United International University

School of Science and Engineering

Final Examination; Year 2023; Trimester: Spring

Course: PHY 2105; Title: Physics; Sec: A-I

Full Marks: 40, Time: 2 Hours

Any examinee found adopting unfair means will be expelled from the trimester/program as per UIU disciplinary rules.

Questions no 1, 2, 3,4 are mandatory to answer. Answer any one from question no 5 and 6.

1. (a) What is equipotential surface? 2 CO1

   (b) Identify if the work done is positive or negative when the +q charge moves from point A to point B (figure 01)? Dose the potential energy increase or decrease in figure 01? 2 CO1

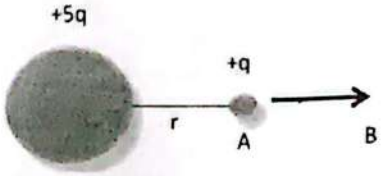


Figure 01

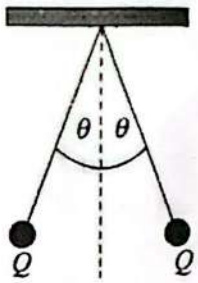


Figure 02

   (c) Two positively charged balls are suspended as shown in figure 02. Draw the figure with appropriate electric filed lines. 2 CO1

2. (a) A charged object has -9.6 nC of charge. How many electrons are present in the object? 2 CO3

   (b) Five protons and three electrons are separated at a distance 5μm from each other. Compare the electrostatic force and gravitational force between them. The gravitational constant is $G = 6.67 \times 10^{-11}\ m^3\ kg^{-1}s^{-2}$ and the mass of each proton is 1.67×10^{-27} kg and the mass of the electron is 9.1×10^{-31} kg. 3 CO3

   (c) Calculate the magnitude and direction of the force experienced by q_0 from figure 03. 3 CO3

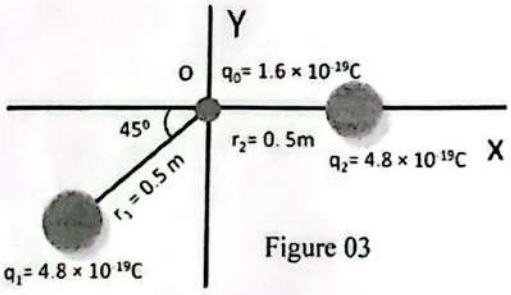


Figure 03

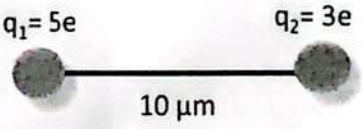


Figure 04

3. (a) Calculate the position between q_1 and q_2 where an electron will experience no force if it is placed. (Figure 04). Here, $e = 1.6 \times 10^{-19}$ C 3 CO3

   (b) Calculate the magnitude and direction of the net electric field at point P. (Figure 05) 3 CO3

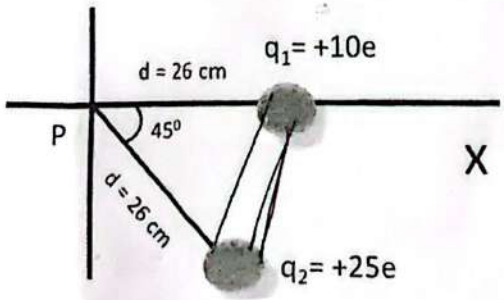


Figure 05

(c) A neutral water molecule in its vapor state has an electric dipole moment of magnitude 6×10^{-30} Cm. If the molecule is placed in an electric field of 3.5×10^{4} N/C, what maximum torque can the field exert on it? 3 CO3

4. (a) What is the electric potential at point P, located at the center of the square of charged particles shown in figure 06? The distance d is 1.3 m, and the charges are
$q_1 = 10$ nC
$q_2 = -20$ nC
$q_3 = 30$ nC
$q_4 = -10$ nC

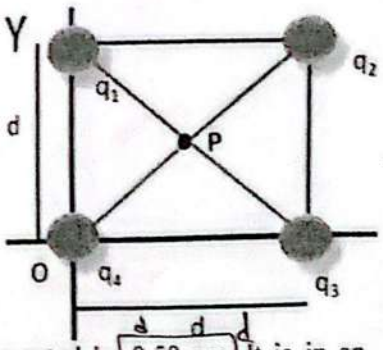


Figure 06

3 CO3

(b) An electric dipole consists of charge +5e and -5e separated by 0.50 nm. It is in an electric field of strength 6.1×10^{-5} N/C. Calculate the magnitude of the torque on the dipole when the dipole moment is (i) parallel to (ii) perpendicular to the electric field. 3 CO3

(c) How much work is required to turn an electric dipole 150^0 in a uniform electric field of magnitude E = 60.0 N/C if the dipole moment has a magnitude of $p = 7.5 \times 10^{-24}$ Cm and the initial angle is 65^0? 3 CO3

$W = -qE\cos\theta$

5. (a) A dipole with charge +q and -q are separated at a distance "d" and lie along the dipole axis (z axis). P is a point along the axis and it is at a distance "z" from the center of the dipole. Calculate the electric field at the point P due to the electric dipole. 4 CO2

(b) Show that, a potential energy U is associated with the orientation of the dipole moment in the field, as given by a dot product: 4 CO2

$$U = -\vec{p}.\vec{E}$$

Where $\vec{E}$ is the external electric field and $\vec{p}$ is the dipole moment.

$dW = \tau d\theta$

$\int W = \int \tau d\theta$

$dW = qE\,ds$

$\int PE\sin\theta$

6. (a) Show that, the electric potential due to a single charged particle at a distance r from that charged particle is, 4 CO2

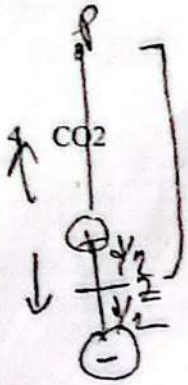
$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

Where V has the same sign as q.
Write down the formula for electric potential due to a group of point charged particles.

(b) At a distance r from an electric dipole with dipole moment magnitude p = qd, the electric potential of the dipole is , 4 CO2

$$V = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2}$$

Where $r \gg d$; the angle θ lies between the dipole moment vector and a line extending from the dipole midpoint to the point of measurement.



CO1: Define different physical quantities with examples. **CO2:** Derive/Show the various equations of electric field, electric potential, electric dipole, dipole moment, electrostatic force, etc. **CO3:** Evaluate different numerical problems based on the basic characteristics of electric charge, electric field, electric potential, electric dipole moment, and electrostatic force.

$E_+ - E_- = \frac{1}{4\pi\varepsilon_0}\frac{q}{(z+d/2)^2} - \frac{1}{4\pi(z+d/2)^2} = \frac{1}{2\pi\varepsilon_0}\frac{qp}{z^3}$