MasteringPhysics®

Signed in as Karrie Frey, Instructor | Help | Sign Out

OCC Physics at Tully High S

My Courses | Course Settings

College Physics, 9e
Young

Course Home **Assignments** Roster Gradebook Item Library Instructor Resources eText Study Area

Chapter 4 Homework [Edit]

Overview Summary View Diagnostics View **Print View with Answers**

Chapter 4 Homework

Due: 8:00am on Monday, October 28, 2013

You will receive no credit for items you complete after the assignment is due. Grading Policy

Conceptual Questions on Newton's 1st and 2nd Laws

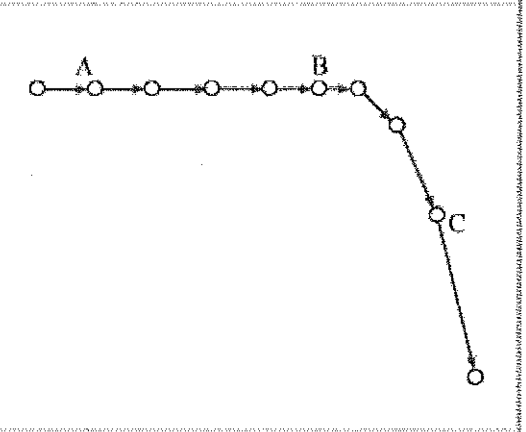
Description: Several conceptual questions regarding force, acceleration, inertial frames of reference, Newton's 1st and 2nd law. (version for algebra-based courses)

Learning Goal:

To understand the meaning and the basic applications of Newton's 1st and 2nd laws.

In this problem, you are given a diagram representing the motion of an object: a *motion diagram*. The dots represent the object's position at moments separated by equal intervals of time. The dots are connected by arrows representing the object's *average* velocity during the corresponding time interval.

Your goal is to use this motion diagram to determine the direction of the net force acting on the object. You will then determine which force diagrams and which situations may correspond to such a motion.



Part A

What is the direction of the net force acting on the object at position A?

Hint 1. Using Newton's 2nd law

According to Newton's 2nd law, vectors $\vec{a}$ and $\vec{F}_{\rm net}$ have the same direction. All you need to do then is to determine the direction of acceleration at position A by analyzing the diagram.

Hint 2. Find the direction of acceleration

Determine the direction of acceleration at position A by analyzing the diagram.

Hint 1. How to analyze the motion diagram

The velocity vectors connecting position A to the adjacent positions appear to have the same magnitude and direction. Does then the object accelerate as it travels through position A?

ANSWER:

○ The acceleration is directed upward.
○ The acceleration is directed downward.
○ The acceleration is directed to the left.
○ The acceleration is directed to the right.
● The acceleration is zero.

Now use Newton's 2nd law to determine the direction of the net force.

ANSWER:

○ upward
○ downward
○ to the left
○ to the right
● The net force is zero.

The velocity vectors connecting position A to the adjacent positions appear to have the same magnitude and direction. Therefore, the acceleration is zero—and so is the net force.

Part B

What is the direction of the net force acting on the object at position B?

Hint 1. Find the direction of acceleration

Determine the direction of acceleration at position B by analyzing the diagram.

Hint 1. How to analyze the motion diagram

The velocity vectors connecting position B to the adjacent positions appear to have the same direction but decreasing magnitude. What is the direction of the acceleration of the object at point B?

ANSWER:

○ The acceleration is directed upward.
○ The acceleration is directed downward.
● The acceleration is directed to the left.
○ The acceleration is directed to the right.
○ The acceleration is zero.

Now use Newton's 2nd law to determine the direction of the net force.

ANSWER:

○ upward
○ downward
● to the left
○ to the right
○ The net force is zero.

The velocity is directed to the right; however, it is decreasing. Therefore, the acceleration is directed to the left—and so is the net force.

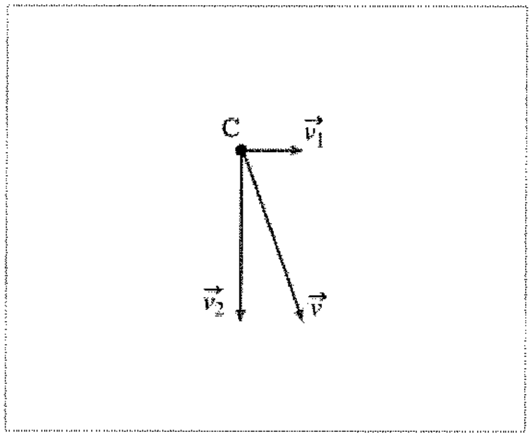
Part C

What is the direction of the net force acting on the object at position C?

Hint 1. Consider the components of the velocity

Instead of representing the velocity of an object with just one vector, one can break the velocity vector into two components. For example, in the figure below the average velocity at position C is shown together with its horizontal component $\vec{v}_1$ and its vertical component $\vec{v}_2$.

As the object travels through position C, the horizontal component of the velocity appears to remain constant. What about the vertical one?



ANSWER:

- ● It increases.
- ○ It decreases.
- ○ It remains constant.

Since the vertical component of the velocity increases, does the object accelerate? What is the direction of the acceleration?

ANSWER:

- ○ upward
- ● downward
- ○ to the left
- ○ to the right
- ○ The net force is zero.

The horizontal component of the velocity does not change. The vertical component of the velocity increases. Therefore, the acceleration—and hence the net force—is directed straight downward.

Part D

Which of these situations describe the motion shown in the motion diagram at point A?

Type the letters corresponding to all the right answers. Do not use commas. For instance, if you think that only situations C and D are correct, type CD.

ANSWER:

AD

Also accepted: DA

Part E

Which of these situations describe the motion shown in the motion diagram at point B?

Type the letters corresponding to all the right answers. Do not use commas. For instance, if you think that only situations C and D are correct, type CD.

ANSWER:

BE

Also accepted: EB

Part F

Which of these situations describe the motion shown in the motion diagram at point C?

Type the letters corresponding to all the right answers. Do not use commas. For instance, if you think that only situations C and D are correct, type CD.

ANSWER:

G

Understanding Newton's Laws

Description: Conceptual questions on Newton's first and second laws.

Part A

An object cannot remain at rest unless which of the following holds?

Hint 1. How to approach the problem

This problem describes a situation of static equilibrium (i.e., a body that remains at rest). Hence, it is appropriate to apply Newton's 1st law.

Hint 2. Newton's 1st law: a body at rest

According to Newton's 1st law, a body at rest remains at rest if the net force acting on it is zero.

ANSWER:

● The net force acting on it is zero.
○ The net force acting on it is constant and nonzero.
○ There are no forces at all acting on it.
○ There is only one force acting on it.

If there is a net force acting on a body, regardless of whether it is a constant force, the body accelerates. If the body is at rest and the net force acting on it is zero, then it will remain at rest. The net force could be zero either because there are no forces acting on the body at all or because several forces are acting on the body but they all cancel out.

Part B

If a block is moving to the left at a constant velocity, what can one conclude?

Hint 1. How to approach the problem

This problem describes a situation of dynamic equilibrium (i.e., a body that moves at a constant velocity). Hence, it is appropriate to apply Newton's 1st law.

Hint 2. Newton's 1st law: a body in motion

According to Newton's 1st law, a body initially in motion continues to move with constant velocity if the net force acting on it is zero.

ANSWER:

○ There is exactly one force applied to the block.
○ The net force applied to the block is directed to the left.
● The net force applied to the block is zero.
○ There must be no forces at all applied to the block.

If there is a net force acting on a body, regardless of whether the body is already moving, the body accelerates. If a body is moving with constant velocity, then it is not accelerating and the net force acting on it is zero. The net force could be zero either because there are no forces acting on the body at all or because several forces are acting on the body but they all cancel out.

Part C

A block of mass $2 \ \mathrm{kg}$ is acted upon by two forces: $3 \ \mathrm{N}$ (directed to the left) and $4 \ \mathrm{N}$ (directed to the right). What can you say about the block's motion?

Hint 1. How to approach the problem

This problem describes a situation of dynamic motion (i.e., a body that is acted on by a net force). Hence, it is appropriate to apply Newton's 2nd law, which allows you to relate the net force acting on a body to the acceleration of the body.

Hint 2. Newton's 2nd law

Newton's 2nd law states that a body accelerates if a net force acts on it. The net force is proportional to the acceleration of the body and the constant of proportionality is equal to the mass of the body. In other words,

$$F = ma,$$

where F is the net force acting on the body, and m and a are the mass and the acceleration of the body, respectively.

Hint 3. Relating acceleration to velocity

Acceleration is defined as the change in velocity per unit time. Keep in mind that both acceleration and velocity are vector quantities.

ANSWER:

○ It must be moving to the left.
○ It must be moving to the right.
○ It must be at rest.
● It could be moving to the left, moving to the right, or be instantaneously at rest.

The acceleration of an object tells you nothing about its velocity--the direction and speed at which it is moving. In this case, the net force on (and therefore the acceleration of) the block is to the right, but the block could be moving left, right, or in any other direction.

Part D

A massive block is being pulled along a horizontal frictionless surface by a constant horizontal force. The block must be __________.

Hint 1. How to approach the problem

This problem describes a situation of dynamic motion (i.e., a body that is acted on by a net force). Hence, it is appropriate to apply Newton's 2nd law, which allows you to relate the net force acting on a body to the acceleration of the body.

Hint 2. Newton's 2nd law

Newton's 2nd law states that a body accelerates if a net force acts on it. The net force is proportional to the acceleration of the body and the constant of proportionality is equal to the mass of the body. In other words,

$$F = ma,$$

where F is the net force acting on the body, and m and a are the mass and the acceleration of the body, respectively.

ANSWER:

- ○ continuously changing direction
- ○ moving at constant velocity
- ● moving with a constant nonzero acceleration
- ○ moving with continuously increasing acceleration

Since there is a net force acting, the body does not move at a constant velocity, but it accelerates instead. However, the force acting on the body is constant. Hence, according to Newton's 2nd law of motion, the acceleration of the body is also constant.

Part E

Two forces, of magnitude $4\ \mathrm{N}$ and $10\ \mathrm{N}$, are applied to an object. The relative direction of the forces is unknown. The net force acting on the object ________.

Check all that apply.

4N →
10N →

Max = 14N
Min = 6N

Fnet is anything between 6 - 14!

Hint 1. How to approach the problem

By definition, the net force is the vector sum of all forces acting on the object. To find the magnitude of the net force you need to add the components of the two forces acting. Try adding the two forces graphically (by connecting the head of one force to the tail of the other). The directions of the two forces are arbitrary, but by trying different possibilities you should be able to determine the maximum and minimum net forces that could act on the object.

Hint 2. Find the net force when the two forces act on the object in opposite directions

Find the magnitude of the net force if both the forces acting on the object are horizontal and the 10-N force is directed to the right, while the 4-N force is directed to the left.

Express your answer in newtons.

Hint 1. Vector addition

The magnitude of the vector sum of two parallel forces is the sum of the magnitudes of the forces. The magnitude of the vector sum of two antiparallel forces is the absolute value of the difference in magnitudes of the forces.

ANSWER:

6.0 N

Is there any other orientation of the two forces that would lead to a net force with a smaller magnitude than what you just calculated?

Hint 3. Find the direction of the net force when the two forces act in opposite directions

If both the forces acting on the object are horizontal and the 10-N force is directed to the right, while the 4-N force is directed to the left, the net force is horizontal and directed ________.

ANSWER:

→ 10 N ← 4N

- ● in the same direction as the 10-N force
- ○ in the opposite direction to the 10-N force

ANSWER:

- ☑ cannot have a magnitude equal to $5\ \mathrm{N}$
- ☐ cannot have a magnitude equal to $10\ \mathrm{N}$
- ☐ cannot have the same direction as the force with magnitude $10\ \mathrm{N}$
- ☐ must have a magnitude greater than $10\ \mathrm{N}$

Video Tutor: Suspended Balls: Which String Breaks?

Description: String hangs from massive ball that is itself suspended by string. Which string breaks when bottom string is pulled quickly? Slowly?

First, launch the video below. You will be asked to use your knowledge of physics to predict the outcome of an experiment. Then, close the video window and answer the question at right. You can watch the video again at any point.

Part A

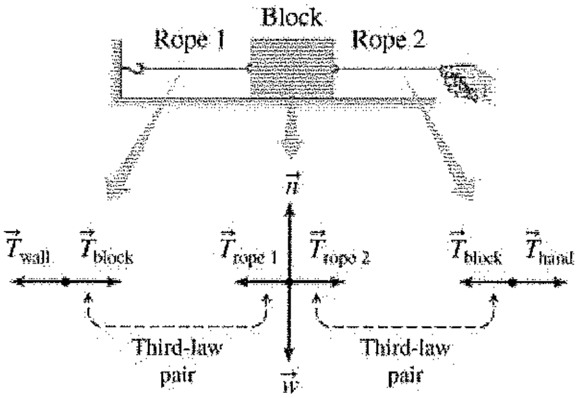
A heavy crate is attached to the wall by a light rope, as shown in the figure. Another rope hangs off the opposite edge of the box. If you slowly increase the force on the free rope by pulling on it in a horizontal direction, which rope will break? Ignore friction and the mass of the ropes.

Hint 1. How to approach the problem

Because you *slowly* increase the force you exert on the rope, the block's inertia does not affect the outcome.

Why is that the case? As you pull harder, the ropes stretch a bit, so the block slides slightly toward you. But the changes are so gradual that the *accelerations* of the block and ropes are practically zero at any instant.

Shown here are free-body diagrams for the ropes and block:



What does Newton's third law say about the tension forces exerted *by the block* on the two ropes?

ANSWER:

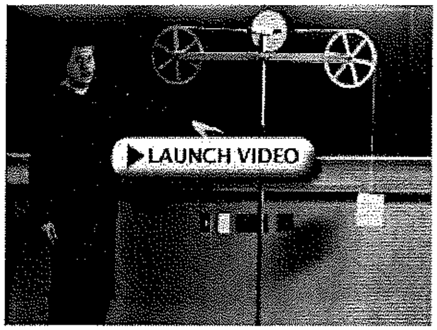
● Both ropes are equally likely to break.
○ The rope attached to the wall will break.
○ The rope that you are pulling on will break.

Since the attached rope doesn't have to support any weight (as it did in the vertical case), the tension is the same in both ropes.

Video Tutor: Tension in String between Hanging Weights

Description: Two stationary, equal-mass hanging blocks are connected by a horizontal string that runs over two pulleys. How does the tension in the string compare to the weight of an individual block?

First, launch the video below. You will be asked to use your knowledge of physics to predict the outcome of an experiment. Then, close the video window and answer the question at right. You can watch the video again at any point.



Part A

Consider the video tutorial you just watched. Suppose that we duplicate this experimental setup in an elevator. What will the spring scale read if the elevator is moving upward at constant speed?

Hint 1. How to approach the problem

What does the phrase "at constant speed" imply about the acceleration of the system?

ANSWER:

● 18 N
○ Less than 18 N but greater than 0 N
○ 0 N
○ More than 18 N

Since the elevator is not accelerating, the reading on the scale is the same as in the video.

Enhanced EOC: Problem 4.04: Jaw injury.

Description: Due to a jaw injury, a patient must wear a strap (see the figure) that produces a net upward force of ## N on his chin. The tension is the same throughout the strap. You may want to review Forces . For help with math skills, you may want...

Due to a jaw injury, a patient must wear a strap (see the figure) that produces a net upward force of 5.00N on his chin. The tension is the same throughout the strap.

You may want to review (pages 99 - 102) .

For help with math skills, you may want to review:

Vector Addition

$T_1 = T_2 = T$

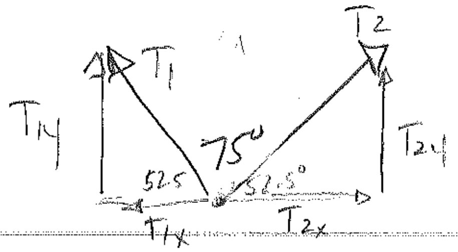
$\Sigma F_y = 5N$

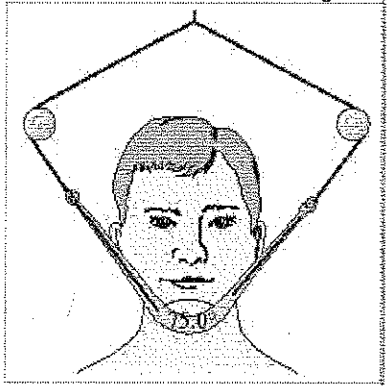
$T_y + T_y = 5N$

$\sin 52.5 T + \sin 52.5 T = 5N$

$1.587T = 5$

$\boxed{T = 3.15 N}$





Part A

To what tension must the strap be adjusted to provide the necessary upward force?

Hint 1. How to approach the problem

What can be said about the sum of the forces acting on the jaw?

Start by drawing a sketch of the jaw and the forces acting on it. Choose an appropriate coordinate system, and resolve the vector components accordingly.

Use this to calculate the force exerted on each side of the jaw by the strap.

ANSWER:

$F = 3.15\ \mathrm{N}$

Enhanced EOC: Problem 4.10

Description: [[Video Tutor Solution]] A hockey puck with mass ## kg is at rest on the horizontal, frictionless surface of a rink. A player applies a force of ## N to the puck, parallel to the surface of the ice, and continues to apply this force for ## s.You may...

A hockey puck with mass $\overset{m}{0.160\mathrm{kg}}$ is at $\overset{V_0}{\text{rest on}}$ the horizontal, frictionless surface of a rink. A player applies a $\overset{F_{net}}{\text{force of } 0.250\mathrm{N}}$ to the puck, parallel to the surface of the ice, and continues to apply this force for 2.00s. time

You may want to review (pages 104 - 109) .

For general problem-solving tips and strategies for this topic, you may want to view a Video Tutor Solution of A box on ice.

Part A

What is the position of the puck at the end of that time?

$\Sigma F = ma$

$0.25\ N = 0.16\ kg\ a$

$a = 1.56\ m/s^2$

Hint 1. How to approach the problem

Start by drawing a sketch of the hockey puck on the ice and its motion across the smooth surface.

Using the information provided about the puck's motion, determine which of the key kinematic variables (displacement, initial velocity, final velocity, acceleration, and time) are known.

How can you determine the others?

$x = \cancel{V_0 t}^{0} + \frac{1}{2} a t^2$

$x = \frac{1}{2}(1.56\ m/s^2)(2s)^2$

$\boxed{x = 3.13m}$

ANSWER:

$|\Delta x| = 3.12\ \mathrm{m}$

Part B

What is the speed of the puck at the end of that time?

$V = \cancel{V_0}^{0} + at$

Hint 1. How to approach the problem

Think about what equation can be used to calculate the velocity using the information given in the question.

$V = (1.56\ m/s^2)(2s)$

$\boxed{V = 3.12\ m/s}$

ANSWER:

$v = 3.12\ \mathrm{m/s}$

Enhanced EOC: Problem 4.23

Car ⟶

Description: [[Video Tutor Solution]] The driver of a ## kg car traveling on a horizontal road at ## (km)/h suddenly applies the brakes. Due to a slippery pavement, the friction of the road on the tires of the car, which is what slows down the car, is ## % of the...

The driver of a $\overset{m}{1800\mathrm{kg}}$ car traveling on a horizontal road at $\overset{v}{116\mathrm{km/h}}$ suddenly applies the brakes. Due to a slippery pavement, the friction of the road on the tires of the car, which is what slows down the car, is 22.0% of the weight of the car.

$f = 0.22(1800kg)(9.8\ m/s^2)$

You may want to review (pages 109 - 112) .

$a = ?$

For general problem-solving tips and strategies for this topic, you may want to view a Video Tutor Solution of The ketchup slide.

Part A

Only friction is ΣF!

$\Sigma F = ma$

$a = -\frac{0.22(\cancel{1800})(9.8\ m/s^2)}{\cancel{1800}}$

What is the acceleration of the car?

Give your answer as the magnitude of the acceleration. — no sign

$-\frac{f}{m} = a$

$a = 2.156\ m/s^2$

Hint 1. How to approach the problem

Start by drawing a sketch with all of the forces acting on the car. Establish a coordinate system. Which direction will indicate positive motion? In what direction must the net force act to slow the car?

Using the information given in the question, calculate the acceleration.

$\frac{116\,\cancel{km}}{1\,\cancel{hr}} \times \frac{1000\,m}{1\,\cancel{km}} \times \frac{1\,\cancel{hr}}{60\,\cancel{min}} \times \frac{1\,\cancel{min}}{60\,s}$

ANSWER:

$a = 9.80x = 2.16\ \mathrm{m/s^2}$

Part B

How many meters does the car travel before stopping under these conditions?

$a = -2.16\,m/s^2$

Hint 1. How to approach the problem

From Part A, you know the acceleration, and from the problem statement, you know the initial velocity. What is the final velocity?

Calculate the displacement using the appropriate equation. Be sure to be consistent with your units.

$V_f = 0 \quad V_0 = \frac{116\,km}{1\,\cancel{hr}} \times \frac{1000\,m}{1\,km} \times \frac{1\,\cancel{hr}}{3600\,s}$

$V_0 = 32.2\,m/s$

ANSWER:

$s = \frac{v^2}{2 \cdot 9.80x} = 241\ \mathrm{m}$

$V^2 = V_0^2 + 2aX$

$\frac{\cancel{V^2}^{0} - V_0^2}{2a} = X \quad \frac{-(32.2)^2}{2(-2.16)} = \boxed{240m}$

Enhanced EOC: Problem 4.45: The space shuttle

Description: [[Video Tutor Solution]] During the first stage of its launch, a space shuttle goes from rest to ## (km)/h while rising a vertical distance of ## km. Assume constant acceleration and no variation in g over this distance.You may want to review Free-b...

$V_i = 0 \quad V_f$

During the first stage of its launch, a space shuttle goes from rest to 4976$\mathrm{km/h}$ while rising a vertical distance of 45.0km . Assume constant acceleration and no variation in g over this distance.

You may want to review (pages 116 - 120) .

$\frac{4976\,km}{1\,hr} \times \frac{1000\,m}{1\,km} \times \frac{1\,hr}{3600\,s} = 1382.2\,m/s = v_f \quad X = 45,000\,m$

For general problem-solving tips and strategies for this topic, you may want to view a Video Tutor Solution of Weighing yourself in an elevator.

Part A

What is the acceleration of the shuttle?

$V^2 = \cancel{V_0^2}^{0} + 2aX$

$\frac{(1382.2)^2}{2(45,000)} = a$

Hint 1. How to approach the problem

Start by drawing a sketch of the space shuttle's motion during the period of acceleration in question. Make sure you choose an appropriate coordinate system and maintain consistency of units.

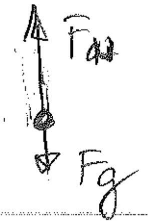
Using the information in the question and the appropriate equation, calculate the acceleration.

$a = 21.23\,m/s^2$

ANSWER:

$a = \frac{\left(\frac{v \cdot 10}{36}\right)^2}{2d} = 21.2\ \mathrm{m/s^2}$

?? Check



Part B

If a 60.0kg astronaut is standing on a scale inside the shuttle during this launch, make a free-body diagram of the astronaut.

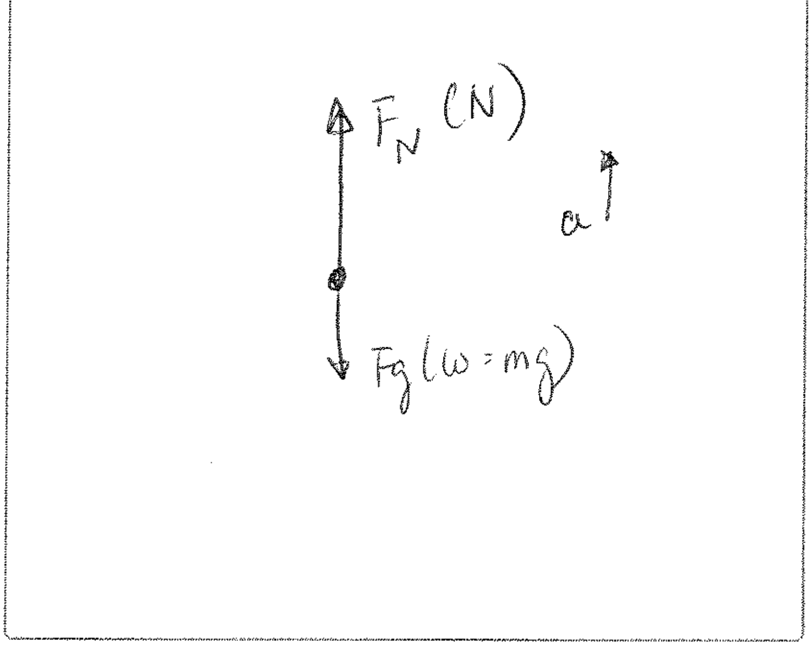
Draw the force vectors with their tails at the dot. The orientation of your vectors will be graded. The exact lengths of your vectors will not be graded, but the relative length of one to the other will be graded.

Hint 1. How to approach the problem

How is the acceleration of the shuttle related to the acceleration of the astronaut? What force(s) does the scale/shuttle exert on the astronaut? Are there any other forces to consider?

Same!

ANSWER:



Part C

How hard will the scale push on the astronaut in Part B?

Hint 1. How to approach the problem

How can you apply $F = ma$ to the astronaut to find the force in question?

ANSWER:

$$F = m\left(9.80 + \frac{\left(\frac{v\cdot 10}{36}\right)^2}{2d}\right) = 1860 \ \mathrm{N}$$

$\Sigma F = ma$

$F_N - F_g = ma$

$F_N = ma + F_g$

$F_N = ma + mg$

$F_N = 60(21.23) + 60(9.8)$

$\boxed{F_N = 1862\,N}$

Part D

If this astronaut did not realize that the shuttle had left the launch pad, what would she think were her weight and mass?

Hint 1. How to approach the problem

How is the scale reading related to weight? Since the astronaut thinks she is on the ground, what would be the acceleration due to gravity she would assume?

ANSWER:

- ● She would think the scale reading is her weight, $1860 \mathrm{N}$, and she would therefore think her mass is $190 \mathrm{kg}$.
- ○ She would think the scale reading is her weight, $588 \mathrm{N}$, and she would therefore think her mass is $60.0 \mathrm{kg}$.
- ○ She would think the scale reading is her weight, $0 \ \mathrm{N}$, and she would therefore think her mass is $0 \ \mathrm{kg}$.

Problem 4.11

Description: A dock worker applies a constant horizontal force of ## N to a block of ice on a smooth horizontal floor. The frictional force is negligible. The block starts from rest and moves ## m in the first ## s. (a) What is the mass of the block of ice?

A dock worker applies a constant horizontal force of 79.0N to a block of ice on a smooth horizontal floor. The frictional force is negligible. The block starts from rest and moves 8.00m in the first 7.00s .

$V_0 = 0 \quad x = 8m \quad t = 7s \quad a = \frac{V - \cancel{V_0}}{t}$

Part A

What is the mass of the block of ice?

ANSWER:

$m = \frac{Ft^2}{2s} = 242\ \mathrm{kg}$

①st

$x = \cancel{V_0 t}^{0} + \frac{1}{2}at^2$

$\frac{2x}{t^2} = a \quad \frac{2(8)}{7^2}$

$a = 0.33 m/s^2$

2nd $\Sigma F = ma$

$m = \frac{F}{a} = \frac{79N}{0.33}$

$\boxed{m = 242Kg}$

Problem 4.20

Description: At the surface of Jupiter's moon Io, the acceleration due to gravity is ## m/s^2. (a) If a piece of ice weighs ## N at the surface of the earth, what is its mass on the earth's surface? (b) What is the mass of this piece of ice on the surface of Io? ...

At the surface of Jupiter's moon Io, the acceleration due to gravity is $1.81 \mathrm{m/s^2}$.

Part A

If a piece of ice weighs 28.0N at the surface of the earth, what is its mass on the earth's surface?

ANSWER:

$m = \frac{var2}{9.8} = 2.86\ \mathrm{kg}$

$F_g = mg$

$m = \frac{F_g}{g} = \frac{28N}{9.8} = 2.86Kg$

Part B

What is the mass of this piece of ice on the surface of Io?

ANSWER:

$m_{Io} = \frac{var2}{9.8} = 2.86\ \mathrm{kg}$

Same!

Part C

What is the weight of this piece of ice on the surface of Io?

ANSWER:

$w_{Io} = \frac{var2}{9.8} var1 = 5.17\ \mathrm{N}$

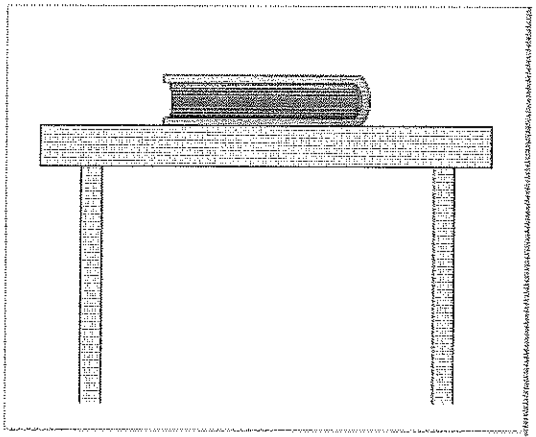
$F_g = mg$

$F_g = 2.86(1.81)$ $\boxed{5.17N}$

A Book on a Table

Description: Conceptual questions around Newton's third law. (Multiple choice.)

A book weighing 5 N rests on top of a table.



Part A

A downward force of magnitude 5 N is exerted on the book by the force of

ANSWER:

○ the table
● gravity
○ inertia

Part B

An upward force of magnitude _____ is exerted on the _____ by the table.

ANSWER:

○ 6 N / table
○ 5 N / table
● 5 N / book
○ 6 N / book

gravity on book
v.
table on book

3 "items"
not a pair!

Part C

Do the downward force in Part A and the upward force in Part B constitute a 3rd law pair?

Hint 1. The force of gravity

The force of gravity is another name for the force exerted by the earth (or any astronomical object) on objects near its surface.

Hint 2. Exploring Newton's 3rd law

Indicate whether the following statements about Newton's 3rd law are true, false, or indeterminate.

t 1. According to Newton's 3rd law, every real force has a unique pair force.
f 2. The pair force is called a "fictitious force."
t 3. The force and pair force must act on different point masses.
t 4. The force and the pair force must always have the same magnitude and must also act in exactly opposite directions.

Enter t for true, f for false, or i for indeterminate for each statement, separating the answers with commas (e.g., if all but the first statement were true, you would enter f,t,t,t).

ANSWER:

t, f, t, t

ANSWER:

○ yes
● no

Part D

The reaction to the force in Part A is a force of magnitude _____, exerted on the _____ by the _____. Its direction is _____ .

Hint 1. The force of gravity

The force of gravity is another name for the force exerted by the earth (or any astronomical object) on objects near its surface.

ANSWER:

● 5 N / earth / book / upward
○ 5 N / book / table / upward
○ 5 N / book / earth / upward
○ 5 N / earth / book / downward

Part E

The reaction to the force in Part B is a force of magnitude _____, exerted on the _____ by the _____. Its direction is _____.

ANSWER:

○ 5 N / table / book / upward
○ 5 N / table / earth / upward
○ 5 N / book / table / upward
● 5 N / table / book / downward
○ 5 N / earth / book / downward

Part F

Which of Newton's laws dictates that the forces in Parts A and B are equal and opposite?

ANSWER:

● Newton's 1st or 2nd law
○ Newton's 3rd law

Since the book is at rest, the net force on it must be zero (1st or 2nd law). This means that the force exerted on it by the earth must be equal and opposite to the force exerted on it by the table.

Part G

Which of Newton's laws dictates that the forces in Parts B and E are equal and opposite?

ANSWER:

○ Newton's 1st or 2nd law
● Newton's 3rd law

A Space Walk

Description: Use Newton's 3rd law to determine the best way to move toward the space shuttle while space walking. Also, use Newton's 2nd law to find the acceleration of an astronaut given her mass and the force acting on her.

Part A

An astronaut is taking a space walk near the shuttle when her safety tether breaks. What should the astronaut do to get back to the shuttle?

Hint 1. How to approach the problem

Newton's 3rd law tells us that forces occur in pairs. Within each pair, the forces, often called *action* and *reaction*, have equal magnitude and opposite direction.

Which of the actions suggested in the problem will result in the force pushing the astronaut back to the shuttle?

ANSWER:

- ○ Attempt to "swim" toward the shuttle.
- ○ Take slow steps toward the shuttle.
- ● Take a tool from her tool belt and throw it *away* from the shuttle.
- ○ Take the portion of the safety tether still attached to her belt and throw it *toward* the shuttle.

As the astronaut throws the tool away from the shuttle, she exerts a force in the direction *away* from the shuttle. Then, by Newton's 3rd law, the tool will exert an opposite force on her. Thus, as she throws the tool, a force directed toward the shuttle will act on the astronaut. Newton's 2nd law stipulates that the astronaut would acquire an acceleration toward the shuttle.

Part B

Assuming that the astronaut can throw any tool *with the same force*, what tool should be thrown to get back to the shuttle as **quickly** as possible? You should consider how much mass is left behind as the object is thrown as well as the mass of the object itself.

Hint 1. How to approach the problem

Recall that the force acting on the astronaut is equal in magnitude and opposite in direction to the force that she exerts on the tool.

Hint 2. Newton's 2nd law

Newton's 2nd law states that $F = ma$. If force is held constant, then acceleration is inversely proportional to mass. For example, when the same force is applied to objects of different mass, the object with the largest mass will experience the smallest acceleration.

ANSWER:

- ○ The tool with the smallest mass.
- ● The tool with the largest mass.
- ○ Any tool, since the mass of the tool would make no difference.

The force that acts on the astronaut must equal in magnitude the force that she exerts on the tool. Therefore, if she exerts the same force on any tool, the force acting on her will be independent of the mass of the tool. However, the acceleration that the astronaut would acquire is inversely proportional to her mass since she is acted upon by a constant force. If she throws the tool with the largest mass, the remaining mass (the astronaut plus her remaining tools) would be smallest—and the acceleration the greatest!

Part C

If the astronaut throws the tool with a force of $16.0\mathrm{N}$, what is the magnitude of the acceleration a of the astronaut during the throw? Assume that the total mass of the astronaut after she throws the tool is $80.0\mathrm{kg}$.

Express your answer in meters per second squared.

$\Sigma F = ma$

$a = \frac{\Sigma F}{m} = \frac{16N}{80kg} = \boxed{0.2\ m/s^2}$

Hint 1. Find the force acting on the astronaut

What is the magnitude of the force F acting *on* the astronaut as she throws the tool?

Express your answer in newtons.

$16N \rightarrow \leftarrow 16N$

equal mag, opp direction

ANSWER:

$F = F_a = 16.0 \ \mathrm{N}$ equal + opposite

Now use Newton's 2nd law to find the acceleration of the astronaut.

Hint 2. Newton's 2nd law

An object of mass m acted upon by a net force F has an acceleration a given by $F = ma$.

ANSWER:

$a = \frac{F_a}{m_a} = 0.200 \ \mathrm{m/s^2}$

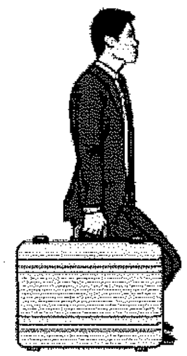
The Normal Force

Description: Short conceptual problem requiring students to identify the normal force acting on an object in situations where it does not equal the weight of the object. This problem is based on Young/Geller Conceptual Analysis 4.5.

When an object rests on a surface, there is always a force perpendicular to the surface; we call this the normal force, denoted by $\vec{n}$. The two questions to the right will explore the normal force.

Part A

A man attempts to pick up his suitcase of weight w_s by pulling straight up on the handle. However, he is unable to lift the suitcase from the floor. Which statement about the magnitude of the normal force n acting on the suitcase is true during the time that the man pulls upward on the suitcase?



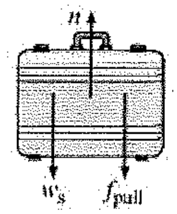
Hint 1. How to approach this problem

First, identify the forces that act on the suitcase and draw a free-body diagram. Then use the fact that the suitcase is in equilibrium, $\sum \vec{F} = 0$, to examine how the forces acting on the suitcase relate to each other.

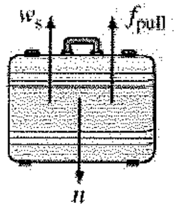
Hint 2. Identify the correct free-body diagram

Which of the figures represents the free-body diagram of the suitcase while the man is pulling on the handle with a force of magnitude f_{pull}?

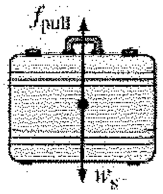
A



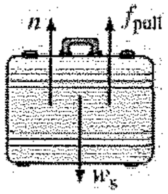
B



C



D



ANSWER:

○ A
○ B
○ C
● D

Now use this diagram to help you identify the true statement.

$\Sigma F = 0$

$F_N + F_a - F_g = 0$

$F_N = F_g - F_a$

w pull

ANSWER:

○ The magnitude of the normal force is equal to the magnitude of the weight of the suitcase.
● The magnitude of the normal force is equal to the magnitude of the weight of the suitcase minus the magnitude of the force of the pull.
○ The magnitude of the normal force is equal to the sum of the magnitude of the force of the pull and the magnitude of the suitcase's weight.
○ The magnitude of the normal force is greater than the magnitude of the weight of the suitcase.

Part B

Now assume that the man of weight w_{m} is tired and decides to sit on his suitcase. Which statement about the magnitude of the normal force n acting on the suitcase is true during the time that the man is sitting on the suitcase?

$\Sigma F = 0$

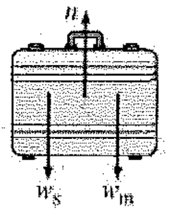
$F_N - F_g - F_{man} = 0$

$F_N = F_g + F_{man}$

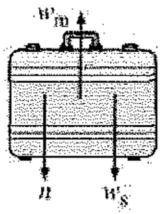
Hint 1. Identify the correct free-body diagram.

Which of the figures represents the free-body diagram while the man is sitting atop the suitcase? Here the vector labeled w_{m} is a force that has the same magnitude as the man's weight.

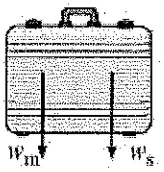
A



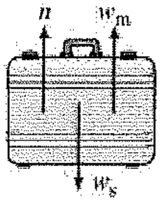
B



C



D



ANSWER:

● A
○ B
○ C
○ D

Now use this diagram to help you identify the true statement.

ANSWER:

○ The magnitude of the normal force is equal to the magnitude of the suitcase's weight.
○ The magnitude of the normal force is equal to the magnitude of the suitcase's weight minus the magnitude of the man's weight.
● The magnitude of the normal force is equal to the sum of the magnitude of the man's weight and the magnitude of the suitcase's weight.
○ The magnitude of the normal force is less than the magnitude of the suitcase's weight.

Recognize that the normal force acting on an object is *not* always equal to the weight of that object. This is an important point to understand.

Free-Body Diagrams

Description: Instructions for creating free-body diagrams are provided. Students practice creating diagrams for two different physical situations.

Learning Goal:

To gain practice drawing free-body diagrams

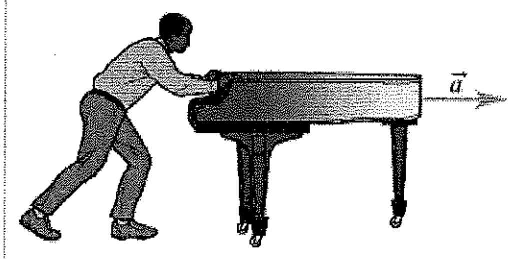
Whenever you face a problem involving forces, always start with a free-body diagram.
To draw a free-body diagram use the following steps:

1. Isolate the object of interest. It is customary to represent the object of interest as a point in your diagram.
2. Identify all the forces acting on the object and their directions. Do not include forces acting on other objects in the problem. Also, do not include quantities, such as velocities and accelerations, that are not forces.
3. Draw the vectors for each force acting on your object of interest. When possible, the length of the force vectors you draw should represent the relative magnitudes of the forces acting on the object.

In most problems, after you have drawn the free-body diagrams, you will explicitly label your coordinate axes and directions. Always make the object of interest the origin of your coordinate system. Then you will need to divide the forces into x and y components, sum the x and y forces, and apply Newton's first or second law.

In this problem you will only draw the free-body diagram.

Suppose that you are asked to solve the following problem:
Chadwick is pushing a piano across a level floor (see the figure). The piano can slide across the floor without friction. If Chadwick applies a horizontal force to the piano, what is the piano's acceleration?
To solve this problem you should start by drawing a free-body diagram.



Part A

Determine the object of interest for the situation described in the problem introduction.

Hint 1. How to approach the problem

You should first think about the question you are trying to answer: What is the acceleration of the piano? The object of interest in this situation will be the object whose acceleration you are asked to find.

ANSWER:

For this situation you should draw a free-body diagram for
○ the floor.
○ Chadwick.
● the piano.

Part B

Identify the forces acting on the object of interest. From the list below, select the forces that act on the piano.

Check all that apply.

ANSWER:

☐ acceleration of the piano
☑ gravitational force acting on the piano (piano's weight)
☐ speed of the piano
☐ gravitational force acting on Chadwick (Chadwick's weight)
☑ force of the floor on the piano (normal force)
☐ force of the piano on the floor
☑ force of Chadwick on the piano
☐ force of the piano pushing on Chadwick

Part C

Select the choice that best matches the free-body diagram you have drawn for the piano.

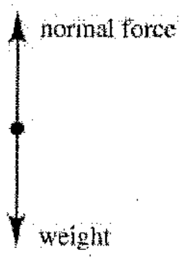
Hint 1. Determine the directions and relative magnitudes of the forces

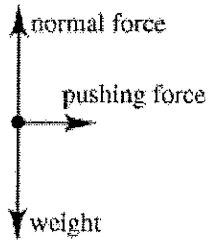
Which of the following statements best describes the correct directions and relative magnitudes of the forces involved?

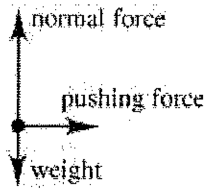
ANSWER:

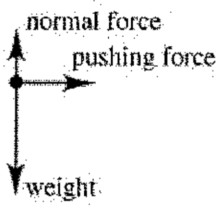
- ○ The normal force and weight are both upward and the pushing force is horizontal.
- ○ The normal force and weight are both downward and the pushing force is horizontal.
- ○ The normal force is upward, the weight is downward, and the pushing force is horizontal. The normal force has a greater magnitude than the weight.
- ● The normal force is upward, the weight is downward, and the pushing force is horizontal. The normal force and weight have the same magnitude.
- ○ The normal force is upward, the weight is downward, and the pushing force is horizontal. The normal force has a smaller magnitude than the weight.

ANSWER:

○ 

● 

○ 

○ 

If you were actually going to solve this problem rather than just draw the free-body diagram, you would need to define the coordinate system. Choose the position of the piano as the origin. In this case it is simplest to let the *y* axis point vertically upward and the *x* axis point horizontally to the right, in the direction of the acceleration.

Part D

Determine the object of interest for this situation.

ANSWER:

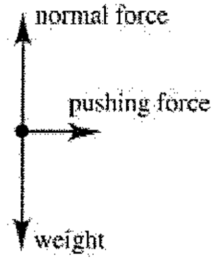
For this situation, you should draw a free-body diagram for
○ the ramp.
○ Chadwick.
● the piano.

Part E

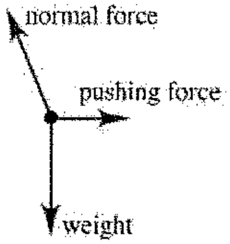
Which diagram accurately represents the free-body diagram for the piano?

ANSWER:

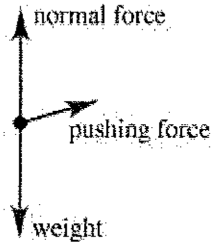
○



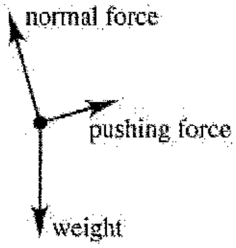
○



○



●



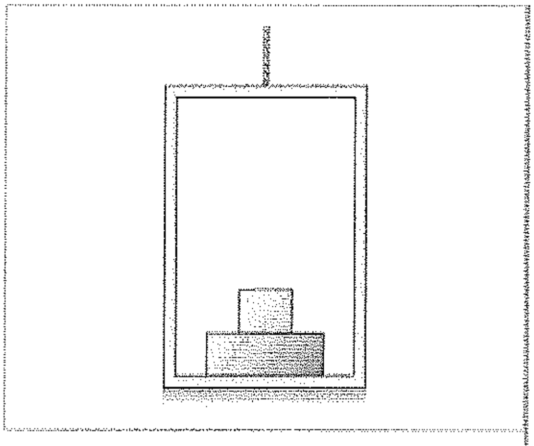
In working problems like this one that involve an incline, it is most often easiest to select a coordinate system that is not vertical and horizontal. Instead, choose the *x* axis so that it is parallel to the incline and choose the *y* axis so that it is perpendicular to the incline.

Forces on Blocks in an Elevator Conceptual Question

Description: Short conceptual questions about the forces on two stacked blocks in a moving elevator.

Two blocks are stacked on top of each other on the floor of an elevator. For each of the following situations, select the correct relationship between the magnitudes of the two forces given.

You will be asked two questions about each of three situations. Each situation is described above the first in the pair of questions. Do not assume anything about a given situation except for what is given in the description for that particular situation.



First situation

The elevator is moving downward at a constant speed. $\Sigma F = 0$

Part A

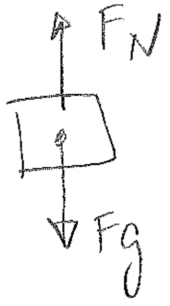
Hint 1. Comparing forces that act on the same object

When comparing forces that act on the same object, draw a free-body diagram of the object being acted on. Then, determine the acceleration of the object. By Newton's 2nd law, the net force must be proportional to the object's acceleration.

Hint 2. Draw a free-body diagram for the top block

Complete the free-body diagram for the top block by drawing the force on the top block due to the earth. This force should act at the center of the block.

ANSWER:



ANSWER:

The magnitude of the force of the bottom block on the top block is

○ greater than
● equal to
○ less than
○ unknown compared to

the magnitude of the force of the earth on the top block.

Part B

Hint 1. Comparing forces that do not act on the same object

If two forces do not act on the same object, they will not appear on the same free-body diagram. Therefore, Newton's 2nd law cannot be used to determine the relative sizes of these forces. Certain forces can, however, be compared using Newton's 3rd law.

Hint 2. Newton's 3rd law

Newton's 3rd law states that when two objects exert forces on each other, these forces are *always* equal in magnitude and opposite in direction. Thus, if you are sitting in a chair, the force the chair exerts upward on you is exactly the same as the force you exert downward on the chair, regardless of whether you are at rest in the chair, or have you feet up on your desk, or are in the process of getting up out of the chair, or in the process of landing in the chair after jumping from a great height, ... it does not matter!

ANSWER:

The magnitude of the force of the bottom block on top block is

○ greater than
● equal to
○ less than
○ unknown compared to

the magnitude of the force of the top block on bottom block.

Second situation

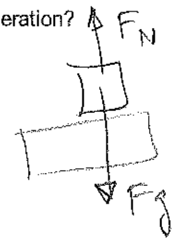
The elevator is moving downward at an increasing speed.

Part C

Hint 1. Determining acceleration

If the elevator is moving downward at an increasing speed, what is the direction of the elevator's acceleration?

$\Sigma F = -ma$



$\Sigma F = \downarrow !$

ANSWER:

○ upward
○ zero
● downward
○ unknown

ANSWER:

The magnitude of the force of the bottom block on the top block is

○ greater than
○ equal to
● less than
○ unknown compared to

the magnitude of the force of the earth on the top block.

Part D

Hint 1. Newton's 3rd law in accelerating elevator

Newton's 3rd law holds that forces come in pairs of equal magnitude and opposite direction in all cases. Thus, the acceleration of the elevator should not affect the *relative* magnitude of two forces that form a 3rd law pair.

ANSWER:

The magnitude of the force of the bottom block on the top block is
○ greater than
● equal to
○ less than
○ unknown compared to
the magnitude of the force of the top block on the bottom block.

Third situation

The elevator is moving upward.

Part E

Hint 1. Determining acceleration

If the elevator is moving upward, what is the direction of the elevator's acceleration?

ANSWER:

○ upward
○ zero
○ downward
● unknown

ANSWER:

The magnitude of the force of the bottom block on the top block is
○ greater than
○ equal to
○ less than
● unknown compared to
the magnitude of the force of the earth on the top block.

Even though the elevator is moving upwards, you do not know in which direction it is accelerating, or indeed whether the elevator is accelerating at all!

Part F

ANSWER:

The magnitude of the force of the bottom block on the top block is
○ greater than
● equal to
○ less than
○ unknown compared to
the magnitude of the force of the top block on the bottom block.

Problem 4.56: Jumping to the ground.

Description: A ## kg man steps off a platform ## m above the ground. He keeps his legs straight as he falls, but at the moment his feet touch the ground his knees begin to bend, and, treated as a particle, he moves an additional ## m before coming to rest. (a)...

m x

A 73.8kg man steps off a platform 3.01m above the ground. He keeps his legs straight as he falls, but at the moment his feet touch the ground his knees begin to bend, and, treated as a particle, he moves an additional 0.630m before coming to rest.

$V^2 = \cancel{V_0^2} + 2ax$

Part A

What is his speed at the instant his feet touch the ground?

ANSWER:

$v = \sqrt{(2gh)} = 7.68\ \mathrm{m/s}$

$V = \sqrt{2(-9.8)(-3.01)}$

$V = 7.68\ m/s$

Part B

Treating him as a particle, what is the magnitude of his acceleration as he slows down if the acceleration is constant?

ANSWER:

$a = \frac{gh}{h1} = 46.8\ \mathrm{m/s^2}$

$\cancel{V^2} \overset{0}{=} V_0^2 + 2ax$

$\frac{-V_0^2}{2y} = a$

$a = \frac{-(7.68)^2}{2(-0.63)}$

$= 46.8\ m/s^2$

Part C

Treating him as a particle, what is the direction of his acceleration as he slows down if the acceleration is constant?

ANSWER:

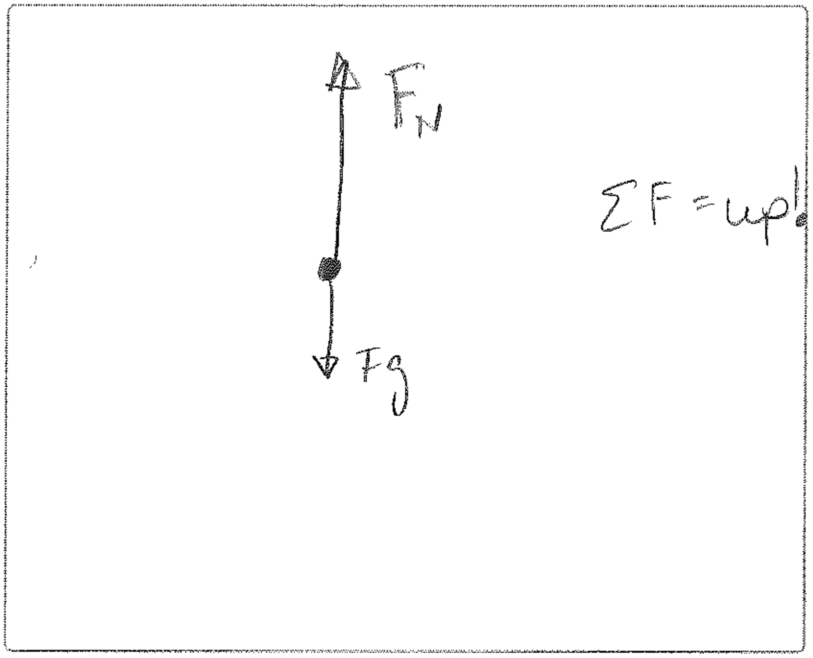
● upward
○ downward

Part D

Draw a free-body diagram of this man as he is slowing down.

Draw the force vectors with their tails at the dot. The orientation of your vectors will be graded. The exact length of your vectors will not be graded but the relative length of one to the other will be graded.

ANSWER:



Part E

Use Newton's laws and the results of part B to calculate the force the ground exerts on him while he is slowing down. Express this force in newtons.

ANSWER:

$$F = mg\left(\frac{h}{h1}+1\right) = 4180 \ \mathrm{N}$$

$\Sigma F = ma$

$F_N - F_g = ma$

$F_N = ma + F_g$

$F_N = 73.8(46.8) + 73.8(9.8)$

$\boxed{4177 N}$

Part F

Use Newton's laws and the results of part to calculate the force the ground exerts on him while he is slowing down. Express this force as a multiple of the man's weight.

ANSWER:

$$F = \frac{h}{h1}+1 = 5.78 \ w$$

$\frac{4177}{(73.8)(9.8)}$ = 5.78 weight

Part G

What is the magnitude of the reaction force to the force you found in part E?

ANSWER:

$$F_{\mathrm{reaction}} = mg\left(\frac{h}{h1}+1\right) = 4180 \ \mathrm{N}$$

Same (opposite direction)

Part H

What is the direction of the reaction force to the force you found in part E?

ANSWER:

○ upward
● downward

ground = up force
man = down force

Problem 4.18: Interpreting a medical chart.

Description: You, a resident physician, are reading the medical chart of a normal adult female patient. Carelessly, one of the nurses has entered this woman's weight as a number without units. Another nurse has offered a suggestion for what the units might be. In...

You, a resident physician, are reading the medical chart of a normal adult female patient. Carelessly, one of the nurses has entered this woman's weight as a number without units. Another nurse has offered a suggestion for what the units might be. In each of the following cases, decide whether this nurse's suggestion is physically reasonable.

Part A

The number is 150 , and the nurse suggests that the units are kilograms.

ANSWER:

○ The suggestion is physically reasonable.
● The suggestion is not physically reasonable.

1Kg = 2.2 lbs
normal adult females
are not 330 lbs!

Part B

The number is 4.25, and the nurse suggests that the units are slugs.

ANSWER:

Slug = 32 pounds of force
436 lb. is reasonable

○ The suggestion is not physically reasonable.`

● The suggestion is physically reasonable.

Part C

The number is 20000, and the nurse suggests that the units are grams.

ANSWER:

○ The suggestion is physically reasonable.

● The suggestion is not physically reasonable.

20,000g = 20Kg = 44lbs

Normal adults

dont weigh 44 lbs

Problem 4.28

Description: A person throws a ## lb stone into the air with an initial upward speed of ## (ft)/s. (a) Make a free-body diagram of the forces for this stone after it is free of the person's hand and is traveling upward. (b) Make a free-body diagram of the forces ...

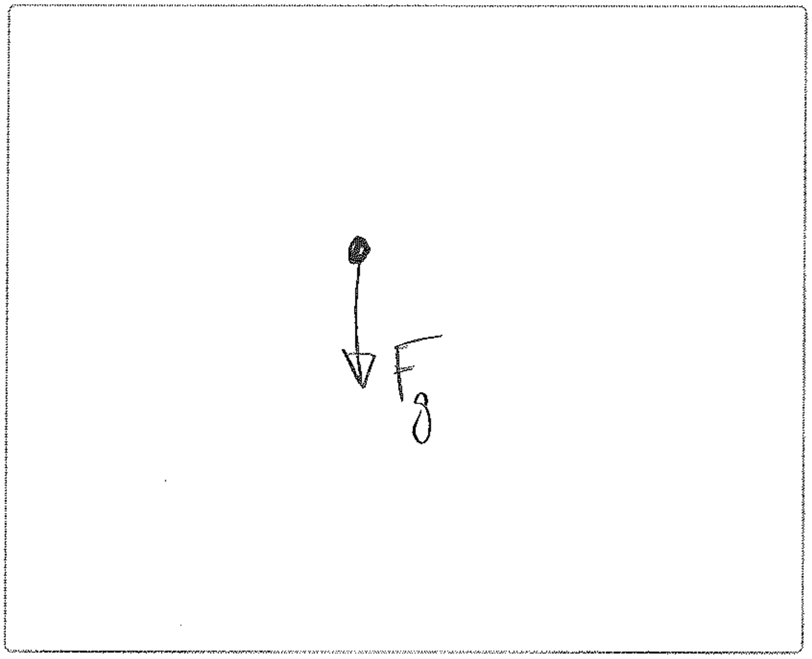
A person throws a 2.50lb stone into the air with an initial upward speed of 15.0ft/s .

Part A

Make a free-body diagram of the forces for this stone after it is free of the person's hand and is traveling upward.

Draw the force vectors with their tails at the dot. The orientation of your vectors will be graded. The exact length of your vectors will not be graded but the relative length of one to the other will be graded.

ANSWER:

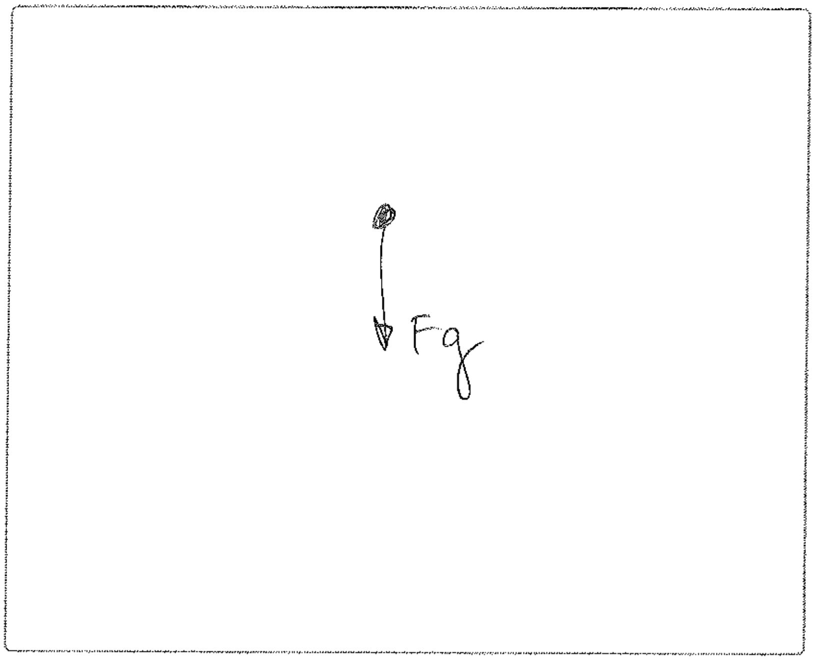


Part B

Make a free-body diagram of the forces for this stone at its highest point.

Draw the force vectors with their tails at the origin of the coordinate system. The orientation of your vectors will be graded. The exact length of your vectors will not be graded but the relative length of one to the other will be graded.

ANSWER:

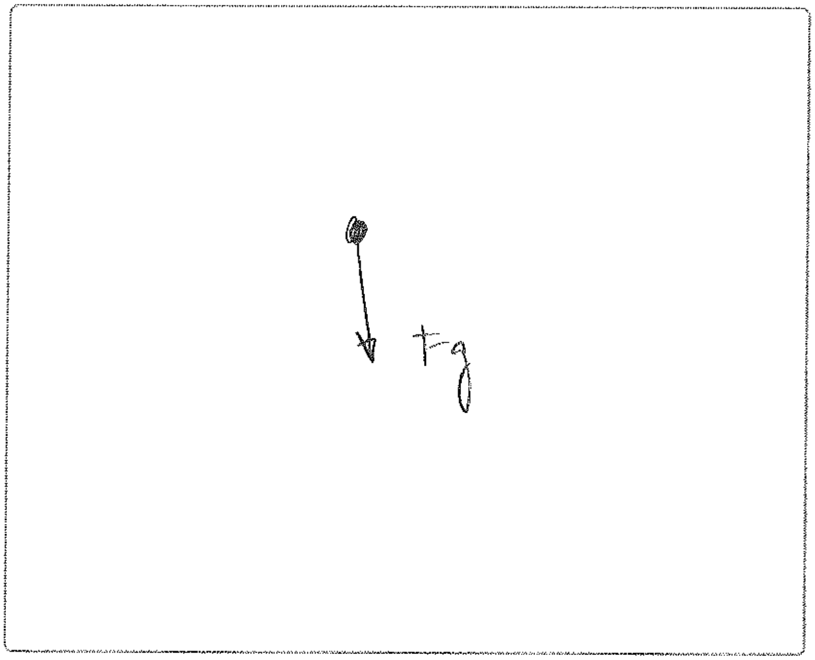


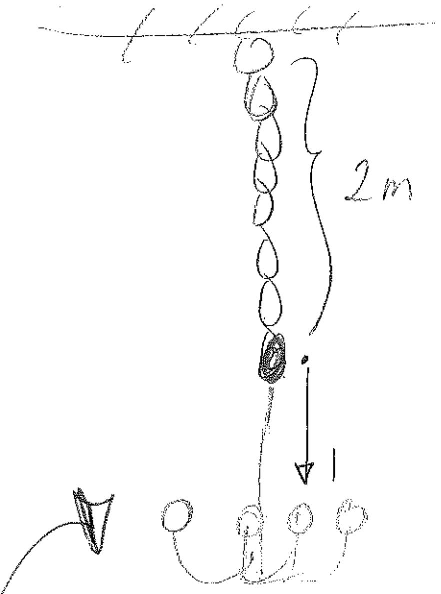
Part C

Make a free-body diagram of the forces for this stone when it is traveling downward.

Draw the force vectors with their tails at the dot. The orientation of your vectors will be graded. The exact length of your vectors will not be graded but the relative length of one to the other will be graded.

ANSWER:

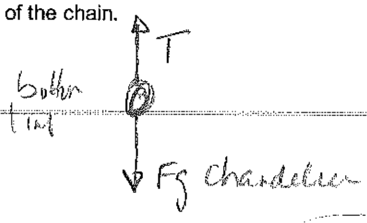




Problem 4.37

Description: A uniform ## kg chain ## m long supports a ## kg chandelier in a large public building. (a) Find the tension in the bottom link of the chain. (b) Find the tension in the top link of the chain. (c) Find the tension in the middle link of the chain.

A uniform 24.5kg chain 2.00m long supports a 46.0kg chandelier in a large public building.



Part A

Find the tension in the bottom link of the chain.

ANSWER:

$\Sigma F_y = 0$

$T - F_g = 0$

$T = F_g = mg = 46(9.8) = \boxed{450.8N}$

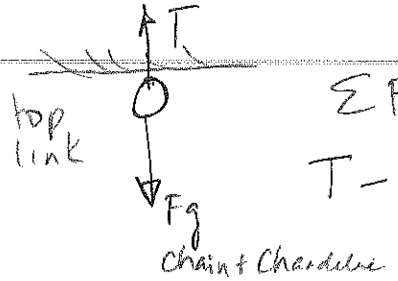
$T_1 = m2g = 451\ \mathrm{N}$

Part B

Find the tension in the top link of the chain.

ANSWER:

$T_2 = (m1 + m2)\,g = 691\ \mathrm{N}$



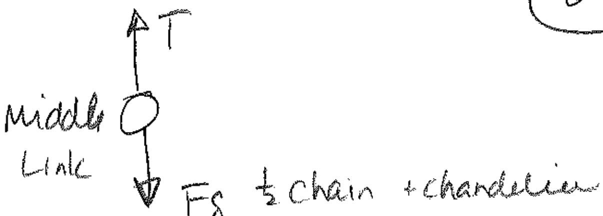
$$\Sigma F_y = 0$$
$$T - F_g = 0$$
$$T = F_g$$
$$T = (46 + 24.5)9.8$$
$$\boxed{691\,N}$$

Part C

Find the tension in the middle link of the chain.

ANSWER:

$T_3 = \left(m2 + \frac{m1}{2}\right) g = 571\ \mathrm{N}$



$$\Sigma F_y = 0$$
$$T - F_g = 0$$
$$T = F_g$$
$$T = \left(46 + \frac{24.5}{2}\right)(9.8)$$
$$\boxed{= 571\,N}$$