EECS 100/42/43 Spring 2006 Midterm # 1

PRINT NAME (Last, First): POOLLA

SIGN YOUR NAME: ____________________

STUDENT ID #: ____________________

# 1	# 2	# 3	# 4	SUBTOTAL
7	8	6	14	35

# 5	# 6	# 7	# 8	SUBTOTAL	TOTAL
15	10	21	4	50	85

Instructions:

1 Print and sign your name and enter your student ID number above.

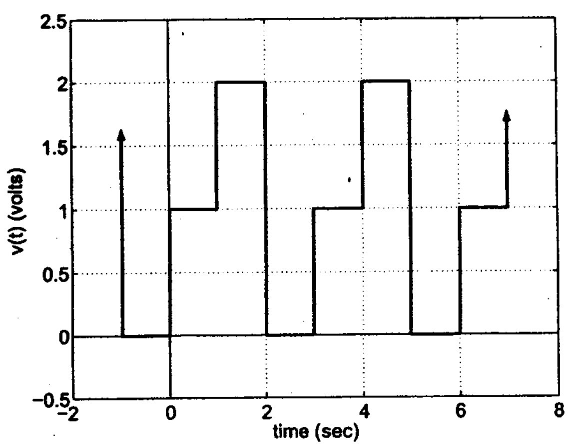
2 Read the questions carefully.

3 Write your solution clearly.

4 You must show your work to get full credit.

5 This exam has 8 questions worth 85 points, so you should proceed at approximately 1 point per minute.

Problem # 1 (1+2+2 = 5 points)
Consider the periodic voltage waveform $v(t)$ shown below.



Find the following:

- Period

3 seconds

Period = 3 seconds

- DC Voltage

DC Voltage = 1 volt

- RMS Voltage

$$\sqrt{\frac{1}{3}\int_0^3 v^2 dt}$$

$$= \sqrt{\frac{1}{3}[1+4]} = \sqrt{\frac{5}{3}}$$

RMS Voltage = $\sqrt{\frac{5}{3}}$ volts

Problem # 2 $(2+2+2+2 = 8$ points)

Convert the following phasors to sinusoids. Assume the frequency is ω.

(a) $5\exp(j\pi/2)$

Answer = $5\cos(\omega t + \pi/2)$

$5\cos(\omega t + \frac{\pi}{2})$

$-5\sin(\omega t)$

(b) $3 + 4j$

Answer = $3\cos(\omega t) - 4\sin(\omega t)$

$5\cos(\omega t + 53.1^\circ)$ .927

$5\sin(\omega t + 143.1^\circ)$

Convert the following sinusoids to phasors.

(c) $3\cos(\omega t) + 4\sin(\omega t)$

Answer = $3 - 4j$

$3 + 4/j$

$5\angle -53.1^\circ$

(d) $\sqrt{2}\sin(\omega t - 45^\circ)$

Answer = $-1 - j$

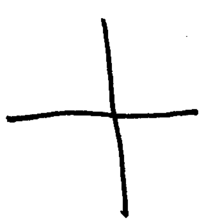
$\sqrt{2}\angle -135^\circ$

$\sqrt{2}\sin(\omega t) \leftrightarrow -j\sqrt{2}$

$\sqrt{2}\sin(\omega t - \frac{\pi}{4}) \leftrightarrow -j\sqrt{2}\, e^{-j\pi/4}$

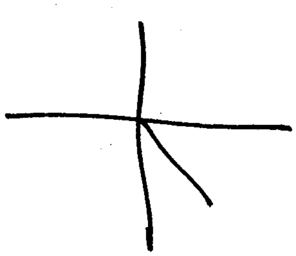
$= -j\sqrt{2}\left(\frac{1}{\sqrt{2}} - \frac{j}{\sqrt{2}}\right)$

$= -1 - j$



$-\cos(\omega t)$

$+\sin(\omega t)$



-1

Problem # 3 ($6 * 1 = 6$ points)

Circle the most appropriate answers.
Incorrect answers receive −1 points.
No explanations are necessary.

The internal resistance R of a practical current source is in **series/parallel** with the source.

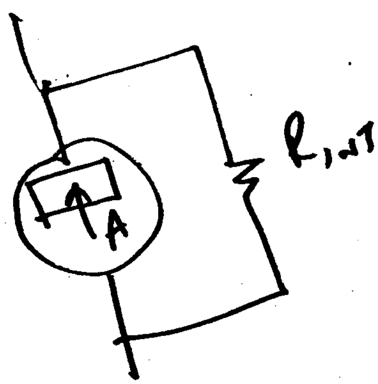
For a well-designed circuit with a practical current source, this internal resistance R should be much **larger/smaller** than the load resistance.

A circuit element that requires an external power supply is called **active/passive**.

We **can/cannot** find the Thevenin equivalent of a circuit containing diodes.

The input resistance of an ammeter is **very low/very big**

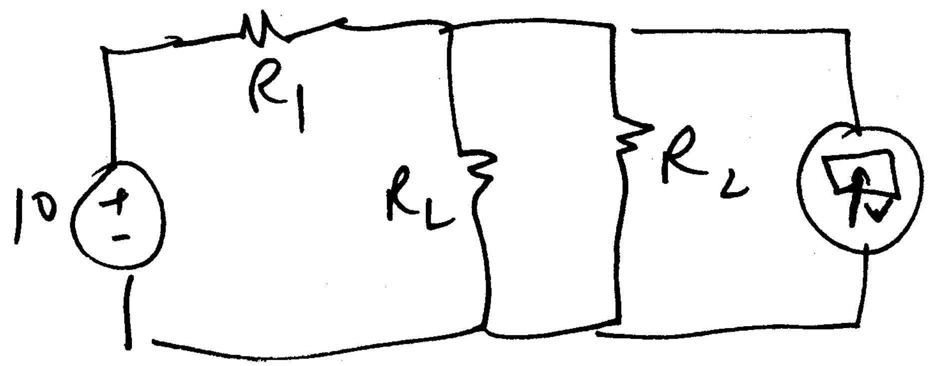
An oscilloscope can easily **be used/not be used** to measure magnetic field strength.



Problem # 4 ($5 + 5 + 2 + 2 = 14$ points)

A 10 volt battery with internal resistance R_1 is connected to a resistive load R_L. The voltage across the load is measured with a voltmeter whose internal resistance is R_2.

(a) Draw a circuit diagram for this problem in the box below.



(b) Find an expression for the voltage recorded by the voltmeter in terms of R_1, R_2, R_L.

$$\frac{R_2 \uparrow\uparrow R_L}{R_1 + R_2 \uparrow\uparrow R_L} \, 10$$

Voltmeter Reading = $10 \, \dfrac{R_2 R_L}{R_2 R_1 + R_L R_1 + R_2 R_L}$

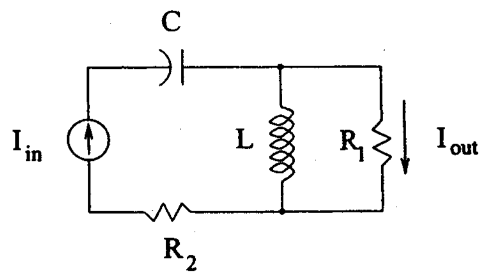
(c) Ideally, would you want $R_1 >> R_L$ or $R_1 << R_L$? (circle your answer)

(d) Ideally, would you want $R_2 >> R_L$ or $R_2 << R_L$? (circle your answer)

4+4+4+3

Problem # 5 (4+8+1+2 = 15 points)

(a) Consider the circuit shown here. Let $\mathbb{I}_{in}$ and $\mathbb{I}_{out}$ be the phasors of the input current I_{in} and the output current I_{out} respectively. Find $\mathbb{I}_{out}$ in terms of R_1, R_2, L, C, ω and $\mathbb{I}_{in}$.



current divider

$$\frac{j\omega R_1 L + \omega^2 L^2}{R_1^2 + \omega^2 L^2} \mathbb{I}_{in}$$

4 pts

$\mathbb{I}_{out} = \dfrac{j\omega L}{R_1 + j\omega L} \mathbb{I}_{in}$

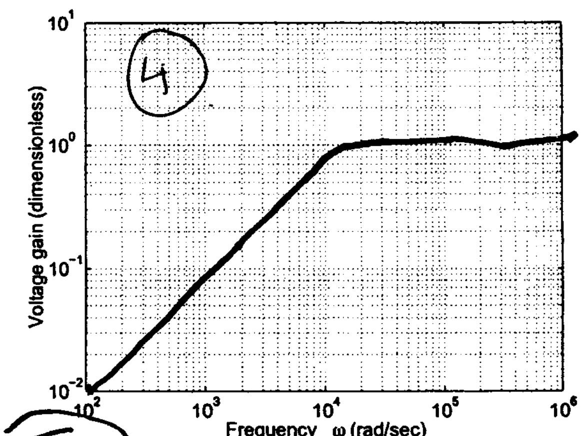
$$\frac{\omega L}{\sqrt{R_1^2 + \omega^2 L^2}}$$

(b) With $R_1 = 1\ K\Omega, R_2 = 5\ k\Omega, L = 100\ mH, C = 3\ \mu F$, sketch the frequency response of the current magnitude gain from $\mathbb{I}_{in}$ to $\mathbb{I}_{out}$. Use the log-log scale graph-paper supplied below.

$$\frac{j\omega}{j\omega + \frac{R_1}{L}}$$

$$\frac{10^3}{0.1} = 10^4$$

10^2



(c) Is this a **low-pass** or **band-pass** or **high-pass** filter ?
(circle your answer)

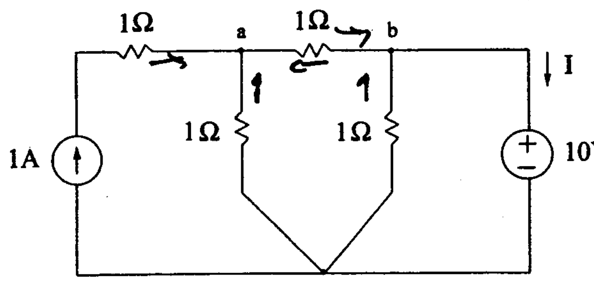
3

4

$$\left[\frac{\omega}{\sqrt{\omega^2 + \frac{R_1^2}{L^2}}}\right]$$

Problem # 6 (3 + 3 + 4 = 10 points)

Consider the circuit shown below.
Let V_a and V_b be the voltages at nodes a and b respectively.
Here, you will use the nodal method to find the voltage V_a.
Let the unknown quantities be the node voltages V_a, V_b and the current I.



(a) Write KCL at node a in terms of the unknown quantities only.

KCL at node a: $1 + V_b - V_a - V_a = 0$

(b) Write KCL at node b in terms of the unknown quantities only.

KCL at node b: $V_a - V_b - V_b - I = 0$

(c) Solve for V_a. You will need one more equation here.

$V_b = 10$

$V_a =$ 5.5 volts

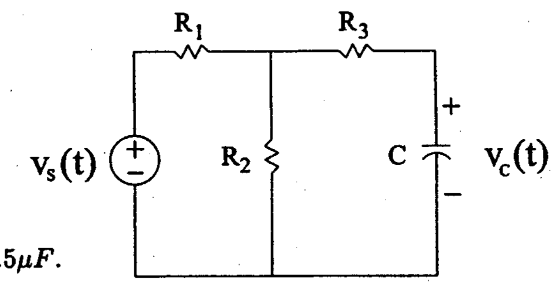
$V_b + 1 = 2V_a$

$V_a = \frac{11}{2}$

Problem # 7 (9+ 8 = 17 points)

Consider the circuit shown here.
The source voltage $v_s(t)$ is given by:

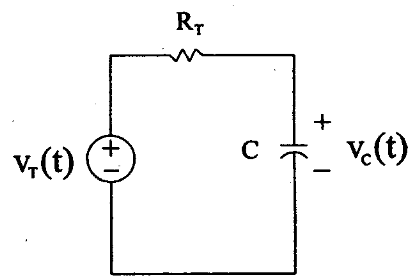
$$v_s(t) = \begin{cases} -4 \text{ volts} & t \leq 0 \\ 6 \text{ volts} & t > 0 \end{cases}$$



Here, $R_1 = 2k\Omega,\ R_2 = 2k\Omega,\ R_3 = 3k\Omega,\ C = 2.5\mu F$.

The problem is to find the voltage $v_c(t)$ for $t > 0$.

(a) (4+4+3 = 11 points) Find the Thevenin equivalent for the circuit above. In other words, find the voltage $v_T(t)$ and the resistance R_T for the equivalent circuit shown below.



$R_T = R_3 + R_1 \parallel R_2$

$= 3 + 1$

$= 4\ k\Omega$

@ $t = 0_-$ $V_s = -4$

voltage divider $V_T(0_-) = -2$

@ $t = 0_+$

$V_s = 6$

$$v_T(t) = \begin{cases} \boxed{-2} \text{ volts} & t \leq 0 \\ \boxed{3} \text{ volts} & t > 0 \end{cases}$$

$R_T = 4\ k\Omega$

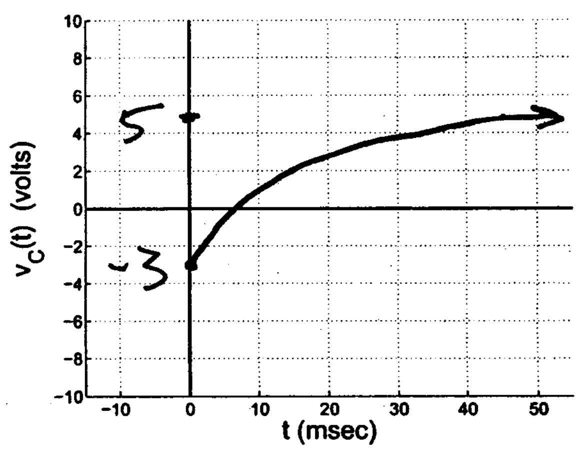
(b) $(2 + 4 + 4 = 10$ points) For the rest of the problem use the following values. These values are **not** correct but will enable you to finish the problem even if you made a mistake in part (a).

Values you should use:

$$v_T(t) = \begin{cases} -3 \text{ volts} & t \leq 0 \\ 5 \text{ volts} & t > 0 \end{cases} \qquad R_T = 6k\Omega$$

Find the time constant of the circuit.
Find $v_C(t)$ for $t > 0$.
Sketch $v_C(t)$ on the graph below.

$R_T C = 6 \times 10^3 \times 2.5 \times 10^{-6}$
$= 15$ msec.



time constant = 15 ms

for $t > 0$, $v_C(t) =$ $5 + (-3-5)e^{-t/15}$

Problem # 8 (4 points)
You have two resistors R_1 and R_2. Using these in various combinations you can make resistances of $4, 6, 12$, and 18Ω.

Find R_1, R_2.

$R_1 =$ 6	$R_2 =$ 12

(2) (2)