PHY101 - MECHANICS AND HEAT

Homework 3

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1.1 A

The motion consists of two distinct ports: the completely inelastic collision and the simple hormonic motion.

Before the collision, system = {m}

$$p_1 = mv$$

After the collision, system = {m+M}

$$p_2 = (m + M)v'$$

Since the collision we have momentum conservative, we have

$$p_1 = p_2 \quad mv = (m + M)v'$$

$$v' = \frac{m}{m + M}v = \frac{9.5 \times 10^{-3}kg}{9.5 \times 10^{-3}kg + 5.4kg} \times 630m/s = 1.11m/s$$

1.2 B

After the collision, the system is energy conservative, we choose system={m+M}.

In this process, the kenemetic energy convert to the potential energy of the string, therefore we have

$$\frac{1}{2}(m + M)v'^2 = \frac{1}{2}kxm^2$$

$$x_m = \sqrt{\frac{M + m}{k}}v' = 3.33 \times 10^{-2}m$$

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2.1 A

Before the collision, we take system={m}. The system is conservative so the mechanic energy is conservative.

$$E_p = E_k$$

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

$$v = \sqrt{2gL} = 3.70m/s$$

2.2 B

In the collision, we have momentum conservation and since the collision is elastic, therefore we also have conservation of total kinetic energy.

$$\begin{cases} mv = mv_1 + mv_2 \\ mgL = \frac{1}{2}mv^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}Mv_2^2 \end{cases}$$

Solve the system of equation we have

$$\begin{cases} v_1 = \frac{m-M}{m+M}v = \frac{0.5kg-2.5kg}{0.5kg+2.5kg} \cdot 3.70m/s = -2.47m/s \\ v_1 = \frac{2m}{m+M}v = \frac{2\times 0.5kg}{0.5kg+2.5kg} \cdot 3.70m/s = 1.23m/s \end{cases}$$

Therefore the speed of the ball is 2.47m/s but the direction of the motion is opposite with the block. The speed of the block is 1.23m/s

3

3.1 A

We apply the formula from the lecture that

$$\omega = \frac{\pi}{T} = \sqrt{\frac{k}{m}} = \sqrt{\frac{k}{M+4m}}$$

The car travels over a direct road with $\lambda = 4m$, as a speed $v = 16km/h = 4.44m/s$. Therefore we have the equation that $T = \frac{v}{\lambda}$

$$\omega = \frac{\pi}{T} = \frac{2\pi v}{\lambda} = \sqrt{\frac{k}{M+4m}}$$

$$k = (M+4m)(\frac{2\pi v}{\lambda})^2 = 64725.11 N \cdot m^{-1}$$

3.2 B

Before people leave the car, we have the equilibrium compression,

$$kx_i = (M+4m)g \Longrightarrow x_i = \frac{M+4m}{k}g$$

After people leave the car, we have the equilibrium compression,

$$kx_f = Mg \Longrightarrow x_f = \frac{M}{k}g$$

Therefore the rise of the suspension is the difference between x_i and x_f

$$\Delta x = x_i - x_f = \frac{4mg}{k} = \frac{4mg}{M+4m}(\frac{\lambda}{2\pi v})^2 = 0.0497m$$