1. A Cessna aircraft has a lift-off speed of 120 km/hr. What minimum constant acceleration does this require if the aircraft is to be airborne after a take-off run of 240 m?

   (a) 2.31 m/s²
   (b) 3.63 m/s²
   (c) 4.63 m/s²
   (d) 5.55 m/s²
   (e) 6.12 m/s²

2. A fireman, 50.0 m away from a burning building, directs a stream of water from a fire hose at an angle of 30.0° above the horizontal. If the initial speed of the stream is 40.0 m/s, at what height will the stream of water strike the building?

   (a) 9.60 m
   (b) 13.4 m
   (c) 18.7 m
   (d) 22.4 m
   (e) 24.3 m

3. At \( t = 0 \), a particle leaves the origin with a velocity of 12 m/s in the positive \( x \) direction and moves in the \( xy \) plane with a constant acceleration of \( \left( -2.0 \hat{i} + 4.0 \hat{j} \right) \text{m/s}^2 \). At the instant the \( y \) coordinate of the particle is 18 m, what is the \( x \) coordinate of the particle?

   a. 30 m
   b. 21 m
   c. 27 m
   d. 24 m
   e. 45 m

4. If \( F = 4.0 \text{ N} \) and \( m = 2.0 \text{ kg} \), what is the magnitude \( a \) of the acceleration for the block shown below? The surface is frictionless.

   (a) 5.3 m/s²
   (b) 4.4 m/s²
   (c) 3.5 m/s²
   (d) 6.2 m/s²
   (e) 8.4 m/s²

5. In the figure shown, the coefficient of kinetic friction between the block and the incline is 0.29. What is the magnitude of the acceleration of the suspended block as it falls? Disregard any pulley mass or friction in the pulley.

   (a) 5.4 m/s²
   (b) 5.2 m/s²
   (c) 4.9 m/s²
   (d) 5.6 m/s²
   (e) 7.9 m/s²

6. A 0.50-kg mass attached to the end of a string swings in a vertical circle (radius = 2.0 m). When the mass is at the lowest point on the circle, the speed of the mass is 12 m/s. What is the magnitude of the force of the string on the mass at this position?

   a. 31 N
   b. 36 N
   c. 41 N
   d. 46 N
   e. 23 N
7. The block shown is pulled across the horizontal surface at a constant speed by the force shown. If $M = 5.0 \text{ kg}$, $F = 14 \text{ N}$ and $\theta = 35^\circ$, what is the coefficient of kinetic friction between the block and the horizontal surface?

![Diagram]

a. 0.44  
b. 0.33  
c. 0.38  
d. 0.28  
e. 0.17

8. A 1000 kg car enters a level, unbanked semi-circular turn of 100 m radius at a speed of 26 m/s. The coefficient of friction between the tires and the road is $\mu = 0.800$. If the car maintains a constant speed of 26 m/s, it will

a. attempt to dig into the road surface.  
b. tend to veer toward the center of the semicircle.  
c. **arrive safely at the end of the semicircle.**  
d. tend to veer toward the outside of the circle.  
e. veer toward the center for the first quarter-circle, then veer toward the outside for the second quarter-circle.

9. A 60 kg skier starts from rest from the top of a 50 m high slope. If the work done by friction is $-6.0 \times 10^3 \text{ J}$, what is the speed of the skier on reaching the bottom of the slope?

a. 42 m/s  
b. 31 m/s  
c. **28 m/s**  
d. 20 m/s  
e. 17 m/s

10. A 2.0-kg particle has an initial velocity of $(5\hat{i} - 4\hat{j}) \text{ m/s}$. Some time later, its velocity is $7\hat{i} + 3\hat{j} \text{ m/s}$. How much work was done by the resultant force during this time interval, assuming no energy is lost in the process?

(a) 17 J  
(b) 49 J  
(c) 19 J  
(d) 53 J  
(e) 27 J

11. A 12-kg projectile is launched with an initial vertical speed of 20 m/s. It rises to a maximum height of 18 m above the launch point. How much work is done by the dissipative (air) resistive force on the projectile during this ascent?

(a) $-0.64 \text{ kJ}$  
(b) $-0.40 \text{ kJ}$  
(c) $-0.52 \text{ kJ}$  
(d) **$-0.28 \text{ kJ}$**  
(e) $-0.76 \text{ kJ}$

12. A 0.5-kg block, initially at rest, slides down a inclined plane 1.5 m long. If the coefficient of kinetic friction between the block and the plane is 0.2, what is the kinetic energy of the object at the bottom of the inclined plane?

A) 0.3 J  
B) **3.2 J**  
C) 4.4 J  
D) 6.9 J  
E) 8.6 J
12. A certain pendulum consists of a 2-kg mass swinging at the end of a string (length = 2.0 m). At the lowest point in the swing the tension in the string is equal to 30 N. What angle will the string make with a vertical when the mass reaches its maximum height?

A) 42.7°
B) 28.4°
C) 12.5°
D) 56°
E) 8.8°

13. A 2.4-kg ball falling vertically hits the floor with a speed of 2.5 m/s and rebounds with a speed of 1.5 m/s. What is the magnitude of the impulse exerted on the ball by the floor?

a. 9.6 N·s
b. 2.4 N·s
c. 6.4 N·s
d. 1.6 N·s
e. 1.0 N·s

14. A 20-g bullet moving at 1000 m/s is fired through a 0.56-kg block of wood emerging at a speed of 100 m/s. If the block had been originally at rest and is free to move, what is its resulting speed?

A) 9 m/s
B) 18 m/s
C) 32 m/s
D) 40 m/s
E) 90 m/s

15. A 2.0-kg object moving with a velocity of 5.0 m/s in the positive x direction strikes and sticks to a 3.0-kg object moving with a speed of 2.0 m/s in the same direction. How much kinetic energy is lost in this collision?

(a) 2.4 J
(b) 9.6 J
(c) 5.4 J
(d) 0.6 J
(e) 6.0 J

16. A massless rope is wrapped around a uniform disk that has radius $R = 0.2$ m and mass $M = 0.5$ kg, as shown in the figure. The disk is released from rest. Find the angular speed of the disk after it descends 2 m.

A) 9.5 rad/s
B) 14.2 rad/s
C) 25.6 rad/s
D) 44.8 rad/s
E) 65.8 rad/s
17. A 3 kg disk with a radius of 0.2 m, initially at rest, accelerates under the action of torque of 0.85 Nm. Its angular velocity 10 sec later is:

A) 95 rad/s  
B) 142 rad/s  
C) 320 rad/s  
D) 448 rad/s  
E) 658 rad/s

18. A solid cylinder (radius $R = 20 \text{ cm}$, mass $M = 2.5 \text{ kg}$) rolls without slipping down an $15^\circ$-incline as shown in the figure. If the incline is 1.2 m long and the cylinder starts from rest, what is the linear velocity of its center of mass at the bottom of the incline?

![Diagram of a cylinder on an incline]

a. 0.7 m/s  
b. 1.3 m/s  
c. **2.0 m/s**  
d. 3.5 m/s  
e. 4.4 m/s

19. The figure shows a uniform rod (length $L = 1.0 \text{ m}$, mass $2.0 \text{ kg}$) suspended from a pivot a distance $d = 0.2 \text{ m}$ from the end. The moment of inertia (in kgm$^2$) about pivot point is

![Diagram of a rod suspended from a pivot]

(a) 0.125  
b) 0.250  
c) 0.425  
d) 0.750  
e) **0.347**

20. In the figure, a 1.6-kg weight swings in a vertical circle at the end of a string having negligible weight. The string is 2 m long. If the weight is released with zero initial velocity from a horizontal position, its angular momentum (in kg · m$^2$/s) at the lowest point of its path relative to the center of the circle is approximately

![Diagram of a weight swinging in a vertical circle]

(a) 40  
b) 10  
c) 30  
d) **20**  
e) 50
21. A 12-g object is dropped onto a record of rotational inertia $I = 2 \times 10^{-4}$ kgm$^2$ initially rotating freely at 33 revolutions per minute. The object adheres to the surface of the record at distance 8 cm from its center. What is the final angular velocity of the record?

A) 12 rev/min  
B) 24 rev/min  
C) 48 rev/min  
D) 78 rev/min  
E) 125 rev/min

22. A puck of mass $m = 0.5$ kg is attached to a taut cord passing through a small hole on a frictionless, horizontal surface. The puck is initially orbiting with a speed of 2 m/s in a circle of a radius of 0.2 m. The cord is then slowly pulled from below, decreasing the radius of the circle. What is the magnitude of the tension force in the cord when the radius of the circle decreases to 0.1 m?

A) 80 N  
B) 40 N  
C) 20 N  
D) 10 N  
E) 5 N

23. A ladder of weight 346 N is placed against a smooth frictionless wall. The base of the ladder makes an angle of 60° with the horizontal ground surface. The ladder is stable and in equilibrium. The friction force (in N) acting on the base of the ladder is:

(a) 100  
(b) 173,  
(c) 200  
(d) 299  
(e) 346.

24. An earth's satellite with a mass of 500 kg orbits the earth in 180 min. What is the linear speed of the satellite? ($M_E = 5.98 \times 10^{24}$ kg, $R_E = 6.37 \times 10^6$ m)

(a) 2200 m/s  
(b) 3825 m/s  
(c) 5227 m/s  
(d) 7033 m/s  
(e) 7980 m/s

25. The gravitational acceleration at the Earth's surface is $g$ and the radius of the Earth is $R$. At a distance $R$ from the surface, the gravitational acceleration is

(a) $4g$  
(b) $2g$  
(c) $g$  
(d) $g/2$  
(e) $g/4$

26. The period of a satellite circling planet Nutron is observed to be 84 s when it is in a circular orbit with a radius of $8.0 \times 10^6$ m. What is the mass of planet Nutron?

a. $6.2 \times 10^{26}$ kg  
b. $5.0 \times 10^{26}$ kg  
c. $5.5 \times 10^{26}$ kg  
d. $4.3 \times 10^{26}$ kg  
e. $3.7 \times 10^{26}$ kg
27. A 50-kg satellite circles the Earth in an orbit with a period of 120 min. What minimum energy is required to change the orbit to another circular orbit with a period of 180 min? (Earth: radius = 6.4 × 10^6 m, mass = 6.0 × 10^{24} kg)
   a. 2.9 × 10^8 J
   b. 3.5 × 10^8 J
   c. 4.1 × 10^8 J
   d. 4.7 × 10^8 J
   e. 5.9 × 10^8 J

28. A projectile is launched from the surface of a planet (mass = M, radius = R). What minimum launch speed is required if the projectile is to rise to a height of 2R above the surface of the planet? Disregard any dissipative effects of the atmosphere. (a)
   a. \left[ \frac{4GM}{3R} \right]^{1/2}
   b. \left[ \frac{8GM}{5R} \right]^{1/2}
   c. \left[ \frac{3GM}{2R} \right]^{1/2}
   d. \left[ \frac{5GM}{3R} \right]^{1/2}
   e. \left[ \frac{GM}{3R} \right]^{1/2}

29. Planet Roton has a mass of 4.0 × 10^{23} kg and a radius of 2.0 × 10^6 m. With what speed should a space probe be launched from the surface of Roton so as to achieve a maximum distance of 3.0 × 10^6 m from the center of Roton?
   a. 4.2 km/s
   b. 3.9 km/s
   c. 3.0 km/s
   d. 3.4 km/s
   e. 6.0 km/s

30. The motion of a piston in an auto engine is simple harmonic. The piston travels back and forth over a distance of 18 cm, and the piston has a mass of 1.6 kg. What is the maximum speed of the piston when the engine is running at 5000 rpm?
   (a) 21 m/s
   (b) 34 m/s
   (c) 47 m/s
   (d) 59 m/s
   (e) 72 m/s

31. The position of simple harmonic oscillator along the x-axis is given by x = (12.4 cm) cos(6.35 rad/s•t). At what time after t = 0 is the mass first located at x = 8.47 cm?
   (a) 4.34 s
   (b) 0.108 s
   (c) 0.129 s
   (d) 7.39 s
   (e) 0.842 s
32. A 0.25 -kg block oscillates on the end of the horizontal spring. The period of oscillations is 0.22 s. If the total mechanical energy of the system is 6 J, what is the oscillation amplitude?

(a) 6 cm  
(b) 17 cm  
(c) **24 cm**  
(d) 4.9 m  
(e) 6.9 m

33. A body oscillates with simple harmonic motion along the x axis. Its displacement varies with time according to the equation \( x = 5.0 \cos(\omega t) \). The magnitude of the acceleration (in m/s\(^2\)) of the body at \( t = 1.0 \) s is approximately

a. 3.5  
b. **49**  
c. 14  
d. 43  
e. 4.3

34. A hydraulic lift raises a 2 000-kg automobile when a 500-N force is applied to the smaller piston. If the smaller piston has an area of 10 cm\(^2\), what is the cross-sectional area of the larger piston?

a. 40 cm\(^2\)  
b. 80 cm\(^2\)  
c. 196 cm\(^2\)  
d. **392 cm\(^2\)**  
e. 160 cm\(^2\)

35. Water pressurized to \( 3.5 \times 10^5 \) Pa is flowing at 5.0 m/s in a horizontal pipe which contracts to 1/3 its former area. What are the pressure and velocity of the water after the contraction?

a. **2.5 \times 10^5 \) Pa, 15 m/s**  
b. 3.0 \times 10^5 \) Pa, 10 m/s  
c. 3.0 \times 10^5 \) Pa, 15 m/s  
d. 4.5 \times 10^5 \) Pa, 1.5 m/s  
e. 5.5 \times 10^5 \) Pa, 1.5 m/s

36. What is the net force inward acting on a spherical bathysphere of diameter 2.00 m at an ocean depth of 1 000 m? (The pressure inside the bathysphere is, hopefully, 1 ATM.) \( \rho_{\text{sea water}} = 1.02 \times 10^3 \) kg/m\(^3\).

a. 1.26 \times 10^4 N  
b. 1.26 \times 10^6 N  
c. **1.26 \times 10^8 N**  
d. 1.26 \times 10^{10} N  
e. 1.26 \times 10^2 N

37. A sample of unknown material appears to weigh 300 N in air and 200 N when immersed in water. The density of the material is closest to

A) 1200 kg/m\(^3\)  
B) 2000 kg/m\(^3\)  
C) **3000 kg/m\(^3\)**  
D) 4000 kg/m\(^3\)  
E) 6500 kg/m\(^3\)

38. An air condition system uses a cylindrical air duct to replenish the air in a room of volume 280 m\(^3\) every 8 min. The air flows in the duct at 5 m/s. What is the cross-section area of the air duct?

A) 0.09 m\(^2\)  
B) **0.12 m\(^2\)**  
C) 0.24 m\(^2\)  
D) 0.38 m\(^2\)  
E) 0.62 m\(^2\)
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39. A block of wood has density 0.50 g/cm$^3$ and mass 1 500 g. It floats in a container of oil (the oil’s density is 0.75 g/cm$^3$). What volume of oil does the wood displace?

a. 3 000 cm$^3$
b. 2 000 cm$^3$
c. 1 500 cm$^3$
d. 1 000 cm$^3$
e. 500 cm$^3$

41. It takes 2.0 minutes to fill a gas tank with 40 liters of gasoline. If the pump nozzle is 1.0 cm in radius, what is the average speed of the gasoline as it leaves the nozzle? (1 000 liters = one cubic meter)

a. 0.27 m/s
b. 1.1 m/s
c. 11 m/s
d. 64 m/s
e. 32 m/s

42. The figure shows a uniform, horizontal beam (length = 10 m, mass = 25 kg) that is pivoted at the wall, with its far end supported by a cable that makes an angle of 51° with the horizontal. A person (mass = 60 kg) stands 3.0 m from the pivot. Find the tension in the cable and force that hinge exerts on the beam?

A) 246 N, 356 N  
B) 672 N, 1350 N  
C) 380 N, 589 N  
D) 28 N, 230 N  
E) 185 N, 780 N

43. If $P = 6.0$ N, what is the magnitude of the force exerted on block 1 by block 2?

a. 6.4 N  
b. 5.6 N  
c. 4.8 N  
d. 7.2 N  
e. 8.4 N

44. The three forces shown act on a particle. What is the direction of the resultant of these three forces?

a. 35°  
b. 45°  
c. 65°  
d. 55°  
e. 85°