UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

Physics 111.6
MIDTERM TEST #4

March 6, 2008 Time: 90 minutes

NAME: MASTER STUDENT NO.: _____
(Last) **Please Print** (Given)

LECTURE SECTION (please check):

- ☐ 01 Dr. A. Robinson
- ☐ 02 B. Zulkoskey
- ☐ 03 D. Loughran
- ☐ 97 M. Lepage
- ☐ C15 F. Dean

INSTRUCTIONS:

1. You should have a test paper, a formula sheet, and an OMR sheet. The test paper consists of 9 pages. **It is the responsibility of the student to check that the test paper is complete.**
2. Enter your name and STUDENT NUMBER on the OMR sheet.
3. The test paper, the formula sheet and the OMR sheet must all be submitted.
4. The test paper will be returned. The formula sheet and the OMR sheet will NOT be returned.

PLEASE DO NOT WRITE ANYTHING ON THIS TABLE

QUESTION NO.	MAXIMUM MARKS	MARKS OBTAINED
Part A	10	
Part B	10	
C1	5	
C2	5	
C3	5	
TOTAL	35	

continued on page 2...

Physics 111 2007-08 Test 4 – Alternative Sitting Answers

A1	B	B1	4.16×10^{3} N/C, DOWN
A2	A		
A3	A	B2	9.09 A
A4	E		
A5	B	B3	4.47 A
A6	B		
A7	D	B4	3.39×10^{-11} s
A8	E		
A9	A	B5	2.44
A10	B		

PART A

FOR EACH OF THE FOLLOWING QUESTIONS IN PART A, ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

A1. Which one of the following statements regarding the electric potential is **FALSE**?

D

(A) The electric potential is a scalar quantity. T
(B) Electric potential is defined as the electric potential energy per unit charge. T
(C) The total electric potential at a point is the sum of the individual potentials. T
(D) The SI unit of electric potential is the Volt/metre. F Unit of electric potential is Volt.
(E) The electric potential due to a point charge is taken by convention to be zero at a distance of infinity from the point charge. T

A2. Which one of the following statements regarding electric field lines is **FALSE**?

C

(A) Electric field lines originate on a positive charge. T
(B) Electric field lines never cross each other. T
(C) An electric field line may terminate on a positive charge. F $\vec{E}$-field lines always terminate on -ve charges.
(D) The direction of an electric field line indicates the direction of the electric field vector.
(E) There are more electric field lines in a region with a larger magnitude of electric field.

A3. A small test charge is placed at a distance R from a point charge Q and the magnitude of the electric field is measured to be E. The test charge is now moved to a distance $2R$ away from charge Q. The new magnitude of the electric field, in terms of E, is

C

(A) $2E$ (B) E (C) $\frac{1}{4}E$ (D) $\frac{1}{2}E$ (E) $4E$

$E = \frac{k|Q|}{R^2}$

$E' = \frac{k|Q|}{(2R)^2} = \frac{1}{4}E$

A4. Charged particles experience different forces when moving in either an electric field or a magnetic field. Which one of the following statements is **FALSE**?

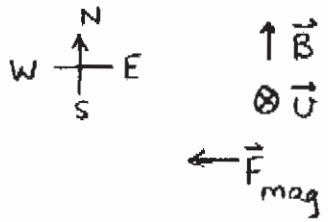
C

(A) No work is done by the magnetic force on a moving charged particle. T
(B) The electric force on a positively charged particle acts in the direction of the electric field. T
(C) The magnetic force is a maximum when a charged particle travels in a direction parallel to the magnetic field. F
(D) The kinetic energy of a charged particle changes when moving solely due to the electric force. T
(E) A charged particle loses electric potential energy when moving solely due to the electric force. T

A5. A negatively charged object is dropped from a tower at the earth's magnetic equator (where the magnetic field direction is horizontal and pointing North). The initial direction of the magnetic force acting on the object is

D

(A) North
(B) South
(C) East
(D) West
(E) undefined. No magnetic force acts on the ball.



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A6. Two copper wires have different lengths ($L_2 = 2\,L_1$) and different radii ($r_2 = 2\,r_1$). Which one of the following statements correctly describes the relationship between the resistances, R_1 and R_2, of the two wires?

D

(A) $R_2 = 4R_1$ (B) $R_2 = R_1$ (C) $R_2 = \frac{1}{4}R_1$ (D) $R_2 = \frac{1}{2}R_1$ (E) $R_2 = \frac{1}{4}R_1$

$R_1 = \frac{\rho L_1}{A_1} = \frac{\rho L_1}{\pi r_1^2}$ $R_2 = \frac{\rho L_2}{\pi r_2^2} = \frac{\rho(2L_1)}{\pi(2r_1)^2} = \frac{2}{4}\frac{\rho L_1}{\pi r_1^2} = \frac{1}{2}\frac{\rho L_1}{\pi r_1^2} = \frac{1}{2}R_1$

A7. A 1 Ω resistor and a 2 Ω resistor are connected in parallel across an ideal voltage source. The power dissipated in the 1 Ω resistor is P_1 and the power dissipated in the 2 Ω resistor is P_2. Which one of the following statements is **TRUE**?

B

$P_1 = \frac{V^2}{R_1}$ $P_2 = \frac{V^2}{R_2} = \frac{V^2}{2R_1} = \frac{1}{2}\frac{V^2}{R_1} = \frac{1}{2}P_1$

(A) $P_2 = \frac{1}{4}P_1$ (B) $P_2 = \frac{1}{2}P_1$ (C) $P_2 = P_1$ (D) $P_2 = 2P_1$ (E) $P_2 = 4P_1$

A8. White light travels through air and enters a glass prism, but when the light emerges from the prism different colours of light are observed. Which one of the following statements explains this observation?

C

(A) The separation of white light into its component colours is due to the increase in the speed of light within the glass.
(B) Some of the colour components of the white light are absorbed by the glass and only the remaining components are observed.
(C) The index of refraction of the glass depends on the wavelength of the light, so the colour components of the white light are refracted at different angles.
(D) Only some of the colour components are refracted by the glass; these are the only ones that are observed.
(E) White light is separated into its component colours by total internal reflection within the prism.

A9. Which one of the following is **not** part of the electromagnetic spectrum?

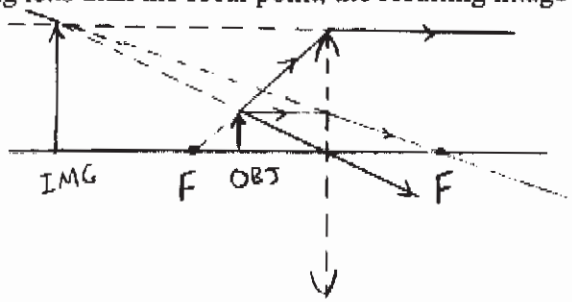
D

(A) FM radio waves (B) X-rays (C) microwaves
(D) ultrasonic waves (E) visible light

A10. When an object is placed closer to a converging lens than the focal point, the resulting image is

A

(A) upright and larger than the object.
(B) upright and smaller than the object.
(C) upright and the same size as the object.
(D) inverted and larger than the object.
(E) inverted and smaller than the object.



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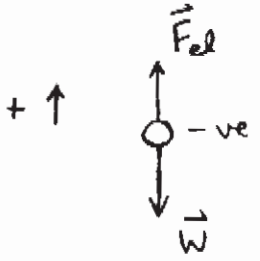
PART B

FOR EACH OF THE FOLLOWING PROBLEMS, WORK OUT THE SOLUTION IN THE SPACE PROVIDED AND ENTER YOUR ANSWERS ON PAGE 6.

ONLY THE ANSWERS WILL BE MARKED. THE SOLUTIONS WILL NOT BE MARKED.

B1. A small drop of water is suspended motionless in air by a uniform electric field. The mass of the drop is 2.53×10^{-9} kg and it has a charge of -1.12×10^{-11} C. Calculate the magnitude and direction of the electric field in which the drop is suspended.



For $\Sigma\vec{F} = 0$, $\vec{F}_{el}$ must be UP. Since $\vec{F}_{el} = q_0\vec{E}$, and q_0 is −ve, $\vec{E}$ must be DOWN

$$\Sigma\vec{F} = 0$$

$$F_{el} - W = 0$$

$$|q_0|E - mg = 0$$

$$E = \frac{mg}{|q_0|} = \frac{(2.53\times10^{-9}\,kg)(9.80\,m/s^2)}{|-1.12\times10^{-11}\,C|}$$

$$E = 2.21 \times 10^3\ N/C$$

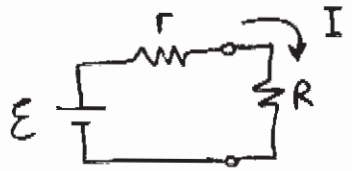
B2. An electric grill has a power rating of 1.00×10^3 W. Calculate the rms current that flows through the grill when it is connected to a 1.20×10^2 V AC outlet.

$$\bar{P} = V_{rms} I_{rms}$$

$$I_{rms} = \frac{\bar{P}}{V_{rms}} = \frac{1.00\times10^3\,W}{1.20\times10^2\,V} = 8.33\,A$$

continued on page 5...

B3. A real voltage source has an emf (open-circuit voltage) of 9.21 V and an internal resistance of 0.245 Ω. Calculate the current through a 1.78 Ω resistor when it is connected to this voltage source.

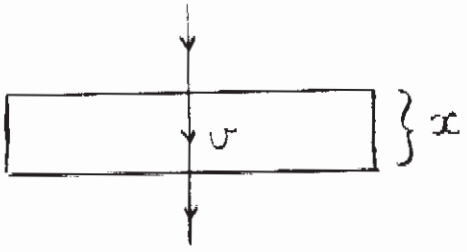


$$I = \frac{\mathcal{E}}{r+R}$$

$$I = \frac{9.21\,V}{(0.245\,\Omega + 1.78\,\Omega)}$$

$$I = 4.55\,A$$

B4. A plate glass window has a thickness of 4.12×10^{-3} m and an index of refraction of 1.56. If a beam of light enters the glass with an angle of incidence of 0.00°, calculate the time for the light to pass through the window.



$$x = vt \Rightarrow t = \frac{x}{v}$$

$$\text{and } n = \frac{c}{v} \Rightarrow v = \frac{c}{n}$$

$$\therefore t = \frac{x}{c/n} = \frac{nx}{c}$$

$$t = \frac{(1.56)(4.12 \times 10^{-3}\,m)}{3.00 \times 10^{8}\,m/s} = 2.14 \times 10^{-11}\,s$$

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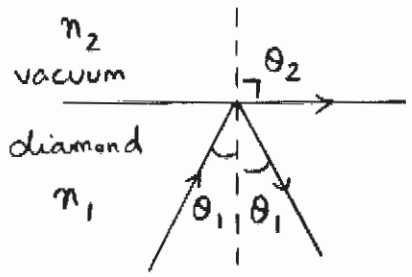
B5. The critical angle for light passing from diamond into vacuum is 24.2°. Calculate the index of refraction for diamond.



At critical angle, $\theta_2 = 90.0°$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$n_1 = \frac{n_2 \sin\theta_2}{\sin\theta_1}$$

$$n_1 = \frac{1.00 \sin(90.0°)}{\sin(24.2°)} = \boxed{2.44}$$

ANSWERS FOR PART B

ENTER THE ANSWERS FOR THE PART B PROBLEMS IN THE BOXES BELOW.

THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

ONLY THE ANSWERS WILL BE MARKED. THE SOLUTIONS WILL NOT BE MARKED.

B1 | 2.21×10^3 N/C | direction: UP ; (DOWN) (circle your choice)

B2 | 8.33 A

B3 | 4.55 A

B4 | 2.14×10^{-11} s

B5 | 2.44

continued on page 7...

PART C

IN EACH OF THE FOLLOWING QUESTIONS, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWER IN THE BOX PROVIDED.

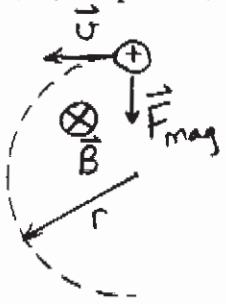
THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY, SHOW AND EXPLAIN YOUR WORK. EQUATIONS NOT PROVIDED ON THE FORMULA SHEET MUST BE DERIVED.

C1. As a result of the solar wind, protons enter the earth's magnetic field at a relatively high speed. Assume that the proton's velocity is perpendicular to the earth's magnetic field.

(a) Derive an expression for the radius of the circular path that the proton will follow, in terms of its mass, m, its speed, v, and the magnitude of the earth's magnetic field, B.

its charge, q_0,



Assume that $\vec{F}_{mag}$ is the only force acting on the proton and apply Newton II:

$\sum \vec{F} = m\vec{a} \Rightarrow F_{mag} = ma$ ①

Since F_{mag} is always $\perp$ to $\vec{v}$, the result is uniform circular motion. $\therefore a = a_c = \frac{v^2}{r}$. Also, $F_{mag} = |q_0| v B \sin\theta$ and since $\vec{v} \perp \vec{B}$, $\theta = 90°$.

Substitution into ① yields $|q_0| v B \sin(90°) = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{|q_0|B}$

$$r = \frac{mv}{|q_0|B}$$

(b) Calculate the radius of the circular path when $v = 6.24 \times 10^6$ m/s and $B = 1.20 \times 10^{-7}$ T.

5.43×10^5 m

$$r = \frac{mv}{|q_0|B} = \frac{(1.67 \times 10^{-27}\,\text{kg})(6.24 \times 10^6\,\text{m/s})}{(|1.60 \times 10^{-19}\,\text{C}|)(1.20 \times 10^{-7}\,\text{T})}$$

$$r = 5.43 \times 10^5\,\text{m}$$

continued on page 8...

C2. Consider the arrangement shown in the diagram. The distance from point A to point C is 9.06 cm and the distance from point B to point C is 3.01 cm. A proton is fixed in place at point C. An electron is released from rest at point A.

(a) Calculate the potential difference from A to B, due to the proton, and indicate which location is at higher electric potential.

$V = \frac{kq}{r}$

$V_B - V_A = \frac{kq}{r_B} - \frac{kq}{r_A}$

3.19×10^{-8} V
point of higher potential: (circle your choice) A ; (B)

$V_B - V_A = kq\left(\frac{1}{r_B} - \frac{1}{r_A}\right) = (8.99 \times 10^9 \text{ N·m}^2/\text{C}^2)(1.60 \times 10^{-19}\text{C})\left(\frac{1}{0.0301\text{m}} - \frac{1}{0.0906\text{m}}\right)$

$V_B - V_A = 3.19 \times 10^{-8}$ V (+ve, so $V_B > V_A$)

(b) Calculate the kinetic energy of the electron as it passes point B. You may express your answer in eV.

Energy is conserved.

$E_B = E_A$

$KE_B + EPE_B = KE_A + EPE_A$ (starts from rest at A)

$KE_B = KE_A + EPE_A - EPE_B = 0 + q_0(V_A - V_B) = -e(V_A - V_B)$

$KE_B = e(V_B - V_A) = e(3.19 \times 10^{-8}\text{V}) = 3.19 \times 10^{-8}$ eV

3.19×10^{-8} eV

(c) Calculate the speed of the electron as it passes point B.

$KE_B = \frac{1}{2} m_e v_B^2$

$v_B = \sqrt{\frac{2KE_B}{m_e}} = \left(\frac{2(3.19 \times 10^{-8})(1.60 \times 10^{-19}\text{C})\text{V}}{9.11 \times 10^{-31}\text{ kg}}\right)^{1/2}$

$v_B = 106$ m/s

106 m/s

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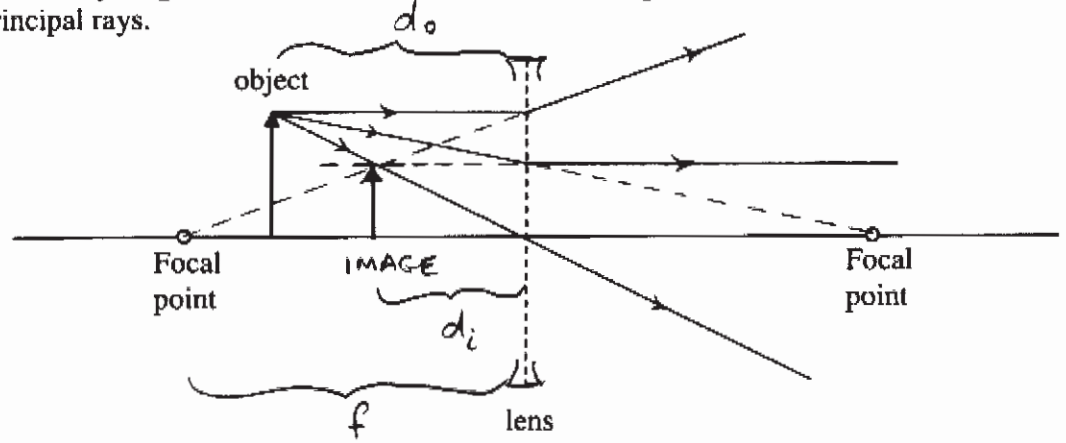
C3. A diverging lens has a focal point that is a distance of 12.0 cm from the centre of the lens. An object that is 2.67 cm high is placed a distance of 9.00 cm from the lens.

(a) Draw a ray diagram that shows the location of the image. Your diagram must show all three principal rays.



(b) Calculate the height of the image.

$f = -12.0\,cm$ (-ve since diverging lens)

$d_o = +9.00\,cm$; $h_o = 2.67\,cm$

1.53 cm

h_i = image height = mh_o where m, the magnification, $= -\frac{d_i}{d_o}$

$\therefore h_i = -\frac{d_i}{d_o} \cdot h_o$

From the thin lens equation, $d_i = \left(\frac{1}{f} - \frac{1}{d_o}\right)^{-1}$

$$\therefore h_i = -\frac{\left(\frac{1}{f} - \frac{1}{d_o}\right)^{-1} \cdot h_o}{d_o} = \frac{-h_o}{\left(\frac{1}{f} - \frac{1}{d_o}\right) d_o} = \frac{-h_o}{\frac{d_o}{f} - 1}$$

$$h_i = \frac{-2.67\,cm}{\frac{9.00\,cm}{-12.0\,cm} - 1} = 1.53\,cm$$

END OF EXAMINATION