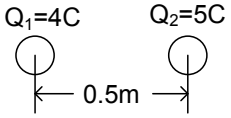
TOPIC
Electricity and Magnetism – Section XI – Question 4

QUESTION
The two charged particles are in free space.



The force experienced by charge Q_1 in Newtons most nearly is

(A) -7.1934×10^{11}
(B) 7.1934×10^{11}
(C) 1.4387×10^{11}
(D) 1.7984×10^{11}

HINT
Any charged particle generates an electric field ($\overline{E}$) measured in Newtons per Coulombs (N/C) or volts per meter (V/m). This Electric Field will exert a force on any charged particle introduced into the field,

$$\overline{F} = Q\overline{E}.$$

Notice, that the force and the electric field are vectors having a magnitude and a direction. Positive force indicates that the charges repel whereas negative force indicates attraction (similar charges repel whereas opposite charges attract).

With what has been said, then two statements can be derived as

Charge Q_2 will experience a force due to the electric field created by Q_1,

$$\overline{F_2} = Q_2\overline{E_1}.$$

Charge Q_1 will experience a force due to the electric field created by Q_2,

$$\overline{F_1} = Q_1\overline{E_2}.$$

The catch here is that the two forces are the same and given by the following equation

$$\overline{F_1} = \overline{F_2} = \overline{F} = \frac{Q_1 Q_2}{4.\pi.\varepsilon.r^2}\overline{a}$$

where $\overline{a}$ is a unit vector, r is the distance between the two charges measured in meters (m) and ε is the permittivity of the medium. For air or free space

$$\varepsilon = \varepsilon_o = 8.85 \times 10^{-12} \text{ F/m}$$
$$= 8.85 \times 10^{-12} \text{ C}^2 / \text{N.m}^2.$$

SOLUTION

$$\overline{F_1} = \overline{F_2} = \overline{F} = \frac{(4)(5)}{(4)(\pi)(8.85 \times 10^{-12})(0.5)^2}\overline{a}$$
$$= 7.1934 \times 10^{11} N$$

ANSWER
(B)

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