1. Which one of the following statements concerning kinetic energy is true?

A) Kinetic energy can be measured in watts.
B) Kinetic energy is always equal to the potential energy.
C) Kinetic energy is always positive.
D) Kinetic energy is a quantitative measure of inertia.
E) Kinetic energy is directly proportional to velocity.

2. A man jumps from the roof of a tall building, but is unhurt because the person lands on an air-filled bag. Which one of the following best describes why no injury occurs?

$$\Delta p = F\Delta t \Rightarrow F = \Delta p/\Delta t; \quad \Delta t \text{ increases, } F \text{ decreases}$$

A) The bag provides the necessary force to stop the person.

B) The bag reduces the impulse to the person.

C) The bag increases the amount of time the force acts on the person and reduces the change in momentum.

D) The bag decreases the amount of time during which the momentum is changing and reduces the average force on the person.

E) The bag increases the amount of time during which the momentum is changing and reduces the average force on the person.

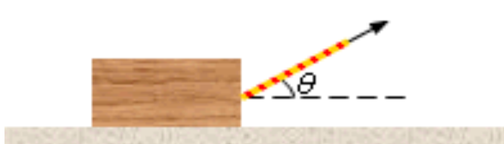
3. A tennis ball has a velocity of 12 m/s downward just before it strikes the ground and bounces up with a velocity of 12 m/s upward. Which statement is true concerning this situation?

Momentum is a <u>vector</u>! Ball collides with Earth.
Momentum of the system (Ball + Earth) remains constant.
Ball's momentum <u>vector</u> changes : $v_{B,0} = -12$ m/s; $v_{B,f} = +12$ m/s
Therefore, Earth's momentum must also change.

A) The momentum of the ball and the momentum of the earth both change.
B) Neither the momentum of the ball nor the momentum of the earth changes.
C) The momentum of the ball is changed; and the momentum of the earth is not changed.
D) The momentum of the ball is unchanged; and the momentum of the earth is changed.
E) Both the momentum and the kinetic energy of the ball change because of the collision.

4. A concrete block is pulled 7.0 m across a frictionless surface by means of a rope. The tension in the rope is 40 N; and the net work done on the block is 211 J. What angle does the rope make with the horizontal?

A) 28°
B) 41°
C) 47°
D) 62°
E) 88°



$s = 7.0\,\text{m}, T = 40\text{ N}, W = 211\text{ J};$

$$W = Fs = (T\cos\theta)s;$$

$$\theta = \cos^{-1}\left(\frac{W}{Ts}\right) = \cos^{-1}\left(\frac{211\text{ J}}{(40\text{ N})(7.0\text{ m})}\right) = 41°$$

5. The kinetic energy of a car is 8×10^6 J, as it travels along a horizontal road. How much power is required to stop the car in 100 s?

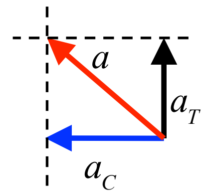
A) zero watts
B) 8×10^4 W
C) 8×10^5 W
D) 8×10^6 W
E) 8×10^7 W

$$\text{Power} = \frac{E}{t} = \frac{8\times10^6 \text{ J}}{100\text{s}} = 8\times10^4 \text{ W}$$

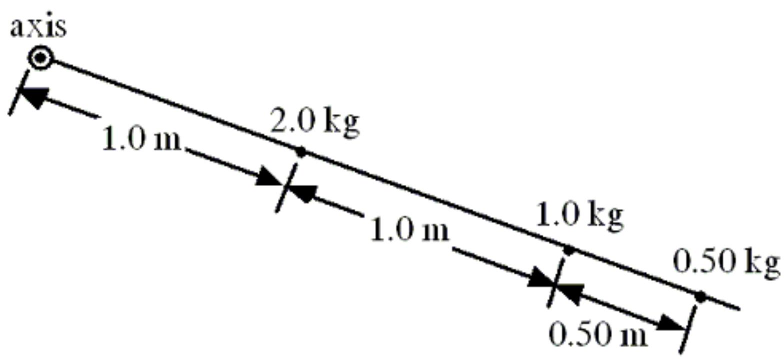
6. At a specific time, an object moving on a circle of radius 5.0 m, experiences a centripetal acceleration of 2.0 m/s^2, and an angular acceleration of 0.70 rad/s^2. What is the total linear acceleration of the object?

A) 2.5 m/s^2
B) 2.9 m/s^2
C) 3.2 m/s^2
D) 4.0 m/s^2
E) 4.5 m/s^2

$$a_C = 2.0 \text{ m/s}^2, \alpha = 0.70 \text{ rad/s}^2, r = 5.0 \text{ m}$$
$$a_T = \alpha r = 3.5 \text{ m/s}^2$$
$$a = \sqrt{a_T^2 + a_C^2} = \sqrt{(3.5)^2 + (2.0)^2}\text{m/s} = 4.0\text{m/s}$$



7. Three objects are attached to a *massless* rigid rod that has an axis of rotation as shown. Assuming all of the mass of each object is located at the point shown for each, calculate the moment of inertia of this



A) 1.3 kg · m^2
B) 3.1 kg · m^2
C) 5.3 kg · m^2
D) 7.2 kg · m^2
E) 9.1 kg · m^2

$$I = \sum mr^2 = (2.0 \text{ kg})(1.0 \text{ m})^2 + (1.0 \text{ kg})(2.0 \text{ m})^2 + (0.5 \text{ kg})(2.5 \text{ m})^2$$
$$= (2+4+3.1)\text{kg}\cdot\text{m}^2 = 9.1\text{kg}\cdot\text{m}^2$$

8. A 5.00-kg block of ice is sliding across a frozen pond at 10.00 m/s. A 7.60-N force is applied *opposite* to the direction of motion. After the ice block slides 15.0 m, the force is removed. The work done by the applied force is

A) –114 J.
B) +114 J.
C) –735 J.
D) +735 J.
E) +19.7 J

$$W = Fs = (-7.60\text{N})(15.0\text{m}) = -114\text{J}$$

9. A rock is dropped from a high tower and falls freely under the influence of gravity. Which one of the following statements concerning the rock as it falls is true? Neglect the effects of air resistance.

$$\Delta p = F\Delta t = (mg)\Delta t$$

A) The rock will gain an equal amount of kinetic energy during each second.

B) The rock will gain an equal amount of momentum during each second.

C) The rock will gain an equal amount of speed for each meter through which it falls.

D) The rock will gain an equal amount of momentum for each meter through which it falls.

E) The amount of momentum the rock gains will be proportional to the amount of potential energy that it loses.

10. A bicycle travels 282 m along a circular track of radius 30 m. What is the angular displacement in radians of the bicycle from its starting position?

A) 1.0 rad
B) 1.5 rad
C) 3.0 rad
D) 4.7 rad
E) 9.4 rad

$$\theta = \frac{s}{r} = \frac{282\text{ m}}{30\text{ m}} = 9.4\text{ rad}$$

11. A child standing on the edge of a freely spinning merry-go-round moves quickly to the center. Which one of the following statements is necessarily true concerning this event and why?

A) The angular speed of the system decreases because the moment of inertia of the system has increased.

B) The angular speed of the system increases because the moment of inertia of the system has increased.

C) The angular speed of the system increases because the moment of inertia of the system has decreased.

D) The angular speed of the system decreases because the moment of inertia of the system has decreased.

E) The angular speed of the system remains the same because the net torque on the merry-go-round is zero N · m.

No external torque: angular momentum conserved

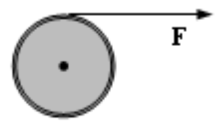
$$I_0\omega_0 = I_f\omega_f; \quad \omega_f = (I_0/I_f)\omega_0$$

Moment of inertia decreases: $I_0 > I_f \Rightarrow$ speed increases: $\omega_f > \omega_0$

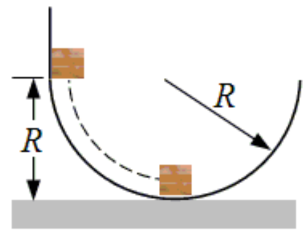
12. A string is wrapped around a pulley of radius 0.05 m and moment of inertia 0.4 kg · m². If the string is pulled with a force $\vec{F}$, the resulting angular acceleration of the pulley is 2 rad/s². Determine the magnitude of the force $\vec{F}$.

A) 0.4 N
B) 2 N
C) 8 N
D) 16 N
E) 40 N

$$\tau = I\alpha; \quad \tau = FR; \quad \Rightarrow \quad FR = I\alpha$$
$$F = \frac{I\alpha}{R} = \frac{(0.4\ \text{kg}\cdot\text{m}^2)(2\ \text{rad/s}^2)}{0.05\ \text{m}} = 16\ \text{N}$$



A block of mass *m* is released from rest at a height *R* above a horizontal surface. The acceleration due to gravity is *g*. The block slides along the inside of a frictionless circular hoop of radius *R*



13. Which one of the following expressions gives the speed of the mass at the bottom of the hoop?

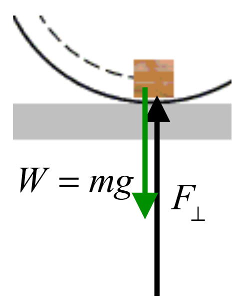
A) zero m/s²
B) $v = mgR$
C) $v = mg/(2R)$
D) $v^2 = 2gR$
E) $v^2 = g^2/R$

$$mgR = \tfrac{1}{2}mv^2$$
$$v^2 = 2gR$$

14. For the mass in the problem above, what is the magnitude of the normal force exerted on the block by the hoop when the block reaches the bottom of the hoop?

A) zero newtons
B) mg^2/R
C) $3mg$
D) $2mg$
E) $1mg$

$$F_C = ma_C = m\frac{v^2}{R} = m\frac{2gR}{R}$$
$$F_C = F_\perp - mg = 2mg; \quad F_\perp = 3mg$$

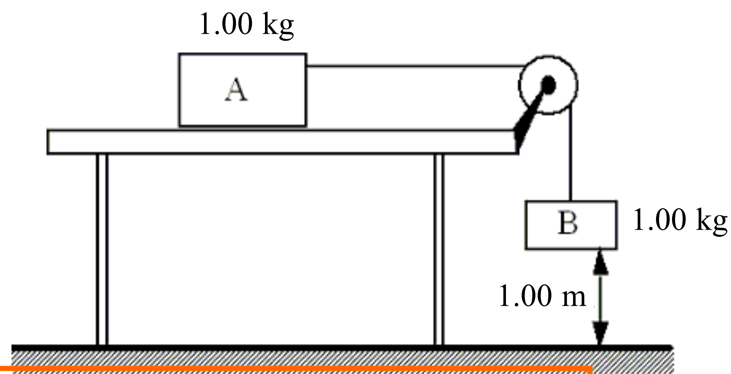


15. A certain string just breaks when it is under 54 N of tension. A boy uses this string to whirl a 0.75-kg stone in a horizontal circle of radius 2.0 m. The boy continuously increases the speed of the stone. At approximately what speed will the string break?

A) 6.4 m/s
B) 8.2 m/s
C) 12 m/s
D) 15 m/s
E) 18 m/s

$$F_{break} = 54\ \text{N},\ m = 0.75\text{N},\ R = 2.0\ \text{m}$$
$$F_C = F_{break}; \qquad F_C = ma_C = m\frac{v^2}{r};$$
$$m\frac{v^2}{R} = F_{break} \quad \Rightarrow \quad v = \sqrt{\frac{F_{break}R}{m}} = \sqrt{\frac{(54\ \text{N})(2.0\,\text{m})}{0.75\ \text{kg}}} = 12\ \text{m/s}$$

16. Two boxes are connected to each other as shown. The system is released from rest and the 1.00-kg box falls through a distance of 1.00 m. The surface of the table is frictionless. What is the kinetic energy of box B just before it reaches the floor?



A) 2.45 J
B) 4.90 J
C) 9.80 J
D) 29.4 J
E) 39.2 J

PE_A (constant); $PE_{B0} = m_B gh = 9.8$ J; $PE_{fB} = 0$

$$KE_f + PE_f = KE_0 + PE_0$$

$$\tfrac{1}{2}(m_A + m_B)v^2 = PE_{B0} \quad \Rightarrow v^2 = \frac{2}{m_A + m_B} PE_{B0}$$

$$KE_f = \tfrac{1}{2} m_B v^2 = \frac{m_B}{m_A + m_B} PE_{B0} = \frac{1}{2} 9.8 \text{ J} = 4.90 \text{ J}$$

17. A 200-kg cannon at rest contains a 10-kg cannon ball. When fired, the cannon ball leaves the cannon with a speed of 90 m/s. What is the recoil speed of the cannon?

A) 4.5 m/s
B) 9 m/s
C) 45 m/s
D) 90 m/s
E) zero m/s

$m_c = 200\,\text{kg},\ m_b = 10\,\text{kg},\ v_b = 90\,\text{m/s}.$

$$P_f = P_0; \quad m_b v_b + m_c v_c = 0; \quad v_c = \frac{m_b}{m_c} v_b = \frac{10}{200}(90\,\text{m/s}) = 4.5\,\text{m/s}$$

18. A car enters a horizontal, curved roadbed of radius 200 m. The coefficient of static friction between the tires and the roadbed is 0.20. What is the maximum speed with which the car can safely negotiate the unbanked curve?

A) 5 m/s
B) 10 m/s
C) 20 m/s
D) 40 m/s
E) 100 m/s

$\mu = 0.20,\ R = 200.0$ m

$$F_\perp = mg; \quad F_f = \mu F_\perp; \quad ma_C = m\frac{v^2}{r};$$

$$\cancel{m}\frac{v^2}{R} = \mu \cancel{mg} \quad \Rightarrow \quad v = \sqrt{\mu g R} = \sqrt{0.20(9.8 \text{ m/s}^2)(200\text{m})} = 20 \text{ m/s}$$

19. A string is tied to a doorknob 0.50 m from the hinge as illustrated in the figure. At the instant shown, the force applied to the string is 5.0 N. What is the magnitude of the torque on the door?

A) 2.1 N · m
B) 3.0 N · m
C) 1.0 N · m
D) 0.78 N · m
E) 0.60 N · m

$\tau = F_{\perp}L = (F\sin\theta)L = (5.0\ \sin 57°)0.50\ \text{N}\cdot\text{m} = 2.1\,\text{N}\cdot\text{m}$

20. In which one of the following situations is zero net work done?

A) A ball rolls down an inclined plane.
B) A physics student stretches a spring.
C) A box is pulled across a rough floor at constant velocity.
D) A projectile falls toward the surface of Earth.
E) A child pulls a toy across a rough surface causing it to accelerate.

v constant, $\Delta KE = 0$

Net work: $W_p + W_f = \Delta KE = 0$