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General Physics-II (PHYS1020AA, AB, AC)
Quiz - 5

Date: 2024-03-12 Spring Semester-112-2

Time: 11:30 am – 12:00 am Maximum marks: 100

Student id: Name:

1. A charge of 170 μC is at the center of a cube of edge 80.0 cm. No other charges are nearby. (a) Find the flux through each face of the cube. (b) Find the flux through the whole surface of the cube. (c) What If? Would your answers to either part (a) or part (b) change if the charge were not at the center? Explain.

Solution:

Ans: The total flux through the surface of the cube is

$$\Phi_E = \frac{q_{\text{in}}}{\epsilon_0} = \frac{170\times10^{-6}\ \text{C}}{8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2} = 1.92\times10^{7}\ \text{N}\cdot\text{m}^2/\text{C}$$

(a) By symmetry, the flux through each face of the cube is the same.

$$(\Phi_E)_{\text{one face}} = \frac{1}{6}\Phi_E = \frac{1}{6}\frac{q_{\text{in}}}{\epsilon_0}$$

$$(\Phi_E)_{\text{one face}} = \frac{1}{6}\left(\frac{170\times10^{-6}\ \text{C}}{8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2}\right) = \boxed{3.20\times10^{6}\ \text{N}\cdot\text{m}^2/\text{C}}$$

(b)

$$\Phi_E = \frac{q_{\text{in}}}{\epsilon_0} = \left(\frac{170\times10^{-6}\ \text{C}}{8.85\times10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2}\right) = \boxed{1.92\times10^{7}\ \text{N}\cdot\text{m}^2/\text{C}}$$

(c) The answer to part (a) would change because the charge could now be at different distances from each face of the cube. The answer to part (b) would be unchanged because the flux through the entire closed surface depends only on the total charge inside the surface.

2. A proton accelerates from rest in a uniform electric field of 640 N/C. At one later moment, its speed is 1.20 Mm/s (nonrelativistic because v is much less than the speed of light). (a) Find the acceleration of the proton. (b) Over what time interval does the proton reach this speed? (c) How far does it move in this time interval? (d) What is its kinetic energy at the end of this interval?

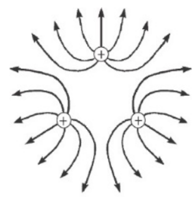
Solution:

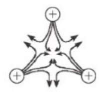
Ans: (a) We obtain the acceleration of the proton from the particle under a net force model, with $F = qE$ representing the electric force:

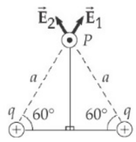
$$a = \frac{F}{m} = \frac{qE}{m} = \frac{(1.602 \times 10^{-19}\ \text{C})(640\ \text{N/C})}{1.67 \times 10^{-27}\ \text{kg}} = \boxed{6.14 \times 10^{10}\ \text{m/s}^2}$$

(b) The particle under constant acceleration model gives us $v_f = v_i + at$, from which we obtain

$$t = \frac{v_f - 0}{a} = \frac{1.20 \times 10^6\ \text{m/s}}{6.14 \times 10^{10}\ \text{m/s}^2} = \boxed{19.5\ \mu\text{s}}$$







(c) Again, from the particle under constant acceleration model,

$$\Delta x = v_i t + \frac{1}{2}at^2 = 0 + \frac{1}{2}(6.14 \times 10^{10}\ \text{m/s}^2)(19.5 \times 10^{-6}\ \text{s})^2$$
$$= \boxed{11.7\ \text{m}}$$

(d) The final kinetic energy of the proton is

$$K = \frac{1}{2}mv^2 = \frac{1}{2}(1.67 \times 10^{-27}\ \text{kg})(1.20 \times 10^6\ \text{m/s})^2 = \boxed{1.20 \times 10^{-15}\ \text{J}}$$