I. Mechanical Waves.
Last semester you learned about mechanical traveling waves. These could be on a string, in water, or through the air. The standard expression for a transverse traveling wave is:

\[ y(x, t) = A \sin(kx - \omega t) \]

Draw this wave for \( t=0 \) and label the wavelength \( \lambda \) and the amplitude \( A \).

Draw this wave for \( x=0 \) and label the period \( T \) and the amplitude \( A \).

II. Representation of an Electromagnetic Wave.
A. Shown below is a pictorial representation of an electromagnetic plane wave propagating through empty space. The electric field is parallel to the \( z \)-axis; the magnetic field is parallel to the \( y \)-axis.

1. Is the wave transverse or longitudinal? Explain in terms of the quantity or quantities that are oscillating.

2. Determine the direction in which the wave is propagating. Explain your reasoning in words.

3. Write tentative equations for the electric and magnetic field vectors that can be represented in the above picture.
B. In the diagram at right, the four points labeled “x” are all located in a plane parallel to the y–z plane. One of the labeled points is located on the x-axis.

1. On the diagram, sketch a vector to show the direction and relative magnitude of the electric field at these “x” points.

2. Justify the use of the term plane wave for the electromagnetic wave shown in the picture. [Hint: How do the wave fronts look? Use the equations from question 3 of the last part.]

C. The points 1 - 4 in the diagram below lie in the x-z plane.

1. For the instant shown, rank the magnitude of the electric field at points 1 – 4 from largest to smallest. If the electric field is zero at any point, state that explicitly.

2. For the instant shown, rank the magnitude of the magnetic field at points 1 – 4 from largest to smallest. If the magnetic field is zero at any point, state that explicitly.
D. Three light waves are represented below. The diagrams are drawn to the same scale.

1. How is the wave in case 1 different from case 2? Explain how you can tell from the diagrams in words.

2. If the wave in case 2 were green light, could the wave in case 3 be *red* light or *blue* light? Explain how you can tell in words. [Hint: Look at Figure 32.4 in textbook.]
III. Review problem - 1

A. In the circuit shown in the figure, neither the battery nor the inductors have any appreciable resistance, the capacitors are initially uncharged, and the switch S has been in position 1 for a very long time.

1. Draw the direction of the current.

2. What is the current in this circuit?

3. What is the equivalent inductance of this circuit?

4. How much energy is stored in the inductor?

B. The switch is now suddenly flipped to position 2 so that the circuit only has inductors and capacitors.

1. What is the equivalent capacitance of this circuit?

2. What is the angular frequency $\omega$ of this circuit?

3. The graphs to the right are plots of the energy stored in the inductors and the energy stored in the capacitor as a function of time. Label the plots with whether they are the energy $U_l$ stored in the inductors or the energy $U_c$ stored in the capacitors. Label the x axis with the period of oscillation of this circuit with only inductors and capacitors.
4. What is the maximum charge that the 25.0 \( \mu \text{F} \) capacitor will receive?

5. What is the maximum charge that the 35.0 \( \mu \text{F} \) capacitor will receive?

6. How much time after the switch is flipped will it take the capacitors to acquire this maximum charge?
IV. Review problem – 2 (optional)

This problem explores how a current-carrying wire can be accelerated by a magnetic field. You will use the ideas of magnetic flux and the induced EMF due to change of flux through a loop.

A conducting rod is free to slide on two parallel rails with negligible friction. At the right end of the rails, a voltage source of strength $V$ in series with a resistor of resistance $R$ makes a closed circuit together with the rails and the rod. The rails and the rod are taken to be perfect conductors. The rails extend to infinity on the left. The arrangement is shown in the figure.

There is a uniform magnetic field of magnitude $B$, pervading all space, perpendicular to the plane of rod and rails. The rod is released from rest, and it is observed that it accelerates to the left.

A. In what direction does the magnetic field point? Explain in words your reasoning.

B. Assuming that the rails have no resistance, describe in words the motion of the rod.

C. What is the induced EMF? Express $\varepsilon$ in terms of the velocity, $v_r(t)$, the separation of the rails, $L$, and the magnetic field $B$.

D. What is the induced current $I$ in the rod? Express $I$ in terms of the velocity, $v_r(t)$ and other quantities.

E. What is the acceleration $a_r(t)$ of the rod? Express your answer as a function of $V$, $B$, the velocity of the rod $v_r(t)$, $L$, $R$ and the mass of the rod $m$.

F. At very long times, the acceleration goes to zero. When $a_r(t)=0$ what is the terminal velocity $v_r(t=\infty)$?