Uni Lee
Jan 6 2014

Grade 12 University Physics Celebration #3

Knowledge		Application		Communication	
[redacted]	out of 13	21.5	out of ~~24~~ 26	[redacted]	out of ~~6~~ 7

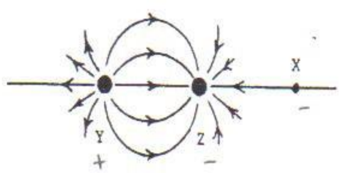
Part A: Knowledge

Answer questions for this part of the test in pen.

1. Which subatomic particles are electrically charged?
   a. protons only
   b. neutrons only
   c. protons and neutrons
   d. electrons and neutrons
   e. electrons and protons

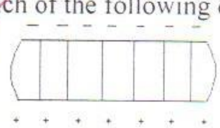
2. To charge an electroscope positively by induction you need
   a. two objects of the same charge
   b. a negatively charged rod
   c. a positively charged rod and a ground
   d. two objects with opposite charges
   e. a negatively charged rod and a ground

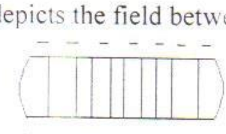
3. The diagram shows the electric field lines in a region of space containing two small charged spheres, Y and Z.

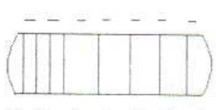


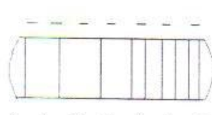
   Which of the following statements is true?
   a. The charge on Y is negative and the charge on Z is positive.
   b. The strength of the electric field is the same everywhere.
   c. The electric field is strongest midway between Y and Z.
   d. A small negatively-charged object placed at X would tend to move toward the right.
   e. Both charged spheres Y and Z carry the same type of charge.

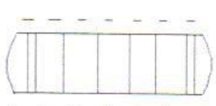
4. Which of the following diagrams most accurately depicts the field between two oppositely charged plates?

a.


d.


b.


e.


c.


5. A pith ball has an excess of 8.00×10^4 electrons. What is the charge on the pith ball?

4

a. 1.28×10^{-14} C
b. -1.28×10^{-14} C
c. 7.90×10^{13} C
d. -7.90×10^{13} C
e. -1.02×10^{23} C

6. An object with charge $+q$ experiences an electric force F_E when put in a particular location in the electric field $\mathcal{E}$. The positive charge $+q$ is removed and an object with charge $-4q$ is placed in the same location in the electric field. This charge would feel an electric force of
   a. $-4F_E$
   b. $\frac{-F_E}{4}$
   c. $\frac{-2F_E}{q}$
   d. $\frac{-F_E}{2}$
   e. $-2F_E$

$F_E = q\,\mathcal{E}$
$F_E = -4q\,\mathcal{E}$

(+q) $\quad$ O -q

7. A sphere of charge $+q$ is in a fixed position. A smaller sphere $-q$ is placed a large distance away from the larger sphere and released from rest. Which one of the following best describes the motion of the small sphere?
   a. decreasing speed and the magnitude of the acceleration is increasing
   b. decreasing speed and the magnitude of the acceleration is decreasing
   c. increasing speed and the magnitude of the acceleration is decreasing
   d. increasing speed and the magnitude of the acceleration is increasing
   e. decreasing speed and constant acceleration

0.05m $\quad$ O 2.5×10^{-4} $\quad$ O 3.2×10^{-5} $\quad$ $k = 9\times10^{9}$

8. Two charged spheres are 0.0500 m apart. One sphere has a charge of 2.50×10^{-4} C and the other sphere has a charge of 3.20×10^{-5} C. Assuming $k = 9.00 \times 10^{9}\ N \cdot m^2/C^2$, the electric force between the two spheres is
   a. 4.44×10^{-20} N
   b. 1.44×10^{1} N
   c. 2.25×10^{19} N
   d. $2.88 \times 10^{+4}$ N
   e. 4.44×10^{-18} N

9. The magnitude of the electrical field in between two parallel plates is 250 N/C. What would be the magnitude of the electrical field in between the plates, if the distance in between the plates halved and the potential difference applied to the plates tripled? $\mathcal{E} = 250$ $\quad$ $\mathcal{E} = \frac{\Delta V}{d}$ $\quad$ $d = 1$ $\quad$ $\Delta V = 1$ $\quad$ $= \frac{0.5}{3}$ $\quad$ $1.5\times10^{3}\ \frac{N}{C}$

10. The electrical potential energy stored in a system of two like point charges is 48 J. What would be the electrical potential energy stored in the system, if the sign of one of the charges changes, the other charge doubles, and the distance separating them triples? $\quad$ -32 J

$E_E = \frac{kq_1q_2}{R} = 48$

11. A charged particle is moving through a magnetic field. The magnitude of the magnetic force acting on the charged particle is 2.4×10^{-4} N. What would be the magnitude of the magnetic force acting on the charged particle if its charge was tripled, its speed was halved and the strength of the magnetic field it is in was quadrupled? $\quad$ 8.0×10^{0} J

12. A 3.64 m straight conductor is in a uniform magnetic field of 0.45 T [E]. The electrons in the conductor are flowing [S25°W]. The magnitude of the magnetic force on the conductor is 4.6 N.
   a) What is the direction of the magnetic force on the conductor? $\quad$ into the paper $\quad$ $\frac{1}{2}$

4.5

b) What is the current flowing through the conductor? ~~2.8×10^0~~ A

Part B: Application

Provide complete solutions for questions on this part of the test.

1. In a mass spectrometer, the potential difference applied to the accelerator plates is 475 V. A Fluorine ion ($^{19}_{9}F^{1-}$) is injected at the negative terminal of the particle accelerator. Once in the magnetic field, the diameter of the ion's circular path is 3.24 cm. What is the strength of the magnetic field?

[8]

Given:

$\Delta V = 475\ V$

$d = 3.24\ cm$

$r = 1.62\ cm$

$= 0.0162 m$

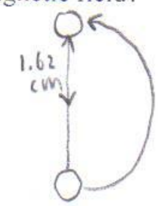
charge?

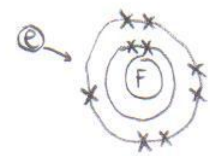
$^{19}_{9}F^{1-}$ one extra e^-

$q = ne$

$= (+1)(-1.602\times10^{-19} C)$

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





Fluorine $^{19}_{9}F^{1-}$

	9 proton	$9\times1.67\times10^{-27}$ kg
	10 neutron	$10\times1.67\times10^{-27}$ kg
+	10 electron	$10\times9.11\times10^{-31}$ kg
This F^{1-}		$3.173911\ldots\times10^{-26}$ kg

$$m = \frac{|q|B^2R^2}{2|\Delta V|}$$

$$3.173911\ldots\times10^{-26}\,kg = \frac{(1.602\times10^{-19}C)(B)^2(0.0162m)^2}{2\,(475\,V)}$$

rearrangement

$-\frac{1}{2}$

$$\sqrt{B^2} = \sqrt{0.717176101\ldots\ T^2}$$

$$B = 0.846862504\ldots T$$

$$\doteq 8.47\times10^{-1}\ T$$

Therefore, the strength of the magnetic field is 8.47×10^{-1} T

7.5

2. A proton is initially at rest, at the positive plate of a simple particle accelerator. The potential difference applied to the accelerator is 125 V. The proton leaves the particle accelerator travelling horizontally. Once leaving the accelerator, the proton enters in between a set of horizontal, deflector plates, that have a length of 12.0 cm, and a separated by 10.0 cm. These plates have a potential difference of 245 V applied to them (the bottom plate is positive).

[8]

a) With what speed does the proton leave the particle accelerator?

Final answer only: 1.55×10^5 m/s

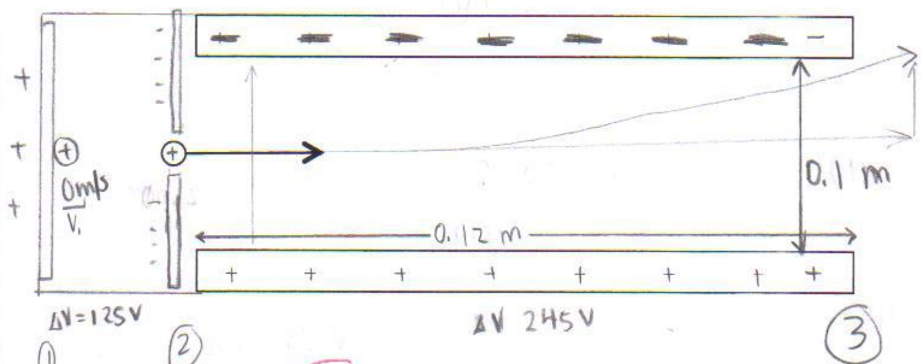
b) What is the electrical field in between the deflector plates (include its direction)?

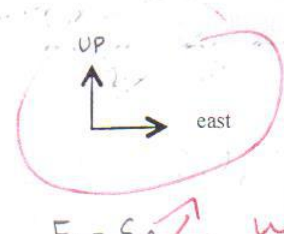
Final answer only: 245×10^3 J/C [up]

c) What is the electrical force acting on the proton while it is in between the deflector plates?

Final answer only: 3.92×10^{-16} N

d) With what velocity does the proton leave the electrical plates?





where are x and y

−1

9

proton

$m = 1.67 \times 10^{-27}$ kg

$q = +1.602 \times 10^{-19}$ C

v:=4

$E_{M1} = E_{M2}$

$\cancel{E_{K1}} + E_{E1} = E_{K2} + E_{E2}$

$\Delta E_E = -E_{K2}$

$q\Delta V = -\frac{1}{2}mv_2^2$

$(1.602 \times 10^{-19}\,C)(125\,V) = -\frac{1}{2}(1.67 \times 10^{-27}\,kg)(v^2)$

$\sqrt{v_2^2} = \sqrt{2.398203593\ldots \times 10^{10}\,m^2/s^2}$

$V_2 = 154861.3442\ldots \times 10^5$ m/s

$\doteq 1.55 \times 10^5$ m/s

$V_2 = V_{3x}$

$V_{3x} \doteq 1.55 \times 10^5$ m/s

$\Delta E_E = q\Delta V$

$= (1.602 \times 10^{-19}\,C)(245\,V)$

$= 3.9249 \times 10^{-17}$ J

$\varepsilon = \frac{\Delta V}{d}$

$= \frac{245\,V}{0.1\,m}$

$= 2450$ N/C

$F_E = \varepsilon q$

$= 2450(1.602 \times 10^{-19}\,C)$

$= 3.9249 \times 10^{-16}$ N

$\Delta d = v_2(\Delta t)$

$0.12\,m = (1.54861.34.. \times 10^5\,m/s)(\Delta t)$

$\Delta t = 7.7488844\ldots \times 10^{-7}$ s

FBD

$\overrightarrow{\Sigma F_y} = m\vec{a}_y$

$F_E = 1.67 \times 10^{-27}\,kg\,(\vec{a}_y)$

$\varepsilon q = 1.67 \times 10^{-27}\,kg\,(\vec{a}_y)$

$\vec{a}_y = 2.350239521 \times 10^{11}\,m/s^2$

$\vec{V}_{3y} = \cancel{\vec{V}_{2y}} + \vec{a}_y(\Delta t)$ ($\vec{V}_{2y} = 0$)

$= +2.35023921 \times 10^{11}\,m/s^2\,(7.7488844 \times 10^{-7}\,s)$

$= +182117.3195$ m/s

subst? −1

$\tan\theta = \frac{V_{3y}}{V_{3x}}$

$\theta = \tan^{-1}\left(\frac{V_{3y}}{V_{3x}}\right)$

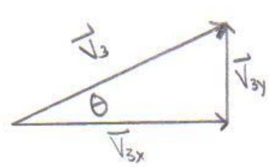
$= 49.624\ldots°$

$\doteq 49.6°$

$V_3 = \sqrt{V_{3y}^2 + V_{3x}^2}$

$= 239057.8327$ m/s

$\doteq 2.39 \times 10^5$ m/s

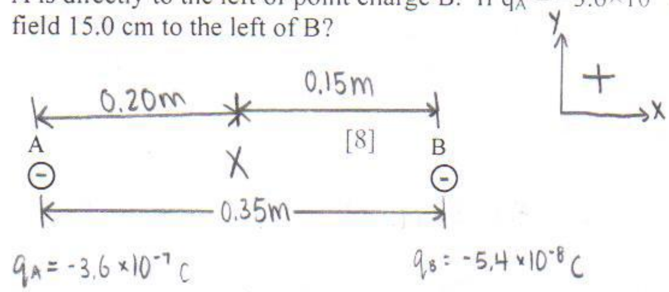


∴ p^+ leaves elect plates with 2.39×10^5 m/s [E 49.6° Up]

3. Two point charges (A and B) are separated by a distance of 35.0 cm (as shown in the diagram). Point charge A is directly to the left of point charge B. If $q_A = -3.6\times10^{-7}$ C and $q_B = -5.4\times10^{-8}$ C, what is the electrical field 15.0 cm to the left of B?

[8]

a)



$\vec{\varepsilon} = \vec{\varepsilon}_A + \vec{\varepsilon}_B$

$$\varepsilon_A = \frac{k|q|}{R^2} = \frac{8.99\times10^9 \frac{Nm^2}{C^2}(3.6\times10^{-7}\,C)}{(0.20m)^2} = 80910\ \tfrac{N}{C}$$

$$\varepsilon_B = \frac{k|q|}{R^2} = \frac{8.99\times10^9 \frac{Nm^2}{C^2}(5.4\times10^{-8}\,C)}{(0.15m)^2} = 21576\ \tfrac{N}{C}$$

$\vec{\varepsilon}_A = -80910\ \frac{N}{C}$

$\vec{\varepsilon}_B = -21576\ \frac{N}{C}$ + ✗

$$\vec{\varepsilon}_{at\,x} = \vec{\varepsilon}_A + \vec{\varepsilon}_B$$
$$= -80910\ \tfrac{N}{C} + (-21576\ \tfrac{N}{C})$$
$$= -102486\ N/C$$
$$\doteq -1.02\times10^5\ \tfrac{N}{C}$$

5

s.d. $-\frac{1}{2}$

Therefore, the electrical field 15cm left of B is $-1.02\times10^5\ \frac{N}{C}$

dir? $-\frac{1}{2}$

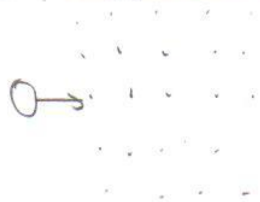
b) What is the electrical potential at the point you found in a?

5.72×10^{-15} J

$E_E = qV$

Part C: Communication (6 marks)

1. A charged particle is moving through a magnetic field. What angle between the particle's velocity and the magnetic field it is moving through will cause the magnetic force acting on the particle to be at a maximum? Justify your answer mathematically.



$F_M = |q| v B \sin\theta$

to make sure the largest nomber for F_M, $\sin\theta$ has to be 1. $\sin\theta$ is 1 when

2

o.k. $\theta = 90°$ $\boxed{\vec{v} \text{ has to be } \perp \text{ to } B}$

other values for θ between $0° \rightarrow 180°$ will be < 1 so F_M will be lower

other than 90°?

eg.

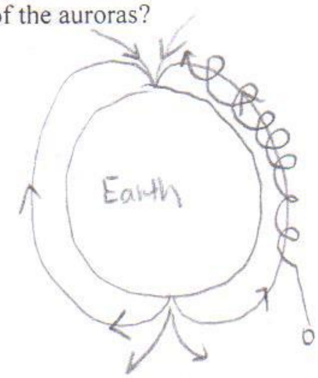
$\theta = 90$, $q = 2\ C$, $v = 2\ v$, $B = 2\ T$

$F_M = 2 \cdot 2 \cdot 2 \cdot \sin 90 = 2 \cdot 2 \cdot 2 \cdot 1 = 8\ N$

but $\theta = 45$, $q = 2C$, $v = 2v$, $B = 2T$

$F_M = 2 \cdot 2 \cdot 2 \cdot \sin 45 = 2 \cdot 2 \cdot 2 \cdot 0.707 = 5.65\ldots N$

2. The aurora borealis (or Northern Lights) is caused by collisions between charged particles from the Sun and particles in the Earth's atmosphere. How does the Earth's magnetic field play a role in the creation of the auroras?



sun's ions coil around Earth's mag field lines and collide into dense air. H_2 and O_2

Earth has north and south poler

It reaches from pole to pole.

The mag field moves ions

1

give more info.

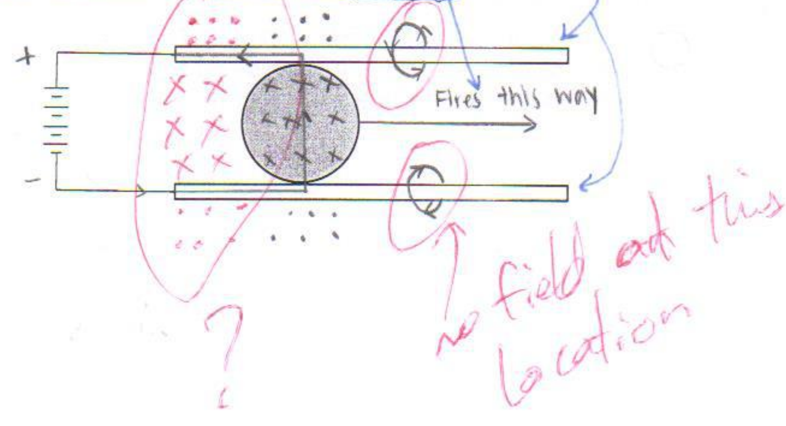
3

3. A basic railgun looks like:

On the following diagram:

Indicate the direction of the magnetic field around the rails

Indicate the direction of force on the projectile

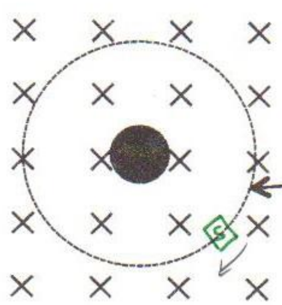


Name: Uni Lee

Unit 3 TIPS

A satellite with a mass of 1550 kg is in a circular orbit around a very small and very dense planet. The planet has a charge of -6000 C (3 s.d.), while the satellite has a charge of -2.50 C. The mass of the planet is 4.81×10^{21} kg, while its radius is 735 km. The orbital speed of the satellite is 0.430 km/s. Somehow, there is a large, uniform magnetic field around the planet, which has a strength of 0.0490 T. The satellite is moving through this magnetic field (see the accompanying diagram). What is the orbital period of the satellite?

[10]



satellite orbit
(orbiting clockwise)

$\boxed{S}$ 1550 kg -2.50 C 430 m/s

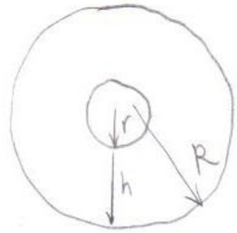
planet -6000 C 4.81×10^{21} kg

mag field 0.0490 T

T = ?

P $r = 735000$ m

9/14



$$F_g = \frac{G m_s m_p}{R^2}$$

$$F_E = \frac{k|q_s||q_p|}{R^2}$$

$$= \frac{8.99\times10^{9}\ \frac{Nm^2}{C^2}|2.5C||6000C|}{(r+h)^2}$$

$$= \frac{1.3485\times10^{14}\ Nm^2}{(735000m+h)^2}$$

$$= \frac{6.67\times10^{-11}\ \frac{Nm^2}{kg^2}(1550\ kg)(4.81\times10^{21}\ kg)}{(r+h)^2}$$

$$= \frac{4.9728185...\times10^{14}\ Nm^2}{(735000m+h)^2}$$

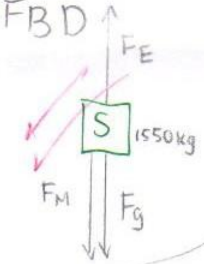
Continued on next page

$F_M = |q| v B$

$= |2.50c| (430 m/s)(0.0490 T)$

$= 52.675$ N

FBD



$\Sigma \vec{F}_y = \cancel{m\vec{a}_y} \rightarrow 0$ not accelerating up/down

$F_E + -F_g + -F_M = 0$

$F_E = F_g + F_M$

actually it is. ✗ + significantly

sub R into (735000m+h)

changes level of difficulty ✗✗

$$F_E = F_g + F_M$$

$$\frac{1.3485\times10^{14}\ Nm^2}{R^2} = \frac{4.9728185\ldots\times10^{14}\ Nm^2}{R^2} + \frac{52.675N}{1}$$

$$\frac{1.3485\times10^{14}\ Nm^2}{R^2} = \frac{4.9728185\ldots\times10^{14}\ Nm^2}{R^2} + \frac{R^2\ (57.675N)}{R^2}$$

$$\frac{1.3485\times10^{14}\ Nm^2}{R^2} = \frac{(4.9728185\ldots\times10^{14}\ Nm^2)+(57.675N)(R^2)}{R^2}$$

for satellite $\vec{F}_g$ only F acting on it. ✗

$$(4.9728185\ldots\times10^{14}\ Nm^2)\cancel{(R^2)} + (57.675N)(R^2)\cancel{(R^2)} = (1.3485\times10^{14}\ Nm^2)\cancel{(R^2)}$$

$$4.9728185\times10^{14}\ Nm^2 + 57.675N\ (R^2) = 1.3485\times10^{14}\ Nm^2$$

$$57.675N(R^2) = -3.6215\ldots\times10^{14}\ Nm^2$$

$$R^2 = 6.279150412\times10^{12}$$

$$R = 2505823.3\ldots m$$

this is an issue ✗

$$T = \sqrt{\frac{4\pi^2 R^3}{GM}}$$

$$= \sqrt{\frac{4(3.14\ldots)^2(2505823.3\ldots m)^3}{(6.67\times10^{-11}\ \frac{Nm^2}{kg^2})(4.81\times10^{21} kg)}}$$

$$= 44001.76304\ldots s$$

$$\doteq 4.40\times10^4 s$$

Therefore, orbital period is 4.40×10^4 s