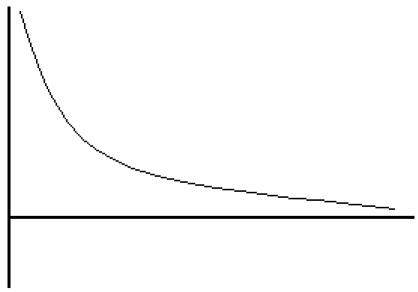
SPH4U Sample Test - Electric & Magnetic Fields

Modified True/False

Indicate whether the sentence or statement is true or false. If false, change the identified word or phrase to make the sentence or statement true.

____ 1. By convention, in electrostatic representations, electric fields start on *negative charges and end on positive charges*. ____

____ 2. The diagram below represents the electric potential near a *negative charge*. The electric potential is large near the charge and decreases, approaching zero, as *r* increases. _________________________



____ 3. If a charge moves one-quarter of the distance between two parallel plates, the charge will experience a *potential difference of* $4\Delta V$. _________________________

____ 4. The relative strength of the magnetic field is indicated by the spacing of adjacent field lines. *The farther apart the lines*, the stronger the magnetic field. ______________________________

____ 5. Some ferromagnetic materials are *aluminum, nickel, calcium, and gadolinium*. ______________________________

____ 6. When the magnetic force is *at an angle other than 90°* to the velocity of a charged particle, the force acts as a deflecting one. It changes the direction of the velocity, not its magnitude. _________________________

____ 7. The value of μ_0 *is* $4\pi \times 10^{-3}\ T \cdot m / A$. _________________________

____ 8. When a conductor is placed in a magnetic field, the force on the conductor is *inversely proportional* to the current in the conductor. _________________________

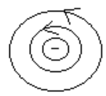
Multiple Choice

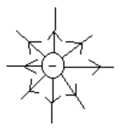
Identify the letter of the choice that best completes the statement or answers the question.

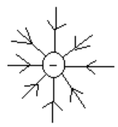
____ 9. Two charged spheres are 5.00 cm apart. One sphere has a charge of 2.50×10^{-4} C and the other sphere has a charge of 3.20×10^{-5} C . Assuming $k = 9.00 \times 10^{9}\ N \cdot m^2/C^2$, the electric force between the two spheres is

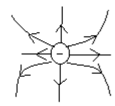
a. 1.44×10^{1} N
b. 4.44×10^{-20} N
c. 2.25×10^{19} N
d. 2.88×10^{-4} N
e. 4.44×10^{-18} N

____ 10. Which of the following diagrams represents the field of force around a negative point charge?

a. 

b. 

c. 

d. 

e. 

____ 11. 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. $-2F_E$
b. $\frac{-F_E}{2}$
c. $\frac{-2F_E}{q}$
d. $-4F_E$
e. $\frac{-F_E}{4}$

____ 12. Magnetic field strength is measured in

a. N
b. N·C
c. kg/C·s
d. $kg{\cdot}m/s^2$
e. $kg{\cdot}m^2/s^2$

____ 13. A proton of charge 1.6×10^{-19} C is moving east with a speed of 8.2×10^7 m/s, as it enters a magnetic field of 2.5 T directed downward. The magnitude and direction of the magnetic force acting on the proton is

a. 3.3×10^{-11} N [N]
b. 1.9×10^{11} N [S]
c. 5.3×10^{-12} N [S]
d. 3.3×10^{-11} N [S]
e. 1.9×10^{11} N [N]

____ 14. Magnetic force is equal to

a. $\frac{BlI}{\sin\theta}$
b. $\frac{Bl}{I\sin\theta}$
c. $\frac{B}{lI\sin\theta}$
d. $BlI\sin\theta$
e. $\frac{\sin\theta}{BlI}$

____ 15. The law of electric charges states that opposite charges

a. attract each other, similar charges attract neutral objects, and charged objects repel one another
b. repel each other, similar charges attract neutral objects, and charged objects attract one another
c. attract neutral objects, similar charges repel each other, and charged objects attract one another
d. attract each other, similar charges repel one another, and charged objects attract some neutral objects
e. attract neutral objects, similar charges attract each other, and charged objects repel one another

____ 16. Solids in which electrons are able to move easily from one atom to another are

a. conductors
b. electrically charged
c. insulators
d. neutral
e. capacitors

Short Answer

17. A negative charge of 2.4×10^{-6} C experiences an electric force of magnitude 3.2 N, acting to the left. What is the magnitude and direction of the electric field at that point?

18. Determine the magnitude and direction of the magnetic force on a proton moving horizontally to the north at 8.6×10^{4} m/s, as it enters a magnetic field of 1.2 T, pointing vertically upward.

19. Calculate the radius of the path taken by an alpha particle (He^{++} ion, of charge 3.2×10^{-19} C and mass 6.7×10^{-27} kg) injected at a speed of 1.5×10^{7} m/s into a uniform magnetic field of 2.4 T, at right angles to the field.

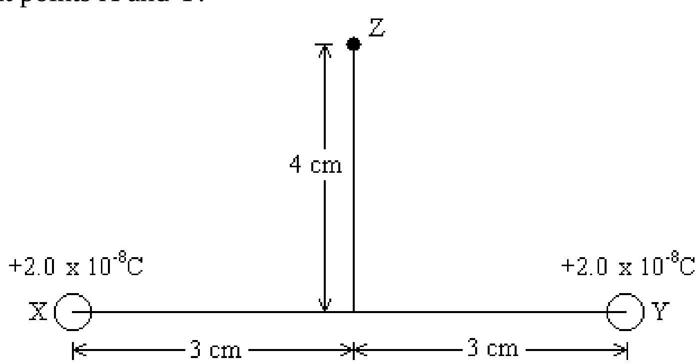
Problem

20. Two charges, one of charge $+2.5 \times 10^{-5}$ C and the other of charge -3.7×10^{-7} C, are 25.0 cm apart. The positive charge is to the left of the negative charge.
(a) Draw a diagram showing the point charges and label a point Y that is 10.0 cm away from the negative charge, on the line connecting the charges. (Field lines do not need to be drawn.)
(b) Calculate the electric field at point Y.

21. An electron starts from rest and travels from a negatively charged plate to a positively charged plate. The electric potential of the plates is 4.1×10^{5} V. Determine the kinetic energy of the electron halfway to the positively charged plate. (Remember: $e = 1.60 \times 10^{-19}$ C.)

22. Two small spheres, with charges 1.6×10^{-5} C and 6.4×10^{-5} C, are situated 2.0 m apart. They have the same sign. Where, relative to these two objects, should a third object be situated, of the opposite sign and whose charge is 3.0×10^{-6} C, so that it experiences no net electrical force? Do we really need to know the charge or sign of the third object?

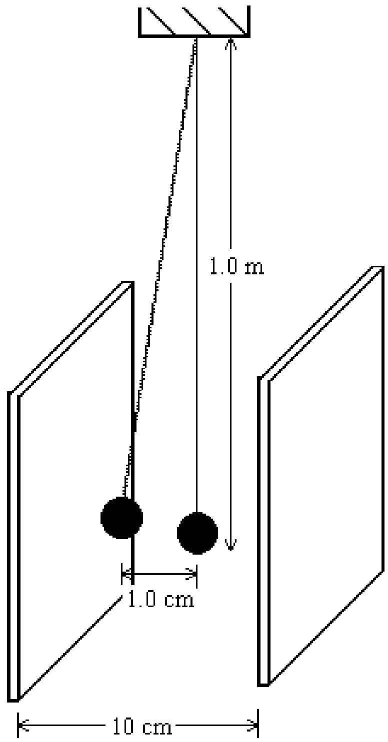
23. Determine the magnitude and direction of the electric field at point Z in the diagram below, due to the charges at points X and Y.



24. One model of the structure of the hydrogen atom consists of a stationary proton with an electron moving in a circular path around it, of radius 5.3×10^{-11} m. The masses of a proton and an electron are 1.67×10^{-27} kg and 9.1×10^{-31} kg, respectively.

(a) What is the electrostatic force between the electron and the proton?
(b) What is the gravitational force between them?
(c) Which force is mainly responsible for the electron's centripetal motion?
(d) Calculate the velocity and period of the electron's orbit around the proton.

25. A ping-pong ball of mass 3.0×10^{-4} kg is hanging from a light thread 1.0 m long, between two vertical parallel plates 10 cm apart, as shown. When the potential difference across the plates is 420 V, the ball comes to equilibrium 1.0 cm to one side of its original position.
(a) What is the electric field intensity between the plates?
(b) What is the tension in the thread?
(c) What is the magnitude of the electric force deflecting the ball?
(d) What is the charge on the ball?



SPH4U Sample Test - Electric & Magnetic Fields
Answer Section

MODIFIED TRUE/FALSE

1. ANS: F, positive charges and end on negative charges

   REF: K/U OBJ: 7.3 LOC: EG1.04
2. ANS: F, positive charge REF: K/U OBJ: 7.4
   LOC: EG1.05
3. ANS: F, potential difference of $\frac{\Delta V}{4}$ REF: C OBJ: 7.4
   LOC: EG1.05
4. ANS: F, the closer together the lines REF: K/U OBJ: 8.1
   LOC: EG1.01
5. ANS: F, iron nickel cobalt and gadolinium

   REF: K/U OBJ: 8.1 LOC: EG1.01
6. ANS: F, perpendicular REF: K/U OBJ: 8.2
   LOC: EG1.08
7. ANS: F, μ_0 is $4\pi \times 10^{-7}$ T·m/A REF: C OBJ: 8.4
   LOC: EG1.01
8. ANS: F, directly proportional REF: K/U OBJ: 8.3
   LOC: EG1.08

MULTIPLE CHOICE

9.	ANS: D	REF: C	OBJ: 7.2	LOC: EG1.03
10.	ANS: C	REF: K/U	OBJ: 7.3	LOC: EG1.04
11.	ANS: D	REF: C	OBJ: 7.3	LOC: EG1.06
12.	ANS: C	REF: K/U	OBJ: 8.2	LOC: EG1.01
13.	ANS: A	REF: C	OBJ: 8.2	LOC: EG1.08
14.	ANS: D	REF: C	OBJ: 8.3	LOC: EG1.01
15.	ANS: D	REF: K/U	OBJ: 7.1	LOC: EG1.01
16.	ANS: A	REF: K/U	OBJ: 7.1	LOC: EG1.01

SHORT ANSWER

17. ANS:

$$\vec{\varepsilon} = \frac{\vec{F}_e}{q}$$

$$= \frac{3.2 \text{ N [left]}}{-2.4 \times 10^{-6} \text{ C}}$$

$$= -1.3 \times 10^{6} \text{ N/C [left], or } 1.3 \times 10^{6} \text{ N/C [right]}$$

REF: K/U OBJ: 7.3 LOC: EG1.01 KEY: FOP 15.4, p.591
MSC: P

18. ANS:

$$F = qvB\sin\theta$$

$$= \left(1.6 \times 10^{-19} \text{ C}\right)\left(8.6 \times 10^{4} \text{ m/s}\right)(1.2 \text{ T})(\sin 90°)$$

$$= 1.7 \times 10^{-14} \text{ N [E]}$$

The direction is given by the right-hand rule.

REF: K/U OBJ: 8.2 LOC: EG1.08 KEY: FOP 16.3, p.632
MSC: P

19. ANS:

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

$$= \frac{\left(6.7 \times 10^{-27} \text{ kg}\right)\left(1.5 \times 10^{7} \text{ m/s}\right)}{(2.4 \text{ T})\left(3.2 \times 10^{-19} \text{ C}\right)}$$

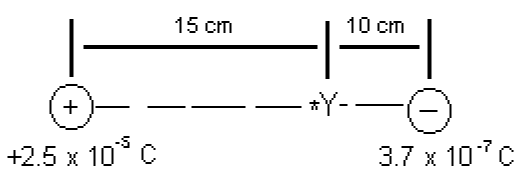
$$= 0.13 \text{ m}$$

REF: K/U OBJ: 8.2 LOC: EG1.08 KEY: FOP 16.3, p.633
MSC: P

PROBLEM

20. ANS:

(a)



(b)
$q_1 = 2.5 \times 10^{-5}$ C
$q_2 = -3.7 \times 10^{-7}$ C
$r_1 = 25.0$ cm
$r_2 = 10.0$ cm
$\varepsilon = ?$

$r_1 = 25.0 \text{ cm} - 10.0 \text{ cm} = 15.0 \text{ cm} = 0.15 \text{ m}$

$$\varepsilon_1 = \frac{kq_1}{r_1^2}$$

$$= \frac{\left(9.0 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2\right)\left(2.5 \times 10^{-5} \text{C}\right)}{(0.15 \text{ m})^2}$$

$$\varepsilon_1 = 1.00 \times 10^7 \text{ N/C}$$

$$\vec{\varepsilon}_1 = 1.00 \times 10^7 \text{ N/C [right]}$$

$$\varepsilon_2 = \frac{kq_2}{r_2^2}$$

$$= \frac{\left(9.0 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2\right)\left(3.7 \times 10^{-7} \text{C}\right)}{(0.10 \text{ m})^2}$$

$$\varepsilon_2 = 3.33 \times 10^5 \text{ N/C}$$

$$\vec{\varepsilon}_2 = 3.33 \times 10^5 \text{ N/C [right]}$$

$$\Sigma\vec{\varepsilon} = \vec{\varepsilon}_1 + \vec{\varepsilon}_2 = 1.0 \times 10^7 \text{ N/C [right]}$$

The net electric field is 1.0×10^7 N/C [right].

REF: C OBJ: 7.3 LOC: EG1.06

21. ANS:
$V = 4.1 \times 10^5$ V
$e = 1.60 \times 10^{-19}$ C
E_K (halfway) = ?

$$\Delta E_E = qV$$

$$= (-1.6 \times 10^{-19}\ \text{C})(4.1 \times 10^{5}\ \text{V})$$

$$\Delta E_E = -6.56 \times 10^{-14}\ \text{J}$$

Since we only need to know the E_E halfway between the plates:

$$\Delta E_E\ (\text{halfway}) = \frac{1}{2}(-6.56 \times 10^{-14}\ \text{J})$$

$$\Delta E_E\ (\text{halfway}) = -3.28 \times 10^{-14}\ \text{J}$$

$$\Delta E_K = -\Delta E_E$$

$$E_{K_k} = E_{K_1} + \Delta E_K$$

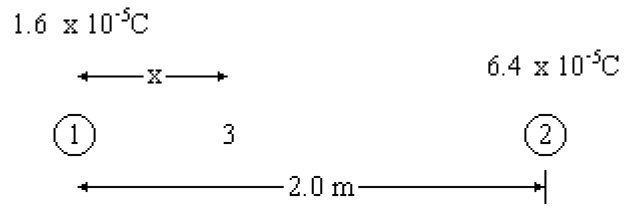
$$= 0 + (-\Delta E_E)$$

$$E_{K_k} = +3.3 \times 10^{-14}\ \text{J}$$

The kinetic energy of the electron is $+3.3 \times 10^{-14}$ J.

REF: C OBJ: 7.6 LOC: EG1.06

22. ANS:



The third charge must be situated on a line joining q_1 and q_2, a distance x from q_1, as shown.

For there to be no net force on q_3:

$$F_{13} = F_{23}$$

$$\frac{kQ_1Q_3}{(d_{13})^2} = \frac{kQ_2Q_3}{(d_{23})^2}$$

$$\frac{k\left(1.6 \times 10^{-5}\ \text{C}\right)(Q_3)}{x^2} = \frac{k\left(6.4 \times 10^{-5}\ \text{C}\right)(Q_3)}{(2.0\ \text{m} - x)^2}$$

Omitting units for simplicity and multiplying both sides by 10^5 ,

$$(1.6)(2 - x)^2 = 6.4x^2 \qquad \text{(divide by 1.6)}$$

$$4 - 4x + x^2 = 4x^2$$

$$3x^2 + 4x - 4 = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-4 \pm \sqrt{16 - 4(3)(-4)}}{6}$$

$$= \frac{-4 \pm 8}{6}$$

$$x = \frac{-12}{6} \text{ or } x = \frac{4}{6}$$

$$x = -2.0 \text{ or } x = 0.67$$

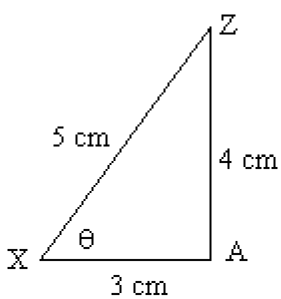
Since $x = -2.0$ is an inadmissible solution, the third charge is located 0.67 m from the 1.6×10^{-5} C charge.

Note: Q_3 divides out of the original equation—we really do not need to know its value or even its sign.

REF: K/U, C OBJ: 7.2 LOC: EG1.06 KEY: FOP 15.3, p.586
MSC: P

23. ANS:

$$d_{xz} = \sqrt{(3.0\text{ cm})^2 + (4.0\text{ cm})^2} = 5.0\text{ cm} = d_{yz}$$



$$\theta = \tan^{-1}\frac{4\text{ cm}}{3\text{ cm}}$$

$$= \tan^{-1} 1.33$$

$$= 53°$$

At Z:

$$\varepsilon_{gx} = \frac{kQ_x}{d_{gx}{}^2}$$

$$= \frac{\left(9.0 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2\right)\left(2.0 \times 10^{-8} \text{ C}\right)}{\left(5.0 \times 10^{-2} \text{ m}\right)^2}$$

$$= 0.72 \times 10^5 \text{ N/C}$$

$$\vec{\varepsilon}_{gx} = 7.2 \times 10^4 \text{ N/C [R53°U]}$$

$$\vec{\varepsilon}_{gy} = 7.2 \times 10^4 \text{ N/C [L53°U]}$$

Taking components:

$$\left(\varepsilon_{gx}\right)_x = \left(7.2 \times 10^4 \text{ N/C}\right)(\cos 53°)$$

$$= 4.3 \times 10^4 \text{ N/C}$$

$$\left(\varepsilon_{gx}\right)_y = \left(7.2 \times 10^4 \text{ N/C}\right)(\sin 53°)$$

$$= 5.75 \times 10^4 \text{ N/C}$$

$$\left(\varepsilon_{gy}\right)_x = -\left(7.2 \times 10^4 \text{ N/C}\right)(\cos 53°)$$

$$= -4.3 \times 10^4 \text{ N/C}$$

$$\left(\varepsilon_{gy}\right)_y = \left(7.2 \times 10^4 \text{ N/C}\right)(\sin 53°)$$

$$= 5.75 \times 10^4 \text{ N/C}$$

$$\therefore \left(\varepsilon_{gnet}\right)_x = 0$$

$$\left(\varepsilon_{gnet}\right)_y = 11.5 \times 10^4 \text{ N/C}$$

$$\vec{\varepsilon}_{gnet} = 1.2 \times 10^5 \text{ N/C [U]}$$

REF: K/U OBJ: 7.3 LOC: EG1.06 KEY: FOP 15.4, p.592
MSC: P

24. ANS:

$$F = \frac{kQ_1Q_2}{d^2}$$

(a)

$$= \frac{\left(9.0 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2\right)\left(1.6 \times 10^{-19} \text{ C}^2\right)}{\left(5.3 \times 10^{-11} \text{ m}\right)^2}$$

$$= 8.2 \times 10^{-8} \text{ N}$$

$$F = \frac{Gm_1m_2}{d^2}$$

(b)

$$= \frac{\left(6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2\right)\left(1.67 \times 10^{-27} \text{ kg}\right)\left(9.1 \times 10^{-31} \text{ kg}\right)}{\left(5.3 \times 10^{-11} \text{ m}\right)^2}$$

$$= 3.6 \times 10^{-47} \text{ N}$$

(c) The electrostatic force is responsible for the electron's centripetal motion around the proton.

$$F = \frac{mv^2}{r}$$

$$v = \sqrt{\frac{Fr}{m}}$$

(d)

$$= \sqrt{\frac{\left(8.2 \times 10^{-8} \text{ N}\right)\left(5.3 \times 10^{-11} \text{ m}\right)}{9.1 \times 10^{-31} \text{ kg}}}$$

$$= \sqrt{4.78 \times 10^{12} \text{ (m/s)}^2}$$

$$= 2.2 \times 10^6 \text{ m/s}$$

$$T = \frac{2\pi r}{v}$$

$$= \frac{2\pi\left(5.3 \times 10^{-11}\ \text{m}\right)}{2.2 \times 10^{6}\ \text{m/s}}$$

$$= 1.5 \times 10^{-16}\ \text{s}$$

REF: K/U, C OBJ: 7.2 LOC: EG1.03 KEY: FOP 15.9, p.612
MSC: P

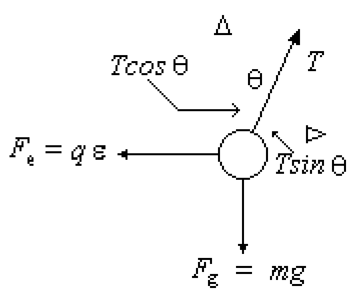
25. ANS:

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

(a) $$= \frac{420\ \text{V}}{(0.10\ \text{m})}$$

$$= 4.2 \times 10^{3}\ \text{N/C}$$

(b) Drawing a free body diagram of the ball:

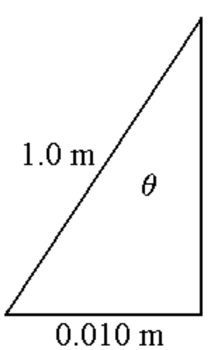


Resolving *T* into horizontal and vertical components:

$T\cos\theta = mg$

$T\sin\theta = q\varepsilon$

For θ:



$$\theta = \sin^{-1} \frac{0.010 \text{ m}}{1.0 \text{ m}}$$

$$= \sin^{-1} 0.010$$

$$= 0.57^\circ$$

$$\therefore \cos\theta = 0.9999$$

Then,

$$T(0.9999) = \left(3.0 \times 10^{-4} \text{ kg}\right)\left(9.8 \text{ N/kg}\right)$$

$$T = 2.94 \times 10^{-3} \text{ N, or } 2.9 \times 10^{-3} \text{ N}$$

(c)

$$F_e = T \sin\theta$$

$$= \left(2.94 \times 10^{-3} \text{ N}\right)(0.01)$$

$$= 2.94 \times 10^{-5} \text{ N, or } 2.9 \times 10^{-5} \text{ N}$$

(d)

$$q = \frac{F_e}{\varepsilon}$$

$$= \frac{2.94 \times 10^{-5} \text{ N}}{4.2 \times 10^{3} \text{ N/C}}$$

$$= 7.0 \times 10^{-9} \text{ C}$$

REF: K/U OBJ: 7.3 LOC: EG1.06 KEY: FOP 15.9, p.614
MSC: P