

Solutions PHYS1121

Question 1 [15 marks]

- a) The rate of collection of energy is $P = 550\text{W/m}^2(600\text{m}^2) = 3300\text{W}$. The amount of energy required to raise the temperature of 1 000 kg of water by 40.0°C is:

$$Q = m\Delta T = 1000\text{kg}(4186\text{J/kg}\cdot^\circ\text{C})(40^\circ\text{C}) = 1.67 \times 10^8 \text{ J}$$

Thus, $P\Delta t = 1.67 \times 10^8 \text{ J}$

or $\Delta t = \frac{1.67 \times 10^8 \text{ J}}{3300 \text{ W}} = \boxed{507 \text{ ks}} = 141 \text{ h.}$

- b) $\bar{F} = Nm \frac{\Delta v}{\Delta t} = 50(5.00 \times 10^3 \text{ kg}) \frac{[8.00\sin 45^\circ - (-8.00\sin 45^\circ)] \text{ m/s}}{300 \text{ s}} = \boxed{0.943\text{N}}$

$$P = \frac{\bar{F}}{A} = 1.57 \text{ N/m}^2 = \boxed{1.57 \text{ Pa}}$$

Question 2 [12 marks]

(a) $k = \frac{|F|}{x} = \frac{200 \text{ N}}{0.200 \text{ m}} = \boxed{1000 \text{ N/m}}$

(b) $\omega = \sqrt{\frac{k}{m}} = \sqrt{500} \text{ rad/s}$ so $f = \frac{\omega}{2\pi} = \boxed{1.13 \text{ Hz}}$

(c) $v_{\text{max}} = \omega A = \sqrt{500}(0.200) = \boxed{1.41 \text{ m/s}}$ at $x = 0$

(d) $a_{\text{max}} = \omega^2 A = 500(0.200) = \boxed{100 \text{ m/s}^2}$ at $x = \pm A$

(e) $|v| = \omega \sqrt{A^2 - x^2} = \sqrt{500} \sqrt{\frac{8}{9}(0.200)^2} = \boxed{1.33 \text{ m/s}}$

(f) $|a| = \omega^2 x = 500 \left(\frac{0.200}{3} \right) = \boxed{3.33 \text{ m/s}^2}$

Question 3 [18 marks]

a)

$$\lambda_G = 2(0.350\text{m}) = \frac{v}{f_G}; \quad \lambda_A = 2L_A = \frac{v}{f_A}$$

$$L_G - L_A = L_G - \left(\frac{f_G}{f_A}\right)L_G = L_G\left(1 - \frac{f_G}{f_A}\right) = (0.350\text{m})\left(1 - \frac{392}{440}\right) = 0.0382\text{ m}$$

Thus, $L_A = L_G - 0.0382\text{ m} = 0.350\text{m} - 0.0382\text{ m} = 0.312\text{m}$,

or the finger should be placed 312 cm from the bridge.

b)

(i) $\Delta x = \sqrt{9.00 + 4.00} - 3.00 = \sqrt{13} - 3.00 = 0.606\text{m}$

The wavelength is

$$\lambda = \frac{v}{f} = \frac{343\text{m/s}}{300\text{Hz}} = 1.14\text{m}$$

Thus,

$$\frac{\Delta x}{\lambda} = \frac{0.606}{1.14} = 0.530 \text{ of a wave}$$

or

$$\Delta\phi = 2\pi(0.530) = \boxed{3.33\text{rad}}$$

(ii) For destructive interference, we want $\frac{\Delta x}{\lambda} = 0.500 = f \frac{\Delta x}{v}$

where Δx is a constant in this set up. $f = \frac{v}{2\Delta x} = \frac{343}{2(0.606)} = \boxed{283\text{Hz}}$

Question 4 [15 marks]

(a) $v = v_0$ when car is at a and c. Rises to a maximum value somewhere between b and c, falls to v_0 at c and continues dropping to a minimum value somewhere between c and d. Then, rises again to v_0 at a.

(b) $v = v_0$ when car is at a. Rises to a maximum value at c, drops discontinuously to its minimum value, then rises again to v_0 at a. Maximum and minimum values are the *same* as for part a).

(c) $v = v_0$ when car is at a and c. Rises to a maximum value somewhere between b and c, falls to v_0 at c and continues dropping to a minimum value somewhere between c and d. Then, rises again to v_0 at a. Maximum and minimum values are closer to v_0 than in part a) and part b). (ie, Δv_0 is less.)

(d) The frequency is unchanged and is equal to v_0 .