PHYS 1004 | **April 2008 Exam Questions**
Carleton University | **Posted to course webct site in March 2009.**

This is a reproduction of the exam questions from April 2008.
To save paper, this document has been reformatted to omit the blank space where answers could be worked out. The two pages of reference material that were included in the exam have also been omitted here.

Try doing these questions in 3 hours, using only a calculator, ruler, and the two pages of reference formulae and constants to aid you. Answers to the multiple choice part are on the last page.

Do both Part A (Multiple Choice) and Part B (Problems) of this exam.
In Part A, do all 20 multiple choice questions.
In Part B, attempt any 3 of the 4 problems.

The maximum number of marks in Part A is 60, and in Part B is 42.
The maximum mark that may be earned for the exam overall is 100.

PART A (60 marks)

This part consists of 20 multiple choice questions of equal weight. Each question is worth 3 marks. No marks will be deducted for incorrect answers. For each question, one and only one of the five proposed answers is correct.

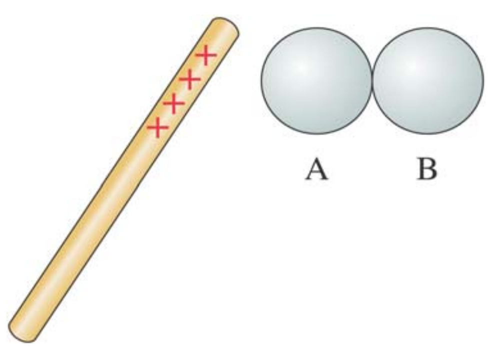
Indicate your choice by filling the correct bubble on the Scantron answer sheet, which is a separate sheet from this booklet. Only your choice of answer recorded on the Scantron sheet will be graded. *Use pencil to fill in the bubbles. If you need to make a change, erase your old answer completely. You may write anywhere on the question pages in this booklet for your rough work and calculations; they will not be considered for grading.*

1. A weightlifter raises an 80 kg barbell a distance of 1.40 m against gravity. Which one of the following statements is incorrect ?

   (a). The work done by the weightlifter is 1.10 kJ.
   (b). The work done by gravity is −1.10 kJ.
   (c). Gravity is a conservative force.
   (d). The work done by gravity is 1.10 kJ.
   (e). The gravitational potential energy of the barbell increases by 1.10 kJ.

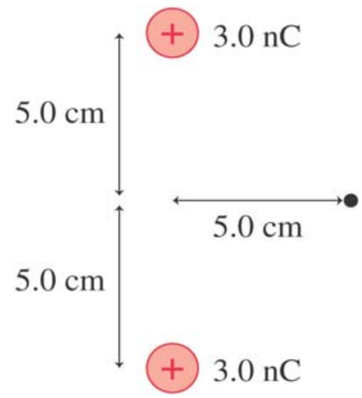
2. Metal spheres A and B are initially neutral and touching when a positively charged rod is brought near A but not touching. Spheres A and B are then separated. Which of the following is correct, where Q is a positive number?

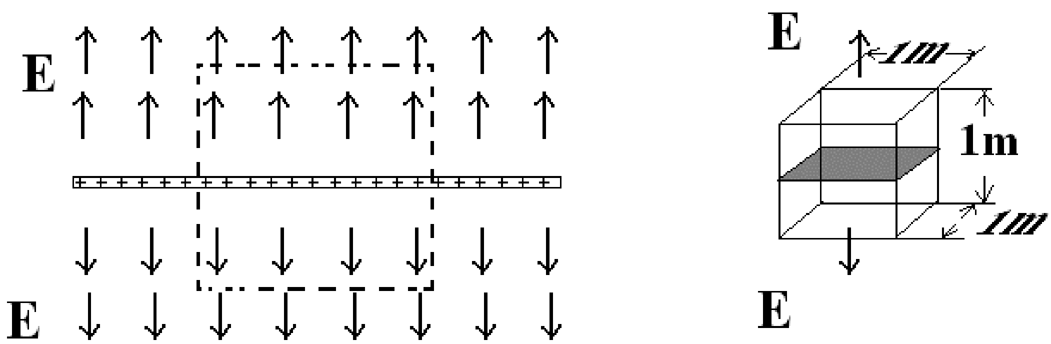
   (a). Charge on A is +Q, charge on B is –Q
   (b). Charge on A = charge on B = 0.
   (c). Charge on A is –Q, charge on B is +Q
   (d). Charge on A is –Q, charge on B is not known
   (e). We have insufficient information to specify anything.



3. What are the strength and direction of the net electric field at the position indicated by the dot in the figure at right?

(a). 7.6×10^3 N/C to the left
(b). 7.6×10^3 V/m to the right
(c). 5.4×10^3 N/C to the right
(d). 10.8×10^3 N/C to the left
(e). 10.8×10^3 N/C to the right





$\mathbf{E = 1.0}$ **N/C**

4. The figure above shows a uniform plane of charge which generates the electric field as shown. What is the electric flux Φ_E through the closed 1 m x 1 m x 1 m cubic box and what is the surface charge density η on the plane?

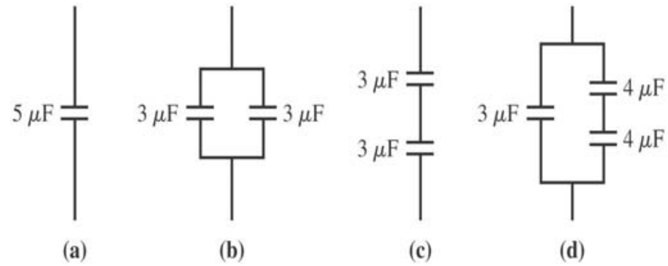
(a). $\Phi_E = 1$ Nm^2/C , $\eta = 8.85 \times 10^{-12}$ C/m^2
(b). $\Phi_E = 0$ Nm^2/C , $\eta = 1.77 \times 10^{-11}$ C/m^2
(c). $\Phi_E = 2$ Nm^2/C , $\eta = 1.77 \times 10^{-11}$ $C^2N^{-1}m^{-2}$
(d). $\Phi_E = 4$ Nm^2/C , $\eta = 1.77 \times 10^{-11}$ $C^2N^{-1}m^{-2}$
(e). $\Phi_E = 2$ Nm^2/C , $\eta = 1.77 \times 10^{-11}$ C/m^2

5. A parallel-plate capacitor with plate separation *d* is connected to a 9-volt battery. Without breaking any of the connections, insulating handles are used to increase the plate separation to 2*d*. Which of the following is true about the voltage across the capacitor, the capacitance, and the charge on the plates?

(a). The voltage across the capacitor stays the same, the capacitance is halved, and the charge on the plates is halved.
(b). The voltage across the capacitor stays the same, the capacitance doubles, and the charge on the plates is halved.
(c). The voltage across the capacitor is doubled, the capacitance is halved, and the charge on the plates stays the same.
(d). The voltage across the capacitor stays the same, the capacitance doubles, and the charge on the plates doubles.
(e). The voltage across the capacitor stays the same, the capacitance is halved, and the charge on the plates is doubled.

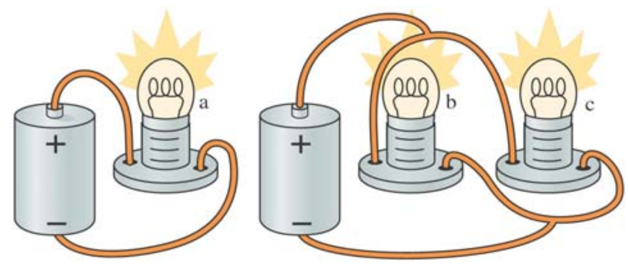
6. Rank in order, from largest to smallest, the equivalent capacitances of circuits a to d.

(a). b > a = d > c
(b). c > a > b > d
(c). c > a > d > b
(d). c > a = d > b
(e). a > d > b > c



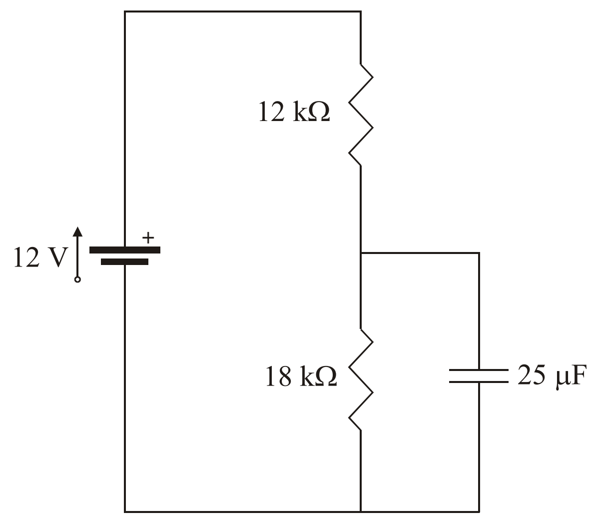
7. Rank in order, from brightest to least bright, the brightness of lightbulbs a to c. The two batteries are identical, the wires have negligible resistance, and all lightbulbs are the same.

(a). a > b = c
(b). a < b = c
(c). a = b = c
(d). a > b > c
(e). a > c > b



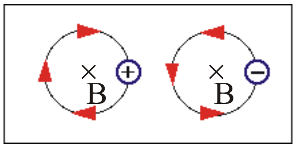
8. In the circuit shown, the current has been flowing for a long time. The magnitude of charge on each plate of the capacitor is

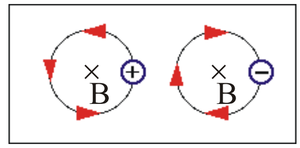
(a). 120 μC
(b). 216 μC
(c). 300 μC
(d). 180 μC
(e). zero

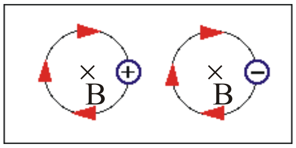


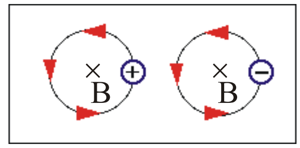
9. All but one of the following statements are true. Which one is false ?
(a). The line integral of magnetic field around a closed loop is linearly proportional to the current enclosed by the loop
(b). The speed of light in vacuum is 2.998×10^{8} m s^{-1}, and in any other medium is always less than this
(c). The simplest electrostatic entity is the single electric charge, while the simplest magnetic entity is the magnetic dipole
(d). Faraday's Law is named after Michael Faraday, scientist in Britain in the 1800's, who discovered electromagnetic induction and whose inventions included the electric motor, the electric generator, and the transformer
(e). The net flux of magnetic field through a closed surface is linearly proportional to the net charge inside the surface

10. A positive charge (+) and a negative charge (−) are in circular orbit in a region where a magnetic field is entering perpendicularly into the plane of the page. How do they move?

(a). 

(b). 

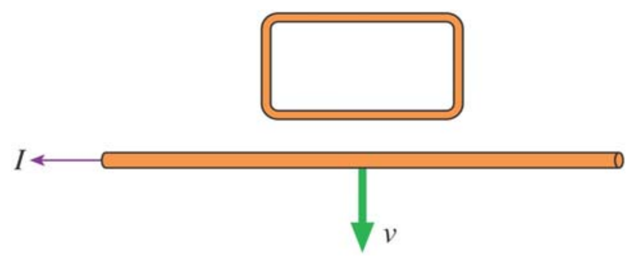
(c). 

(d). 

(e). It depends on whether you are in Canada or in Australia.

11. A current-carrying wire is pulled away from a conducting loop in the direction shown. As the wire is moving, the direction of current around the loop is:

(a). there is no current
(b). counterclockwise
(c). counterclockwise until the field becomes weaker than that of the Earth, then becomes clockwise
(d). clockwise
(e). it depends on whether this is in the Northern or Southern hemisphere



12. A 1.0 A current passes through an ideal 10 mH inductor coil. What emf is induced across the coil if the current drops (assume uniformly) to zero in 5 ms ?

(a). 10 V
(b). 2 V
(c). 200 V
(d). 2 kV
(e). 1 kV

13. If we increase the driving frequency in a circuit with a purely capacitive load, what happens to the amplitude of the voltage V_C and to the amplitude of the current, I_C ?

(a). V_C remains the same and I_C increases
(b). V_C increases and I_C remains the same
(c). V_C decreases and I_C increases
(d). V_C remains the same and I_C remains the same
(e). V_C remains the same and I_C decreases

14. A 60 W incandescent light bulb is plugged into a 120 V (rms) 60 Hz outlet.
The peak current through the bulb is:

(a). 0.35 A
(b). 1.4 A
(c). 0.50 A
(d). 2.8 A
(e). 0.71 A

15. The magnetic field of an electromagnetic wave within some medium is described by the following vector equation:

$$\mathbf{B} = \mathbf{j}\, 10.0 \sin(2.410 \times 10^{7} z + 4.621 \times 10^{15} t) \quad \text{Tesla},$$

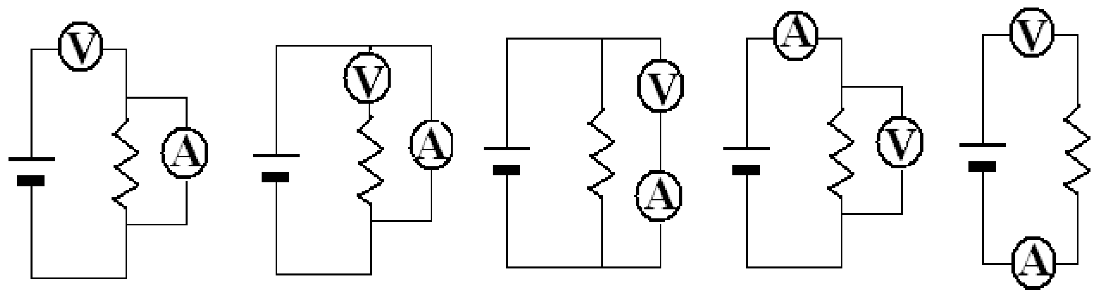
where z is in metres and t is in seconds. The speed of the wave's propagation, and its direction, are:

(a). 2.998×10^{8} m/s in the +y direction
(b). 2.998×10^{8} m/s in the −z direction
(c). 1.917×10^{8} m/s in the −z direction
(d). 1.917×10^{8} m/s in the +z direction
(e). 4.621×10^{8} m/s in the +x direction

16. Unpolarized light with intensity 50.0 W m^{-2} passes first through a polarizing filter with its transmission axis horizontal, and then through a second filter. The transmitted light intensity is 18.0 W m^{-2}. The transmission axis of the second filter is at:

(a). 31.9° from the horizontal
(b). 43.9° from the horizontal
(c). 84.9° from the horizontal
(d). 43.9° from the vertical
(e). 31.9° from the vertical

17. Consider the five connections of ammeter (A) and voltmeter (V) shown below. Which one of these is the correct one to measure the current through the resistor R and the voltage across resistor R ?



(a). (b). (c). (d). (e).

18. In the oscilloscope experiment, the period is measured with the following setting:

Sweep time / div was at 2 ms
smallest division was 0.4 ms

The period was measured to be 4.6 divisions long. The correct expression for the period, with uncertainty, is

(a). 9.2 ± 0.2 ms
(b). 9.2 ± 0.3 ms
(c). 9.2 ± 0.283 ms
(d). 1.84 ± 0.28 ms
(e). 1.8 ± 0.3 ms

19. In a lab experiment, the uncertainty on the slope was $\sigma_{slope} = 0.03$. The maximum slope was 0.41 and the minimum slope was 0.29. The number of data points on the graph was

(a). 4
(b). 2
(c). 8
(d). 9
(e). 6

20. A measured quantity f follows the normal law. The expected value $<f>$ (mean value of f) is obtained with a standard deviation σ and standard deviation of the mean σ_m. If a single measurement is performed, then with probability 0.68 it should be within which of the following intervals?

(a). $(<f> - \sigma_m, \quad <f> + \sigma_m)$
(b). $(<f> - 2\sigma_m, \quad <f> + 2\sigma_m)$
(c). $(<f> - \sigma, \quad <f> + \sigma)$
(d). $(<f> - 3\sigma, \quad <f> + 3\sigma)$
(e). $(<f> - 3\sigma_m, \quad <f> + 3\sigma_m)$

This completes Part A - Multiple Choice. Your answers must be on the Scantron sheet to be marked.

PART B (42 marks)

Attempt any three problems and give complete solutions in the space provided in this book.

This part consists of four problems of equal value (14 marks each). ***Attempt any three and only three of these problems.*** *For this part of exam, your detailed solutions including starting assumptions or physical laws, physical or logical reasoning, and mathematical calculations will be examined and evaluated. They are as important as your actual results. Make sure you give clear and adequate, but short, explanations.*

Problem 1

Consider an ideal parallel plate capacitor. Each plate is a 4.0 cm diameter disk, and the space between the plates is air. Assume that all the charge will reside on the inside surfaces of the plates.

(a). Specify and explain the direction of the electric field between the plates of the capacitor. Your answer must include a diagram.
(b). Using Gauss' Law, prove that the magnitude of the electric field between the plates of the capacitor is given by $E = \eta/\varepsilon_o$ where η is the surface charge density.
(c). Air breaks down when the electric field strength exceeds 30 kV/cm. How many electrons must be transferred from one disk to the other to create a spark between the disks?

Problem 2

A thin, uniformly charged rod with length L and total charge Q is oriented along the y axis with its centre at the origin. The rod extends from $(0, -L/2)$ to $(0, +L/2)$.

(a). Write an expression for the charge dq of an infinitesimal element at position y in terms of L, Q, and spatial coordinates.
(b). Obtain an expression for the differential electric potential dV at a point on the x axis, due to a charge element dq at position y. Assume that the electric potential is zero at infinity. Your answer to this part must include a diagram.
(c). Determine an expression for the electric potential $V(x, y)$ at a point on the x axis, i.e. at coordinates $(x,0)$, with $x \neq 0$. Your expression for V should involve only spatial coordinates, constants, and the quantities L and Q given in the problem.
(d). If we now bring an electron from infinity to the position $(+L/2, 0)$ along the x axis, how much work is done on the electron by the electric field ? Assume that Q is positive.

Some potentially relevant integrals: (a is a constant)

$$\int (a^2 + z^2)^{-1}\, dz = a^{-1} \tan^{-1}(z/a)$$
$$\int (a^2 + z^2)^{-0.5}\, dz = \ln[\, z + (a^2 + z^2)^{+0.5} \,]$$
$$\int (a^2 + z^2)^{-0.5}\, z\, dz = (a^2 + z^2)^{+0.5}$$

Problem 3

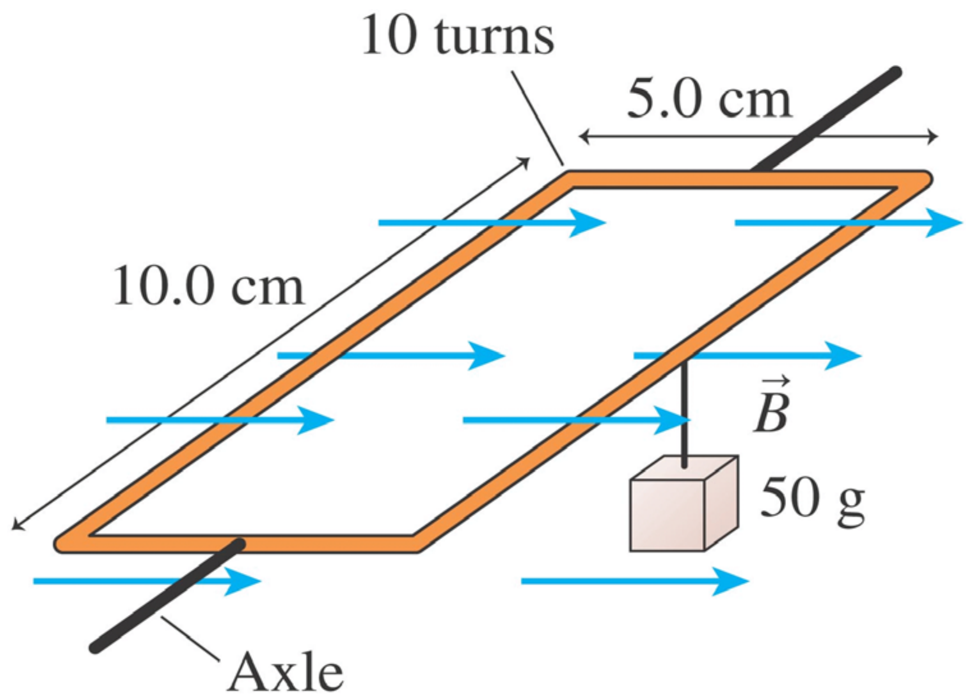
The 10-turn loop of wire shown below lies in a horizontal plane, parallel to a uniform horizontal magnetic field, and carries a constant current I. The loop is free to rotate about a nonmagnetic axle through the centre. A 50 gram mass hangs from one side of the loop. The magnetic field strength is 1.5 Tesla.

(a). In order to prevent the loop from rotating about the axle due to the gravitational force on the mass, in what direction should the current I flow around the loop? Neatly indicate the direction on the diagram below. Give a one-sentence explanation of how you obtained the direction.

(b). For each of the four sides of the loop, neatly indicate on the diagram the direction of the magnetic force, given the direction of current I from part (a). Again, in one sentence explain how you obtained the directions.

(c). Evaluate the torque about the axle, due to the magnetic force and the current I.

(d). Solve for the value of current I, in amperes, that prevents the loop from rotating about the axle.



Problem 4

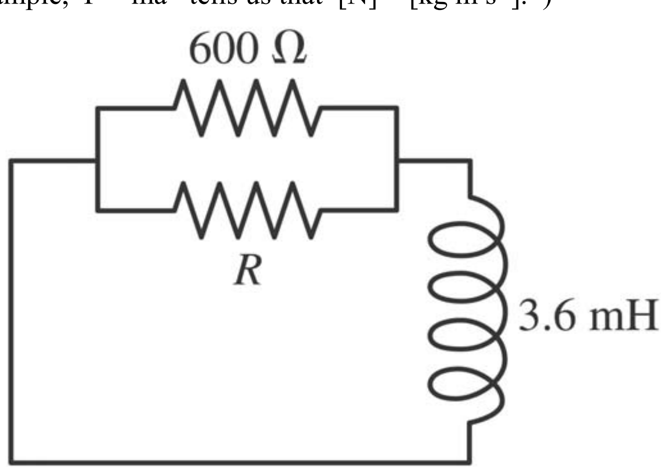
In the RL circuit below the time constant is $\tau = 10.\ \mu s$. Justifying all equations used:

(a). Determine R_{eq}, the equivalent resistance of the two resistors, in terms of $600\ \Omega$ and the unknown resistance R.

(b). Determine the value of R_{eq} needed to give the known time constant.

(c). Determine the value of R needed to give the known time constant.

(d). Time constants are in units of s. Prove this is the case starting from the units of R and L.
(Hint: If you cannot remember a unit, start from a basic equation.
For example, $F = ma$ tells us that $[N] = [kg\ m\ s^{-2}]$.)



1				d	
2			c		
3		b			
4					e
5	a				

6	a				
7			c		
8				d	
9					e
10		b			

11				d	
12		b			
13	a				
14					e
15			c		

16	a				
17				d	
18		b			
19					e
20			c		