

In all problems, neglect air resistance and take $g = 9.80 \text{ m/s}^2$, unless stated otherwise.

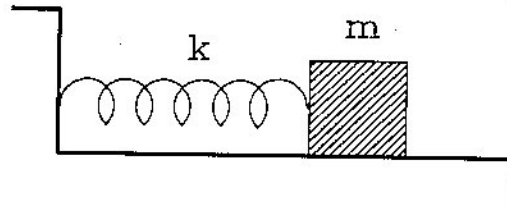
$\mu_{\text{air}} = 0, g,$

A. [35 points; show the details of your calculations; put a box around each final answer.]

A block of mass $m = 2.0 \text{ kg}$ is attached to a Hooke's-law spring with force constant $k = 50 \text{ N/m}$ and is on a rough horizontal surface. The block is slowly pulled by an external force from its equilibrium position a distance of 0.50 m and released. The block just manages to return to its equilibrium position before stopping completely.

$x_i = 0, x_f = 0.50 \text{ m}$

$M = 2.0 \text{ kg}$



1. [9 pts] How much work (sign and magnitude) does the spring force do on the block on its return trip from the release point to the equilibrium position?

$W_s = \frac{1}{2} k x^2 = \frac{50 \frac{\text{N}}{\text{m}} (0.5^2)}{2} = \boxed{6.25 \text{ J}}$

$\Delta E = \Delta K + \Delta U = -fd$ 9

2. [8 pts] What is the energy dissipated by friction during the return trip?

$\boxed{6.25 \text{ J}}$
how? 7

3. [8 pts] Determine the magnitude of the impulse on the block for the return trip.

$\cancel{m(v_0 - v_1)} = \boxed{0 \frac{\text{N}}{\text{s}}}$

4. [10 pts] If friction were not present, what would be the speed of the block when it reaches the equilibrium position.

~~$K_f = K_i + W - f_x d = K_i + \Delta U = K_i + U_{\text{spring}} = U_{\text{spring}}$~~
 ~~$\sqrt{\frac{2 \cdot 50 \cdot 0.5^2}{2.0}}$~~
 $K = 0$
 $v = \sqrt{\frac{2 \cdot 50 \cdot 0.5^2}{2.0}} = \boxed{2.5 \frac{\text{m}}{\text{s}}}$ 10

B. [35 points; show the details of your calculations; put a box around each final answer.]
 A bullet, of mass 0.010 kg and traveling with horizontal velocity 300 m/s, strikes a suspended pendulum bob of mass 2.0 kg and passes completely through it, emerging with a horizontal velocity of 100 m/s.

1. [7 points] Determine the velocity (speed and direction) of the center-of-mass (of the bullet and bob system) before the collision?

$$\frac{\sum m_i v_i}{M} = \frac{0.01 \times 300}{0.01 + 2} = \boxed{1.5 \frac{m}{s}}$$

7/7

2. [10 points] Determine the speed of the bob just after the collision?

$$M_b v_{bf} = M_b v_{bi} + m v_{pi} - m v_{pf}$$

$$\frac{M_b v_{bf}}{M_b} = \frac{M_b v_{bi} + m v_{pi} - m v_{pf}}{M_b} = \frac{0(300 - 100)}{2} = \boxed{1 \frac{m}{s}}$$

10/10

3. [8 points] Determine the magnitude of the impulse on the bullet due to the collision.

$$\Delta p = 0.01(100 - 300) = \boxed{2 \frac{N \cdot s}{m}}$$

8/8

4. [10 points]

- Was total momentum conserved during the collision? If not, by how much did it change?

$$I_{total} = \Delta p = \boxed{2 \frac{N \cdot s}{m}}$$

7/10

- Was total mechanical energy conserved during the collision? If not, by how much did it change?

$$- \left(\frac{0.01 \times 300^2}{2} \right) + \left(\frac{0.01 \times 100^2}{2} + \frac{2 \times 1^2}{2} \right) = \boxed{-399 \text{ J No}}$$

15

C. Multiple-choice questions [30 pts. (5 pts. each)]

Each question should be solvable by simply identifying the correct principle and/or equation(s). Write down the appropriate equation(s) and solve, and circle the correct solution. If an incorrect answer is circled, some partial credit will be awarded if the appropriate work is written clearly, coherently, and completely in the space adjacent to the the multiple-choice answers.

If a multiple-choice question takes you more than about 2 minutes, move on, do the other multiple-choice questions and the two long problems, and come back to it later. Pace yourself.

1. An object moving along the x-axis is acted on by a single force given by $F_x = (3x^2 - 4x) \text{ N}$, where x is measured in m. By how much does the kinetic energy of the object change as it moves from $x = 0 \text{ m}$ to $x = -2 \text{ m}$?

- (a) -12 J
 (b) -4 J
 5 (c) 0 J
 (d) -4 J
 (e) -12 J

$$\Delta K = \int F_x dx$$

$$\int_0^{-2} (3x^2 - 4x) dx = x^3 - 2x^2 \Big|_0^{-2} = 2^3 - 2(2)^2 = 8 - 8 = 0$$

2. A 2.0 kg ball is thrown off of a cliff at a speed of 5.0 m/s at an angle of 30° above the horizontal, and hits the ground later with a speed of 10.0 m/s . How high is the cliff?

- (a) 6.38 m
 (b) 5.10 m
 5 (c) 3.83 m
 (d) 1.28 m

θ / \sin

$$\sin 30^\circ \left(\frac{v_f^2 - v_i^2}{2g} \right) = \frac{v_f^2 - v_i^2}{2g}$$

$$\frac{\Delta v^2}{2g} = \Delta h$$

$$\Delta K + \Delta U = 0$$

$$\Delta U = -\Delta K$$

$$mgh = -\left(\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \right)$$

$$h = \frac{2m(g)}{2mg}$$

3. A pendulum bob has a speed of 1.4 m/s when it is at its lowest point of oscillation. How high above its lowest point does it reach?

- (a) 0.07 m
 5 (b) 0.10 m
 (c) 0.14 m
 (d) 0.20 m

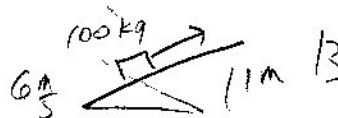
$$\Delta K + \Delta U = 0$$

$$K_f + U_f - (K_i + U_i) = 0$$

$$U_i = -K_f$$

$$mgh = -\frac{mv^2}{2}$$

$$h = \frac{-v^2}{2g}$$



4. A block of mass $m = 100.0 \text{ kg}$ is set into motion up a rough inclined plane with an initial speed of 6.00 m/s . It stops after moving 1.0 m higher. What mechanical energy was dissipated? $v_i =$

- 5 (a) 820 J
- (b) 980 J
- (c) 1960 J
- (d) 2780 J
- (e) 1800 J
- (f) 3600 J

$$\Delta K + \Delta U = -f_k d$$

$$K_f + U_f - (K_i + U_i)$$

$$mgh - \frac{1}{2}mv^2 =$$

$$100 \cdot (9.8 \times 1) - \frac{6^2}{2} = 820 \text{ J}$$

5. A 5.0 kg ball falling vertically hits the floor with a speed of 3.0 m/s and rebounds with a speed of 1.0 m/s . What is the magnitude of the impulse exerted on the ball by the floor?

- \sqrt{f} (a) $20.0 \text{ N}\cdot\text{s}$
- (b) $15.0 \text{ N}\cdot\text{s}$
- 3 - (c) $10.0 \text{ N}\cdot\text{s}$
- (d) $5.0 \text{ N}\cdot\text{s}$
- (e) Cannot be determined unless we are told whether or not the collision is elastic.

$$\int (1 - 3) =$$

$$M(v_f - v_i) = 10 = 10$$

6. A man standing on a railroad track throws a ball at 30 mph directly at an oncoming train which is moving at 20 mph towards the man. After making a perfectly elastic collision, the ball bounces straight back towards the man. With what speed?

- 5 (a) 70 mph
- (b) 50 mph
- (c) 30 mph
- (d) 20 mph
- (e) 10 mph

$$m_b v_{bf} = -m_t v_{tf} + m_t v_{ti} + m_b v_{bi}$$

$$30 + 2(20) = 70$$