PRINT NAME (Last, First):  POOLLA

SIGN YOUR NAME: 

STUDENT ID #: 

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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
  
  \[ \text{Period} = 3 \text{ seconds} \]

- DC Voltage
  
  \[ \text{DC Voltage} = 1 \text{ volt} \]

- RMS Voltage
  
  \[
  \text{RMS Voltage} = \sqrt{\frac{1}{3} \int_0^3 v^2 \, dt} = \sqrt{\frac{1}{3} [1+4]} = \sqrt{\frac{5}{3}} \text{ volts}
  \]
Problem # 2 (2 + 2 + 2 + 2 = 8 points)

Convert the following phasors to sinusoids. Assume the frequency is $\omega$.

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

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

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

- $5 \sin(\omega t)$

(b) $3 + 4j$

\[
3 \cos(\omega t) - 4 \sin(\omega t)
\]

Answer = $3 \cos(\omega t + 53.1^\circ)$

\[
\begin{align*}
3 \cos(\omega t + 53.1^\circ) & = 0.921 \\
5 \sin(\omega t + 143.1^\circ) & = -0.921
\end{align*}
\]

Convert the following sinusoids to phasors.

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

Answer = $3 - 4j$

\[
\begin{align*}
5 \angle 53.1^\circ
\end{align*}
\]

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

\[
\begin{align*}
\sqrt{2} \sin(\omega t) & \leftrightarrow -j \sqrt{2} \\
\sqrt{2} \sin(\omega t - \frac{\pi}{4}) & \leftrightarrow -j \sqrt{2} e^{-j\pi/4}
\end{align*}
\]

\[
\begin{align*}
3 = -1 + -j
\end{align*}
\]
**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 $R_1, R_2, R_L$.

\[
\frac{R_2 + R_L}{R_1 + R_2 + R_L} \quad 10
\]

Voltmeter Reading = \[
10 \frac{R_2 R_L}{R_2 + R_L + R_1 + R_2 + R_L}
\]

(c) Ideally, would you want $R_1 \gg R_L$ or $R_1 \ll R_L$? (circle your answer)

(d) Ideally, would you want $R_2 \gg R_L$ or $R_2 \ll R_L$? (circle your answer)
Problem # 5 (4+8+1+2 = 15 points)

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

(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 $I_{in}$ to $I_{out}$. Use the log-log scale graph-paper supplied below.

(c) Is this a low-pass or band-pass or high-pass filter? (circle your answer)
Problem # 6 \( (3 + 3 + 4 = 10 \text{ points}) \)

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.

\[
\text{KCL at node a: } 1 + V_b - V_a - V_a = 0
\]

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

\[
\text{KCL at node b: } V_a - V_b - V_b - I = 0
\]

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

\[ V_b = 10 \]

\[ V_b + 1 = 2V_a \]

\[ V_a = \frac{11}{2} \]

\[ V_a = 5.5 \text{ volts} \]
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.

\[
R_T = R_3 + R_1 + R_2 \\
= 3 + 1 \\
= 4 \text{ k}\Omega
\]

@ \( t=0^- \) \( V_s = -4 \)

Voltage divider \( V_T(0^-) = -2 \)

@ \( t=0^+ \) \( V_s = 6 \) \( v_T(t) = \begin{cases} 
-2 \text{ volts} & t \leq 0 \\
\frac{3}{3} \text{ volts} & t > 0 
\end{cases} \)
(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:

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

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

\[ R_T C = 6 \times 10^3 \times 2.5 \times 10^{-6} \]

\[ = 15 \text{ msec} \]

\[ \text{time constant} = 15 \text{ ms} \]

\[ \text{for } t > 0, \quad v_c(t) = 5 + (-3) \cdot 5 e^{-t/15} \]
Problem # 8 (4 points)
You have two resistors $R_1$ and $R_2$. Using these in various combinations you can make resistances of $4, 6, 12, \text{ and } 18\Omega$.

Find $R_1, R_2$.

\[
R_1 = 6
\]
\[
R_2 = 12
\]