1. A merry-go-round can be approximated as a solid disk of mass $M = 100$ kg (the base) and a 20-kg thin cylindrical shell (railing) around the edge of the disk. The diameter of the merry-go-round is 2.0 m. A point-like 30-kg child sits on the edge as her mother pushes to get it rotating at 5.0 rad/s. What is the angular momentum of the merry-go-round+child system?

   (A) 100 kg m^2/s

   (B) 400 kg m^2/s

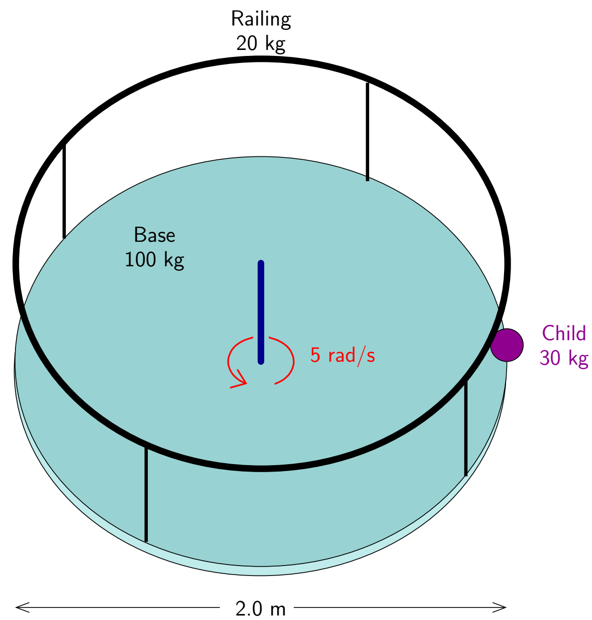
   (C) 350 kg m^2/s

   (D) 500 kg m^2/s

   (E) 1,000 kg m^2/s

   (F) 2,000 kg m^2/s

   Answer LOs:
   A:
   B: 51,57
   C: 51,57
   D: 51,53,57
   E:
   F: 53,57



2. Continuing with the previous question, if the child walks to the middle of the merry-go-round, which statement is true?

   (A) The angular speed of the merry-go-round would increase

   (B) The angular speed of the merry-go-round would decrease

   (C) The angular speed of the merry-go-round would stay the same

   (D) The angular speed of the merry-go-round would depend on one or both of (*i*) if there was friction between the child and merry-go-round or not; and/or (*ii*) the speed with which the child walked.

   Answer LOs:
   A: 6,59
   B:
   C:
   D:

3. A uniform piece of sheet steel is shaped as shown below. Compute the x and y coordinates of the center of mass of the piece.

   (A) $x_{\text{cm}} = 20$ cm, $y_{\text{cm}} = 20$ cm

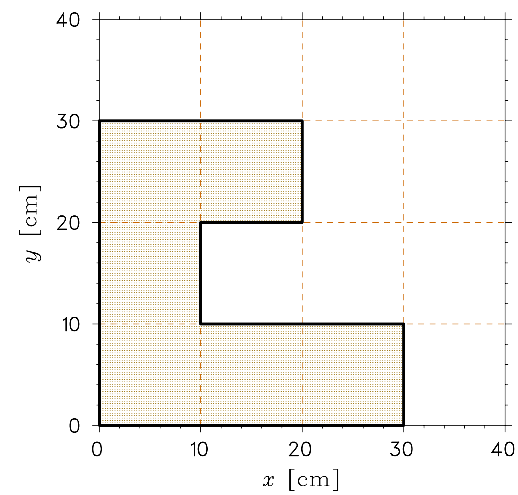
   (B) $x_{\text{cm}} = 50/6$ cm, $y_{\text{cm}} = 40/6$ cm

   (C) $x_{\text{cm}} = 25/3$ cm, $y_{\text{cm}} = 50/6$ cm

   (D) $x_{\text{cm}} = 15$ cm, $y_{\text{cm}} = 15$ cm

   (E) $x_{\text{cm}} = 70/6$ cm, $y_{\text{cm}} = 80/6$ cm

   (F) $x_{\text{cm}} = 30/6$ cm, $y_{\text{cm}} = 45/6$ cm



Answer LOs:
A:
B:
C:
D:
E: 45
F:

4. A 40.0-kg child stands at one end of a 40.0-kg boat that is 4.00 m in length. The boat is initially 3.00 m from the pier. The child notices a turtle on a rock near the far end of the boat and proceeds to walk to that end to catch the turtle. Neglecting friction between the boat and the water, where is the child relative to the pier when he reaches the far end of the boat?

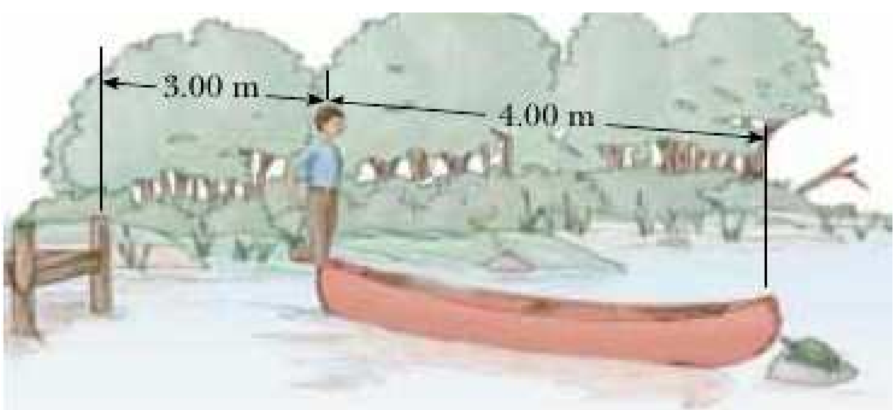
   (A) 3 m

   (B) 5 m

   (C) 8 m

   (D) 7 m

   (E) 6 m

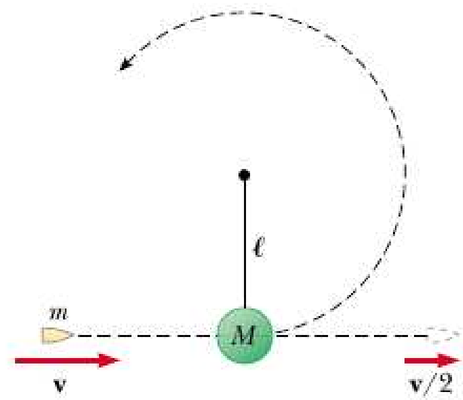


Answer LOs:
A:
B: 6,45,48
C:
D:
E:

5. As shown below, a bullet of mass m and speed v passes completely through a pendulum bob of mass M. The bullet emerges with a speed of $v_f = v/2$. The pendulum bob is suspended by a stiff rod of length l and negligible mass. What is the minimum value of the bullet's initial speed, v, such that the pendulum bob will barely swing through a complete vertical circle? *Hint:* since the rod is stiff, it is enough if the bob has *any* kinetic energy at the top.

   (A) $v = \frac{2M}{m}\sqrt{2gl}$
   (B) $v = \frac{4M}{3m}\sqrt{gl}$
   (C) $v = \frac{4M}{m}\sqrt{gl}$
   (D) $v = \frac{2M}{3m}\sqrt{2gl}$
   (E) $v = \frac{M}{m}\sqrt{gl}$
   (F) $v = \frac{M}{m}\sqrt{2gl}$

   Answer LOs:
   A: 38,40,46,48
   B:
   C: 38,40,46,46,48
   D:
   E:
   F: 40



6. The type of collision between the bullet and the blob was:

   (A) elastic.
   (B) inelastic.
   (C) completely inelastic.
   (D) not enough information; one would need values for m, M and v.

   Answer LOs:
   A:
   B: 48,50
   C:
   D:

7. Four tiny (point-like) spheres are fastened to the corners of a frame of negligible mass lying in the x-y plane. If the system rotates about the y axis with an angular speed ω, find the rotational kinetic energy about this axis.

(A) $mb^2\omega^2$

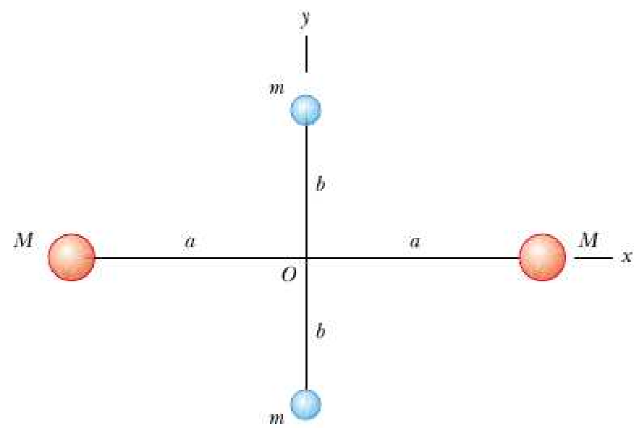
(B) $\frac{1}{2}mb^2\omega^2$

(C) $\frac{1}{2}(M+m)\omega^2$

(D) $Ma^2\omega^2$

(E) $(Ma^2+mb^2)\omega^2$

(F) $\frac{1}{2}Ma^2\omega^2$



Answer LOs:
A:
B:
C:
D: 35,51,53
E:
F: 35,51

8. A uniform rod of length L and mass M is attached at one end to a frictionless pivot and is free to rotate about the pivot in the vertical plane, as shown below. The rod is released from rest in the horizontal position. What is the initial angular acceleration of the rod and the initial linear acceleration of its tip at the right end?

(A) $\alpha = \frac{3g}{2L},\ a_{\text{tan}} = \frac{3g}{2}$

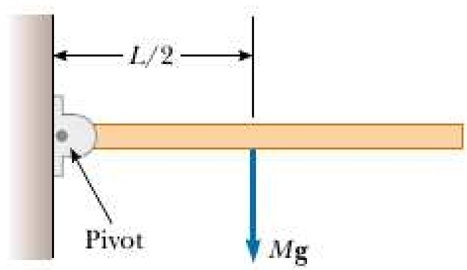
(B) $\alpha = \frac{3g}{2L},\ a_{\text{tan}} = g$

(C) $\alpha = \frac{6g}{L},\ a_{\text{tan}} = g$

(D) $\alpha = \frac{6g}{L},\ a_{\text{tan}} = 6g$

(E) $\alpha = \frac{g}{2L},\ a_{\text{tan}} = \frac{1}{2}g$

(F) $\alpha = \frac{g}{2L},\ a_{\text{tan}} = g$



Answer LOs:
A: 12,51,54,55
B: 51
C:
D: 12,54
E: 12
F:

9. A wad of sticky clay of mass m and speed v_0 is fired at a solid cylinder of mass M and radius R as shown. The cylinder is initially at rest and is mounted on a fixed horizontal, frictionless axle that runs through the center of mass. The line of motion of the projectile is perpendicular to the axle and at a distance d, less than R, from the center. Find the angular speed, ω, of the system just after the clay strikes and sticks to the surface of the cylinder. *Hint:* there are no external torques acting on the clay-cylinder system.

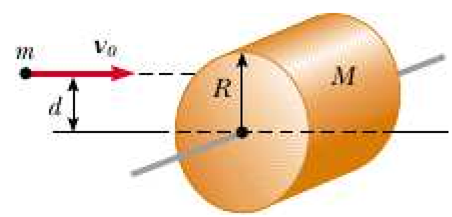
   (A) $\omega = \dfrac{mv_0 d}{(M+m)R^2}$

   (B) $\omega = \dfrac{v_0}{R}$

   (C) $\omega = \dfrac{mv_0 R}{\left(\frac{1}{2}M+m\right)R^2}$

   (D) $\omega = \dfrac{v_0 d}{R^2}$

   (E) $\omega = \dfrac{mv_0 d}{\left(\frac{1}{2}M+m\right)R^2}$



Answer LOs:
A: 53,57,59
B:
C: 51,53,59
D:
E: 51,53,57,59

10. Continuing with the previous problem, the type of collision between the sticky clay and the cylinder was:

   (A) elastic

   (B) inelastic

   (C) completely inelastic

   (D) not enough information

Answer LOs:
A:
B:
C: 48,50
D:

11. A point-like ball of mass m is thrown tangentially with a speed $v_0 = 10$ m/s against the inside edge of a roulette wheel rotating counter-clockwise with an angular speed $\omega_0 = 20$ rad/s (the axle through the middle of the wheel is frictionless). The roulette wheel has a radius $R = 1$ m and moment of inertia $I_{\text{wheel}} = \frac{1}{8}MR^2$, where its mass is $10\times$ the mass of the ball, $M = 10m$. Eventually, the ball settles in slot 8 at a distance $r = \frac{1}{2}R$ from the axis of rotation. The final angular speed of the roulette wheel with the ball in this position is closest to:

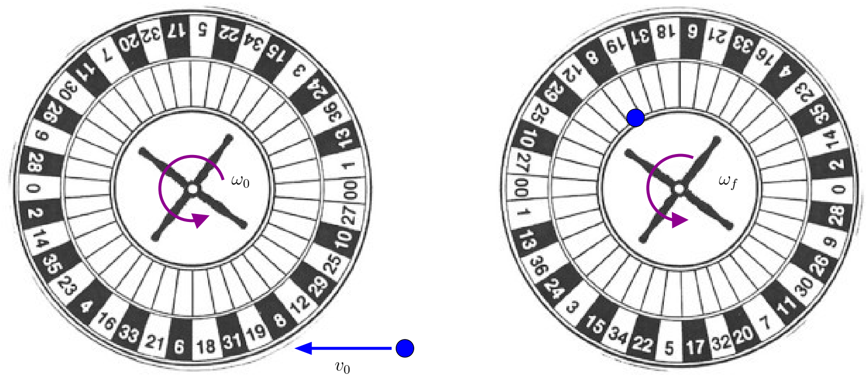
(A) $\omega_f = \frac{10}{7}$ rad/s

(B) $\omega_f = \frac{60}{7}$ rad/s

(C) $\omega_f = 10$ rad/s

(D) $\omega_f = \frac{100}{6}$ rad/s

(E) $\omega_f = \frac{70}{3}$ rad/s



Answer LOs:

A:
B: 51,57,59
C: 51,57,57,59
D:
E: 51,57,59

12. A 9.0-kg block is at rest on a frictionless horizontal table. (See the figure below.) Suddenly it is struck by a 3.0 kg steel ball-bearing traveling horizontally at 6.0 m/s to the right, whereupon the ball-bearing rebounds at 3.0 m/s horizontally to the left. What is the speed of the block just after the collision?

(A) 3 m/s to the right

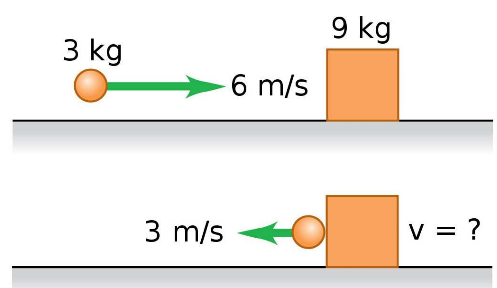
(B) 3 m/s to the left

(C) 1 m/s to the right

(D) 1 m/s to the left

(E) 9 m/s to the right

(F) 9 m/s to the left



Answer LOs:

A: 13,46,46,46,48
B: 46,46,48
C: 13,46
D:
E: 13
F:

13. Continuing with the previous problem, based on the initial and final kinetic energies, the type of collision between the ball and block was:

    (A) elastic

    (B) inelastic

    (C) completely inelastic

    (D) not enough information

    Answer LOs:
    A: 34,34,50
    B:
    C:
    D:

14. A certain rock is very close to being a solid, uniform sphere with a radius of R. It is sitting at a height H at the top of a hill overlooking a valley as shown. The terrain is rough enough to cause the rock to roll down most of the mountainside without slipping (but not enough that any energy is lost), and the rock never leaves the surface of the hill. What is the angular speed of the rock when it reaches the valley at the bottom of the hill?

    (A) $\omega = \frac{1}{R}\sqrt{3gH}$

    (B) $\omega = \frac{1}{R}\sqrt{5gH}$

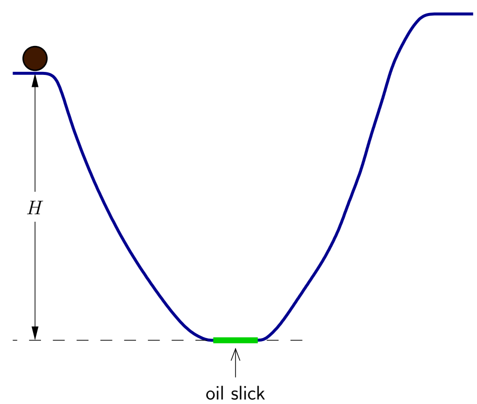
    (C) $\omega = \frac{1}{R}\sqrt{5gH/6}$

    (D) $\omega = \frac{1}{R}\sqrt{10gH/7}$

    (E) $\omega = \frac{1}{R}\sqrt{2gH}$

    (F) $\omega = \frac{1}{R}\sqrt{10gH/9}$

    (G) $\omega = \frac{1}{R}\sqrt{7gH/2}$



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

15. Continuing with the previous problem, at the bottom of the hill the rock encounters an oil slick which removes all friction for the rest of its motion. (The rock does not slow down going through the oil slick). How high up the other side of the valley will the rock go before stopping and sliding back down?

(A) $\frac{1}{2}H$

(B) $\frac{3}{4}H$

(C) H

(D) $\frac{5}{7}H$

(E) $\frac{2}{3}H$

(F) $\frac{5}{12}H$

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

16. A 2-m long uniform beam weighing 2000 N is connected to a wall by a frictionless hinge and supported by two cables as shown below. The tension in the cables are both equal in magnitude to the weight of the beam, and they are both connected a distance x in from the free end of the beam. What is x if the beam is in equilibrium?

(A) $x = \frac{11}{8}$ m

(B) $x = \frac{5}{7}$ m

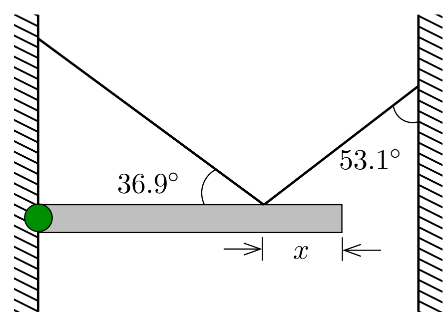
(C) $x = \frac{5}{6}$ m

(D) $x = \frac{7}{6}$ m

(E) $x = \frac{9}{7}$ m

(F) $x = \frac{1}{3}$ m

(G) $x = \frac{3}{4}$ m



Answer LOs:
A: 54,54,54
B:
C:
D: 1,1,54,54,54
E: 54,54,54
F: 1,54,54
G:

17. A basketball can be approximated as a hollow sphere of radius $R = 40$ cm that has a moment of inertia $I_{\text{cm}} = 8 \times 10^{-2}$ kg m^2. Danuel House puts it on his fingertip and slaps the side of the ball with his other hand, applying a tangential force $F_{\perp} = 20$ N to get it spinning from rest. What is the angular acceleration of the ball during the time Danuel was slapping it?

(A) 150 rad/s^2

(B) 200 rad/s^2

(C) 250 rad/s^2

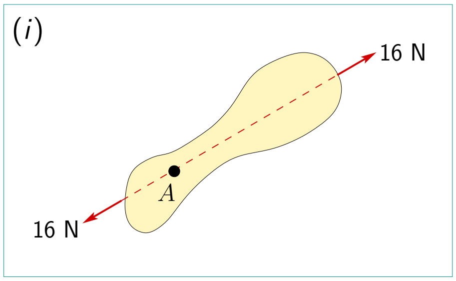
(D) 100 rad/s^2

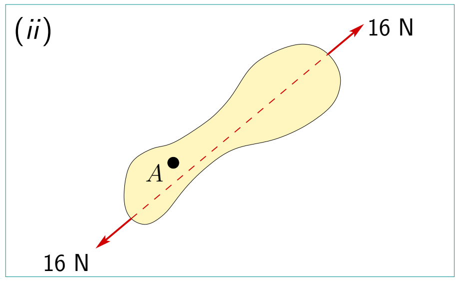
(E) 10,000 rad/s^2

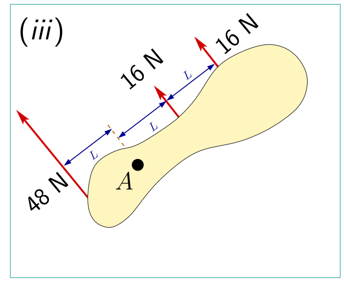
Answer LOs:

A:
B:
C: 55
D: 10,54,55
E: 54,55

18. A rigid body is resting on a horizontal, frictionless surface. Forces are applied to the body in the horizontal plane in three different ways, (i), (ii) and (iii), as shown below. Point A denotes the center of mass of the body. In each case, is the body in equilibrium (both translational and rotational equilibrium)?







(A) (*i*): yes; (*ii*): yes; (*iii*): yes

(B) (*i*): yes; (*ii*): yes; (*iii*): no

(C) (*i*): yes; (*ii*): no; (*iii*): yes

(D) (*i*): yes; (*ii*): no; (*iii*): no

(E) (*i*): no; (*ii*): yes; (*iii*): yes

(F) (*i*): no; (*ii*): yes; (*iii*): no

(G) (*i*): no; (*ii*): no; (*iii*): yes

(H) (*i*): no; (*ii*): no; (*iii*): no

Answer LOs:

A: 31,31
B: 31,31,31
C: 31
D: 31,31
E: 31
F: 31,31
G:
H: 31

19. A rod is wound around by two strings and hung horizontally as shown below. The rod itself is a solid, uniform cylinder of weight $W = 360$ N, and when it is released from rest it unwinds without slipping. What is the tension, T, in each of the strings as the rod unwinds? (Being perfectly horizontal, the tensions in the two strings are the same).

    (A) 30 N

    (B) 180 N

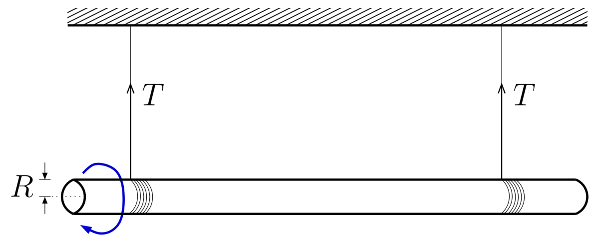
    (C) 90 N

    (D) 60 N

    (E) 120 N

    (F) 150 N

    (G) 200 N



Answer LOs:

A:
B: 4,45,54,55
C: 4,45,54,54,55
D: 4,45,51,54,54,55
E:
F:
G: