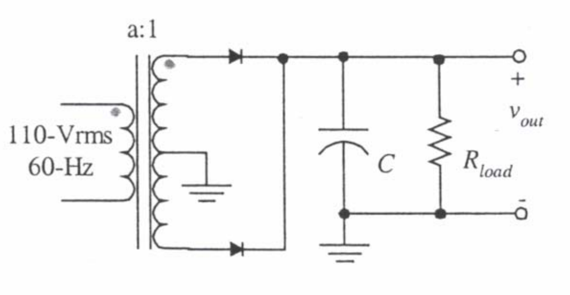
**ETEE3211** **Fall 2003** **Test #1** **Name:__________________**

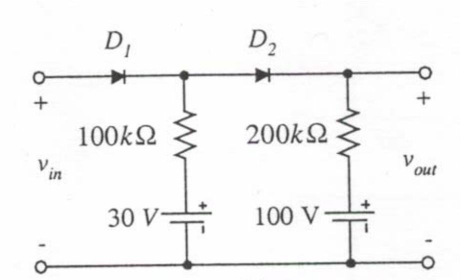
**Show all work. Clearly indicate final answer(s).**

1. (20 points) A particular diode has a reverse saturation current of 0.2μA, n=1.6, and $V_T$=26mV. Determine the diode current when the voltage across the diode is 0.4V. Also determine the forward resistance of the diode at this operating point. Hint: Assume zero contact resistance.

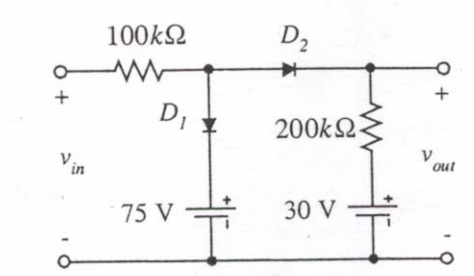
2. (40 points) Determine the capacitor size for the circuit shown to the right when a=6 and $R_{load}$=100Ω. The minimum voltage to the load must not drop by more than 20%. Consider the diodes and transformer ideal.



3. (40 points)
   a. The input voltage to the clipper circuit in figure (a) varies linearly from 0 to 150V. Sketch the output voltage, vout, on the same time plot as the input. Assume the diodes are ideal.
   b. Repeat part (a) for the circuit in figure (b).

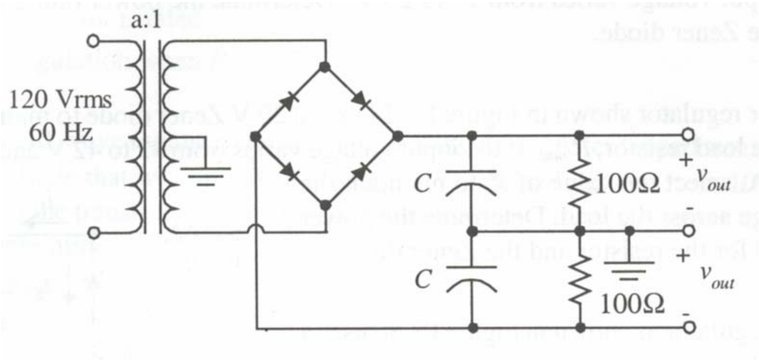


(a)



(b)

EXTRA CREDIT (20 points max):
An integrated circuit requires plus and minus voltages for their operation. Using the circuit to the right, determine the transformer winding ratio and the capacitor size needed to get a maximum of 14V and a minimum of 12V at the output when the input is 120Vrms 60Hz, $V_{ON}$=0.7V for each of the diodes and $R_f$=0. Ignore transformer loss.



# *(HOPEFULLY!) USEFUL STUFF*

$$v_{out,avg} = \frac{1}{T}\int_0^T v_{out}(t)dt = \frac{1}{T}\int_0^{T/2} V_0 \sin\frac{2\pi t}{T}dt + \frac{1}{T}\int_{T/2}^{T} 0dt = \frac{V_0}{\pi} + 0 \approx 0.318V_0$$

$$R_i = \frac{V_{s\min} - V_z}{I_{L\max} + I_{z\min}} = \frac{V_{s\max} - V_z}{I_{L\min} + I_{z\max}}$$

$k_T$ = -2.0 mV/$^o$C for Si, –2.5 mV/$^o$C for Ge

$$i_D = I_O(e^{\frac{v_D}{nV_T}} - 1)$$

26mV@room temperature

$$\%reg = \frac{V_{out\max} - V_{out\min}}{V_{outnominal}} * 100$$

$$r_d = \frac{nV_T}{i_D}$$

$$C = \frac{V_{\max}}{\Delta V f_p R_L}$$

$$C_F = \frac{V_{s\max} - V_Z}{\Delta V f_p R_i}$$

$$V_{ON}(T_{New}) - V_{ON}(T_{room}) = k_T(T_{New} - T_{room})$$

$$I_0(atT_2) = I_0(atT_1)e^{k_i(T_2 - T_1)}$$

$$J = q(p\mu_p + n\mu_n)E$$

$$R = \frac{\rho L}{A} = \frac{L}{\sigma A}$$

$$I_{z\max} = \frac{I_{L\min}(V_z - V_{s\min}) + I_{L\max}(V_{s\max} - V_z)}{V_{s\min} - 0.9V_z - 0.1V_{s\max}}$$

1)
P3.11

Given: $I_0 = 0.2\mu A$
$n = 1.6$
$V_T = 26mV$

Want $i_D$, when $v_D = 0.4V$
$R_f$

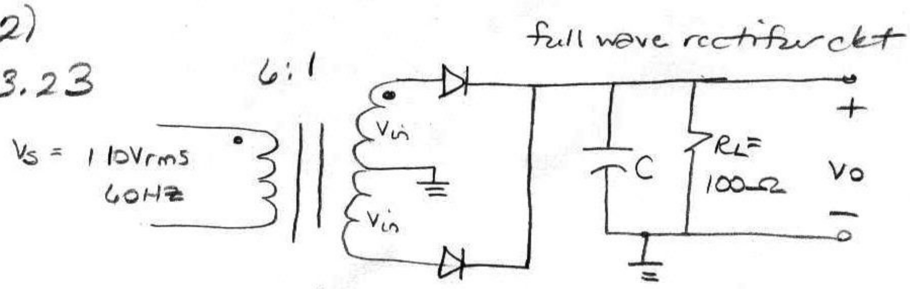
$$i_D = I_0\left(e^{\frac{v_D}{nV_T}} - 1\right) = (2\times10^{-7})\left(e^{\left(\frac{0.4}{(1.6)(0.026)}\right)} - 1\right)$$

$$\underline{\underline{i_D \cong 3mA}}$$

$$R_f \simeq r_d = \frac{nV_T}{i_D} = \frac{(1.6)(26m)}{3m} = \underline{\underline{13.9\,\Omega}}$$

2)

P3.23



C = ?

Given: Ideal diode ( $V_{on} = 0$, $R_f = 0$, $R_r = \infty$ )

Ideal transformer

free 10pts

$V_{in\,min} \geq 0.8\, V_{in\,max}$ (can't drop by more than 20%)

$V_{s\,peak} = 110\sqrt{2} = 155.6\ V_{peak}$

$V_{in\,peak} = \frac{155.6}{(6)(2)} \cong 13\ V_{peak}$

↖ center tap

$\Delta V_{max} = (0.2) V_{in\,max} = (0.2)(13) = 2.6\,V$

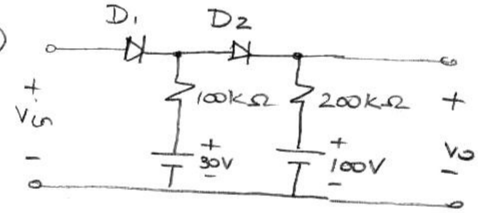
$V_{in\,min} = (0.8)(13) = 10.4\,V$ (not a necessary calculation - could use $\Delta V = V_{max} - V_{min} = 2.6V$)

$$C = \frac{V_{in\,max}}{\Delta V_{max}\, f_p\, R_L} = \frac{(13)}{(2.6)(120)(100)} \cong \underline{\underline{417\mu F}}$$

3) ideal diodes ⇒ $V_{on} = 0$, $R_f = 0$, $R_r = \infty$

P3.41

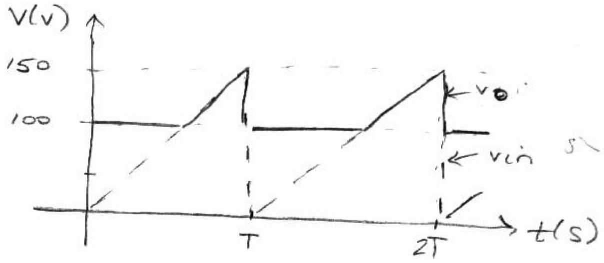
a)



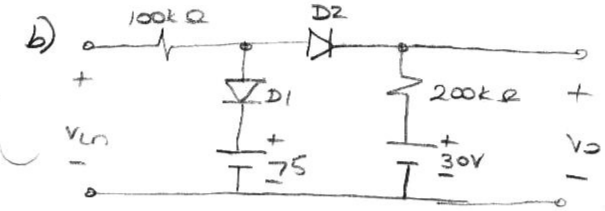
$v_{in} < 30V$ $D_1$ off, $D_2$ off, $\underline{v_o = 100V}$

$30 \le v_{in} < 100V$ $D_1$ on, $D_2$ off, $\underline{v_o = 100V}$

$v_{in} \ge 100V$, $D_1$ on, $D_2$ on, $\underline{v_o = v_{in}}$
(everything is in parallel
if diodes are ideal!)



b)



$v_{in} < 30V$, $D_1$ off, $D_2$ off, $\underline{v_o = 30V}$

$30 < v_{in} < 75$, $D_1$ off, $D_2$ on

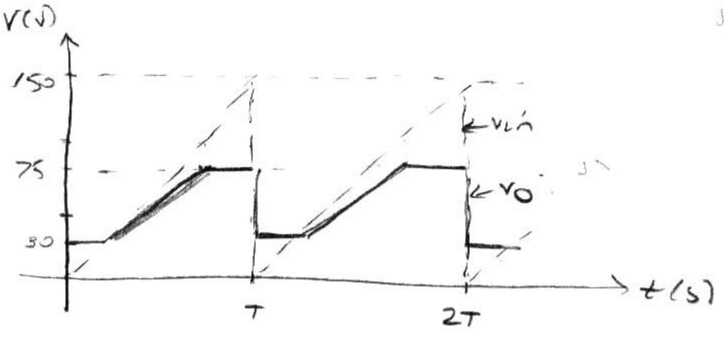
$$v_o = 30 + \left(\frac{v_{in} - 30}{300k}\right)(200k)$$

$$\underline{v_o = 10 + \tfrac{2}{3} v_{in}}$$

max $v_o = 75V$ (when $D_1$ on)

$v_o = 75$ @ $75 = 10 + \frac{2}{3} v_{in}$

$v_{in} = \frac{3}{2}(75 - 10) = 97.51$



| Vin | Vo |
|---|---|
| <30 | 30 |
| 50 | 43.3 |
| 75 | 60 |
| >97.51 | 75 |

EC P3.25

voltage needed @ secondary:

5 $$\underset{\substack{\uparrow \\ \text{center tap}}}{2}\left(V_{o\max} + \underset{\substack{\uparrow \\ \text{2 diodes on each path}}}{2}V_{on}\right) = 2\,(14+1.4) = 30.8\,V_{(\text{peak})}$$

$V_{in_{peak}} = 120\sqrt{2} \cong 169.7\,V$

5 $$a = \frac{169.7}{30.8} \cong 5.5 \qquad (\text{ie: } 5.5:1, \text{ or } 11:2)$$

2 $\Delta V = (14-12) = 2V$

2 $f_p = 120\,Hz$ (full wave rectifier)

5

$$C = \frac{V_{max}}{\Delta V f_p R_L} = \frac{14}{2\,(120)(100)} = \underline{583\mu F}$$