Rules of engagement:

- This exam is open book:
  - You **may** use all materials at your disposal including the internet, Zybooks, textbooks, lecture notes and videos, example problems and your calculator.
  - You **may not** consult anyone other than yourself about anything related to this test until 5pm on Wednesday, May 27.
- You are allocated a total of 3 hours, in one sitting, to work on this exam. You must monitor yourself and stay within this time frame. Once you open the test, you must submit the finished product to the D2L drop box **test2** within 3 hours.
- The drop box will close at 5pm on Wednesday, May 27 and late submissions will not be accepted.
- You may email me your test directly, but only if D2L is not available.
- Students with documented disabilities – I am willing to help you in any way I can, but you are responsible for arranging for your allowed accommodations, including appropriate time extensions.
- I will be generally available, by email only, during the hours you can take the exam, except for 8pm – 6am.
- You will be asked to sign your name below. When you do, I will take this to indicate that you abided by these rules. You must sign your name to get a non-zero grade on the exam.

NAME__________________________
8 pts  First-Order Circuits
The switch in the figure at the right has been in position 1 for a very long time. It is moved to position 2 at $t = 0$ seconds. The component values are:

$I_1 = 4 \text{ mA}$
$I_2 = 6 \text{ mA}$
$R_1 = 3 \Omega$
$R_2 = 6 \Omega$
$C = 0.2 \text{ mF}$

2 pts  Find the initial capacitor voltage $V_C(0)$.

$V_C(0) = (4 \text{ mA})(3 \Omega) = 12 \text{ V}$

2 pts  Find the time constant ($\tau$) of this circuit for $t > 0$ seconds.

$\tau = RC = (0.2 \times 10^{-3})(6 \text{ k}\Omega)$

$= 1.2 \text{ seconds}$

2 pts  Find the voltage across the capacitor at time infinity, $V_C(\infty)$.

$V_C(\infty) = (6 \text{ mA})(6 \text{ k}\Omega) = 36 \text{ V}$

2 pts  Find an expression for $V_C(t)$ for $t > 0$ seconds.

$V_C(t) = V_C(\infty) + \left[V_C(0) - V_C(\infty)\right]e^{-\frac{t}{RC}}$

$= 36 + \left[12 - 36\right]e^{-\frac{t}{0.2}}$

$= 36 - 24e^{-\frac{t}{1.2}} \text{ V}$
6 pts  Second-Order Circuits
The switch in the circuit at the right has been closed since
Noah built the ark. It is opened at $t = 0$ seconds.

2 pt  Find $V_C(0)$

$$V_C(0) = (1)(4.7k) = 4700V$$

2 pt  Find $I_L(0)$

$$I_L(0) = 0A$$

1 pt  Find $I_L(\infty)$

Because the capacitor
is an open circuit,

$$I_L(\infty) = 0A$$

2 pts  Find $\alpha$ and $\omega_0$  

Series RLC Circuit

$$\alpha = \frac{R}{2L} = \frac{4700}{2} \text{ rad/sec}$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{2\pi}{447.2} \text{ rad/sec}$$

1 pt  Is this system overdamped, critically damped, or underdamped?

$\alpha > \omega_0$ so over Damped

2 pts  Find $s_1$ and $s_2$ (the roots of the characteristic equation)

$$s_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$$

$$= -4700 \pm \sqrt{4700^2 - 447.2^2}$$

$$= -4700 \pm 4679$$

$s_{1,2} = -21.3 \text{ and } -9379$
8 pts Phasor Circuits
The following four problems are worth **one point each**
and refer to the figure at the right. Circle the best answer.

The DC component of the voltage source is:
- (a) 30 V
- (b) 8 V
- (c) 2000π V
- (d) Cannot be determined
- (e) None of the above

The frequency of the source in Hz is:
- (a) 2000π
- (b) 1000
- (c) 8
- (d) Impossible to tell
- (e) None of the above

The value of capacitance is:
- (a) 0.159 mF
- (b) 0.159 F
- (c) 0.159 μF
- (d) Impossible to tell
- (e) None of the above

The phase difference between the resistor voltage and current (θV - θI) is:
- (a) 90°
- (b) -90°
- (c) 180°
- (d) 0°
- (e) None of the above

4 pts Calculate the voltage across the capacitor and express your answer in **polar, rectangular, and sinusoidal** forms.

Using Voltage Divider,

\[ V_C = V_s \frac{Z_{\text{cap}}}{Z_{\text{cap}} + R} = \frac{860 (-1000j)}{-1000j + 2000} \]

\[ V_C = 3.578 \angle -63.43° \text{ V} \]

\[ = 1.60 - 3.20j \text{ V} \]

\[ = 3.578 \cos (2000 \pi t - 63.43°) \text{ V} \]
4 pts  Phasor Circuits

Find the value of \( \omega \) such that \( v_s(t) \) and \( i_s(t) \) are in-phase.

Component values are:
- \( R_1 = 5\,\Omega \)
- \( R_2 = 3\,\Omega \)
- \( L = 35\,\text{mH} \)
- \( C = 7\,\text{mF} \)
- \( i_s(t) = 10\cos(100t)\,\text{mA} \)

\[
\text{the quick:}
\]

In order for \( v_s \) and \( V_a \) to be in phase (say 0°), then the phase of the capacitor must cancel the phase of the inductor, or \( \frac{1}{j\omega C} \).

Solving,
\[
W = \frac{1}{\sqrt{LC}} = 63.89\,\text{rad}/\text{sec}
\]

\[
\text{the long way:}
\]

\[
v_a = i_r \frac{R_2}{R_1 + R_2} = \frac{i_s (R_1)}{R_1 + R_2 + \frac{1}{j\omega C} + \frac{2\pi}{2\\text{rad/s}}}
\]

or

\[
\left[ R_1 + R_2 + \frac{1}{j\omega C} + \frac{2\pi}{2\\text{rad/s}} \right] v_a = R_1 i_s
\]

for \( \Theta_{VA} = \Theta_{IS} \)

\[
\frac{1}{j\omega C + j\omega L} = 0
\]

For that \( L \) to be 0°,

\[
\frac{1}{j\omega C} = -j\omega L
\]

or

\[
W = \frac{1}{\sqrt{LC}} = 63.89\,\text{rad}/\text{sec}
\]