

Memorial University of Newfoundland  
Department of Physics and Physical Oceanography

**Physics 2055 – Final Examination**

April 15, 2006, 3-5 pm – 2 hours

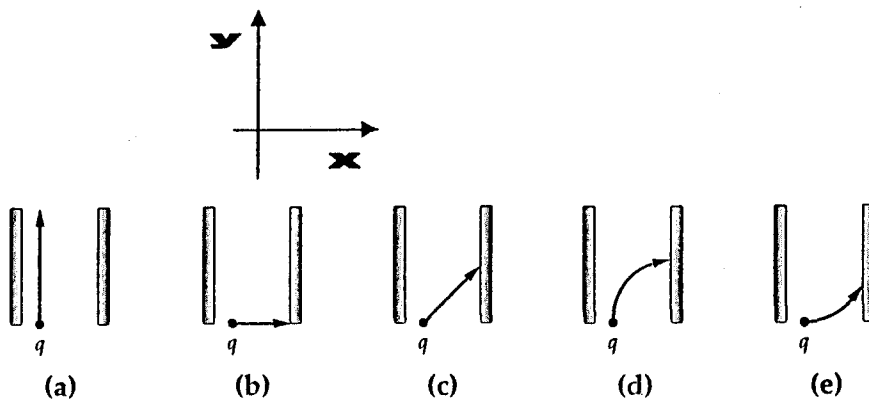
**Name:**

**Student Number:**

There are **two parts** in this test. Part A consists of **10 multiple choice questions** worth 2 mark each. Part B consists of **problems** of equal value with multiple parts worth 80 marks altogether. **Formulae sheet** is attached at the back of the test.

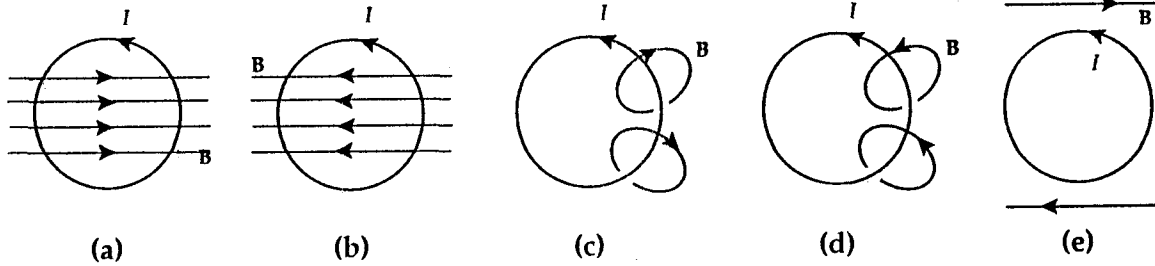
**Part A: Multiple Choice Questions**

1. A positively charged particle is moving in the  $+y$ -direction when it enters a region with a uniform electric field pointing in the  $+x$ -direction. Which of the diagrams below shows its path while it is in the region where the electric field exists. The region with the field is the region between the plates bounding each figure. The field lines always point to the right. The  $x$ -direction is to the right; the  $y$ -direction is up.

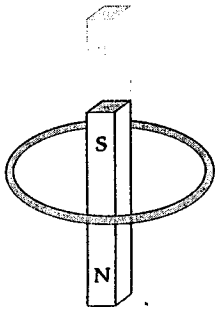


2. An astronaut is in an all-metal chamber outside the space station when a solar storm results in the deposit of a large positive charge on the station. Which statement is correct?
- The astronaut must abandon the chamber immediately to avoid being electrocuted.
  - The astronaut will be safe only if she is wearing a spacesuit made of non-conducting materials.
  - The astronaut does not need to worry: the charge will remain on the outside surface.
  - The astronaut must abandon the chamber if the electric field on the outside surface becomes greater than the breakdown field of air.
  - The astronaut must abandon the chamber immediately because the electric field inside the chamber is non-uniform.
3. An initially uncharged parallel plate capacitor of capacitance  $C$  is charged to potential  $V$  by a battery. The battery is then disconnected. Which statement is correct?
- There is no charge on either plate of the capacitor.
  - The capacitor can be discharged by grounding any one of its two plates.
  - Charge is distributed evenly over both the inner and outer surfaces of the plates.
  - The magnitude of the electric field outside the space between the plates is approximately zero.
  - The capacitance increases when the distance between the plates increases.
4. In a loop in a closed circuit, the sum of the currents entering a junction equals the sum of the currents leaving a junction because
- the potential of the nearest battery is the potential at the junction.
  - there are no transformations of energy from one type to another in a circuit loop.
  - capacitors tend to maintain current through them at a constant value.
  - current is used up after it leaves a junction.
  - charge is neither created nor destroyed at a junction.

5. Which diagram correctly shows the magnetic field lines created by a circular current loop in which current flows in the direction shown?



6. A bar magnet is dropped from above and falls through the loop of wire shown below. The north pole of the bar magnet points downward towards the page as it falls. Which statement is correct?

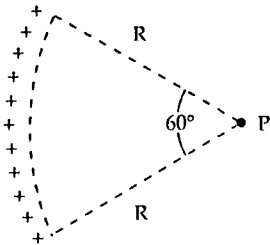


- The current in the loop always flows in a clockwise direction.
  - The current in the loop always flows in a counterclockwise direction.
  - The current in the loop flows first in a clockwise, then in a counterclockwise direction.
  - The current in the loop flows first in a counterclockwise, then in a clockwise direction.
  - No current flows in the loop because both ends of the magnet move through the loop.
7. Alternating currents in power lines usually cannot produce significant electrical currents in human brains because power lines
- carry high current at high voltage.
  - carry low current at high voltage.
  - carry low current at low voltage.
  - carry high current at low voltage.
  - have high  $I^2R$  (resistive) losses.

8. The total impedance  $Z$  of an series  $RLC$  circuit driven by an ac voltage source at angular frequency  $\omega$  is,
- $\sqrt{R^2 + (\omega L)^2 - X_C^2}$
  - $\sqrt{R^2 + (X_L - X_C)^2}$
  - $\frac{1}{\sqrt{R^2 + (X_L - X_C)^2}}$
  - $\sqrt{R^2 + (X_L + X_C)^2}$
  - $\sqrt{R^2 - (X_L + X_C)^2}$
9. An alternating current circuit has resistance  $R$ , inductance  $L$  and capacitance  $C$  in series with a voltage source. Which statement is correct?
- The voltage across the capacitor leads the voltage across the inductor by  $90^\circ$ .
  - The voltage across the inductor leads the voltage across the capacitor by  $90^\circ$ .
  - The voltage across the inductor leads the voltage across the resistor by  $180^\circ$ .
  - The voltage across the inductor leads the voltage across the capacitor by  $180^\circ$ .
  - Both voltages lead the voltage across the resistor by  $90^\circ$ .
10. If the input to an  $RLC$  series circuit is  $V = V_m \cos \omega t$ , then the current in the circuit is
- $\frac{V_m}{R} \cos \omega t$
  - $\frac{V_m \cos \omega t}{\sqrt{R^2 + \omega^2 L^2}}$
  - $\frac{V_m \sin \omega t}{\sqrt{R^2 + (\omega L + 1/\omega C)^2}}$
  - $\frac{V_m \cos(\omega t - \phi)}{\sqrt{R^2 + (\omega L - 1/\omega C)^2}}$
  - $V_m \sqrt{R^2 + (\omega L - 1/\omega C)^2} \cos \omega t$

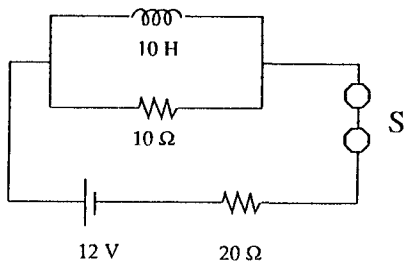
**Part B: Long Answer Questions – Do 4 questions out of 5.**  
**All questions are of equal value.**

1. Charge of uniform density ( $3.5 \text{ nC/m}$ ) is distributed along the circular arc ( $R = 3.0 \text{ m}$ ) shown. Determine (i) the magnitude and the direction of the electric field at point P; (ii) the electric potential (relative to zero at infinity) at point P; (iii) the magnitude and the direction of the magnetic field at point P if instead of a uniform charge there is a counterclockwise current ( $I = 2.0 \text{ A}$ ) flowing in the circular arc.

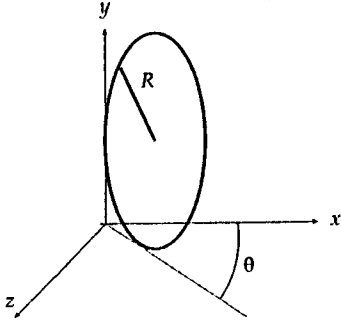


2. The axis of a long hollow metallic cylinder (inner radius = 1.0 cm, outer radius = 2.0 cm) coincides with a long wire. The wire has a linear charge density of  $-8.0 \text{ pC/m}$ , and the cylinder has a net charge per unit length of  $-4.0 \text{ pC/m}$ . Using Gauss's Law determine (i) the magnitude of the electric field 3.0 cm from the axis; (ii) the magnitude of the electric field 1.5 cm from the axis and the charge on the inner and outer surface of the cylinder. (iii) Suppose that, instead of linear charge densities, the hollow cylinder is filled with a conducting material and it carries a current of 3.00 A into the page and the long wire carries a current of 1.00 A out of the page, using Ampere's Law determine the magnitude and the direction of the magnetic field 4.0 cm from the axis.

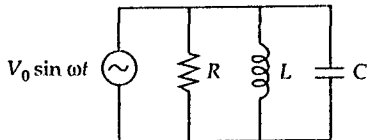
3. For the circuit shown, (i) using the Kirchhoff's loop and current rules determine the currents through the  $20\ \Omega$  resistor and  $10\ \text{H}$  inductor as a function of time (hint: remember the solution of a first order homogeneous differential equation has an exponential form); (ii) find the values of these currents just after the switch is closed ( $t=0\ \text{s}$ ) and a long time after the switch is closed ( $t=\text{infinity}$ ). (iii) What is the rate of change of the current in the inductor when the current in the battery is  $0.50\ \text{A}$ ?



4. The figure shows the orientation of a flat circular loop consisting of 50 closely wrapped turns each carrying a current  $I$ . The magnetic field in the region is directed in the positive  $z$  direction and has a magnitude of 50 mT. The loop can turn about the  $y$  axis. (i) If at  $t = 0.5$  s,  $\theta = 20^\circ$ ,  $R = 0.50$  m, and  $I = 12$  A, what is the magnitude of the torque exerted on the loop? (ii) Suppose the current is set to zero, determine the magnetic flux through the loop as function of time as the loop continues to rotate (with the help of external means) with the same constant angular speed  $\omega$  as in (i) about the  $y$  axis and then determine the induced emf in the loop, also as a function of time. Sketch the induced emf as a function of time and give an example or two of possible applications of this phenomena.

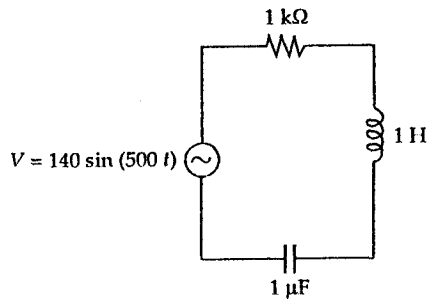


- (iv) Using the phasor diagram method, determine the impedance of the parallel RLC circuit shown below





5. For the figure as shown (i) determine the instantaneous and rms voltage drops across the resistor, inductor and the capacitor in the circuit. Is the current leading or lagging the voltage in this circuit? (ii) Determine the resonant frequency of the circuit and (iii) the amplitude of the current at the resonance.



Useful Constants and Formulae:

$$\epsilon_0 = 8.8542 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

$$k_e = 8.9876 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

$$|e| = 1.60218 \times 10^{-19} \text{ C}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$$

$$\mathbf{E} = k_e \int \frac{dq}{r^2} \hat{\mathbf{r}}$$

$$V = k_e \int \frac{dq}{r}$$

$$\Phi_E = \oint \mathbf{E} \cdot d\mathbf{A} = \frac{q_{\text{in}}}{\epsilon_0}$$

$$\Delta V = \Delta U/q_0 = - \int_A^B \mathbf{E} \cdot d\mathbf{s}$$

$$C = \frac{Q}{\Delta V}$$

$$I = \frac{dQ}{dt}$$

$$U = -\mathbf{p} \cdot \mathbf{E}$$

$$U = -\mathbf{u} \cdot \mathbf{B}$$

$$\tau = N u_{\text{loop}} \times \mathbf{B}, \quad u_{\text{loop}} = IA$$

$$\tau = \mathbf{p} \times \mathbf{E}, \quad \mathbf{p} = 2aq$$

$$U = \frac{1}{2} Q \Delta V$$

$$U = \frac{1}{2} LI^2$$

$$\Delta V = RI$$

$$I = nqv_d A$$

$$R = \rho \frac{l}{A}$$

$$\mathcal{P} = I \Delta V$$

$$\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 I$$

$$\Phi_B = \int \mathbf{B} \cdot d\mathbf{A}$$

$$d\mathbf{B} = \frac{\mu_0}{4\pi} \frac{I d\mathbf{s} \times \hat{\mathbf{r}}}{r^2}$$

$$\epsilon = - \frac{d\Phi_B}{dt}$$

$$\epsilon_L = -N \frac{d\Phi_B}{dt} = -L \frac{dI}{dt}$$

$$L = \frac{N\Phi_B}{I}$$

Some Prefixes for Powers of Ten

Power	Prefix	Abbreviation	Power	Prefix	Abbreviation
$10^{-36}$	yocto	y	$10^1$	deka	da
$10^{-31}$	zepto	z	$10^2$	hecto	h
$10^{-18}$	atto	a	$10^3$	kilo	k
$10^{-15}$	femto	f	$10^6$	mega	M
$10^{-12}$	pico	p	$10^9$	giga	G
$10^{-9}$	nano	n	$10^{12}$	tera	T
$10^{-6}$	micro	$\mu$	$10^{15}$	peeta	P
$10^{-3}$	milli	m	$10^{18}$	exa	E
$10^{-2}$	centi	c	$10^{21}$	zetta	Z
$10^{-1}$	deci	d	$10^{24}$	yotta	Y