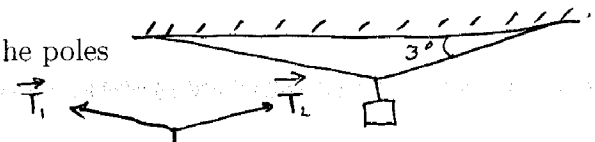
1. Why do raindrops fall with constant speed during the later stages of their descent?

   a) The gravitational force is the same for all drops.
   (b) The force from air resistance just balances the force of gravity.
   c) The drops all fall from the same height.
   d) The force of gravity is negligible for objects as small as raindrops.
   e) Gravity can not increase the speed of a falling object to more than 9.8 m/s.

Constant speed $\Rightarrow$ net $\vec{F} = 0 \Rightarrow m\vec{g} + \vec{F}_f = 0$

2. A 100-kg stoplight hangs from the midpoint of a cable strung between two poles. Each half of the cable makes an angle of 3° with the horizontal.. The tension in each half of the cable is

   a) depends on the distance between the poles
   b) 1900 N
   c) 950 N
   d) 18.6 kN
   (e) 9.4 kN



$2T \sin 3^\circ = 100g$

$T \cong \frac{100 \times 10}{2 \sin 3^\circ} \cong 9.5 \times 10^3$ N

3. A small car has a mass of 1000 kg, and an SUV has a mass of 2000 kg. They both have the same coefficient of kinetic friction with the road when sliding while braking. Starting at the same initial velocity, both vehicles brake suddenly, eventually they come to rest when sliding stops. Which statement is true?

   a) The small car travels 1/4 as far as the SUV does before stopping.
   b) The small car travels 1/2 as far as the SUV does before stopping.
   (c) The small car and the SUV travel the same distance before stopping.
   d) The small car travels two times as far as the SUV does before stopping.
   e) The small car travels four times as far as the SUV does before stopping.

D = distance traveled

$\frac{1}{2}mv^2 = \mu mg D$

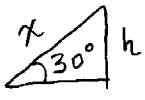
$\frac{1}{2}v^2 = \mu g D$

$D = \frac{v^2}{\mu g}$ does not depend on m

4. A block slides without friction up an inclined plane which makes an angle of 30° with the horizontal. If its initial velocity is 2.0 m/s, how far does it travel along the plane before coming to rest?

   a) Need to know the mass of the block.
   b) 0.1 m
   c) 0.2 m
   (d) 0.4 m
   e) 0.8 m

$\frac{1}{2}mv^2 = mgh \Rightarrow h = \frac{v^2}{2g} \cong \frac{4}{2\times 10} = 0.2$



$x = \frac{h}{\sin 30^\circ} = \frac{0.2}{0.5} = 0.4$ m

5. Two identical carts, A and B, are initially at rest on parallel frictionless tracks. (They are NOT connected to each other.) Equal constant forces are used to accelerate them. The force is applied to cart A for twice the length of time as it is applied to cart B. The work the force does on A is W_A; that on B is W_B. Which statement is correct?

a) $W_A = W_B$.
b) $W_A = \sqrt{2}\, W_B$
c) $W_A = 2\, W_B$
(d) $W_A = 4\, W_B$
e) $W_B = 2\, W_A$

$F_A = F_B \quad D_A = \frac{1}{2}at^2 = \frac{1}{2}\frac{F_A}{M}t^2$

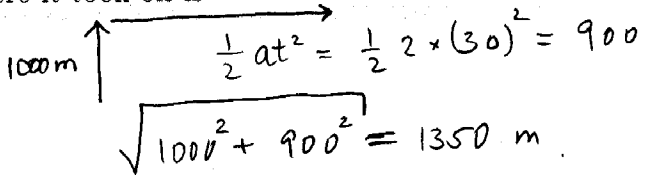
$W_A = F_A \cdot D_A = \frac{1}{2}\frac{F_A^2}{M}t^2$

$W_B = \frac{1}{2}\frac{F_B}{M}\left(\frac{t}{2}\right)^2$

$\Rightarrow W_B = \frac{W_A}{4} \quad \text{or} \quad W_A = 4\, W_B$

6. A helicopter takes off, going straight up 1000 m. It then goes northeast at this altitude for 30 seconds at a constant acceleration of 2 m/s^2. At this point its displacement from where it took off is

a) 900 m
b) 1900 m
(c) 1350 m
d) 1640 m
e) Need more information.



7. A bumper on a car can be thought of as a spring with constant $k = 9.0\times10^5$ N/m. If a 1.0×10^3-kg car with such a bumper is coasting at 3 m/s and hits a wall, what will the maximum compression of the bumper be? Assume the collision is elastic, and that the bumper has negligible mass compared with the car.

a) 1.0×10^{-2} m
(b) 1.0×10^{-1} m
c) 1.0 m
d) 1.0×10^{-3} m
e) 1.0×10^{-4} m

$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$

$1.0\times10^3\ 3^2 = 9.0\times10^5\ x^2$

$x^2 = \frac{1.0\times10^3}{10^5} = 10^{-2}\ m^2$

$x = 10^{-1}\ m$

8. An empty rail car coasts along a track at constant velocity v and couples to a full rail car initially at rest. If the velocity of the two cars coupled together is $v/5$, the ratio, (the mass of the empty car)/(the mass of the full car), is

(a) 1/4
b) 4
c) 1/5
d) 5
e) need more information

$mv = (m+M)\frac{v}{5}$

$5m = m + M$

$4m = M$

$\frac{m}{M} = \frac{1}{4}$

9. A juggler throws two balls to the same height so that one is at the halfway point going up when the other is at the halfway point coming down. At that point:

$v_1 v_2$ ↑↓ $a_1 a_2$ ↓

a) Their velocities and accelerations are equal.
b) Their velocities are equal but their accelerations are equal and opposite.
c) Their accelerations are equal but their velocities are equal and opposite.
d) Their velocities and accelerations are both equal and opposite.
e) None of the other answers are true.

10. Two skiers start at the top of a hill as the same place (P1) and finish at the bottom of the hill, also at the same place (P2). Skier A takes a straight, smooth route to the finish whereas Skier B takes a curvy, bumpy route to the finish. If you assume that friction is negligible, which of the following statements is true?

$mgh = \frac{1}{2}mv^2$

$v^2 = 2gh$ independent of path

a) Skier A has the same speed as skier B at the finish.
b) Skier B has the greater speed at the finish.
c) Skier A has the greater speed at the finish because the route is straight.
d) Skier A has the greater speed at the finish because the route is smooth.
e) Skier A has the greater speed at the finish because the route is both straight and smooth.

11. A Blackhawk helicopter is winching up an injured soldier from a danger zone. The soldier and his kit have a mass of 150 kg and are pulled up 51 m in the air at a steady rate. If it takes 30 s to pull the soldier up, how much power has been used by the helicopter's winch engine (assume no power losses in the engine)?

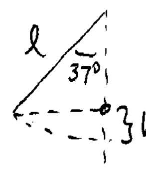
$W = mgh = 150 \times 10 \times 51$

$P = \frac{W}{\Delta t} = 2.5 \text{ kW}$

a) 1.63 kW
b) 2.5 kW
c) 1.0 kW
d) 2.7 kW
e) 2.1 kW

12. A child is sitting on the seat of a swing with ropes 10 m long. Her father pulls the swing back until the ropes make a 37° angle with the vertical and then releases the swing. If air resistance is neglected, what is the speed of the child at the bottom of the arc of the swing when the ropes are vertical?

a) 11 m/s
b) 8.8 m/s
c) 14 m/s
(d) 6.3 m/s
e) 12 m/s



$h = l - l\cos 37° = 2.0$ m.

$mgh = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2gh} \simeq 6$ m

13. A car of mass m_1 traveling at velocity v passes a car of mass m_2 parked at the side of the road. The momentum of the system of two cars is

a) 0.
(b) $m_1 v$.
c) $(m_1 - m_2)v$.
d) $\frac{m_1 v}{m_1 + m_2}$
e) $(m_1 + m_2)v$.

$m_1 v_1 + m_2 v_2$, $v_2 = 0$

$m_1 v$

14. At t = 0, a wheel rotating about a fixed axis with a constant angular acceleration has an angular velocity of 2.0 rad/s. Two seconds later it has turned through 5.0 complete revolutions. What is the angular acceleration of this wheel?

a) 17 rad/s^2
(b) 14 rad/s^2
c) 20 rad/s^2
d) 23 rad/s^2
e) 12 rad/s^2

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

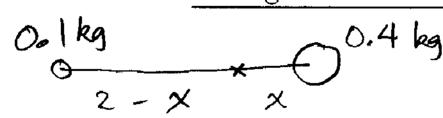
$5 \times 2\pi = 2.0 \times 2 + \frac{1}{2}\alpha\, 4$

$= 4 + 2\alpha$

$\alpha = \frac{31 - 4}{2} = \frac{27}{2} = 13.5 \frac{rad}{s^2}$.

15. Two particles($m_1 = 0.10$ kg, $m_2 = 0.40$ kg) are positioned at the ends of a 2.0-m long rod of negligible mass. What is the moment of inertia of this rigid body about an axis perpendicular to the rod and through the center of mass?

(a) 0.32 kg m^2
b) 0.50 kg m^2
c) 1.2 kg m^2
d) 0.17 kg m^2
e) 0.70 kg m^2



$0.4x = (2 - x)\,0.1$

$0.5x = 0.2 \Rightarrow x = 0.4$

$I = 0.4 \times (0.4)^2 + 0.1 \times (1.6)^2$

$= 0.064 + 0.256$

$= 0.32$ kg m^2

16. A sphere and a cylinder having the same mass and the same outer radius are released from rest at the same height on an inclined plane. Both roll down the plane without slipping. When they reach the bottom of the incline, which of these has the larger velocity of the center of mass? Hint: the moment of inertia of the cylinder is larger than that of the sphere.

(a) Sphere
b) Cylinder
c) Both have the same velocity.
d) The answer depends on the initial height.
e) The answer depends on the length of the cylinder.

$mgH = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

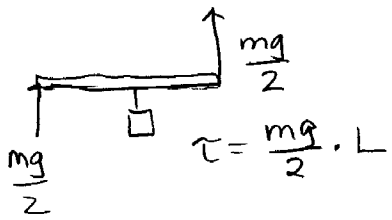
$= \frac{1}{2}mv^2 + \frac{1}{2}I\frac{v^2}{R^2}$

$= \frac{1}{2}v^2\left[m + \frac{I}{R^2}\right]$

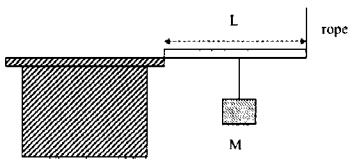
$\Rightarrow$ the smaller I, large v

17. A block of mass M is hanging from the middle of a horizontal bar of length L as shown in the figure. One end of the bar is held on the edge of a desk and the other end is held up by a rope vertically. What is the magnitude of the torque exerted by the rope about the edge of the desk? Assume that the mass of the bar is negligible.

a) MgL
b) 2MgL
(c) MgL/2
d) MgL/4
e) The answer depends on the length of the rope.



$\tau = \frac{mg}{2} \cdot L$



18. A string is wrapped several times around the rim of a small hoop with radius 0.15 m and mass 0.25 kg. The free end of the string is held fixed and the hoop is released from rest. After the hoop has descended 0.50 m, what is the angular speed (in rad/s) of the rotating hoop?

a) 9.81
b) 30
c) 144
d) 51
(e) 15

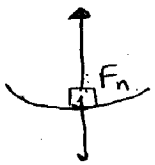
$mgh = \frac{1}{2}mv^2 + \frac{1}{2}mr^2 \cdot \frac{v^2}{r^2}$

$= mv^2 = \omega^2 r^2$

$\omega = \frac{\sqrt{gh}}{r} = \frac{\sqrt{10 \times 0.5}}{0.15} = 14.9 \frac{rad}{s}$

$\frac{1}{2}mv^2 = mgr \rightarrow \frac{mv^2}{r} = 2mg$

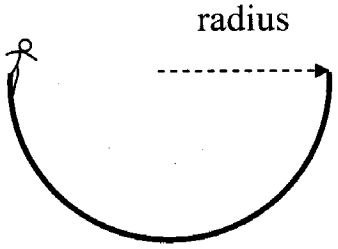
19. Tony Hawk is on his skateboard initially at rest, and drops into a half pipe of radius 3 m at the rim as shown in the figure. The instant he reaches the bottom, the pipe exerts a normal force of F_n. Later that day, he drops in the same way into a half pipe of radius 6 m. When he reaches the bottom of that pipe, it exerts a normal force of



$\therefore F_n - mg = m\frac{v^2}{r}$

$F_n = mg + 2mg = 3mg$

independent of radius.



a) $2F_n$
b) $4F_n$
c) $\sqrt{2}F_n$
(d) F_n
e) $\frac{1}{2}F_n$

20. Two blocks with masses m and M are connected by a spring with spring constant k and placed on a frictionless floor. The blocks are pressed against each other such that the spring is compressed by a distance x from its equilibrium length and the blocks are initially held at rest. After the blocks are released, the blocks move apart with different speeds. The ratio of the speeds of the blocks

$\frac{1}{2}kx^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}Mv_2^2$

$mv_1 = Mv_2$

$\frac{v_1}{v_2} = \frac{M}{m}$

a) depends only on x.
b) depends only on k.
c) depends on both x and k.
(d) depends only on the ratio of the masses
e) depends on x, k and the ratio of the masses.

M m

21. A 2 kg block is at rest on a frictionless patch of ice on a sidewalk. A 1kg snowball, thrown horizontally with a speed of 6 m/s hits and sticks to the block. The coefficient of kinetic friction ~~of~~ between the block and the sidewalk is $\mu_k = 0.25$. How far from the edge of the ice patch does the block come to rest?

$(M+m)v = 6m \Rightarrow v = \frac{6m}{m+m} = \frac{6\times 1}{3} = 2\frac{m}{s}$

$\frac{1}{2}(m+M)v^2 = (m+M)g\mu D$

$D = \frac{\frac{1}{2}v^2}{g\mu} = \frac{\frac{1}{2}\cdot 4}{10\times 0.25} = 0.8m$

a) 2 m
b) 12 m
(c) 0.8 m
d) 6 m
e) need to know the size of the ice patch

22. Taking the acceleration due to gravity (acting vertically) to be 9.8 m/s^2, which of the following statements is false for a body moving freely near the surface of the earth? Ignore air friction.

a) The horizontal component of the velocity of the body remains constant.
b) After 2 seconds, the body has fallen 19.6 m in the vertical direction no matter what the initial velocity of the body is..
c) After 1 second, the speed of the body changes by 9.8 m/s no matter what the initial velocity of the body is.
d) When the vertical velocity is zero during the motion, the acceleration of the body is 9.8 m/s^2 in the vertical direction
e) The kinetic energy of the body changes during the motion.

$x = v_0 t + \frac{1}{2} g t^2$ ↑ depends on v_0

23. Two objects with different masses collide and stick together. Compared to before the collision, the system of two objects after the collision has:

a) the same total momentum and the same total kinetic energy
b) the same total momentum but less total kinetic energy
c) less total momentum but the same total kinetic energy
d) less total momentum and less total kinetic energy
e) not enough information given to decide.

inelastic collision

24. One cart is pushed towards another cart placed on a horizontal straight track. The two carts stick together after the impact and both move a distance of 0.72 m before coming to rest. If the coefficient of kinetic friction is 0.26, what is the speed of the two carts immediately after the impact?

a) It cannot be answered without knowing the speed of the first cart.
b) 1.9 m/s
c) The masses of each cart must be known to find the answer.
d) 0.26 times the initial speed of the first cart.
e) 0.26 times the initial speed of the second cart.

$\frac{1}{2} m v^2 = mg\mu D$

$v = \sqrt{2 g \mu D}$

$= \sqrt{2 \times 10 \times 0.26 \times 0.72}$

$= 1.9$ m/s

25. The rower club president Rick rows on the Raritan River for 1.00 mi straight upstream and returns to the original point in 1.50 h. Rick's speed in still water is 2.00 mi/h. What is the flow speed (in mi/h) of the river?

a) 1.15
b) 0.67
c) 1.33
d) 1.00
e) 0.50

$\frac{1}{2 - v} + \frac{1}{2 + v} = 1.5$

$\frac{4}{4 - v^2} = 1.5$

$4 = (4 - v^2) 1.5$

$v^2 = 4 - \frac{4}{1.5} = 1.33$

$v = 1.15 \frac{mi}{h}$

26. A vertical spring with a force constant $k = 4800$ N/m is compressed 0.10 m from its equilibrium position. An 8 kg bowling ball is placed on the compressed spring. After the spring is released, what is the speed of the ball the instant the spring returns to its equilibrium position?

(a) 2 m/s
b) 1.4 m/s
c) 2.4 m/s
d) 4.0 m/s
e) 25 m/s

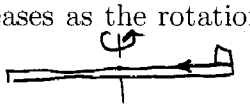
$$\frac{1}{2}kx^2 = mgx + \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{kx^2}{m} - 2gx}$$

$$= \sqrt{\frac{4800 \times (0.1)^2}{8} - 2 \times 10 \times 0.1} = \sqrt{6-2} = 2\ \frac{m}{s}$$

27. When a piece of dust is moving without slipping on the rim of a rotating CD,

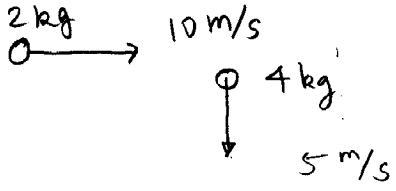
a) the net force on the dust is zero.
b) the net force on the dust does not depend on the angular velocity of the CD.
c) force of gravity on the dust increases as the angular velocity of the CD increases.
d) the net force on the dust is directed outward from the center of CD.
(e) the frictional force on the dust decreases as the rotational speed of the CD decreases.



$F_s = m\omega^2 r$

28. A 2.0 kg object moving 10.0 m/s in the positive x direction makes an elastic collision with a 4.0 kg object moving 5.0 m/s in the negative y direction. What is the total kinetic energy after the collision?

a) 50 J
(b) 150 J
c) 75
d) 25
e) 300



$$\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$= \frac{1}{2} \cdot 2 \times 10^2 + \frac{1}{2}\ 4 \times 5^2$$

$$= 100 + 50$$

$$= 150\ J$$

29. Vince Carter dribbles a 1.0 kg basketball. The ball, which is moving vertically, has a speed of 3.0 m/s just before it hits the floor, and has a speed of 2.5 m/s just after it bounces. The ball was in contact with the floor for 0.10 sec. As an award-winning student of physics, Vince realizes that the average force the floor applied to the ball during the period they were in contact was:

a) 5.0 N
b) 30 N
c) 25 N
(d) 55 N
e) 0.50 N

$$\frac{\Delta P}{\Delta t} = \frac{(2.5 + 3.0)\,1}{0.1} = 55\ N$$

30. Suppose an elevator without a ceiling is ascending with a constant speed of 10m/s. A ball is thrown directly upwards, from a height of 2.0m above the elevator floor, just when the elevator floor is 28m above the ground. The initial speed of the ball with respect to the elevator is 20m/s. What maximum height above the ground does the ball reach?

a) 24 m
b) 56 m
c) 105 m
(d) 76 m
e) 98 m

$v_0 = 30\ m/s$

$$mgh = \frac{1}{2} m v^2$$

$$h = \frac{1}{2}\frac{v^2}{g} = \frac{1}{2}\frac{900}{10} = 45$$

$$H = h + 30 = 45 + 30 = 75.$$