AP Physics – Wavin' Them Waves – 3 Ans

1. A lass on a skate board throws a 5.6 kg medicine ball away from herself, giving it a speed of 15.0 m/s. The girl/skateboard's mass is 36 kg. What is the final velocity gained by the young woman?

$$0 = m_1 v_{1f} + m_2 v_{2f} \quad m_1 v_{1f} = -m_2 v_{2f} \qquad v_{1f} = -\frac{m_2 v_{2f}}{m_1} \qquad v_{1f} = -\frac{(5.6\ kg)15.0\frac{m}{s}}{36\ kg} = \boxed{-2.3\frac{m}{s}}$$

2. A 1250 kg car has 3 passengers with a combined mass of 135 kg. The car has four identical springs that have a spring constant of 18 500 N/m. (a) Find the frequency of vibration for the car when it goes over the old speed bump. (b) How much time does it take for the car to go through 2 oscillations?

(a) $mass\ loading = \frac{1250\ kg + 135\ kg}{4} = 346.25\ kg \qquad T = 2\pi\sqrt{\frac{m}{k}}$

$$T = 2\pi\sqrt{\frac{346.25\ kg}{18\,500\frac{kg\cdot m}{s^2\cdot m}}} = 2\pi\sqrt{0.01872\ s^2} = 0.8596\ s \qquad f = \frac{1}{T} = \frac{1}{0.8596\ s} = \boxed{1.16\ Hz}$$

(b) $f = \frac{n}{t} \quad t = \frac{n}{f} = \frac{2}{1.16\frac{1}{s}} = \boxed{1.72\ s}$

3. Sketch a series of standing waves on a string between two solid points. Show the first three harmonics.

4. You are at a stop light in your car, stuck behind a red light. Just before the light is supposed to change, a fire engine comes zooming up towards you traveling at a horrendous 85.0 km/h. If the siren has a rated frequency 665 Hz, (a) what frequency do you hear? (b) what is the wavelength of the sound you hear?

(a) $f' = f\left(\frac{v}{v - v_s}\right) \qquad 85\frac{km}{h}\left(\frac{1\,000\ m}{1\ km}\right)\left(\frac{1\ h}{3\,600\ s}\right) = 23.61\frac{m}{s}$

$$f' = 655\ Hz\left(\frac{345\frac{m}{s}}{345\frac{m}{s} - 23.61\frac{m}{s}}\right) = \boxed{703\ Hz}$$

(b) $v = f\lambda \qquad \lambda = \frac{v}{f} = 345\frac{m}{s}\left(\frac{1}{703\frac{1}{s}}\right) = \boxed{0.491\ m}$

5. A pipe is 155 cm long and open on one of its ends. (a) What are the frequencies of the first three harmonics that resonate in the pipe? (b) What is the wavelength of the first harmonic?

(a) $f = \frac{v}{4L} \qquad f = 345\frac{m}{s}\left(\frac{1}{4(1.55\ m)}\right) = \boxed{55.6\ Hz}$

$f_3 = 3(55.6\ Hz) = \boxed{167\ Hz} \qquad f_5 = 5(55.6\ Hz) = \boxed{278\ Hz}$

(b) $v = f\lambda \quad \lambda = \frac{v}{f} = 345\frac{m}{s}\left(\frac{1}{55.6\frac{1}{s}}\right) = \boxed{6.21\ m}$

6. You spot a large pendulum that is swinging through a small arc. If the length of the pendulum is 5.5 m, what is the period of the thing?

$$T = 2\pi\sqrt{\frac{L}{g}} \quad = 2\pi\sqrt{\frac{5.5\ \cancel{m}}{9.8\frac{\cancel{m}}{s^2}}} \quad = \quad \boxed{4.7\ s}$$

7. You are on a train traveling at 105 km/h. You approach a stationary 455 Hz siren. What is frequency you hear?

$$105\frac{\cancel{km}}{\cancel{h}}\left(\frac{1000\ m}{1\ \cancel{km}}\right)\left(\frac{1\ \cancel{h}}{3600\ s}\right) \quad = \quad 29.17\ \frac{m}{s}$$

$$f' = f\left(\frac{v + v_0}{v}\right) \quad = 455\ Hz\left(\frac{345\frac{\cancel{m}}{\cancel{s}} + 29.17\frac{\cancel{m}}{\cancel{s}}}{345\frac{\cancel{m}}{\cancel{s}}}\right) \quad = \quad \boxed{493\ Hz}$$

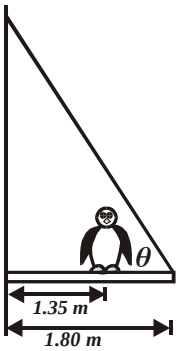
8. You throw a 675 g ball straight up. If the ball takes 4.2 seconds to go up and down (where you like catch it at the same height) and if we ignore wind resistance, then fine: (a) How high the ball goes, (b) the ball's initial velocity, (c) the ball's kinetic energy at the top of the flight, and (d) the kinetic energy just before you catch it.

(a) $y = \frac{1}{2}at^2 \quad = \frac{1}{2}\left(9.8\frac{m}{\cancel{s}^2}\right)(2.1\ \cancel{s})^2 \quad = \quad \boxed{21.6\ m}$

(b) $v = v_o + at \quad v_o = -at \quad = -\left(-9.8\frac{m}{\cancel{s}^2}\right)(2.1\ \cancel{s}) \quad = \quad \boxed{20.6\frac{m}{s}}$

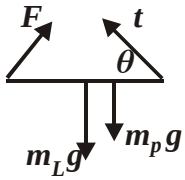
(c) zero (d) $K = \frac{1}{2}mv^2 \quad = \frac{1}{2}(0.675\ kg)\left(20.6\frac{m}{s}\right)^2 \quad = \quad \boxed{143\ J}$

9. A beam sticks out from a wall as shown. The mass of the uniform beam is 12.6 kg, the mass of the penguin is 1.25 kg. The angle of the cable is 65.0°. (a) Find the tension and (b) find the force exerted by the wall on the beam.



(a) $\Sigma\tau = 0 \quad m_p g\, r_p + m_L g\frac{r_L}{2} - t\sin\theta r_L \qquad t = \frac{m_p g\, r_p + m_L g\frac{r_L}{2}}{\sin\theta r_L}$

$$t = \frac{(1.25\ kg)\left(9.8\frac{m}{s^2}\right)(1.35\ \cancel{m}) + (12.6\ kg)\left(9.8\frac{m}{s^2}\right)(0.900\ \cancel{m})}{\sin\left(65.0^o\right)(1.80\ \cancel{m})} \quad = \quad \boxed{78.3\ N}$$



(b) $\Sigma F_x = 0 \quad t\cos\theta - F_x = 0 \quad F_x = t\cos\theta \quad = (78.3\ N)\cos 65^o \quad = \quad 33.09\ N$

$\Sigma F_y = 0 \quad t\sin\theta + F_y - m_L g - m_p g = 0 \quad F_y = m_L g + m_p g - t\sin\theta$

$$F_y = (12.6kg)\left(9.8\frac{m}{s^2}\right) + (1.25\ kg)\left(9.8\frac{m}{s^2}\right) - (78.3\ N)\sin 65^o \quad = \quad 64.77\ N$$

$$F = \sqrt{F_x{}^2 + F_y{}^2} \quad = \sqrt{(33.09\ N) + (64.77\ N)} \quad = \quad \boxed{72.7\ N}$$