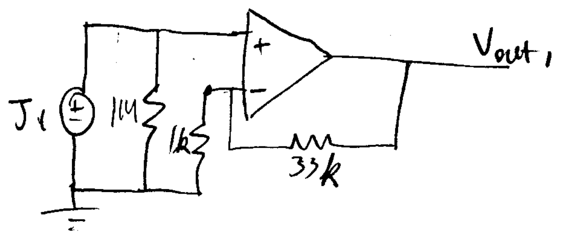
EE100 Problem Set 9 - Soln

2)

IC1-a

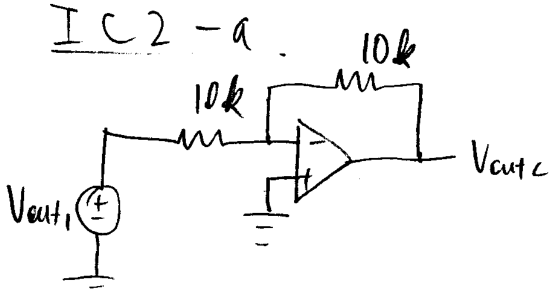


$$\frac{J_1}{1k} + \frac{J_1 - V_{out1a}}{33k} = 0$$

$$J_1\left(1 + \frac{1}{33}\right) = \frac{V_{out1a}}{33}$$

$$V_{out1a} = 34\, J_1 \Rightarrow \boxed{A_{1a} = 34}$$

IC2-a



$$\frac{0 - V_{out1a}}{10k} + \frac{0 - V_{out2}}{10k} = 0$$

$$V_{out2} = -V_{out1a} \Rightarrow \boxed{A_{2a} = -1}$$

IC3-b

By Symmetry, this is the same as IC3-a

$\boxed{A_{3b} = -10}$

IC1-b

By symmetry, this is the same as IC1-a

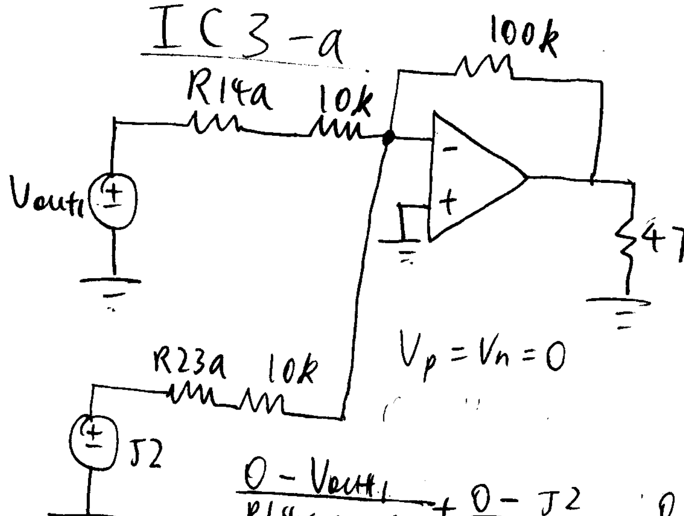
$\boxed{A_{1b} = 34}$

IC2-b

By symmetry again, this is the same as IC2-b

$\boxed{A_{2b} = -1}$

IC3-a



$V_p = V_n = 0$

$$\frac{0 - V_{out1}}{R14a + 10k} + \frac{0 - J2}{R23a + 10k} + \frac{0 - V_{out}}{100k} = 0$$

$$V_{out} = -100k\left(\frac{V_{out1}}{R14a + 10k} + \frac{J2}{R23a + 10k}\right)$$

Gain from $V_{out1a}/V_{out2a} = \frac{-100k}{R14a + 10k}$

Gain from $J2 = \frac{-100k}{R23a + 10k}$

For maximum signal amplitude

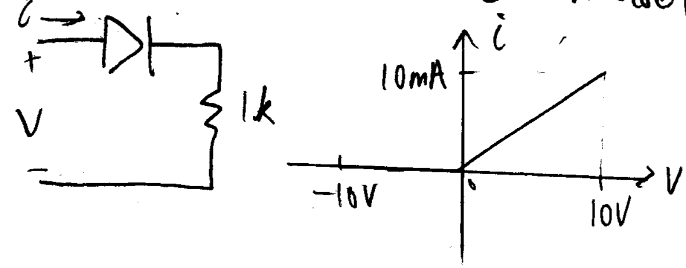
$R14a / R14b \rightarrow 0k \Rightarrow \frac{-100k}{10k} = -10$

$R23a / R23b \rightarrow 0k \Rightarrow -\frac{100k}{10k} = -10$

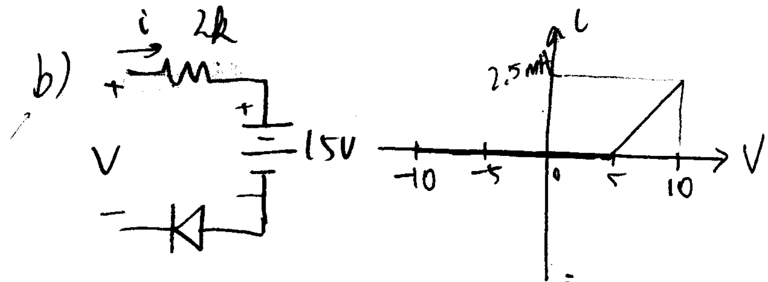
$\boxed{A_{3a} = -10}$

3) P10.35 ⇒ Ideal diode model, V ranges from −10 V to 10 V

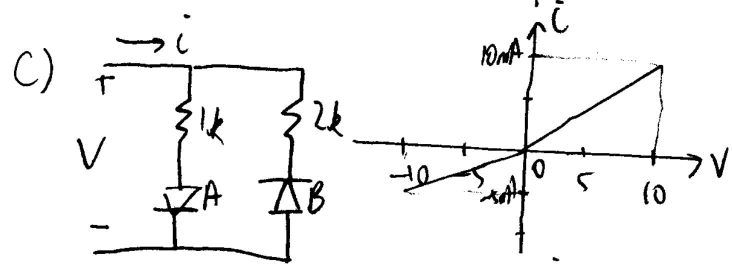
a)



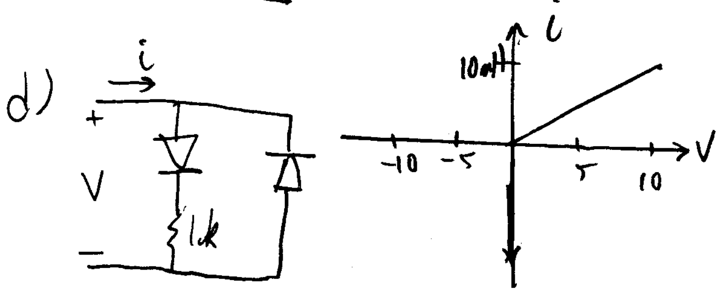
b)

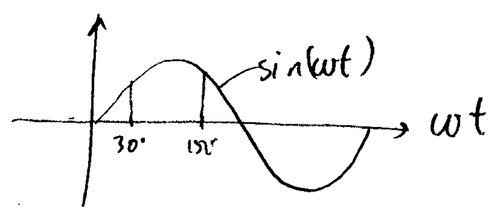


c)

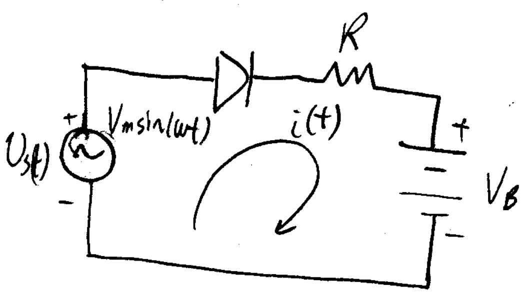


d)





4) 10.44



$V_m = 24V$, $f = 60Hz$, $R = 2\Omega$, $V_B = 12V$,
Ideal diode

⇒ Diode on when $V_m \sin(\omega t) > V_B$

$24\sin(\omega t) \geq 12V$

$\sin(\omega t) \geq \frac{1}{2} \Rightarrow \omega t \geq 30° / \frac{\pi}{6}$

$i(t) = \frac{24\sin(\omega t) - 12V}{2\Omega} = 12\sin(\omega t) - 6\ A$

$2\pi f = \omega \Rightarrow \omega = 120\pi$

4) (Con't)

The Q(t) is $\int_{\pi/6}^{5\pi/6} 12 \sin(120\pi t) - 6 \, dt$

$= \left[-\frac{12}{120\pi} \cos(120\pi t - 6t \right|_{\pi/6}^{5\pi/6} = \frac{12\sqrt{3} - 4\pi}{120\pi}$

Total Charge in 1 sec ⇒ Q(t) (60 sec)

$= \frac{12\sqrt{3} - 4\pi}{2\pi} = \frac{6\sqrt{3}}{\pi} - 2 \simeq 1.308A$

Time required for battery $T = \frac{100}{1.308} = 76.45$ hr

5) 10.46

a) $V_{avg} = \frac{1}{T}\int_0^T v(t)\,dt \qquad T = \frac{1}{f} = \frac{2\pi}{\omega}$

$= \frac{\omega}{2\pi}\int_0^{2\pi/\omega} V_m \sin(\omega t)\,dt$

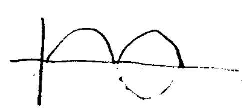
$= \frac{-1}{2\pi} V_m \left[\cos(\omega t) \Big|_0^{2\pi/\omega}\right] = 0$

b) Half-wave rectified ⇒ only half period

$V_{avg} = \frac{\omega}{2\pi}\int_0^{\pi/\omega} V_m \sin(\omega t)\,dt$

$= \frac{-1}{2\pi} V_m \left[\cos(\omega t) \Big|_0^{\pi/\omega}\right]$

$= \frac{2V_m}{2\pi} = \frac{V_m}{\pi}$

c) Full-wave ⇒ 

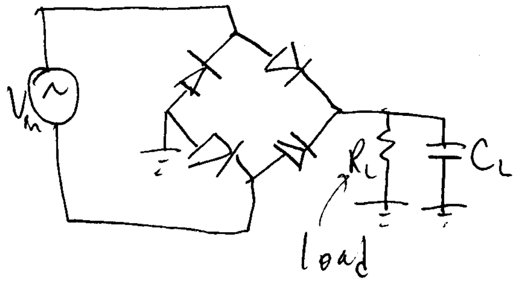
2 times the half-wave version

$V_{avg} = \frac{2V_m}{\pi}$

6) 10.48

$V_{avg} = 9V$, $V_r = 2V$, $I_{avg} = 100\,mA$

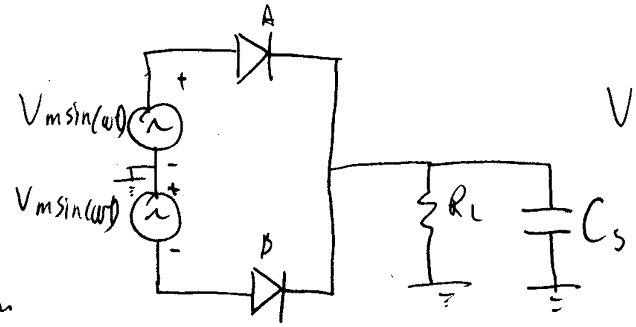
Ideal diodes, $f = 60$ Hz



Using equation from P. 464,

$$C_L = \frac{I_L T}{2V_r} = \frac{(100\,mA)\left(\frac{1}{60}\right)}{2(2)} = 417\,\mu F$$

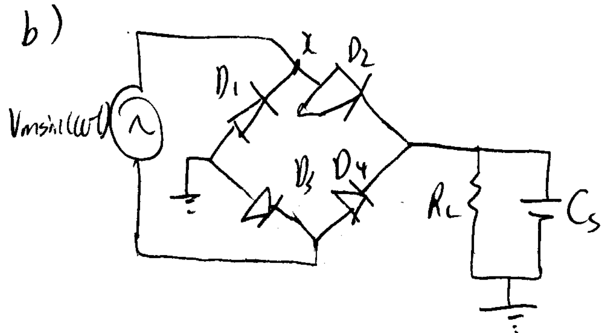
7) 10.53



$V_m = 12V$

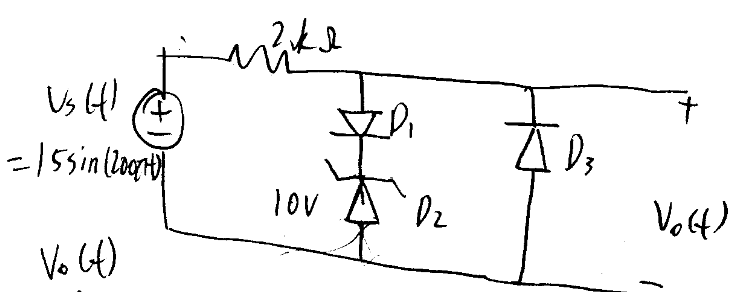
a) The maximum voltage on the capacitor is V_m, and the minimum voltage on the source is $-V_m$ ⇒ total reverse bias $= 2V_m$.

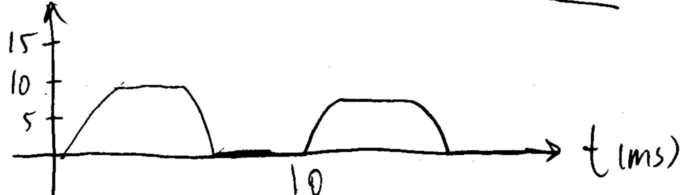
b)



let's assume D_2 and D_3 are on, that means the max voltage at x is V_m and the max reverse bias is V_m ⇒ by symmetry this is true for all diodes

8) 10.55





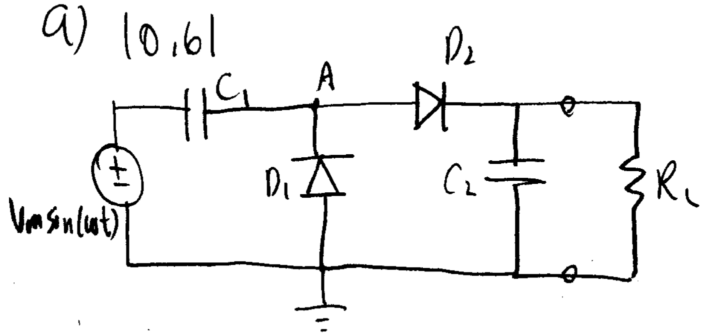
for $V_s(t) < 0$, D_3 turns on → shorts ⇒ $V_o(t) \to 0$

for $V_s(t) > 0$, we have 2 regions of operation ⇒ $0 < V_s < 10$ and $V_s \geq 10$

for $0 < V_s < 10$, the Zener diode is off and thus $V_o(t) = V_s(t)$

for $V_s \geq 10$, the D_1 is on and D_2 has 10 V across it for breakdown mode operation $V_o(t) \to 10V$.

a) 10.61



By looking at the combination of C_1 and D_1, we can see that the diode conducts if $V_{in} < 0$, therefore we know the minimum voltage at the output is 0 V. (Center point moved to V_m)
D_2 and C_2 together forms a half-wave rectifier and thus $V_L(t) \simeq 2V_m$. This is called a voltage-doubler because the load voltage is twice V_m. The PIV for both diodes are also $2V_m$