

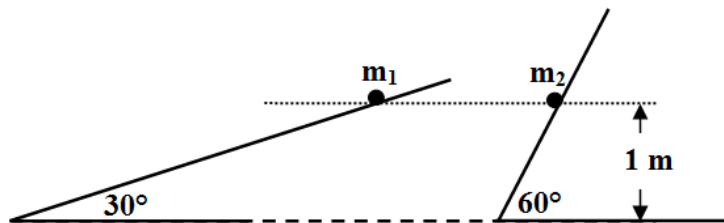
Q1.

A car, of mass 2300 kg, reaches a speed of 29.0 m/s in 6.10 s starting from rest. What is the average power used by the engine during the period of acceleration?

- A) 159 kW
- B) 52.3 kW
- C) 267 kW
- D) 352 kW
- E) zero

Q2.

Two masses  $m_1$  and  $m_2 = 2m_1$  start from rest from the same height from the top of two frictionless inclines of angles  $30^\circ$  and  $60^\circ$  (see **Figure 1**). When the masses reach the bottom of the inclines:



- A) Both masses are moving with the same speed.
- B)  $m_1$  moves faster than  $m_2$ .
- C)  $m_2$  moves faster than  $m_1$ .
- D) Both masses have the same kinetic energy.
- E)  $m_1$  has more kinetic energy than  $m_2$ .

Q3.

A 500 kg elevator is pulled upward with a constant force of 5500 N for a distance of 50 m. What is the net work done on the elevator by all forces acting on it?

- A)  $+ 3.0 \times 10^4$  J
- B)  $- 5.2 \times 10^5$  J
- C)  $- 3.6 \times 10^5$  J
- D)  $+ 2.1 \times 10^5$  J
- E)  $+ 1.7 \times 10^4$  J

Q4.

A simple pendulum is 1.30 m long. The mass at its end is pulled to one side until the pendulum makes an angle of  $29.0^\circ$  with the vertical and then released from rest. If the kinetic energy of the mass at the lowest point of its motion is 0.360 J, what is the value of the mass?

- A) 0.225 kg
- B) 0.106 kg
- C) 0.140 kg
- D) 0.980 kg
- E) zero

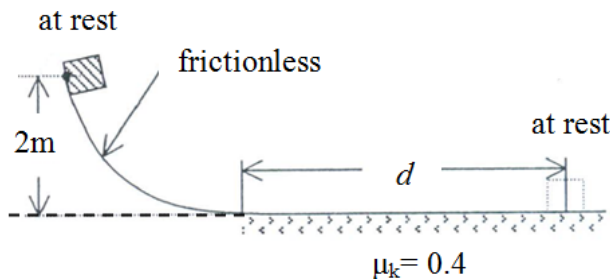
Q5.

A ball falls from the top of a building to the floor. At the moment when it is 0.70 m above the floor, its gravitational potential energy equals its kinetic energy. What is the speed of the ball at that moment? Take the floor as the reference of gravitational potential energy.

- A) 3.7 m/s
- B) 6.9 m/s
- C) 9.8 m/s
- D) 14 m/s
- E) zero

Q6.

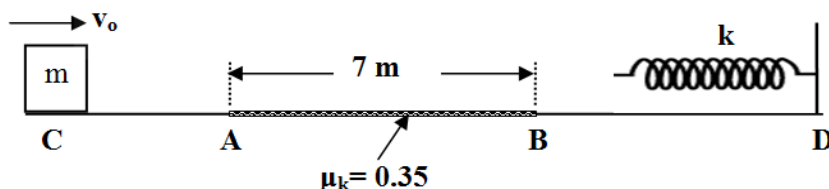
A block slides along the track shown in **Figure 2**. The curved portion of the track is frictionless, but for the horizontal part the coefficient of kinetic friction is 0.40. The block is released from rest from a height of 2.0 m above the horizontal part of the track. Find the distance  $d$  that the block moves on the horizontal part before it stops. Treat the block as a particle.



- A) 5.0 m
- B) 0.80 m
- C) 2.4 m
- D) 7.5 m
- E) 1.5 m

Q7.

As shown in **Figure 3**, a 4.0-kg block has speed 8.5 m/s at point C. Tracks CA and BD are frictionless, but track AB (of length 7.0 m) is rough ( $\mu_k = 0.35$ ). The block runs into and compresses a spring ( $k = 2400$  N/m) until it momentarily stops. By what distance is the spring compressed when the block stops?



- A) 0.20 m
- B) 0.45 m
- C) 0.35 m
- D) 0.57 m
- E) 0.15 m

Q8.

A 6.0-kg object, initially at rest, explodes into three pieces A, B, and C. After the explosion, A (2.0 kg) has velocity  $+3.0\hat{i}$  (m/s), and B (3.0 kg) has velocity  $-1.0\hat{j}$  (m/s). Find the velocity of C.

- A)  $-6.0\hat{i} + 3.0\hat{j}$  (m/s)
- B)  $+3.0\hat{i} + 6.0\hat{j}$  (m/s)
- C)  $+6.0\hat{i} - 3.0\hat{j}$  (m/s)
- D)  $+6.0\hat{i} + 3.0\hat{j}$  (m/s)
- E)  $+3.0\hat{i} - 6.0\hat{j}$  (m/s)

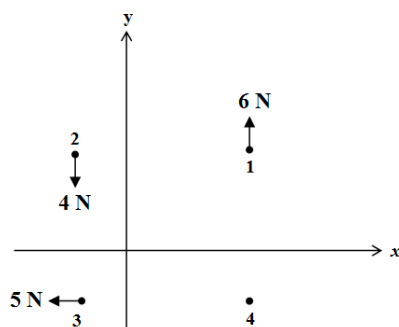
Q9.

A 0.15 kg ball, moving along a straight line, has a velocity of  $+20\hat{i}$  (m/s). It collides with a wall and rebounds with a velocity of  $-10\hat{i}$  (m/s). If the ball is in contact with the wall for 0.005 s, what is the average force exerted by the wall on the ball?

- A)  $-900\hat{i}$  (N)
- B)  $+900\hat{i}$  (N)
- C)  $-300\hat{i}$  (N)
- D)  $+300\hat{i}$  (N)
- E) zero

Q10.

**Figure 4** shows an overhead view of four particles on which external forces act as shown. What are the  $x$  and  $y$  components of the force acting on the fourth particle if the center of mass of the system moves with constant velocity?



- A)  $F_x = +5\text{ N}, F_y = -2\text{ N}$
- B)  $F_x = +5\text{ N}, F_y = +8\text{ N}$
- C)  $F_x = 0, F_y = 0$
- D)  $F_x = -5\text{ N}, F_y = -8\text{ N}$
- E)  $F_x = -5\text{ N}, F_y = -2\text{ N}$

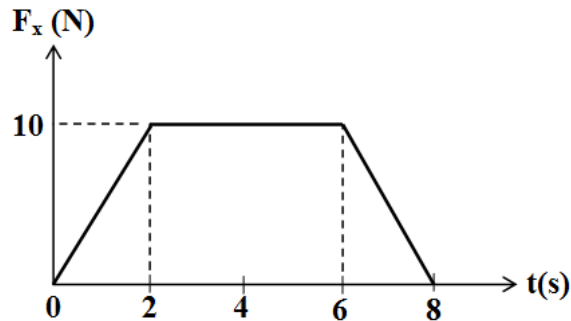
Q11.

Block 1 of mass 1 kg slides along a frictionless surface and undergoes a one dimensional elastic collision with stationary block 2 of mass 3 kg. Before the collision, the center of mass of the two-block system had a speed of 3 m/s. After the collision, what is speed of block 2?

- A) 6 m/s
- B) 2 m/s
- C) 4 m/s
- D) 8 m/s
- E) 3 m/s

Q12.

The force  $F_x$  on a 5.0-kg particle varies with time as shown in **Figure 5**. If the particle is initially ( $t = 0$ ) moving along the  $x$ -axis with a velocity of  $-3.0$  m/s, find its velocity at  $t = 8.0$  s.



- A) + 9.0 m/s
- B) + 5.0 m/s
- C) + 3.0 m/s
- D) - 15 m/s
- E) - 3.0 m/s

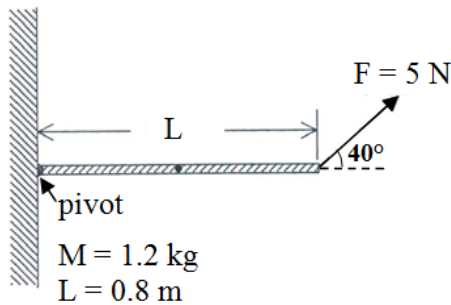
Q13.

A disk, initially rotating at 42 rad/s, stops after 10 s (assume constant angular acceleration). Through what angle does the disk turn during this time?

- A) 210 rad
- B) 320 rad
- C) 150 rad
- D) 440 rad
- E) 900 rad

Q14.

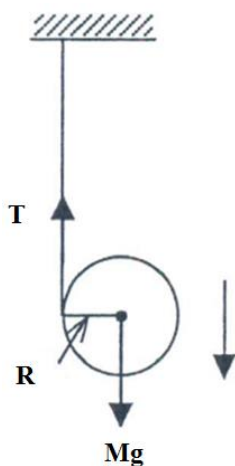
A uniform rod, of mass  $1.2\text{ kg}$  and length  $0.80\text{ m}$ , is free to rotate in a vertical plane about one end, where a force  $F = 5.0\text{ N}$  acts on the rod as shown in **Figure 6**. What is the net torque on the rod about the pivot at the instant shown in the figure?



- A)  $2.1\text{ N}\cdot\text{m}$ , clockwise
- B)  $2.6\text{ N}\cdot\text{m}$ , counterclockwise
- C)  $4.7\text{ N}\cdot\text{m}$ , clockwise
- D)  $7.3\text{ N}\cdot\text{m}$ , clockwise
- E)  $7.3\text{ N}\cdot\text{m}$ , counterclockwise

Q15.

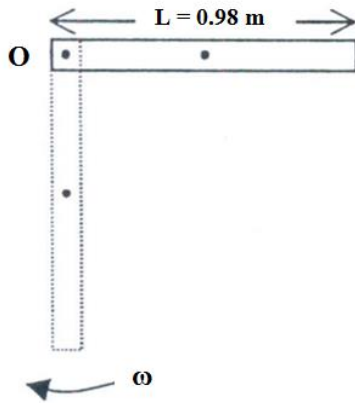
A massless string is wound around a uniform disk (see **Figure 7**). The disk is released from rest with the string vertical. Find the magnitude of the acceleration of the center of mass of the disk.



- A)  $6.53\text{ m/s}^2$
- B)  $3.23\text{ m/s}^2$
- C)  $8.34\text{ m/s}^2$
- D)  $1.13\text{ m/s}^2$
- E)  $9.25\text{ m/s}^2$

Q16.

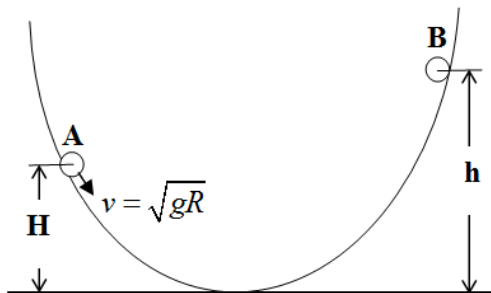
A uniform rod of length 0.98 m is free to rotate in a vertical plane about a frictionless pin through one end (point O in **Figure 8**). The rod is released from rest when it is in the horizontal position. What is the angular speed of the rod at its lowest position?



- A) 5.5 rad/s
- B) 3.4 rad/s
- C) 6.8 rad/s
- D) 4.0 rad/s
- E) 7.9 rad/s

Q17.

A solid sphere, of radius  $R$ , rolls without slipping, as shown in **Figure 9**. As the sphere passes point **A** of height  $H = 5.3 R$ , the speed of its center of mass is  $\sqrt{gR}$ . If the sphere comes momentarily to rest at point **B**, then the height  $h$  of point **B** is



- A)  $6 R$
- B)  $2 R$
- C)  $8 R$
- D)  $9 R$
- E)  $10 R$

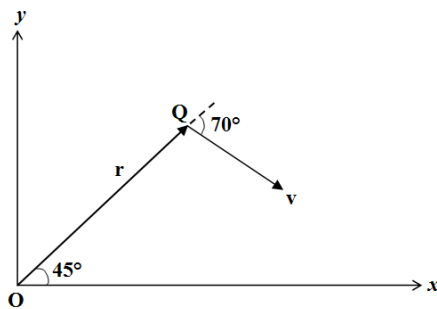
Q18.

The torque about the origin on a particle located at  $(0, -4.0, 3.0)$  m due to the force  $\vec{F} = 6.0 \hat{i}$  (N) is:

- A)  $+18\hat{j} + 24\hat{k}$  (N.m)
- B)  $-18\hat{j} + 24\hat{k}$  (N.m)
- C)  $-18\hat{j} - 24\hat{k}$  (N.m)
- D)  $+18\hat{j} - 24\hat{k}$  (N.m)
- E) zero

Q19.

A particle Q with a mass of 2.00 kg has a position vector  $\vec{r}$  (of magnitude 5.00 m) and velocity  $\vec{v}$  (of magnitude 4.00 m/s) oriented as shown in **Figure 10**. Calculate the angular momentum of the particle (in units of  $\text{kg}\cdot\text{m}^2/\text{s}$ ) about the origin.



- A)  $-37.6\hat{k}$
- B)  $+17.6\hat{k}$
- C)  $+37.6\hat{k}$
- D)  $-17.6\hat{k}$
- E)  $+7.68\hat{j}$

Q20.

A man stands at the center of a frictionless rotating disk. His arms are extended and he holds a weight in each hand. The rotational inertial of the system (man + weights + disk) about the central axis is  $6.0 \text{ kg}\cdot\text{m}^2$ . The man pulls the weights toward himself, reducing the rotational inertia of the system to  $2.0 \text{ kg}\cdot\text{m}^2$ , and changing the angular speed to  $3.6 \text{ rad/s}$ . What was the initial angular speed of the system?

- A) 1.2 rad/s
- B) 2.5 rad/s
- C) 3.6 rad/s
- D) 7.2 rad/s
- E) 0.36 rad/s

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