Circle instructor: Poduska or Morrow

Name: test-2-W07-answers

Lab period: ____________

Student Number: ____________

MEMORIAL UNIVERSITY OF NEWFOUNDLAND
DEPARTMENT OF PHYSICS AND PHYSICAL OCEANOGRAPHY

Physics 1051 Winter 2007

Term Test 2 — March 15, 2007

INSTRUCTIONS:

1. Do all questions. Marks are indicated in the left margin. Budget time accordingly.
2. Write your name and student number on each page.
3. You may use a calculator. All other aids are prohibited.
4. Write answers neatly in space provided. If necessary, continue onto the back of the page.
5. Do not erase or use "whiteout" to correct answers. Draw a line neatly through material to be replaced and continue with correction.
6. Assume all information given is accurate to 3 significant figures.
7. Don't panic. If something isn't clear, ASK!

SEE LAST PAGE FOR SOME POTENTIALLY USEFUL FORMULAE AND CONSTANTS

For office use only:

1	2	3	4	5	6	7	8	9	total

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SECTION 1: MULTIPLE CHOICE. (answer in the box provided for each question)

[2] 1. An electron is traveling with a velocity $\vec{v} = 550\,\text{m/s}\,\hat{\text{i}}$ when it enters a region of space where the electric field is $\vec{E} = -1.0\times10^{-9}\ \text{N/C}\,\hat{\text{j}}$.

D

A. After the electron has been in the field for 0.10 s, the x-component of its velocity is positive and the y-component of its velocity is negative.

B. After the electron has been in the field for 0.10 s, the x-component of its velocity is zero and the y-component of its velocity is positive.

C. After the electron has been in the field for 0.10 s, the x-component of its velocity is positive and the y-component of its velocity is zero.

D. After the electron has been in the field for 0.10 s, the x-component of its velocity is positive and the y-component of its velocity is positive.

[2] 2. Which of the following statements **IS TRUE**?

B

A. The surface charge density is uniform over the surface of any charged conductor.

B. The electric field at the surface of a charged conductor is perpendicular to the surface of the conductor.

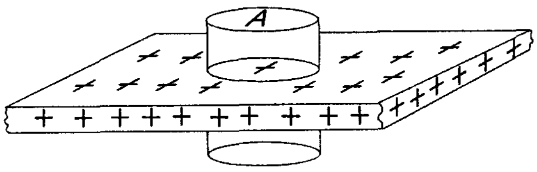
C. The excess charge on a charged conductor is uniformly distributed over its volume.

D. The equipotentials near the surface of a charged conductor are perpendicular to the surface of the conductor.

E. The electric field at the surface of a charged conductor is zero.

[2] 3. Imagine a cylinder with cross-sectional area A drawn through an infinite, uniformly charged insulating slab as shown. The charge per unit area of the slab is σ in C/m^2. Which of the following statements **IS TRUE**?

B



A. The total electric flux through the cylinder ends is 0.

B. The sum of the electric fluxes through the two cylinder ends is $\dfrac{\sigma A}{\varepsilon_0}$.

C. The sum of the electric fluxes through the two cylinder ends is $-\dfrac{\sigma A}{\varepsilon_0}$.

D. The sum of the fluxes through the two cylinder ends and the curved cylindrical surface is 0.

[2] 4. The electric potential is a region of space is given by $V = 7x^2y$ in SI units. Which of the following statements **IS FALSE**?

D

A. The magnitude of the electric field at the origin is 0.

B. The x-component of the electric field depends on both x and y.

C. The z-component of the electric field is 0 everywhere in this region.

D. The y-component of the electric field is proportional to y.

[2] 5. A positive charge $+q$ traveling with velocity $\vec{v} = 357 \text{ m/s}\,\hat{k}$ enters a region where the magnetic field is $\vec{B} = 5.75\,\text{T}\,\hat{j}$ as shown. Which of the following statements **IS TRUE** ?

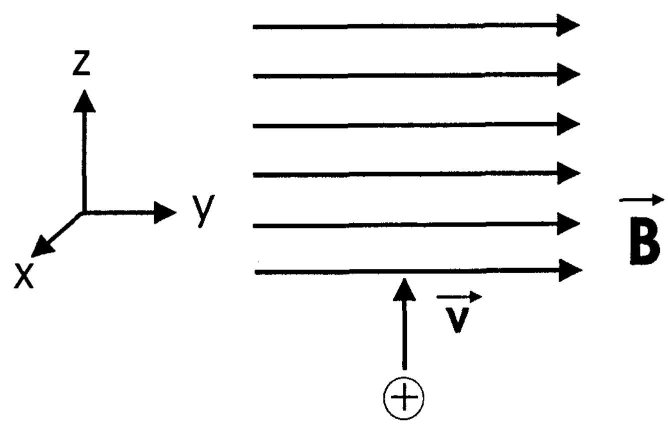
D

A. The magnetic force on the charge is in the positive x direction.

B. The magnetic force on the charge is in the positive y direction.

C. The magnetic force on the charge is in the negative y direction.

D. The magnetic force on the charge is in the negative x direction.



SECTION 2: DO ALL FOUR (4) QUESTIONS

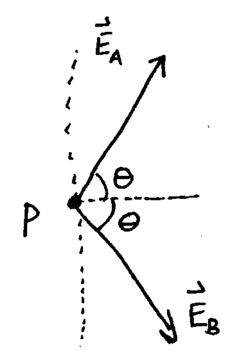
[10] 6. A charge of +2 μC (charge A) is located at $x = -1.0\,\text{m}$ along the x-axis. A second charge of -2 μC (charge B) is located on the x-axis at $x = +1.0\,\text{m}$. The point P is located on the y-axis at $y = 2.0\,\text{m}$.

[2] (a) Draw vectors representing the electric field at point P due to charge A $(\vec{E}_A)$ and the electric field at point P due to charge B $(\vec{E}_B)$.

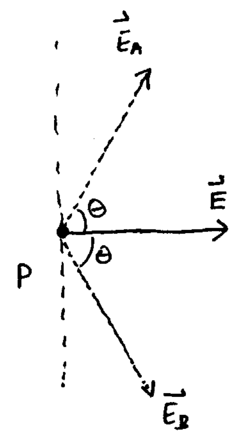
[2] (b) Draw the vector representing the total electric field $(\vec{E})$ at point P.

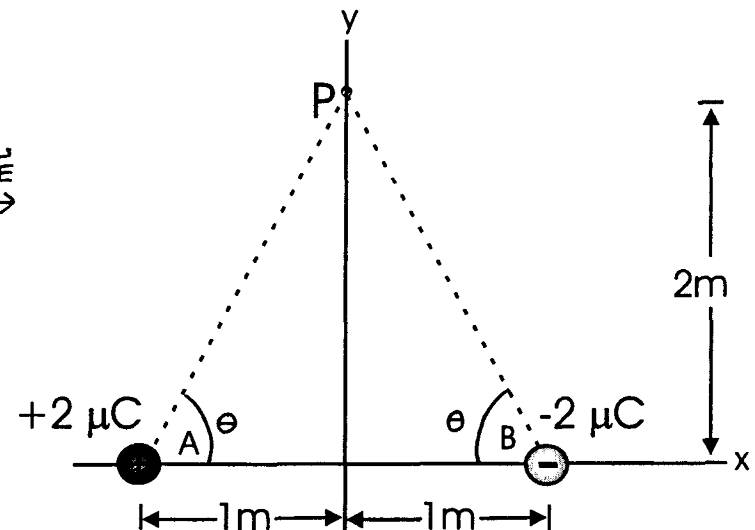
[6] (c) Find the x-component and y-components of the total electric field $(\vec{E})$ at point P.

(a)



(b)





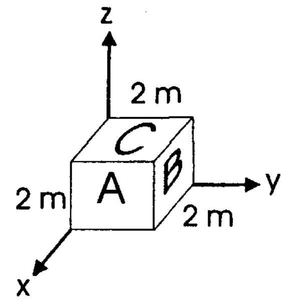
(c) $E_x = E_{Ax} + E_{Bx} = 2E_{Ax}$

$$E_x = 2 \cdot \frac{kq_A}{r^2}\cos\theta = \frac{2\left(8.99\times10^9\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)\left(+2\times10^{-6}\,\text{C}\right)}{\left(\sqrt{(1\text{m})^2+(2\text{m})^2}\right)^2}(\cos 63.435^\circ)$$

$E_x = 3220\ \text{N/C}$

$E_y = E_{Ay} + E_{By} = 0\ \text{N/C}$

[10] 7. A region of space is filled with a uniform electric field $\vec{E} = 1.0\ \text{N/C}\ \hat{\jmath} + 3.0\ \text{N/C}\ \hat{k}$.
Consider a cube with edges of 2.0 m aligned with the x, y, and z axes as shown:



[2] (a) What is the electric flux through the face, **A**, which is perpendicular to the x-axis?

[2] (b) What is the electric flux through the face, **B**, which is perpendicular to the y-axis?

[2] (c) What is the electric flux through the face, **C**, which is perpendicular to the z-axis?

[2] (d) What is the total electric flux through the surface of the cube?

[2] (e) What is the total charge enclosed by the cube surface?

(a) $\Phi_A = \int \vec{E}\cdot d\vec{A} = \int (1.0\ \text{N/C}\ \hat{\jmath} + 3.0\ \text{N/C}\ \hat{k})\cdot(dA\ \hat{\imath}) = 0\ \frac{\text{N}\cdot\text{m}^2}{\text{C}}$

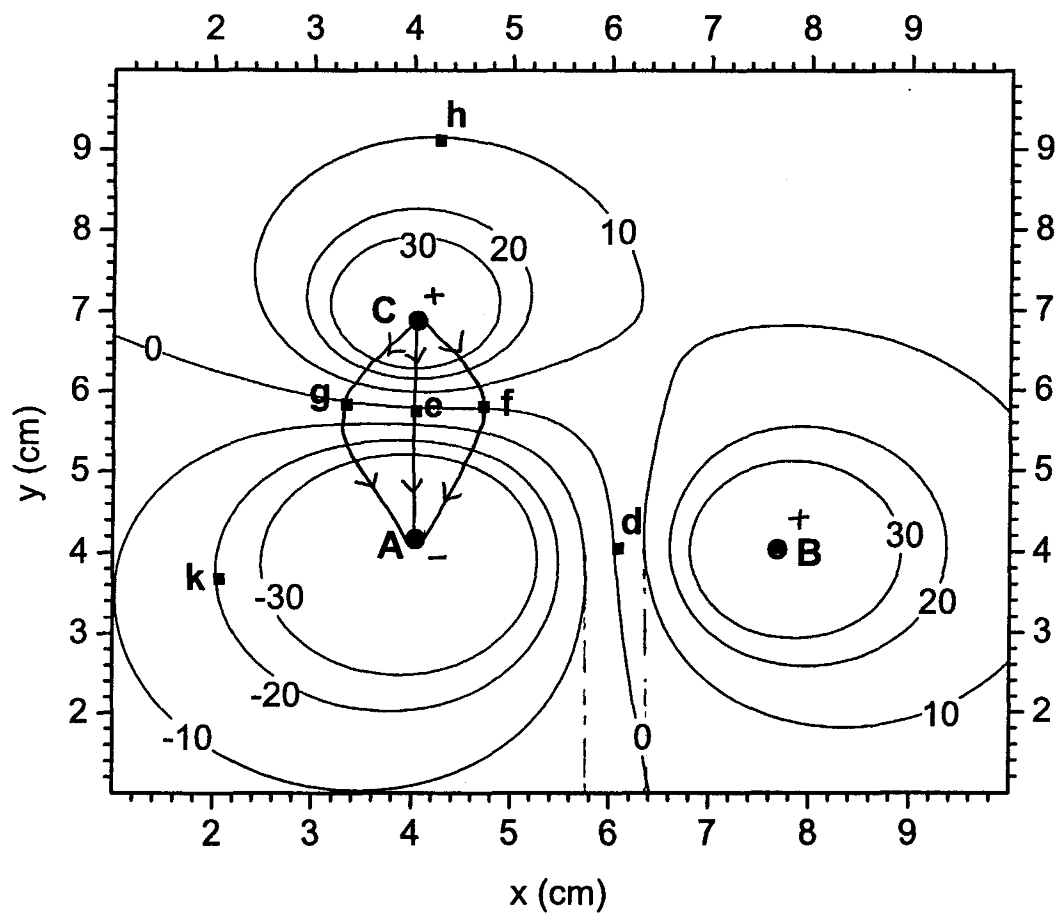
(b) $\Phi_B = \int \vec{E}\cdot d\vec{A} = \int (1.0\ \text{N/C}\ \hat{\jmath} + 3.0\ \text{N/C}\ \hat{k})\cdot(dA\ \hat{\jmath}) = \int (1.0\ \text{N/C})(dA) = (1.0\ \text{N/C})(2\text{m})^2 = 4.00\ \frac{\text{N}\cdot\text{m}^2}{\text{C}}$

(c) $\Phi_C = \int \vec{E}\cdot d\vec{A} = \int (1.0\ \frac{\text{N}}{\text{C}}\hat{\jmath} + 3.0\ \frac{\text{N}}{\text{C}}\hat{k})\cdot(dA\ \hat{k}) = \int (3.0\frac{\text{N}}{\text{C}})dA = (3.0\frac{\text{N}}{\text{C}})(2\text{m})^2 = 12.0\ \frac{\text{N}\cdot\text{m}^2}{\text{C}}$

(d) $\Phi = \frac{q_{\text{inside}}}{\varepsilon_0} = \frac{0\ \text{C}}{\varepsilon_0} = 0\ \frac{\text{N}\cdot\text{m}^2}{\text{C}}$ OR $\Phi_{\text{TOTAL}} = \Phi_{+A} + \Phi_{-A} + \Phi_{+B} + \Phi_{-B} + \Phi_{+C} + \Phi_{-C}$
$= (0 + 0 + 4 - 4 + 12 - 12)\frac{\text{N}\cdot\text{m}^2}{\text{C}}$
$= 0\ \frac{\text{N}\cdot\text{m}^2}{\text{C}}$

(e) THE CUBE ENCLOSES NO CHARGED OBJECTS; TOTAL CHARGE ENCLOSED = 0.

[10] 8. The graph below shows equipotential lines around three point charges; **A**, **B**, and **C**. The lines are drawn in steps of 10 V for all voltages between -30 V and +30 V. The potential is taken to be 0 at infinity.



[2] (a) What are the signs of charge **A** and charge **B**? A IS NEGATIVE, B IS POSITIVE

[2] (b) Is the magnitude of the electric field larger at point **d** or at point **e**? Briefly explain your choice.

[2] (c) Using the scale on the *x*-axis and the equipotentials, estimate the magnitude of the electric field at point **d**.

[2] (d) Carefully draw the electric field lines that pass through points **e**, **f**, and **g**. Be sure to indicate direction and the charges on which the field lines start and end.

[2] (e) How much work must an external agent do in order to move an electron from point **h** to point **k**?

(b) $|\vec{E}| = \frac{\partial V}{\partial r}$. AT POINT e, THE LINES OF CONSTANT POTENTIAL ARE MORE CLOSELY SPACED THAN THEY ARE AT POINT d. THUS, AT POINT e THE CHANGE IN POTENTIAL WITH RESPECT TO DISTANCE IS LARGER, AND SO IS THE MAGNITUDE OF THE ELECTRIC FIELD.

(c) $|\vec{E}_d| = \frac{\Delta V}{\Delta x} = \frac{20\,V}{0.6\,cm} = 33.3\ V/cm = 3330\ V/m$

(e) $W = -\Delta U = -q\,\Delta V = (-1.6\times10^{-19}\,C)(-20\,V - (+10\,V))$

$W = -(1.6\times10^{-19}\,C)(30\,V) = -4.80\times10^{-18}\,J$ ⟸ THIS IS WORK BY ELEC FIELD

W by ext. agent $= +4.80\times10^{-18}\,J$ (must push electron to move from h→k)

[10] 9. A positive charge ***Q*** is uniformly distributed over a rod of length ***L*** situated along the x-axis. Point **P** is located a distance ***a*** from the left end of the rod along the x-axis as shown.

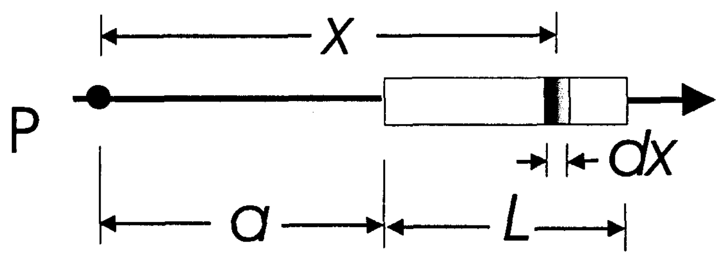
[6] (a) What is the contribution, ***dV***, to the electric **potential** at **P** from an element of the rod of length ***dx*** located a distance ***x*** from point **P** as shown?

(b) Show that the electric **potential** at **P** due to the entire rod is given by

$$V = k_e \lambda \ln\left(1 + \frac{L}{a}\right)$$

where $\lambda = \frac{Q}{L}$. (Hint: some integrals are provided on the cover page.)

[4] (c) Calculate the electric potential 35 cm along the x-direction from one end of the rod if the length of the rod is 57 cm and the total charge on the rod is 5.5 μC.



ⓐ $dV = k\frac{dq}{x} = k\frac{\frac{Q}{L}dx}{x} = k\lambda\frac{dx}{x}$, WHERE $\lambda = \frac{Q}{L}$

ⓑ $V = \lim_{N\to\infty}\sum_{i=1}^{N} dV = \int dV = \int_a^{a+L} k\lambda\frac{dx}{x} = k\lambda\int_a^{a+L}\frac{dx}{x}$

$V = k\lambda\left[\ln x\right]_{x=a}^{x=a+L} = k\lambda\left[\ln(a+L) - \ln a\right] = k\lambda\ln\left(\frac{a+L}{a}\right) = k\lambda\ln\left(1+\frac{L}{a}\right)$

ⓒ $V = k\lambda\ln\left(1+\frac{L}{a}\right) = \left(8.99\times10^9\ \frac{N\cdot m^2}{C^2}\right)\left(\frac{5.5\times10^{-6}C}{0.57\,m}\right)\ln\left(1+\frac{0.57\,m}{0.35\,m}\right)$

$V = 83{,}800\ V$

Some Potentially Useful Formulae and Constants:

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

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

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

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

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

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

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

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

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

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

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

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

$$\Delta U = q \Delta V$$

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

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

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

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

Physical constants:

$$k_e = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$$

$$\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 / \text{N} \cdot \text{m}^2$$

$$e = 1.602 \times 10^{-19} \text{ C}$$

$$m_e = 9.11 \times 10^{-31} \text{ kg}$$

Mathematical formulae:

$$\int \frac{dr}{r^2} = -\frac{1}{r}$$

$$\int \frac{dx}{x} = \ln x$$

$$\int \frac{dx}{\sqrt{x^2 + y^2}} = \ln\left[x + \sqrt{x^2 + y^2}\right]$$

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

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

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

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