

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

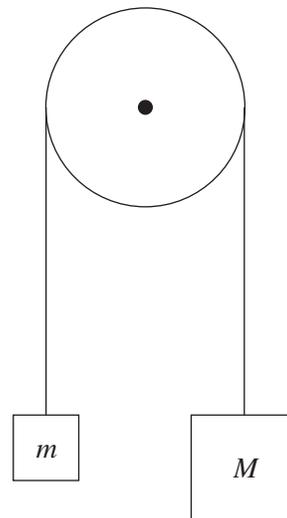
4. A 20 N block is being pushed across a horizontal table by an 18 N force. If the coefficient of kinetic friction between the block and the table is 0.4, find the acceleration of the block.

- (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 of 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?

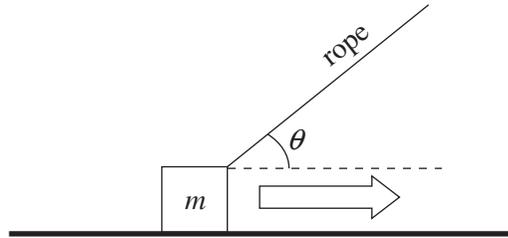
- (A) 0.6 m/s
- (B) 1.8 m/s
- (C) 2.4 m/s
- (D) 3.2 m/s
- (E) 4.8 m/s

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?

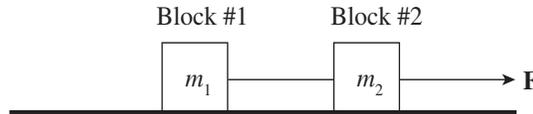
- (A) 0
- (B) $2\pi^2 r$
- (C) $2\pi^2 r^2$
- (D) $4\pi^2 r$
- (E) $4\pi^2 r^2$

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 F_T .



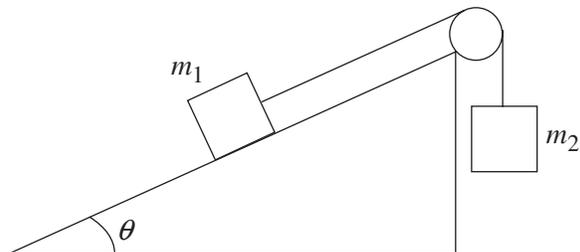
- Draw and label all of the forces acting on the crate.
 - Compute the normal force acting on the crate in terms of m , F_T , θ , and g .
 - Compute the acceleration of the crate in terms of m , F_T , θ , μ , and g .
 - Assume that the magnitude of the tension in the rope is fixed but that the angle 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.

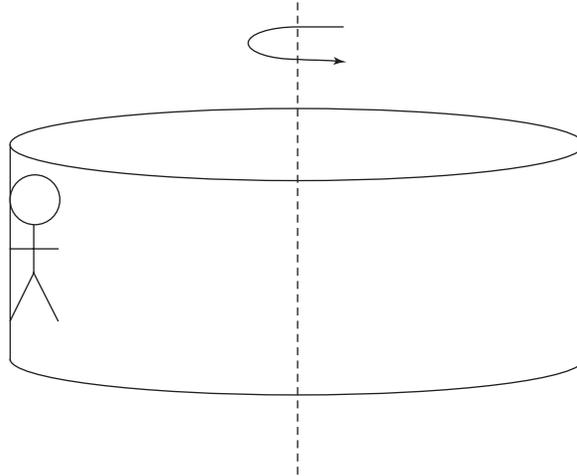
- Draw and label all of the forces acting on Block #1.
- Draw and label all of the forces acting on Block #2.
- What is the acceleration of Block #1?
- What is the tension in the string connecting the two blocks?
- If the string connecting the blocks were not massless, but instead had a mass of m , find
 - the acceleration of Block #1, and
 - 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 .

- Draw and label all the forces acting on a passenger of mass m as the cylinder rotates with the floor lowered.
 - Describe what conditions must hold to keep the passengers from sliding down the wall of the cylinder.
 - 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 .
- Draw and label all the forces acting on a car of mass m traveling along this curved part of the highway.
 - 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.

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