PART A

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

A1. At a distance r_1 from a point charge, the magnitude of the electric field created by the charge is E_1. At a distance r_2 from the charge, the field is $E_2 = E_1/9$. Which of the following expressions is correct for the relationship between r_2 and r_1?

D

$E = \frac{k|q|}{r^2}$

(A) $r_2 = 1/9\ r_1$ (B) $r_2 = 1/3\ r_1$ (C) $r_2 = \sqrt{3}\, r_1$ (D) $r_2 = 3\ r_1$ (E) $r_2 = 9\ r_1$

So $r^2 = \frac{k|q|}{E} \Rightarrow \frac{r_2}{r_1} = \sqrt{\frac{k|q|/E_2}{k|q|/E_1}}$

$\therefore \frac{r_2}{r_1} = \sqrt{\frac{E_1}{E_2}} = \sqrt{\frac{E_1}{E_1/9}} = \sqrt{9}$

$\therefore r_2 = \sqrt{9} \cdot r_1 = 3r_1$

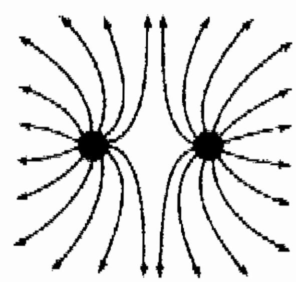
A2. Which one of the following statements is ***NOT*** correct?

D

(A) The SI unit of electric potential may be expressed as joules/coulomb.
(B) The SI unit of electric potential energy is joules.
(C) The SI unit of electric field strength is newtons/coulomb.
(D) A non-SI unit of the electric field strength is the electron volt.
(E) The SI unit of electric potential may be expressed as volts.

$eV = (1.60\times10^{-19}\,C)(J/C) = 1.60\times10^{-19}\,J$ (energy)

A3. The diagram shows the electric field lines due to two charges. Which one of the following statements is ***NOT*** correct?



E

(A) The charges are both positive.
(B) The charges have the same magnitude.
(C) There is a single point in space between the two charges where the net electric field strength is zero.
(D) The electric field strength is strongest in regions with more field lines.
(E) The charges have different signs.

electric field lines originate on +ve charges and terminate on −ve charges.

A4. What quantity is measured by a battery rating given in ampere-hours (A·h)?

D

(A) electric current (B) electric resistance (C) electric potential
(D) electric charge (E) power

$A\cdot h = \frac{C}{s} \cdot 3600\,s = 3600\,C$

A5. The resistivity of aluminum is greater than that of copper. Is it possible for a copper wire and an aluminum wire of the same length to have the same resistance?

C

(A) No, the copper wire will have a greater resistance.
(B) No, the aluminum wire will have a greater resistance.
(C) Yes, and the aluminum wire will have a larger diameter than that of the copper wire.
(D) Yes, and the copper wire will have a larger diameter than that of the aluminum wire.
(E) It is impossible to answer this question without knowing the values of the resistivities.

$R = \rho\frac{L}{A}$ $R_{Al} = R_{Cu}$ if $A_{Al} > A_{Cu}$,

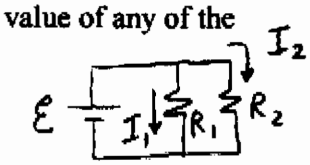
since $\rho_{Al} > \rho_{Cu}$

continued on page 3 ...

A6. Consider an ideal voltage source connected to several resistors in parallel. Which one of the following statements is ***NOT*** correct?

B

(A) The equivalent parallel resistance is less than the smallest resistance value of any of the individual resistors.
(B) The same current flows through all resistors connected in parallel.
(C) The same voltage drop occurs across all resistors in parallel.
(D) The current can diverge at junctions in the circuit.
(E) The total power delivered to the resistors in parallel is equal to the power delivered to the equivalent resistance.



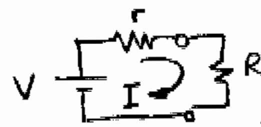
$\mathcal{E} = I_1 R_1 = I_2 R_2$ $\quad I_1 \neq I_2$ if $R_1 \neq R_2$ $\quad R_p = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$

A7. A real battery has an emf of V volts and an internal resistance of r ohms. When this battery is connected to a radio with a resistance of R ohms, an expression for the current I flowing in the circuit is

A

(A) $I = \dfrac{V}{(r+R)}$. (B) $I = \dfrac{V}{(R-r)}$. (C) $I = V(r+R)$.

(D) $I = V\left(\dfrac{r}{R+r}\right)$. (E) $I = \dfrac{(r+R)}{V}$.



$I = \frac{V}{R_s} = \frac{V}{(r+R)}$

A8. Which one of the following is ***NOT*** an electromagnetic wave?

B

(A) radio waves (B) sound waves (C) heat
(D) ultraviolet radiation (E) visible light

A9. Which one of the following statements concerning electromagnetic waves is ***NOT*** correct?

D

(A) Electromagnetic waves are transverse waves.
(B) Electromagnetic waves can travel through a vacuum.
(C) Electromagnetic waves can travel through a material substance.
(D) Electromagnetic waves are made up of electric and magnetic fields that are parallel to each other.
(E) All electromagnetic waves travel at the speed of light in a vacuum.

$\vec{E} \perp \vec{B}$

A10. White light travels through the 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.

dispersion.

continued on page 4 ...

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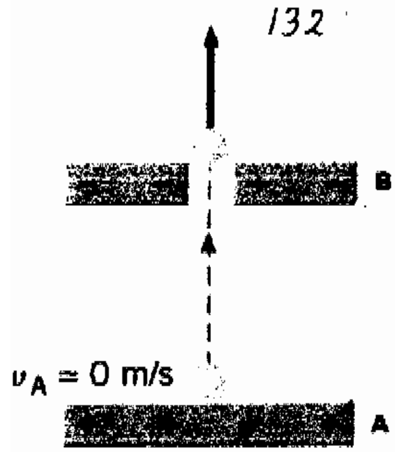
PART B

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 proton is accelerated from rest at plate A. Plate A has a potential of +45.0 V and plate B has a potential of –1~~25~~ V. Calculate the kinetic energy of the proton as it passes through plate B.



$E_A = E_B$

$\Delta E_{AB} = 0$

$\Delta KE_{AB} + \Delta EPE_{AB} = 0$

$\Delta KE_{AB} = -\Delta EPE_{AB} = -q\Delta V_{AB}$

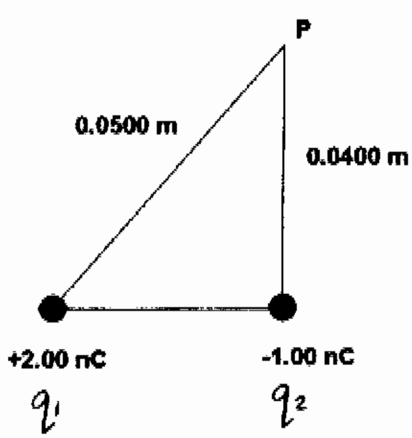
$KE_B - KE_A = -q(V_B - V_A)$

$KE_B = -e(-132\text{V} - 45.0\text{V})$

$KE_B = 177\,\text{eV}$

$KE_B = 177\,(1.60\times10^{-19}\text{C})\,\text{J/C} = 2.83\times10^{-17}\,\text{J}$

B2. Calculate the electric potential at point P, due to the two charges shown in the diagram.



$V_P = V_1 + V_2$

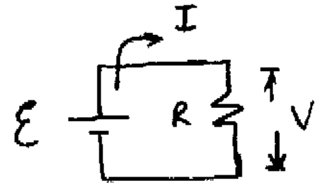
$V_P = \frac{kq_1}{r_1} + \frac{kq_2}{r_2} = k\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right)$

$V_P = 9.00\times10^{9}\,\frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\left(\frac{2.00\times10^{-9}\text{C}}{0.0500\text{m}} + \frac{(-1.00\times10^{-9}\text{C})}{0.0400\text{m}}\right)$

$V_P = 135\,\text{V}$

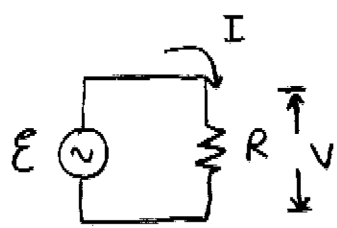
continued on page 5 ...

B3. Calculate the power consumed by a 267 Ω resistor when it is connected to a 12.0 V battery.



$$P = \frac{V^2}{R} = \frac{\mathcal{E}^2}{R} = \frac{(12.0\,\text{V})^2}{267\,\Omega} = 0.539\,\text{W}$$

B4. An ac voltage, whose peak value is 170 V, is applied across a toaster that has a resistance of 26.2 Ω. Calculate the ***rms*** current that flows through the toaster.



$$I_o = \frac{V_o}{R}$$

$$I_{rms} = \frac{I_o}{\sqrt{2}} = \frac{V_o}{\sqrt{2} \cdot R}$$

$$I_{rms} = \frac{170\,\text{V}}{\sqrt{2}(26.2\,\Omega)} = 4.59\,\text{A}$$

continued on page 6 ...

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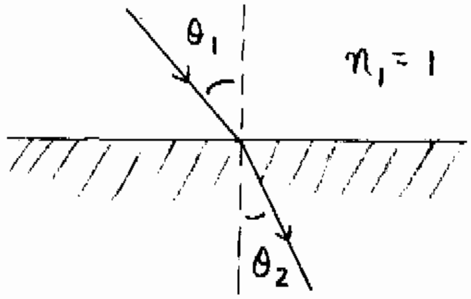
B5. Light in a vacuum is incident on the surface of a solid slab of transparent material. The angle of incidence is 32.0° and the angle of refraction is 21.0°. Calculate the index of refraction of the slab material.



$n_1 = 1$

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

$$n_2 = \frac{1 \cdot \sin(32.0°)}{\sin(21.0°)}$$

$$n_2 = 1.48$$

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	177 eV or 2.83×10^{-17} J
B2	135 V
B3	0.539 W
B4	4.59 A
B5	1.48

continued on page 7 ...

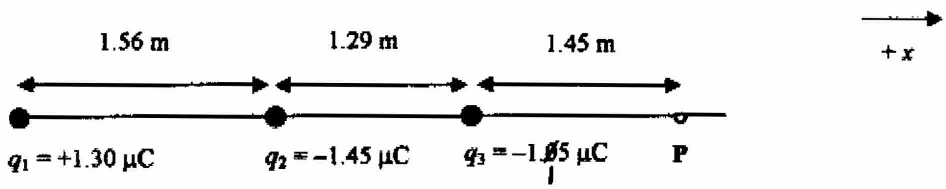
PART C

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.

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

C1. Consider the arrangement of charges shown below:



(a) Calculate the magnitude and direction of the electric field at point P due to the three collinear charges.

$$E_1 = \frac{k|q_1|}{r_1^2} = \frac{9.00\times10^9\,\text{N}\cdot\text{m}^2/\text{C}^2\,(1.30\times10^{-6}\,\text{C})}{(1.56\,\text{m} + 1.29\,\text{m} + 1.45\,\text{m})^2}$$

magnitude:	6.03×10^3 N/C
direction:	left (−ve x)

$E_1 = 633$ N/C , to right (+)

Similarly, $E_2 = 1{,}738$ N/C , to left (−)

and $E_3 = 4{,}923$ N/C, to left (−)

$$\therefore\ \vec{E}_{tot} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 = 633\,\text{N/C} - 1738\,\text{N/C} - 4{,}923\,\text{N/C}$$

$$\vec{E}_{tot} = -6.03\times10^3\,\text{N/C}$$

(b) If a test charge of −1.85 µC was placed at point P, what would be the magnitude and direction of the electric force on it?

$$\vec{F} = q\vec{E}$$

magnitude:	1.12×10^{-2} N
direction:	right (+ve x)

$$\vec{F} = (-1.85\times10^{-6}\,\text{C})(-6.03\times10^3\,\text{N/C})$$

$$F = +1.12\times10^{-2}\,\text{N}$$

continued on page 8 ...

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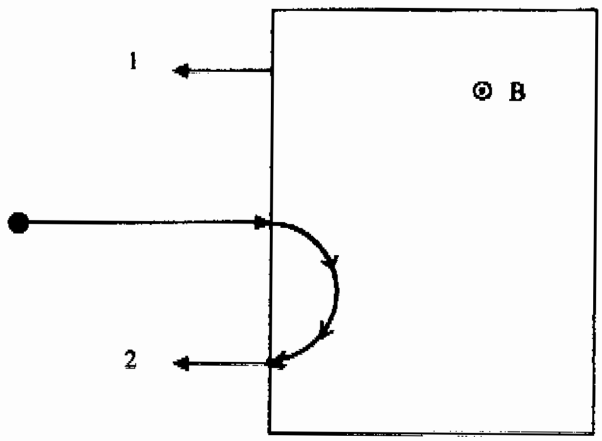
C2. An alpha particle (charge of $+2e$, mass of 6.64×10^{-27} kg) has a kinetic energy of 4.24×10^{3} eV. The alpha particle enters a region where there is a uniform magnetic field of 0.341 T that is directed perpendicularly to the alpha particle's velocity.

When the alpha particle leaves the region of magnetic field it is moving opposite to its original direction.



(a) On the diagram, draw the trajectory of the alpha particle while it is in the region of magnetic field. Which one of the exit paths, 1 or 2, correctly shows the direction of the velocity of the alpha particle when it leaves the region of magnetic field?

$\boxed{2}$

(b) Calculate the time, t, during which the alpha particle is in the region of magnetic field. You must derive any equations that are not on the formulae sheet.

$\boxed{1.91 \times 10^{-7}\,\mathrm{s}}$

Apply Newton II for uniform circular motion.

$F_{mag} = ma_c$

Note that $v = \frac{2\pi r}{T}$ and that $t = \frac{T}{2}$

$q\cancel{v}B = \frac{mv^{\cancel{2}}}{r}$

$\therefore v = \frac{\pi r}{t}$

$qB = \frac{mv}{r}$

$qB = \frac{m\left(\pi r/t\right)}{r} = \frac{\pi m}{t} \Rightarrow t = \frac{\pi m}{qB}$

$$t = \frac{\pi\left(6.64\times10^{-27}\,\mathrm{kg}\right)}{2\left(1.60\times10^{-19}\,\mathrm{C}\right)\left(0.341\,\mathrm{T}\right)} = 1.91\times10^{-7}\,\mathrm{s}$$

continued on page 9 ...

Stu. No.: ____________________

C3. An object is placed 20.0 cm to the left of a thin diverging lens whose focal points are 35.0 cm from the lens.

(a) Draw a ray diagram showing the image formed by the lens. Indicate clearly whether the final image is real or virtual, and whether the image is upright or inverted.

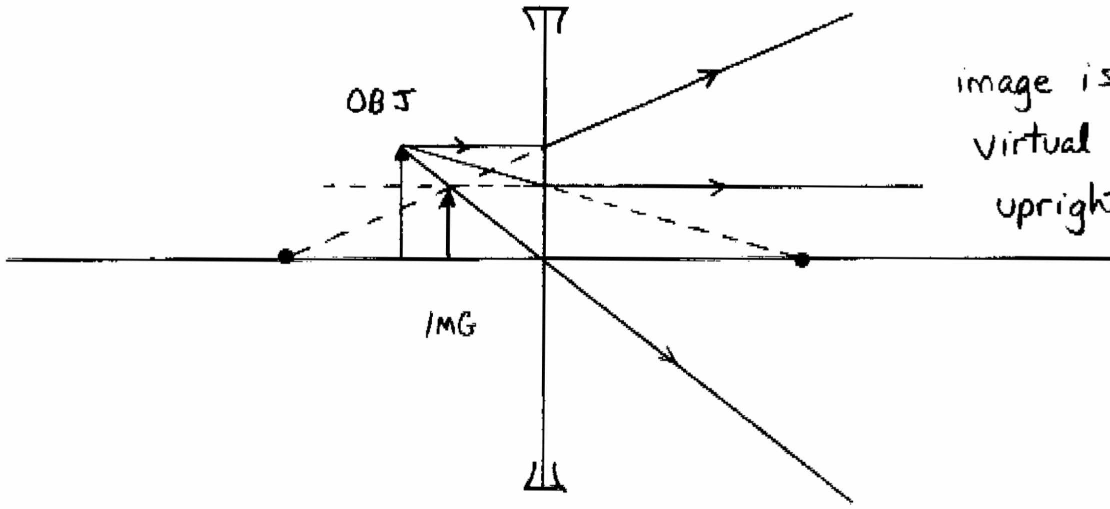


image is virtual and upright

(b) Calculate the image distance (including the sign).

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$\boxed{-12.7\text{ cm}}$

$$d_i = \left(\frac{1}{f} - \frac{1}{d_o}\right)^{-1} = \left(\frac{1}{-35.0\text{cm}} - \frac{1}{+20.0\text{cm}}\right)^{-1} = -12.7\text{ cm}$$

diverging lens

(b) Calculate the magnification (including the sign).

$$m = -\frac{d_i}{d_o} = \frac{-(-12.7\text{cm})}{+20.0\text{ cm}}$$

$\boxed{+0.635}$

END OF EXAMINATION