15-Phys-202

SUMMER 2003

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Quiz 1

Name _____

Formulae and constants:

$$x(t) = x_m \cos(\omega t + \phi)$$

$$\omega = 2\pi f = \frac{2\pi}{T}$$

$$F = \frac{1}{4\pi\varepsilon_0} \frac{|q_1|\,|q_2|}{r^2}$$

1. In an electric shaver, the blade moves back and force over a distance of 2.0 mm in simple harmonic motion with frequency 120 Hz. Find (a) amplitude, (b) the maximum blade speed, and (c) the magnitude of the maximum blade acceleration.

   Solution

$$x_m = 1.0 \text{ mm}$$

$$v_m = \omega x_m = 2\pi f x_m = 2\pi\,(120)\left(1.0 \times 10^{-3}\right) = 0.75 \text{ m/s}$$

$$a_m = \omega^2 x_m = (2\pi f)^2\, x_m = (2\pi\,(120))^2\left(1.0 \times 10^{-3}\right) = 570 \text{ m/s}^2$$

2. In Fig. 1, three charged particles lie on a straight line and are separated by distances d. Charges q_1 and q_2 are held fixed. Charge q_3 is free to move but happens to be in equilibrium (no net electrostatic force acts on it). Find q_1 in terms of q_2.

   Solution

$$F_{31} = \frac{1}{4\pi\varepsilon_0}\frac{|q_3|\,|q_1|}{(2d)^2} = \frac{1}{4\pi\varepsilon_0}\frac{|q_3|\,|q_2|}{d^2} = F_{32}$$

$$|q_2| = \frac{|q_1|}{4}$$

$$q_2 = -\frac{q_1}{4},\; q_1 = -4q_2$$

3. Calculate the direction and the magnitude of the electric field at point P in Fig. 2, due to the three point charges.

   Solution

   By symmetry, the contributions to the electric field from the two $+q$ charges cancel each other at P, so that the only contribution there is from the charge $+2q$. The electric field is, therefore, directed along the line connecting the charge $+2q$ and point P and away from the charge $+2q$. (It is also perpendicular to the line connecting the two $+q$ charges). Its magnitude is given by

$$E = \frac{1}{4\pi\varepsilon_0}\frac{2q}{(a/2)^2 + (a/2)^2} = \frac{q}{\pi\varepsilon_0 a^2}$$

Figure 1

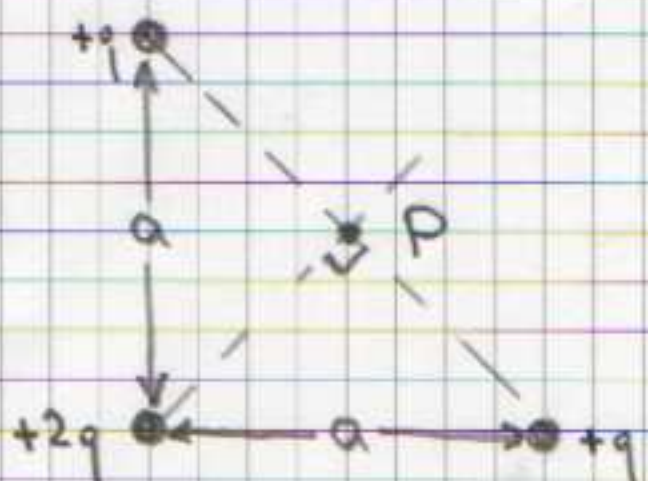

Figure 2