BRAC UNIVERSITY
Principles of Physics-II (PHY-112)
Department of Mathematics and Natural Sciences
Quiz: 01, **Section**: 30
Date: June 27, 2024

Duration: 30 Minutes | **Summer 2024 (10F-31C)** | Marks: 15

Name: Student ID:

Use SI Units only. Partial Marks will be given for partially correct answers ONLY.

1. A singular point charge produces an electric field — **(1)**
◯ independent of observers ◯ different for different charges ◯ only when an observer comes in ◯ Need more information

2. What condition must be followed to get an $\vec{E}$-field equilibrium in between two point (both positive) charges placed in the horizontal axis? Equilibrium means the net force on a test charge is zero. **(1)**
◯ $\vec{E}_+ + \vec{E}_- = 0$ ◯ $-E_+ = E_-$ ◯ No equilibrium can be found in the given interval ◯ $E_+ = -E_-$

3. "Microscopic charges can never come in fractions." This statement implies which of the following fundamental properties of electric charge? **(1)**
◯ conservation of electric charges ◯ additivity of electric charges ◯ quantization of electric charges ◯ electric charges are scalars, and thus always an integer

4. Two point charges placed r distance apart feels a mutual electrostatic force F_E. If both charges and the distance between them is tripled, the new force is— **(1)**
◯ tripled ◯ doubled ◯ the same ◯ one-third of the prior

5. A negative electric charge causes a radially inward electric field around it. Placing a negative charge 1 cm away from the source will measure — **(1)**
◯ a radially outward field ◯ a radially inward field ◯ no field ◯ a radially inward acceleration

6. What is the total mass of a lump of protons measuring 1.5 C? **(2)**

total number of protons, $n = \dfrac{+1.5C}{+1.602\times10^{-19}C} = 9.3633\times10^{18}$

total mass of proton, $M = nm_p = 9.3633\times10^{18}\times 1.67\times10^{-27}\,kg$
$= 1.564\times10^{-8}\,kg.$

7. Two **equally charged** metal spheres are 3 cm apart in air and attract each other with a force of 4×10^{-5} N. Compute the charges on the spheres. Are the charges positive or negative? Assume the spheres to be pointlike. **(2)**

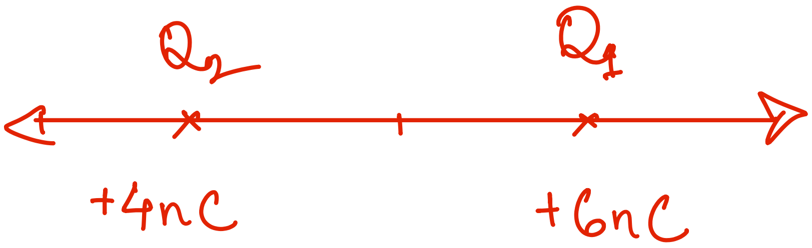
$\to$ Opposite charges

$F_E = \dfrac{Cq_1q_2}{r^2}$; $q_1 = q_2 = q$.

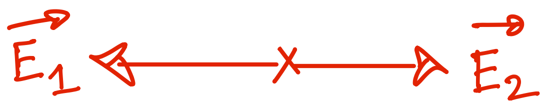
$= \dfrac{Cq^2}{r^2}$

$\Rightarrow q = \pm\sqrt{\dfrac{F_E r^2}{C}} = \sqrt{\dfrac{5\times10^{-5}N\times(3\times10^{-2}m)^2}{8.986\times10^{9}NC^{-2}m^2}} = \pm 2.24nC.$

8. A test charge is placed exactly halfway between charges $Q_1 = +4\text{nC}$ and $Q_2 = +6\text{nC}$, which are 10 cm apart. Find the electric field on the test charge in vector notation. Use the Cartesian convention. **Note**: All three charges are placed in a horizontal line. **(4)**



$$\vec{E}_{net} = \vec{E}_1 + \vec{E}_2$$



$$= -\frac{CQ_1}{(5\times10^{-2}\,m)^2}\hat{i} + \frac{CQ_2}{(5\times10^{-2}\,m)^2}\hat{i}$$

$$= \left(-21581.523\,\hat{i} + 14387.682\,\hat{i}\right) N.$$

$$= \left(-7193.841\,\hat{i}\right) N$$

9. A positron and an electron are released from rest in the center of a capacitor. (a) Is the force ratio $F_p : F_e$ greater than 1, less than 1, or equal to 1? Explain. (b) Is the acceleration ratio $a_p : a_e$ greater than 1, less than 1, or equal to 1? Explain. **Hint**: A capacitor contains a uniform electric field between the plates. Positron is the anti-particle of electron with equal but opposite charge and the same mass. **(2)**

Capacitors hold a uniform $\vec{E}$ between the two plates. Placing a proton and an electron in this field from rest will accelerate them.

Force ratio, $F_p : F_e = |q_{positron} E| : |q_{electron} E|$.

$= 1$; Since $|q_{positron}| = |q_{electron}|$

Acceleration ratio, $a_p : a_e = \frac{F_p}{m_p} : \frac{F_e}{m_e} = \frac{m_e}{m_p}$

$= 1$; Since $m_{positron} = m_{electron}$

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Inspiring Excellence

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2. What condition must be followed to get an $\vec{E}$-field equilibrium in between two point (one positive, one negative) charges placed in the horizontal axis? Equilibrium means the net force on a test charge is zero. **(1)**

   ○ $\vec{E}_+ + \vec{E}_- = 0$ ○ $-E_+ = E_-$ ✓ No equilibrium can be found in the given interval ○ $E_+ = -E_-$

3. "Microscopic charges come in fractions." This statement violates which of the following fundamental properties of electric charge? **(1)**

   ○ conservation of electric charges ○ additivity of electric charges ✓ quantization of electric charges ○ electric charges are scalars, and thus always an integer

4. Two point charges placed r distance apart feels a mutual electrostatic force F_E. If both charges and the distance between them is tripled, the new force is— **(1)**

   ○ tripled ○ one-ninth of the prior ✓ the same ○ one-third of the prior

5. A positive electric charge produces a radially outward electric field around it. Placing a negative charge 1 cm away from the source will measure — **(1)**

   ✓ a radially outward field ○ a radially inward field ○ no field ○ a radially outward acceleration

6. What is the total mass of a lump of electrons measuring 1.5 C? **(2)**

total numbers of electrons, $n = \frac{-1.5C}{-1.602\times10^{-19}C} = 9.3633\times10^{18}$

total mass of electron, $M = nm_e = 9.3633\times10^{18}\times 9.1\times10^{-31}\,\text{kg}$

$= 8.521\times10^{-12}\,\text{kg}.$

7. Two **equally charged** metal spheres are 3 cm apart in air and repel each other with a force of 4×10^{-5} N. Compute the charges on the spheres. Are the charges positive or negative? Assume the spheres to be pointlike. **(2)**

Like charges.

$F_E = \frac{Cq_1q_2}{r^2}$; $q_1 = q_2 = q$.

$= \frac{Cq^2}{r^2}$

$\Rightarrow q = \pm\sqrt{\frac{F_E r^2}{C}} = \sqrt{\frac{4\times10^{-5}N\times(3\times10^{-2}m)^2}{8.986\times10^{9}NC^{-2}m^2}} = \pm 2.00\,nC.$

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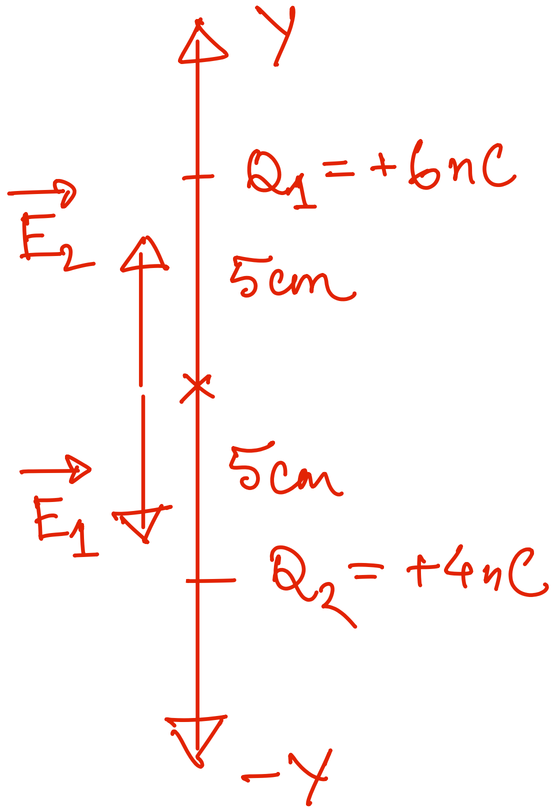

$$\vec{E}_{net} = \vec{E_1} + \vec{E_2}$$

$$= -\frac{CQ_1}{(5\times10^{-2}\,m)^2}\hat{j} + \frac{CQ_2}{(5\times10^{-2}\,m)^2}\hat{j}$$

$$= (-21581.523\,\hat{j} + 14387.682\,\hat{j})\,N.$$

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Force ratio, $F_p : F_e = |q_{proton} E| : |q_{electron} E|$.

$= 1$; Since $|q_{proton}| = |q_{electron}|$

Acceleration ratio, $a_p : a_e = \frac{F_p}{m_p} : \frac{F_e}{m_e} = \frac{m_e}{m_p}$

< 1; Since $m_{proton} > m_{electron}$