SPH 4U Name: ANSWER #WINTER 2019

RE

UNIT # 3 TEST – GRAVITATIONAL, ELECTRIC AND MAGNETIC FIELDS

Knowledge & Understanding / 11 Application / 30 Thinking & Inquiry / 12

Multiple Choice (1 mark each, total 7 Knowledge & Understanding Marks)

1. 1. The gravitational force between two spherical masses is F_g. Which of the following would increase the gravitational force between the objects to $16F_g$?

   a. Increasing the distance by a factor of 4
   b. Increasing the distance by a factor of 16
   c. Increasing the mass of one object by a factor of 4
   (d) Increasing the mass of both objects by a factor of 4
   e. None of the above

2. The period of a satellite is independent of:

   (a.) its own mass
   b. the mass of the planet it orbits
   c. the value of the gravitational constant
   d. the orbital radius
   e. none of the above

3. A sulfide ion has one more electron than it has protons. Determine the charge on this sulfide ion.

   a. 1.0 C
   b. -1.0 C
   c. 1.6×10^{-19} C
   (d.) -1.6×10^{-19} C
   e. None of the above

4. Two plastic spheres are placed on a number line. Both spheres have a negative charge of equal magnitude. The region where the net electric field is zero will be located:

   a. To the right of the rightmost sphere
   b. To the left of the leftmost sphere
   (c.) between the spheres on the number line
   d. below the spheres
   e. nowhere

5. Which of the following statements for a coil is NOT true?

   a. To determine the magnetic field you grasp the coil in your right hand
   b. A coil consists of a coiled conductor
   c. Your right-hand thumb points in the direction of the north pole
   d. The fingers of your right hand are curled in the direction of the electric current
   (e.) None of the above

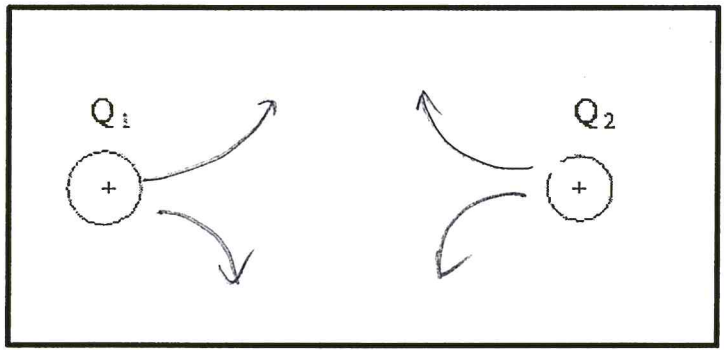
6. The direction of a magnetic field $\vec{B}$ is from left to right as shown below. A proton travels into and perpendicular to the plane of the page. The direction of the magnetic force acting on the proton is:

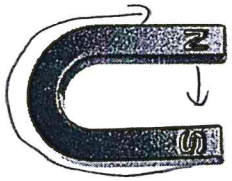
(a) down
b. up
c. right
d. left
e. out of the page

7. The magnetic field lines outside of a magnet are conventionally drawn:

(a) north to south
b. south to north
c. either north to south or south to north
d. east to west
e. west to east

Diagrams (2 marks each, 4 Knowledge & Understanding Marks)
Draw the electric or magnetic field in each situation.





SPH 4U

Name: _____

Problems (30 Application Marks)
Answer in the space provided.

1. A satellite of mass 1.1 x 10^3 kg is 3.00 x 10^2 km above the surface of a planet with a radius equal to that of Earth, but with a mass five times that of Earth. Find the force of gravity acting on the satellite. (~~5~~ 6 marks)

$m = 1.1 \times 10^3$ kg

$r_h = 3.00 \times 10^2$ km

$= 3.00 \times 10^5$ m ①

$M = 5 M_E$ ①

$= 5(5.98 \times 10^{24}$ kg)

① $F_g = \frac{G m M}{r^2}$ ①

$F_g = \frac{G m M}{(r_E + r_h)^2}$ ①

$F_g = ?$

$r_E = 6.38 \times 10^6$ m

$F_g = \frac{(6.67 \times 10^{-11} N m^2/kg^2)(1.1 \times 10^3 kg)(5)(5.98 \times 10^{24} kg)}{(3.00 \times 10^5 m + 6.38 \times 10^6 m)^2}$

$F_g = 49162.81957 N$

$F_g = 4.9 \times 10^4 N$ ①

SPH 4U Name: _____

2. A small sphere, carrying a charge of -8.0×10^{-6} C, exerts a repulsive force of 0.50 N on another sphere carrying a charge of magnitude 5.0×10^{-6} C.

   a. What is the sign on the second charge? Explain your choice. (2 marks)

   b. What is the distance of separation of the centres of the two spheres? (3 marks)

a) Negative (1) b/c repulsive (1)

b) $q_1 = -8.0 \times 10^{-6}$ C
$F_e = 0.50$ N
$q_2 = -5.0 \times 10^{-6}$ C (1)
$r = ?$

$$F_e = \frac{k q_1 q_2}{r^2} \quad (1)$$

$$r = \sqrt{\frac{k q_1 q_2}{F_e}}$$

$$r = \sqrt{\frac{(9.0 \times 10^9 \text{ N m}^2/\text{C}^2)(8.0 \times 10^{-6} \text{C})(5.0 \times 10^{-6} \text{C})}{0.50 \text{N}}}$$

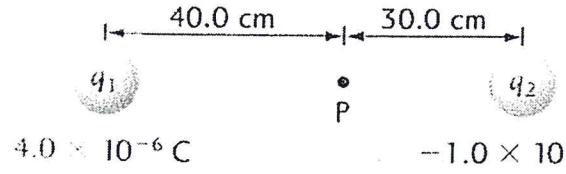
$r = 0.8485281374$ m

$r = 0.85$ m (1)

SPH 4U

Name: _____

3. Determine the magnitude and direction of the electric field strength at point P between the two charges in the figure below. (6 marks)



$\mathcal{E} = ?$

$r_1 = 0.400\ m$

$r_2 = 0.300\ m$ } (1) } (1)

Electric Fields (1)

$\vec{\mathcal{E}} = \vec{\mathcal{E}}_1 + \vec{\mathcal{E}}_2$ (1)

$\mathcal{E} = \frac{kq_1}{r_1^2} + \frac{kq_2}{r_2^2}$ (1)

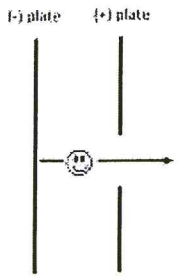
$\mathcal{E} = \frac{(9.0\times10^9\ N m^2/C^2)(4.0\times10^{-6}\ C)}{(0.400\ m)^2} + \frac{(9.0\times10^9\ N m^2/C^2)(1.0\times10^{-6}\ C)}{(0.300\ m)^2}$

$\mathcal{E} = 325000\ N/C$

$\mathcal{E} = 3.2\times10^5\ N/C.$

SPH 4U Name: _____

4. An electron accelerates from rest through a parallel plate apparatus, as shown below. The plates have a potential difference of 500.0 V.



Calculate the speed of the electron when it has exited the electric plates.
Recall $m_e = 9.11 \times 10^{-31}$ kg and $q_e = 1.602 \times 10^{-19}$ C) (3 marks)

$\Delta V = 500.0V$
$m_e = 9.11 \times 10^{-31} kg$
$q_e = 1.602 \times 10^{-19} C$
$v_1 = 0 m/s$
$v_2 = ?$

$qV = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$ ①

$v_2 = \sqrt{\frac{2}{m}\left(qV + \frac{1}{2}mv_1^2\right)}$

$v_2 = \sqrt{\frac{2}{(9.11\times10^{-31}kg)}\left((1.602\times10^{-19}C)(500.0V) + \frac{1}{2}(9.11\times10^{-31}kg)(0m/s)^2\right)}$

$v_2 = 13260871.52 m/s$

$v_2 = 1.33 \times 10^7 m/s$ ①

5. A circular coil with 12 turns and a radius of 2.5 cm carries a current of 0.52 A. What is the magnetic field strength at the centre of this coil? (4 marks)

$N = 12$
$r = 2.5cm$
$= 2.5 \times 10^{-2} m$ ①
$I = 0.52A$
$B = ?$

① $B = \frac{\mu_0 N I}{2r}$ ①

$B = \frac{(4\pi\times10^{-7} Tm/A)(12)(0.52A)}{2(2.5\times10^{-2}m)}$

$B = 1.568283053 \times 10^{-4} T$

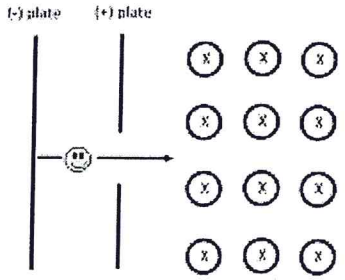
$B = 1.6 \times 10^{-4} T$ ①

7

SPH 4U

Name: _____

6. A proton enters a magnetic field as shown in the diagram below. The proton has a velocity of 3.7×10^6 m/s and the magnetic field has a magnitude of 1.2500 T.



a. Calculate the magnetic force acting on the proton once it enters the field. (3 marks)

b. State the direction of the force acting on the proton. (1 mark)

c. Calculate the radius of the proton's circular path. (3 marks)

a) $F_m = ?$

$v = 3.7 \times 10^6 \text{ m/s}$
$B = 1.2500 \text{ T}$
$q = 1.602 \times 10^{-19} \text{ C}$
$\theta = 90.0^\circ$ } ①

$F_m = qvB\sin\theta$ ①

$F_m = (1.602 \times 10^{-19} \text{ C})(3.7 \times 10^6 \text{ m/s})(1.2500 \text{ T})\sin 90$

$F_m = 7.40925 \times 10^{-13} \text{ N}$

$F_m = 7.4 \times 10^{-13} \text{ N}$ ①

b) Counter clockwise ①

c) $F_c = F_m$ ①

① $\frac{mv^2}{r} = qvB\sin\theta$ ①

$r = \frac{mv^2}{qvB\sin\theta}$

$r = \frac{(1.67 \times 10^{-27} \text{ kg})(3.7 \times 10^6 \text{ m/s})}{(1.602 \times 10^{-19} \text{ C})(1.2500 \text{ T})\sin 90.0^\circ} = 0.030856 \text{ m}$

$= 0.031 \text{ m}$ ①

SPH 4U Name: _____

Making Connections (12 Thinking & Inquiry Marks)
Answer on the paper provided.

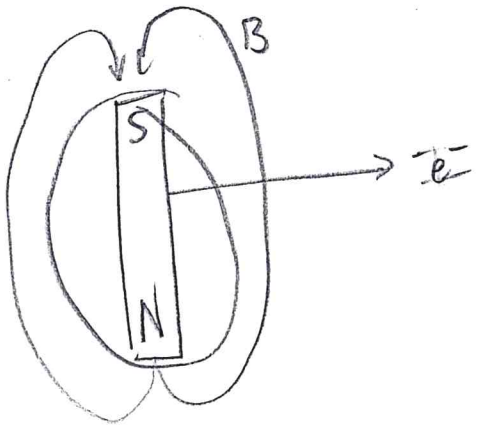
1. In 1970, Apollo 13 experienced an explosion which crippled the spacecraft. Engineers and scientists evaluated whether they should turn the spacecraft around immediately and use rockets to get home or use the Moon's gravitational field to get back. They chose to use the Moon's gravitational field. Explain why this was the better option. (4 marks)

Name: _____

2. A proton and an electron are released from rest a distance apart and allowed to accelerate toward each other. Just before the collision, which particle is travelling faster? Use equations and / or concepts from this unit to explain your answer. (4 marks)

SPH 4U Name: _____

3. A beam of electrons travels vertically upward from the ground. Prove that this beam be deflected eastward by Earth's magnetic field. (HINT: Start by drawing a diagram of Earth's magnetic field.) (4 marks)



RHR #3 ⊙

But e^-, ∴ ⊗ which is East