ECE 248
HW2 Solutions

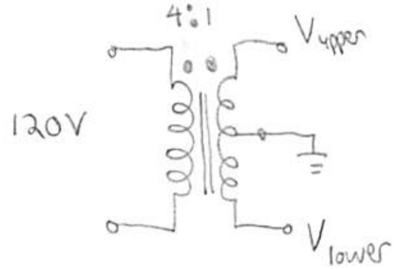
Total = 100 pts

4.9 (+9)

$$V_{upper} = \frac{120}{4} \times \frac{1}{2} = \boxed{15\,V_{rms}}$$

$$V_{peak} = 15\sqrt{2} = \boxed{21.2\,V_p}$$

$$V_{lower} = \frac{120}{4} \times \frac{1}{2} = \boxed{15\,V_{rms}}$$

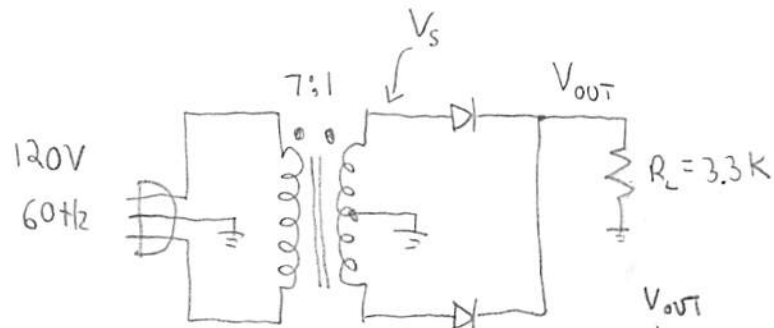


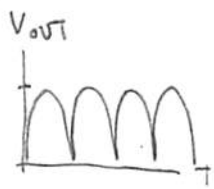
4.11 (+9)

$$\text{Peak } V_s = \frac{120V}{7} \times \frac{1}{2} \times \sqrt{2} = 12.1V$$

$$\text{Peak } V_{OUT} = 12.1 - 0.7 = \boxed{11.4\,V_p}$$

$$\text{Average value} = \text{DC value} = 2 \times \frac{11.4}{\pi} = \boxed{7.3V}$$



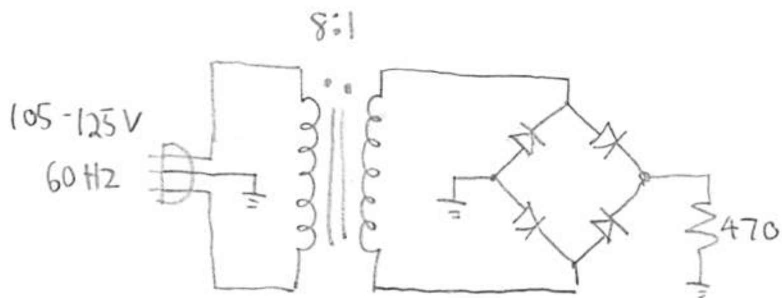


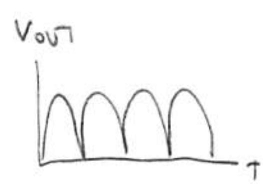
4.14 (+9)

Minimum DC output voltage

$$V_{min} = \left(\frac{105}{8} \times \sqrt{2} - 1.4\right) \times \frac{2}{\pi}$$

$$= \boxed{10.9V}$$

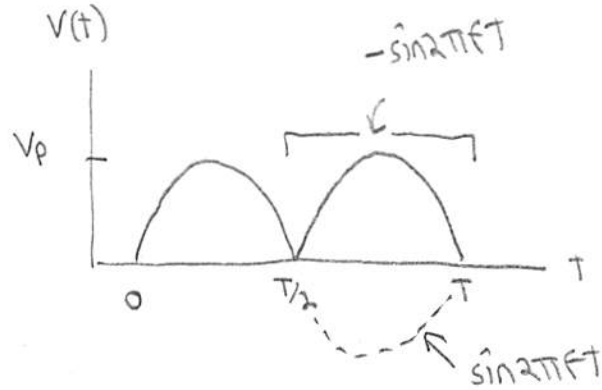




Max DC output voltage

$$V_{max} = \left(\frac{125}{8} \times \sqrt{2} - 1.4\right) \times \frac{2}{\pi} = \boxed{13.2V}$$

4-xx (+5)



$$\langle v \rangle = \frac{1}{T}\int_0^T v(t)\,dt$$

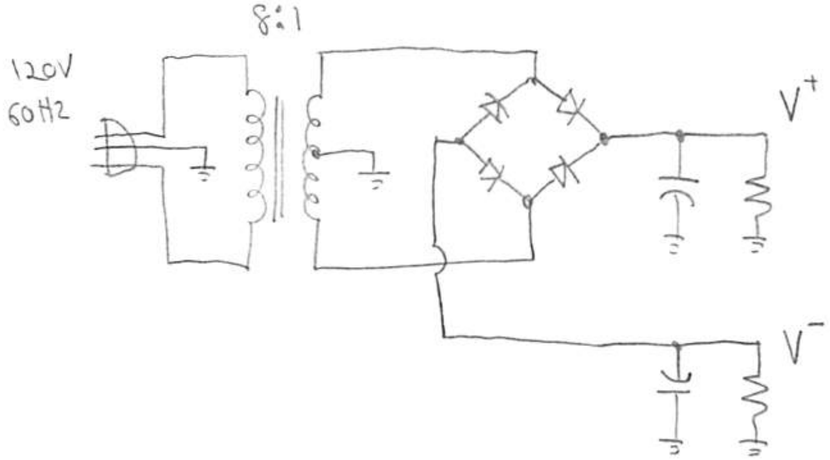
$$= \frac{1}{T}\left[\int_0^{T/2} V_p \sin 2\pi f t\,dt + \int_{T/2}^{T} V_p(-\sin 2\pi f t)\,dt\right]$$

$$= \frac{V_p}{T}\left[\frac{-1}{2\pi f}\cos 2\pi f t\Big|_0^{T/2} + \frac{1}{2\pi f}\cos 2\pi f t\Big|_{T/2}^{T}\right]$$

$$= \frac{V_p}{\underbrace{2\pi f T}_{1}}\left[-\underbrace{(\cos\pi - \cos 0)}_{-2} + \underbrace{(\cos 2\pi - \cos\pi)}_{2}\right]$$

$$= \frac{4V_p}{2\pi} = \boxed{\frac{2V_p}{\pi}}$$ ✓

4.45 (+9)



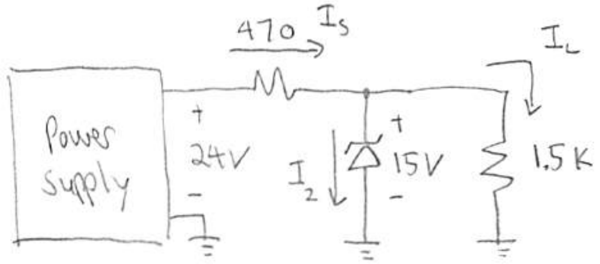
$$V^+ = \left[\frac{120}{8}\times\sqrt{2}\times\frac{1}{2}\right] - 0.7$$

$$= \boxed{9.9V}$$

$$V^- = -\left[\frac{120}{8}\sqrt{2}\times\frac{1}{2}\right] + 0.7$$

$$= \boxed{-9.9V}$$

5.5 (+9)



$$I_s = \frac{24-15}{470} = \boxed{19.1\text{ mA}}$$

$$I_L = \frac{15}{1.5K} = \boxed{10\text{ mA}}$$

$$I_z = I_s - I_L = \boxed{9.1\text{ mA}}$$

5.6 (+9)

Max zener current involves lowest R_s and highest R_L.

$$I_{s,max} = \frac{24-15}{.95\times470} = 20.2\text{ mA}$$

$$I_{L,min} = \frac{15}{1.05\times1.5k} = 9.5\text{ mA}$$

$$I_{z,max} = I_{s,max} - I_{L,min} = \boxed{10.7\text{ mA}}$$

5.7 (+9)

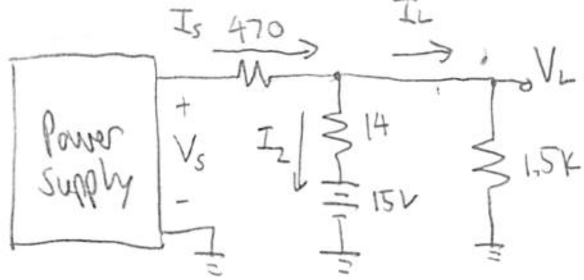
Max zener current involves highest supply

$$I_{s,max} = \frac{40-15}{470} = 53.2\text{ mA}$$

$$I_L = \frac{15}{1.5K} = 10\text{ mA}$$

$$I_{z,max} = I_{s,max} - I_L = \boxed{43.2\text{ mA}}$$

5.11 (+9)



$$I_s = I_z + I_L$$

$$\frac{V_s - V_L}{470} = \frac{V_L - 15}{14} + \frac{V_L}{1500}$$

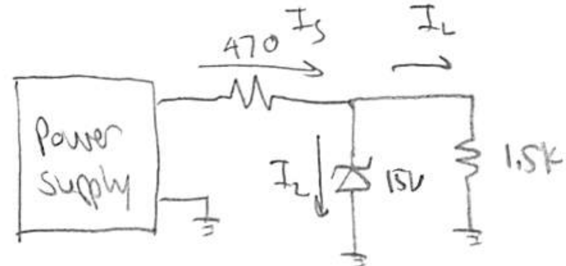
$$\frac{V_s}{470} + \frac{15}{14} = \left(\frac{1}{470} + \frac{1}{14} + \frac{1}{1500}\right) V_L = .074\, V_L$$

$$V_L = \frac{1}{.074}\left(\frac{V_s}{470} + \frac{15}{14}\right)$$

$V_s = 21.5V \rightarrow V_L = \boxed{15.1V}$

$V_s = 25V \rightarrow V_L = \boxed{15.2V}$

5.12 (+5)



Drop out occurs when $I_z = 0$

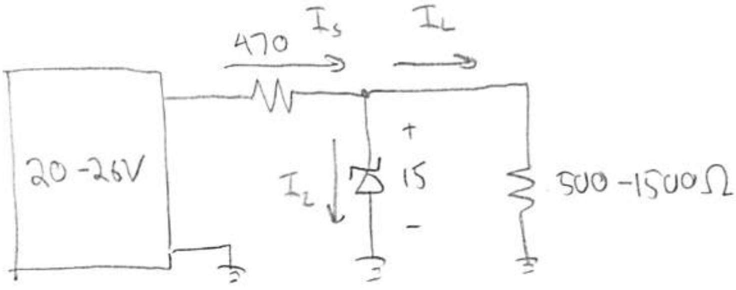
$\rightarrow I_s = I_L$

$$\frac{V_s - 15}{470} = \frac{15}{1500}$$

$$V_s = \left(\frac{15}{1500} + \frac{15}{470}\right) 470 = \boxed{19.7V}$$ ← Voltage regulation is completely gone.

Note: Regulation becomes poor when $I_z \lesssim 10$ mA

5.13 (+9)



worst case scenario:

$$I_z = I_s - I_L$$

$$= \frac{20-15}{470} - \frac{15}{500}$$

$$= 10.6\text{ mA} - 30\text{ mA} = -19.4\text{ mA} < 0 \text{ !}$$

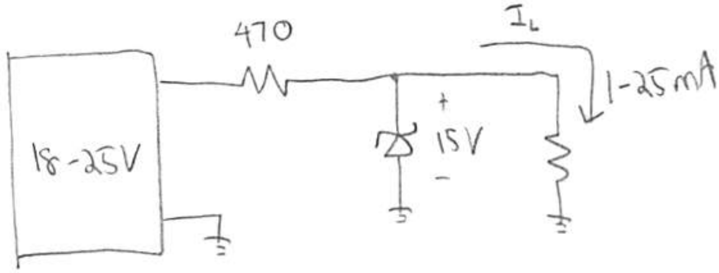
YES, the zener regulator will fail. :(

want $I_{z,min} = 0 = \frac{20-15}{R_{s,max}} - \frac{15}{500}$

$$R_{s,max} = (20-15)\frac{500}{15} = \boxed{167\Omega}$$

← NOTE: In practice, R_s should be lower than this to keep $I_z > 10\text{ mA}$.

5.14 (+9)



worst case scenario:

$$I_z = I_s - I_L$$

$$= \frac{18-15}{.470k} - 25\text{ mA}$$

$$= -18.6\text{ mA} < 0 \text{ !}$$

YES, the zener will fail. :(

want $I_{z,min} = 0 = \frac{18-15}{R_{s,max}} - 25\text{ mA}$

$$R_{s,max} = \frac{3}{25\text{ mA}} = 0.12k = \boxed{120\Omega}$$

← NOTE: In practice, R_s should be lower than this to keep $I_z > 10\text{ mA}$