Circle instructor: Poduska or Morrow Name:________________________
Lab period: ____________ Student Number:____________________

MEMORIAL UNIVERSITY OF NEWFOUNDLAND
DEPARTMENT OF PHYSICS AND PHYSICAL OCEANOGRAPHY

Final Exam **Physics 1051 Winter 2007** April 2007

INSTRUCTIONS:

1. Do all **TEN (10) parts** in section **1** and all **FIVE (5)** questions in section **2**. Do **TWO** questions from section **3**. Marks are indicated in the left margin. Section 1 contains 20 marks, Section 2 contains 50 marks, and section 3 contains 30 marks. Budget time accordingly.
2. You may use a calculator. All other aids are prohibited.
3. Write answers neatly in space provided. If necessary, continue onto the back of the page.
4. Do not erase or use "whiteout". Draw a line neatly through material to be replaced.
5. Assume all information given is accurate to 3 significant figures.
6. Don't panic. If something isn't clear, ASK!

SEE LAST PAGE FOR SOME POTENTIALLY USEFUL FORMULAE AND CONSTANTS

For office use only:

1 (MC)	2	3	4	5	6	7	8	9	total

SECTION 1: There are 10 multiple choice questions. Each question is worth 2 marks for a maximum of 20 marks. Answer in the boxes next to each part.

1a) A lightly damped mass/spring system is observed to oscillate at 5 Hz when driven by an external oscillating force. If the natural frequency of the mass/spring system is 3 Hz, what is the oscillating frequency of the external force?

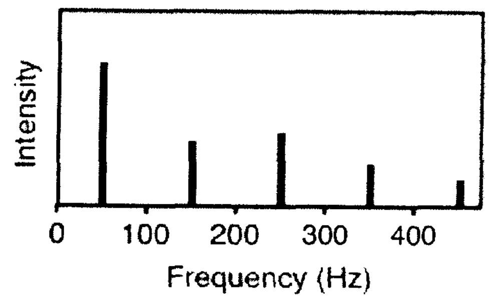
A. 2 Hz
B. 3 Hz
C. 5 Hz
D. 8 Hz

1b) To describe the oscillatory motion of a physical pendulum, which combination of variables would yield a plot with a straight line?

A. Period *vs.* distance from centre of mass
B. Period *vs.* moment of inertia
C. Period *vs.* accleration due to gravity
D. Period *vs.* mass.

1c) The figure below shows a Fast Fourier Transform (FFT) sound spectrum of a tube filled with air. Which one of the following statements is true?

A. The FFT spectrum is consistent with a tube that is closed at both ends.
B. The FFT spectrum is consistent with a tube with one open end and one closed end.
C. The FFT spectrum is consistent with a tube that is open at both ends
D. There is not enough information to decide.



1d) Which one of the following can be classified as a longitudinal wave?

A. The vibration of a guitar string.
B. The pressure wave produced by a vibrating guitar string.
C. An electromagnetic wave.
D. A water wave

1e) Which one of the following is a vector quantity?

A. Electric potential
B. Current
C. Torque
D. Polarization angle

1f) Which one of the following statement about conductors is FALSE?

A. The electric field inside a conductor depends on the magnitude of charge it holds.
B. Excess electric charge resides on the surface of a conductor.
C. Electric field lines are perpendicular to the surface of a conductor.
D. The charge density at the surface of a conductor depends on its shape.

1g) Physicists can calculate the speed of electromagnetic waves from
A. The Biot-Savart law.
B. The right-hand rule.
C. Maxwell's equations.
D. Malus' law.

1h) A point charge $+q$ is placed at the centre of a conducting spherical shell with inner radius r and outer radius R. Which of the following statements is FALSE?

A. The magnitude of the flux passing through the conducting shell $\frac{q}{\varepsilon_0}$.
B. The direction of the flux is toward the centre of the sphere.
C. The electric field at a point $d < r$ (i.e. inside the shell) is $\frac{k_e q}{d^2}$.
D. The electric field at a point $d > R$ (i.e. outside of the shell) is $\frac{k_e q}{d^2}$.

1i) Two polarizers are arranged in a line such that sunlight cannot pass through both. Which one of the following will NOT increase the amount of light passing through both polarizers?

A. Removing the first polarizer.
B. Rotating the optical axis of the second polarizer by 10 degrees.
C. Placing a third polarizer, with an optical axis of 10 degrees relative to the first polarizer, between the first two polarizers.
D. Shining laser light on the polarizers instead of sunlight.

1j) A beam of white light is incident on a drop of water and produces a rainbow. Which statement below is FALSE?

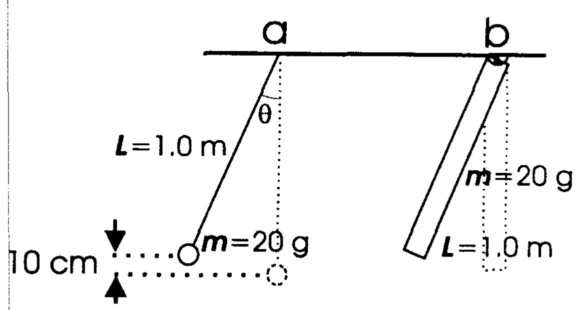
A. The speed of light in water is different for different wavelengths of light.
B. Some light is reflected when it hits the water droplet's surface.
C. Some light is refracted when it hits the water droplet's surface.
D. The frequency of the light traveling in air is different than its frequency while traveling in water.

SECTION 2: Do ALL five (5) questions. Each question is worth 10 marks for a maximum of 50 marks.

[10] 2. (a) A simple pendulum of mass 20.0 g is suspended from the ceiling by a thin string of length 1.0 m. The pendulum is pulled away from its equilibrium position, to increase its height by 10.0 cm, and released. The angular position of the pendulum *vs.* time is given by

$$\theta(t) = \theta_{max}\cos(\omega t + \phi).$$

(i) What is the period of oscillation?
(ii) What is the maximum speed of the pendulum?
(iii) What is the phase constant ϕ if the mass passes through its lowest point at t=0?



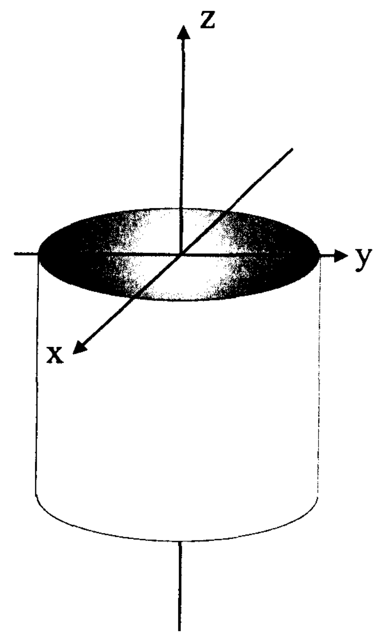
(b) If the simple pendulum in part (a) is replaced by a uniform rod of length 1.0 m, mass of 20.0 g, and moment of inertia about its end of $6.66\times10^{-3}\ \text{kg}\cdot\text{m}^2$, what is the resulting period of oscillation?

[10] 3. Two strings of equal length are clamped at each end and are under the same tension. The first string has a mass of 40.00 g and vibrates at a frequency of 440 Hz. The second string is slightly heavier so that, when the two strings are plucked simultaneously, beats with a period of 0.25 s are heard.

a. Briefly describe why beats are heard in this situation.
b. What is the vibrational frequency of the second string?
c. What is the mass of the second string?

[10] 4. A uniform electric field in a particular region may be written as

$$\vec{E} = 2.0\ \text{V/m}\left[\frac{1}{\sqrt{2}}\hat{i} - \frac{2}{\sqrt{3}}\left(\hat{j}+\hat{k}\right)\right].$$

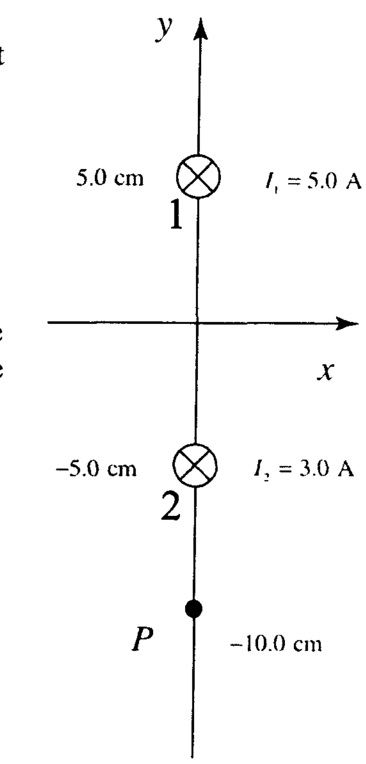


(a) List the components of $\vec{E}$.

(b) Calculate the magnitude of the electric field.

(c) A cylinder of radius $R = 10.0$ cm is located in this uniform field with its top surface centred at the origin and lying on the x-y plane as shown. Calculate the electric flux through this surface (i.e. the top surface of the cylinder which is shown as shaded in the figure).

[10] 5. Two infinitely long parallel wires carry current into the page as shown. Wire 1 is at $x = 0\,\text{cm}$, $y = +5.0\,\text{cm}$ and carries a current $I_1 = 5.0$ A. Wire 2 is at $x = 0\,\text{cm}$, $y = -5.0\,\text{cm}$ and carries a current $I_2 = 3.0$ A.



(a) Calculate the magnitude and direction of the total magnetic field at the point P located at $x = 0\,\text{cm}$, $y = -10.0$ cm.

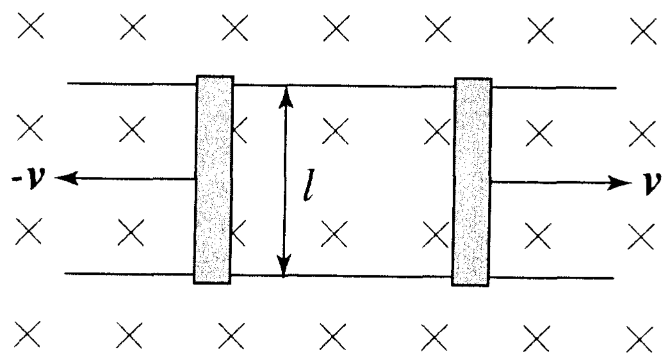
(b) Calculate the magnitude and direction of the magnetic force that a 2.0 metre long section of wire 2 exerts on a 2.0 metre long section of wire 1.

[10] 6. Two sliding metal bars of length $l = 20.0$ cm are moving along two parallel rails, in opposite directions, with constant speeds of $v = 0.5$ m/s, as shown in the figure below. The rails are located in a uniform magnetic field with a magnitude 0.15 T that is directed into the page as shown.

(a) Calculate the rate of change of the magnetic flux within the loop formed by the sliders and the rails.

(b) If the current flowing through each slider is 0.25 A, calculate the total resistance of the loop.

(c) In what direction does the current flow? Indicate this clearly on the diagram and briefly justify your answer.



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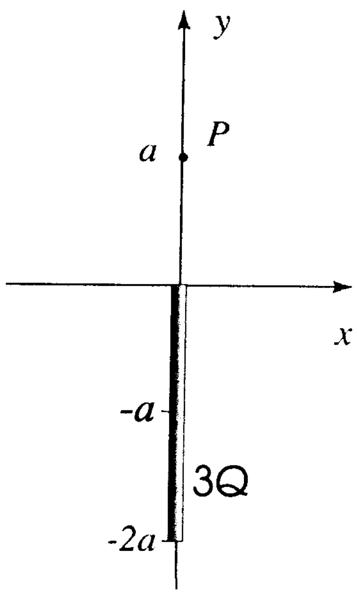
SECTION 3: Do TWO (2) of the three questions. Each question is worth 15 marks for a total of 30 marks. Indicate clearly the one question that you do not want marked by drawing a line through it (don't erase!).

[15] 7. A charge $3Q$ is distributed uniformly on rod of length $2a$ which is located on the y-axis with its centre at the origin as shown below.

(a) What is the linear charge density on the rod?

(b) Calculate the **electric field** at a point P located on the y-axis a distance a from the origin. Start your calculation with the contribution to the field at P due to a small element of charge and then integrate to find the electric field at P due to the entire charge. Hint: integrals are given on the formula sheet.

(c) If the entire charge, $3Q$, was concentrated in a point located at $y = -a$ on the y-axis, would the resulting electric field at P be greater or smaller than the electric field due to the rod that you calculated in part (b)? Justify your answer.



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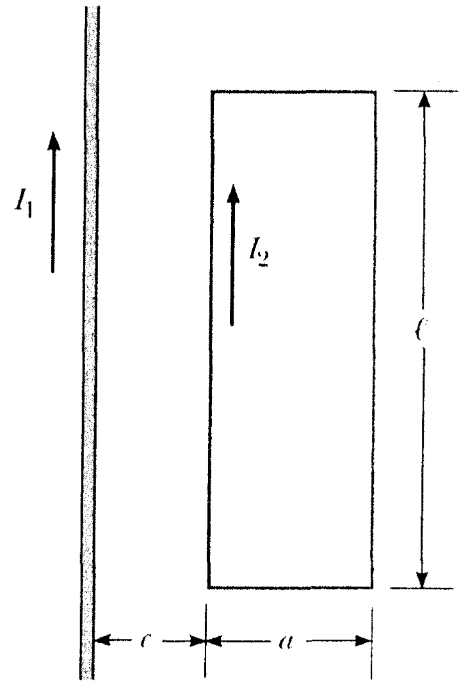
[15] 8. A long straight wire carrying a current $I_1 = 3.0\,\text{A}$ lies in the plane of a rectangular loop which carries a current $I_2 = 5.0\,\text{A}$. Referring to the figure, the dimensions of the loop are $l = .60\,\text{m}$ and $a = 0.25\,\text{m}$. The distance between the left edge of the loop and the long wire is $c = 0.2\,\text{m}$.

(a) On the diagram, show the direction of the average magnetic force on each of the sides of the loop caused by the magnetic field created by the long wire.

(b) Calculate the net force on the loop due to the magnetic field created by the long wire.

(c) Calculate the net torque on the loop due to the magnetic field created by the long wire.



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[15] 9. (a) In Young's double slit experiment, light from a single monochromatic (single wavelength) source passes through a pair of slits (i.e. a double slit) and produces an intensity pattern, on a distant screen, consisting of a series of equally spaced bright and dark bands. Briefly explain the origin of these bands.

(b) In Young's double slit experiment, the light from a laser of unknown wavelength λ produces fringes on a screen 3.4 m away. If the distance between 16 successive maxima (8 on each side of the central maxima) is measured to be 16.8 cm, calculate the wavelength of the light. The slits are 0.21 mm apart.

(c) If the slits are moved closer together (and the screen remains at the same distance), would the maxima move closer together or further apart? Justify your answer.

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Some Potentially Useful Formulae:

$\frac{d^2x}{dt^2} = -\omega^2 x$

$k = \frac{2\pi}{\lambda}$

$\omega = \frac{2\pi}{T}$

$v = f\lambda$

$\omega^2 = \frac{k_{\text{spring}}}{m}$

$\omega^2 = \frac{g}{L}$

$\omega^2 = \frac{mgd}{I}$

$v = \sqrt{\frac{T}{\mu}}$

$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$

$\vec{F}_{12} = k_e \frac{q_1 q_2}{r^2}\hat{r}_{12}$

$\vec{E} = k_e \frac{q}{r^2}\hat{r}$

$\vec{E} = k_e \sum_i \frac{q_i}{r_i^2}\hat{r}_i$

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

$\Phi_E = \int \vec{E}\cdot d\vec{A}$

$\Phi_E = \frac{q_{\text{inside}}}{\varepsilon_0}$

$V = k_e \frac{q}{r}$

$V = k_e \sum_i \frac{q_i}{r_i}$

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

$U_{12} = k_e \frac{q_1 q_2}{r_{12}}$

$\Delta U = -q\int_A^B \vec{E}\cdot d\vec{s}$

$\Delta U = q\Delta V$

$R = \frac{\Delta V}{I}$

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

$\vec{F}_B = q\vec{v}\times\vec{B}$

$\vec{F}_B = I\vec{l}\times\vec{B}$

$\vec{\mu} = I\vec{A}$

$\vec{\tau} = \vec{r}\times\vec{F}$

$\vec{\tau} = \vec{\mu}\times\vec{B}$

$B = \frac{\mu_0 I}{2\pi a}$

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

$\frac{F_1}{l} = \frac{\mu_0 I_1 I_2}{2\pi a}$

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

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

$\varepsilon = -N\frac{d\Phi_B}{dt}$

$c = \frac{1}{\sqrt{\varepsilon_0\mu_0}}$

$E_{\max} = cB_{\max}$

$\Delta\phi = \left(\frac{2\pi}{\lambda}\right)\delta$

$\delta = d\sin\theta$

$n = \frac{c}{v}$

$\Delta V = V_B - V_A = -\int_A^B \vec{E}\cdot d\vec{s}$

$\vec{E} = -\left(\frac{dV}{dx}\hat{i} + \frac{dV}{dy}\hat{j} + \frac{dV}{dz}\hat{k}\right)$

$d\sin\theta_{\text{bright}} = m\lambda \quad (m = 0, 1, 2\ldots)$

Equations of Electromagnetism (Maxwell's Equations):

$\oint \vec{E}\cdot d\vec{A} = \frac{q_{\text{inside}}}{\varepsilon_0}$

$\oint \vec{B}\cdot d\vec{A} = 0$

$\oint \vec{E}\cdot d\vec{s} = -\frac{d\Phi_B}{dt}$

$\oint \vec{B}\cdot d\vec{s} = \mu_0 I + \mu_0\varepsilon_0\frac{d\Phi_E}{dt}$

Physical constants:

$k_e = \frac{1}{4\pi\varepsilon_0} = 8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$

$\varepsilon_0 = 8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2$

$\mu_0 = 4\pi\times10^{-7}\ \text{T}\cdot\text{m}/\text{A}$

$e = 1.602\times10^{-19}\ \text{C}$

$m_e = 9.11\times10^{-31}\ \text{kg}$

$c = 2.99\times10^8\ \text{m/s}$

Mathematical formulae

$\vec{A}\cdot\vec{B} = AB\cos\theta = A_x B_x + A_y B_y + A_z B_z$

$\left|\vec{A}\times\vec{B}\right| = AB\sin\theta$

$\hat{i}\times\hat{j} = \hat{k} \quad \hat{j}\times\hat{k} = \hat{i} \quad \hat{k}\times\hat{i} = \hat{j}$

$\vec{A}\times\vec{B} = (A_y B_z - A_z B_y)\hat{i} + (A_z B_x - A_x B_z)\hat{j} + (A_x B_y - A_y B_x)\hat{k}$

$\int \frac{dx}{(x^2+a^2)^{3/2}} = \frac{x}{a^2\sqrt{x^2+a^2}}$

$\int \frac{x\,dx}{(x^2+a^2)^{3/2}} = -\frac{1}{\sqrt{x^2+a^2}}$

$\int \frac{dx}{x^2} = -\frac{1}{x}$