PHYS101 Quiz 3 - Solution Set

Department of Physics

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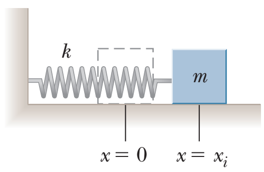
Questions:

1. A block of mass $m = 2.00$kg is attached to a spring of force constant $k = 500$N/m as shown in Figure below. The block is pulled to a position $x_i = 5.00$cm to the right of equilibrium and released from rest. Find the speed the block has as it passes through equilibrium if



   (a) the horizontal surface is frictionless and
   Solution:
   The mass-spring system is isolated without friction, therefore the mechanical Energy is conserved.

$$K_i + U_i = K_f + U_f$$
$$0 + \frac{1}{2}kx^2 = \frac{1}{2}mv^2 + 0$$
$$v = \sqrt{\frac{k}{m}}x = \sqrt{\frac{500N/m}{2.00kg}}0.05m = 0.79m/s$$

(b) the coefficient of friction between block and surface is $\mu_k = 0.350$.

The mass-spring system is isolated with friction, so the total energy is conserved.

The internal energy is equal to the work done by the frictional force on the distance x.

$$E_{int} = W = \int_0^x F_N \mu_k dx = F_N \mu_k x = mg\mu_k x$$

From the conservation of the total energy:

$$\begin{aligned} K_i + U_i &= E_{int} + K_f + U_f \\ 0 + \frac{1}{2}kx^2 &= mg\mu_k x + \frac{1}{2}mv^2 + 0 \\ v &= \sqrt{\frac{kx^2 - mg\mu_k x}{m}} = \sqrt{\frac{500(0.05)^2 - 2 \cdot 9.80 \cdot 0.350 \cdot 0.05}{2}} \frac{m}{s} = 0.67 m/s \end{aligned}$$

2. On a frictionless horizontal air table, puck A with mass $m_A = 0.250$kg is moving toward puck B with mass $m_B = 0.350$kg, which is initially at rest. Just after collision, puck A has a velocity of $v_{A_f} = 0.120$m/s to the left, and puck B has a velocity of $v_{B_f} = 0.650$m/s to the right.

(a) What is the speed of the puck A just before the collision?

Solution:

$$\begin{aligned} p_{A_i} + p_{B_i} &= p_{A_f} + p_{B_f} \\ m_A v_{A_i} + 0 &= m_A v_{A_f} + m_B v_{B_f} \\ v_{A_i} &= v_{A_f} + \frac{m_B}{m_A} v_{B_f} \\ v_{A_i} &= -0.120 m/s + \frac{0.350kg}{0.250kg} 0.650 m/s = 0.79 m/s \end{aligned}$$

(b) Calculate the change in the total kinetic energy of the system that occurs during the collision.

Solution:

$$K_i = \frac{1}{2} m_A v_{A_i}^2, \quad K_f = \frac{1}{2} m_A v_{A_f}^2 + \frac{1}{2} m_B v_{B_f}^2$$

The change in the kinetic energy is:

$$\Delta K = K_f - K_i = \frac{1}{2} m_A v_{A_f}^2 + \frac{1}{2} m_B v_{B_f}^2 - \frac{1}{2} m_A v_{A_i}^2 =$$
$$= \frac{1}{2}\left(0.25kg(0.12m/s)^2 + 0.35kg(0.65m/s)^2 - 0.25kg(0.79m/s)^2\right) = 0.002J$$