - i_L$$

$$= 75mA - 50mA = \boxed{25mA}$$

$$d) P = I \cdot V$$

$$P_S = I_S \cdot V_S = 563mW$$

$$P_L = I_L \cdot V_L = 375mW$$

$$P_Z = I_Z \cdot V_Z = \boxed{188mW}$$

$$e) R_L = 250\Omega \text{ find } i_L, i_S, i_Z$$

$$i_L = 30mA$$

$$i_S = 75mA$$

$$i_Z = \boxed{45mA}$$

$$f) P_S = i_S \cdot V_S = 563mW$$

$$P_L = i_L \cdot V_L = 225mW$$

$$P_Z = i_Z \cdot V_Z = \boxed{338mW}$$