1. A centrifuge starts from rest accelerating with an angular acceleration $\alpha(t) = (1\ \mathrm{rad/s^{5/2}})\sqrt{t}$. How much time does it take to reach an angular velocity of 3240 revolutions per minute?

   (A) 63.7 s

   (B) 287 s

   (C) 48.6 s

   (D) 78.3 s

   (E) 120. s

   (F) 90.2 s

Answer LOs:

A: 8,10,14,15,16
B: 8,14,15,16
C: 10,14,15,16
D:
E:
F:

2. A point-like mass $m = M/2$ a distance $R/2$ from the center axis of a cylinder which has mass M and radius R. What is the moment of inertia of the system with respect to the axis "A" shown in the figure?

(A) $\frac{5}{4}MR^2$

(B) MR^2

(C) $\frac{3}{4}MR^2$

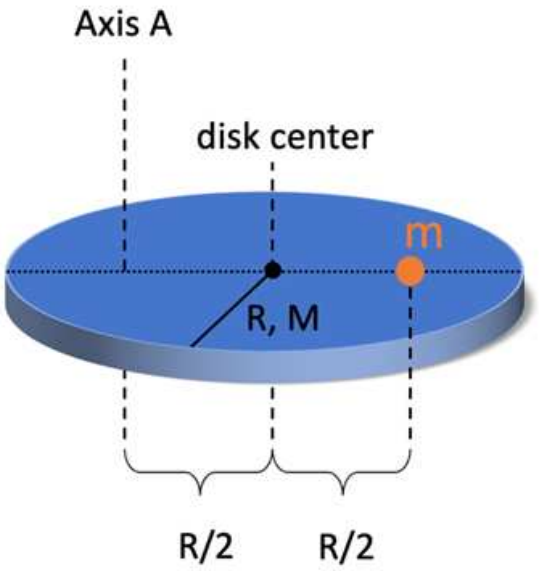
(D) $\frac{1}{2}MR^2$

(E) $\frac{1}{4}MR^2$

(F) $\frac{3}{2}MR^2$

Answer LOs:

A: 51,52,53
B: 51,53
C: 52
D:
E:
F:



3. An object is rotating about an axis such that it has a moment of inertia of 3.25 kg·m^2. A point that is 0.750 m from the rotation axis has a constant magnitude of tangential acceleration of 1.25 m/s^2 that causes the object's angular speed to increase. At $t = 0$ the angular velocity is known to be $\omega_0 = -12.0$ rad/s. What is the rotational kinetic energy of this object at $t = 3.00$ s?

(A) 79.6 J

(B) 234 J

(C) 470 J

(D) 403 J

(E) 110 J

(F) 39.9 J

(G) 654 J

(H) 304 J

Answer LOs:

A: 4,14,16,17,35
B: 35
C: 4,13,14,16,17,35
D: 4,13,16,35
E: 4,16,35
F:
G:
H:

4. As shown in the figure below, a baton of length ℓ is resting at a 60 degree angle on a rough floor. It leans against a smooth, frictionless sphere in such a way that the contact point is $2\ell/3$ from the lower end. The baton has a total mass $3m$, consisting of two point-masses m connected by a uniform bar which also has mass m. The floor is sufficiently rough so that the baton sits stationary in this position. What is the normal force exerted on the bar *by the sphere*?

(A) $\frac{9}{8}mg$

(B) $\frac{3}{8}mg$

(C) $\frac{9}{4}mg$

(D) $\frac{3}{4}mg$

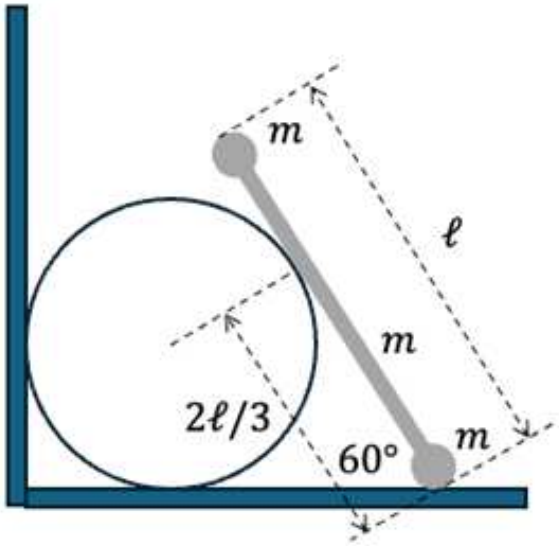
(E) $3mg$

(F) $\frac{7}{4}mg$

(G) $\frac{7}{8}mg$

Answer LOs:

A: 3,23,26,31,54,55
B: 3,26,31,55
C: 3,23,26,31,55
D: 3,26,31,55
E:
F:
G:



5. Jane and Jim are playing on a horizontal wooden plank that is effectively massless. Jane has a mass of 65.0 kg and Jim has a mass of 55.0 kg. Jim stands at the end of the 3.00 m-long plank, and sawhorses support the plank at the left end and at the 1.60 m point as shown. How far (distance x) can Jane safely stand on the plank before it will start to tip over?

(A) 0.415 m

(B) 1.18 m

(C) 2.54 m

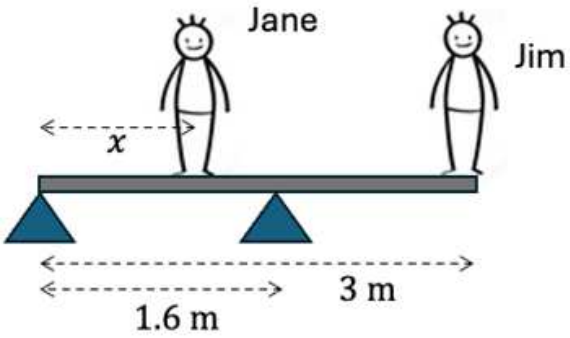
(D) 0.803 m

(E) 0.0482 m

(F) 0.689 m

Answer LOs:

A: 3,6,21,23,26,31,54,55
B: 6,21,23,26,31,54,55
C: 21,23,31,54
D:
E:
F:



6. Two boxes are held stationary against a massless compressed spring as shown. The masses are $m_1 = 20.0$ kg and $m_2 = 35.0$ kg. When released, both masses slide on the frictionless surface. After the masses lose contact with the spring, m_1 has a speed of 3.41 m/s. How much elastic potential energy was stored in the spring initially?

(A) 183 J

(B) 117 J

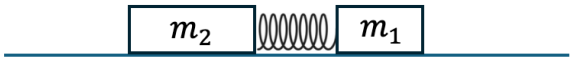
(C) 321 J

(D) 80.5 J

(E) 237 J

Answer LOs:

A: 4,34,38,40,46,48
B: 34,38
C: 34,38,40
D:
E:



7. A piece of thin uniform wire of mass $3m$ and length $3b$ is bent into an equilateral triangle. Find the moment of inertia of the triangle wire about an axis perpendicular to the plane of the triangle and passing through one of its vertices.

   (A) $\frac{3}{2}mb^2$

   (B) $2mb^2$

   (C) $\frac{21}{4}mb^2$

   (D) mb^2

   (E) $\frac{7}{4}mb^2$

   (F) $\frac{3}{4}mb^2$

   Answer LOs:
   A: 51,52,53
   B:
   C:
   D: 53
   E: 51,53
   F: 51,53

8. A dumbbell-shaped object is composed of two equal masses, m, connected by a rod of negligible mass and length r. Let I_1 be the moment of inertia of this object with respect to an axis passing through the center of the rod and perpendicular to it. Let I_2 be the moment of inertia with respect to an axis passing through one of the masses and parallel to the axis defining I_1. Wich of the following is true?

   (A) $I_1 = I_2$

   (B) $I_1 > I_2$

   (C) $I_1 < I_2$

   Answer LOs:
   A:
   B:
   C: 51,53

9. Four objects listed below have the same mass M and same radius R. They simultaneously start to roll without slipping from the top of an incline. Which of them will arrive at the bottom of the incline *last*? The different moments of inertia are given as the answers below.

   (A) Solid cylinder

   (B) Hollow cylinder

   (C) Solid sphere

   (D) Hollow sphere

   Answer LOs:
   A:
   B: 34,35,38,40,51
   C:
   D:

10. Two boxes are connected by a massless string around a pulley like the Atwood's machine shown below. The pulley is a solid uniform cylinder of mass $M = 500$ kg, radius $R = 0.400$ m rotating about a frictionless axle. The boxes have masses $m_1 = 1100$ kg and $m_2 = 900$ kg. What is the angular acceleration of the pulley after the masses are released?

(A) 2.18 rad/s^2

(B) 1.96 rad/s^2

(C) 2.45 rad/s^2

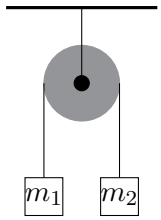
(D) 1.02 rad/s^2

(E) 4.81 rad/s^2

(F) 3.63 rad/s^2

Answer LOs:

A: 4,21,22,23,24,31,51,54,55
B: 4,21,22,23,24,31,54,55
C: 4,21,22,23,24,31
D:
E:
F:



11. A metal bar is hanging from a hook in the ceiling when it is suddenly struck by a ball that is moving horizontally (see figure). The ball is covered with glue, so it sticks to the bar in a very short time. During this collision

(A) the angular momentum of the system (ball and bar) is conserved about the hook because only gravity is acting on the system.

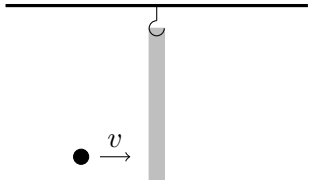
(B) the angular momentum of the system (ball and bar) is not conserved about the hook because the hook exerts a force on the bar.

(C) the angular momentum of the system (ball and bar) is conserved about the hook because neither the hook nor gravity exerts any torque on this system about the hook. The linear momentum of the system (ball and bar) is not conserved since the hook exerts a force on the bar.

(D) both the linear momentum and the angular momentum of the system (ball and bar) are conserved since these are conserved quantities in any collision.

Answer LOs:

A:
B:
C: 30,48,50,57,59
D:



12. A puck in the shape of a solid disk with a mass of 2.0 kg and a radius of 0.40 m slides along an air table at a speed of 1.50 m/s, as shown in figure (a) below. It makes a glancing collision with a disk having a radius of 0.6 m and a mass of 8 kg such that their rims just touch. The disk is fixed to the table and free to rotate about its center. Because their rims are coated with instant-acting glue, the puck and disk stick together and spin after the collision about the center of the disk, shown in figure (b). What is their final angular velocity?

(A) 0.83 rad/s

(B) 1.88 rad/s

(C) 2.28 rad/s

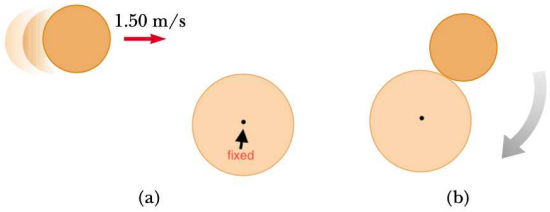
(D) 3.12 rad/s

(E) 1.25 rad/s

(F) 0.77 rad/s

Answer LOs:

A: 3,6,46,50,51,52,53,57,59
B: 3,6,46,50,51,53,57,59
C:
D:
E: 3,6,51,52,53
F: 3,46,50,51,53,57,59



13. A uniform solid cylinder of radius R and a thin uniform spherical shell of radius R both *roll without slipping*. If both objects have the same mass and the same total kinetic energy, what is the ratio of the linear speed of the cylinder to the linear speed of the spherical shell?

(A) $\frac{\sqrt{3}}{2}$

(B) $\frac{\sqrt{10}}{3}$

(C) $\frac{2}{\sqrt{3}}$

(D) $\frac{4}{\sqrt{3}}$

(E) $\frac{4}{3}$

Answer LOs:

A: 35,51
B: 3,34,35,51
C: 3,35,51
D:
E: 35,51

14. A 15.0-g bullet is fired upward through the center of mass of a thin, 5.00-kg wooden block as shown. Just before the bullet strikes the block it is travelling at 1000 m/s. The bullet passes *through* the block, exiting upwards at a speed of 350 m/s. How far above the block's initial position will the block travel before beginning to fall back down? Assume this collision happens effectively instantaneously.

(A) 0.194 m

(B) 134 m

(C) 0.456 m

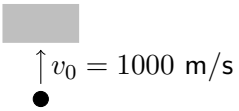
(D) 153 m

(E) 2.74 m

(F) 6.78 m

Answer LOs:

A: 4,34,38,40,46,48,50
B: 4,34,38,40,46,48
C: 4,34,38,40,46,48
D:
E:
F:



15. A block of mass $m_1 = 2.00$ kg is released from rest and slides down a frictionless ramp from a height of 2.00 m and collides with a second block of unknown mass. The two blocks stick together, then slide into a region where the coefficient of kinetic friction between each block and the surface is $\mu_k = 0.300$. The two blocks travel a distance of 3.00 m and then come to rest. What is the mass of the second block?

(A) 0.981 kg

(B) 2.44 kg

(C) 3.93 kg

(D) 0.469 kg

(E) 1.89 kg

(F) 4.44 kg

Answer LOs:

A: 4,28,32,34,38,39,46,48,50
B: 28,32,34,38,39,50
C:
D:
E:
F: 28,32,34,38,39