Practice Problems (Physics - 2)

Mazhar Iqbal

Problem

When the displacement in SHM is one-half the amplitude x_m, what fraction of the total energy is (a) kinetic energy and (b) potential energy? (c) At what displacement, in terms of the amplitude, is the energy of the system half kinetic energy and half potential energy?

Solution

(a) Since $x(t) = \frac{1}{2}x_m$, then

$$K = E - U = \frac{1}{2}kx_m^2 - \frac{1}{2}kx^2$$

$$K = \frac{1}{2}kx_m^2 - \frac{1}{2}k(\frac{1}{4}x_m^2) = \frac{3}{8}kx_m^2$$

So

$$Fraction = \frac{K}{E} = \frac{\frac{3}{8}kx_m^2}{\frac{1}{2}kx_m^2} = \frac{3}{4}$$

Solution

(b)

$$Fraction = \frac{U}{E} = \frac{\frac{1}{2}kx^2}{\frac{1}{2}kx_m^2}$$

$$Fraction = \frac{\frac{1}{4}x_m^2}{x_m^2} = \frac{1}{4}$$

(c)

$$U = \frac{1}{2}E = \frac{1}{2}(\frac{1}{2}kx_m^2)$$

$$\frac{1}{2}kx^2 = \frac{1}{4}kx_m^2$$

$$x = \frac{x_m}{\sqrt{2}}$$

Problem

A sinusoidal wave travels along a string. The time for a particular point to move from maximum displacement to zero is $0.170s$.What are the (a) period and (b) frequency? (c) The wavelength is $1.40m$; what is the wave speed?

Solution

(a) T = ?

$$T = 4(0.170) = 0.68\ s$$

(b) f =?

$$f = \frac{1}{T} = \frac{1}{0.68} = 1.47\ s^{-1}$$

(c) v =?

$$v = \frac{\omega}{k} = f\lambda$$

$$v = (1.47)(1.4) = 2.058\ m/s$$

Problem

In a double-slit experiment, the distance between slits is 5.0 *mm* and the slits are 1.0 *m* from the screen. Two interference patterns can be seen on the screen: one due to light of wavelength 480 *nm*, and the other due to light of wavelength 600 *nm*.What is the separation on the screen between the third-order ($m = 3$) bright fringes of the two interference patterns?

Solution

Let say $\lambda_1 = 480\ nm$ and $\lambda_2 = 600\ nm$. So for wavelength λ_1 and $m = 3$

$$d sin\theta_1 = 3\lambda_1$$

$$\theta_1 = sin^{-1}(\frac{3\lambda_1}{d})$$

As

$$tan\theta_1 = \frac{y_1}{D}$$

$$y_1 = D\ tan(sin^{-1}(\frac{3\lambda_1}{d}))$$

Then y_2 is

$$y_2 = D\ tan(sin^{-1}(\frac{3\lambda_2}{d}))$$

Solution

Then the separation between the two is

$$\Delta y = y_2 - y_1 = D[\ tan(sin^{-1}(\frac{3\lambda_2}{d})) - \ tan(sin^{-1}(\frac{3\lambda_1}{d}))]$$

$$\Delta y = 7.2 \times 10^{-5} m$$

Problem

An electron has a de Broglie wavelength $\lambda = 4.5 \times 10^{-10} m$(a) What is its momentum? (b) What is its speed? (c) What voltage was needed to accelerate it from rest to this speed?

Solution

(a) $p =?$

$$p = \frac{h}{\lambda}$$

$$p = \frac{6.63 \times 10^{-34}}{4.5 \times 10^{-10}} = 1.47 \times 10^{-24} kg.m/s$$

(b) $v =?$

$$v = \frac{p}{m} = \frac{1.47 \times 10^{-24}}{9.1 \times 10^{-}31} = 1.62 \times 10^{6}\ m/s$$

Solution

(c) Voltage, $V = ?$

As

$$eV = \frac{1}{2}mv^2$$

$$V = \frac{mv^2}{2e} = \frac{(9.1 \times 10^{-31})(1.62 \times 10^6)^2}{2(1.6 \times 10^{-19})}$$

$$V = 7.46 \ volts$$