

Q1.

On a dry road, a car with good tires is able to brake with a constant deceleration of  $5.00 \text{ m/s}^2$ . If the car is traveling initially at a constant speed of  $30.0 \text{ m/s}$ , how far does the car travel from the moment the brakes are applied until it comes to a complete stop?

- A) 90.0 m
- B) 6.00 m
- C) 150 m
- D) 180 m
- E) 30.0 m

Q2.

Which ONE of the following statements is TRUE?

- A) The kinetic energy of a system of colliding bodies is always conserved in elastic collision.
- B) Linear momentum of a system of colliding bodies is always not conserved in inelastic collision.
- C) Linear momentum of a system of colliding bodies is always not conserved in elastic collision.
- D) The kinetic energy of a system of colliding bodies is always conserved in inelastic collision.
- E) If the net external torque on a system is zero, the angular momentum of the system is not conserved.

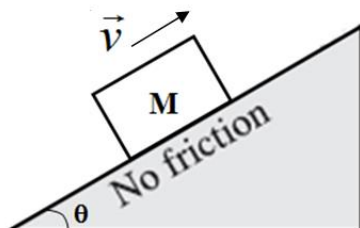
Q3.

The water in a river flows due north with a speed of  $2.00 \text{ m/s}$ . A boat crosses the river with a velocity of  $4.20 \text{ m/s}$  due east relative to the water. The river is  $800 \text{ m}$  wide. What is the magnitude of the velocity of the boat relative to the ground?

- A) 4.65 m/s
- B) 2.85 m/s
- C) 2.20 m/s
- D) 3.10 m/s
- E) 3.69 m/s

Q4.

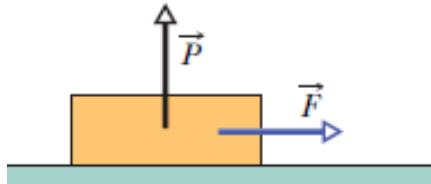
A block is given an initial velocity of  $5.00 \text{ m/s}$  up a frictionless incline of angle  $\theta = 20.0^\circ$ , as shown in **Figure 1**. How far up the incline does the block slide before coming to rest?



- A) 3.73 m
- B) 1.28 m
- C) 2.55 m
- D) 7.46 m
- E) 5.00 m

Q5.

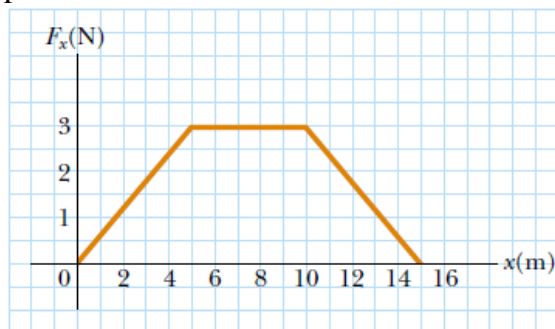
A 2.5 kg block is initially at rest on a horizontal surface. A horizontal force  $F$  of magnitude 6.0 N and a vertical force  $P$  of magnitude 10 N are then applied to the block, as shown in **Figure 2**. The static and kinetic friction coefficients between the block and surface are  $\mu_s = 0.40$  and  $\mu_k = 0.25$ , respectively. Determine the acceleration of the block.



- A)  $0.95 \text{ m/s}^2$
- B) Zero
- C)  $2.40 \text{ m/s}^2$
- D)  $1.40 \text{ m/s}^2$
- E)  $1.20 \text{ m/s}^2$

Q6.

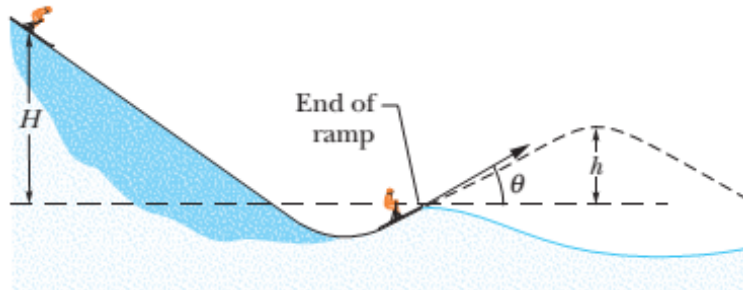
A 4.00-kg particle is subject to a force that varies with position, as shown in **Figure 3**. The particle starts from rest at  $x = 0$ . What is its speed at  $x = 15.0 \text{ m}$ ?



- A) 3.87 m/s
- B) 2.74 m/s
- C) 7.50 m/s
- D) Zero
- E) 4.70 m/s

Q7.

A 60 kg skier starts from rest at height  $H = 20$  m above the end of a ski-jump ramp (see **Figure 4**) and leaves the ramp at angle  $\theta = 28^\circ$ . Neglect the effects of air resistance and assume the ramp is frictionless. What is the maximum height ( $h$ ) of his jump above the end of the ramp?



- A) 4.4 m
- B) 8.5 m
- C) 16 m
- D) 5.7 m
- E) 3.6 m

Q8.

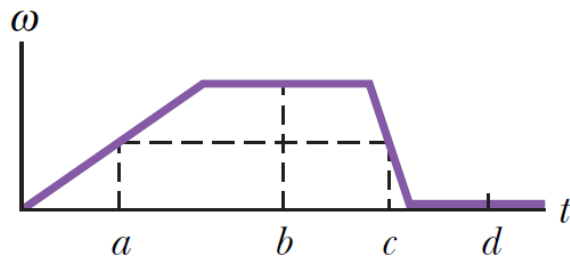
A 150 gram baseball is hit toward the left by a bat. The magnitude of the force the bat exerts on the ball as a function of time is shown in **Figure 5**. Find the magnitude and direction of the impulse that the ball imparts to the bat.



- A) 12.0 N.s to the right
- B) 12.0 N.s to the left
- C) 20.0 N.s to the right
- D) 20.0 N.s to the left
- E) 14.0 N.s to the right

Q9.

**Figure 6** is a plot of the angular velocity versus time for a rotating disk. For a point on the disk rim, rank the instants  $a$ ,  $b$ ,  $c$ , and  $d$  according to the magnitude of the radial acceleration, **greatest** first.



- A)  $b$ , then  $a$  and  $c$  tie, then  $d$   
 B)  $c$ ,  $a$ , then  $b$  and  $d$  tie  
 C)  $a$ ,  $c$ , then  $b$  and  $d$  tie  
 D)  $c$ ,  $b$ ,  $a$ ,  $d$   
 E)  $c$ , then  $a$  and  $b$  tie, then  $d$

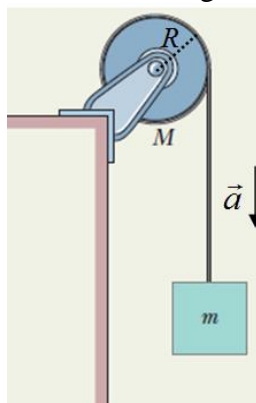
Q10.

A uniform rod (length 6.00 m, mass 1.00 kg) rotates at 240 rev/min in a horizontal plane about a vertical axis through one end. Calculate the magnitude of its angular momentum about the axis of rotation.

- A) 302 kg.m<sup>2</sup>/s  
 B) 75.4 kg.m<sup>2</sup>/s  
 C) 50.3 kg.m<sup>2</sup>/s  
 D) 173 kg.m<sup>2</sup>/s  
 E) 86.4 kg.m<sup>2</sup>/s

Q11.

**Figure 7** shows a uniform disk, with mass  $M = 2.5$  kg and radius  $R = 20$  cm, mounted on a fixed horizontal axle. A block with mass  $m = 1.2$  kg hangs from a massless cord that is wrapped around the rim of the disk. The cord does not slip, and there is no friction at the axle. What is the magnitude of the tension in the cord, when the block is moving downward?



- A) 6.0 N  
 B) 27 N  
 C) 44 N  
 D) 50 N  
 E) 18 N

Q12.

What is the applied pressure to a solid copper cube in order to reduce its volume to 40 % of the original volume? The bulk modulus of copper is  $1.4 \times 10^{11} \text{ N/m}^2$ .

- A)  $8.4 \times 10^{10} \text{ N/m}^2$
- B)  $5.6 \times 10^{10} \text{ N/m}^2$
- C)  $3.5 \times 10^{11} \text{ N/m}^2$
- D)  $2.3 \times 10^{11} \text{ N/m}^2$
- E)  $1.4 \times 10^{11} \text{ N/m}^2$

Q13.

The mass of a planet is 1/100 that of Earth and its radius is 1/4 that of Earth. If the weight of a person on the surface of Earth is 600 N, what is the weight of the same person on the surface of this planet?

- A) 96.3 N
- B) 24.1 N
- C) 48.2 N
- D) 193 N
- E) 600 N

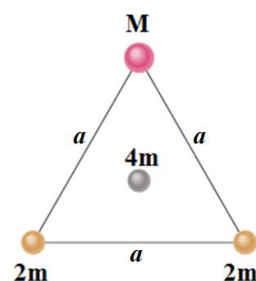
Q14.

A satellite of mass  $5.0 \times 10^3 \text{ kg}$  moves around a planet in a circular orbit of radius  $9.4 \times 10^6 \text{ m}$  with a period of  $2.8 \times 10^4 \text{ s}$ . What is the mass of the planet?

- A)  $6.3 \times 10^{23} \text{ kg}$
- B)  $4.8 \times 10^{23} \text{ kg}$
- C)  $3.1 \times 10^{24} \text{ kg}$
- D)  $8.3 \times 10^{23} \text{ kg}$
- E)  $1.5 \times 10^{24} \text{ kg}$

Q15.

As seen in **Figure 8**, two spheres of mass  $2m$  and a third sphere of mass  $M$  form an equilateral triangle of side  $a$ , and a fourth sphere of mass  $4m$  is at the center of the triangle. The net gravitational force on that central sphere from the three other spheres is zero. What is the mass  $M$  in terms of  $m$ ?



- A)  $M = 2m$
- B)  $M = 6m$
- C)  $M = 4m$
- D)  $M = 3m$
- E)  $M = m$

Q16.

A 150.0 kg rocket moving radially outward from Earth has a speed of 3.70 km/s at 200 km above Earth's surface. What is the rocket's kinetic energy when the rocket is 1000 km above Earth's surface? (Neglect the air drag acts on the rocket)

- A)  $3.83 \times 10^7$  J
- B)  $1.03 \times 10^9$  J
- C)  $7.09 \times 10^7$  J
- D)  $5.88 \times 10^{10}$  J
- E) Zero

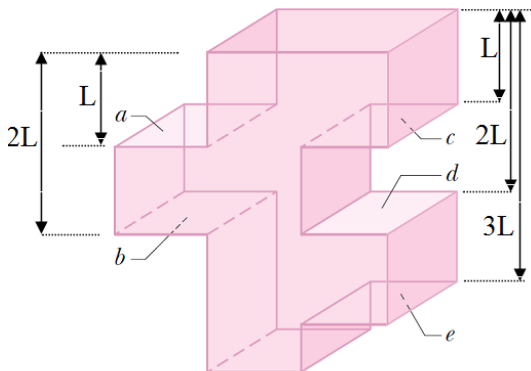
Q17.

A solid uniform sphere has a mass of  $5.0 \times 10^3$  kg and a radius of 2.0 m. What is the magnitude of the gravitational force due to the sphere on a particle of mass 1.0 kg located at a distance of 1.0 m from the center of the sphere?

- A)  $4.2 \times 10^{-8}$  N
- B)  $8.3 \times 10^{-8}$  N
- C)  $1.7 \times 10^{-7}$  N
- D) Zero
- E)  $9.8 \times 10^{-7}$  N

Q18.

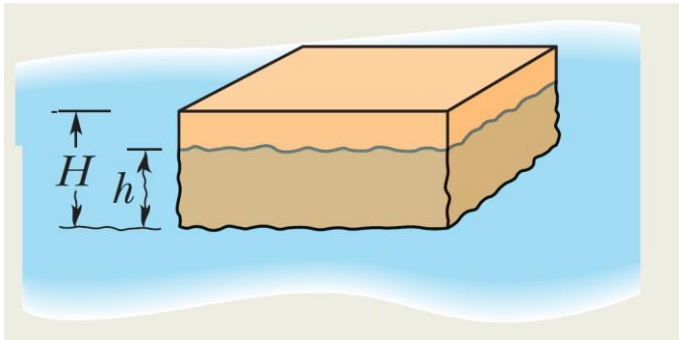
**Figure 9** shows a tank filled with water. Five horizontal floors and ceilings (a, b, c, d, and e) are indicated; all have the same area and are located at distances  $L$ ,  $2L$ , or  $3L$  below the top of the tank. Rank the floors and ceilings according to the force on them due to the water, **greatest** first?



- A)  $e$ , then  $b$  and  $d$  tie, then  $a$  and  $c$  tie
- B)  $a$  and  $c$  tie, then  $b$  and  $d$  tie, then  $e$
- C) ( $b$ ,  $c$  and  $e$ ) tie, then ( $a$  and  $d$ ) tie
- D)  $b$  and  $d$  tie, then  $a$  and  $c$ , then  $e$
- E) all tie

Q19.

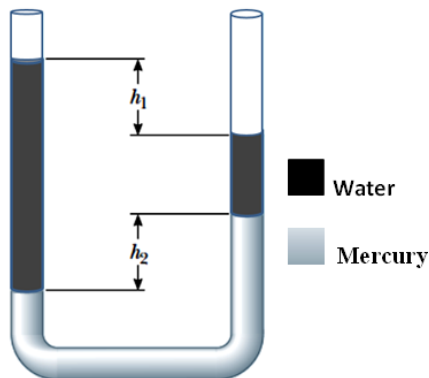
In **Figure 10**, a block of density  $\rho = 800 \text{ kg/m}^3$  floats face down in a fluid of density  $\rho_f = 1200 \text{ kg/m}^3$ . The block has height  $H = 12.0 \text{ cm}$ . By what depth  $h$  is the block submerged?



- A) 8.00 cm
- B) 10.0 cm
- C) 11.0 cm
- D) 9.00 cm
- E) 6.00 cm

Q20.

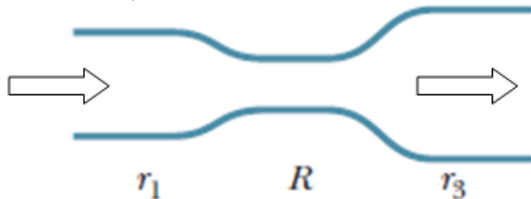
A U-tube of uniform cross-sectional area, open to the atmosphere, is partially filled with mercury. Water is then poured into both arms. If the equilibrium configuration of the tube is as shown in **Figure 11**, with  $h_2 = 1.00 \text{ cm}$ , determine the value of  $h_1$ . (Densities of water and mercury are  $\rho_w = 1.00 \text{ g/cm}^3$  and  $\rho_m = 13.6 \text{ g/cm}^3$ , respectively). (Note that  $h_1$  and  $h_2$  are not drawn to scale).



- A) 12.6 cm
- B) 14.6 cm
- C) 11.6 cm
- D) 13.6 cm
- E) 10.6 cm

Q21.

In **Figure 12**, water flows steadily from the left pipe section (radius  $r_1 = 2.00R$ ), through the middle section (radius  $R$ ), and into the right section (radius  $r_3 = 3.00R$ ). The speed of the water in the middle section is  $0.500$  m/s. What is the net work done on  $400$  kg of the water as it moves from the left section to the right section? (The arrows represent the direction of water flow).



- A)  $-2.51$  J
- B)  $3.75$  J
- C)  $0.617$  J
- D)  $-1.50$  J
- E)  $3.20$  J

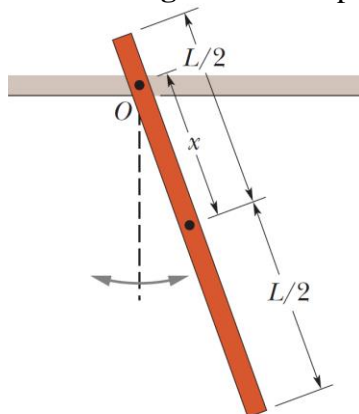
Q22.

An object of mass  $m = 2.00$  kg oscillates with simple harmonic motion along the  $x$  axis. Its position varies with time according to the equation  $x = 5.00 \cos(\pi t + \pi/4)$ , where  $t$  is in second,  $x$  is in meter and the angles are in radians. What is the kinetic energy of the object at time  $t = 2.00$  s?

- A)  $123$  J
- B)  $25.0$  J
- C)  $9.89$  J
- D)  $11.1$  J
- E)  $78.5$  J

Q23.

A physical pendulum consists of a uniform meter stick that is pivoted at a small hole drilled through the stick at point  $O$ , which is at distance  $x$  from the center of mass of the stick, as shown in **Figure 13**. The period of oscillation is  $2.5$  s. What is the value of  $x$ ?



- A)  $0.056$  m
- B)  $0.123$  m
- C)  $0.215$  m
- D)  $0.079$  m
- E)  $0.432$  m



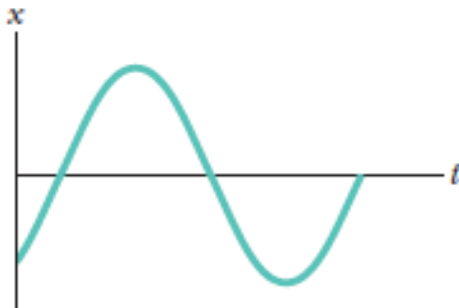
Q24.

A block oscillates in simple harmonic motion on the end of a spring, with position given by  $x = x_m \cos(\omega t + \pi/5)$ . At  $t = 0$ , what percentage of the total mechanical energy is potential energy?

- A) 66 %
- B) 81 %
- C) Zero
- D) 31 %
- E) 20 %

Q25.

Which of the following describe  $\phi$  for the simple harmonic motion, which is represented by  $x = x_m \cos(\omega t + \phi)$  and shown in **Figure 14**?



- A)  $\pi < \phi < 3\pi/2$
- B)  $0 \leq \phi < \pi/6$
- C)  $\pi/4 \leq \phi \leq \pi/2$
- D)  $0 \leq \phi < \pi/2$
- E)  $3\pi/2 < \phi < 2\pi$