University Physics 1
Midterm Exam 2

Name: _____

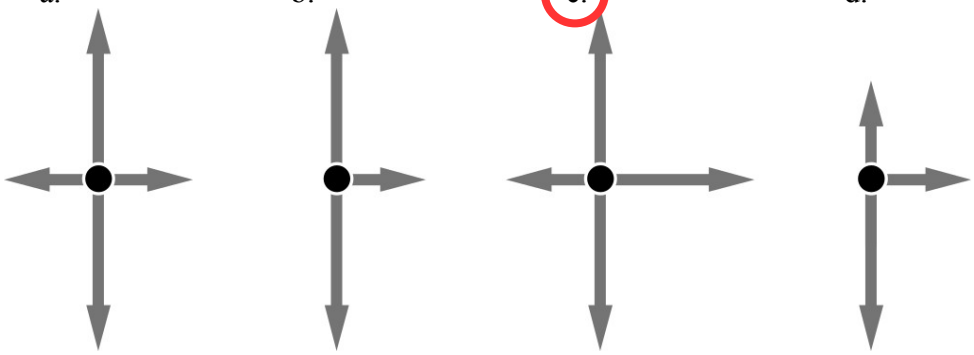
Multiple Choice Questions:
Select the best answer by circling the letter.

1. A bucket is being lowered into a well by a rope. The bucket's downward speed is *decreasing*. Which statement best describes the forces on the bucket?

a. the upward force by the rope is greater than the downward force of gravity.
b. the upward force by the rope is equal to the downward force of gravity.
c. the upward force by the rope is smaller than the downward force of gravity.
d. which force is greater depends on the weight of the bucket

2. A boy is pushing a box across the floor toward the right at a steadily increasing speed. There is some friction. Which could be a free-body diagram for the box?

a. b. c. d.



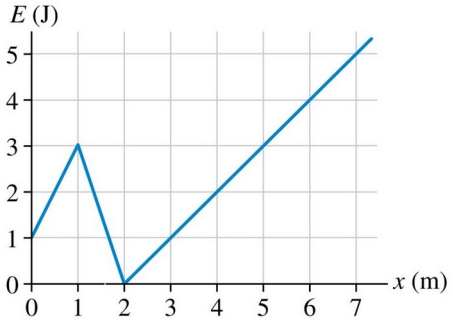
3. A rope pulls a box toward the left across a horizontal frictionless floor. What are the correct descriptions of the work done by the rope's tension force (W_{tens}), the work done by gravity (W_{grav}), and the work done by the normal force (W_{norm}) ?

a. $W_{tens} > 0$, $W_{grav} > 0$, $W_{norm} > 0$
b. $W_{tens} < 0$, $W_{grav} < 0$, $W_{norm} = 0$
c. $W_{tens} > 0$, $W_{grav} = 0$, $W_{norm} = 0$
d. $W_{tens} < 0$, $W_{grav} = 0$, $W_{norm} = 0$

4. A 2 kg plastic cart and a 20 kg lead cart both roll without friction on a horizontal surface. Equal forces are used to push both carts forward a distance of 1m, starting from rest. Compare the kinetic energies of the plastic cart K_1 and the lead cart K_2 after travelling 1m.

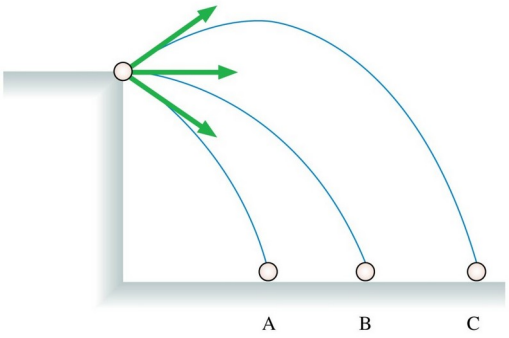
a. $K_1 = K_2$
b. $K_1 = 10K_2$
c. $10K_1 = K_2$
d. $K_1 = 100K_2$

5. A particle with the potential energy shown is moving to the right. It has 1.0 J of kinetic energy at $x = 1.0$ m. In the region $1.0\text{ m} < x < 2.0\text{ m}$, the particle is



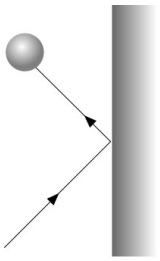
a. Speeding up.
b. Slowing down.
c. Moving at constant speed.
d. Cannot be determined from this information.

6. Three balls are thrown from a cliff with the same speed but at different angles. Which ball has the greatest speed just before it hits the ground? (ignore air resistance)



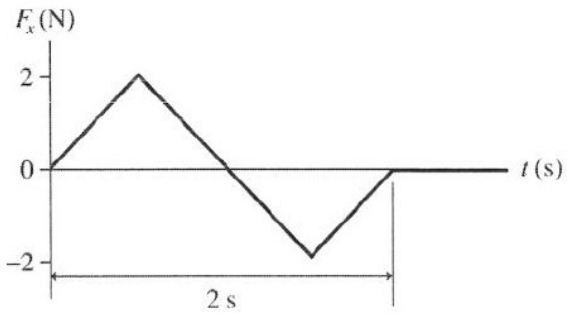
a. Ball A
b. Ball B
c. Ball C
d. All balls have the same speed.

7. A ball bounces elastically off a wall as shown. What is its change in momentum?



a. $\Delta\vec{p} = 0$
b. $\Delta\vec{p} =$ ↑
c. $\Delta\vec{p} =$ ←
d. $\Delta\vec{p} =$ →

8. A 2kg object is moving to the right (+) with a speed of 1 m/s when it experiences an impulse as shown in the graph. What is the object's velocity after the impulse?



a. 0
b. 1 m/s
c. 2 m/s
d. –2 m/s

Long Answer Problems:

Correct units must be included with every answer.
Answers should be written on the blank provided, and work that you want credit for must be done in the box. If you need more space, note that the work is continued on another page.

1. An aircraft moves such that its horizontal position is given by $x(t) = at^2 - b$ and its vertical position is given by $y(t) = ce^{-dt}$, where a, b, c, d are constants with appropriate units. If the aircraft has a mass m, find the the net force on it as a function of time.

   Give the answer as a vector in $\hat{\imath}\ \hat{\jmath}\ \hat{k}$ notation, in terms of the variables given.

   answer: $\vec{F} =$ $2ma\hat{\imath} + mcd^2e^{-dt}\hat{\jmath}$

$$\vec{F} = m\vec{a} = m\frac{d}{dt}\left(\frac{d}{dt}\vec{r}\right)$$

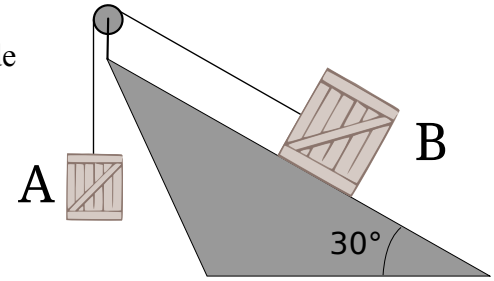
$$\vec{r} = (at^2 - b)\hat{\imath} + ce^{-dt}\hat{\jmath}$$

$$\frac{d}{dt}\vec{r} = 2at\,\hat{\imath} - cde^{-dt}\hat{\jmath}$$

$$\frac{d^2}{dt^2}\vec{r} = 2a\hat{\imath} + cd^2e^{-dt}\hat{\jmath}$$

$$\vec{F} = 2ma\hat{\imath} + mcd^2e^{-dt}\hat{\jmath}$$

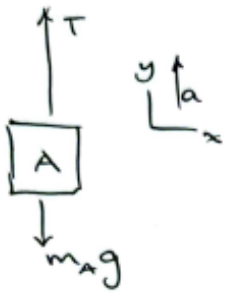
2. Two masses, A and B, are connected on a frictionless ramp as shown. If $m_A = 2.0$ kg, $m_B = 8.0$ kg, find the magnitude of the acceleration of block A. Also find the tension in the string that connects them.



answers:

acceleration = 1.96 m/s^2

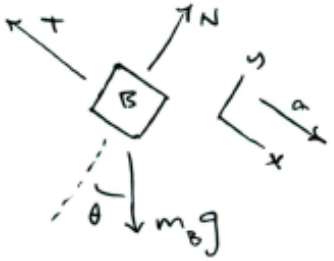
tension = 23.5 N



$\vec{F} = m\vec{a}$

$T\hat{j} - m_A g\hat{j} = m_A a\hat{j}$

$T = m_A g + m_A a$ ①



$\vec{F} = m\vec{a}$

$-T\hat{i} + N\hat{j} + m_B g(\hat{i}\sin\theta - \hat{j}\cos\theta) = m_B a\hat{i}$

x-direction:

$-T + m_B g\sin\theta = m_B a$ ②

Plug equation ① into ②:

$-m_A g - m_A a + m_B g\sin\theta = m_B a$

$a = \dfrac{m_B g\sin\theta - m_A g}{m_A + m_B} = 1.96\ m/s^2$

Back into equation ①:

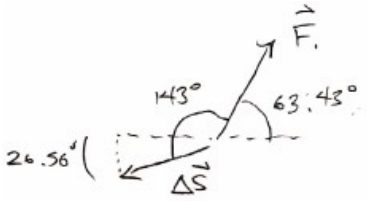
$T = m_A(g + a) = 23.52$ N

3. Consider a particle on which several forces act, one of which is known to be constant in time: $\vec{F}_1 = (2\text{ N})\hat{\imath} + (4\text{ N})\hat{\jmath}$. As a result, the particle moves along a straight path from a Cartesian coordinate of (2 m, 2 m) to (0 m, 1 m). What is the work done by $\vec{F}_1$?

answer: -8 J

$$W = \vec{F} \cdot \Delta\vec{s} = (2\hat{\imath} + 4\hat{\jmath}) \cdot (-2\hat{\imath} - 1\hat{\jmath})\ \text{N m}$$

$$= -4 - 4 = -8\ \text{N m}$$



$$F_1\,\Delta s \cos\theta = \sqrt{20} \cdot \sqrt{5} \cdot \cos 143^\circ = -8\ \text{J}$$

4. A skier starts from rest at point *A* and slides downhill to point *B*, dropping by 30 meters in vertical height. Between *A* and *B*, the work done by air resistance on the skier is −1000 J. (The work done by air resistance is negative since the it acts in the opposite direction to the displacement.) If the mass of the skier is 40 kg, what is the speed of the skier at point *B*? Ignore any friction between the skis and the snow.

answer: 23.2 m/s

$$W = \Delta K + \Delta U$$

$$-1000\ \text{J} = \tfrac{1}{2}mv^2 - mgy$$

$$\tfrac{1}{2}v^2 = \tfrac{W}{m} + gy$$

$$v = \sqrt{2\left(\tfrac{W}{m} + gy\right)} = 23.19\ \text{m/s}$$

5. Two carts on a straight track collide head on. The first cart was moving at 4.0 m/s in the positive x direction and the second was moving at 3.0 m/s in the opposite direction. After the collision, the second car continues moving in its initial direction of motion at 0.3 m/s. If the mass of the second car is 5.0 times that of the first, what is the final x-velocity of the first cart?

answer: -9.5 m/s