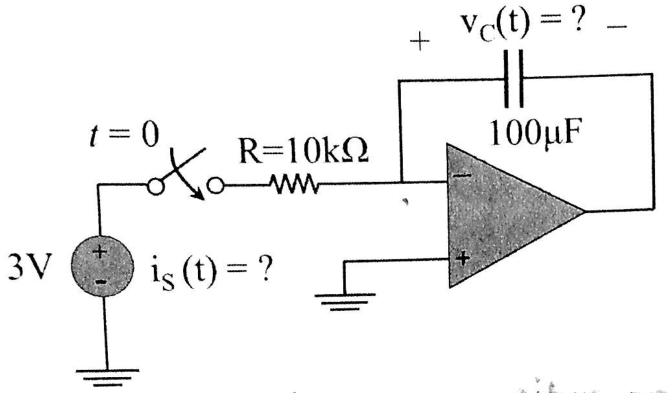
PROBLEM 4: (20 points)

The switch in the circuit in the figure below was open for a long time (from t = -∞ till t = 0) and is closed at t = 0. Assume the capacitor is completely discharged before t = 0. Opamp is ideal.

(a) Find the current supplied by the voltage source, is(t) for t > 0.

(b) Find the voltage across the capacitor, vc(t) at t = 2s.



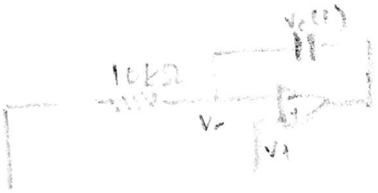
$i_S(t)$	0
$v_C(t)$	

At t=0, capacitor ~~op~~ removed,

$V_+ = V_- = 0$ ↳ ground

4

At t > 0 source removed



$\frac{V_- - 3V}{10k\Omega} = i_s(t)$ $\frac{0 - 3V}{10k\Omega} = i_s(t) = \frac{-3V}{10k\Omega}$

2

~~$V_- - V_o$~~ ~~$V_- - V_o$~~

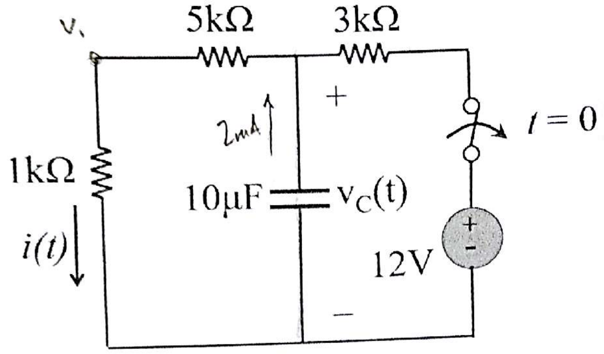
$* \frac{78}{100}$

PROBLEM 2: (30 points)

The switch in the circuit in the figure below has been closed for a long time (from t = -∞ till t = 0) and is opened at t = 0.

(a) Find the voltage across the capacitor, vc(t) for t > 0.

(b) Find the current passing through the 1kΩ resistor for t > 0.



$v_C(t)$	~~12V~~
$i(t)$	~~2mA~~

$R_{eq} = \cancel{(5+1) \| 3 \Rightarrow 2k\Omega}$

$6 \| 3$

$\frac{1}{6} + \frac{1}{3} = \frac{1}{R}$

$\frac{1}{6} + \frac{2}{6} = \frac{1}{R}$

$\boxed{\tau = RC} \Rightarrow (2\times10^3)(10\times10^{-6})$

$= 20\times10^{-3}$

$= 0.02s$

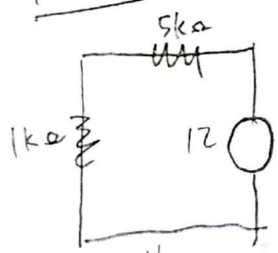
+2

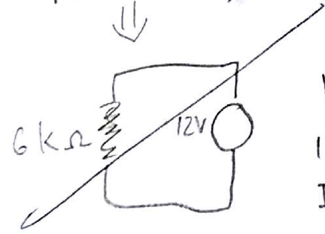
for t = 0:

$\tau = RC$

$\boxed{V_c(t) = V_0 e^{-t/\tau}}$

+2

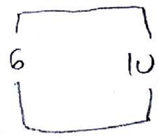




$V = IR$

$12 = I\,6k$

$I = 2mA$



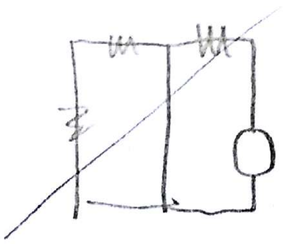
$\frac{V - V_0}{6} = 0$

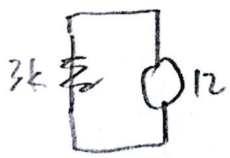
$\frac{V - 12}{6} = 0$

$V - 12 = 0$

$V = 12$

for t < 0:





$V = IR$

$12 = I(3k)$

$I = 4mA$

18/100 A

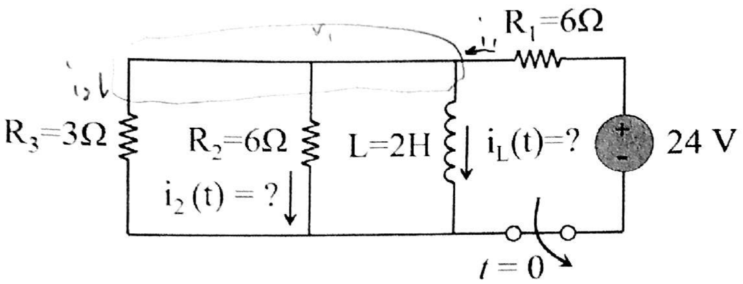
4/30

PROBLEM 3: (30 points)

The switch in the circuit in the figure below was closed for a long time and is opened at t = 0.

(a) Find the expression of the $i_L(t)$ for $t > 0$.

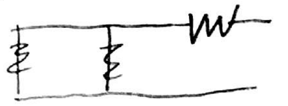
(b) Find the expression of the current passing R_2, $i_2(t)$ for $t > 0$.



$i_L(t)$	$i_L(t>0) = 24 e^{-t/.25}$
$i_2(t)$	$i_2(t>0) = (V_1-24) e^{-t/.25}$

$i_L(t) = V_0 e^{-t/\tau}$

$R_{eq} =$



$(3 \| 6) + 6$

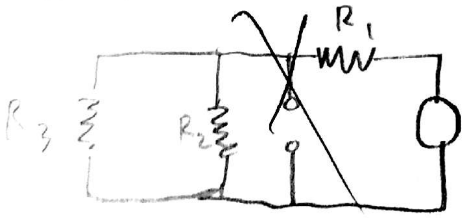
$\left(\frac{1}{3}+\frac{1}{6}\right) + 6 = 8\Omega$

3 $\tau = L/R = \frac{2}{8} = \frac{1}{4}$

$i_1 = i_L + i_2 + i_3$

$\frac{V_1 - 24}{6} = i_2$

for $t > 0$



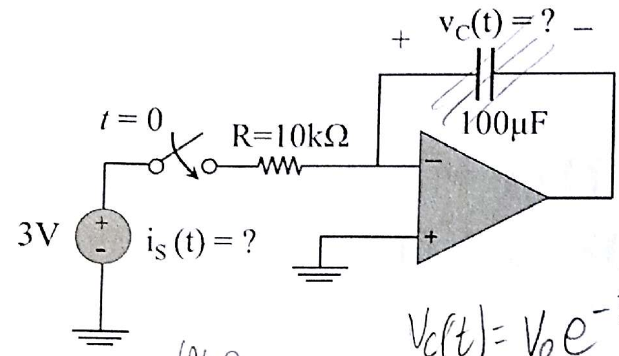
$\frac{18}{100}$

PROBLEM 4: (20 points)

The switch in the circuit in the figure below was open for a long time (from t = -∞ till t = 0) and is closed at t = 0. Assume the capacitor is completely discharged before t = 0. Opamp is ideal.

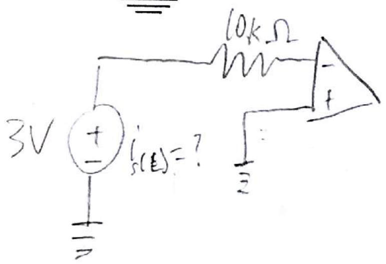
(a) Find the current supplied by the voltage source, $i_S(t)$ for $t > 0$.

(b) Find the voltage across the capacitor, $v_C(t)$ at $t = 2s$.



$i_S(t)$	$\frac{3-3e^{-t}}{10}$ A
$v_C(t)$	$3e^{-2}$ V or $\frac{3}{e^2}$ V

$V_c(t) = V_0 e^{-t/\tau}$ $\tau = RC$ $i_s(t) = \frac{V_0}{R} e^{-t/\tau}$



$$\boxed{i_s(t) = \frac{3V}{10k\Omega} - \frac{3e^{-t}}{10k\Omega}}$$

① $\frac{V^- - 3V}{10K} = 0$

$V^- = 3V$

$V^- = V^+ = V_0 = 3V$

$V_c(t) = 3e^{\frac{-t}{(10,000)(0.0001)}}$

$$\boxed{V_c(t) = 3e^{-t}}$$

$$\boxed{V_c(2) = 3e^{-2}}$$

***

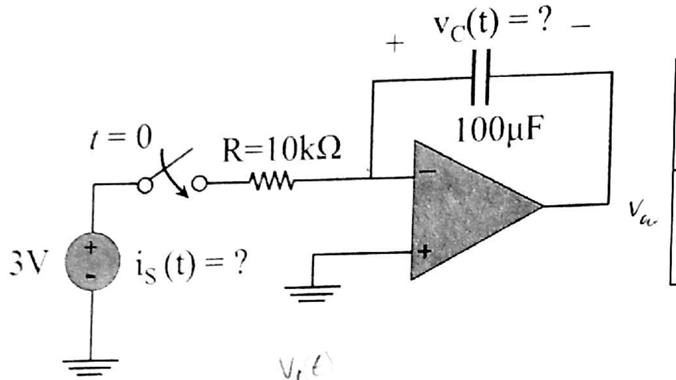
6/100

PROBLEM 4: (20 points)

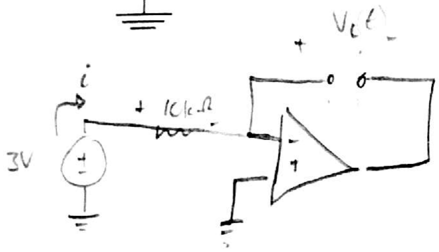
The switch in the circuit in the figure below was open for a long time (from t = -∞ till t = 0) and is closed at t = 0. Assume the capacitor is completely discharged before t = 0. Opamp is ideal.

(a) Find the current supplied by the voltage source, is(t) for t > 0.

(b) Find the voltage across the capacitor, vC(t) at t = 2s.



$i_s(t)$	.0003A
$v_C(t)$	$\left(\left(\frac{.0003}{100}\right) \cdot 2\right)$ V·sec (-2)



$V_+ = 0 = V_-$

× 60/80

W/out a calculator its hard for me to do division like this in my head. It would be unfair if you mark off students' answers even if math is wrong b/c we weren't able to use a calculator.

$\frac{3V - 0}{10k\Omega} = i_s = 3V/10k\Omega = \left(\frac{3}{10000}\right) A = (.0003A)$

$V_- - V_{out} = V_c$

$V_c(t) = -V_{out}$

$V_c(t) = i_s \frac{1}{C} t$

$= (.0003A)/100\mu F \; (2)$

How difficult is this?!

$\frac{3V}{10k\Omega} = 0.3mA$

if a student cannot do this division he should pursue another career but the engineering

PROBLEM 2: (30 points)

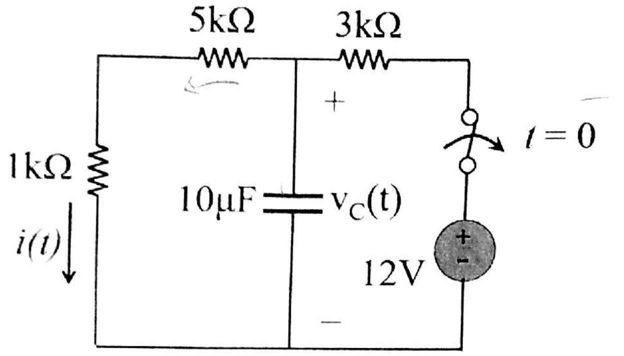
.000010
× 6000.

The switch in the circuit in the figure below has been closed for a long time (from t = -∞ till t = 0) and is opened at t = 0.

(a) Find the voltage across the capacitor, $v_C(t)$ for t > 0.

(b) Find the current passing through the 1kΩ resistor for t > 0.

6000
× .000010



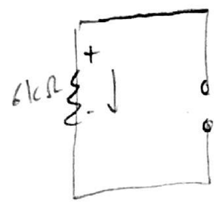
$v_C(t)$	$12e^{-t/.06}$
$i(t)$	$C\frac{dv}{dt} = 10\mu F \frac{dv}{dt}$

b/c switch opens Volt. source is gone ∴ as $t \to \infty$ V_C & $i_C = 0$ but @ $t > 0$ the capacitor will be discharg

+4

$x(t) = x(t=\infty) + [x(0) - x(t=\infty)]e^{-t/\tau}$

t > 0



$V_C t$

+2

+3

& $i(t)$ also = 0 b/c voltage source as $t \to \infty$

but $i(t) = C\frac{dv}{dt}$

$= 10\mu F \frac{dv}{dt}$

$V_C(t=\infty) = 0$

Voltage decays to 0 b/c the Voltage source is eliminated.

τ @ t > 0

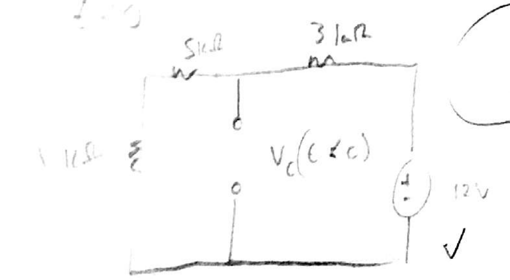
$R_{eq} = 6k\Omega$

$\tau = (6k\Omega)\,10\mu F$ = 6000 • 10E−6

$\tau = .06$

+3

I need a calculator but I think its .06



+2

$V_L = i\,L$

$V_C = \frac{1}{C} i$

$i = C\frac{dv}{dt}$

$\therefore i_{R_1} = V/R = \frac{di/dt \cdot \frac{1}{C}}{R}$

$i = C\,\frac{dv}{dt} = 10\mu F$

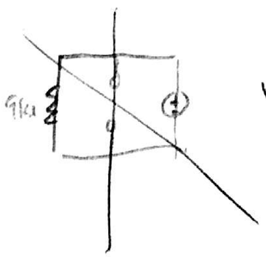
A

60/100

+2

$V_C(t) = v(t=\infty) + (v(t<0) - v(t=\infty))e^{-t/\tau}$

$= 12e^{-t/.06}$



$V_C(t<0)$

$V_C = 12V$

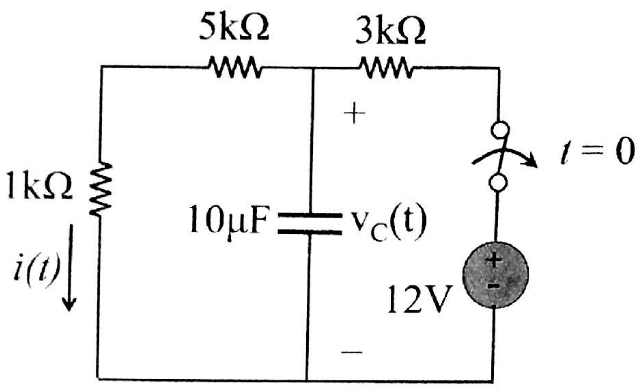
16/30

PROBLEM 2: (30 points)

The switch in the circuit in the figure below has been closed for a long time (from t = -∞ till t = 0) and is opened at t = 0.

(a) Find the voltage across the capacitor, $v_C(t)$ for t > 0.

(b) Find the current passing through the 1kΩ resistor for t > 0.



$v_C(t)$	$8e^{-t/0.06}$	V
$i(t)$	$\cancel{-4.8\times10^{-6}} e^{-t/0.06}$	A

-1

$i_{nf} + [i_{nit} - i_{nf}]e^{-t/\tau}$

$t < 0$

$V_{(t=0)} = 12V\left(\frac{6}{9}\right) = 8V$ ✓

$t > 0$

$\tau = RC$

$6\times10^3 \quad 10\times10^{-6}$

$V_{(t>0)} = 0$

$6k\Omega \; 10\mu F = 60\times10^{-3}\,s = 0.06\,s$ ✓

$i_C(t)$

$V_C(t) = 8e^{-t/0.06\,s}$ ✓

-1

$i(t) = C\frac{dv}{dt} = 10\mu F\left(-8\times(6\times10^{-2})^{-1} e^{-t/0.06}\right) = 10\mu F\,(-0.48e^{-t/0.06})$

$= -4.8\times10^{-6}e^{-t/0.06}$

$i(t) = -i_C(t)$

-5

$\frac{24}{30}$

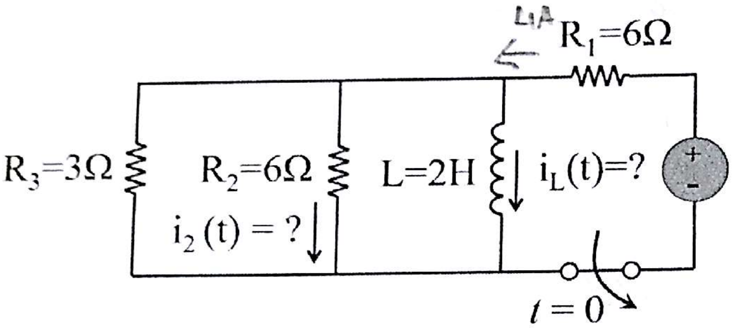
$\frac{61}{100}$ A*

PROBLEM 3: (30 points)

The switch in the circuit in the figure below was closed for a long time and is opened at t = 0.

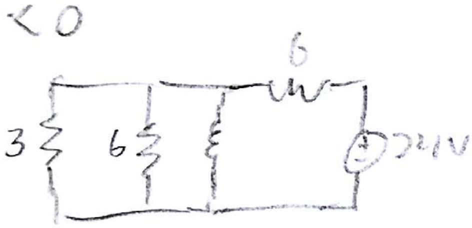
(a) Find the expression of the $i_L(t)$ for $t > 0$.

(b) Find the expression of the current passing R_2, $i_2(t)$ for $t > 0$.



$i_L(t)$	0
$i_2(t)$	$\frac{4}{3}e^{-3/4 t}$

t<0



$\cancel{i_L(t) = 0}$

$R_{eq} = \frac{3}{2}\,\Omega$

t>0

2 $\tau = \frac{L}{R_{eq}} = \frac{2H}{3/2\,\Omega} = \frac{4}{3}\,s$

2 2

2 $i_2(t) = 4\left(\frac{3}{9}\right)e^{-t/4/3s}$

$= \frac{12}{9}e^{-\frac{3}{4}t}$

61/100

*

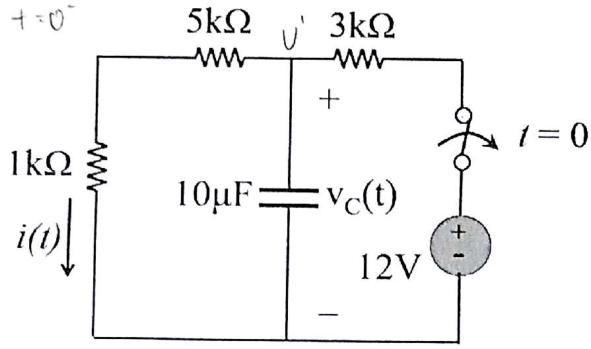
PROBLEM 2: (30 points)

The switch in the circuit in the figure below has been closed for a long time (from t = -∞ till t = 0) and is opened at t = 0.

(a) Find the voltage across the capacitor, $v_C(t)$ for t > 0.

(b) Find the current passing through the 1kΩ resistor for t > 0.

t = 0⁻



$v_C(t)$	$12e^{-6\times10^5 t}$ V
$i(t)$	$-72e^{-6\times10^5 t}$ A

$\frac{v'}{6} + \frac{v'-12}{3} = 0$

$v' + 2v' - 24 = 0$

$3v' = 24$

$v' = 12V$ $v' = 8V$

$V(0) = i(0)R_{eq}$

(2) (2)

(3) (2)

6×10^{-2} (+1)

$\tau = RC = 6^{k}(10^{-5})$

$V_C = V(\infty) + [V(0) - V(\infty)]e^{-t/\tau} = 12e^{-6\times10^5 t}$ (+1)

$V_C = i(t)R_{eq} = i(t)6$

$i(t) = C\left(-\frac{1}{\tau}\right)V_C$

$= 10^{-5}(-6\times10^5)(12e^{-6\times10^5 t})$

$i(t) = \frac{V^2}{1}$

$\frac{V_2}{1} = \frac{V_2 - V_c}{5}$

11/30

38/100