Closed book. No work needs to be shown for multiple-choice questions.

1. Alex throws a 0.15 kg rubber ball down onto the floor. The ball's speed just before impact is 6.5 m/s, and just after is 3.5 m/s. If the ball is in contact with the floor for 0.025 s, what is the magnitude of the average force applied by the floor on the ball?

a. 60 N.
b. 133 N.
c. 3.0 N.
d. 3.5 N.
e. 20 N.

2. Mitch throws a 100 g lump of clay at a 500 g target, which is at rest on a horizontal surface. After impact, the target, including the attached clay, slides 2.1 m before stopping. If the coefficient of kinetic friction between the target and the surface is $\mu_k = 0.50$, find the speed of the clay before impact.

a. 4.5 m/s.
b. 12 m/s.
c. 27 m/s.
d. 36 m/s.
e. 5.0 m/s.

3. A 30.0 kg child is standing on a frozen pond 12 m away from its shore. The child throws a 2.0 kg stone in the direction opposite the shore at a speed of 3.0 m/s. The pond is horizontal and frictionless. The time the child will take to reach the shore is:

a. 24 s.
b. 60 s.
c. 78 s.
d. 92 s.
e. 7.5 s.

4. Consider two vehicles approaching a right angle intersection and colliding. After the collision, they become entangled. Initially, car A has a mass of M and a velocity of (14.0 m/s) in the positive x-direction. Initially, car B has a mass of $3M$ and a velocity of (13.0 m/s) in the positive y-direction. What is the magnitude of the final velocity of the wreck?

a. 9.10 m/s.
b. 10.4 m/s.
c. 12.1 m/s.
d. 13.8 m/s.
e. 19.1 m/s.

5. A 0.40 kg pendulum bob passes through the lowest point of its path at a speed of 3.0 m/s. The pendulum is 80 cm long. When if the pendulum reaches its highest point, what angle does the cable make with the vertical?

a. 55°.
b. 45°.
c. 25°.
d. 65°.
e. 35°.

6. Two identical billiard balls have velocities of 2.0 m/s and –1.0 m/s when they meet in an elastic head-on collision. What is the final velocity of the first ball after the collision?

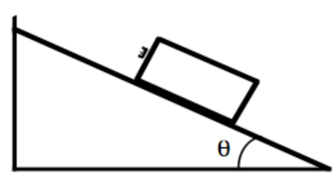
a. –2.0 m/s.
b. –1.0 m/s.
c. –0.50 m/s.
d. +1.0 m/s.
e. –1.5 m/s

7. What is the initial velocity required to launch an object from the Earth surface and reach an altitude twice the Earth radius?

a. 242 km/s.
b. 357 km/s
c. 16.5×10^6 m/s.
d. 8.3×10^6 m/s.
e. 9.1 km/s.

8. A 20-N crate starting at rest slides down a rough 5.0-m long ramp, inclined at 25° with the horizontal. 30 J of energy is lost to friction. What will be the speed of the crate at the bottom of the incline?

a. 0.98 m/s.
b. 4.7 m/s.
c. 8.4 m/s.
d. 3.5 m/s.
e. 6.4 m/s.



Equations and constants:

$$\begin{Bmatrix} x = r\cos\theta \\ y = r\sin\theta \end{Bmatrix}; \quad \begin{Bmatrix} r = \sqrt{x^2 + y^2} \\ \theta = \tan^{-1}\left(\dfrac{y}{x}\right) \end{Bmatrix}; \quad \begin{Bmatrix} v_x = v_{ox} + a_x t \\ \Delta x = \frac{1}{2}\left(v_{ox} + v_x\right)t \\ \Delta x = v_{ox}t + \frac{1}{2}a_x t^2 \\ v_x^2 = \left(v_{ox}\right)^2 + 2a_x\Delta x \end{Bmatrix}; \quad \begin{Bmatrix} v_y = v_{oy} + a_y t \\ \Delta y = \frac{1}{2}\left(v_{oy} + v_y\right)t \\ \Delta y = v_{oy}t + \frac{1}{2}a_y t^2 \\ v_y^2 = \left(v_{oy}\right)^2 + 2a_y\Delta y \end{Bmatrix}; \quad \begin{Bmatrix} \Delta x = x_f - x_i \\ speed_{avg} = \dfrac{d}{\Delta t} \end{Bmatrix};$$

$$\begin{Bmatrix} a_{avg} = \dfrac{\Delta v}{\Delta t} \\ v_{avg} = \dfrac{\Delta x}{\Delta t} \end{Bmatrix}; \quad \begin{Bmatrix} a = \lim\limits_{\Delta t \to 0} \dfrac{\Delta v}{\Delta t} \\ v = \lim\limits_{\Delta t \to 0} \dfrac{\Delta x}{\Delta t} \end{Bmatrix}; \quad \begin{Bmatrix} 0 \le f_s \le \mu_s F_N \\ f_k = \mu_k F_N \\ F_g = mg \end{Bmatrix}; \quad \begin{Bmatrix} \sum \vec{\mathbf{F}} = 0;\ \vec{\mathbf{a}} = 0 \\ \sum \vec{\mathbf{F}} = m\vec{\mathbf{a}} \\ \vec{\mathbf{F}}_{2on1} = -\vec{\mathbf{F}}_{1on2} \end{Bmatrix}; \quad PE_{grav} = mgh; \quad KE = \tfrac{1}{2}mv^2;$$

$$PE_{spring} = \tfrac{1}{2}k\left(\Delta x\right)^2; \quad W = \left|\vec{F}\right|\left|\Delta\vec{x}\right|\cos\theta; \quad W_{\text{net}} = W_1 + W_2 + W_3 \ldots; \quad W_{\text{nc}} = \Delta E_{mec};$$

$$E_{mec} = KE + PE_{grav} + PE_{spring}; \quad \mathcal{P} = \vec{\mathbf{F}} \cdot \vec{\mathbf{v}} = \frac{W}{\Delta t};$$

$$\vec{\mathbf{p}} = m\vec{\mathbf{v}}; \quad \vec{\mathbf{I}} = \vec{F}\Delta t = \Delta\vec{\mathbf{p}} = m\left(\vec{\mathbf{v}}_f - \vec{\mathbf{v}}_i\right); \quad v_{1i} - v_{2i} = -\left(v_{1f} - v_{2f}\right); \quad \vec{p}_i = \vec{p}_f;$$

$$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = m_1\vec{v}_{1f} + m_2\vec{v}_{2f}; \quad \sum \vec{F}_{external} = \frac{\Delta\vec{p}}{\Delta t};$$

$$\begin{Bmatrix} F = G\dfrac{m_1 m_2}{r^2} \\ G = 6.67 \times 10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2 \end{Bmatrix}; \quad \begin{Bmatrix} M_{Earth} = 5.98 \times 10^{24}\ \text{kg} \\ R_{Earth} = 6.37 \times 10^{6}\ \text{m} \end{Bmatrix}; \quad PE = -G\frac{m_1 m_2}{r}; \quad g = 9.80\ \text{m/s}^2;$$

$$g = G\frac{M}{r^2};\ 100\ \text{cm} = 1\ \text{m};\ \ 1{,}000\ \text{m} = 1\ \text{km};\ \ 60\ \text{s} = 1\ \text{min};\ 60\ \text{min} = 1\ \text{hr};\ \ 2.54\ \text{cm} = 1\ \text{in};$$

$$12\ \text{in} = 1\ \text{ft};\ \ 5{,}280\ \text{ft} = 1\ \text{mi};\ \ 1{,}609\ \text{m} = 1\ \text{mi};\ \ 0.3048\ \text{m} = 1\ \text{ft};\ 2\pi\ \text{rad} = 1\ \text{rev} = 360\ \text{deg}.$$