PHYS 1004 **April 2005 Exam Questions**
Carleton University **Posted to course webct site, April 1, 2006.**

This is a reproduction of the exam questions from April 2005.
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.

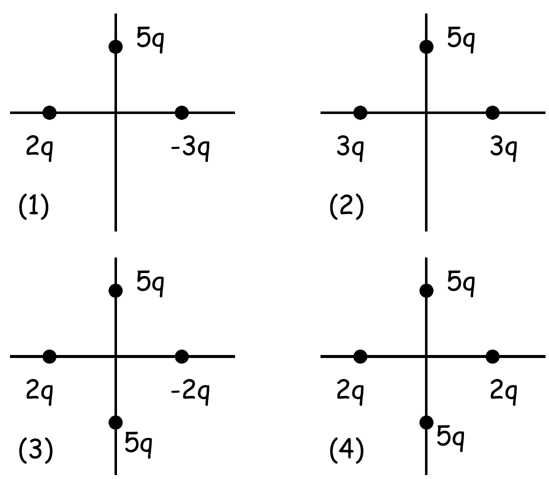
PART A (60 marks)

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.

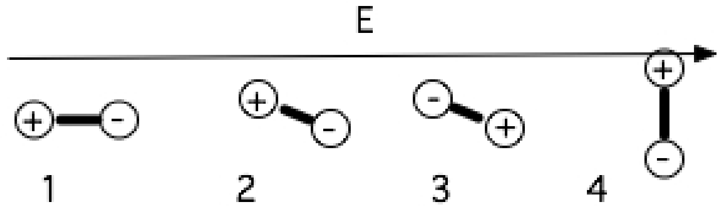
Indicate your choice by marking the correct box on the answer sheet for Part A. Only your choice of answer recorded on the answer sheet will be graded. *We recommend that you use pencil to fill in the boxes. If you need to make a change, erase your old answer. Your rough work and calculations for this part will not be considered. You may use the blank pages opposite the questions for these.*

1. Two spheres of charge q_1 and q_2 experience a net electrostatic force of magnitude F. The distance between the two spheres is halved and the charge on the first sphere is doubled ($q_1^{new} = 2\,q_1$). They now experience an electrostatic force of magnitude F^{NEW}. What is the relation between F and F^{NEW}?
(a). $F^{NEW} = 2\,F$
(b). $F^{NEW} = 16\,F$
(c). $F^{NEW} = F$
(d). $F^{NEW} = 4\,F$
(e). $F^{NEW} = 8\,F$

2. The diagrams at right depict four different charge distributions. The charged particles are all the same distance from the origin. The magnitude of the electric field at the origin:
(a). is least for distribution 1
(b). is least for distribution 2
(c). is least for distribution 3
(d). is least for distribution 4
(e). is the same for all four distributions



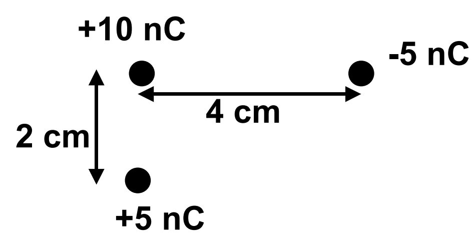
3. The diagrams below show four possible orientations of an electric dipole in a uniform electric field **E**.



Rank the diagrams according to the magnitude of the torque exerted on the dipole by the field, greatest first.
(a). 1, 2, 3, 4
(b). 4 and 1 tie, then 2 and 3 tie
(c). 4, 3, 2, 1
(d). 4, 2, 3, 1
(e). 4, then 2 and 3 tie, finally 1 which is zero

4. Consider Gauss' law: $\oint \mathbf{E}\cdot d\mathbf{A} = q/\varepsilon_o$. Which one of the following is true?
(a). **E** must be the electric field due to the enclosed charge
(b). If $q = 0$ then **E** = 0 everywhere on the Gaussian surface
(c). If there are three particles inside with charges of $+q$, $+q$ and $-2q$, then the integral is zero
(d). On the surface **E** is everywhere parallel to $d\mathbf{A}$
(e). If a charge is placed outside the surface, then it cannot affect **E** at any point on the surface

5. What is the electric potential energy of the system of three charges shown at right, assuming V = 0 at infinity?



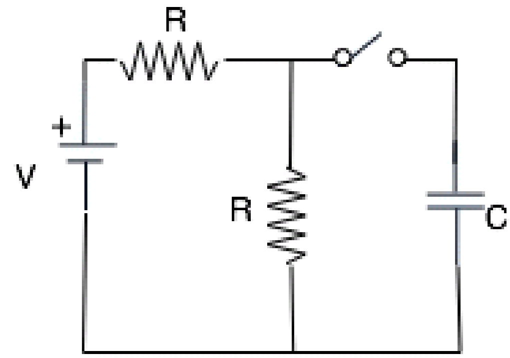
(a). 6.21 µJ
(b). 38.7 µJ
(c). 3.87 µJ
(d). 0.00 µJ
(e). 0.062 µJ

6. A beam of electrons has a cross-section of 1.0×10^{-7} m^2 and a speed of 3.0×10^6 m s^{-1}. If the density of electrons is 4.0×10^{12} m^{-3}, then the current is
(a). 0.19 µA
(b). 0.19 A
(c). 2.1×10^{-20} A
(d). 1.9×10^7 A
(e). 1.2×10^{-32} A

7. A wire of length L, cross-sectional area A and resistivity ρ is connected across an EMF $\mathscr{E}$. The wire is then cut in half and one half is connected again in the same fashion while the other half is discarded. The ratio of the new power consumption to the old will be
(a). 0.25
(b). 0.5
(c). 1
(d). 2
(e). 4

8. In the circuit at right, initially the switch is open and the capacitor is uncharged. The current has been flowing for some time. The switch is then closed. Just after closing the switch, the current leaving the battery

(a). decreases
(b). increases
(c). stays the same
(d). increases if C > R and decreases if C < R
(e). reverses



9. An electron, moving in the +y direction, encounters a magnetic field **B**. If the force on the electron is towards −x, what is the direction of **B** ?

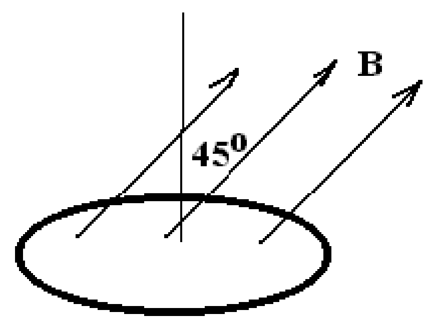
(a). +x
(b). −x
(c). +z
(d). −z
(e). +y

10. A long straight wire carries a current of 10.0 amperes. At what distance from the wire is the magnetic field due to this current equal in magnitude to that of the Earth, namely 0.600 Gauss ? (1 Gauss = 10^{-4} Tesla).

(a). 18.3 cm
(b). 3.33 cm
(c). 10.5 cm
(d). 26.5 km
(e). 167 km

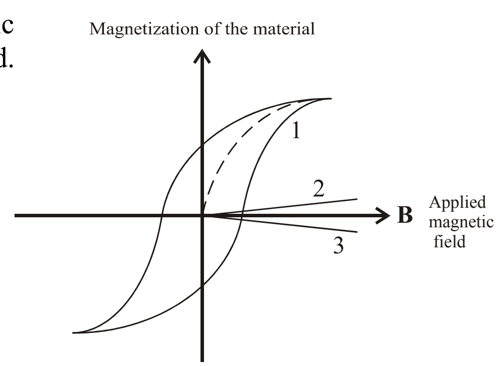
11. The uniform magnetic field in the diagram changes with time as B = 0.40t Tesla. The radius of the circular loop is r = 11.3 cm, and its resistance is 1.0 Ω. The magnitude and direction of the current in the loop, observed from above, is

(a). 1.8 A, counterclockwise
(b). 250 mA, clockwise
(c). 11 mA, clockwise
(d). 0.17 A, counterclockwise
(e). 0.17 A, clockwise



12. The figure shows how the three different types of magnetic material magnetize in response to an external magnetic field. The correct identification of materials 1, 2, and 3 is:

(a). 1 = paramagnetic, 2 = diamagnetic, 3 = ferromagnetic
(b). 1 = diamagnetic, 2 = ferromagnetic, 3 = paramagnetic
(c). 1 = paramagnetic, 2 = ferromagnetic, 3 = diamagnetic
(d). 1 = ferromagnetic, 2 = paramagnetic, 3 = diamagnetic
(e). 1 = ferromagnetic, 2 = diamagnetic, 3 = paramagnetic



13. An LC circuit oscillates at f = 20 kHz. The inductance of the circuit is L = 32 H. The capacitance is

(a). 2.0 pF
(b). 3.2 pF
(c). 4.6 nF
(d). 0.46 pF
(e). 2.0 nF

14. Assuming L to represent inductance and C capacitance, then the units of $\sqrt{\frac{L}{C}}$ reduce to

(a). W
(b). J
(c). A
(d). s
(e). Ω

15. Consider a series AC circuit consisting of a resistance R = 41.0 Ω and inductance L = 2.00 H, driven by $\mathscr{E}$ = 45.0 cos(40.0 t) volts. The amplitude of the AC current which flows in the circuit is:
(a). 501 mA
(b). 1.10 A
(c). 562 mA
(d). 1.12 A
(e). 22.5 A

16. Consider a transformer used to step the voltage down from an amplitude of 5.00 kV to 600 V. If the current in the primary windings has root-mean-square value 35.0 A rms, what is the amplitude of the current in the secondary windings ?
(a). 206 A
(b). 1720 A
(c). 292 A
(d). 412 A
(e). 4.20 A

17. A beam of light has electric and magnetic fields described by

$$\mathbf{E} = \mathbf{k}\, E_o \sin(kx + \omega t),$$
$$\mathbf{B} = \mathbf{j}\, B_o \sin(kx + \omega t).$$

This tells you that the wave is
(a). propagating in the y direction
(b). propagating in the $-y$ direction
(c). propagating in the x direction
(d). propagating in the $-x$ direction
(e). propagating in the z direction

18. A beam of natural light is incident on two linear polarizers, which have their transmission axes at angle θ from each other. The intensity downstream of the second polarizer is 0.0625 that of the incident natural light. The value of θ is
(a). 3.58°
(b). 1.32 radian
(c). 82.8°
(d). π/3 radian
(e). 1.21 radian

19. Light passes from water (n_w = 1.33) into glass (n_{glass} = 1.50). Which of the following is true ?
(a). Upon entering the glass, the light speed increases
(b). None of the other four statements are true
(c). When the angle of incidence on the water side is 62.5°, no light penetrates into the glass due to total internal reflection
(d). When the angle of incidence on the water side is 48.4°, the light transmitted into the glass is completely polarized
(e). When the angle of incidence on the water side is 26.3°, the transmission angle on the glass side is 30.0°

20. A candle is placed 1.5 m in front of a wall. A concave mirror is placed behind the candle so that a sharp image of the candle is projected on the wall. The size of the image is twice the size of the object. The distance between the mirror and the wall is:

(a). 1.5 m
(b). 2.0 m
(c). 3.0 m
(d). 3.5 m
(e). 4.0 m

Make sure that you have put your name, student number, and tutorial section at the top of the answer sheet on page 11 for the portion of the exam you've just completed (Part A - Multiple Choice), and go on to Part B which starts on page 15.

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PART B (42 marks)

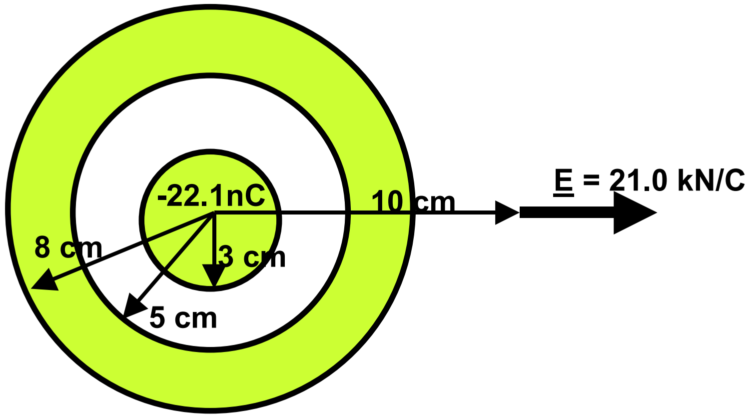
Attempt any three problems and give complete solutions in the space provided in this book.

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

A spherical conductor of radius 3.00 cm has a charge of -2.21×10^{-8} C. This conductor is centered inside a hollow metal conducting spherical shell which extends from 5.00 to 8.00 cm. The total charge on the spherical shell is unknown. At a point 10.0 cm from the centre of the sphere and the shell, the electric field due to the charges on these two conductors is 21.0 kN/C directed radially outward.

(a). Using Gauss' Law, determine the charge on the inner surface of the shell.
(b). In similar fashion, use Gauss' Law to find the charge on the outer surface of the shell.
(c). What are the magnitude and direction of the electric field at 2.00, 4.00 and 6.00 cm from the centre of the system?



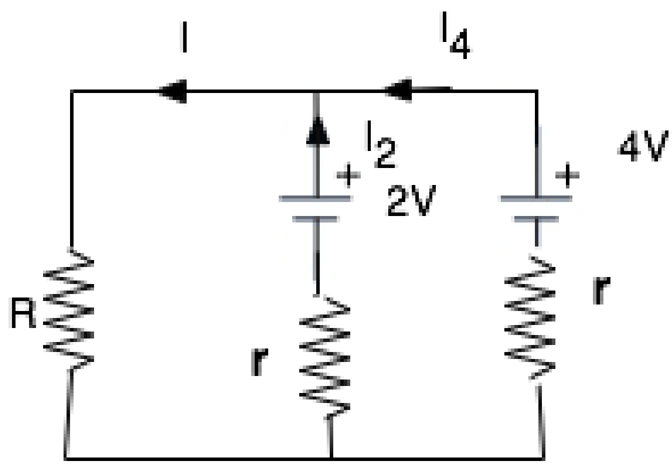
Problem 2

My flashlight requires a current of 2.0 A through the bulb to work properly.

(a). If a single 3.0 V battery is used, the current is 2.0 A and the flashlight works well. Deduce the bulb's resistance R, if the internal resistance of the 3.0 V battery is 0.20 Ω.

(b). Now consider the diagram below. Unfortunately I have only a 2.0 V and a 4.0 V battery, each with internal resistance of r = 0.40 Ω, so I wire these in parallel as shown. Find the current through R and hence say if the bulb will light.

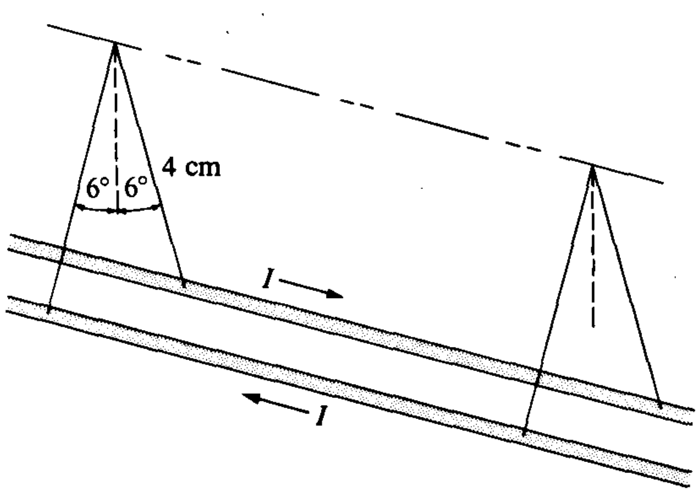
(c). What is the current (magnitude and direction) through the 2.0 V battery?

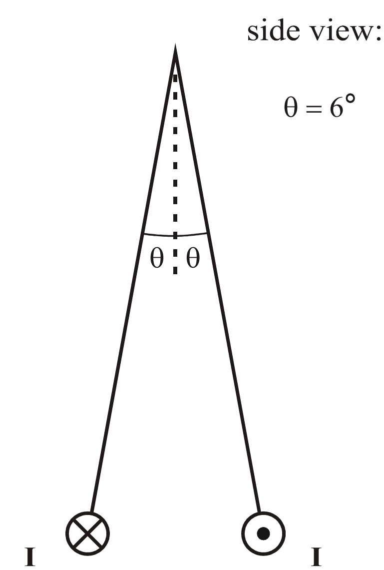


Problem 3

Two parallel wires of length 2.00 m are hung by cords of length a = 4.00 cm from a common axis, as shown below. Each wire has a mass of 50.0 g. The wires carry the same current I, in opposite directions. When a certain current I flows, the cords hang at an angle of 6.00º from the vertical.

(a). What is the distance between the wires ?
(b). Draw a free-body diagram for one of the wires.
(c). Determine the value of the current I, in Amperes.
(d). Determine the magnitude of the magnetic field that each wire is in, due to the other wire, in Tesla.





Problem 4

The fuse in the diagram has resistance r = 0.00100 Ω, and a current greater than 3.00 A will melt it (thereby causing its resistance to become infinite). The switch S is closed at time $t = 0$.

(a). Starting with Kirchhoff's Loop Rule, show that as long as the fuse is conducting, the current through the inductor is

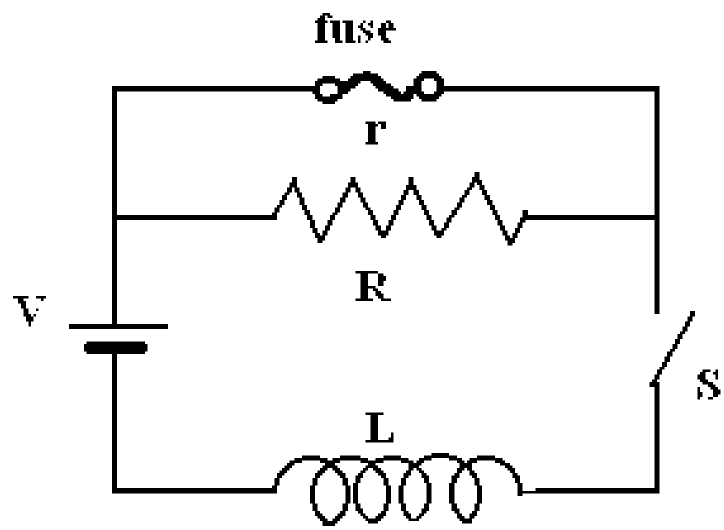
$$i = \frac{V}{R_{eq}}\left(1 - e^{-\left(R_{eq}/L\right)t}\right) ,$$

where R_{eq} is the equivalent resistance of the resistor R and fuse resistance r in parallel.

(b). Assuming that V = 10.0 volts, R = 15.0 Ω, and L = 5.00 H, calculate the time t when the fuse will "blow".

(c). Sketch a rough graph of the behaviour of the inductor current $i(t)$ versus t after the fuse "blows".

(d). Calculate the value of the current i after a very long time.



- Answers to Multiple Choice -

	a	b	c	d	e
1.	☐	☐	☐	☐	X
2.	☐	☐	☐	X	☐
3.	☐	☐	☐	☐	X
4.	☐	☐	X	☐	☐
5.	X	☐	☐	☐	☐

	a	b	c	d	e
6.	X	☐	☐	☐	☐
7.	☐	☐	☐	X	☐
8.	☐	X	☐	☐	☐
9.	☐	☐	X	☐	☐
10.	☐	X	☐	☐	☐

	a	b	c	d	e
11.	☐	☐	X	☐	☐
12.	☐	☐	☐	X	☐
13.	X	☐	☐	☐	☐
14.	☐	☐	☐	☐	X
15.	X	☐	☐	☐	☐

	a	b	c	d	e
16.	☐	☐	☐	X	☐
17.	☐	☐	☐	X	☐
18.	☐	☐	☐	☐	X
19.	☐	X	☐	☐	☐
20.	☐	☐	X	☐	☐