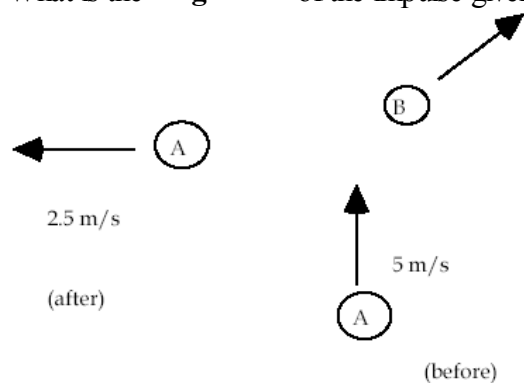


1. A 2 kg block A traveling with a speed of 5 m/s as shown collides with a stationary 4 kg block B. After the collision, A is observed to travel at right angles with respect to the initial direction with a speed of 2.5 m/s. What is the **magnitude** of the impulse given to B by A (in kg m/s)?

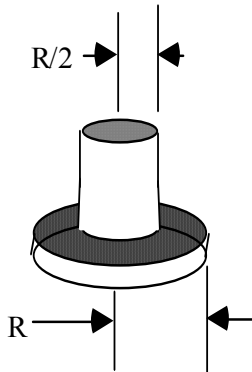


- A. 4.0
B. 11.2
C. 16.3
D. 25
E. 0
2. A 2.0 g coin is placed on a flat, horizontal turntable. The turntable is observed to make three revolutions in 3.0 s. The coin is observed to slide off the turntable when it is more than 8.0 cm from the center of the turntable. What is the coefficient of static friction between the coin and the turntable?
- A. 2.90
B. 1.32
C. 0.899
D. 0.322
E. 6.45×10^{-4}

3. A flying saucer deep in interstellar space, free of external forces, rotates about its symmetry axis with angular velocity ω . The aliens inside the saucer rearrange the furniture to make room for a Christmas tree they have just procured from Elvis. As a result, the angular velocity of the saucer decreases to $\omega/2$. If originally the rotational kinetic energy of the saucer was K , after the rearrangement its new *rotational kinetic energy* is:

- A. $K/4$
- B. $K/2$
- C. K
- D. $2K$
- E. $4K$

4. A disk of radius r and mass M has a moment of inertia given by $I = 1/2 Mr^2$ for rotations about an axis through the center of the disk as shown. If a second disk of twice the mass and half the radius is added as shown in the figure, the new moment of inertia of the combined disks is:

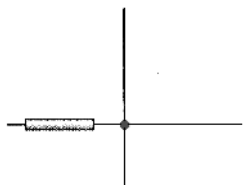


- A. $3/4 Mr^2$
- B. $7/8 Mr^2$
- C. Mr^2
- D. $5/4 Mr^2$
- E. $3/2 Mr^2$

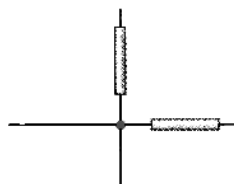
7. A satellite circles planet Roton every 2.8 h in an orbit having a radius of 1.2×10^7 m. If the radius of Roton is 5.0×10^6 m, what is the magnitude of the free-fall acceleration on the surface of Roton?
- A. 31 m/s^2
 - B. 27 m/s^2
 - C. 34 m/s^2
 - D. 40 m/s^2
 - E. 19 m/s^2

8. The figure below shows four arrangements of a particle of mass m and one or more uniform rods of mass M and length L , each a distance d from the particle. Which has the largest magnitude net gravitational force on the particle from the rods?

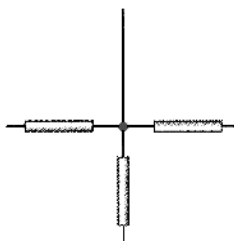
A.



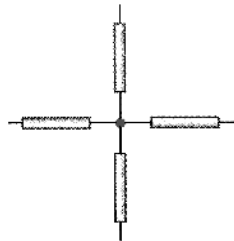
B.



C.



D.



E. there is a tie

9. A certain mass on a spring system has a mass M and a spring constant k , and is oscillating with a period T . If 8 kg is added to the original mass, the period is found to triple. The original mass is:
- A. 8 kg
 - B. 1 kg
 - C. $1/8$ kg
 - D. 5 kg
 - E. 2 kg
10. A model rocket launches with initial net upward acceleration of $1.50g$, where g is the absolute value of the acceleration due to gravity. This acceleration is maintained for 3.00 seconds. After the 3.00 seconds has passed the rocket coasts and eventually falls back to earth. At what time does the rocket reach its maximum height?
- A. 3.0 s
 - B. 4.5 s
 - C. 7.5 s
 - D. 10.5 s
 - E. 12.0 s
11. Vectors u and v each have magnitude L . When drawn with their tails at the same point, the angle between them is 30° . The magnitude of $u \times v$ is:
- A. $L^2 / 2$
 - B. L^2
 - C. $\sqrt{3}L^2 / 2$
 - D. $2L^2$
 - E. none of these

12. A dart is thrown horizontally toward the bull's eye, point P on the dart board, with an initial speed of 9.50 m/s. It hits at point Q on the rim, vertically below P , 0.17 s later. What is the distance PQ ?



- A. 0.07 m
B. 0.14 m
C. 0.28 m
D. 0.42 m
E. 1.62 m
13. Two footballs A and B are kicked from a field line at an angle of 15° from the horizontal. Ball A has initial speed V , and ball B has initial speed $2V$. If ball A travels a distance D before hitting the ground, then the distance travelled by ball B is:
- A. $D/4$
B. $D/2$
C. D
D. $2D$
E. $4D$

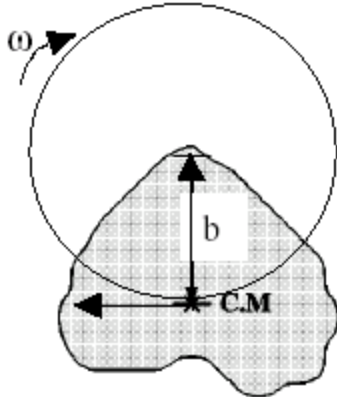
14. A block of mass 4.0 kg lies on a frictionless horizontal table in contact with a 6.0 kg block. At the opposite side of the 4.0 kg block, a constant horizontal force of 100.0 N is applied as shown in the diagram. What is the magnitude of the horizontal force on the 6.0 kg block?



- A. 40 N
B. 60 N
C. 100 N
D. 150 N
E. 0 N
15. An astronaut is rotated in a horizontal centrifuge at a radius of 8.0 m. What is the astronaut's speed if the centripetal acceleration has a magnitude of $6.0g$?
- A. 2.7 m/s
B. 6.9 m/s
C. 15.3 m/s
D. 21.7 m/s
E. 30.7 m/s

16. A ski lift raises 100 passengers averaging 80 kg in mass to a height of 150 m in 60 seconds. What average power does it output during the 60 seconds?
- A. 2.0×10^4 W
 - B. 1.0×10^5 W
 - C. 2.0×10^5 W
 - D. 1.2×10^7 W
 - E. 7.1×10^8 W
17. A 2200 kg railroad flatcar, which can move with negligible friction, is motionless next to a platform. A 260 kg sumo wrestler runs at +5 m/s along the platform (parallel to the track) and then jumps onto the flatcar. What is the speed of the flatcar if the wrestler keeps running at +5 m/s *relative to it* in his original direction?
- A. +5 m/s
 - B. -5 m/s
 - C. 0 m/s
 - D. +0.59 m/s
 - E. -0.59 m/s
18. How fast would an 80 kg student need to run to have the same linear momentum as a 1600 kg car moving at 1.8 km/h?
- A. 2.2 m/s
 - B. 10 m/s
 - C. 20 m/s
 - D. 36 m/s
 - E. 43 m/s

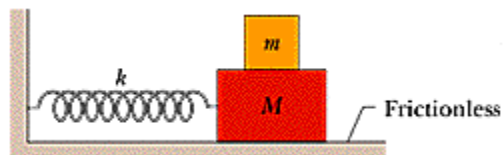
19. An irregularly shaped object of mass 3 kg has a moment of inertia 11 kg m^2 about an axis through its center of mass. It is rotating with uniform angular velocity $\omega = 3 \text{ rad/s}$ about a parallel axis separated by $b = 0.5 \text{ m}$ from the center of mass. What is the rotational kinetic energy of the object?



- A. 49.5 J
B. 52.9 J
C. 35.3 J
D. 37.1 J
E. 17.6 J
20. A merry-go-round of radius $R = 3 \text{ m}$ has a moment of inertia $I = 250 \text{ kg m}^2$, and is rotating at $\omega = 6 \text{ rev/min}$. A child whose mass is 25 kg jumps onto the edge of the merry-go-round, heading directly toward the center at 5 m/s. What is the new **angular speed** of the merry-go-round *immediately* after the child has boarded it?
- A. 0.029 rad/s
B. 0.060 rad/s
C. 0.165 rad/s
D. 0.105 rad/s
E. 0.330 rad/s

21. The amplitude of a system moving with simple harmonic motion is doubled. The maximum velocity of the object will then be
- A. 4 times larger
 - B. 3 times larger
 - C. 2 times larger
 - D. same as it was
 - E. half as much

22. Two blocks ($m = 2.0$ kg and $M = 9$ kg) and a spring ($k = 160$ N/m) are arranged on a horizontal, frictionless surface as shown in the figure below. The coefficient of static friction between the two blocks is $\mu_s = 0.5$. What is the **maximum possible amplitude** of simple harmonic motion of the spring blocks system if no slippage is to occur between the blocks?



- A. 0.044 m
- B. 0.220 m
- C. 0.169 m
- D. 0.270 m
- E. 0.337 m

23. You are once again traveling at night on I-99 in your 1400 kg vehicle, driving at a legal 29.1 m/s. Suddenly, you see a deer in the middle of the road straight ahead of you, at a distance of 200 m. What minimum force must be provided by the brakes to stop the vehicle before hitting the deer?
- A. 3,390 N
 - B. 2,960 N
 - C. 5,930 N
 - D. 660 N
 - E. 6,600 N
24. A block slides down an inclined plane that makes an angle θ with the horizontal. What must be the coefficient of static friction, μ_s , in order for the block to remain at rest?
- A. $\mu_s \geq \sin \theta$
 - B. $\mu_s \geq \cos \theta$
 - C. $\mu_s \geq \tan \theta$
 - D. $\mu_s \geq \cot \theta$
 - E. $\mu_s \geq \sec \theta$
25. An archer pulls his bow string back 0.5 m by exerting a force that increases uniformly from zero to 300 N. The equivalent spring constant of the bow is:
- A. 575 N/m
 - B. 150 N/m
 - C. 600 N/m
 - D. 1200 N/m
 - E. 300 N/m