Chapter 6 Drill

The answers and explanations can be found in Chapter 17.

Section I: Multiple Choice

1. Consider a box being dragged across a table at a constant velocity by a string. Which of the following would be considered an action-reaction pair?

    I. The force of gravity pulling the box down and the normal force pushing the box up
    II. The force of friction on the box and the tension force pulling the box
    III. The force of the box pushing down on the table and the normal force pushing the box up

    (A) I only
    (B) I and II only
    (C) II only
    (D) I and III only
    (E) III only

2. A person who weighs 800 N steps onto a scale that is on the floor of an elevator car. If the elevator accelerates upward at a rate of 5 m/s^2, what will the scale read?

    (A) 400 N
    (B) 800 N
    (C) 1,000 N
    (D) 1,200 N
    (E) 1,600 N

3. A frictionless inclined plane of length 20 m has a maximum vertical height of 5 m. If an object of mass 2 kg is placed on the plane, which is the net force it feels?

    (A) 5 N
    (B) 10 N
    (C) 15 N
    (D) 20 N
    (E) 30 N

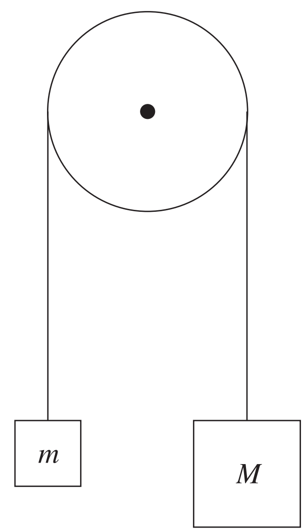
4. A 20 N block is being pushed across a horizontal table by an 18 N force. If the coefficient of kinetic friction between the block and the table is 0.4, find the acceleration of the block.

    (A) 0.5 m/s^2
    (B) 1 m/s^2
    (C) 5 m/s^2
    (D) 7.5 m/s^2
    (E) 9 m/s^2

5. The coefficient of static friction between a box and a ramp is 0.5. The ramp's incline angle is 30°. If the box is placed at rest on the ramp, the box will do which of the following?

    (A) Accelerate down the ramp
    (B) Accelerate briefly down the ramp but then slow down and stop
    (C) Move with constant velocity down the ramp
    (D) Not move
    (E) Cannot be determined from the information given

6.



Assuming a frictionless, massless pulley, determine the acceleration of the blocks once they are released from rest.

(A) $\frac{m}{M+m}g$

(B) $\frac{M}{M+m}g$

(C) $\frac{M-m}{m}g$

(D) $\frac{M+m}{M-m}g$

(E) $\frac{M-m}{M+m}g$

7. If all of the forces acting on an object balance so that the net force is zero and the object's mass remains constant, then

(A) the object must be at rest
(B) the object's speed will decrease
(C) the object will follow a parabolic trajectory
(D) the object's direction of motion can change, but not its speed
(E) none of the above

8. An object of mass m is allowed to slide down a frictionless ramp of angle θ, and its speed at the bottom is recorded as v. If this same process was followed on a planet with twice the gravitational acceleration as Earth, what would be its final speed?

(A) $2v$
(B) $\sqrt{2}v$
(C) v
(D) $\frac{v}{\sqrt{2}}$
(E) $\frac{v}{2}$

9. An engineer is designing a loop for a roller coaster. If the loop has a radius of 25 m, how fast do the cars need to be moving at the top to ensure people would be safe even if the safety bars malfunctioned?

(A) 12.7 m/s
(B) 15.8 m/s
(C) 21.2 m/s
(D) 29.3 m/s
(E) 33.3 m/s

10. An object moves at constant speed in a circular path. Which of the following statements is/are true?

I. The velocity is constant.
II. The acceleration is constant.
III. The net force on the object is zero.

(A) II only
(B) I and III only
(C) II and III only
(D) I and II only
(E) None of the above

Questions 11–12:

A 60 cm rope is tied to the handle of a bucket which is then whirled in a vertical circle. The mass of the bucket is 3 kg.

11. At the lowest point in its path, the tension in the rope is 50 N. What is the speed of the bucket?

(A) 1 m/s
(B) 2 m/s
(C) 3 m/s
(D) 4 m/s
(E) 5 m/s

12. What is the critical speed below which the rope would become slack when the bucket reaches the highest point in the circle?

(A) 0.6 m/s
(B) 1.8 m/s
(C) 2.4 m/s
(D) 3.2 m/s
(E) 4.8 m/s

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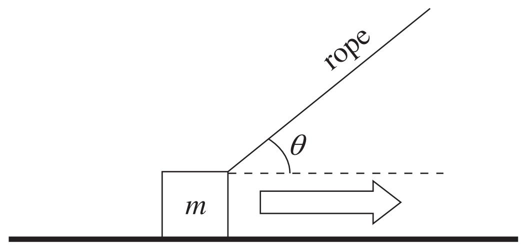
13. An object moves at a constant speed in a circular path of radius r at a rate of 1 revolution per second. What is its acceleration?

(A) 0
(B) $2\pi^2 r$
(C) $2\pi^2 r^2$
(D) $4\pi^2 r$
(E) $4\pi^2 r^2$

Section II: Free Response

1. This question concerns the motion of a crate being pulled across a horizontal floor by a rope. In the diagram below, the mass of the crate is m, the coefficient of kinetic friction between the crate and the floor is μ, and the tension in the rope is $\mathbf{F}_T$.



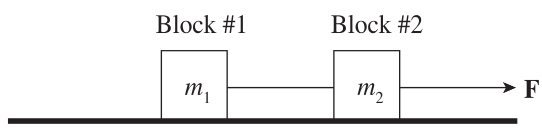
(a) Draw and label all of the forces acting on the crate.

(b) Compute the normal force acting on the crate in terms of m, F_T, θ, and g.

(c) Compute the acceleration of the crate in terms of m, F_T, θ, μ, and g.

(d) Assume that the magnitude of the tension in the rope is fixed but that the angle may be varied. For what value of θ would the resulting horizontal acceleration of the crate be maximized?

2. In the diagram below, a massless string connects two blocks—of masses m_1 and m_2, respectively—on a flat, frictionless tabletop. A force $\mathbf{F}$ pulls on Block #2, as shown:



Solve for the following in terms of given quantities.

(a) Draw and label all of the forces acting on Block #1.

(b) Draw and label all of the forces acting on Block #2.

(c) What is the acceleration of Block #1?

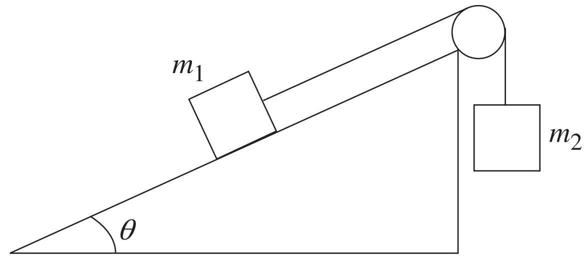
(d) What is the tension in the string connecting the two blocks?

(e) If the string connecting the blocks were not massless, but instead had a mass of m, find

(i) the acceleration of Block #1, and

(ii) the difference between the strength of the force that the connecting string exerts on Block #2 and the strength of the force that the connecting string exerts on Block #1.

3. In the figure shown, assume that the pulley is frictionless and massless.



Solve for the following in terms of given quantities and the acceleration of gravity, g.

(a) If the surface of the inclined plane is frictionless, determine what value(s) of θ will cause the box of mass m_1 to

(i) accelerate up the ramp

(ii) slide up the ramp at constant speed

(b) If the coefficient of kinetic friction between the surface of the inclined plane and the box of mass m_1 is μ_k, derive (but do not solve) an equation satisfied by the value of θ which will cause the box of mass m_1 to slide up the ramp at constant speed.

4. A sky diver is falling with speed v_0 through the air. At that moment (time $t = 0$), she opens her parachute and experiences the force of air resistance whose strength is given by the equation $F = kv$, where k is a proportionality constant and v is her descent speed. The total mass of the sky diver and equipment is m. Assume that g is constant throughout her descent.

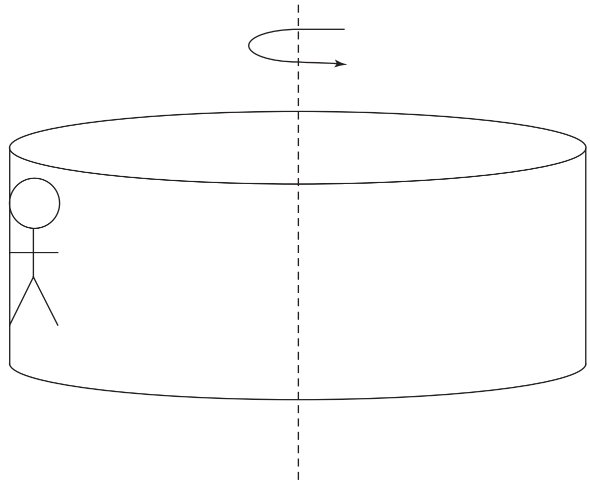
(a) Draw and label all the forces acting on the sky diver after her parachute opens.

(b) Determine the sky diver's acceleration in terms of m, v, k, and g.

(c) Determine the sky diver's terminal speed (that is, the eventual constant speed of descent).

(d) Sketch a graph of v as a function of time, starting at $t = 0$ and going until she lands, being sure to label important values on the vertical axis.

(e) Derive an expression for her descent speed, v, as a function of time t since opening her parachute in terms of m, k, and g.



5. An amusement park ride consists of a large cylinder that rotates around its central axis as the passengers stand against the inner wall of the cylinder. Once the passengers are moving at a certain speed v, the floor on which they were standing is lowered. Each passenger feels pinned against the wall of the cylinder as it rotates. Let r be the inner radius of the cylinder.

   Solve for the following in terms of given quantities and the acceleration of gravity, g.

   (a) Draw and label all the forces acting on a passenger of mass m as the cylinder rotates with the floor lowered.

   (b) Describe what conditions must hold to keep the passengers from sliding down the wall of the cylinder.

   (c) Compare the conditions discussed in part (b) for an adult passenger of mass m and a child passenger of mass $m/2$.

6. A curved section of a highway has a radius of curvature of r. The coefficient of friction between standard automobile tires and the surface of the highway is μ_s.

   (a) Draw and label all the forces acting on a car of mass m traveling along this curved part of the highway.

   (b) Compute the maximum speed with which a car of mass m could make it around the turn without skidding in terms of μ_s, r, g, and m.

   City engineers are planning on banking this curved section of highway at an angle of θ to the horizontal.

   (c) Draw and label all of the forces acting on a car of mass m traveling along this banked turn. Do not include friction.

   (d) The engineers want to be sure that a car of mass m traveling at a constant speed v (the posted speed limit) could make it safely around the banked turn even if the road were covered with ice (that is, essentially frictionless). Compute this banking angle θ in terms of r, v, g, and m.