Physics Wkb Chapter 2a on the Concepts of Motion

Nick's R&R (Rant & Rave)

Big Question: If Einstein proved Newton's theories false, why must we learn this false theory?

Answer 1 - Newton created the language and basic definitions that permeate not only physics, but all of science and math.

Answer 2 - He also created the basic tools of science, Calculus, and the language and tools are entertwined.

Answer 3 - Remember that one of the most important aspects of solving any physics problem is to be able to make assumptions that simplify the problem to make it solve-able. When speeds are less than half the speed of light, differences in outcomes of motion problems between Einstein's and Newton's are virtually immeasurable.

Introduction to (uniform)Motion

Elementary (but not necessarily trivial) Concepts

- Placement & displacement;
- position, distance & position;
- time, time intervals & clock readings;
- ratios and what information they give you
- speed, velocity, average velocity & instantaneous velocity;
- acceleration, average acceleration & instantaneous acceleration:

The Greeks, for all their mathematical skills and accomplishments in logic, failed to develop these concepts and hence failed to discover the laws of motion. If you have difficulties with these concepts, you are in good company, they eluded the best minds in the world for 2000 years.

(In fact, they still do, ask almost any physics teacher, high school or college, what information does acceleration tell you about motion? You will frequently get a fuzzy answer, because they too, are a bit weak on exactly what ratios mean.)

The idea of model building

(The "physics" of physics)

When studying the motion of an object, what all must be considered ?

For instance, if all we want to know is how many meters an object travels in a straight line in a set amount of time, do we need to know its shape, or whether it is rotating ?

No.

We will first study the motion of the whole object, and ignore its shape, or whether or not it rotates as it moves, so we will treat the whole object as if it were a single dot, or **particle.**

Linear motion

1. Instantaneous velocity
What it means - How far an object would travel and in what direction, in the next second, if it were to continue at this velocity.

2. Changing velocity = acceleration
What it means

Speeding up

Slowing down

These diagrams are called **Motion diagrams** . They are useful in understanding these concepts as well as an aid in setting up problems. Also for these problems, a reference frame is essential.

3. a. Draw a motion diagram of an object with positive velocity and positive acceleration.

b. Draw a motion diagram of an object with positive velocity and negative acceleration.

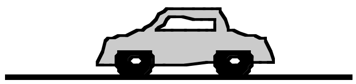
c. Draw a motion diagram of an object with negative velocity and positive acceleration
.

d. Draw a motion diagram of an object with negative velocity and negative acceleration.

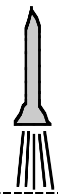
4.

Motion Diagrams—2

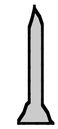
(a) Construct a motion diagram for a car traveling toward the left at decreasing speed.



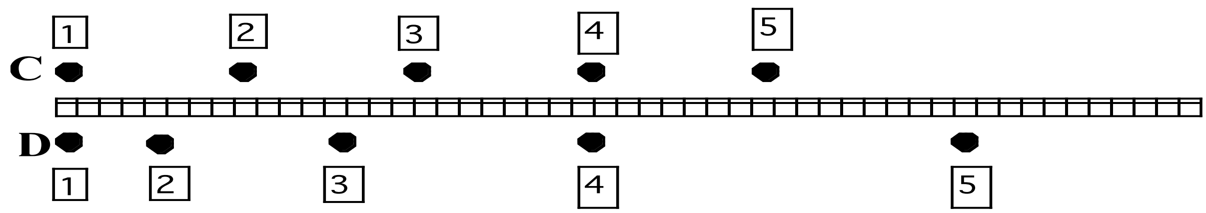
(b) Construct a motion diagram for a bottle rocket whose burning fuel causes it to move vertically upward at increasing speed.



(c) Construct a motion diagram for the bottle rocket described in (b) after its fuel is burned and while it still moves upward but now at decreasing speed.



5. Below is the motion diagrams for two different objects C and D. Clock readings are indicated in the boxes.



a) Do both have uniform velocity?

b) Which is traveling fastest to begin with?

c) Which travels for the greatest length of time?

d) Which travels the greatest distance?

e) At which clock readings (instants) do they occupy the same location at the same time?

f) Is there any time interval over which they have the same average velocity?

g) Are they ever traveling the same speed at any clock reading?

h) Which would accurately indicate the speed of the object **at** clock reading 2, an arrow drawn from 2 to 3 for C or an arrow drawn from 2 to 3 for D?

6. Be careful with the word "average". It's much more complex than most people realize, as the following problem found in many an algebra text illustrates:

John travels 3 miles per hour from home to work and 4 miles per hour back home. If the entire round trip travel time is 1.5 hours, how far does John live from his business.

The following answer was given:

Distance = average speed x time, average speed is (3 + 4)/2 = 3.5 mph, so total distance must be
D = 3.5 miles/hr x 1.5 hr = 5.25 miles, hence John must live 5.25/2 = 2.625 miles from work.

Explain why this answer is wrong and find the correct answer to the problem.

Hint: Look at this problem first.

1 mph for 9 hours, then 9 mph for 1 hour
9 mph for 9 hours, then 1 mph for 1 hour
What about 4 mph for 5 hours then 6 mph for 5 hours, what's the difference?

In all three of these examples the "average" of the two speeds times the total time interval is 50 miles. But is either total distance traveled 50 miles? Do it in your head!

The Rambo Problem

Rambo parachutes onto the island. His mission is to help 20 prisoners escape from the evil island ruler. His plan is to release the prisoners, lead them to the hidden runway where a plane awaits, which, of course , he knows how to fly, load them all into the airplane and fly them to safety. All goes well until they reach the runway, and he finds the runway has been bombed. He estimates only 700m of runway remains. Being the expert in everything that he is, he knows:

- the airplane requires a speed of 90 m/s to become airborne,
- that acceleration of the empty plane is 9 m/s^2 ,
- that given the constant force of the engines, Newton's second law says acceleration is inversely proportional to mass, which means if mass of the plane doubles its acceleration halves,
- that the mass of the empty airplane is 3000kg,
- he estimates the mass of the 20 prisoners and himself to be approximately 1500 kg.

Should he attempt to takeoff or should he lead his desperate band into the jungle and hide until he thinks up another idea?

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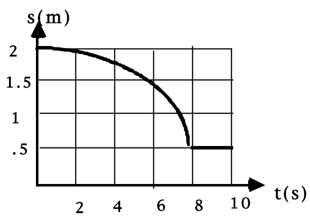
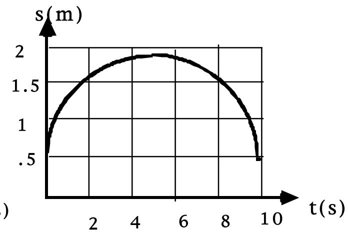
Physics Wkb Chap 2b Disp, Vel, & Acc Ranking Task #1

In the displacement vs time graphs below, all the times are in seconds (s) and all the displacements are in meters (m). Rank these graphs on the basis of which graph indicates the greatest **displacement** from beginning to end of motion. Give the highest rank to the one(s) with the greatest displacement, and give the lowest rank to the one(s) indicating the least displacement. If two graphs indicate the same displacement, give them the same rank.

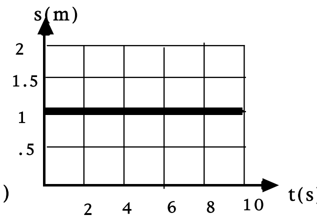
A.



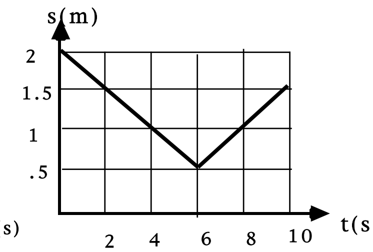
B.



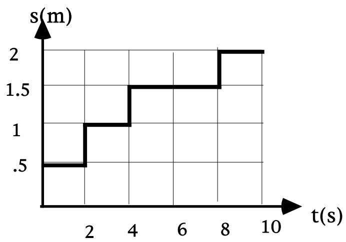
C.



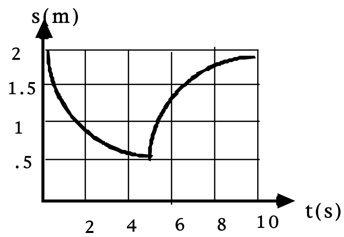
D.



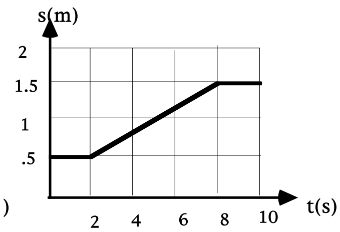
E.



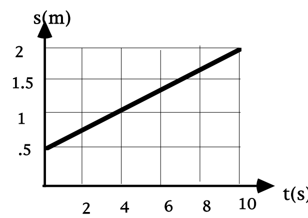
F.



G.



H.



Greatest 1._____ 2._____ 3._____ 4._____ 5._____ 6._____ Least
Highest Lowest

Which of these indicate no displacement at all._________
Please carefully explain how you arrived at your ranking.

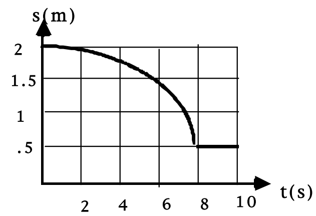
How sure are you of your ranking? (Circle one)
Basically Guessed Sure Very Sure

1 2 3 4 5 6 7 8 9 10

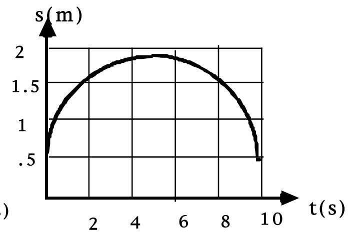
Physics Wkb Chap 2b Disp, Vel, & Acc Ranking Task #2

In the displacement vs time graphs below, all the times are in seconds (s) and all the displacements are in meters (m). Rank these graphs on the basis of which graph indicates the greatest **average velocity** from beginning to end of motion. Give the highest rank to the one(s) with the greatest displacement, and give the lowest rank to the one(s) indicating the least displacement. If two graphs indicate the same displacement, give them the same rank.

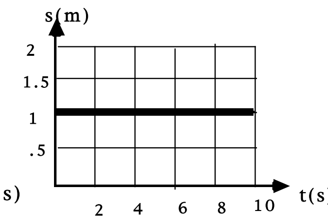
A.



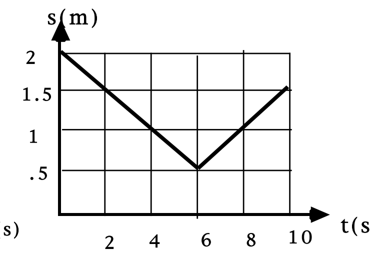
B.



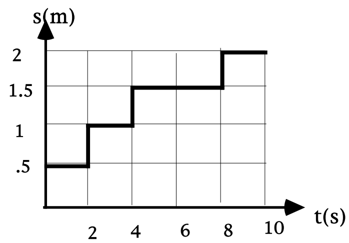
C.



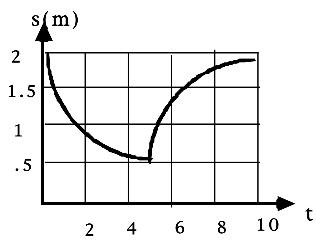
D.



E.



F.



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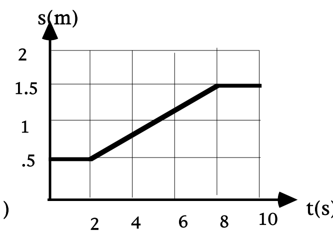

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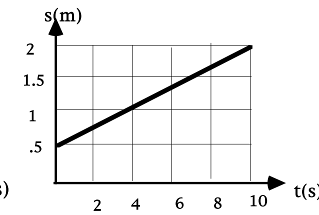


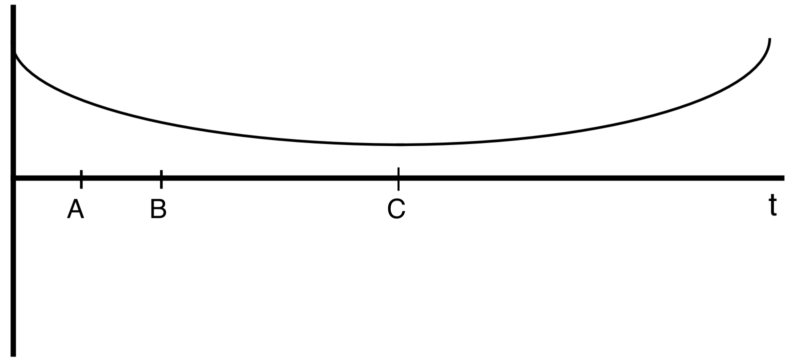
Greatest 1._____ 2._____ 3._____ 4._____ 5._____ 6._____ Least
Highest Lowest

Which of these indicate no displacement at all._________
Please carefully explain how you arrived at your ranking.

How sure are you of your ranking? (Circle one)
Basically Guessed Sure Very Sure

1 2 3 4 5 6 7 8 9 10

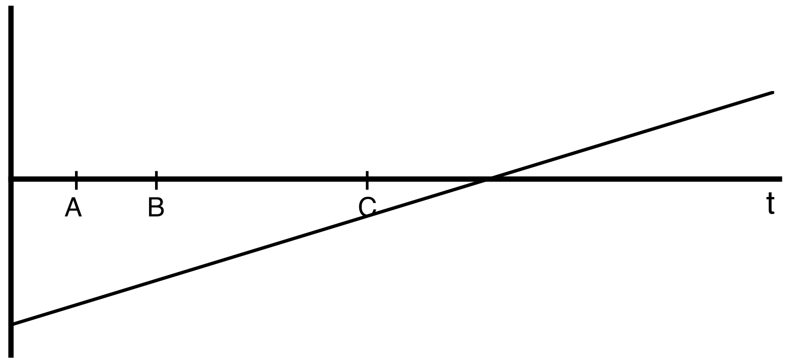
Interpreting Motion Graphs - 1



An object moves in such a way as to produce the position vs. time graph at the top of the page.
a) At which of the lettered times is the object the furthest from the origin?
b) At which of the lettered times is the object moving the fastest?
c) Is the object moving away from or toward the origin between times A and B?
d) Describe the object's motion at time C.

An object moves in such a way as to produce the velocity vs. time graph at the top of the page. Assume object starts at the origin.
e) At which of the lettered times is the object the furthest from the origin?
f) At which of the lettered times is the object moving the fastest?
g) Is the object moving away from or toward the origin between times A and B?
h) Describe the object's motion at time C.

Interpreting Motion Graphs - 2



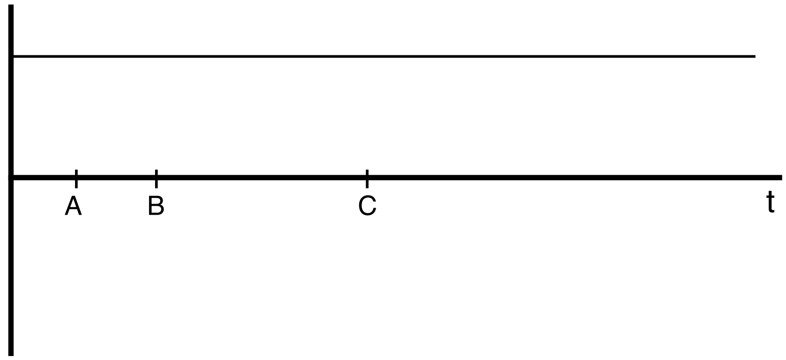
An object moves in such a way as to produce the position vs. time graph at the top of the page.

a) At which of the lettered times is the object the furthest from the origin?
b) At which of the lettered times is the object moving the fastest?
c) Is the object moving away from or toward the origin between times A and B?
d) Describe the object's motion at time C.

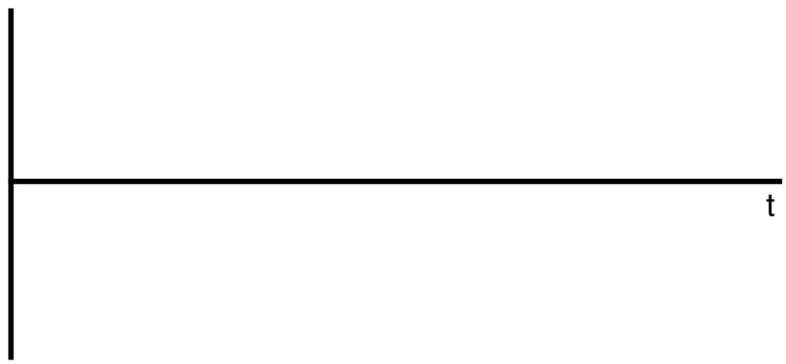
An object moves in such a way as to produce the velocity vs. time graph at the top of the page. Assume object starts at the origin.

e) At which of the lettered times is the object the furthest from the origin?
f) At which of the lettered times is the object moving the fastest?
g) Is the object moving away from or toward the origin between times A and B?
h) Describe the object's motion at time C.

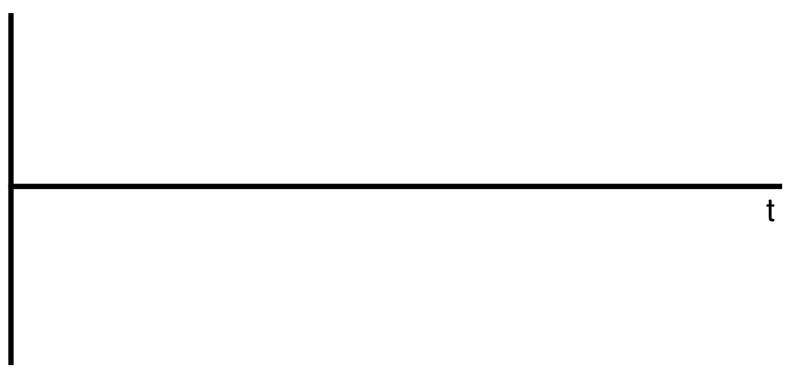
Interpreting Motion Graphs - 3



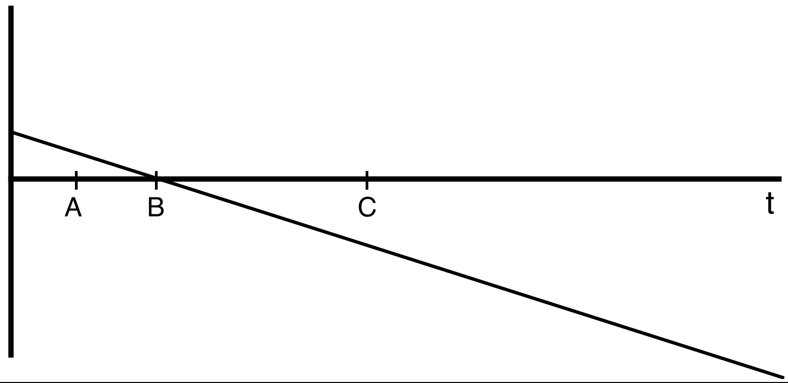
An object moves in such a way as to produce the velocity vs. time graph at the top of the page. Assume object starts at the origin.
a) At which of the lettered times is the object the furthest from the origin?
b) At which of the lettered times is the object moving the fastest?
c) Is the object moving away from or toward the origin between times A and B?
d) Sketch the graph of this object's position vs. time.



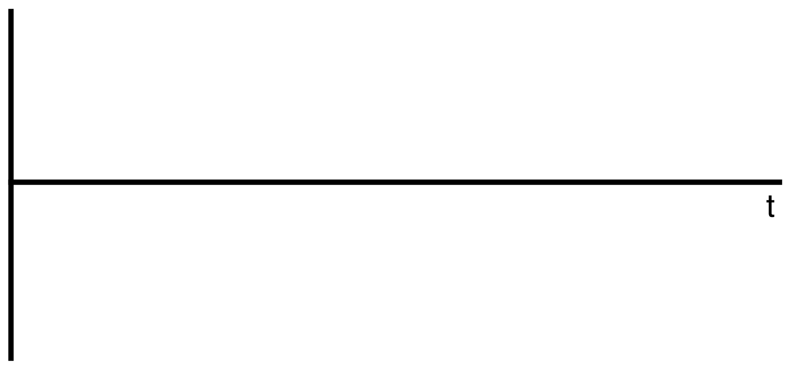
An object moves in such a way as to produce the acceleration vs. time graph at the top of the page. Assume object starts at the origin.
e) At which of the lettered times is the object the furthest from the origin?
f) At which of the lettered times is the object moving the fastest?
g) Is the object moving away from or toward the origin between times A and B?
h) Sketch the graph of this object's velocity vs. time.



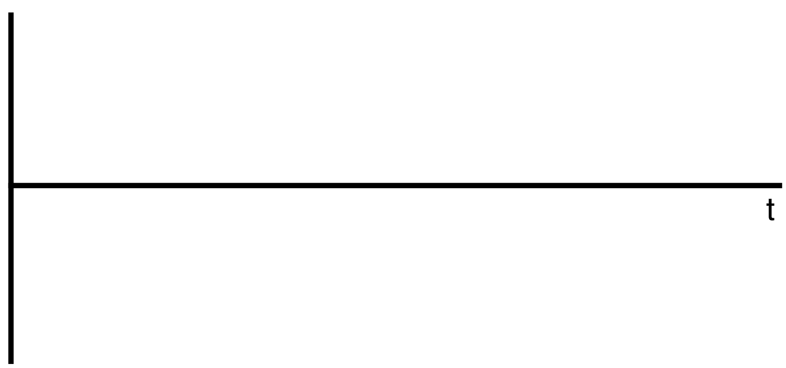
Interpreting Motion Graphs - 4



An object moves in such a way as to produce the velocity vs. time graph at the top of the page.
a) At which of the lettered times is the object the furthest from the origin?
b) At which of the lettered times is the object moving the fastest?
c) Is the object moving away from or toward the origin between times A and B?
d) Sketch the graph of this object's acceleration vs. time.



An object moves in such a way as to produce the position vs. time graph at the top of the page.
e) At which of the lettered times is the object the furthest from the origin?
f) At which of the lettered times is the object moving the fastest?
g) Is the object moving away from or toward the origin between times A and B?
h) Sketch the graph of this object's acceleration vs. time.



The graphs on this page represent the motion of objects along a line which is the positive distance (position) axis. Notice that the motion of objects is represented by distance, velocity, or acceleration graphs.

Answer the following questions. You may use a graph more than once or not at all, and there may be more correct choices than blanks. If none of the graphs is correct, answer J.

16. Pick one graph that gives enough information to indicate that the velocity is always negative.

Pick three graphs that represent the motion of an object whose velocity is constant (not changing).

________17. ____18. ____19.

20. Pick one graph that <u>definitely indicates</u> an object has reversed direction.

________21. Pick one graph that might possibly be that of an object standing still.

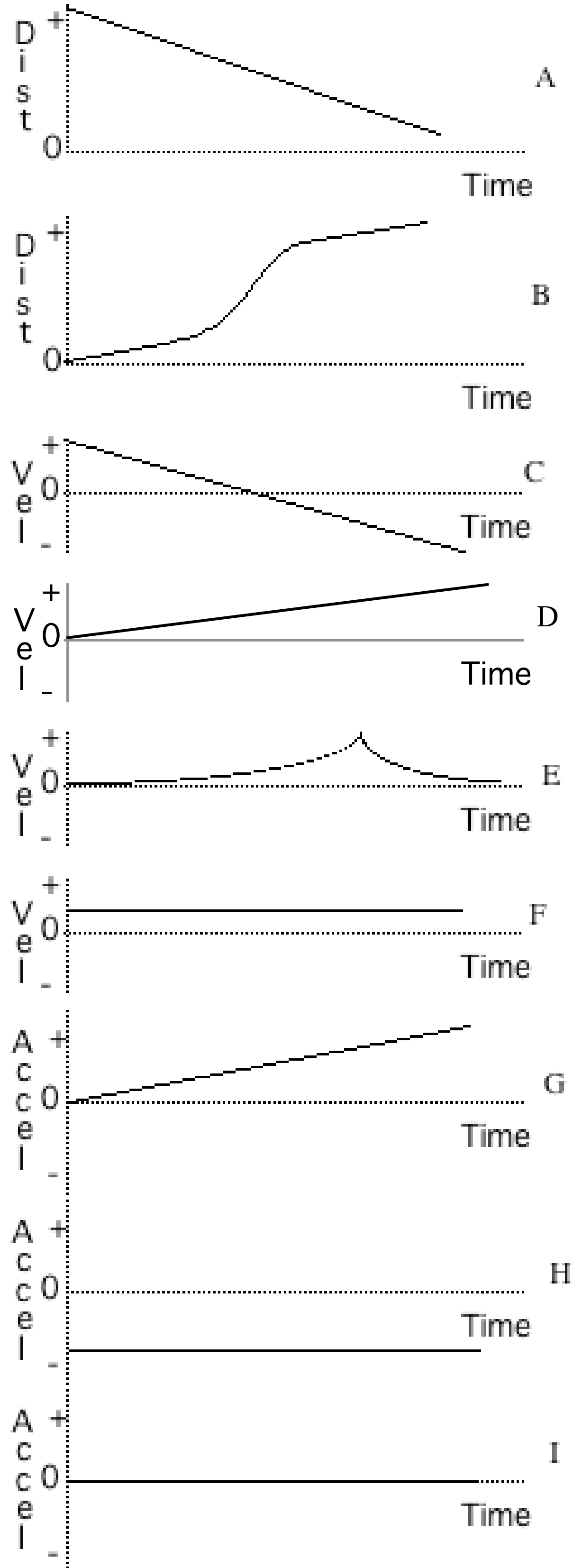
Pick 3 graphs that represent the motion of objects whose acceleration is changing.

________22. ____23. ____24.

Pick a velocity graph and an acceleration graph that could describe the motion of the same object during the time shown.

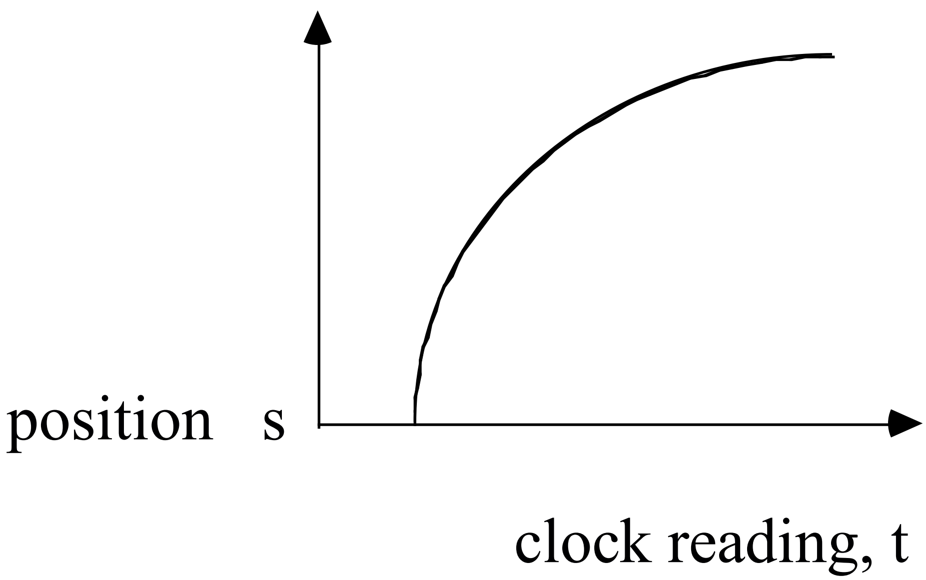
________25. Velocity graph.

________26. Acceleration graph.



PB 0924-Q1

QUESTION: A train car moves along a long straight track. The graph below shows a position vs. clock reading of the motion of this train.



The graph shows that the train:

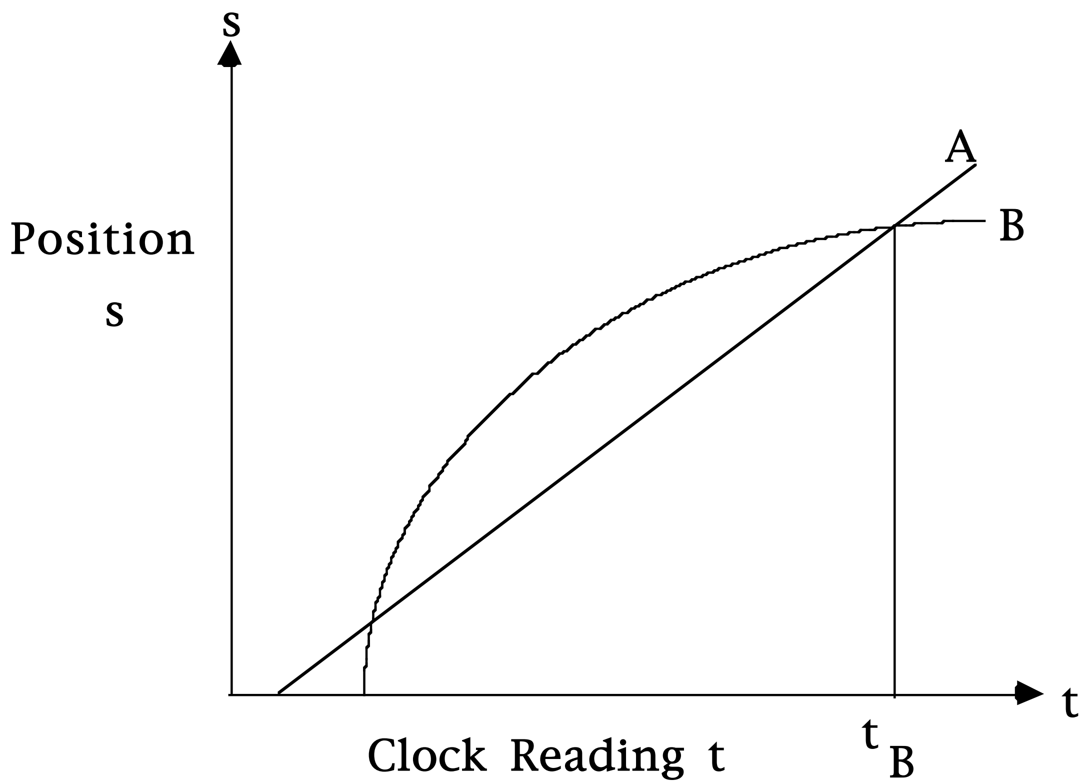
1. speeds up all the time

2. slows down all the time

3. speeds up part of the time and slows down part of the time

4. moves at constant velocity

QUESTION 1: The graph below shows the position vs. clock readings of the motion of *two* trains running on parallel tracks.



Which of the following is true:

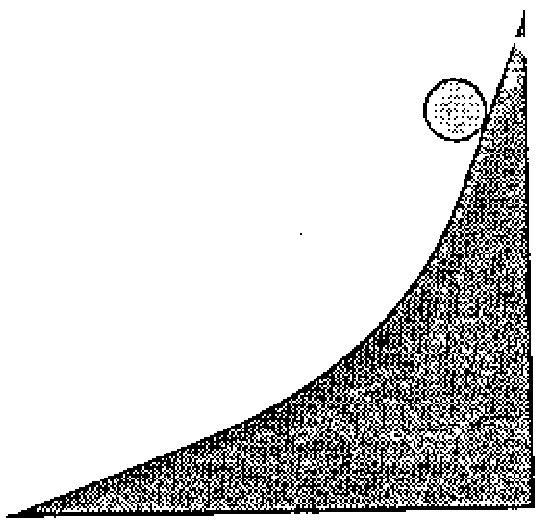
1. at time t_B both trains have the same velocity

2. both trains speed up all the time

3. both trains have the same velocity at some time before t_B

4. somewhere on the graph, both trains have the same acceleration

QUESTION: As the ball rolls down this hill



1. its speed increases and acceleration decreases

2. its speed decreases and acceleration increases

3. both increase

4. both remain constant

Workbook Chapter 2c Kinematics
Situations Where Acceleration is Constant

Falling Body Problems (Plug & Chug, Oh Boy!)Discuss and Derive the equations.

Let's do like Galileo did, slow this motion down by putting it on an incline, so we can study it.

Demo / 5 Groups -

- Roll cart down incline - three different slopes
- Drop a book (different sizes) from the ceiling and obtain good data for a falling body.
- Toss up bowling ball, baseball, and nerf ball
- Get average acceleration
- Highlite data and transfer to GA
- Look at x vs t, v vs t, a vs t,
- Discuss coefficients and what they ought to be, then correct time and redo.

Question: So, how does the acceleration due to gravity changes for different objects?

More questions to ponder. (Use acceleration due to gravity g= 10m/s/s)

A girl tosses a ball straight up with an initial velocity of 30 m/s.

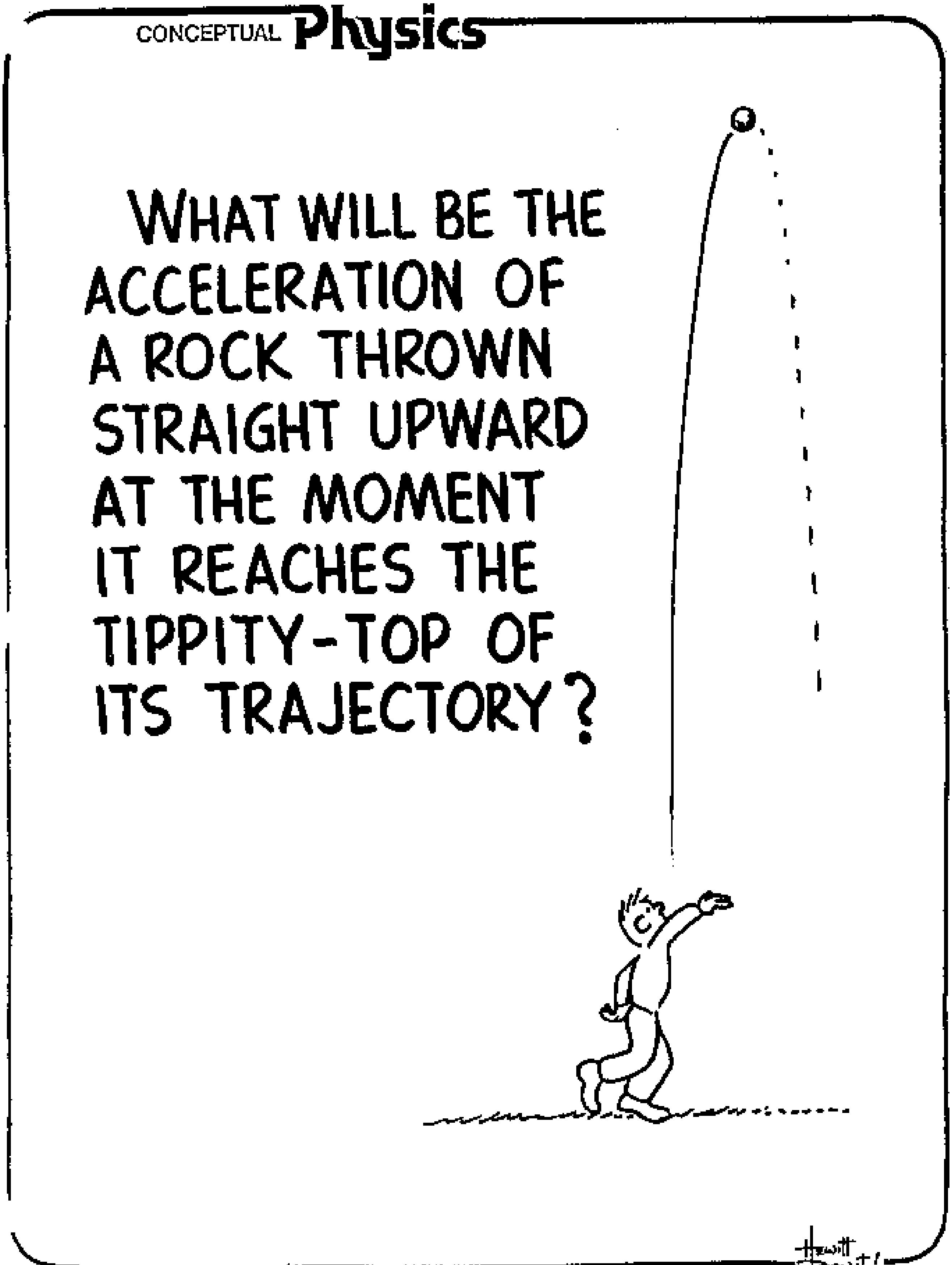
1. How fast will it be traveling after 2 seconds?

2. How long will it take it to reach its maximum altitude?

3. How fast will it be traveling 2 seconds after it reaches its maximum altitude?

4. How fast will it be traveling when it returns to the girl who tossed it?

5. What is its acceleration: a) half way up, at the top, half way down ?


CONCEPTUAL Physics
WHAT WILL BE THE ACCELERATION OF A ROCK THROWN STRAIGHT UPWARD AT THE MOMENT IT REACHES THE TIPPITY-TOP OF ITS TRAJECTORY?

CHAP. 4-9

Pictorial Representations 1

A Metro Train in Washington D.C. starts from rest and accelerates at 2.0 m/s^2 for a time interval of 12 s. The train then travels at a constant speed for 60 s. The speed of the train then decreases for 12 s until it comes to a stop. Construct a pictorial representation for this process.

• Draw an x coordinate axis in the space below. The axis should have an arrow at one end indicating the positive direction and an origin. The axis serves as a reference frame to indicate the positions of the train at different times. You might think of the reference frame as a series of marks beside the track. If the conductor holds a watch, she or he can record at different times the position of the train relative to these marks on the coordinate axis. The position-versus-time data provides a history of the train's trip. We will not have such a record, but will use the axis to represent qualitatively and symbolically as much information as is known.

• Next, decide the number of parts into which the trip should be broken. During each part, the acceleration is approximately constant. Indicate at the right the number of parts for the train trip described above.

Number of parts to the train trip

• Construct a sketch above the coordinate axis. In the sketch, include a drawing of the train engine at the beginning and end of each part of the trip. The beginning of the second part is the end of the first part; the beginning of the third part is the end of the second; etc. The positions of the train are unknown at these times, so the positions in the drawing are symbolic and not necessarily to scale.

• Use distinct symbols to label the times, positions, and velocities of the train at each of these positions. Also, use a unique symbol to indicate the acceleration during each part of the trip. An acceleration symbol can be placed in the middle of the displacement during that part of the trip. At the bottom (or side), list any known values of these quantities.

Pictorial Representation

Values of known quantities (be very careful about signs!!!)

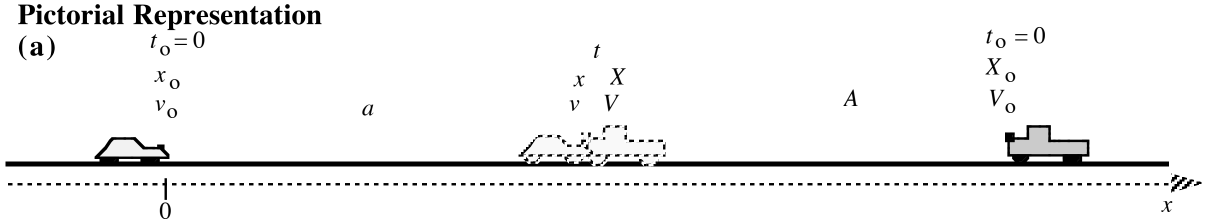
Save space below for reminders about things omitted when trying the activity above—don't make a mistake twice.

Pictorial Representations 5

A car, initially moving east at 12 m/s, accelerates toward the east at 1.0 m/s^2. At the same initial time, a truck 1000 m east of the car and moving at 18 m/s toward the west starts to move slower losing speed at a rate of 2.0 m/s^2. A kinematics problem might ask at what position and at what time the car and truck pass each other? Several pictorial representations of this process are shown below. Each has a different coordinate axis. List the known information for each coordinate system. Then apply the kinematic equation below to describe the changing motion of each object.

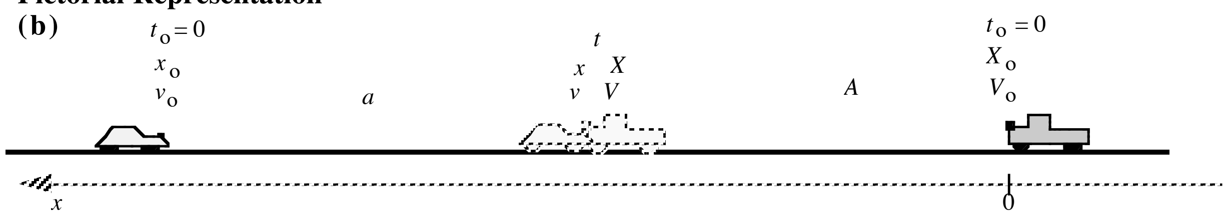
$$x = x_o + v_o t + \frac{1}{2} a t^2$$

Pictorial Representation
(a)



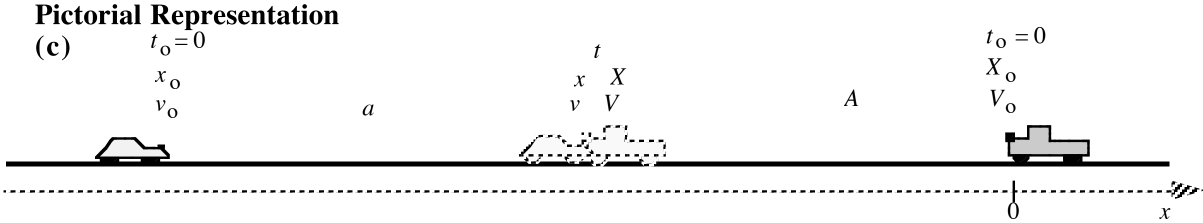
List the values of known quantities (be very careful about signs!!!). Then construct kinematic equations that can be used to determine the position of each object at arbitrary times in the future.

Pictorial Representation
(b)



List the values of known quantities (be very careful about signs!!!). Then construct kinematic equations that can be used to determine the position of each object at arbitrary times in the future.

Pictorial Representation
(c)



List the values of known quantities (be very careful about signs!!!). Then construct kinematic equations that can be used to determine the position of each object at arbitrary times in the future.

Multiple Representation Problem Solving—1 (Pole Vaulter)

	A pole vaulter, just before touching the cushion on which he lands after a jump, is falling downward at a speed of 10 m/s. The vaulter sinks about 0.20 m into the cushion before stopping. Estimate the average acceleration of the vaulter while stopping.	Save space below to note common errors.
PICTORIAL REPRESENTATION Construct a pictorial representation of the situation described in the problem. Include: • a coordinate axis (for consistency, have the axis pointing up), • a sketch of the situation just before the vaulter touches the cushion and a sketch of the situation at the instant the vaulter stops, • symbols that represent the known values of kinematic quantities (be careful of signs), and • a symbol representing the unknown that you wish to determine.		
PHYSICAL REPRESENTATION Construct a motion diagram for the vaulter while stopping as he sinks into the cushion. Check the signs of the known kinematic quantities in the skeches above against the directions of the arrows in the motion diagram.		
MATH REPRESENTATION Choose one or more of the kinematic equations that relate the variables involved in the problem. This equation describes the way in which these variables are related to each other.		
SOLUTION Rearrange the equation so that the unknown is alone on one side and the known quantities are on the other side. Substitute the known information to determine the answer to the problem.		
EVALUATION •Does the sign of the answer agree with the direction of the arrow in the motion diagram? •Is the unit of the answer correct? •Is the magnitude reasonable?		

Multiple Representation Problem Solving—3 (Car's Acceleration)

The velocity of a car decreases as it travels down a hill that points down and to the left. Initially it travels at speed 9.0 m/s and 20 m further down the hill the car's speed is 4.0 m/s. Determine the acceleration (magnitude and direction) of the car.

Save space below to note common errors.

PICTORIAL REPRESENTATION

Construct a pictorial representation of the situation described in the problem. Include:
- a coordinate axis (use one that is parallel to the surface of the hill),
- a sketch that shows the car at the initial and final situations described in the problem,
- symbols that represent the known values of kinematic quantities at these times, and
- a symbol representing the unknown that you wish to determine.

PHYSICAL REPRESENTATION

Construct a motion diagram for the car during this time interval. Use the directions of the arrows in the motion diagram to check the signs of the quantities in your pictorial representation.

MATH REPRESENTATION

Choose one or more of the kinematic equations that relate the variables involved in the problem. This equation describes the way in which these variables are related to each other.

SOLUTION

Rearrange the equation so that the unknown is alone on one side and the known quantities are on the other side.

Substitute the known information to determine the answer to the problem.

EVALUATION

- Does the sign of the answer agree with the direction of the arrow in the motion diagram?
- Is the unit of the answer correct?
- Is the magnitude reasonable?

Multiple Representation Problem Solving—4 (Rocket Sled)

A rocket sled used to test automobile restraining devices (seat belts, air cushions, and so forth) accelerates from rest at 8.0 m/s^2 for a distance of 16 m. In what time interval should the rocket now be stopped so that the magnitude of the average acceleration is 32 m/s^2?

Save space below to note common errors.

PICTORIAL REPRESENTATION

Construct a pictorial representation of the situation described in the problem. Include:
- a coordinate axis,
- a sketch that shows the sled at the initial and final situations for each part of the problem,
- symbols that represent the known values of kinematic quantities at these times, and
- symbols representing the unknowns that you wish to determine.

PHYSICAL REPRESENTATION

Construct a separate motion diagram for the sled during each part of the problem. Use the directions of the arrows in the motion diagrams to check the signs of the quantities in your pictorial representation.

MATH REPRESENTATION and SOLUTION

Choose a kinematic equation that relates the variables involved in the first part of the problem. Solve the equation to determine some needed quantity that can then be used in the second part of the problem.

Use the results of the previous calculation and other information in the pictorial representation to determine the unknown.

EVALUATION

- Does the sign of the answer agree with the situation shown in the pictorial representation?
- Is the unit of the answer correct?
- Is the magnitude reasonable?

Multiple Representation Problem Solving—7 (Two Stones)

A person standing on a cliff uses a sling to shoot a stone vertically upward with initial speed 30 m/s. Simultaneously, a person on a ledge 15 m below shoots a second stone vertically upward. At what speed must the second stone be shot so that it hits the the first stone at the apex of the first stones flight? Assume that $g=10\ m/s^2$ and ignore air resistance.

Save space below to note common errors.

PICTORIAL REPRESENTATION

Construct a pictorial representation of the initial and final situations for each stone. The final situation is when the stones are side by side at the top of their flights. Include:
- a coordinate axis,
- a sketch that shows both of the stones at the initial and final situations,
- symbols that represent the known values of kinematic quantities at these times, and
- a symbol representing the unknown that you wish to determine.

Stone 1 Stone 2

PHYSICAL REPRESENTATION

Construct a motion diagram for each stone. Use the directions of the arrows in the motion diagrams to check the signs of the quantities in the pictorial representation.

Stone 1 Stone 2

MATH REPRESENTATION

Write equations that could be used to determine the position and velocity of the first stone at any time after the initial time.

Write equations that could be used to determine the position and velocity of the second stone at any time after the initial time.

SOLUTION

Use two or more of the above equations to solve the problem.

EVALUATION

- Does the sign of the answer make sense?
- Is the unit of the answer correct?
- Is the magnitude reasonable?

Changing Kinematic Representations—1

(a) An object moves along a horizontal surface. The application of two kinematic equations to that motion is shown below. Construct a motion diagram representing the motion and then invent some real process that might be represented by the equations and by the motion diagram.

$$x = 0 + (12\text{ m/s})(2.0\text{ s}) + \frac{1}{2}a\,(2.0\text{ s})^2$$

$$0 = (12\text{ m/s}) + a\,(2.0\text{ s})$$

(b) An object moves vertically. The application of two kinematic equations to that motion is shown below. Construct a motion diagram representing the motion and then invent some real process that might be represented by the equations and by the motion diagram.

$$v_1^2 - 0 = 2(-10\text{ m/s}^2)[(0) - (5.0\text{ m})]$$

$$0 - v_1^2 = 2\,a_{12}\,[(-0.020\text{ m}) - (0)]$$

Solve the equations for the unknowns.

Solve the equations for the unknowns.

Draw a motion diagram that is consistent with the kinematic quantities and with the motion described by the equations. The object is moving horizontally.

Draw a motion diagram(s) that is consistent with the kinematic quantities and with the motion described by the equations. The object is moving vertically. You need one motion diagram for each part of the motion—for each part with a different acceleration.

Construct a pictorial representation of some process that is consistent with the motion diagram and the equations above (there are many possibilities).

Construct a pictorial representation of some process that is consistent with the motion diagram and the equations above (there are many possibilities).

Instructions: You will turn this in as a group. Use the graph paper supplied to draw your motion graphs, that way you should be able to obtain the exact answer easily.

KINEMATICS - The Battle of Hastings

The Event: In the early fall of 1066, William, Duke of Normandy descended on England to claim the throne. The man who three years earlier, in 1063, had promised to help William to the throne in gratitude for being saved from drowning had just accepted the title of King Harold of England. Angry and determined, William disembarked on English soil at Pevensey in Sussex on the southern coast of England on October 4th and moved eastward toward Hastings.

Harold, with his battered army straight from the battle of Stamford Bridge, raced to head off the invaders. Taking up a position on a ridge ten miles north of Hastings, Harold's army prepared to meet the invading Normans who had meanwhile swung northward from Hastings, approaching the ridge from the south. From the ridge, the English army gave a good account of itself for a while, badly battering William's forces with slings and arrows. In frustration, William pulled his forces back, feinting retreat, and drew Harold's less experienced warriors charging down from the ridge position. Too late, the English army realized its mistake and attempted to regroup and regain the ridge. William's army reversed and caught the hapless English in full flight.

The Graphical Analysis: Taking an arbitrary zero starting time, assign William's army a position of 8 mi (from Hastings) and a retreat rate of 3 mi/hr. Assign Harold's army an initial position of 10 mi and a charge rate of 2 mi/hr. Two hours later, William's forces stop and reverse direction. A full half-hour after that, Harold recognizes the trap and reverses the direction of his army. Each of the armies moves 1 mi/hr slower in back-tracking across the wasted English countryside.

Sketch an EFR (Event Frame Representation) of the battle with labels to explain the action.

Draw a graph of position vs time for the supposed motions of the two armies. Use the graph to find how long after Harold's army leaves its safehaven on the ridge and how far they are from regaining it, when they are overtaken by William's forces.

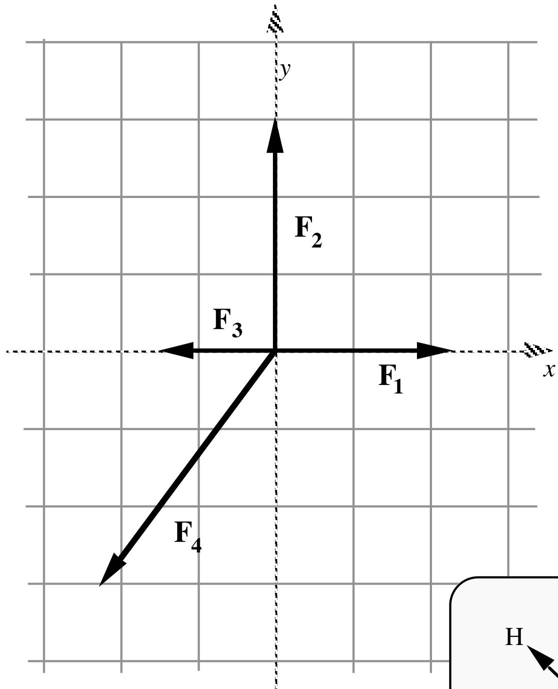
Discuss the two motions and explain how the time and distance information is obtained from your plot.

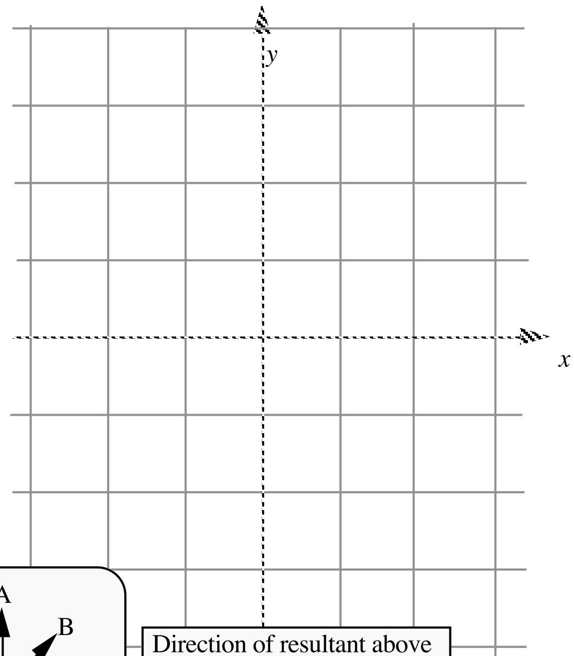
Workbook Chapter 3: Study of Vectors

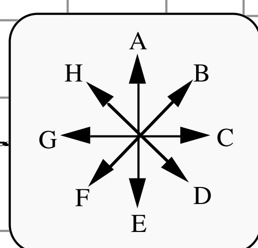
1.

Graphical Vector Addition—1

For each situation shown below, add the four forces and determine graphically the direction that is closest to the direction of the resultant force.

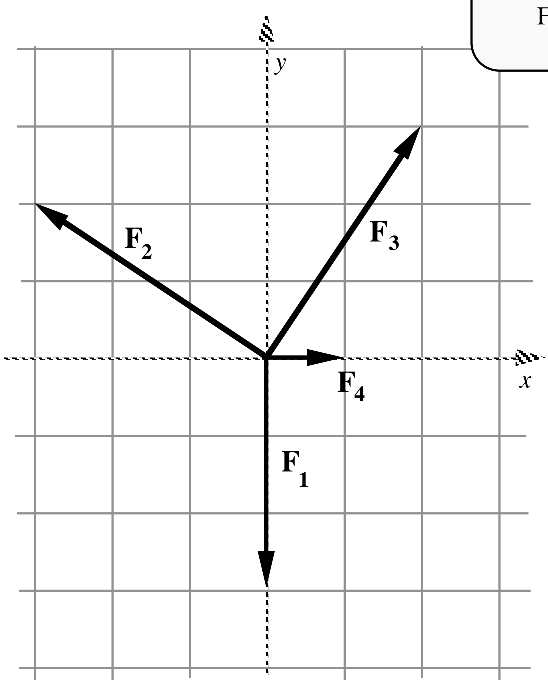


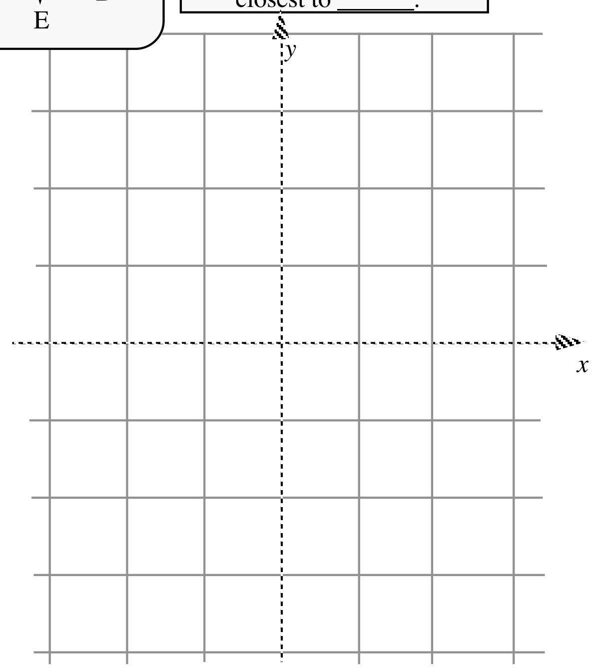




Direction of resultant above closest to ______.

Direction of resultant below closest to ______.

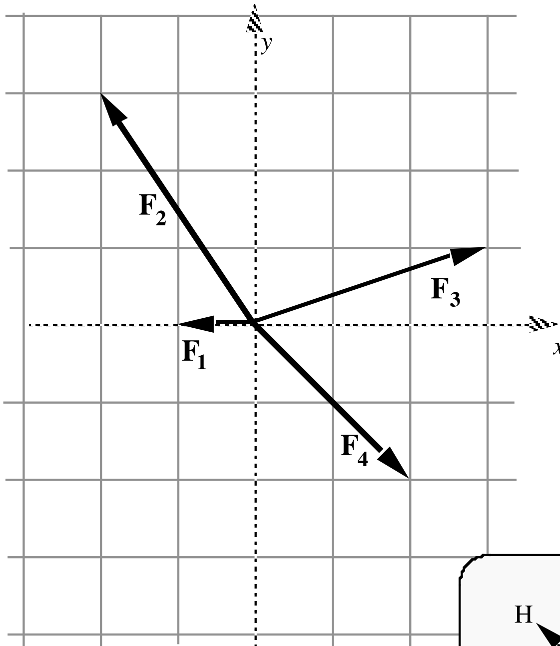


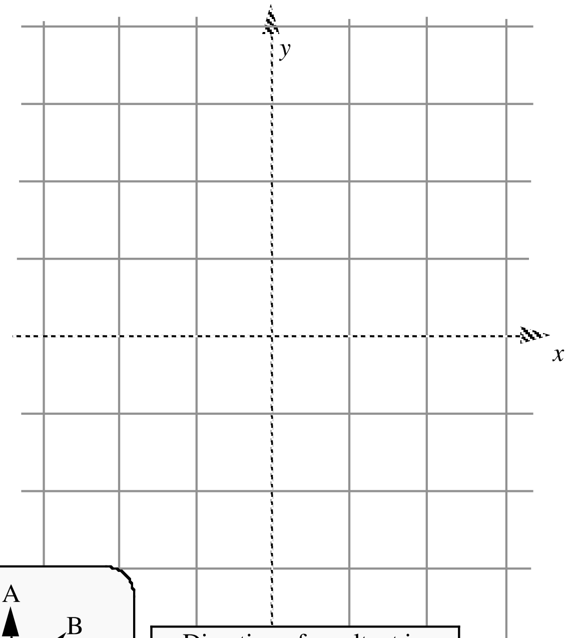


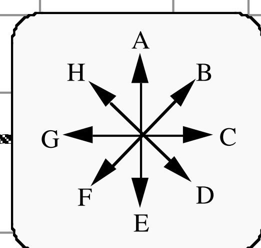
2.

Graphical Vector Addition—2

For each situation shown below, add the four forces and determine graphically the direction that is closest to the direction of the resultant force.

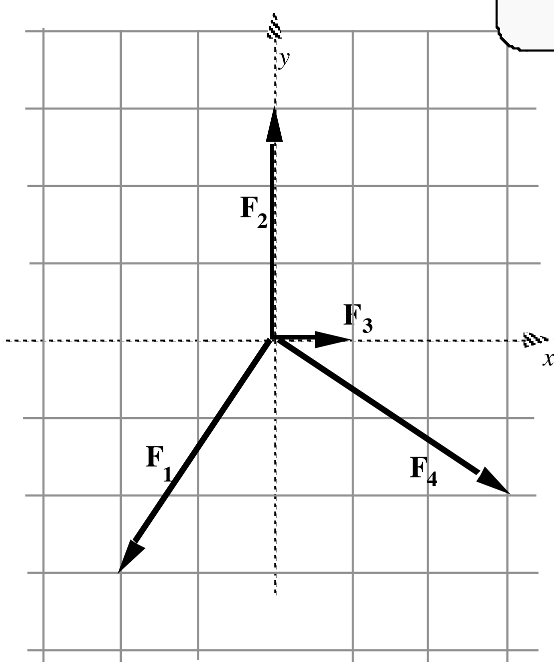


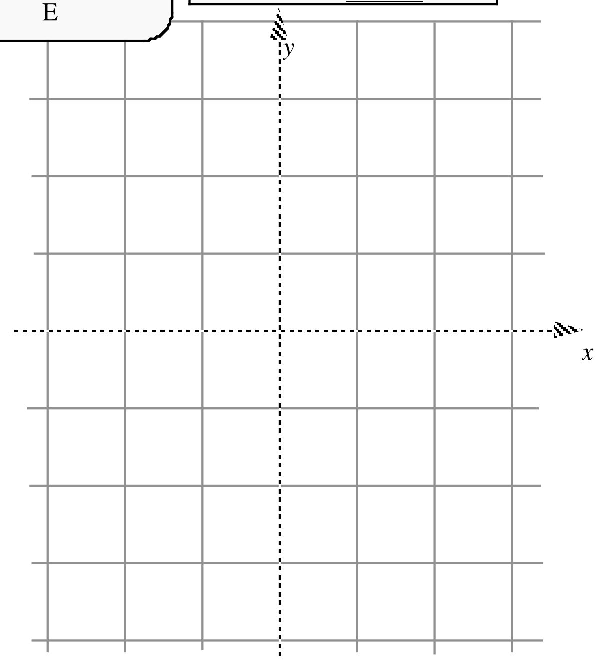




Direction of resultant is closest to ______.

Direction of resultant is closest to ______.

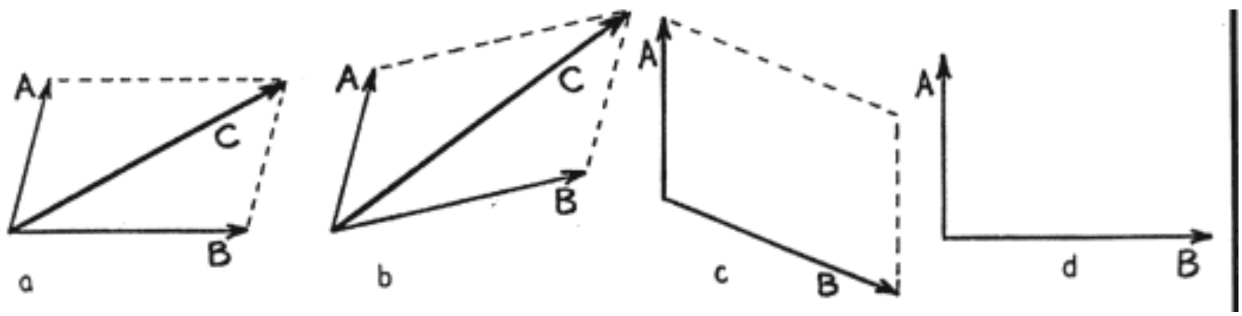




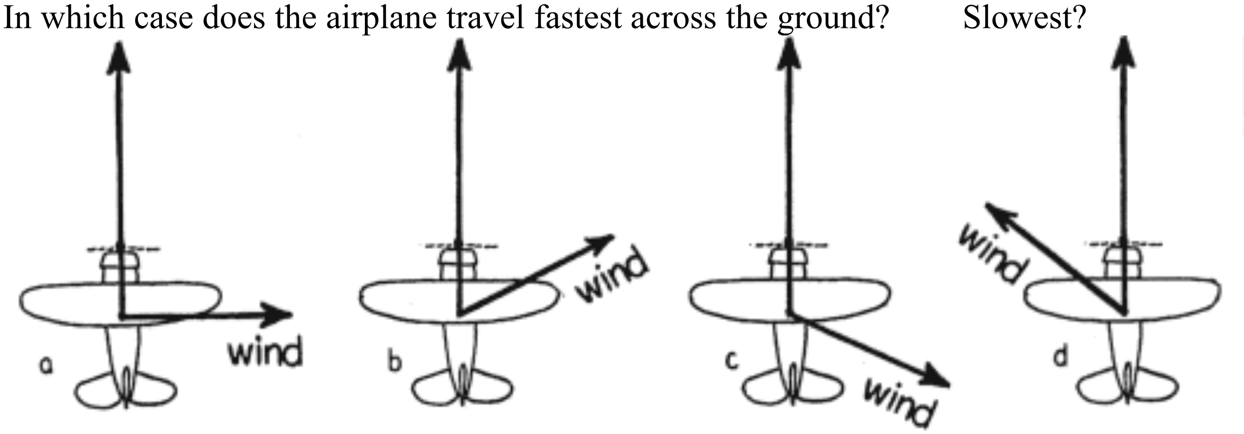
Chapter3 Nonlinear Motion

Vectors and the Parallelogram Rule

3. When vectors A and B are at an angle to each other, they add to produce the resultant C by the *parallelogram rule.* Note that C is the diagonal of a parallelogram where A and B are adjacent sides. Resultant C is shown in the first two diagrams, a and b. Construct the resultant C in diagrams c and d. Note that in diagram d you form a rectangle (a special case of a parallelogram).



4. Below we see a top view of an airplane being blown off course by wind in various directions. Use the parallelogram rule to show the resulting speed and direction of travel for each case.
In which case does the airplane travel fastest across the ground? Slowest?

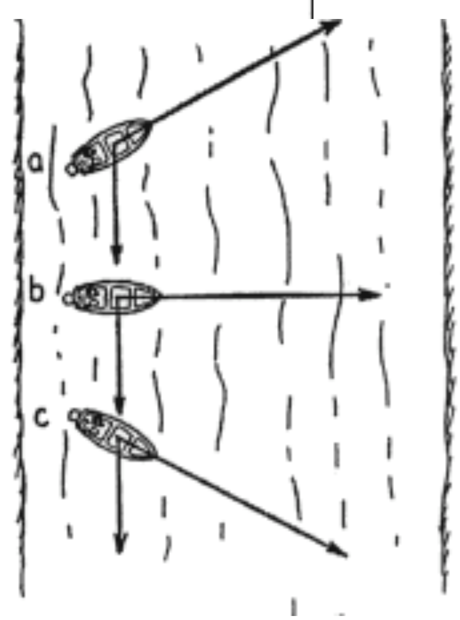


5.
To the right we see top views of 3 motorboats crossing a river. All have the same speed relative to the water, and all experience the same water flow.

Construct resultant vectors showing the speed and direction of the boats.

a. Which boat takes the shortest path to the opposite shore?

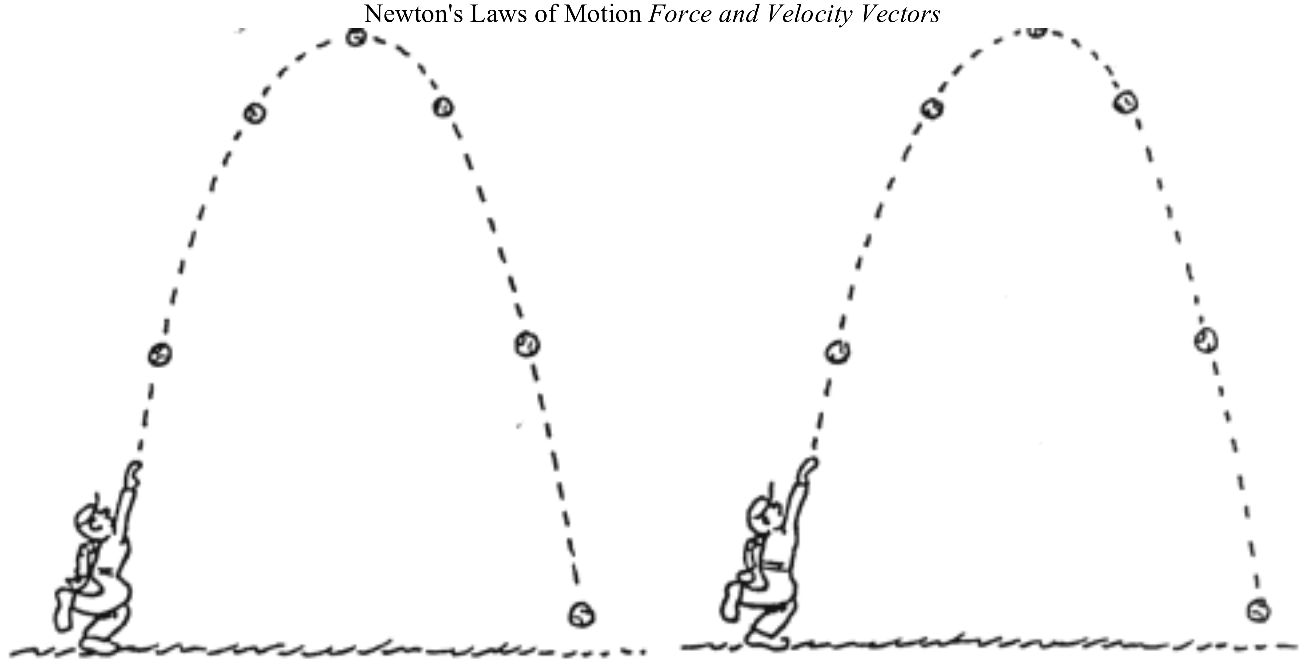
b. Which boat reaches the opposite shore first?



Workbook Chapter 4 Projectile Motion

Physical and Conceptual issues

Newton's Laws of Motion *Force and Velocity Vectors*



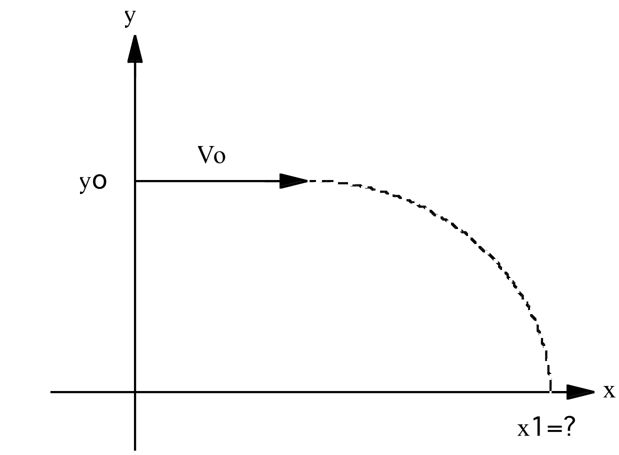
1. Draw sample vectors to represent the force of gravity on the ball in the positions shown above (after it leaves the thrower's hand). Neglect air drag.
2. Draw sample bold vectors to represent the velocity of the ball in the positions shown above. With lighter vectors, show the horizontal and vertical components of velocity for each position. Neglect air drag.
3. (a) Which velocity component in the previous question remains constant? Why?

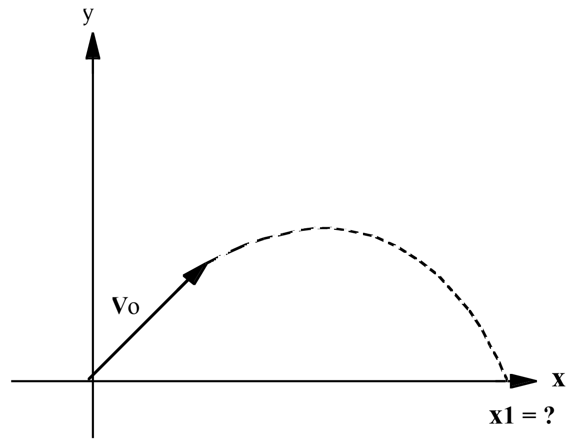
(b) Which velocity component changes along the path? Why?

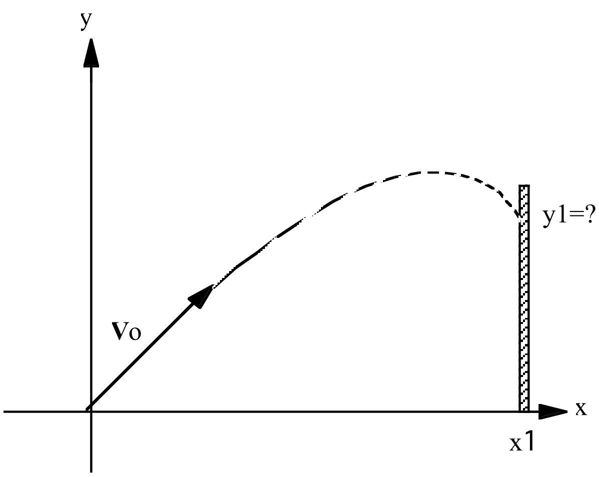
Mathematical Aspects of Projectile Motion

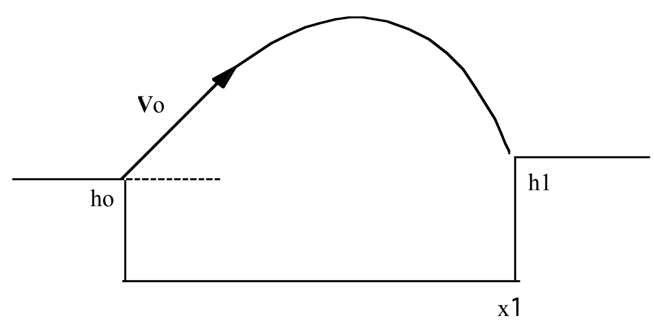
Conceptual and physical aspects are essential, and the best way to begin a study of projectile motion. However, projectile motion problems can appear to be a vast array of "types" of problems to learn, unless you **get mathematical!**

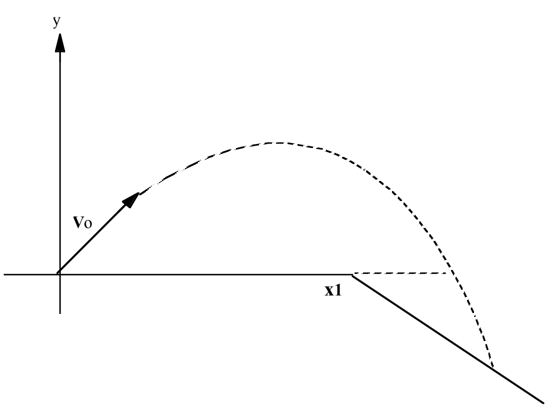
So how many different ways are there to slice this apple, really? How many numbers in each of the following problems?

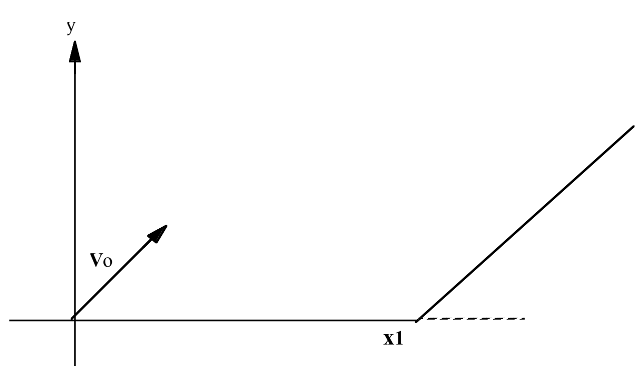












Phy 213 & 201 Projectile Motion Practice Sheet

Draw ref. Frame **1 pt**

2. Draw motion diagrams in both vertical and horizontal directions. **1 pt**

3. Mark on picture points A and B. **1 pt**

4. Write down in neat column form, values for x, vx , ax,, y, vy , ay and t at each point. If you do not know the value, write down the equation for that value. **2 pts**

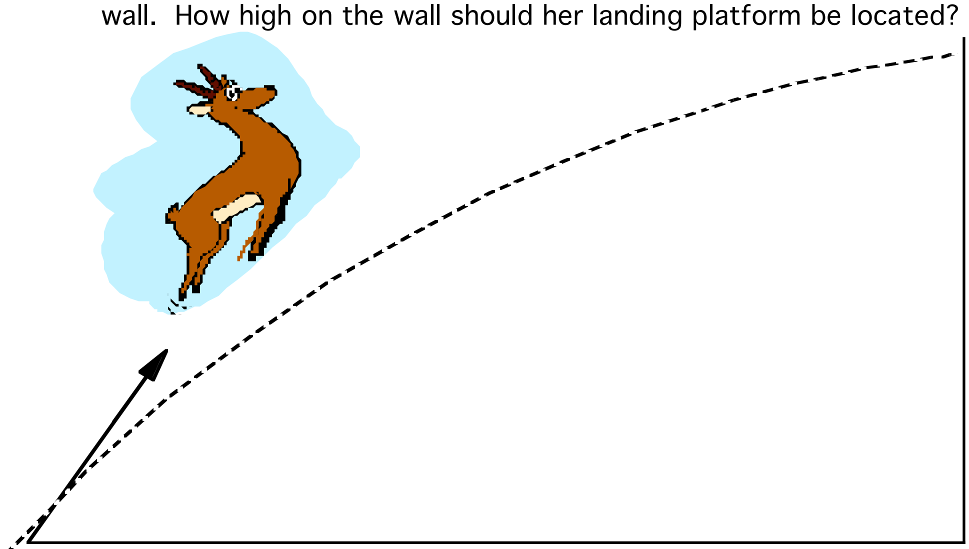
Do not solve the problem.

1. A building is 125 m tall. A rock is thrown horizontally off the top at 20 m/s. It strikes the ground . A is the top of the building , B is the location it strikes the ground.

2. A building is 80 m tall. A rock is thrown off the top at angle of 37° above the horizontal at 20 m/s. It strikes the ground . Ais the top of the building , B is the location it strikes the ground.

3. A ball is kicked at an angle of 53° above the horizontal at an initial velocity of 50 m/s. A is the location from which it is kicked, B is where it lands.

4. Gigi the dare devil gazelle leaps from the ground at an angle of 53° above the horizontal and a speed of 50 m/s. She strikes the wall 80 meters way. A is where she takes off, B is where she strikes the wall. How high on the wall should her landing platform be located?



Workbook Chapter 4a: Circular motion

Trivia Question: How can an object be moving with constant speed and still be accelerated ?
What is the direction of this acceleration? First we need to answer the question what is the direction of the linear speed at any instant of an object traveling in a circle? Redo the blue ring thing?

Recommended: Read about circular motion in your physics text book.

Class development of direction and value of acceleration of an object moving in a circular with **constant** speed.
What is angular speed of circular motion?

How is it related to linear speed? v = ___________

What is the period (T) of circular motion? ____

What is T in terms of v? T = ___________

What is the frequency (f) of circular motion ? ____

What is frequency in terms of T? f = ________________

What is frequency in terms of v ? f = _________________

What happens to these formulas if we try to use degrees to measure the angles and angular speed ?

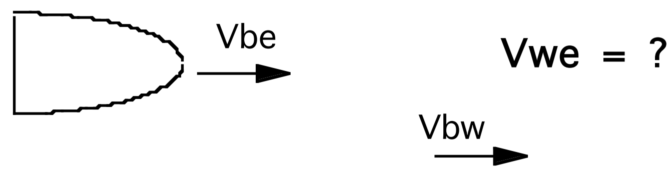
(Suppose the radius of rotation is 2 m and the angle of rotation is 90^o, does 2m x 90^o tell how far the object travelled?)

Drill:

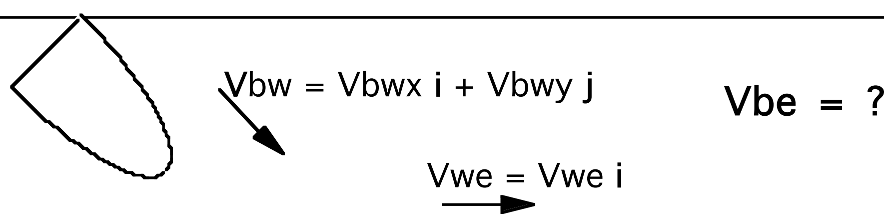
1. An object travels 30 m/s in a circular path of radius 4 m. Find a, v, T, and f.
2. An object travels 5 rad /s in a circular path of radius 4 m. Find a, v, T, and f.
3. An object rotates 30 rpm's in a circle of radius 100m. Fnd a, v, T, and f.

Workbook Chapter 4b Relative Velocity Dunn Rite

$V_{be} = V_{bw} + V_{we}$



$V_{we} = V_{wb} + V_{be}$ but $V_{wb} = - V_{bw}$, so,
$V_{we} = - V_{bw} + V_{be}$



$V_{be} = \mathbf{V}_{bw} + \mathbf{V}_{we} = (V_{bw}\,\mathbf{i} + V_{bw}\,\mathbf{j}) + V_{we}\,\mathbf{i}$
$\quad = (V_{bwx} + V_{wex})\,\mathbf{i} + V_{bwy}\,\mathbf{j}$

Workbook Chapter 5 Preview - Identifying Forces

1. Get kid up and pull and push on them and ask,

do you feel a force?

What or who is applying this force?

2. Then step back and stretch out hand toward student and ask same questions.
3. Hand him a rope and pull on other end and ask the questions.

Differentiate between **Immediate cause** and **ultimate cause**

4. Hand him a spring and pull and ask same questions.
5. Now hang the spring and attach a block and ask does the spring exert a force on the block?
6. Now hang mass from a string and ask if string exerts a force on mass.
7. Drop a block - What exerts a force on the block?
8. Block on table. What forces are being exerted on it by what?
9. Have them squeeze a spring. Does it push back?
10. Stand a spring on the table and place masses on it. Does it exert force on the object?
11. Repeat with a stiffer spring.
12. Repeat placing mass on thin board.
13. Now place it on table and ask is the table acting as a spring to hold up this block?
14. Sum up.

Forces are pushes or pulls between obj and some identifiable immediate cause.

They occur at a point of contact.

Can be exerted by animate or inanimate objects.

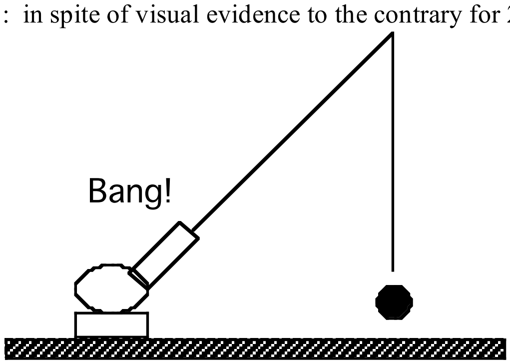
15. Next : Friction. Push your hand across the table. Do you feel a force? In which direction?
16. Next : Action at a distance forces. Demo Mag, electrical and gravity.
17. Throw the ball up and ask what force acts at point thrown, mid way up , and at top? How do you know? How can it keep going up if there without an upward force acting on it?
18. Next do glider on air track. And ask, is there a force on the glider?
19. Next push hover craft and ask same thing.
20. Next have them pull HC with one, two, three, and four people on it using the same force. What happens to acceleration? What conclusions can you make?

Workbook Chapter 5a: Force, Mass, & Newton's Laws of Motion

Overview:

Force: A push or pull that causes an object to slow down, speed up, change direction, or heat up. To put it briefly, force causes a change in velocity of either an object or the molecules it contains. The concept of force permeates every facet of physics and everyday life. If you obtain a thorough understanding of this concept you will find yourself using it from time to time to make life a little easier. It may even save your life. Mention seatbelts, babies and Hodini Buried alive in a coffin trick.

Aristotle believed that all motion required a force, or "impetus" due to a force. That is, he believed when the force stopped, or the impetus given by a force was exhausted, used up in some way, that the object stopped. In fact, believers in Aristotle believed arrows shot into the air and cannon balls fired out of cannons did this
: in spite of visual evidence to the contrary for 2000 years!



New concepts -

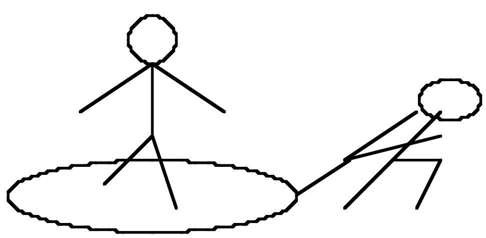
Inertia: First coined by Galileo observing objects' resistance to change in motion.

Mass : Newton's refinement, mass, is a measure of how much matter an object contains. Those that contain more matter require more force to cause the same change in velocity.

Weight: The gravitational force exerted on an object by the planet. Mass and weight are often confused because of the amazing "coincidence ?" that the force of gravity on an object at the surface of the Earth is proportional to its mass. In other words, gravitational mass turns out to be the same as inertial mass!

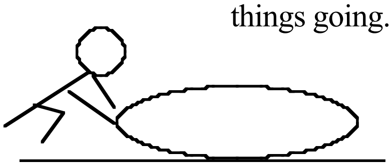
Just how force, mass, velocity and acceleration are related is the subject of these activities.

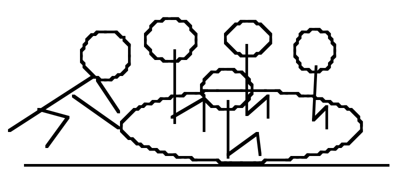
Newton's First Law. **Mass- A measure of Inertia**



Objects at rest tend to stay at rest, what happens to the rider when I jerk the hovercraft?

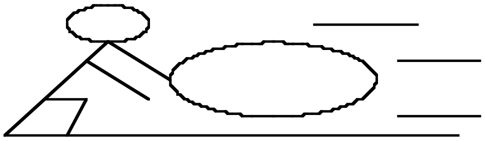
The more mass, (inertia) the harder it is to get things going.

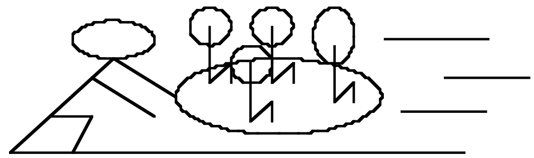


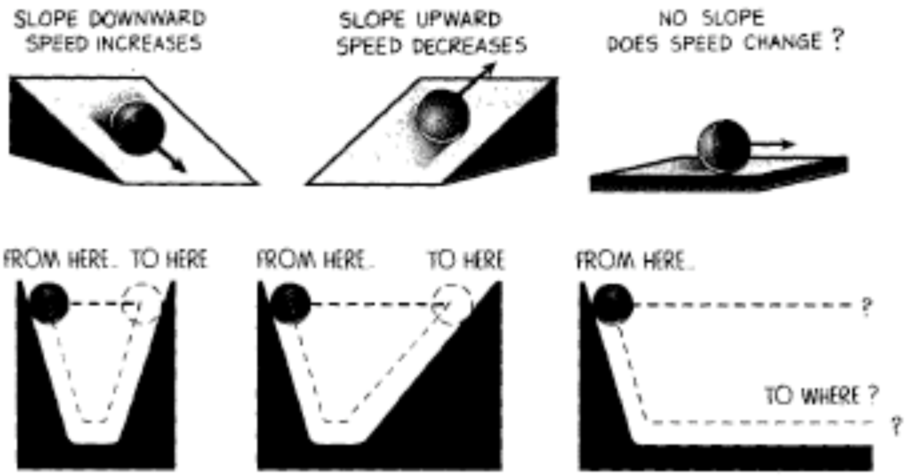


Objects in motion tend to stay in motion.

The more mass, the harder it is to stop.





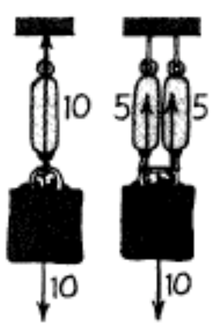


(Left) The ball rolling down the incline rolls up the opposite incline and reaches its initial height.

(Center) As the angle of the upward incline is reduced, the ball rolls a greater distance before reaching its initial height.

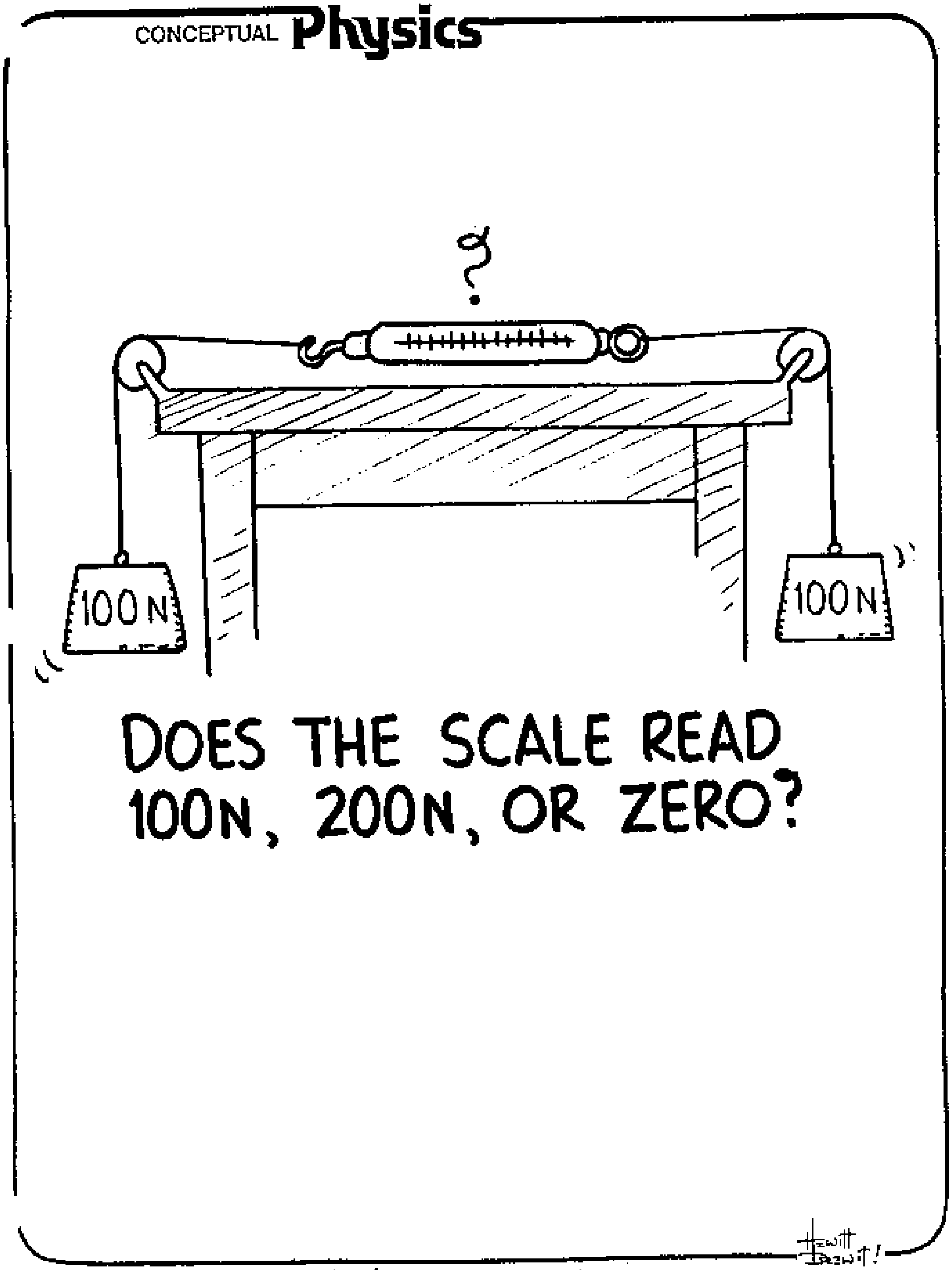
(Right) How far will the ball roll along the horizontal?

Combinations of forces, vector components of force.

	(Left) When a 10-N load hangs vertically from a single spring scale, the scale pulls upward with a force of 10 N. (Right) When the load hangs vertically from two spring scales, each scale pulls upward with a force equal to half of the load's weight, or 5 N.

Activity 1. A massive ball is suspended on a string and slowly pulled by another string attached to it from below, as shown in Figure A below.

 Figure A	a. Is the string tension greater in the upper or the lower string? Which string is more likely to break? Which property, mass or weight, is important here? b. If the string is instead snapped downward, which string is more likely to break? Is mass or weight important this time?


CONCEPTUAL Physics
?
100 N
100 N
DOES THE SCALE READ
100N, 200N, OR ZERO?

CHAP. 4-11

QUESTION 1:

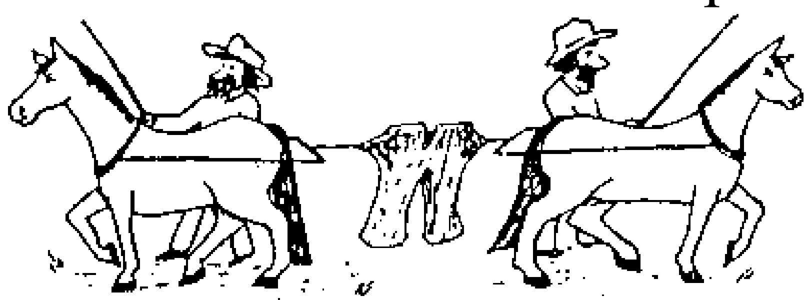
The Levi Strauss trademark shows two horses trying to pull apart a pair of pants. Suppose Levi had only one horse and attached the other side of the pants to a fencepost.

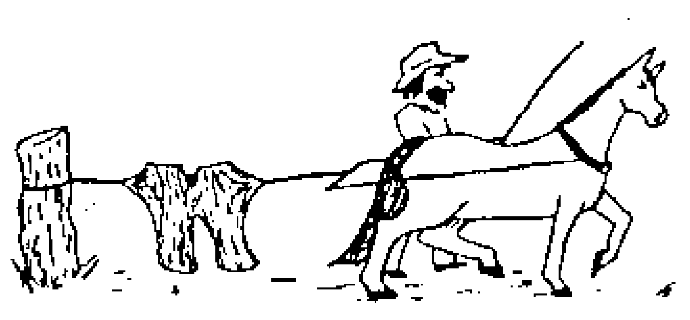
Using only one horse would:

1. cut the tension on the pants by one-half

2. not change the tension at all

3. double the tension on the pants





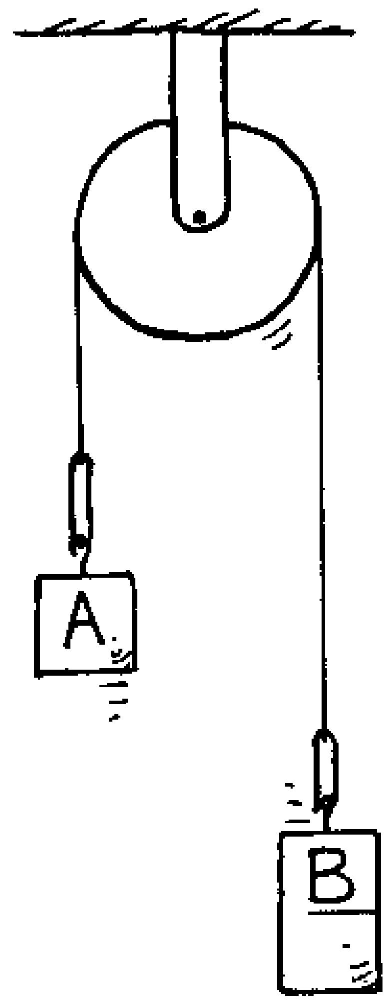
CONCEPTUAL **Physics**

Two identical rubber bands connect masses A and B to a string over a frictionless pulley of negligible mass. The amount of stretch is greater in the band that connects

a) A

b) B

c) Both the same



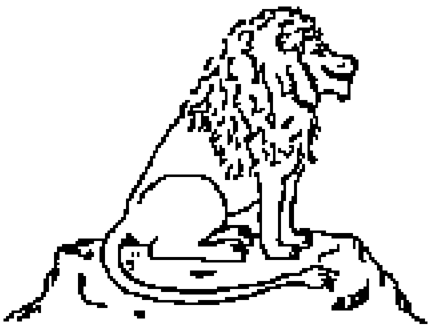
Hewitt Drew it!

Born Free

Given below are six hungry lions with nothing better to do than sit on a termite mound looking for some sickly antelopes to run by. Each lion has about the same size and shape, and each one sits on a termite mound with similar heights. The mass of each lion is given below.

Rank the situations in order of which lion has the greatest Normal Force (Fn) being exerted on it by the termite mound, to the lion who has the least Normal Force being exerted on it.

A



150 kg

B

300 kg

C

100 kg

D

200 kg

E

500 kg

F

234 kg

Greatest 1. ___ ___ 3. ___ 4. ___ 5. ___ 6. ___ Least

All lions have the same normal force. ___________

All lions have a zero normal force. ___________

Please explain the reason for your ranking. ______________________________________

____

____

How sure are you of your ranking?

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

Mass and Weight

Answer each of the following questions. If needed, use a value of 10 m/s2 for the gravitational acceleration on earth and 3 m/s2 on the moon.

1. What is the SI unit for mass?

2. What is the SI unit for weight?

3. What is the mass of a 3 kg object on the earth?

4. What is the mass of a 3 kg object on the moon?

5. What is the weight of a 3 kg object on the earth?

6. What is the weight of a 3 kg object on the moon?

7. An object weighs 60 N when on the earth. What is the mass of this object?

8. What is the weight of this object on the moon?

9. Another object weighs 60 N when on the moon. What is the mass of this object?

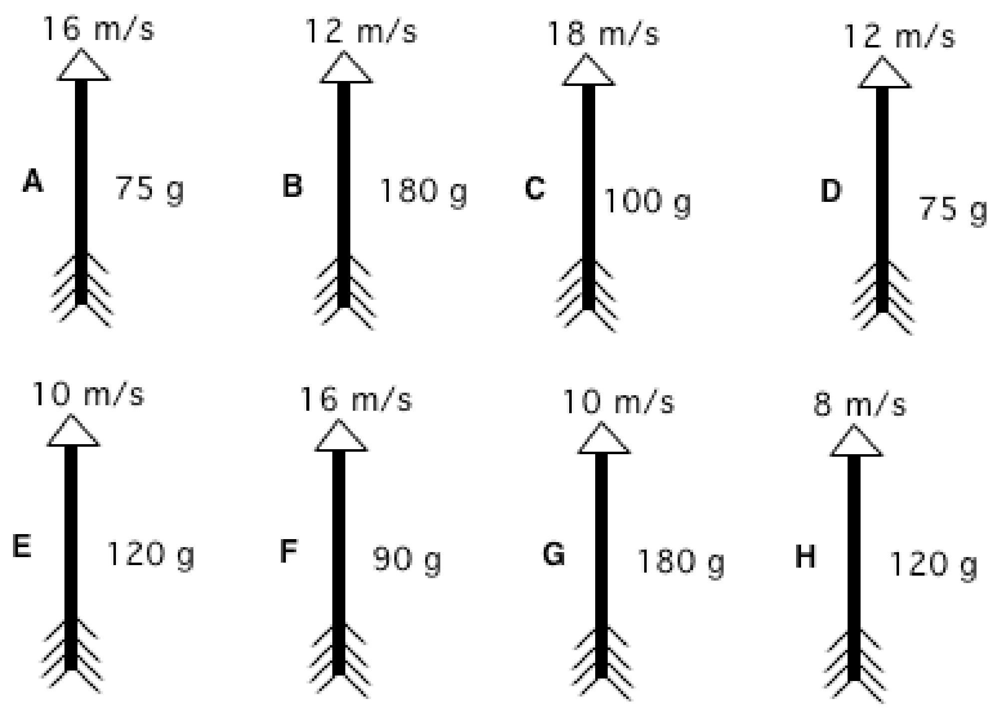
10. Research and reward. The gravitational force on a satellite when a distance **r** from the center of the earth is 4000N. Determine the gravitational force when a distance of 2**r** from the center of the earth. Hint: Look up gravitational force in your text.

Exercise 1.

Arrows—Acceleration[19]

The eight figures below show arrows which have been shot into the air. All of the arrows were shot straight up and are the same size and shape. But the arrows are made of different materials so they have different masses, and they have different speeds as they leave the bows. The values for each arrow are given in the figures. (We assume for this situation that the effect of air resistance can be neglected.) All start from same height.

Rank these arrows, from greatest to least, on the basis of the acceleration of the arrows at the top of their flight.



Greatest 1_____ 2_____ 3_____ 4_____ 5_____ 6_____ 7_____ 8_____ Least

All arrows have the same acceleration but not zero. ___________

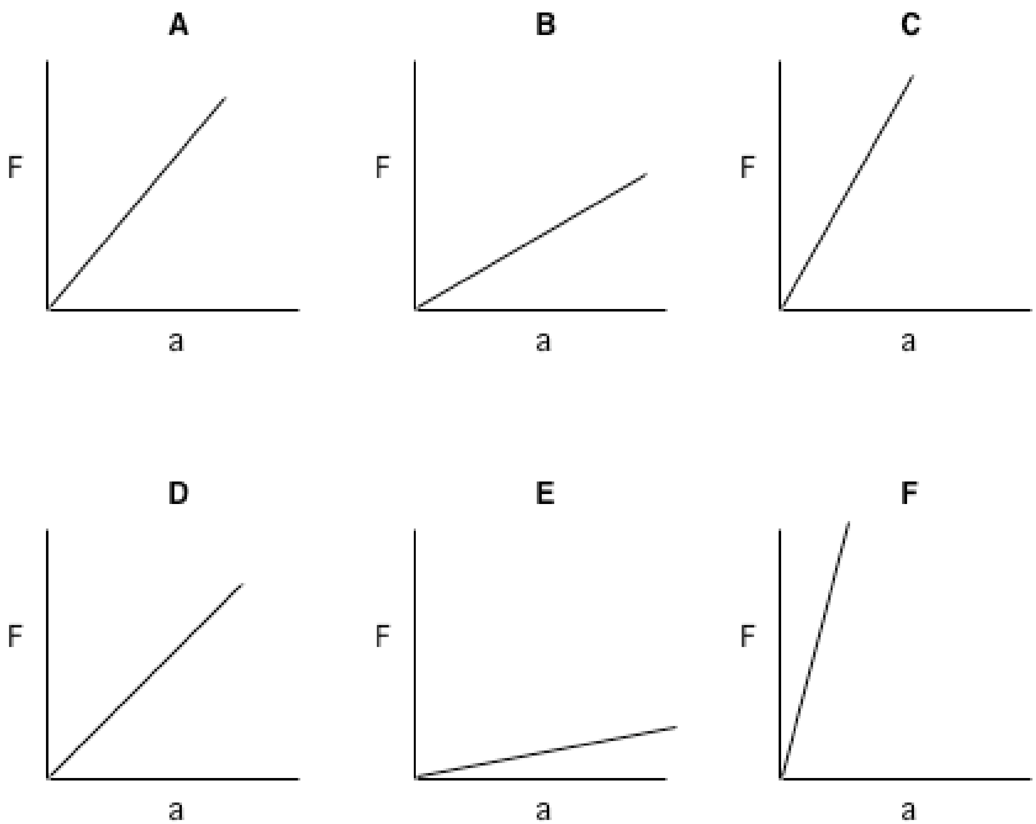
The acceleration at the top is zero for all these. ___________

Please explain the reasoning for your ranking.

Exercise 2.

Force Acceleration Graphs—Mass [24]

The following graphs plot force vs acceleration for several objects. Rank each situation according to mass. That is, order the situations from the largest to the smallest mass that the force is acting upon. All graphs have the same scale for each respectivie axis.

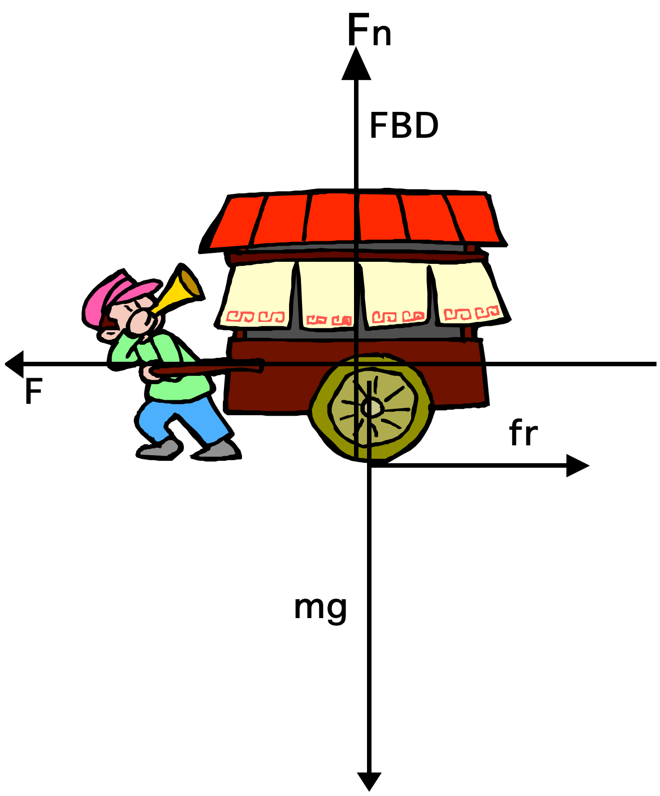


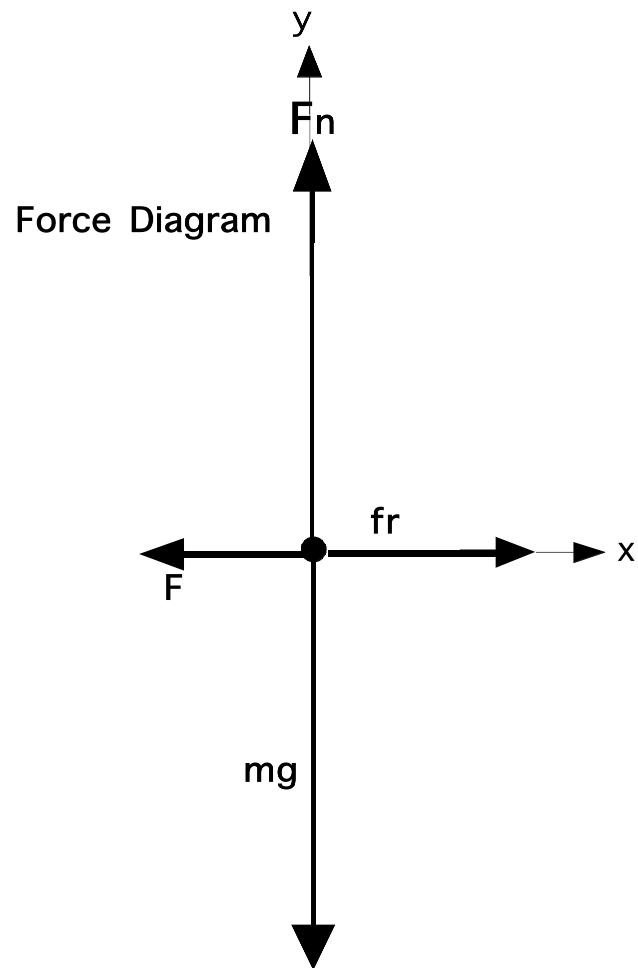
Largest 1________ 2________ 3________ 4________ 5________ 6_______ Smallest

Or, all the masses are the same. _________

Please carefully explain your reasoning.

Force diagrams and Free Body Diagrams (FBD's) clarified





Workbook Chapter 5b Forces and Free Body Diagrams

FREE-BODY DIAGRAMS

A free-body diagram uses arrows to represent all forces acting on the object or objects in the system. The tail of an arrow representing a force is placed at the point where the force acts on the object and the arrow points in the direction of the force. Try to make the relative lengths of the arrows representative of the magnitudes of the forces (this is not always possible. Label each force arrow with a symbol that indicates: (a) the object in the environment that causes the force, (b) the object in the system on which the force acts, and (c) the magnitude of the force, if known. Alternatively, make a separate list of the forces using abbreviated symbols (T, w, N, etc.) and indicate in some other way (for example, a list) the object causing the force and the object on which the force acts. Remember that some other object must cause each force shown in your free-body diagram. Do not include in your diagram forces that an object in the system exerts on another object in the system or on objects outside the system. We only want forces that act on an object in the system caused by an object outside the system. Your free-body diagram should also have a set of coordinate axes. Usually, one axes is oriented in the direction of motion, and the other axis is oriented perpendicular to the direction of motion.

How do we decide what forces act on an object in the system? You first need a sketch of the whole situation described in the problem (see the example shown in Fig. l.lOa). For now, we assume that the sketch is provided in the problem statement. To construct a free-body diagram for some object in the system, look for two types of forces: (1) short-range forces caused by objects in the environment that touch one in the system, and (2) **long-range (action-at-a- distance) forces** between an object in the environment (like the earth) and one in the system. First, consider short-range forces. Look along the boundary of the system for an object in the environment that touches an object in the system. These touching environmental objects might exert a short-range force on the object in the system: a normal force pointing perpendicular to the surface of contact, a friction force parallel to the surface of contact and opposite the direction that the object in the system moves or tries to move relative to the object it touches, a rope or cable tension force parallel to the direction of the cable, an air or water drag force opposite the direction of motion, and so forth. For the system shown in Fig. l.lOa, the floor touches the base of the piano and exerts an upward normal force N, and the cable above the piano pulls up on it with a tension force T. These are the only two places where environmental objects touch the system.

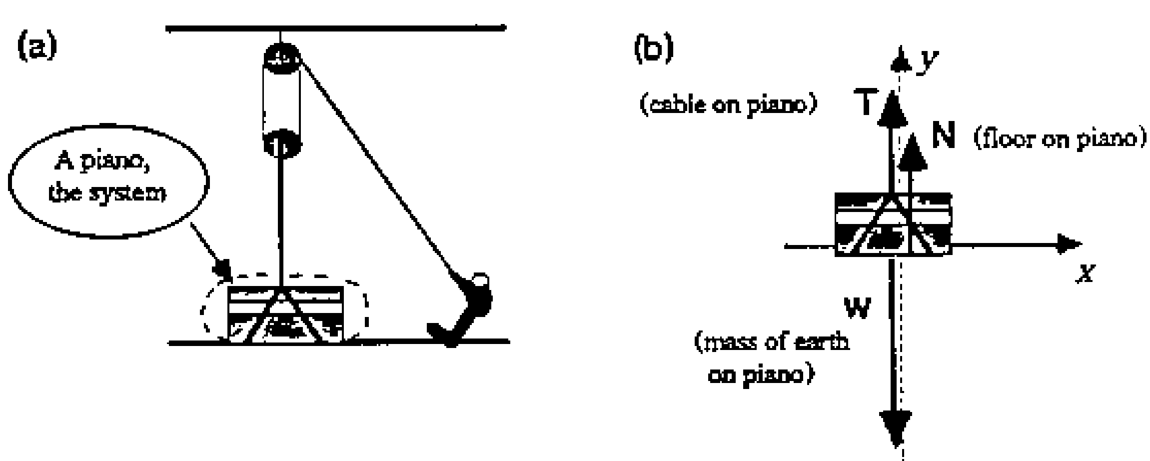


Fig. 1.10 The forces acting on the piano in (a) are shown in the free-body diagram in (b).

The second type of force to include in a free-body diagram is a long-range (action-at-a Distance) forces caused by an object in the environment that does not touch objects in the system. For now, the only long-range force we use is the weight force w. Note that the downward weight force acting on the piano is not considered a contact force because the piano does not touch most of the earth's mass. As far as weight is concerned, the average position of the earth's mass pulling down on the piano is at the earth's center, far from where the piano resides. A completed free-body diagram for the piano, including a coordinate system, is shown in fig. 1.10b. A checklist for types of forces that might act on an object in a system is provided in Table I.l. Use the table to help construct free-body diagrams. The construction of a free-body diagram is illustrated on the next page for a skier being pulled up a ski slope by a rope.

Table I. 1
Forces to include in Free-Body Diagrams.

Normal Force
Static Friction Force
Kinetic Friction Force
Tension Force
_ Air or Water Drag Forces
_ Other

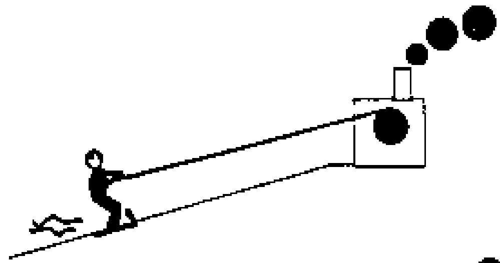
Long-Range Forces

_ Weight
_ Gravitational
_ Other

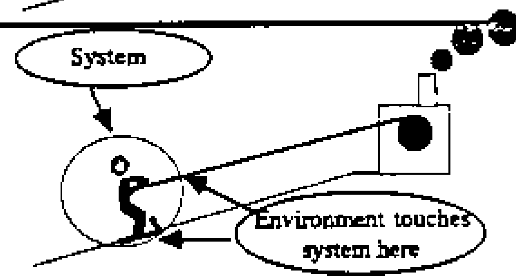
A brief note about Newton's Third Law of Motion: This is a very important law and needs to be studied in some depth, which we'll do later. But to do even the simplest free body diagram analysis requires at least an awareness that it exists and what it is. It says that whenever any object applies a force to a second object, the second object always applies the exact same force on the first object. This seems impossible to most people at first glance, but that is because the world of friction in which we live gives us a deep down instinct conceptional definition of force that causes us to confuse velocity and acceleration with force.

Constructing Free-Body Diagrams

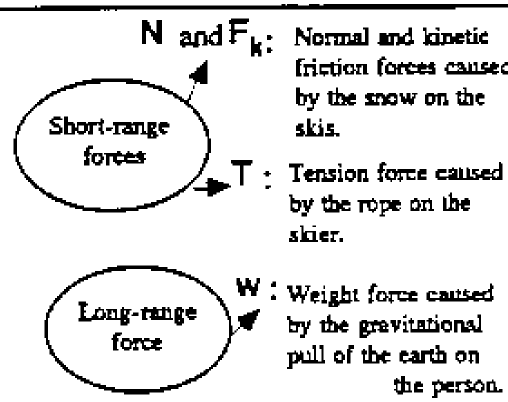
EXAMPLE 1.6 Draw a free-body diagram for the skier and skis shown in the sketch at theright. Ignore air resistance. Cover the right side of the page below the sketch and try each step on a separate sheet of paper before looking at the answer at the side



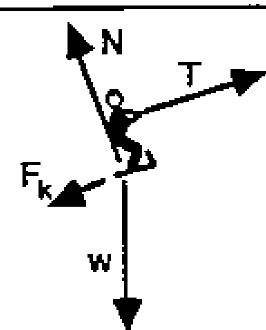
STEP 1: Use a line to encircle and identify the system in the sketch that accompanies the problem statement.



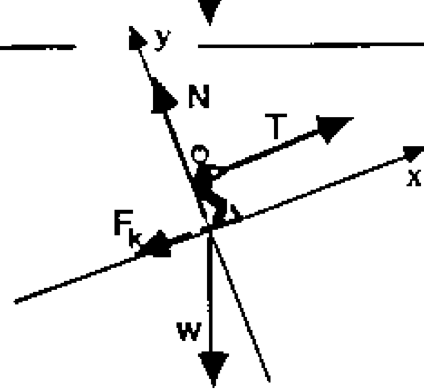
STEP 2: Look along the system boundary for objects in the environment that touch objects in the system. Choose symbols for the forces caused by these touching objects. Also, represent in symbol form any long-range forces acting on the system. Describe in words the environmental object causing each force and the part of the system on which the force acts.



STEP 3: Draw a separate sketch of the object(s) in the system. Then, draw arrows representing all forces acting on the system. Label the arrows with the same symbols as used in Step 2. If possible, try to make the lengths of the arrows representative of the relative magnitudes of the forces.

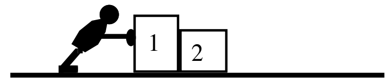


STEP 4: Add coordinate axes to the free-body diagram. Make one axis parallel to the direction of motion and the other axis perpendicular. The head of the coordinate axis arrow points in the positive direction. Do not use two-headed coordinate axis arrows!

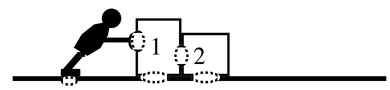


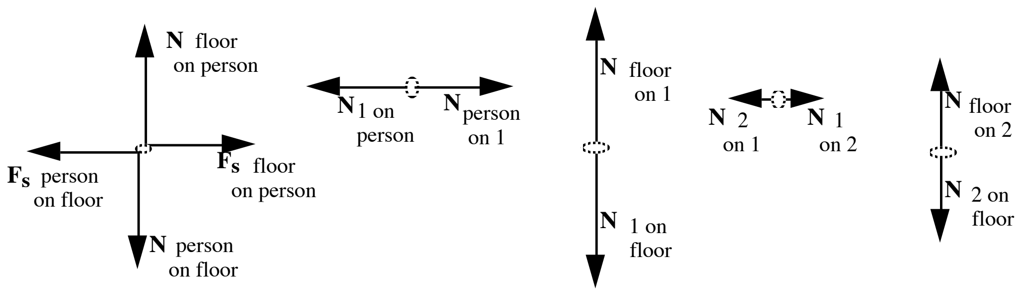
Interactions, Free-body Diagrams, and Newton's third law—1

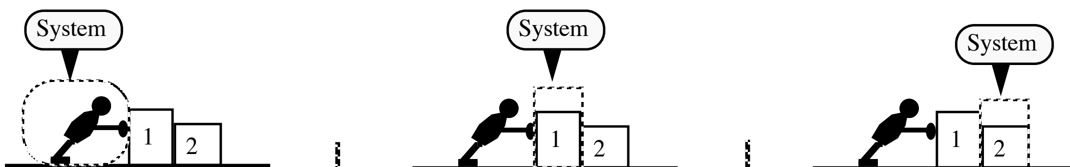
You are to construct a free-body diagram and a force diagram for the person and for each block shown at the right. The blocks have frictionless gliders.



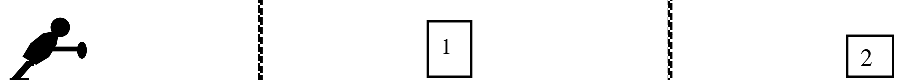
* Points or surfaces of contact between touching objects ( ) are "interaction points or surfaces." At each point, one object exerts a force on the other and the other exerts an equal magnitude, oppositely directed force on the first. ~~Use this menu of forces to construct~~ the free-body and force diagrams below. Also include any long-range forces needed.







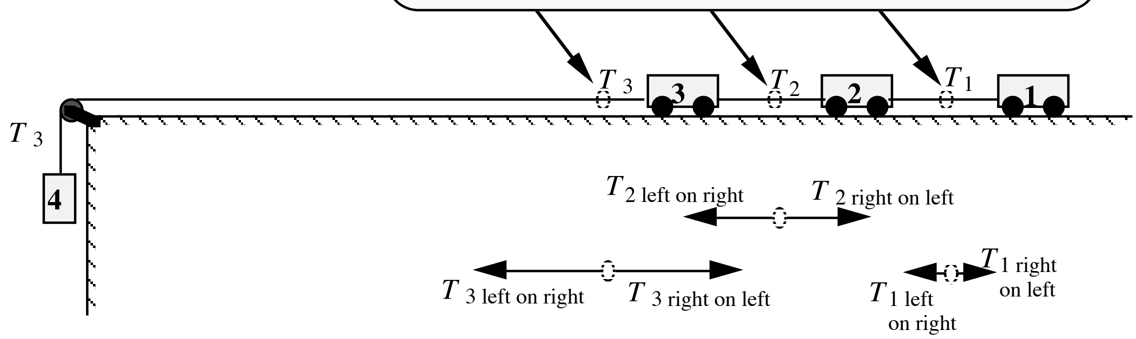
	Include all contact (short range) and long-range forces acting <u>on</u> the person.	Include all contact (short range) and long-range forces acting <u>on</u> block 1.	Include all contact (short range) and long-range forces acting <u>on</u> block 2.
Free-body diagrams			
Force diagrams	•	•	•



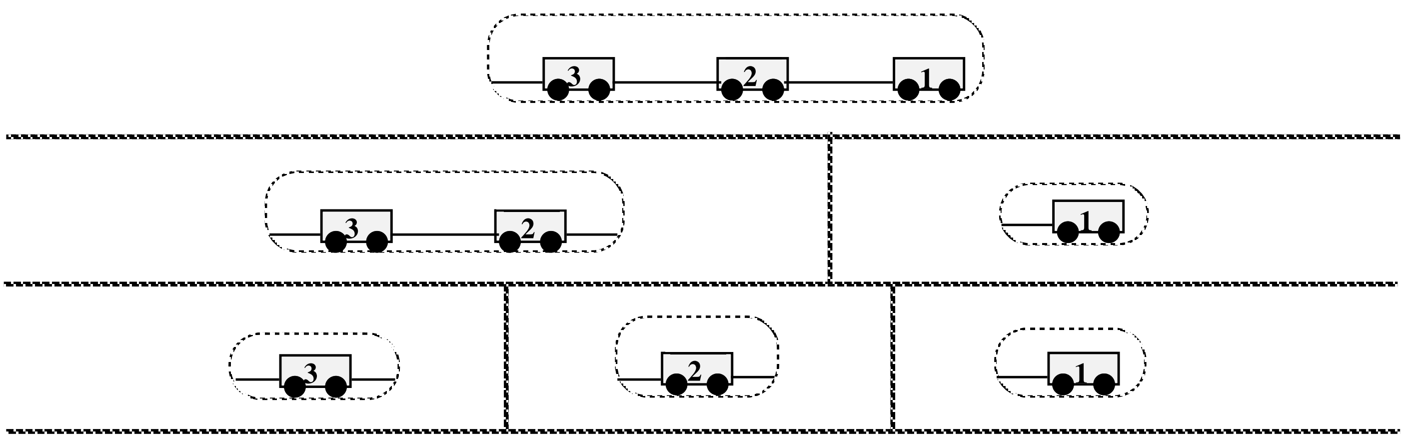
* The idea of using interaction bubbles in helping to construct free-body diagrams and to understand Newton's second and third laws was provided by Jill Larkin.

Interactions, Free-body Diagrams, and Newton's third law—2

* The bubbles are “interaction points” that involve forces needed to construct the free-body diagrams below. At each interation point, two equal magnitude forces pull in opposite directions. One force is caused by the rope on the left of the point pulling the rope on the right. The other force is caused by the rope on the right pulling the rope on the left.



(a) Choose from the menu of forces shown above to construct free-body diagrams for each cart or for each group of carts shown below. Include only forces caused by objects outside the system acting on objects inside the system. For this problem, we include only forces directed along the horizontal direction (we ignore forces with componenets in the vertical direction). The surface does not have friction.



(b) Write the horizontal component form of Newton's second law for the system with all three carts (at the top) and separately for the three systems at the bottom. Assume that the positive x axis points toward the left. The carts have equal mass.

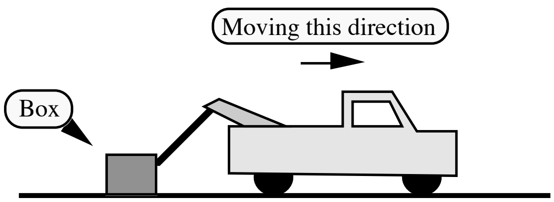
(c) How does the net force acting on cart 1 compare to the net force acting on cart 3 (they have the same mass)? Explain.

* The idea of using interaction bubbles in helping to construct free-body diagrams and to understand Newton's second and third laws was provided by Jill Larkin.

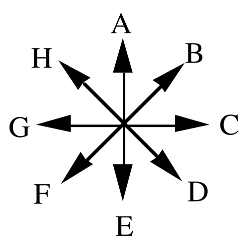
Directions of Forces—1

For each situation below, indicate the arrow that points closest to the direction of the force that some object exerts on the box.

A rope attached to a truck pulls a box along a horizontal surface with friction.



Possible directions of the forces.



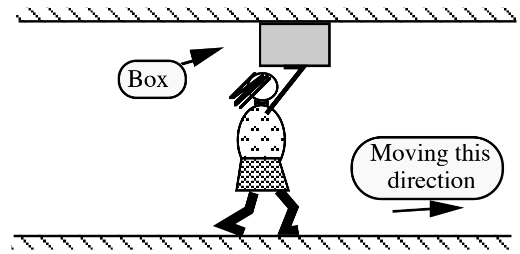
(a) Direction of the tension force of the rope on the block is closest to ____.

(b) Direction of the normal force of the surface on the block is closest to ____.

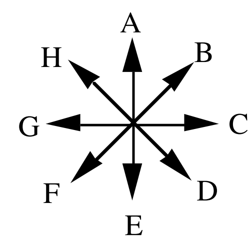
(c) Direction of the kinetic friction force of the surface on the block is closest to ____.

(d) Direction of the force of the earth's mass on the block (the weight force) is closest to ____.

A person pushes a box along the ceiling that has friction.



Possible directions of the forces.



Direction of the normal force of the ceiling on the block is closest to ____.

Direction of the kinetic friction force of the ceiling on the block is closest to ____.

Direction of the normal force of the person's hands on the block is closest to ____.

Direction of the static friction force of the person's hands on the block is closest to ____.

Why is this friction force of person on the box static even though the block is moving?

____

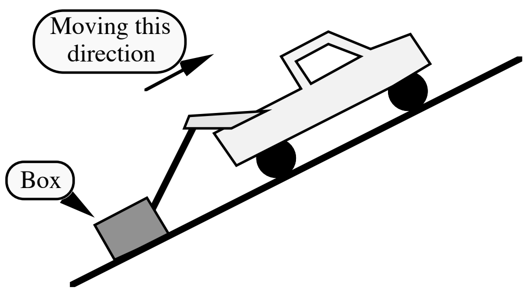
____

Direction of the force of the earth's mass on the block (the weight force) is closest to ____.

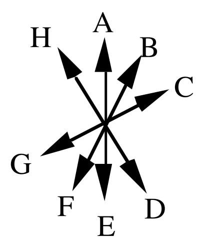
Directions of Forces—2

For each situation below, indicate the arrow that points closest to the direction of the force that some object exerts on the box.

A rope attached to a truck pulls a box along hill with friction.



Possible directions of the forces.



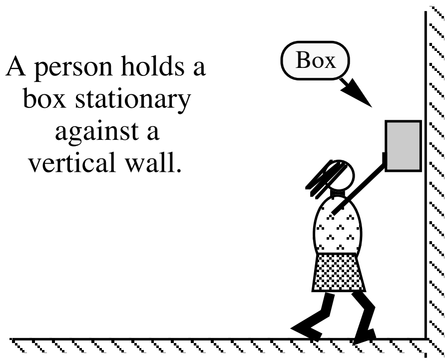
(a) Direction of the tension force of the rope on the block is closest to ____.

(b) Direction of the normal force of the surface on the block is closest to ____.

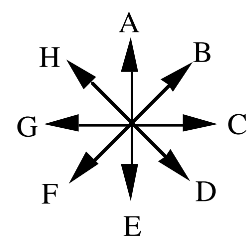
(c) Direction of the kinetic friction force of the surface on the block is closest to ____.

(d) Direction of the force of the earth's mass on the block (the weight force) is closest to ____.

A person holds a box stationary against a vertical wall.



Possible directions of the forces.



Direction of the normal force of the wall on the block is closest to ____.

Direction of the static friction force of the wall on the block is closest to ____.

Could it point in another direction? Explain.

____

____

Direction of the normal force of the person's hands on the block is closest to ____.

Direction of the static friction force of the person's hands on the block is closest to ____.

Direction of the force of the earth's mass on the block (the weight force) is closest to ____.

Free Body Diagrams - 1

Construct free body diagrams for the **boldface** objects described below.

---

a) A **person** hanging from a rope.

b) A **book** sitting on a **table**.

c) A **person** sitting on a stool.

Free Body Diagrams - 2

Construct free body diagrams for the **boldface** objects described below.

---

a) A **person** climbing down a rope.

b) A **skydiver** before opening her parachute.

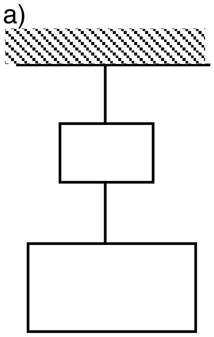
c) A **skydiver** after opening her **parachute**.

Free Body Diagrams - 3

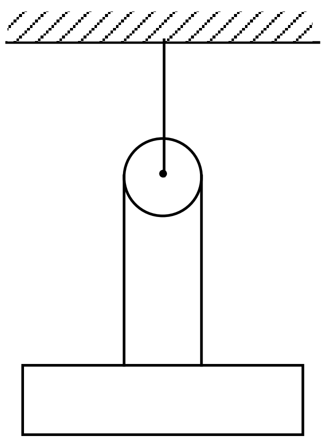
Construct free body diagrams for each of the objects pictured below.

---

a)



b



Qualitative Reasoning About Forces - 1

A block is hung by a string from the ceiling of an elevator. For each of the situations below state which force is larger, the force of the string on the block or the force of gravity on the block.

---

a) The elevator is at rest.

b) The elevator is moving upward at an increasing speed.

c) The elevator is moving upward at a decreasing speed.

d) The elevator is moving upward at constant speed.

e) The elevator is moving downward at decreasing speed.

f) The elevator is moving downward at constant speed.

Qualitative Reasoning About Forces - 2

A man stands on a bathroom scale inside an elevator. When the elevator is at rest, the scale reads 750 N (170 lb). Compare the scales reading to 750 N when:

---

a) The elevator is moving upward at an increasing speed.

b) The elevator is moving upward at a decreasing speed.

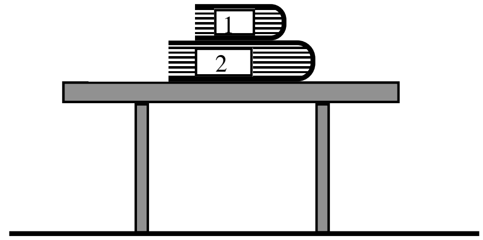
c) The elevator is moving upward at constant speed.

d) The elevator is moving downward at decreasing speed.

e) The elevator is moving downward at constant speed.

Free-Body Diagrams—1

Draw a free-body diagram for book two shown in the sketch at right.



Encircle and identify the system in the sketch that accompanies the problem statement.

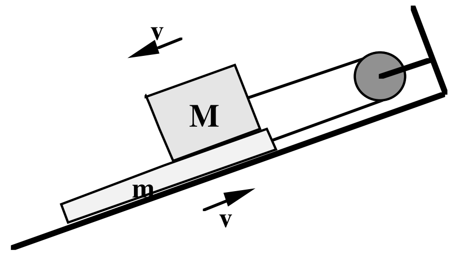
Look along the system boundary for interaction points or surfaces where objects in the environment touch an object in the system. Choose symbols for the forces caused by these touching objects. Also, represent in symbol form any long-range forces acting on the system. Describe in words the environmental object causing each force.

Draw a separate sketch of the object(s) in the system. Then, draw arrows representing all forces acting on the system. Label the arrows with the same symbols as used previously. If possible, try to make the length of the arrows representative of the relative magnitudes of the forces.

Add coordinate axes to the free-body diagram. Make one axis parallel to the direction of motion and the other axis perpendicular. The head of a coordinate axis arrow points in the positive direction. (Do not use two-headed coordinate axis arrows.)

Free-Body Diagrams—2

Construct a free-body diagram for mass M as it moves down the incline—mass m moves up the incline. All surfaces have a small amount of friction.



Encircle and identify the system in the sketch that accompanies the problem statement.

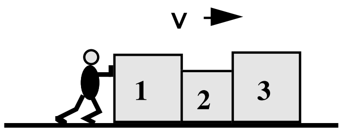
Look along the system boundary for interaction points or surfaces where objects in the environment touch an object in the system. Choose symbols for the forces caused by these touching objects. Also, represent in symbol form any long-range forces acting on the system. Describe in words the environmental object causing each force.

Draw a separate sketch of the object(s) in the system. Then, draw arrows representing all forces acting on the system. Label the arrows with the same symbols as used previously. If possible, try to make the legnth of the arrows representative of the relative magnitudes of the forces.

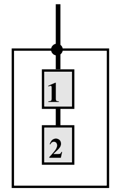
Add coordinate axes to the free-body diagram. Make one axis parallel to the direction of motion and the other axis perpendicular. The head of a coordinate axis arrow points in the positive direction. (Do not use two-headed coordinate axis arrows.)

Free-Body Diagrams—4

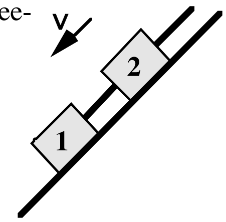
Construct a free-body diagram for block 2. The horizontal surface has friction.



Construct a free-body diagram for block 1 hanging in the upward moving elevator.



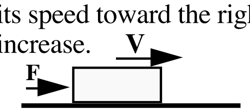
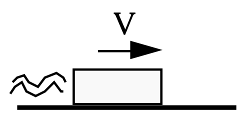
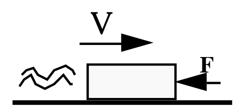
Construct a free-body diagram for block 2. The surface has friction.



Save space below for answer.

Relating Force and Motion

A block is shown below in three different situations.
(a) For each situation construct a motion diagram for the block.
(b) Next, construct a free-body diagram for the block, and
(c) determine the direction of the net force.
(d) Complete the table near the bottom of the page indicating the directions of the velocity, the acceleration, and the net force for each situation.
(e) Finally, decide if the net force seems to be proportional to the velocity, to the acceleration, or to neither one.

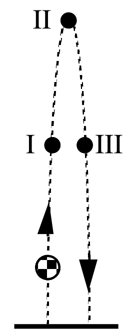
	(I) A block, intitially at rest, is pushed gently toward the right on a horizontal, frictionless surface causing its speed toward the right to increase. 	(II) The block coasts at constant speed on the horizontal, frictionless surface. 	(III) The block, moving right, is opposed by a gentle push that causes its speed to decrease. 
(a) Motion diagram			
(b) Free-body diagram			
(c) Direction of net force if not zero.			

(d) Complete the table indicating if each quantity is zero (0), points left (←), or points right (→).

	I	II	III
v			
a			
F_{net}			

(e) Based on the information shown in the table, does there seem to be a relation between the net force acting on the block and its velocity or acceleration? If so, describe that relationship.

Relating Force and Motion—2



A ball is thrown vertically upward.

(a) Use either a motion diagram or the subtracting velocity technique to determine the direction of the ball's acceleration at positions I, II, and III.

(b) Construct a free-body diagram for the ball at positions I, II and III. Ignore air resistance.

(c) Complete the table near the bottom of the page indicating the directions of the velocity, the acceleration, and the net force at each position.

(d) Finally, decide if the net force is proportional to the velocity, to the acceleration, or to neither one.

(a)	Motion diagram at I	Subtract velocities to find direction of the acceleration at II (or is the acceleration zero?)	Motion diagram at III
(b)	Free-body diagram at I	Free-body diagram at II	Free-body diagram at III

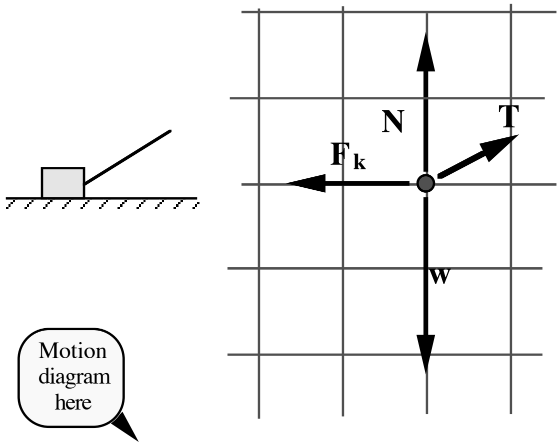
(c) Complete the table below indicating if each quantity is zero (0), points up (↑), or points down (↓) at each position.

	I	II	III
v			
a			
$\mathbf{F}_{net}$			

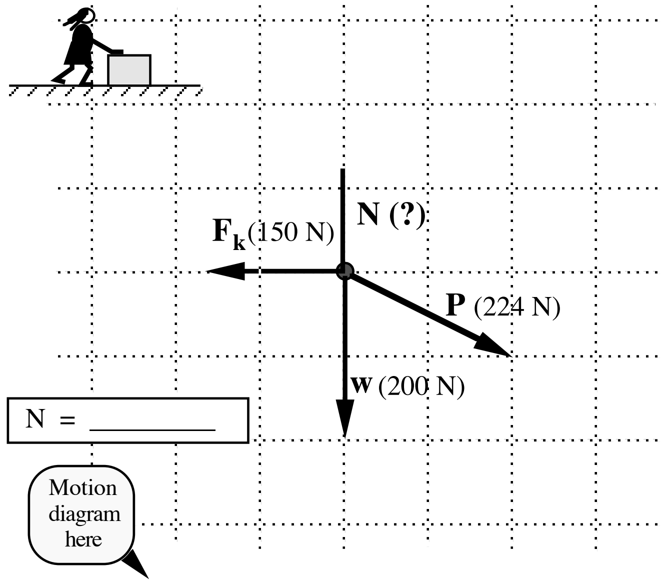
(e) Based on the information shown in the table, does there seem to be a relation between the net force acting on the block and its velocity or acceleration? If so, describe that relationship.

Qualitative Reasoning about Newtonian Processes—8

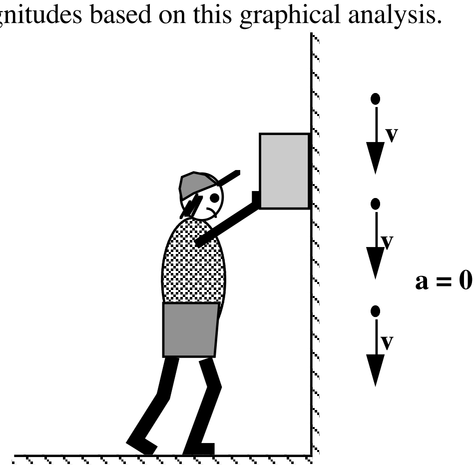
1. Construct a motion diagram for the block whose force diagram is shown below.

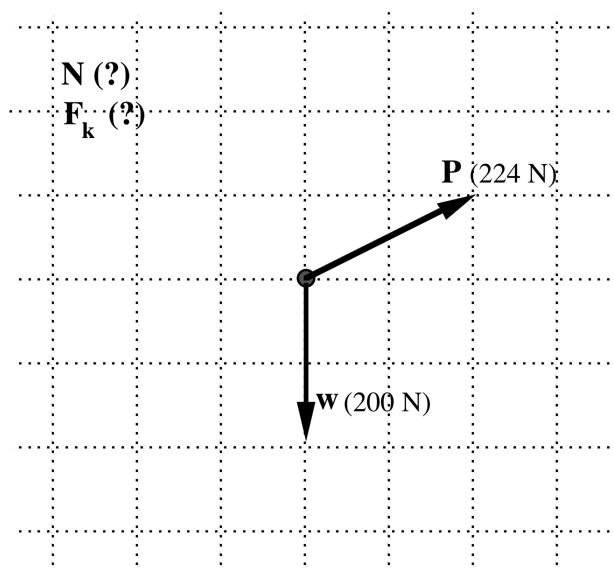


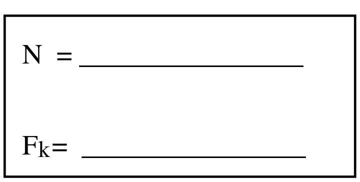
2. Draw the normal force to the appropriate length, determine its magnitude graphically, and then construct a motion diagram for the crate initially moving right.



3. A motion diagram for the crate is shown beside it. Place arrows with the correct lengths on the force diagram to represent the normal and kinetic friction forces and indicate their magnitudes based on this graphical analysis.







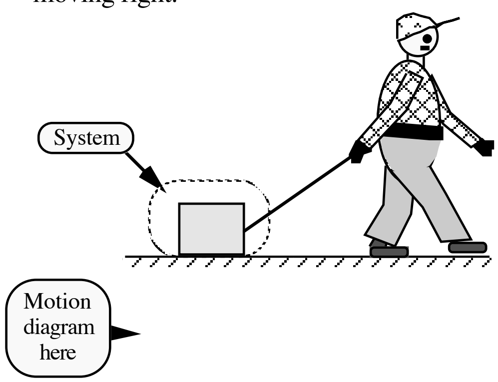
Qualitative Reasoning about Newtonian Processes—9

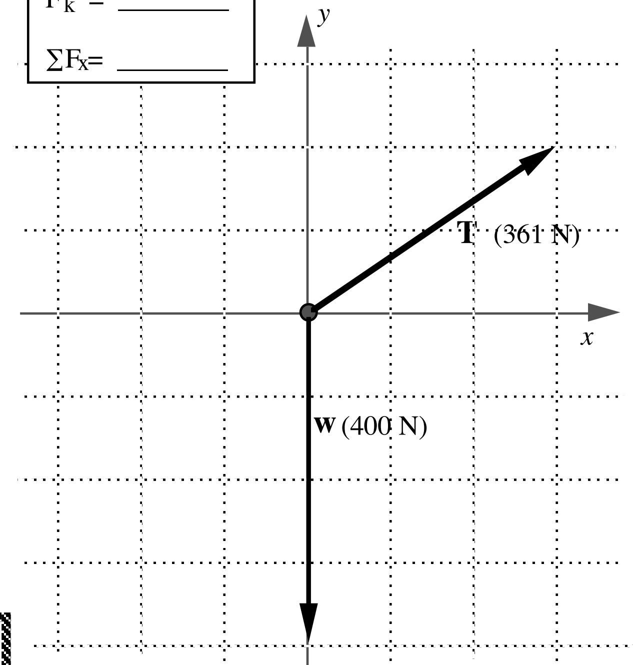
1. (a) Draw the normal force to the appropriate length and determine its magnitude graphically.
(b) The coefficient of friction between the block and surface is 0.70—the kinetic friction force is 0.70 times the normal force. Draw the kinetic friction force and determine its magnitude.
(c) Determine the net force acting on the block in the x direction.
(d) Construct a motion diagram for the crate, initially moving right.

N = ________

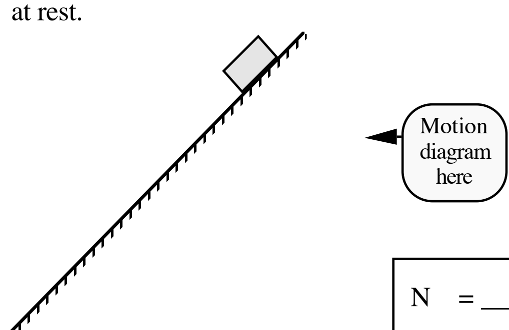
F_k = ________

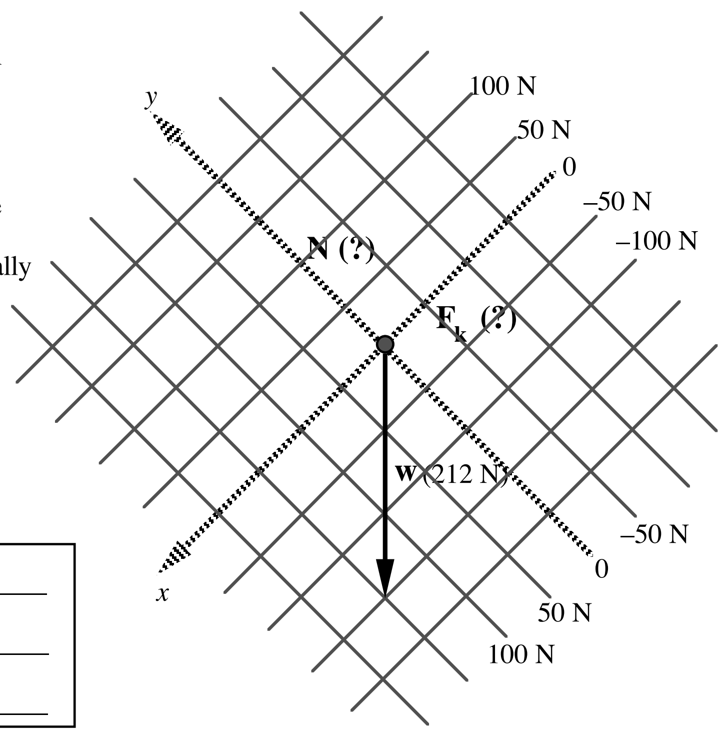
$\sum F_x$= ________





2. The crate below slides down a 45˚ incline.
(a) Draw on the graph an arrow representing the normal force of the plane on the block and indicate the magnitude of the normal force. Note that the crate's acceleration in the y direction is zero. Do all work graphically.
(b) Draw the kinetic friction force assuming a 0.67 coefficient of kinetic friction—the ratio of the friction force and the normal force.
(c) By graphical analysis, estimate the magnitude and sign of the net force in the x direction.
(d) Construct a motion diagram for the cart, initially at rest.





N = ________

F_k = ________

$\sum F_x$= ________

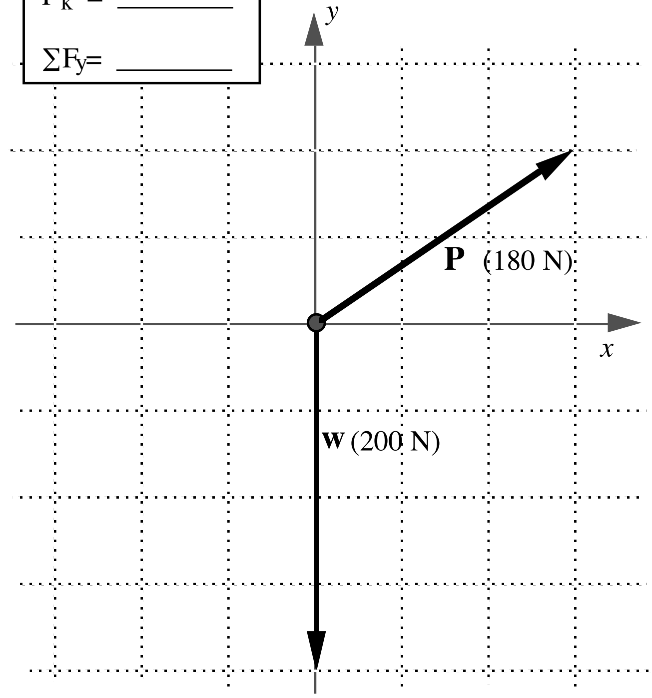
Qualitative Reasoning about Newtonian Processes—10

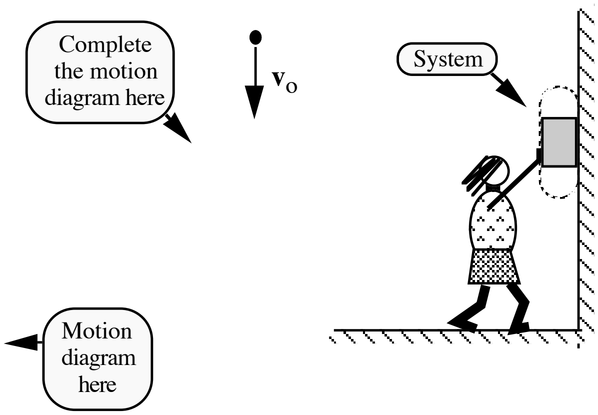
1. A woman pushes a 20-kg crate with force **P** as she lowers it down a vertical wall, as shown below.
(a) Determine graphically the magnitude of the normal force and draw it on the force diagram at the right.
(b) The coefficient of friction between the crate and surface is 0.80—the kinetic friction force is 0.80 times the normal force. Determine the magnitude of the kinetic friction force and draw it on the diagram.
(c) Determine the net force acting on the crate in the y direction.
(d) Complete below the motion diagram for the crate, which is initially moving downward at moderate speed.

N = ________

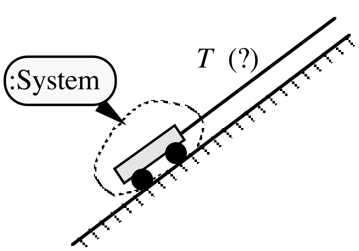
F_k = ________

ΣF_y = ________





2. A rope lowers a 50-kg wagon down a hill. The coefficient of kinetic friction between the hill and the wagon is 0.50. Determine the tension needed in the rope in order for the wagon to move at constant velocity.
(a) Graphically determine the magnitude of the normal force and draw an arrow representing the force.
(b) Determine the magnitude of the kinetic friction force and draw it graphically.
(c) Graphically determine the magnitude of the tension needed in order for the wagon to move down the hill at constant velocity.



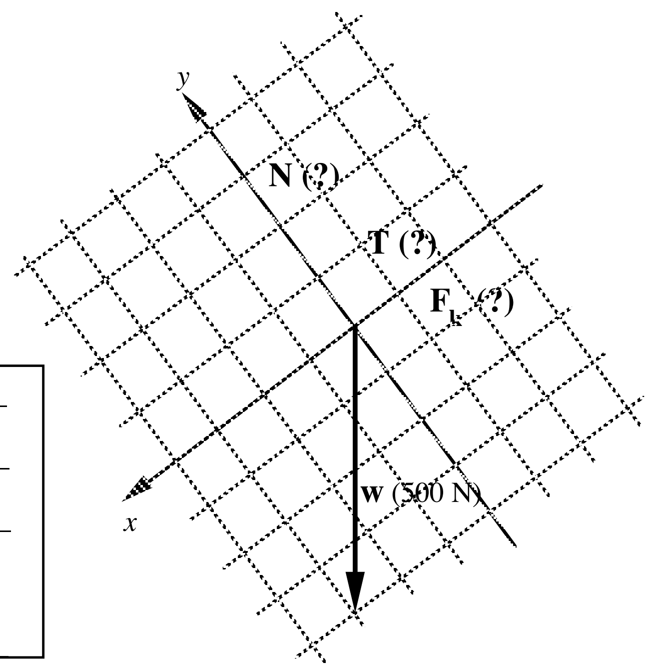
N = ________

F_k = ________

T = ________

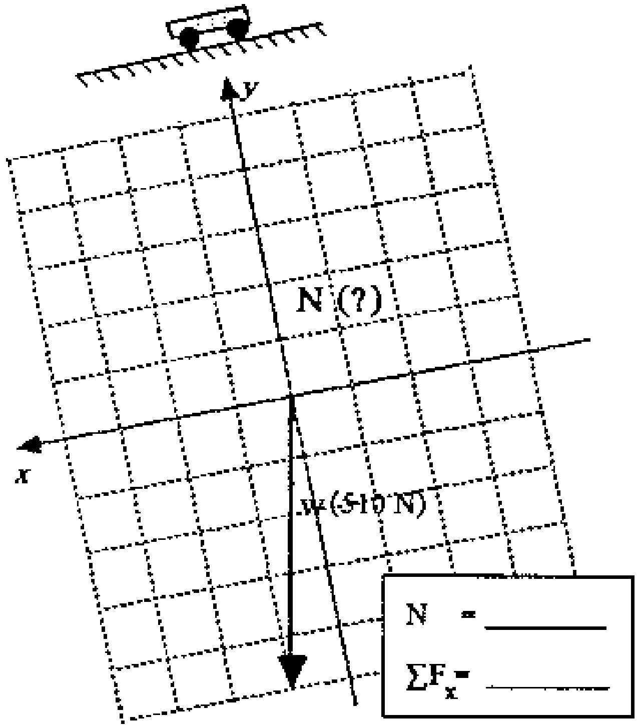
in order that

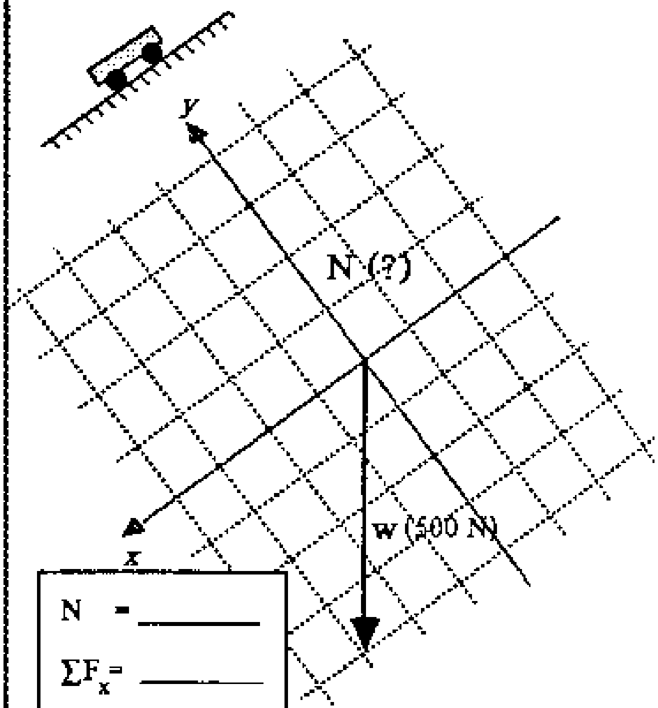
ΣF_x = ________

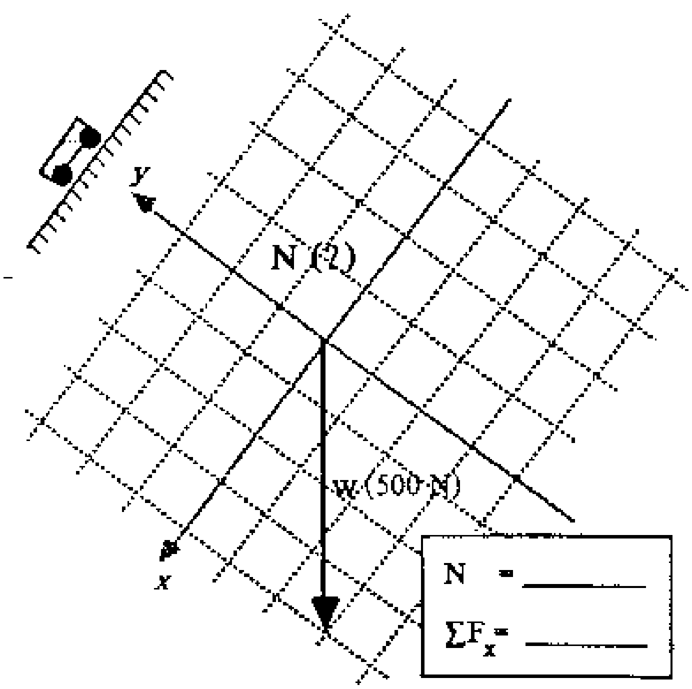


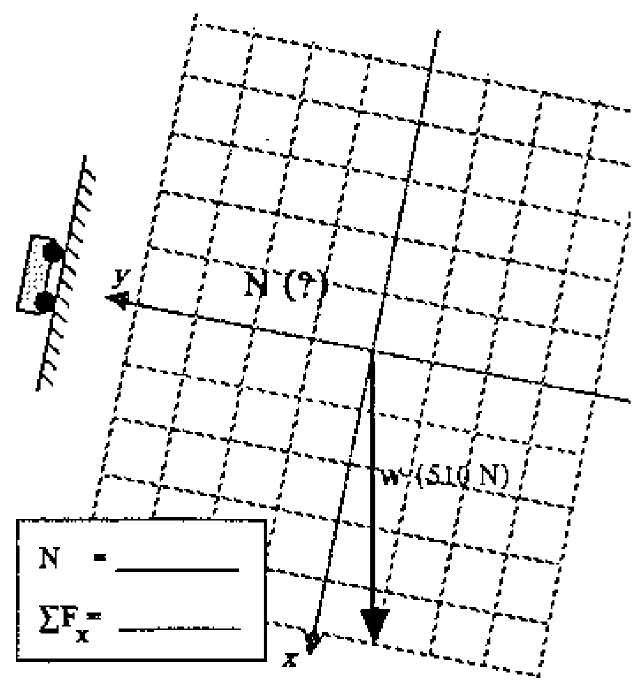
Qualitative Reasoning about Newtonian Processes—11

In each case below, a cart slides down a frictionless incline. For each case, draw a vector representing the normal force and graphically determine its magnitude and the magnitude of the net force in the x direction.



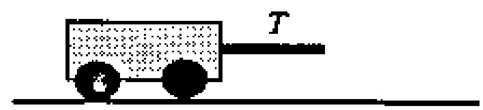






Qualitative Reasoning About Newtonian Processes - 1

A rope with tension T gently pulls a cart, initially at rest, along a horizontal frictionless surface. At the instant the cart's speed becomes 10 m/s, the tension is reduced to $T/2$. Now, what happens to the speed of the cart ?



If asked a question about motion, you often begin by considering the known forces acting on the object. Construct a free-body diagram for the cart at the instant the tension is reduced to T/2.

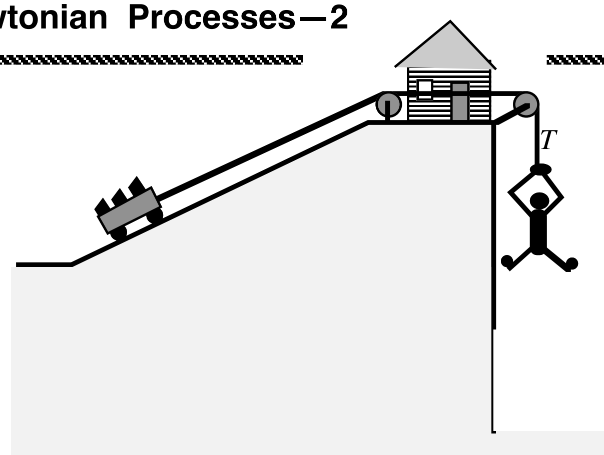
Next, decide if the net force acting on the cart is zero or not zero. If not zero, determine the direction of the net force. Then, use Newton's second law to determine the direction of the cart's acceleration.

Now, construct a motion diagram for the cart starting at the time the tension is reduced.

Finally, answer the question.

Qualitative Reasoning about Newtonian Processes—2

A miner pulls a wagon of supplies to the top of a hill where he lives by hanging from a rope attached to the wagon. As the cart moves at increasing speed up the hill, the miner moves with increasing downward speed. How does the tension in the rope compare to his weight ?



If asked a question about force, you often begin by determining the direction of the acceleration using either a motion diagram or by subtracting velocities. Determine the direction of the miner's acceleration.

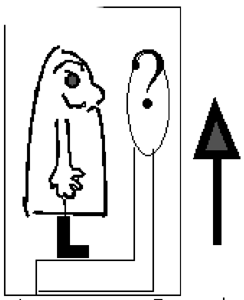
Next, use Newton's second law to determing the direction of the net force acting on the miner.

Construct a free-body diagram for the miner. The arrows representing forces should have the appropriate relative length so that the net force is in the direction determined above.

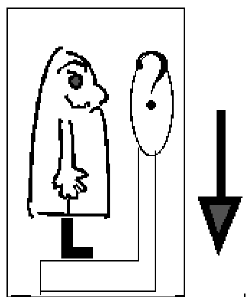
Finally, answer the question.

Free Body Ranking Task #2

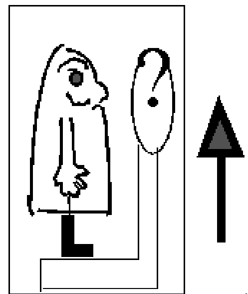
The figures below depict eight identical 60 kg people riding eight identical elevators. Each elevator is moving in the direction of the arrow on its right. The reference frame for each of these pictures assumes that up is the positive direction, so a negative acceleration implies a downward acceleration. Give the highest rank to the person whose scales registers the most weight, and the least rank to the person whose scales registers the least weight. (Use acceleration due to gravity g = 10 m/s2.)



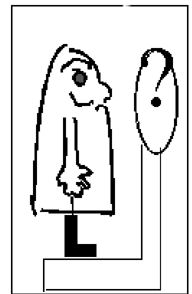
A. v = 3m/s, a = 2m/s/s



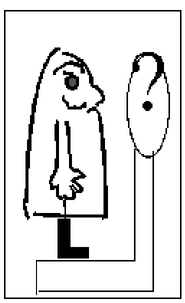
B. v = -3m/s, a = 2 m/s/s



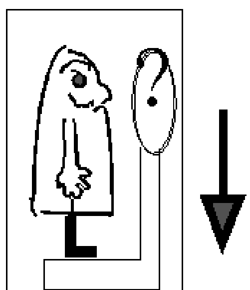
C. v = 3m/s, a = 0m/s/s



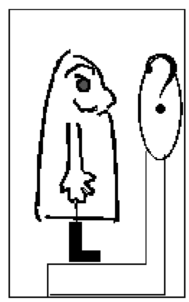
D. v = 0 m/s, a = 0 m/s/s



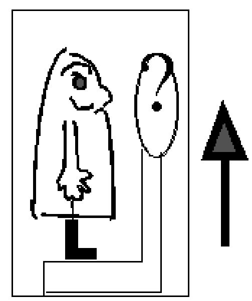
E. v = 0m/s, a = -2m/s/s



F. v = -3m/s, a = 0m/s/s



G. v = 0m/s, a = -10 m/s/s



H. v = 3m/s, a = -10m/s/s

Highest 1_____ 2_____ 3_____ 4_____ 5______ 6 ______ 7 ______ 8_______ Lowest

All the scales read the same weight_______.

Please carefully explain your reasoning:

How sure are you of your reasoning?

Basically Guessed Sure Very Sure

1 2 3 4 5 6 7 8 9 10

Physics Workbook 5c: The Saga of Sally & Hank

Vectors

1. A dog trots 30 m from home east, then turns and trots 50m 37° north of east. Draw his total displacement.

2. A cow ambles west for 400 m, then turns and wanders in a straight line in another direction. Her total displacement turns out to be 600m in a direction 53° north of west. Draw the second leg of the journey.

The Saga Begins: Part I

1. A 50 N bag hangs from a rope attached to a limb.

Draw a FBD of the bag.
Is the bag in equilibrium?
Sum the forces acting on the bag.
What is this sum equal to?
Find the tension in the rope.

2. A squirrel appears and gnaws the rope in two to allow his buddies on the ground to catch the bag of goodies.

Draw a FBD of the bag.
Is the bag in equilibrium?
Sum the forces acting on the bag.
What is this sum equal to?
Find the tension in the rope.

3. Suddenly an orangutan appears and in a daring act swings down from the limb and grabs the rope. Then she begins pulling the rope upward at a constant speed of 8 m/s.

Draw a FBD of the bag.
Is the bag in equilibrium?
Sum the forces acting on the bag.
What is this sum equal to?
Find the tension in the rope.

4. When she sees a bear approaching the tree eying the bag, she begins to pull faster, causing the bag to speed up with an acceleration of 4 m/s^2.

Draw a FBD of the bag.
Is the bag in equilibrium?
Sum the forces acting on the bag.
What is this sum equal to?
Find the tension in the rope.

5. But, not fast enough. The 80 kg bear leaps up and grabs the bag and rides it down, causing it to slip in the orangutan's grasp, and fall at a constant speed of 3 m/s.

Draw a FBD of the bag.

Is the bag in equilibrium?
Sum the forces acting on the bag.
What is this sum equal to?
Find the tension in the rope.

6. Then, the stubborn orangutan exerts all her strength and manages to slow the fall at a rate of 1 m/s^2.

Draw a FBD of the bag.
Is the bag in equilibrium?
Sum the forces acting on the bag.
What is this sum equal to?
Find the tension in the rope.

***End of First Day

7. But alas, the extra weight proves too much for the branch, which breaks, plunging bear, bag, orangutan and limb to the ground. The bear leaps up and bounds away, dragging the bag behind him, applying a force of 60N to the rope, causing it to follow him reluctantly at a constant speed of 7 m/s. (The impact causes the orangutan to lose her grip.)

Draw a FBD of the bag.
Is the bag in equilibrium?
Sum the forces acting on the bag.
What is this sum equal to?
Find the net friction force on the bag .

8. The dazed, but unharmed, orangutan finally recovers her composure, and leaps to her feet. Unlike the bear, she is unhampered by the bag, she quickly catches up and dives onto the bag. The added 30 kg mass of the orangutan increases the friction force which slows the bear, (still applying a 60N force to the rope) down at a rate of 2 m/s^2. (don't forget the bear has a mass of 80 kg and the bag of goodies has a mass of 5 kg.)

Draw a FBD of the bag.
Is the bag in equilibrium?
Sum the forces acting on the bag-orangutan mass.
What is this sum equal to?
Find the net friction force acting on the bag-orangutan mass.

9. But then the bag hits a rock, causing the orangutan to fall off, and the bag and bear, who now pulls even harder trying to escape the orangutan with a 80 N force, to move off speeding up as it goes.

Draw a FBD of the bag.
Is the bag in equilibrium?
Sum the forces acting on the bag.
What is this sum equal to?
Find the acceleration of the bag.

****

10. A 200 N block sits on a horizontal surface and a dog tugs the rope attached to it with a force of 80 N, but fails to budge it.

Draw a FBD of the block.

Is the block in equilibrium?
Sum the forces acting on the bag.
What is this sum equal to?
Find the static friction force.

11. The 200 N block finally begins to move when the dog jerks on the rope with a mighty lunge and he finds that he can now make it move at a constant speed of 2 m/s with a force of only 50 N.

Draw a FBD of the block.
Is the block in equilibrium?
Sum the forces acting on the bag..
What is this sum equal to?
Find the kinetic friction force.

13. Now the dog increases the force back to 60N and the block begins to accelerate .

Draw a FBD of the block.
Is the block in equilibrium?
Sum the forces acting on the bag.
What is this sum equal to?
What must be this acceleration?

****

Physics Workbook 5 d: Focus on Friction

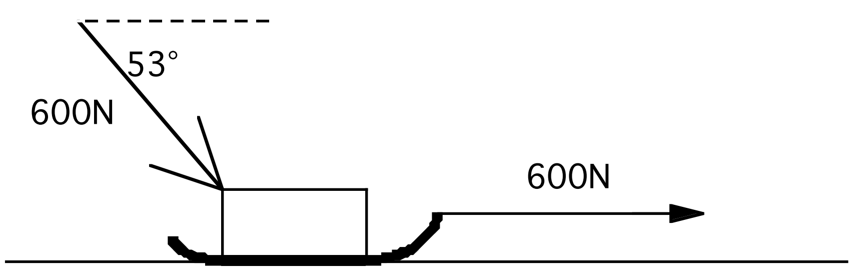
Quest for the bag of goodies: The saga continues.....Part II.

When we left our battling twosome , the bear was finally making his triumphant get-away dragging the bag behind him. But alas, it was not to be, the bag snags on a root, ripping open with goodies scattering everywhere. Both the bear and the orangutan quickly begin to eat as fast as they can. After stuffing themselves, they suddenly discover how ridiculous they are and begin to laugh. The bear (Hank) invites the orangutan (Sally) over to his place for a cup of tea. He picks up the rope as they leave saying it may come in handy getting his sled full of firewood home.

1. As they are finishing up the tea, Sally asks Hank about the sled of firewood he mentioned, saying she might be of help. He says "come on , I'll show you. They go down into the valley where the 200 kg sled sits. The bear attaches the rope and tugs with a force of 1000 N parallel to the ground, but just as the sled begins to move, the rope breaks. Hank says "humm, the breaking strength of this rope must be 1000N", as he ties it back together.

Draw a FBD of the sled
Draw a x and y axis.
what is the weight of the sled ?
What is the apparent weight of the sled ?
Is the sled in equilibrium in either the x or y directions?
Sum the forces acting on the sled in both x and y directions.
What are these sums equal to?
What is the friction force equal to?
Is it static or kinetic friction ?
What is the acceleration of the sled ?

2. Sally leaps behind to push, trying to help. Being taller than the sled, she must lean over to push, applying a force of 600N at an angle of 53° below the horizontal, while Hank is careful to pull on the rope with exactly 600 N so as not to break it again. Considering that the "Big Bear Book of Wisdom" reveals that the static coefficient of friction between a sled and dirt is 0.5, while the kinetic coefficient of friction is 0.3, do the two together manage to budge the sled? If so, what is it's acceleration?



.Draw a FBD of the sled
Draw a x and y axis.
what is the weight of the sled ?
What is the apparent weight of the sled ?
Is the sled in equilibrium in either the x or y directions?
Sum the forces acting on the sled in both x and y directions.
What are these sums equal to?
What is the friction force equal to?

Is it static or kinetic friction ?
What is the acceleration a_x of the sled?
What is the acceleration a_y of the sled?

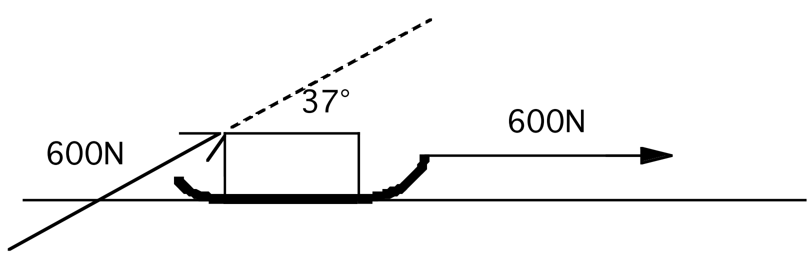
3. Next Sally hunkers down so that she is pushing horizontally with 600 N, in the same direction as Hank. What is the acceleration of the sled ?

Draw a FBD of the sled
Draw a x and y axis.
what is the weight of the sled ?
What is the apparent weight of the sled ?
Is the sled in equilibrium in either the x or y directions?
Sum the forces acting on the sled in both x and y directions.
What are these sums equal to?
What is the friction force equal to?
Is it static or kinetic friction ?
What is the acceleration a_x of the sled?
What is the acceleration a_y of the sled?

4. Ahah! For those of you who haven't figured it out, the sled is finally moving! Sally, decides to play a joke on Hank. She jumps onto the sled for a ride. The question is, with Sally no longer pushing and her added mass of 80 kg , is Hank still able to keep the sled moving?

Draw a FBD of the sled
Draw a x and y axis.
what is the weight of the sled ?
What is the apparent weight of the sled ?
Is the sled in equilibrium in either the x or y directions?
Sum the forces acting on the sled in both x and y directions.
What are these sums equal to?
What is the friction force equal to?
Is it static or kinetic friction ?
What is the acceleration a_x of the sled?
What is the acceleration a_y of the sled?

5. Bored with the free ride, Sally leaps off to help again and pushes upward at an angle of 37° above the horizontal hoping to lighten the load a bit, so they move along faster.



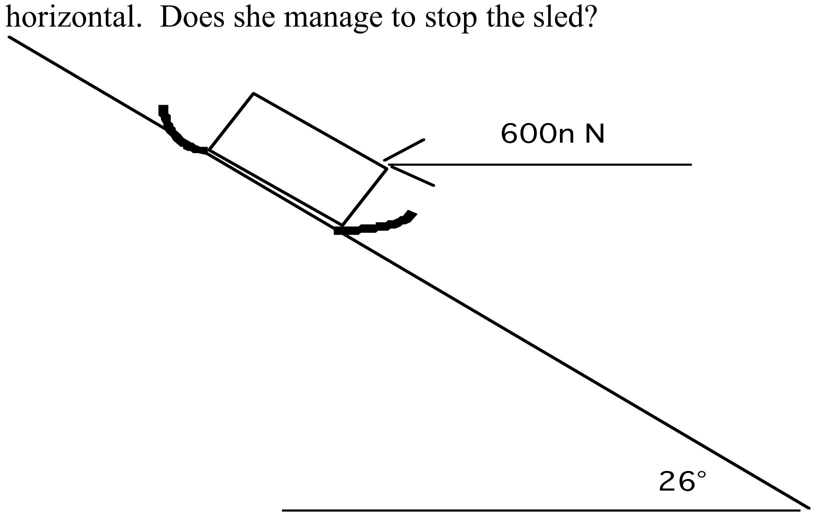
Draw a FBD of the sled
Draw a x and y axis.
what is the weight of the sled ?
What is the apparent weight of the sled ?
Is the sled in equilibrium in either the x or y directions?

Sum the forces acting on the sled in both x and y directions.
What are these sums equal to?
What is the friction force equal to?
Is it static or kinetic friction ?
What is the acceleration a_x of the sled?
What is the acceleration a_y of the sled?

6. Presently, when they begin to go down a hill that slopes down at an angle of 26° below the horizontal, they stop for a rest. The question is, does the sled stay at rest on the hill, or does it begin to slide down the hill by itself? (recall that the static coefficient of friction is .5 and the kinetic coefficient of friction is .3.)
Draw a FBD of the sled
Draw a x and y axis.
what is the weight of the sled ?
What is the apparent weight of the sled ?
Is the sled in equilibrium in either the x or y directions?
Sum the forces acting on the sled in both x and y directions.
What are these sums equal to?
What is the friction force equal to?
Is it static or kinetic friction ?
What is the acceleration a_x of the sled?
What is the acceleration a_y of the sled?

7. However, when Sally accidently bumps the sled it begins to move down the hill!
Draw a FBD of the sled
Draw a x and y axis.
what is the weight of the sled ?
What is the apparent weight of the sled ?
Is the sled in equilibrium in either the x or y directions?
Sum the forces acting on the sled in both x and y directions.
What are these sums equal to?
What is the friction force equal to?
Is it static or kinetic friction ?
What is the acceleration a_x of the sled?
What is the acceleration a_y of the sled?

8. Sally leaps in front of the sled and begins to push as hard as she can (600 N) with a force that is horizontal. Does she manage to stop the sled?



Draw a FBD of the sled
Draw a x and y axis.
what is the weight of the sled ?
What is the apparent weight of the sled ?
Is the sled in equilibrium in either the x or y directions?
Sum the forces acting on the sled in both x and y directions.
What are these sums equal to?
What is the friction force equal to?
Is it static or kinetic friction ?
What is the acceleration a_x of the sled?
What is the acceleration a_y of the sled?

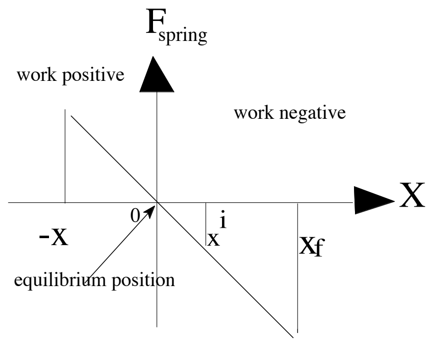
9. The Grand Slam!

A car traveling at 20 m/s stops in a distance of 50 m. Assume that the deceleration is constant. The coefficients of friction between the passenger and the seat are $\mu_s = 0.5$ and $\mu_k = 0.3$. Will a 70 kg passenger slide off the seat if not wearing a seat belt?

wks # 6 WORK AND ENERGY

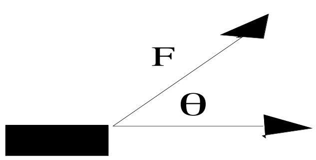
1. Energy: What is it? Energy is an entity, concept, or whatever you want to call it that, when added to an object causes it to heat up, (heat energy $Q = mc\Delta T$), speed up, kinetic energy $K = .5\ mv^2$), or change its altitude, (potential energy $U_g = mg\Delta y$). An effort to quantify this concept is what is known as energy. There are many ways to transfer energy to or from an object, but one of the simplest is to apply a force to it and speed it up.

Vork is a sub-concept of energy. Work is defined to be energy transferred to or from an object by means of a force. More specifically, **Work = force (*in the direction of motion)* x distance (*over which the force is applied)*.** Since this applied force causes the object to speed up, the Law of conservation of energy, (which comes from the law of conservation of momentum), requires that the net work done ***on the object*** equals the amount of change in its Kinetic energy ΔK, hence, the



Work-Energy theorem $W_{net} = \Delta K$

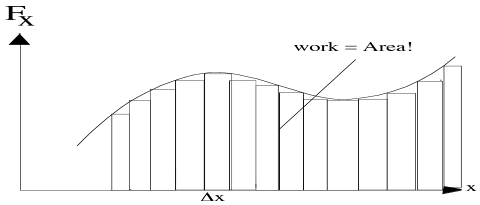
Friction Free Surface W = F



3. But what happens when the force is not in the direction of motion? For instance, suppose the force is applied at an angle q with the horizontal. What force contributes to the acceleration of the object? Conclude $W = F\cos\theta \cdot x$

Define the Dot Product of two vectors $\mathbf{F} \cdot \mathbf{x} = Fx\cos\theta$ Where θ is the <u>angle between F and the direction of motion</u>, thus, W = **F•x**, where **x** and **F** are vector quantities.

4. Work due to friction force. Since friction is always a reaction to the applied force, it will always be in the opposite direction to the direction of motion. i.e. the angle between $\mathbf{F_k}$ and displacement **x** is always 180^o, thus,



$W_{friction} = F_k x \cos 180^o = -F_k x$. i.o.w. Work due to friction is **always** negative !

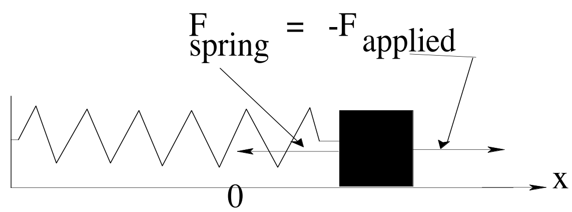
5. Work done by varying force. How to find F•X if F is changing?

$W = \text{limit} \sum W_i$: = limit $\sum F_i \Delta x$ = _F dx ! Moreover,
Δx 0 Δx 0

The RBD Work is area under curve!

W_{net} = _F_{net}dx = _ma dx = _m(dv/dt)dx = _m dv(dx/dt) = _mvdv = $.5mv^2 - .5mv_o^2 = \Delta K$

6. Work done by a Hooke's Law spring. Pg 2



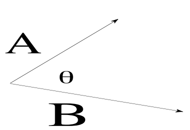
$F_s(x) = -Kx = -F_{app}$ (see figures at left), thus,

W_{app}= _F_{app}dx = _kxdx = $.5kx^2$, and
W_s = _$F_s$dx = -_F_{app}dx = $-W_{app}$= - $.5kx^2$

7. Now suppose **F** = (3**i** + 2 **j**) and r = 2**i** - 5**j**. How's an easy way to find W = **F** · **r** ?

Recall **A** · **B** = AB cos θ. How could one find **A·B** without knowing A,B and θ ? i.e. How to find (A_x i + A_y j) · (B_x i +B_y j)= ? Just multiply it out !

$A_x A_y + B_x B_y = AB \cos\theta$. So, $AB \cos\theta = A_xB_x + A_yB_y$, or



$\cos\theta = (A_xB_x + A_yB_y)/AB$

8. If **F** = F_x **i** + F_y**j** and displacement is **dr** = dr_x **i** + dr_y **j**, then W =_$_{r1}^{r2}$ **F** **dr** = ?

9. $Power_{avg}$ = work/time = W/Δ t = P
P = limit dW/Δt = dW / dt = d **(F · r)** / dt =(d/dt) ?
Δt 0

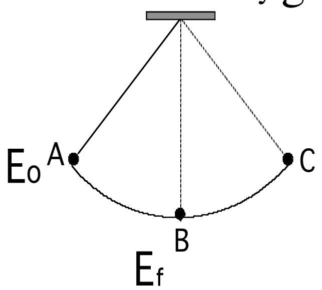
DISCUSS limitations of the P = F v formula , Pg 187 :
units of power = J / s = Watts (W)
1 hp = 746 W. = 550 ft lb.

Potential Energy

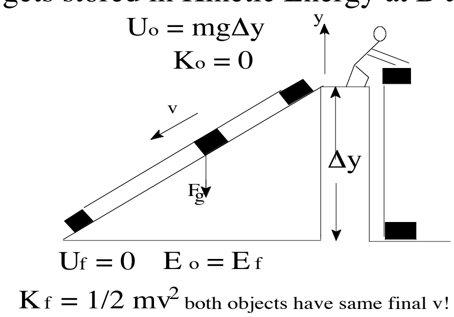
Def. Pot - ENERGY - Energy an object has by virtue of its location relative to some equilibrium position. Note: Since it is the energy obtained from some force applied to the system, for both gravity and springs, potential energy = $W_{app} = \Delta U_g$ or ΔU_s. Specifically,

$$U_g = mgh \text{ or } mg\Delta y, \text{ and } U_s = .5kx^2 \text{ or } .5k(x^2 - x_o^2)$$

so the work done by gravity or a spring is W_g or $W_s = -\Delta U_{s \text{ or } g}$



Def. Conservative Force (F_c) - All energy expended goes into savings and can be retrieved. NO ENERGY IS LOST, so total energy $E_o = E_f$. Work done by g when the pendulum in the figure moves from A to B gets stored in Kinetic Energy at B and is used to raise ball to C.



$E_o = E_f$,

$K_o + U_o = K_f + U_f$

Work done by a conservative Force is independent of path.

$F_g = -mg = F_c$, so $Wg = -mg\Delta y = -\Delta U$ = _-mgdy = _ F_g dy = $-\Delta U_g$.

Notice the two objects at right travel different displacements, but both travel the same Δy, the distance parallel to the direction of the conservative force F_g.

So, $Wg = -mgh = -\Delta U$ or if $U(x_o) = 0$, $\Delta U = U$ = -_$F_g$dy so $dU/dy = -F_c(y)$ or $F_c = -dU/dy$

This is a characteristic of a conservative force in general: U_c = - _ F_c dx = $-W_c$.

F_{nc} - nonconservative force, all energy lost forever. --(friction, in our case).

W_{nc} = Work done by F_{nc}, so $W_{net} = W_{nc} + W_c$.

Work-- Energy Theorem revisited $W_{net} = W_{nc} + W_c = \Delta K$.

But since $W_c = -\Delta U$, $W_{net} = W_{nc} - \Delta U = \Delta K$, so

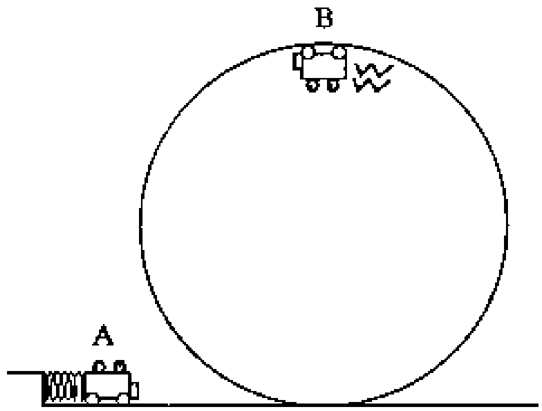
$$W_{nc} = \Delta K + \Delta U = \Delta E,$$ (Remember E represents total energy.)

Spring Pot. Energy

$F_s = -Kx$, so W_s = _$F_s$dx = _-kxdx = $-.5k(x^2 - x_o^2) = -\Delta U_s$, so $\Delta U_s = .5k(x^2 - x_o^2)$, or,

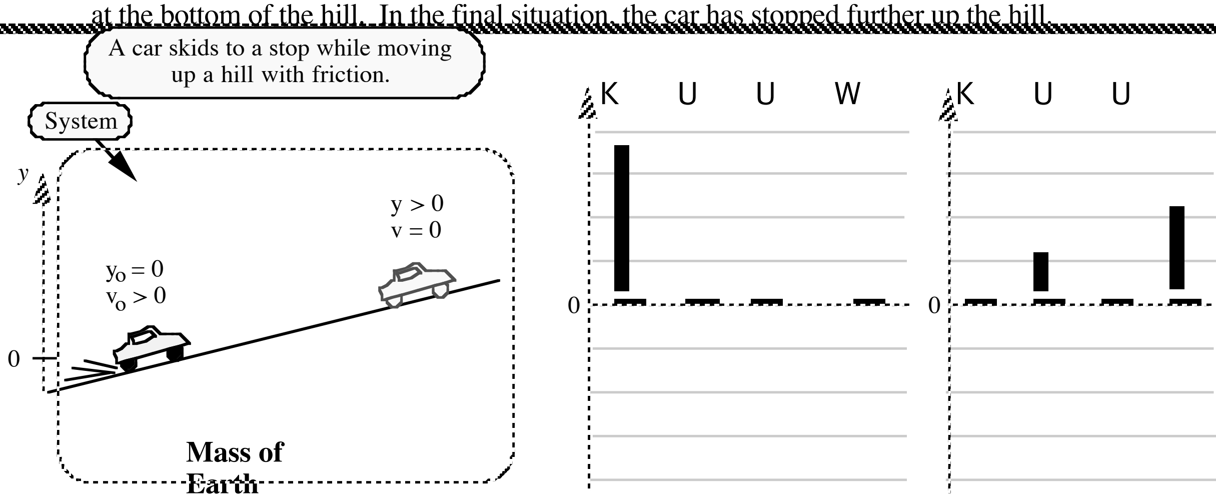
if $x_o = 0$, $U_s = .5kx^2$, so the work done by gravity or a spring is W_g or $W_s = -\Delta U_{s \text{ or } g}$

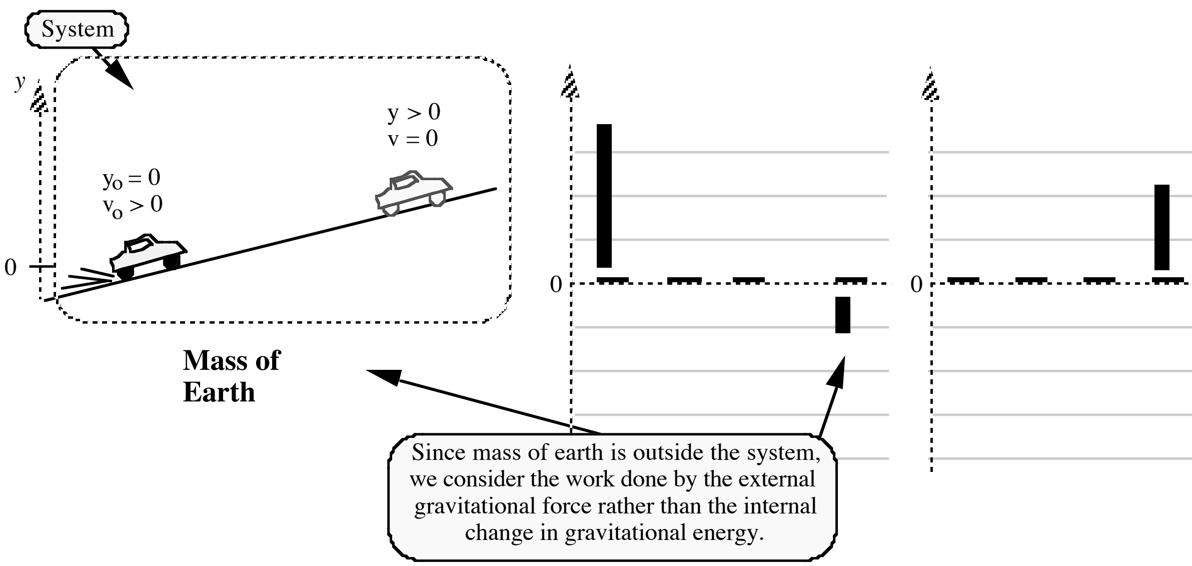
VI. WORK-ENERGY KIT

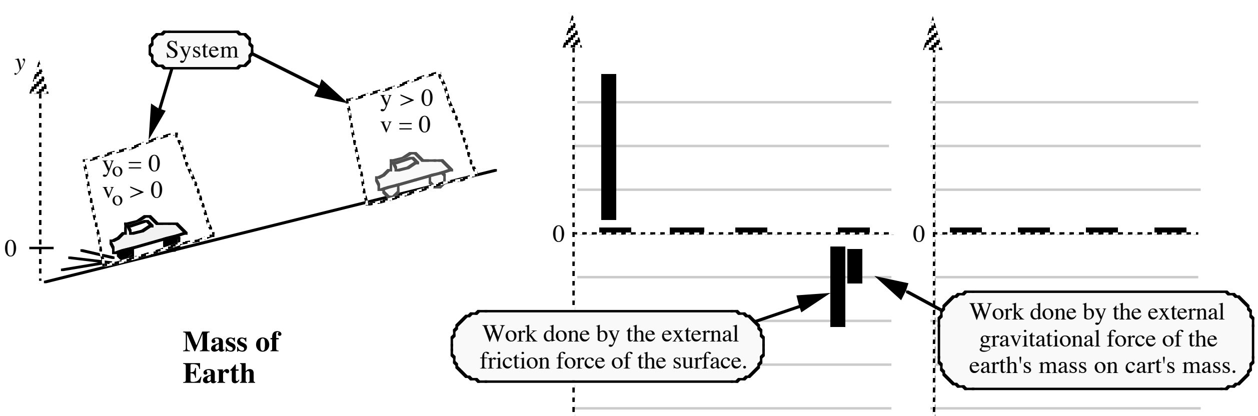


Work-Energy Bar Graphs and System Choice—2

The work-energy bar graphs below illustrate the way in which we account for work and energy for the same process but using different systems. Initially, the car is skidding with brakes locked at the bottom of the hill. In the final situation, the car has stopped further up the hill.



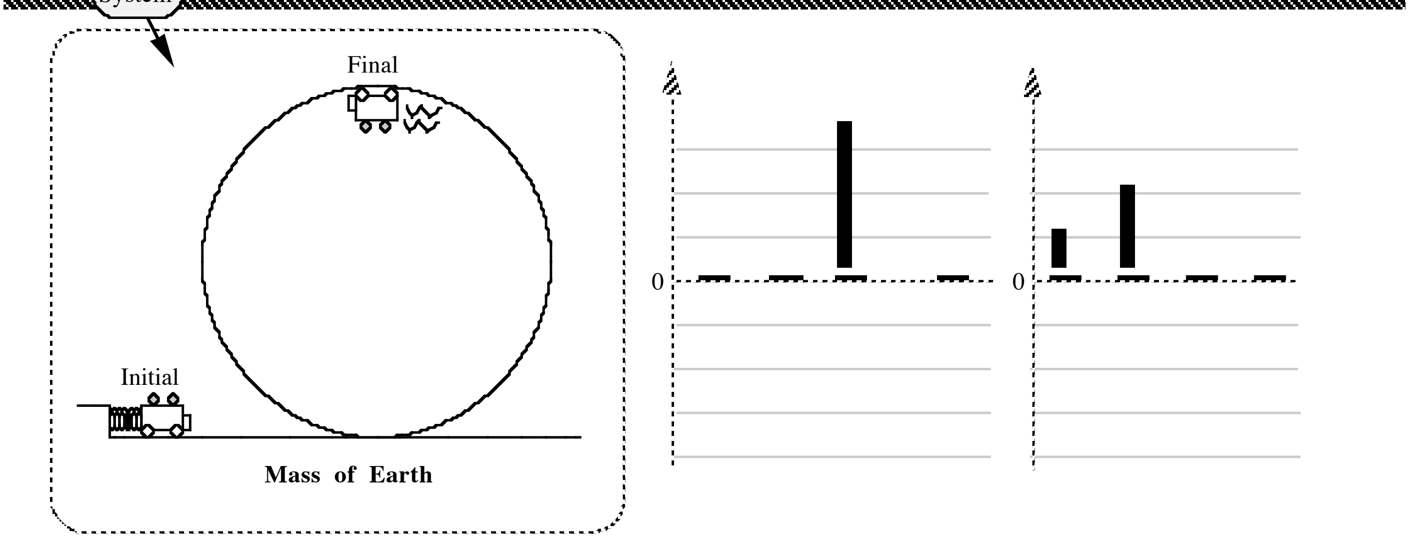


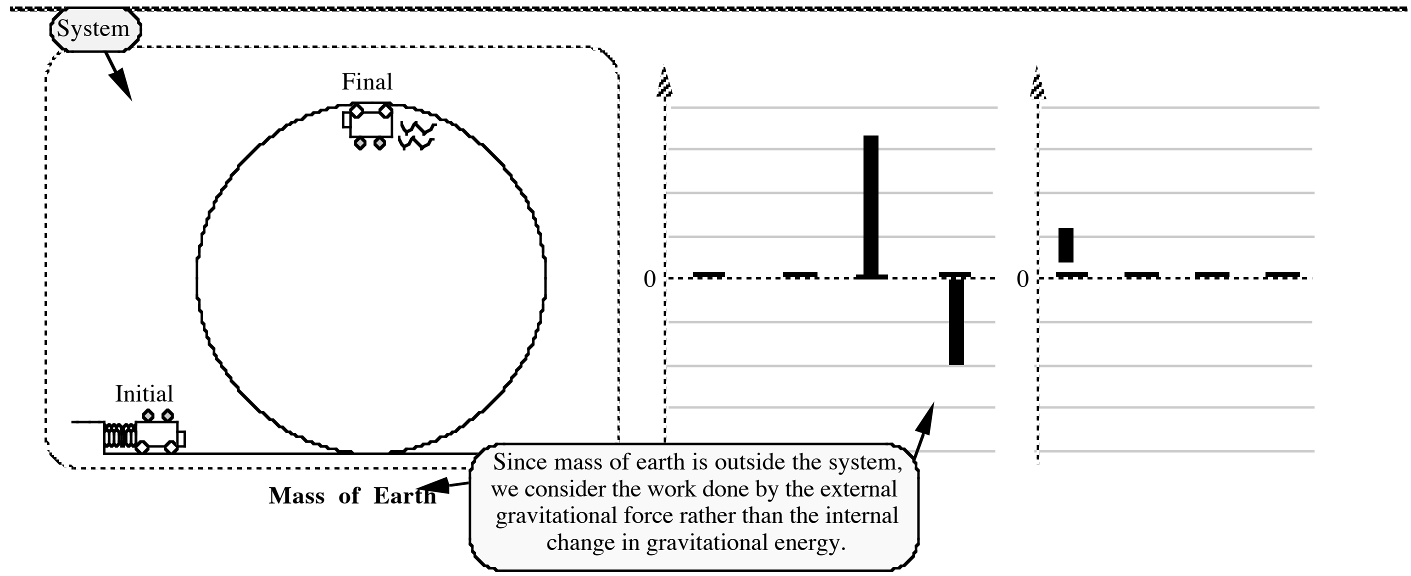


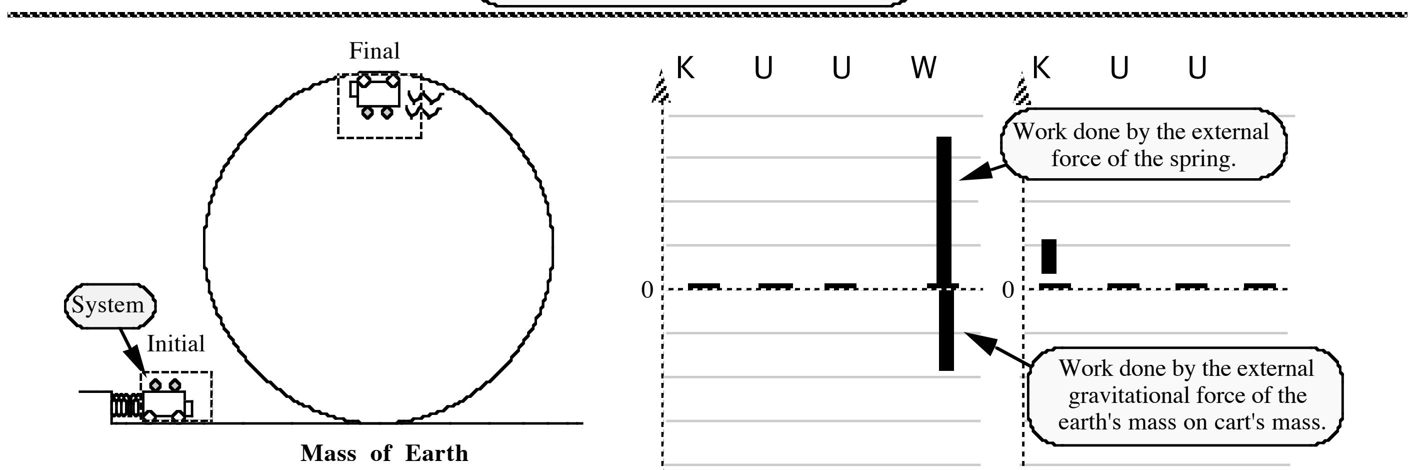
Thanks to Bob Sledz for the idea of analyzing the same process with different systems.

Work-Energy Bar Graphs and System Choice—1

The work-energy bar graphs below illustrate the way in which we account for work and energy for the same process but using different systems. Initially the spring is compressed and the cart is at rest ready to be launched. In the final situation, the cart is moving at the top of the frictionless loop.

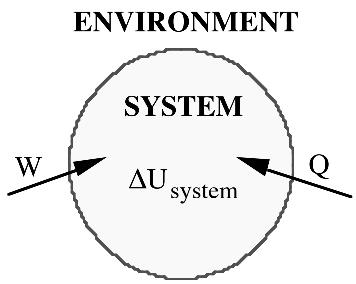






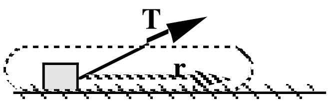
Thanks to Bob Sledz for the idea of analyzing different systems with the bar graphs.

Cues for Analyzing Work-Heat-Energy Processes

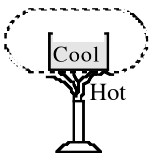


$$W + Q + ... = \Delta U_{system}$$

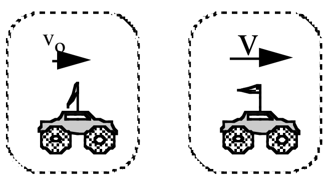
$$= \Delta K + \Delta U_g + \Delta U_s + \Delta U_{int\ th} + \Delta U_{int\ pot}$$



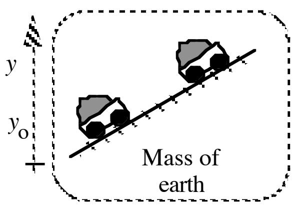
W: Object outside system exerts force on object inside system as the object inside undergoes a displacement.



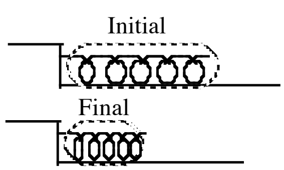
Q: Object inside system <u>touches</u> object outside that is at a <u>different temperature</u> (object can be a gas, liquid or a solid).



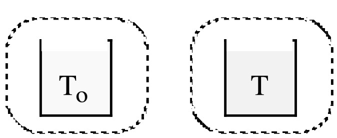
ΔK: Look for an object or objects that change speed.



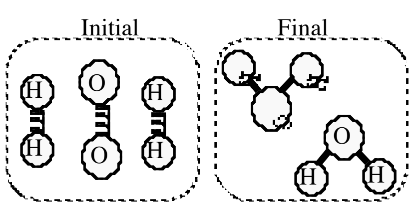
ΔU_g: Look for an object or objects that change vertical elevation relative to the earth, which is also in the system.



ΔU_s: Look for a change in the distance that an elastic object is stretched or compressed.



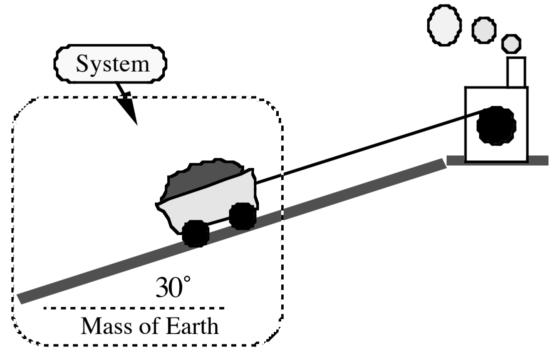
$\Delta U_{int\ th}$: Look for a change in the temperature of a system or for a friction force that causes a thermal energy increase.



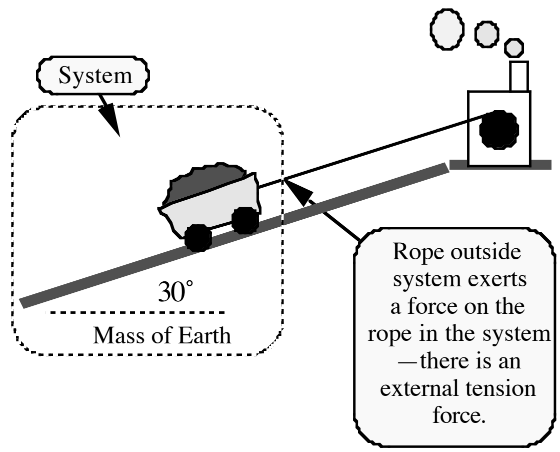
$\Delta U_{int\ pot}$: Look for a change in state or a change in atomic, nuclear, or molecular structure.

Work Done by a Constant External Force

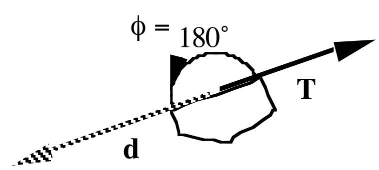
Construct a sketch of the situation described in the problem. In the example shown at the right, a cart is lowered a distance d down a hill. We wish to determine the work done by external forces on an object or objects in the system, which has already identified in the sketch.



Identify any external forces that act on objects in the system. An external force is a force exterted on an object in the system by an object outside that system.



Draw an arrow representing the force exerted by the object outside the system on the object inside the system. Next, draw an arrow representing the displacement of the object inside the system during the time interval that the external force acts on it. The force and the displacement arrows should be placed tail to tail. Then, determine the angle ϕ between the direction of the force and the direction of the displacement.



Calculate the work done by the external force:

$$W = F\, r\, \cos\phi$$

- F: Magnitude of the force—a positive number.
- r: Magnitude of the displacement—a positive number.
- ϕ: Angle between direction of **F** and **r**.

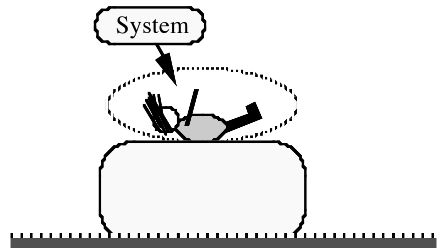
Work done by the tension force:

$$W_T = T\ d\ \cos 180^\circ$$
$$= T\ d\ (-1) = -T\ d$$

VI-2

Determining the Work Done by a Constant External Force: Example 1

Sketch: In the example shown at the right, a woman weighing 600 N sinks 0.50 m into a cushion while being stopped. The average force of the cushion on the woman while stopping her is 6000 N. Choosing the woman as the system, determine the work done on her by each external force. The system is circled in the sketch at the right.



Identify any external forces that act on objects in the system. An external force is a force exterted on an object in the system by an object outside that system.

Draw an arrow representing each external force acting on the object inside the system. Then, draw an arrow representing the displacement of the object inside the system during the time interval that the external force or forces act on it. The force and the displacement arrows should be placed tail to tail. Finally, determine the angle ϕ between the direction of the force and the direction of the displacement.

Determine the work done by each external force:

$$W = F\,r\,\cos\phi$$

Magnitude of the force—a positive number. (F)

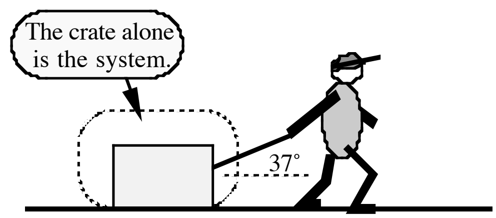
Magnitude of the displacement—a positive number. (r)

Angle between direction of **F** and **r**. (ϕ)

vi-3

Determining the Work Done by Constant External Forces: Example 2

Sketch: In the example shown at the right, a man pulls a crate a distance of 5.0 m along the floor. The tension in the rope is 100 N. Choosing the crate alone as the system, determine the work done on it by each external force. A 50-N friction force opposes the motion. The system is circled in the sketch at the right.

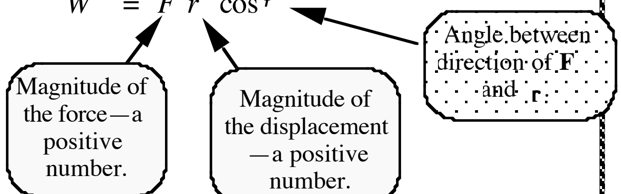


Identify any external forces that act on objects in the system. An external force is a force exterted on an object in the system by an object outside that system.

Draw an arrow representing each external force acting on the object inside the system. Then, draw an arrow representing the displacement of the object inside the system during the time interval that the external force or forces act on it. The force and the displacement arrows should be placed tail to tail. Finally, determine the angle ϕ between the direction of the force and the direction of the displacement.

Calculate the work done by each external force:

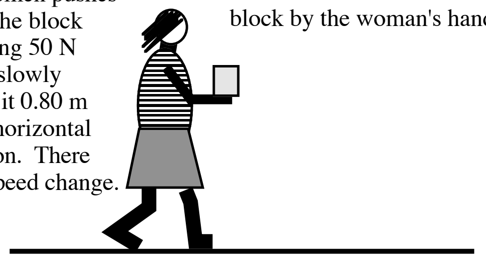
$$W = F\, r\, \cos\phi$$



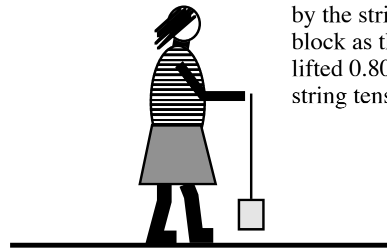
Practice Calculating the Work Done by Constant Forces

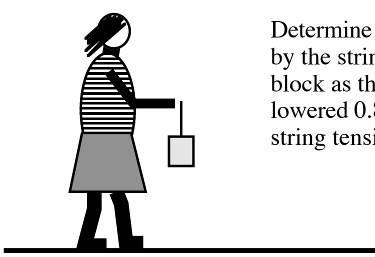
The women pushes up on the block weighing 50 N as she slowly carries it 0.80 m in the horizontal direction. There is no speed change.

Determine the work done on the block by the woman's hand.

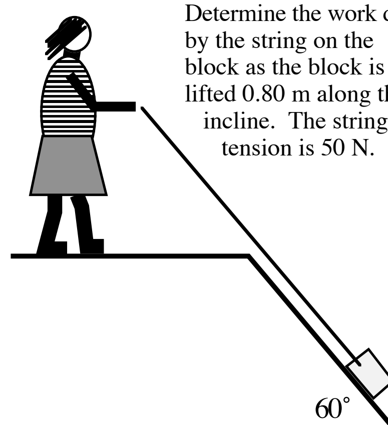


Determine the work done by the string on the block as the block is lifted 0.80 m. The string tension is 50 N.





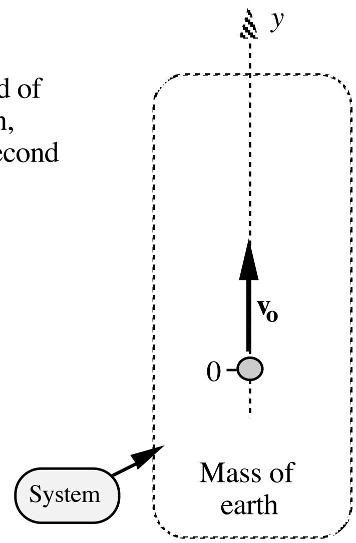
Determine the work done by the string on the block as the block is lowered 0.80 m. The string tension is 50 N.



Determine the work done by the string on the block as the block is lifted 0.80 m along the incline. The string tension is 50 N.

Conservation of Energy

A 2.0-kg ball is projected vertically from the origin with an initial speed of 30 m/s. Complete the table below indicating the ball's velocity, position, kinetic energy, gravitational potential energy, and total energy at one-second time intervals. Ignore air resistance and assume that $g = 10\ m/s^2$.
[Hint: Use Newtonian concepts to determine the velocities and the positions. You should be able to determine the velocities in about 20 s if you understand the meaning of acceleration. The displacement during each one-second time interval can be determined easily using the average velocity during that time interval.]



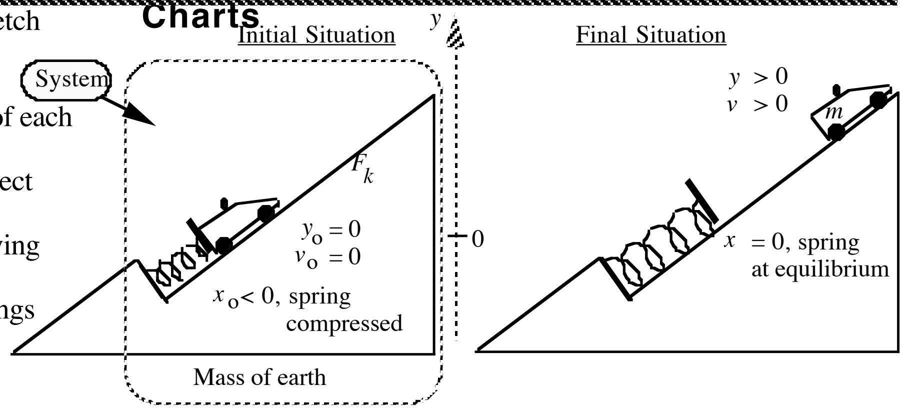
Note that this is a very special problem involving only two types of energy for a system for which no work is done by external forces. The activity is intended to show how energy ideas apply to a very simple system.

time (s)	velocity (m/s)	position (m)	K (J)	U_g(J)	total energy (J)
0	+ 30	0			
1					
2					
3					
4					

Constructing Qualitative Work-Energy Bar Charts

The problem is first represented in a sketch that indicates:

- the initial and final situations,
- the initial and final vertical positions of each object relative to a vertical y axis,
- the initial and final speeds of each object involved in the process (if known),
- distances traveled for situations involving friction,
- the initial and final distances that springs are compressed or stretched, and
- any other information that is needed or seems useful.



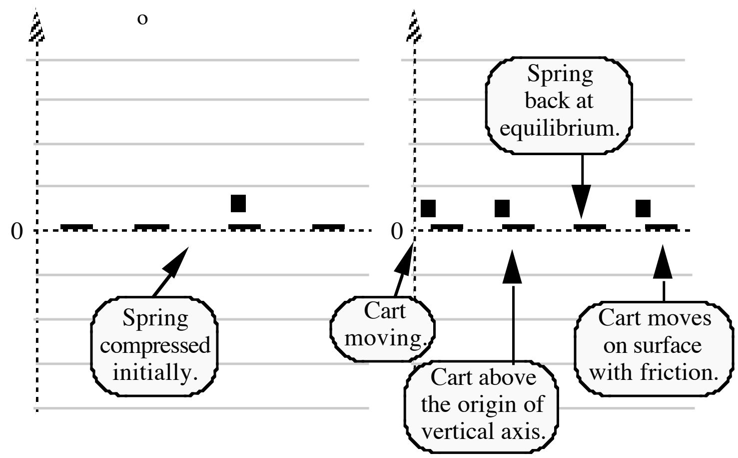
- Identify the system in either the initial or the final sketch above.
- Next, draw bars that indicate non-zero energy terms in the initial situation and in the final situation. You will not know the relative magnitudes of the different types of energy. Thus, make each bar one unit long (this is a qualitative graph). The lengths will be adjusted later so that the work-energy principle is not violated.

The gravitational energy is positive if the object is above the origin of the y axis and is negative if below.

An object has kinetic energy if it is moving.

An elastic object has elastic potential energy if it is stretched or compressed.

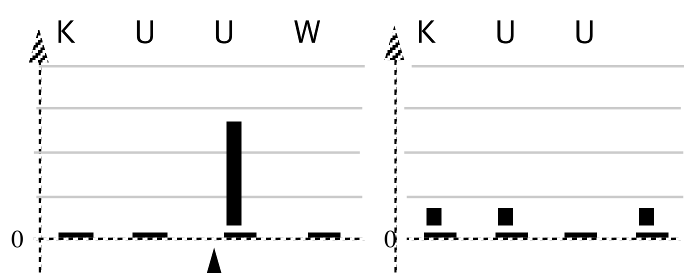
Internal thermal energy is added to the final state if objects move across surfaces in the system that have friction



- Look along the boundary of the system to see if objects outside the system exert forces on objects in the system. If so, decide if these "external" forces do work on an object in the system and the sign of the work. Add bars to the work-energy bar chart for work done on the system by these external forces. The bar is above the axis for positive work and below for negative work.

For the situation in this problem, there are no external forces that do work on the system.

- To satisfy the work-energy principle, the sum of all types of initial energy plus the work done on the system by external forces must equal the sum of all types of the final energy. Consequently, make the sum of the bars on the left side of the chart equal the sum of bars on the right side.

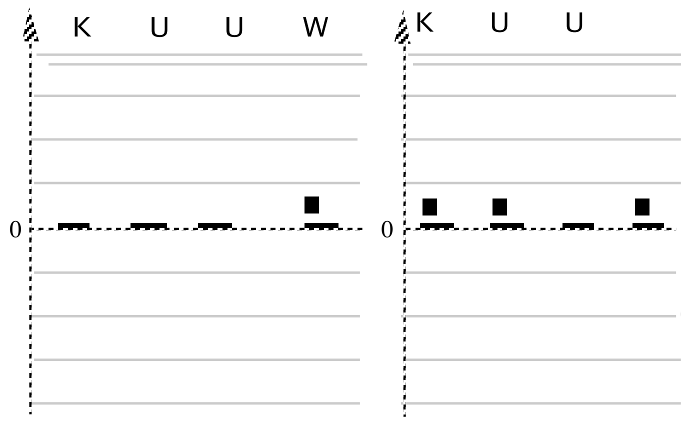


Since there is only one form of initial energy, it must have the same magnitude as the sum of the three final energy terms. The initial elasitic energy is converted into final kinetic, gravitational potential, and internal thermal energies (not necessarily in equal amounts, as shown above).

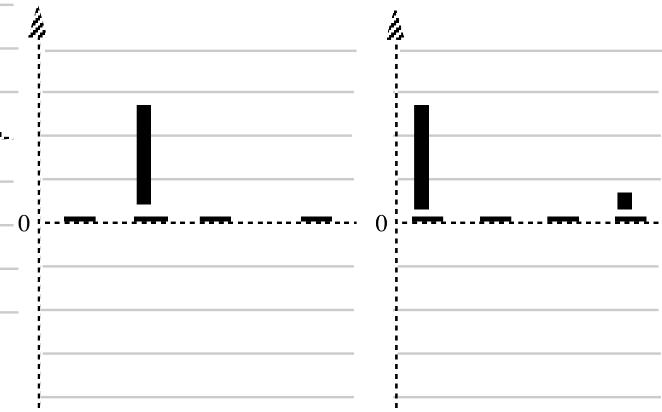
Balancing the Work-Energy Equation

For each work-energy bar graph shown below, change the length of one bar so that the work-energy principle is balanced. There are several ways to balance the charts.

(a)

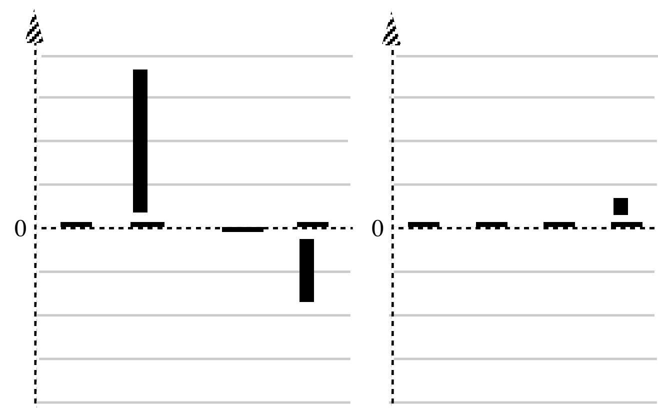


(b)

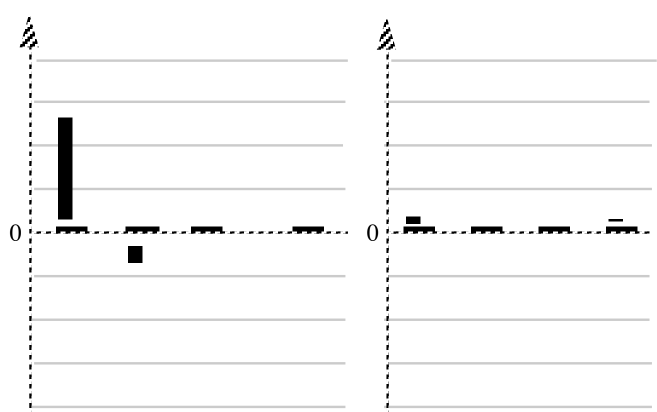


(c)

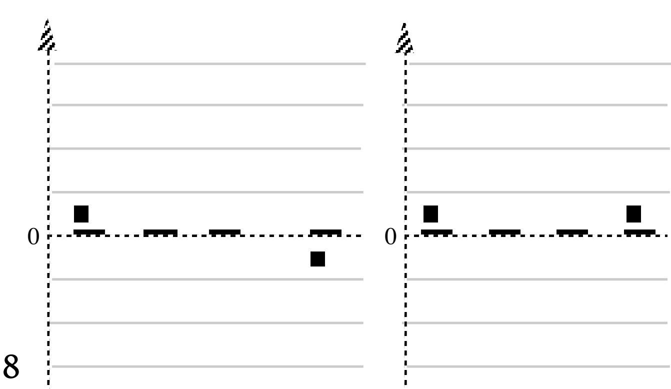
(d)



(e)

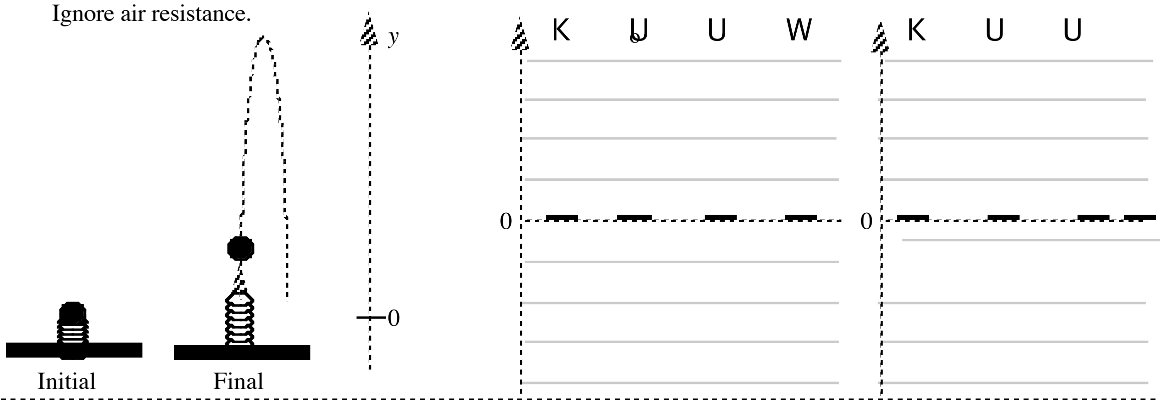


(f)

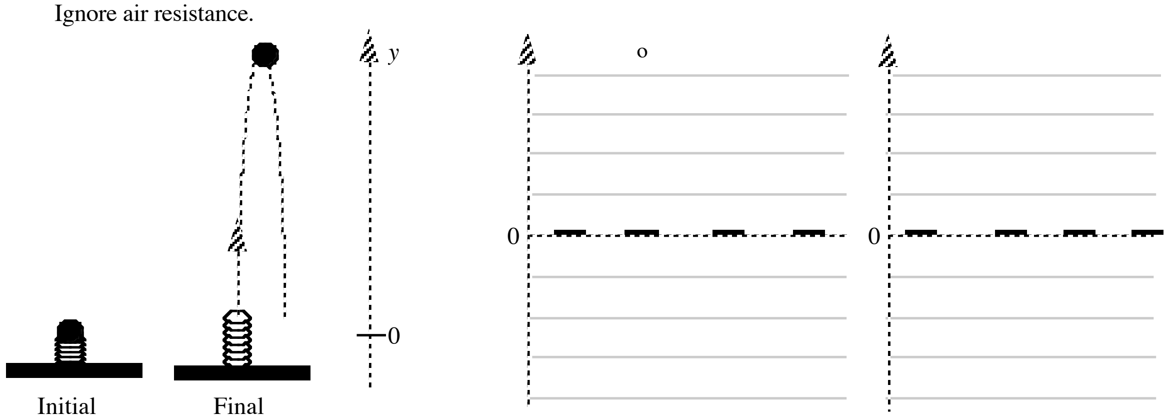


A ball is launched into the air by a compressed spring. Complete the qualitative work-energy bar graphs below for the initial situation with the spring compressed and for final situations in which the ball is in the air and the spring is back at equilibrium.

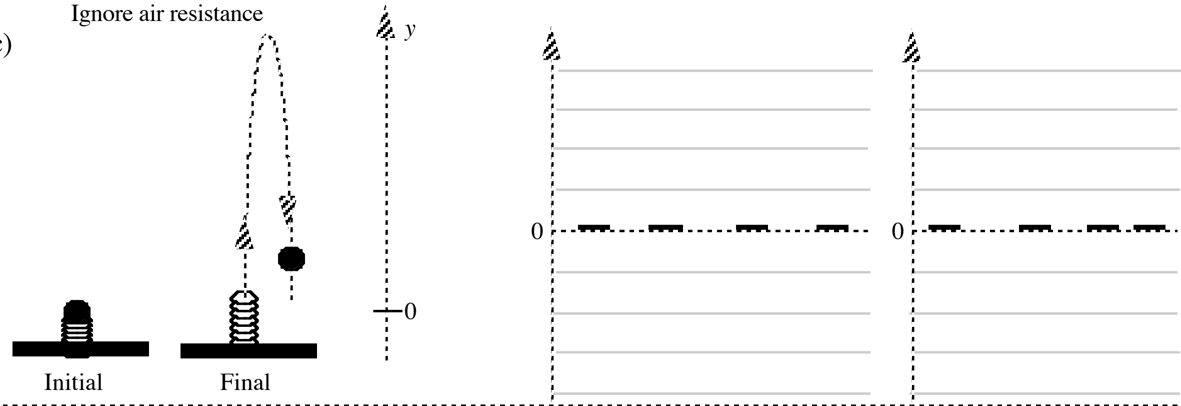
(a) Ignore air resistance.



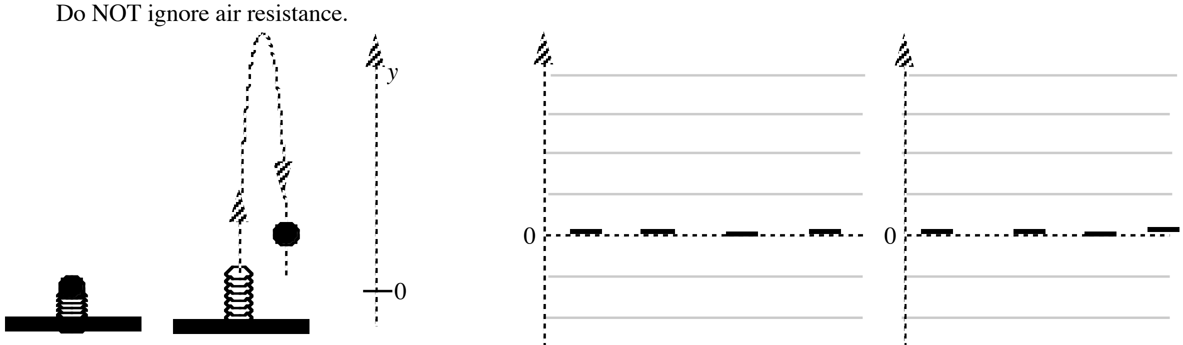
(b) Ignore air resistance.



(c) Ignore air resistance



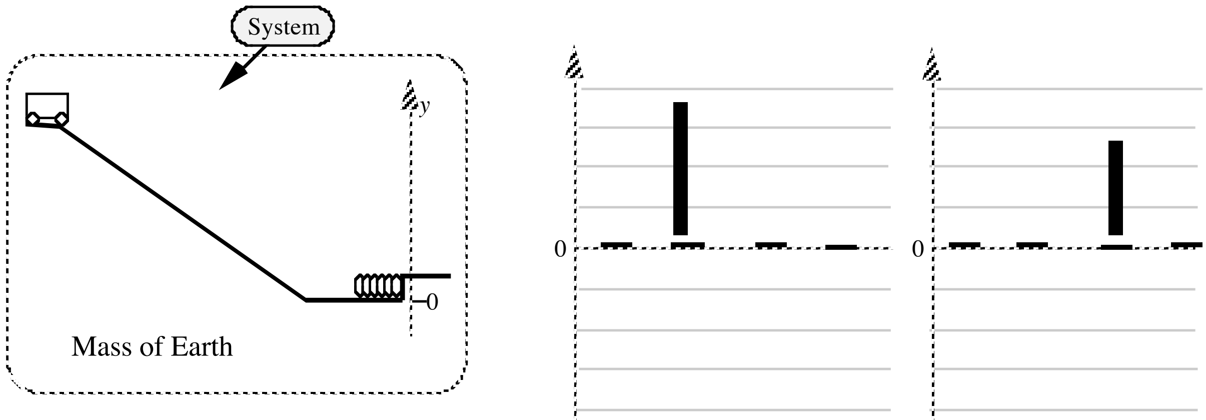
(d) Do NOT ignore air resistance.



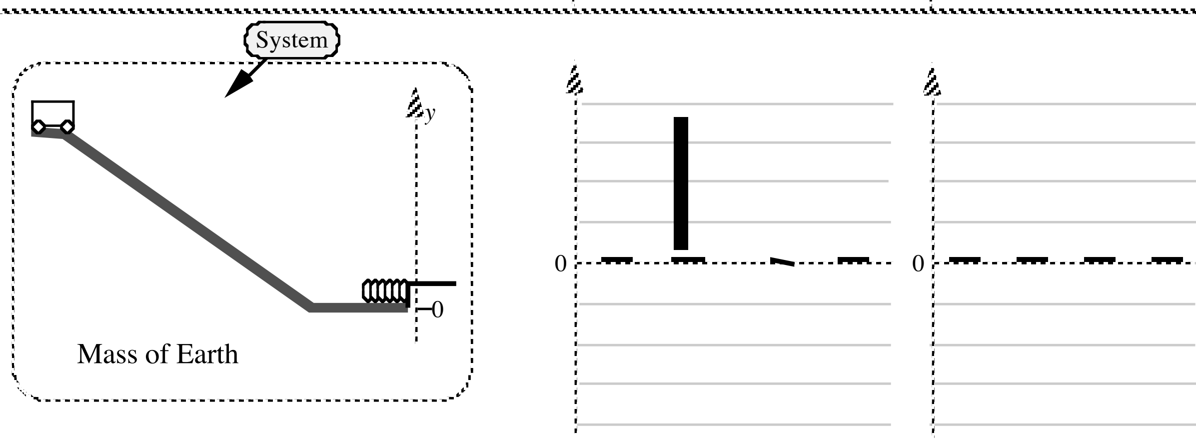
vi-8a (approximately)

Complete the bar graphs below. The cart is initially at rest at the top of the identical hills (except (b)). The final situations are as follows. (a) The cart is at rest after being stopped by compressing the spring. (b) Same as (a) only the average friction force is twice as great. (c) The cart stops after coasting on a very rough horizontal surface. (d) The cart is stopped after plowing into a hay stack that is not in the system.

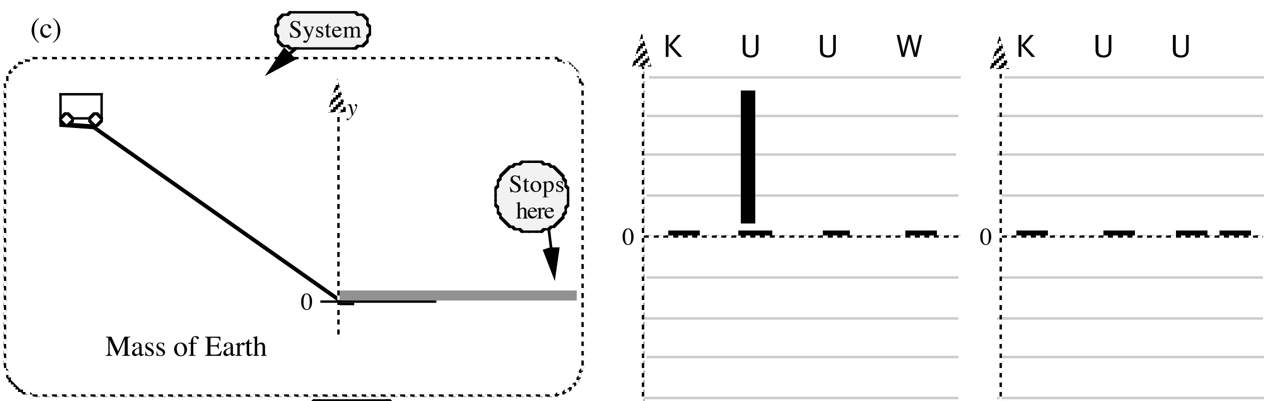
(a)



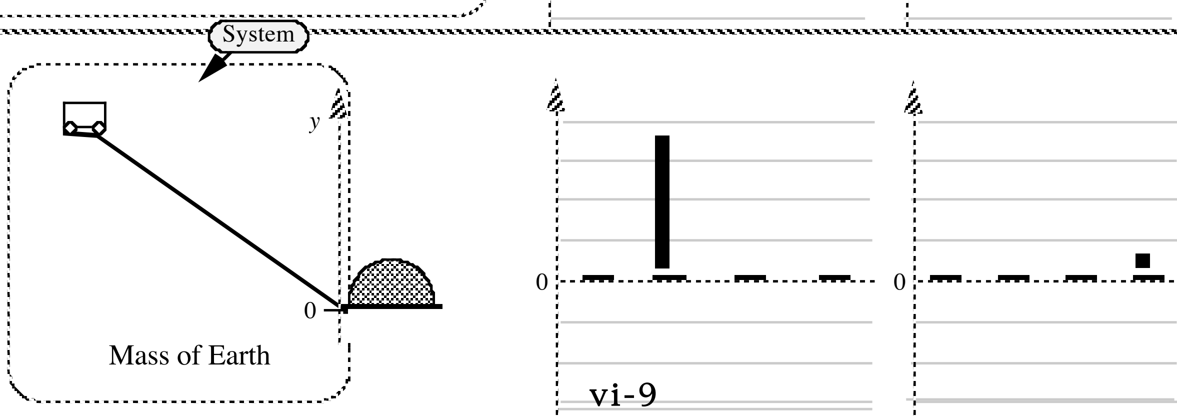
(b)



(c)



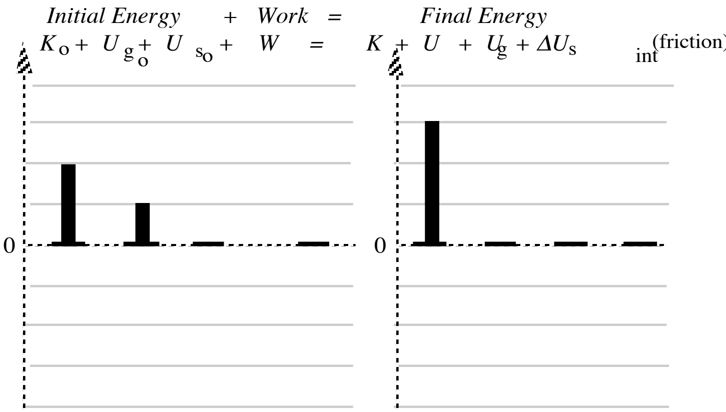
(d)



Work-Energy Bar Graphs and the Work-Energy Equation—8

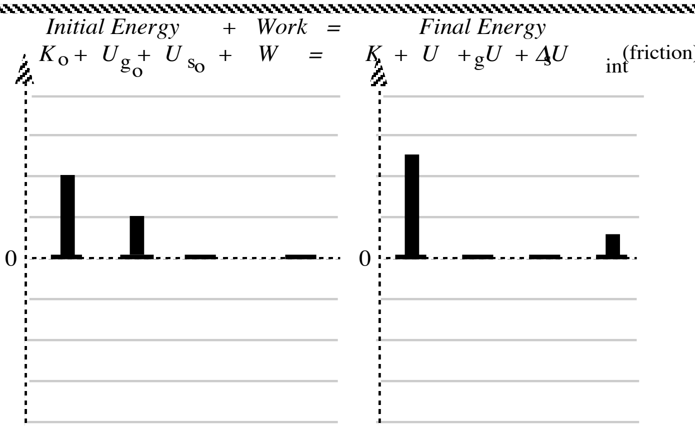
A complete work-energy bar graph is shown for some unknown process. Apply the work-energy equation to the process and then invent a pictorial representation of the process that is consistent with the bar graph.

(a) Construct a sketch of initial and final situations of some process that is consistent with the work-energy bar graph at the right.



Apply the work-energy equation to the process represented in the work-energy bar graph shown above.

(b) Construct a sketch of initial and final situations of some process that is consistent with the work-energy bar graph at the right.



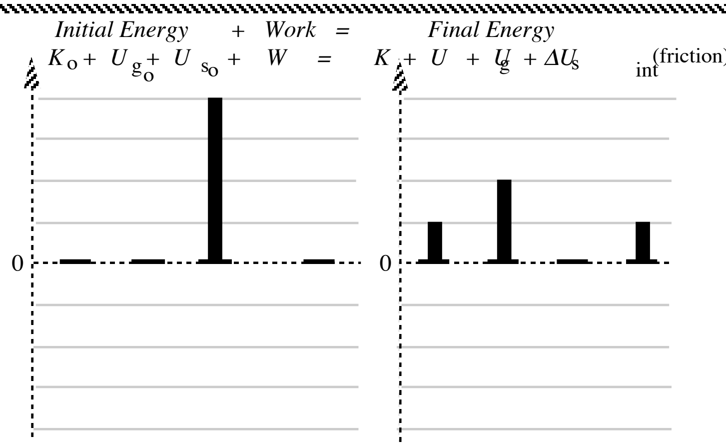
Apply the work-energy equation to the process represented in the work-energy bar graph shown above.

Suppose that the friction force is doubled, and assume the same initial situation and the same final position. By what percent is the final speed changed?

Work-Energy Bar Graphs and the Work-Energy Equation—9

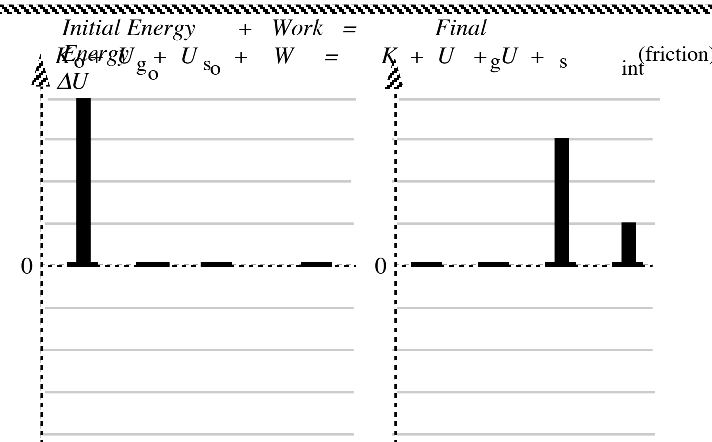
A complete work-energy bar graph is shown for some unknown process. Apply the work-energy equation to the process and then invent a pictorial representation of the process that is consistent with the bar graph.

(a) Construct a sketch of initial and final situations of some process that is consistent with the work-energy bar graph at the right.



Apply the work-energy equation to the process represented in the work-energy bar graph shown above.

(b) Construct a sketch of initial and final situations of some process that is consistent with the work-energy bar graph at the right.



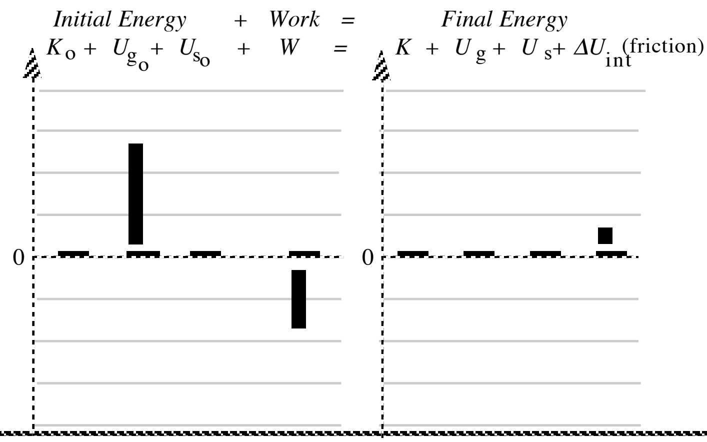
Apply the work-energy equation to the process represented in the work-energy bar graph shown above.

Suppose that the friction force is doubled, and assume the same initial situation and the same final position. By what percent does the final distance that the spring is compressed change?

Work-Energy Bar Graphs and the Work-Energy Equation—10

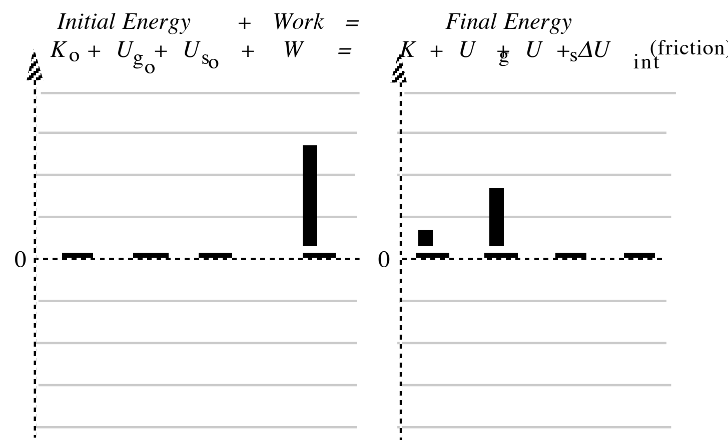
A complete work-energy bar graph is shown for some unknown process. Apply the work-energy equation to the process and then invent a pictorial representation of the process that is consistent with the bar graph.

(a) Construct a sketch of initial and final situations of some process that is consistent with the work-energy bar graph at the right.



Apply the work-energy equation to the process represented in the work-energy bar graph shown above.

(b) Construct a sketch of initial and final situations of some process that is consistent with the work-energy bar graph at the right.

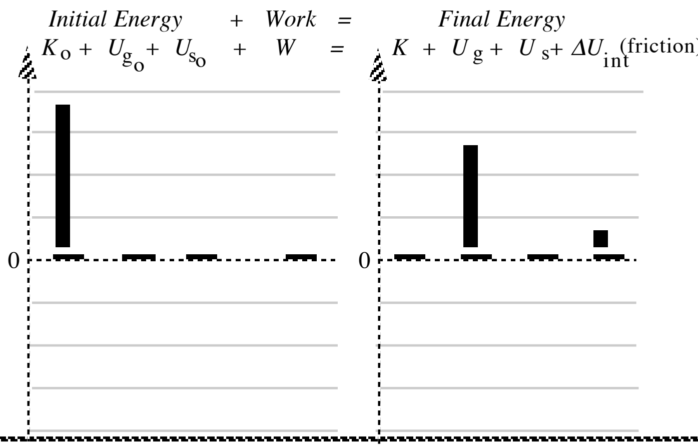


Apply the work-energy equation to the process represented in the work-energy bar graph shown above.

Work-Energy Bar Graphs and the Work-Energy Equation—11

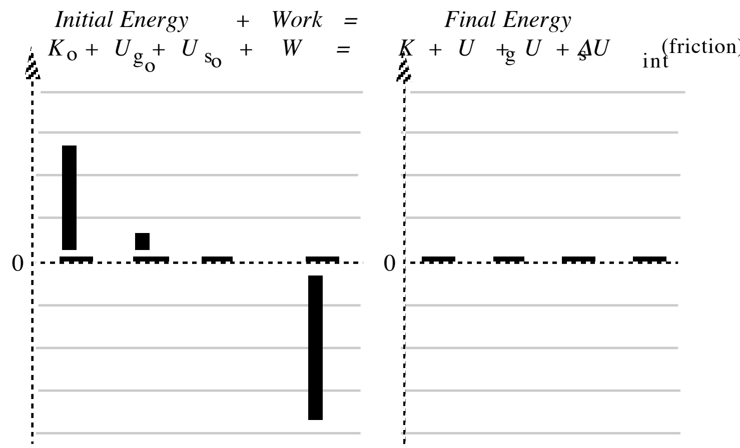
A complete work-energy bar graph is shown for some unknown process. Apply the work-energy equation to the process and then invent a pictorial representation of the process that is consistent with the bar graph.

(a) Construct a sketch of initial and final situations of some process that is consistent with the work-energy bar graph at the right.



Apply the work-energy equation to the process represented in the work-energy bar graph shown above.

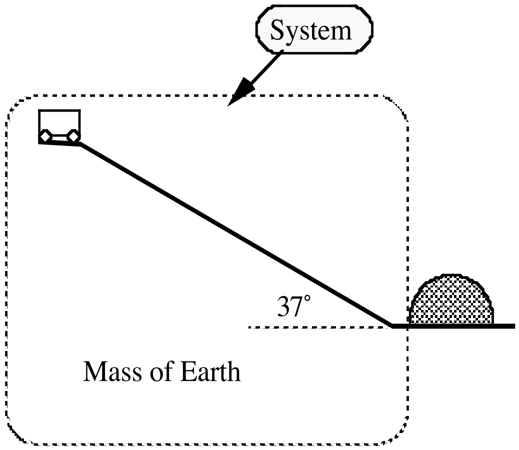
(b) Construct a sketch of initial and final situations of some process that is consistent with the work-energy bar graph at the right.



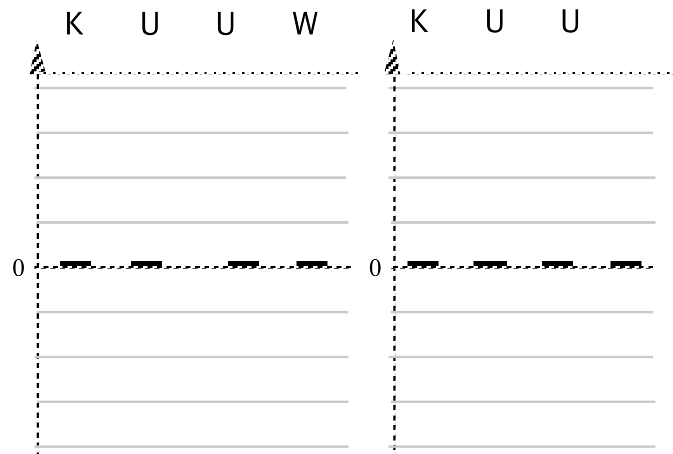
Apply the work-energy equation to the process represented in the work-energy bar graph shown above.

Stopped by a Hay Stack

A 100-kg cart, initially at rest, rolls down a 50-m long frictionless hill. At the bottom, the cart stops after plowing 2.0 m into a hay stack. Determine the average force of the hay stack on the cart while stopping it. Assume that $g = 10\ m/s^2$.



(a) Construct a qualitative work-energy bar chart for the process at the left.



(b) Use the work-energy bar chart to help construct the work-energy equation for this process.

(c) Rearrange the above to determine the unknown force of the hay stack on the cart while stopping it.

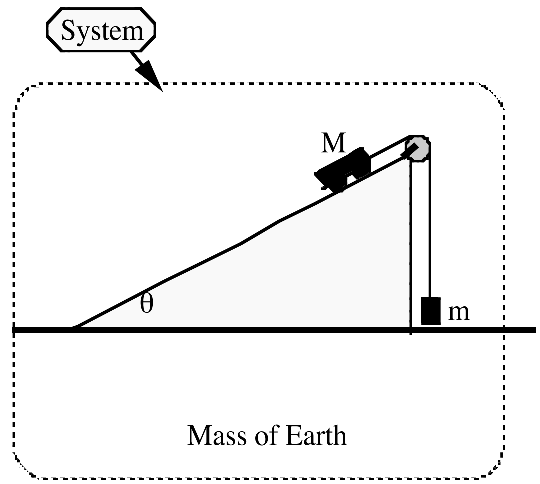
(d) Evaluation

- Does the answer have the correct units?
- Does the answer seem reasonable?
- How would the answer differ if the incline was somewhat less than 37°? Does this make sense?

vi-22

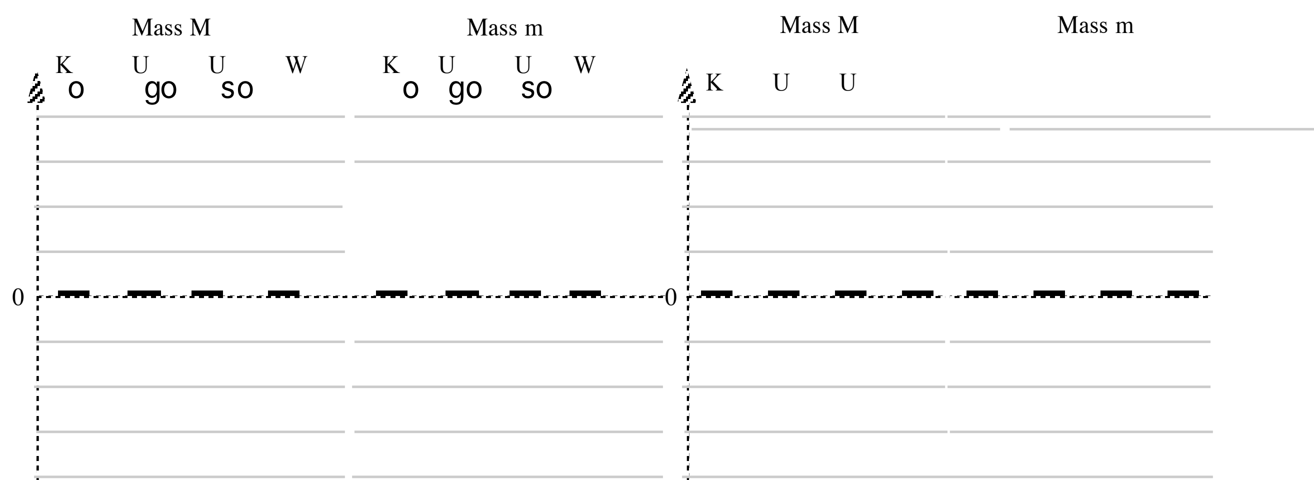
A System with Two Masses Whose Energies Change

A 100-kg cart, initially at rest, rolls 10 m down a 37˚ frictionless incline. A rope attached to the back of the cart passes over a massless, frictionless pulley (poor thing) and down to a 50-kg hanging mass. Determine the speed of the two carts after moving 10 m. Assume that $g = 10\ m/s^2$.



(a) Construct a qualitative work-energy bar chart for the process described above.

If two or more masses in a system undergo energy changes, then the changes for each mass must be included in the work-energy equation. Include the energy changes for both M and m in this problem.



(b) Use the work-energy chart to help construct the work-energy equation for this process.

(c) Rearrange the above to determine the unknown speed of the cart and block after moving 10 m.

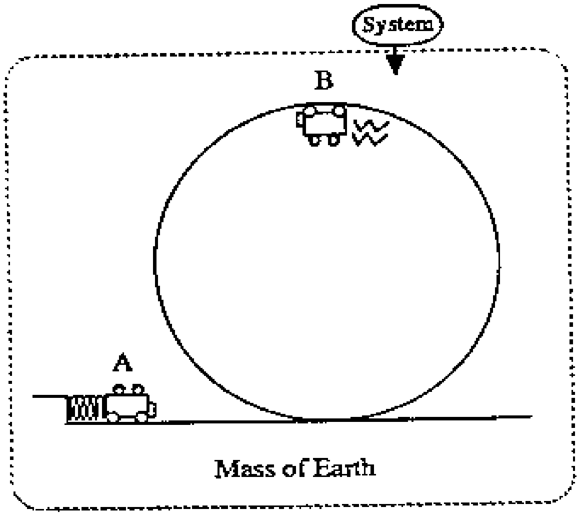
(d) Evaluation

- Does the answer have the correct units?
- Does the magnitude of the answer seem reasonable?
- Would the speed be greater or less if the angle of the incline was greater than 37˚? Does this agree with the equation in (b)?

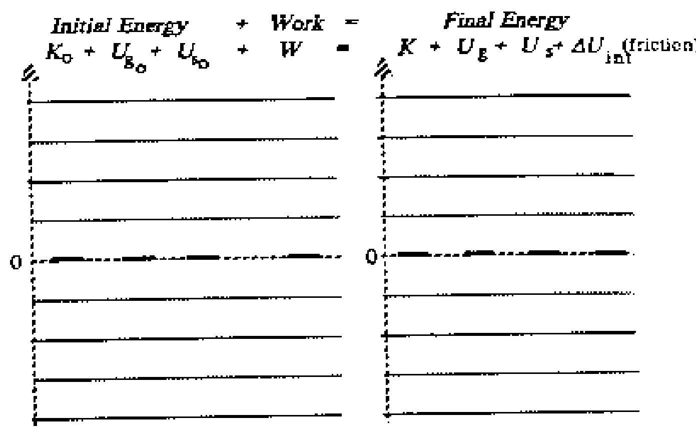
vi-23

Loop-the-Loop

A 500-kg cart, including the passengers, is initially at rest. When the spring is released, the cart is launched for a trip around the loop-the-loop whose r ''us is 10 m. Determine the distance the spring /rce constant 68,000 N/m must be compressed in order that the cart's speed at the top of the loop is 12 m/s. Ignore friction. Assume that $g = 10\ m/s^2$.



(a) Construct a qualitative work-energy bar chart for the process at the left.



) Use the work-energy bar chart to help construct the work-energy equation for this process.

(c) Rearrange the above to determine the unknown distance that the spring must be compressed.

(d) Evaluation

- Does the answer have the correct units?
- Does the answer seem reasonable?
- How would the answer differ if the loop had a smaller radius? Does this agree wit the equation in part (c)?

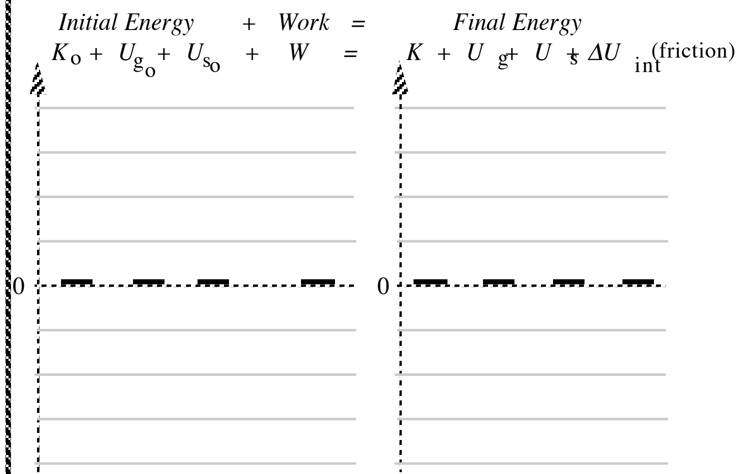
Ski Lift Design

You are to design a rope tow for a 50-m long slope that is inclined 15° above the horizontal. What tension is needed in a rope that pulls parallel to the slope on an 80-kg skier (including skis) so that the skier's speed increases from zero at the bottom to 4.0 m/s at the top of the slope? A 100-N friction force opposes the motion. g = 10 N/kg.

(a) Construct a pictorial representation for the problem. Include:

- a coordinate system with origin,
- very clearly specified initial and final situations,
- the values of known quantities at each situation, and
- identify the unknown you wish to determine.

(b) Choose a system by placing a dashed line around the objects in the system shown in the sketch in (a). Then, construct a qualitative work-energy bar chart for the process.



(c) Use the results of the qualitative analysis above to apply the work-energy equation to the problem and then (d) solve for the unknown.

(e) Evaluation

- Does the answer have the correct units?
- Does the answer have the correct sign?
- Does the answer have a reasonable magnitude?

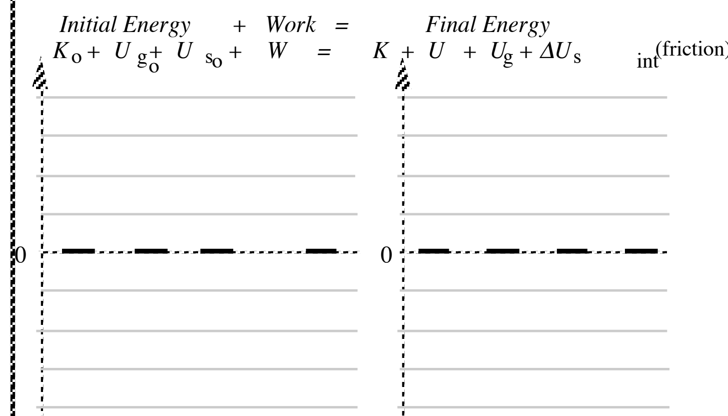
Ejector Seat

An 80-kg daredevil driver wishes to buy a spring for the ejector seat of his car. When loaded, the spring is compressed 0.30 m and when released, should launch the driver to a maximum height of 9.0 m above the top of the loaded spring. What should be the force constant of the spring she buys? Assume that $g = 10\ m/s^2$ and ignore air resistance.

(a) Construct a pictorial representation for the problem. Include:

- a coordinate system with origin,
- very clearly specified initial and final situations,
- the values of known quantities at each situation, and
- identify the unknown you wish to determine.

(b) Choose a system and carefully identify the system either in words or by placing a dashed line around the objects in the system shown in the sketch in (a). Then, construct a qualitative work-energy bar chart.



(c) Use the results of the qualitative analysis above to apply the work-energy equation to the problem and then (d) solve for the unknown.

(e) Evaluation

- Does the answer have the correct units?
- Does the answer have the correct sign?
- Does the answer have a reasonable magnitude?

Wkb Chapter 6c
Doing Energy Problems: A Summary

Like real Estate: The RBD is Location, how you got there is of no interest.

The System in which energy is added, subtracted, or altered, is equally important.

Kinds of energy

$\mathbf{K = (1/2)\, mv^2}$ = kinetic energy = energy of motion

$\mathbf{PE_g = U_g = mgy}$ = gravitational potential energy = energy due to position

$\mathbf{PE_s = U_s = (1/2)kx^2}$ = spring potential energy = energy due to compression or extension of a spring.

W = work done on the system (positive work), or by the system (negative work) that enables us to arrive at the final location.

$\mathbf{DU_{int} = F_k\, Dx}$ =change in internal energy of the system, heated up (positive DU_{int}) or cooled down (negative DU_{int})

DU_{int} will be **negative** in the **initial position** if the **surface is not included** in the system.

DU_{int} will be **positive** in the **final position** if the surface **is** included in the system.

Wkb Chapter 7a
Lecture Notes on Momentum & Impulse

Definition: **Momentum** (designated **P** for some sicko reason) = m**v**

Definition: **Impulse** (denoted by **I** !) = chg in **P** = m**v** - m$\mathbf{v}_o$ = Δ **P**

notice $\Delta \mathbf{P}/\Delta T = m\Delta \mathbf{v}/\Delta t = m\ \Delta \mathbf{v}/\Delta t = m\ \mathbf{a} = \mathbf{F}_{avg}$

$\mathbf{I} = \Delta \mathbf{P} = \mathbf{F}_{avg}\ \Delta T$ but if **F** <u>varies</u> $\mathbf{I} = \Delta \mathbf{P} = \int \mathbf{F}\ dt$ or $\mathbf{F}_{inst} = d\mathbf{P}/dt$ (original def. of **F**)

LAW OF CONSERVATION OF MOMENTUM - COMES FROM NEWTONS 3RD

$\mathbf{F}_{12}\ \Delta t = -\mathbf{F}_{21}\ \Delta t$

$\Delta\ \mathbf{P}_1 = -\Delta \mathbf{P}_2$

$m_1\ \mathbf{v}_1 - m_1\ \mathbf{v}_{10} = -(m_2\ \mathbf{v}_2 - m_2\ \mathbf{v}_{20}) = m_1\ \mathbf{v}_1 + m_2\ \mathbf{v}_2 = m_1\ \mathbf{v}_{10} + m_2\ \mathbf{v}_{20}$

$$\mathbf{P} = \sum \mathbf{P}_i = \mathbf{P}_o = \sum \mathbf{P}_{io}$$

<u>Collisions 2 Kinds</u>

Def. Perfectly in elastic collisions - hit and stick. $P_f = P_o$

$$(m_1 + m_2)\ v_f = m_1\ v_{10} + m_2\ v_{20} \quad \text{etc.}$$

Def. Perfectly elastic collisions - hit and bounce off so that Kinetic Energy is conserved.

so

$$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1o} + \frac{2m_2}{m_1 + m_2} v_{2o} \qquad v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1o} + \frac{m_2 - m_1}{m_1 + m_2} v_{2o}$$

Discuss what happens when $m_1 = m_2$?

get out the moon & Earth, the horse and the roller thing.

Center of Mass - The point of balance - How to find it:

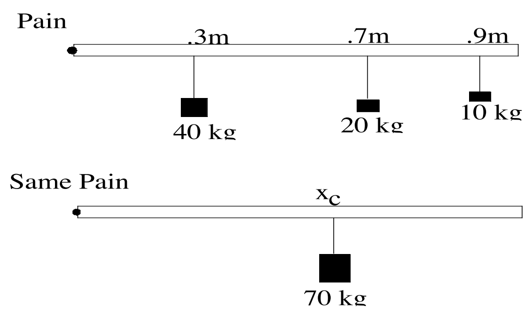
Center of mass of an object, or set of objects is the balance point for this object(s). To discuss this we really must introduce a related topic; **Torque**. Torque can be thought of as the tendency to make something rotate and officially, **τ r x F**, where r is the distance from the pivot point (called the moment arm), and F is the force and x represents the cross product (Later).

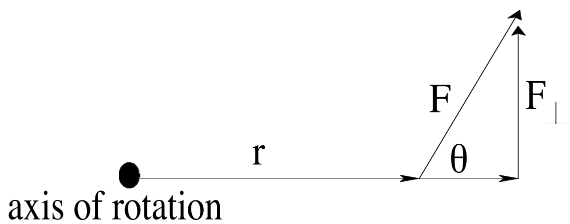
Perspective:
Velocity v is the rate of change of distance w.r.t. time. Force F is a measure of an objects tendency to change velocity. Angular velocity about some axis of rotation is the rate of change of angle w.r.t. time.
Torque about some axis of rotation is a measure of an objects tendency to change angular velocity.

Definition: The magnitude of Torque τ = r F , where r(called the moment arm), is the distance from the axis of rotation, to the point of application of force, and F is the component of force perpendicular to the moment arm. F = Fsin θ, where θ is the angle between the direction of r and the direction of F.

Now suppose we have a meter stick with masses attached like so. Pain is caused by torque $\tau_{@0}$
The center of mass of this system of objects is the balance point of the stick, but it is also the point at which all the mass could be located to get equivalent torque.

i.e. $\sum m_i g x_i = m_T g x_{cm}$, or $x_{cm} = (\sum m_i x_i)/m_T$

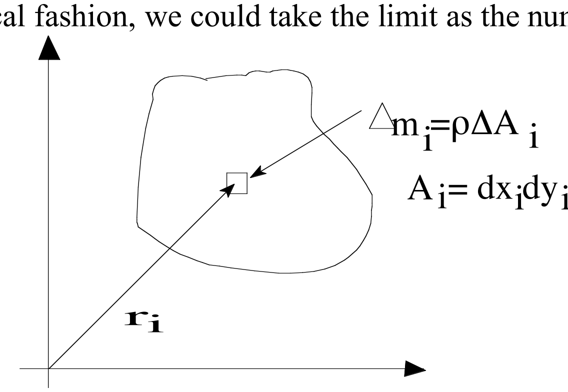




Now suppose we had a set of point masses located in a two dimensional plane. The x_{cm} and y_{cm} could be found independently of one another in exactly the above fashion, so, $y_{cm} = (\sum m_i y_i)/m_T$

Do example here with the set of mass points 2 kg at (-5,-2), 5 kg at (-2,2), 4 kg at (2,3), and 3 kg at (5,1).

Furthermore, if we wanted to obtain the center of mass of a two dimensional object, we could approximate its center of mass by dividing it up into rectangles, using the center of each rectangle as the center of mass of that rectangle, then obtain x_{cm} and y_{cm} as above. Then, in typical analytical fashion, we could take the limit as the number of



rectangles goes to ∞, and bingo, we have another integral!

So, for planar objects, $x_{cm} = \dfrac{\int x\,dm}{\int dm}$ and $y_{cm} = \dfrac{\int y\,dm}{\int dm}$

Now for a two dimensional object density r = mass/area = m/A= dm/dA

If we assume uniform density, then the density cancels out and we can just talk about the center of a plane region (called the Centroid of that region), in which case, the dm's above become dA's.

dA = dx dy, $\mathbf{r}_i = \mathbf{x_i i} + \mathbf{y_i j}$ so $\mathbf{r_{cm}} = (\mathbf{x_{cm}}, \mathbf{y_{cm}})$, where

$$x_{cm} = \frac{\int_A x_c\, r dx\, dy}{\int_A r dx\, dy} \quad \text{and } y_{cm} = \frac{\int_A y_c\, dx\, dy}{\int_A dx\, dy}$$

and x_c and y_c are expressions of the center of mass of the arbritrary mass point dm.

Workbook Chapter 7b
Impulse-Momentum Questions 1

Answer the following questions about a basketball that is dropped vertically on a hard floor.

Definition: Impluse = Δp = avg force times Δt or $I = \int f\, dt$

(a) Draw an arrow representing the initial momentum of the ball as it first touches the floor and another arrow representing the final momentum at the instant the ball leaves contact with the floor. Then, draw a third arrow representing the change in momentum.

(b) What is the direction of the average net impulse acting on the ball during its contact with the floor? Explain.

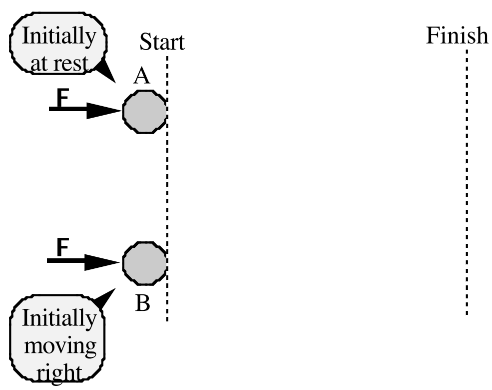
(c) Construct a free-body diagram for the ball while it contacts the floor. Which answer below best represents the magnitude of the average force of the floor on the ball and of the ball's weight? Explain.

(i) $N > w$ (ii) $N = w$ (iii) $N < w$

(iv) $N < w$ as the ball stops while moving down.
$N > w$ as the ball rebounds back upward.

(d) Identical constant forces continuously push identical blocks A and B from the start line to the finish line. Block A is initially at rest whereas block B is initially moving right. Which block has the larger change in momentum?

(i) A
(ii) B
(iii) They have the same momenta change.
(iv) Too little information to answer.

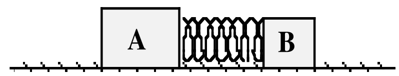


(e) The reason for your answer to the question above is:

(i) The same force acts on identical blocks for the same distance.
(ii) Block B already has some momentum, so its change isn't as great.
(iii) The impulse on block B is less since the force acts for a shorter time interval.
(iv) Block B is moving faster at the finish line, so its change is greater.
(v) The initial and final velocities are not given.

Impulse-Momentum Questions 2

Two blocks, A and B, rest on a horizontal frictionless table. The blocks are separated by a compressed spring of negligible mass. The mass of block A is twice that of block B. When the blocks are released, they move apart. Please choose the correct statement concerning these blocks for each set of answers below.



(a) . (i) The magnitude of the momentum of block A equals that of B after release.
(ii) The magnitude of the momentum of A is greater than that of B after release.
(iii) The magnitude of the momentum of A is less than that of B after release.
(iv) Not enough information given to make conclusions about the relative magnitudes of the momenta of the blocks after release.

(b) . (i) The total momentum of the blocks after release is the same as before release.
(ii) The total momentum of the blocks after release is greater than before release.
(iii) The total momentum of the blocks after release is less than before release.
(iv) Not enough information is given to make conclusions about the relative momentum of the blocks after release.

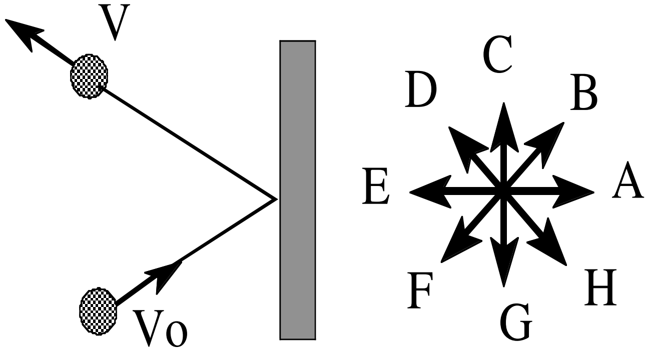
(c) . (i) The speed of block A is the same as that of B at all times after release.
(ii) The speed of block A is greater than that of B after release.
(iii) The speed of block A is less than that of B after release.
(iv) Not enough information given to make conclusions about the relative speed of the blocks.

1

Alps iv-2

Impulse - Momentum Question 3

(a) A ball hits a wall as shown at the right. In which direction is the impulse of the wall on the ball?

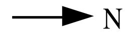


(b) In which direction is the impulse of the ball on the wall?

(c) How do the magnitudes of the two impulses compare ? Justify your answer.

One Dimensional Car Collision & Momentum Conservatior

A 1000-kg car traveling north at 24 m/s collides with and sticks to a 1600-kg car traveling south at 20 m/s. Determine the velocity of the two cars, which remain locked together, immediately after the collision.

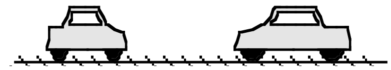


PICTORIAL and PHYSICAL REPRESENTATION

Include:
- a coordinate axis ____,
- sketches of the objects in the initial and final situations ____,
- arrows representing all known velocities ____,
- symbols for and the values of all known quantities ____, and
- a symbol representing the unknown that you wish to determine ____.

Complete the above check list before going to the next part of the solution.

Initial Situation



Final Situation

Circle the system in the above sketch. Then, decide if momentum is conserved. How do you know?

MATH REPRESENTATION and SOLUTION

Apply the conservation of momentum principle to the above process (if appropriate). In some cases, one or more kinematics equations are useful. Then, determine the answer.

EVALUATION

- Does the sign of the answer make sense?
- Is the unit of the answer correct?
- Is the magnitude reasonable

Radioactive Decay

The nucleus of an atom travels east at a speed of 1.0×10^6 m/s relative to the earth. The nucleus undergoes radioactive decay and breaks into two masses, the smaller being 1/10 the mass of the original nucleus. This smaller fragment travels east at 2.0×10^7 m/s. Determine the velocity of the larger fragment.

→ E

PICTORIAL and PHYSICAL REPRESENTATION

Include:
- a coordinate axis ____,
- sketches of the objects in the initial and final situations ____,
- arrows representing all known velocities ____,
- symbols for and the values of all known quantities ____, and
- a symbol representing the unknown that you wish to determine ____.

Complete the above check list before going to the next part of the solution.

Initial Situation

Final Situation

Circle the system in the above sketch. Then, decide if momentum is conserved. Ignore the weight of the particles— very small compared to other forces.

MATH REPRESENTATION and SOLUTION

Apply the conservation of momentum principle to the above process (if appropriate). In some cases, one or more kinematics equations are useful. Then, determine the answer.

EVALUATION

- Does the sign of the answer make sense?
- Is the unit of the answer correct?
- Is the magnitude reasonable

Momentum Conservation -Pushing Off

A 30-kg boy coasts east on a 20-kg cart at a speed of 4.0 m/s. The boy pushes off the cart which flies east at a speed of 13.0 m/s relative to the ground. Determine the speed of the boy immediately after the push off.

→ E

PICTORIAL and PHYSICAL REPRESENTATION

Include:
- a coordinate axis ____,
- sketches of the objects in the initial and final situations ____,
- arrows representing all known velocities ____,
- symbols for and the values of all known quantities ____, and
- a symbol representing the unknown that you wish to determine ____.

Complete the above check list before going to the next part of the solution.

Initial Situation

Final Situation

Circle the system in the above sketch. Then, decide if momentum is conserved. How do you know?

MATH REPRESENTATION and SOLUTION

Apply the conservation of momentum principle to the above process (if appropriate). In some cases, one or more kinematics equations are useful. Then, determine the answer.

Answer: 2.0 m/s west

EVALUATION
- Does the sign of the answer make sense?
- Is the unit of the answer correct?
- Is the magnitude reasonable

Paul D'Alessandris' Momentum Conservation Problems

Momentum Conservation - 4

In the farthest reaches of deep space, an 800 kg spaceship, including contents, is traveling at 1300 m/s. The spaceship recoils after it launches a 60 kg scientific probe into space with a speed of 300 m/s relative to the fixed, distant stars.

Momentum Conservation - 5

In the farthest reaches of deep space, an 800 kg spaceship, including contents, is traveling at 1300 m/s. The spaceship recoils after it launches a 60 kg scientific probe into space with a speed of 300 m/s **relative to the spaceship.**

Momentum Conservation - 6

In the farthest reaches of deep space, an 800 kg spaceship, including contents, is traveling at 1300 m/s. The spaceship recoils after it launches a 60 kg scientific probe into space. After launching the probe, the spaceship is at rest.

Momentum Conservation - 10

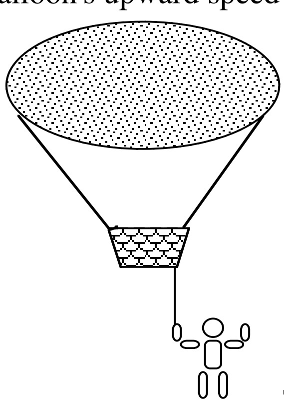
A 140 kg astronaut is standing on the extreme edge of a stationary 1000 kg space platform. He walks at a constant speed of 5 m/s, with respect to the fixed stars, toward the other edge of the platform. (He wears special magnetic shoes which allow him to walk along the metal platform.) As he walks, the platform moves through space.

Momentum Conservation - 11

A 140 kg astronaut is standing on the extreme edge of a stationary 1000 kg space platform. He walks at a constant speed of 5 m/s, **with respect to the platform**, toward the other edge of the platform. (He wears special magnetic shoes which allow him to walk along the metal platform.) As he walks, the platform moves through space.

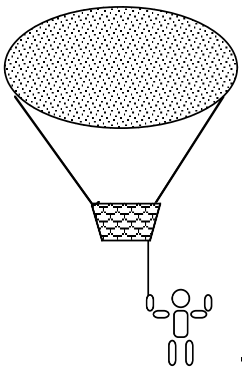
Momentum Conservation - 12

A 70 kg student is hanging from a 150 kg helium balloon (including basket and mass of helium). The balloon is rising at a constant speed of 8 m/s. The "lift" on the balloon due to the buoyant force is constant. The student begins to climb up the rope at a speed of 15 m/s as measured by an earthbound observer. The balloon's upward speed is decreased as the student climbs.



Momentum Conservation - 13

A 70 kg student is hanging from a 150 kg helium balloon (including basket and mass of helium). The balloon is rising at a constant speed of 8 m/s. The “lift” on the balloon due to the buoyant force is constant. The student begins to climb up the rope at a speed of 15 m/s **as measured from the balloon**. The balloon's upward speed is decreased as the student climbs.



Momentum Conservation - 14

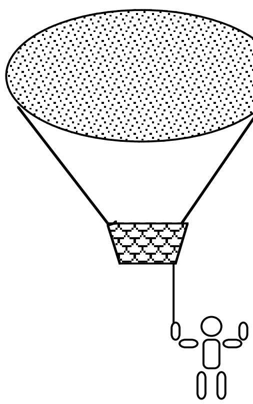
Two astronauts, one 140 kg and the other 170 kg, are standing on opposite edges of a stationary 1000 kg space platform. They walk at constant speeds of 5 m/s, **with respect to the platform,** toward the other edge of the platform. (They wear special magnetic shoes which allow them to walk along the metal platform.) As they walk, the platform moves through space.

Momentum Conservation - 19 Center of Mass

A 140 kg astronaut is standing on the extreme edge of a stationary 1000 kg, 20 m long space platform. He walks at a constant speed of 5 m/s, with respect to the platform, toward the other edge of the platform. (He wears special magnetic shoes which allow him to walk along the metal platform.) As he walks, the platform moves through space. When he stops at the other edge, the platform is not in it's original position.

Momentum Conservation - 20 Center of Mass

A 70 kg student is hanging from a 150 kg helium balloon (including basket and mass of helium). The balloon is stationary. The "lift" on the balloon due to the buoyant force is constant. The student begins to climb up the rope. The balloon moves downward. The rope is 10 m long, and the student climbs safely to



the top.

Momentum Conservation - 21 Center of Mass

Two astronauts, one 140 kg and the other 170 kg, are standing on opposite edges of a stationary 1000 kg, 25 m long space platform. They walk toward the other edge of the platform. (They wear special magnetic shoes which allow them to walk along the metal platform.) As they walk, the platform moves through space. The platform is not in it's original position when they finish their maneuver.

Wkb Chapter8: Lecture Notes on Rotational Motion

Objectives:

Fnd Center of mass of a 1 dim object
find torque
find moment of inertia
do rot inertia problems (dynamics)
do torque problems (statics)

1. Torque defined as pain in the wrist & finding center of mass of 1 and 2 dimensional objects.

2. Do the meterstick and cardboard tricks.
Moral to this story is: In statics problems, objects behave as if all their mass was located at their center of mass.
3. Torque defined graphically. $T = r F \sin u$ make sure they know how to obtain u.
Note: ccw torque > 0
cw torque < 0

Drill on finding torque.

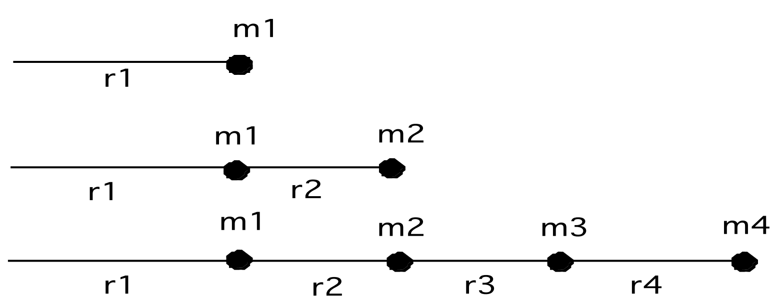
Dialogue: If an object rotates, not every part of it has the same linear speed or acceleration, but every part does have the same angular speed and angular acceleration.

Recall Newton's 2nd Law for linear motion: $F = ma$

So what is the rotational counterpart?

$t = r F = r ma = r m ra = (m r^{2)} a = I a$. I is known as the **moment of inertia** of the mass m about a designated pivot point a distance of r away from the center of mass of m.

4. Find I for sets of points.



Find$\sum t$ for each of these systems

Result: $I_{sys} =$
Do the nine point masses drill

Discuss the I for common continuous distributions. S&J pg 305 + parallel axis thm pg 305 $I = I_{cm} + mD^2$

Demo the race between the hoop, disk and sphere

first godda talk about how ball rolling on cm travels as fast as a point on the rim of a round rolling object.

Each point on the rim has kinetic energy $dE = 1/2\ dm\ v^2$

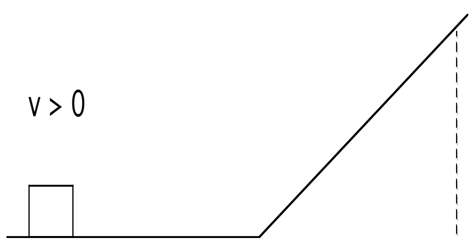
What about all the points on the rolling object not on the rim? They do not travel at the same v !?
But they do all have the same v, and since $v = r$v, $dE = 1/2\ dm\ (r\text{v})^2$

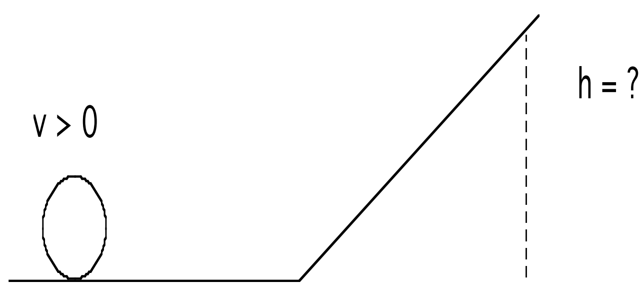
so total kinetic energy <u>due to rotation</u> of the rotating mass = $1/2 \int dm\ r^2\ \text{v}^2 = \frac{1}{2}\omega^2 \int_0^R r^2 dm = 1/2\ I\ \text{v}^2$

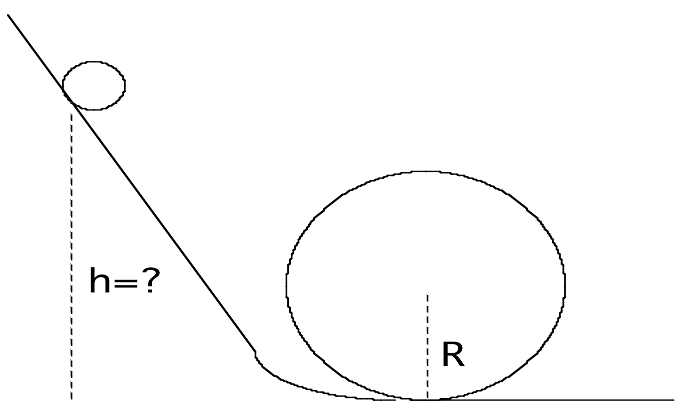
But in addition, all the point masses in the object are travelling forward at the same speed as the center of mass and collectively act as if they were all located at the center of mass, so in addition to the **rotational kinetic energy = K_{rot}** , the object also has **translational kinetic energy = K_{tran}**

Now discuss and explain the race.

Rotational Dynamics problems







Wkb Chapter 9: Lecture Notes on Angular Momentum

Objectives:
Find vector products (cross products)
Find angular momentum if given **r, v** & m
Find torque if given **r & F**
Find direction of torque, angular velocity & momentum, and angular acceleration using right hand rule.
Solve angular momentum problems using the law of conservation of momentum
do torque problems (statics)

Thangs u gotta know.

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$\vec{\tau} = I\,\vec{\alpha}$$

$$L = \vec{r} \times \vec{p}$$

$$L = I\vec{\omega}$$

Know the rules for cross products, read pgs 337 & 338

Know how to find the direction of a cross product.

mini drill on finding cross products and their directions.

Know that if **C=A x B**, then C is perpendicular to both A and B, and therefore,
A•C = B•C = 0 (why is that?)
Demo this using problem 6.

mini drill on finding the direction of a and v for rotating objects (do the two pages below)

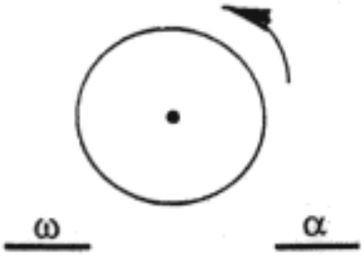
Know that angular momentum is conserved if a system of particles are isolated.
Demo this using the turntable
The wheel trick on the turntable explained

The wheel trick on the string explained

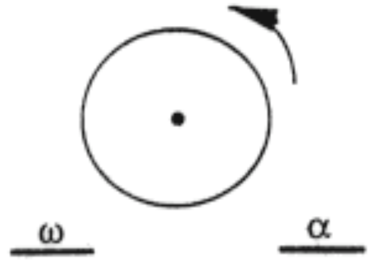
Rotational Kinematics

For each situation below, indicate the direction of the angular velocity v and of the angular accelerationa. (Note: in = into the paper, out = out of the paper and 0 = zero.)

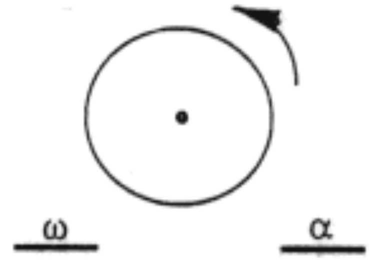
Disc turning at constant angular velocity in ccw direction



Increasing v in ccw direction

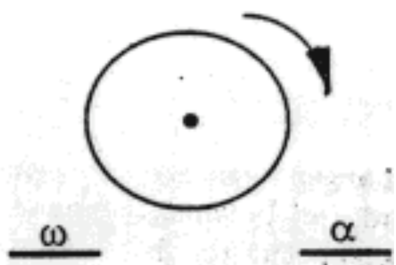


Decreasing v in ccw direction.

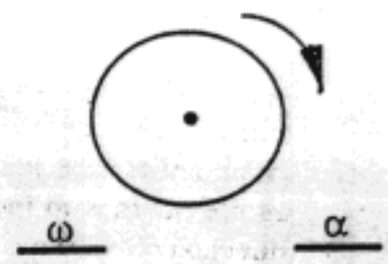


Constant v in the cw direction.

Increasing v in rhe cw direction.

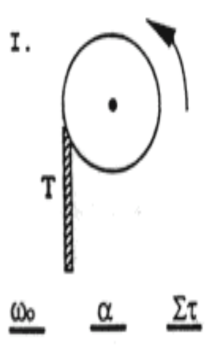
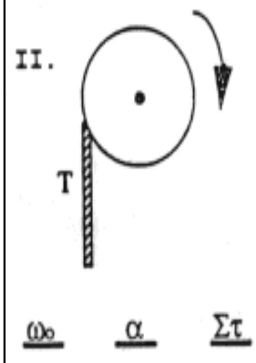
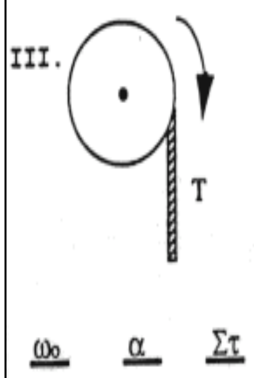
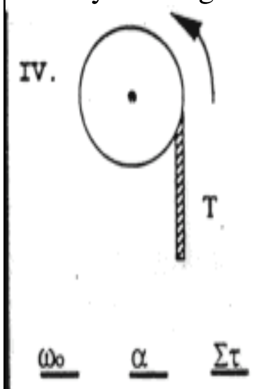


Decreasing v in the cw direction.



ROTATIONAL FORM OF NEWTON'S SECOND LAW

For each situation shown below, determine the direction of the angular velocity, the direction of the angular acceleration, and the directions of the resultant torque. Place these directions (in = into the paper, out = out of the paper, or 0 = zero) in the table.

Initially rotating ccw	Initially rotating cw	Initially rotating cw	Initially rotating ccw
			

(b.) Describe in words how the angular velocity changes.

I.	II.	III.	IV.

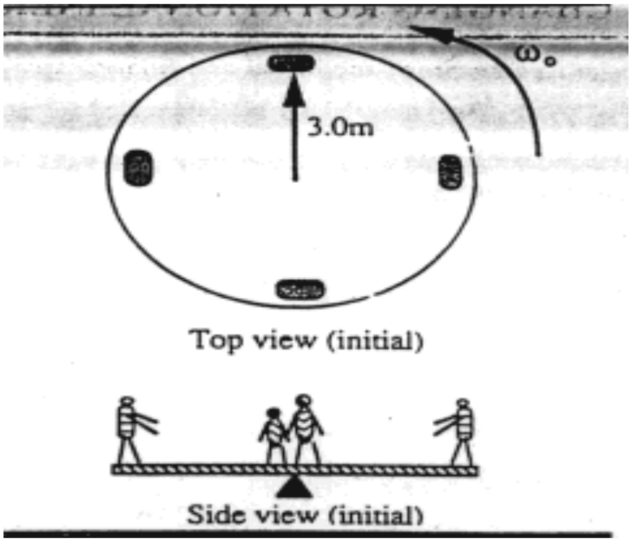
(c.) Complete the table.

	Direction ω	Direction α	Direction $\Sigma\tau$
I.			
II.			
III.			
IV.			

(d.) Bases on the information in the table, is ∑t propartional to v? Explain.

(e.) Is ∑t proportional to a?

CHANGING ROTAIONAL INERTIA AND ANGULAR VELOCITY



Four 60-kg people stand 3.0 m from the center of a freely rotating disc. Initially the angular velocity of the disc is +1.0 rads/s (ccw). The people then move inward so that they are 1.0m from the center of the disc. Now what is the angular velocity of the disc? The rotational inertia of the disc is 160 kg • m^2.

(a) Choose a system. Is its angular momentum conserved? Explain.

(b) Does the rotational inertia of the system increase or decrease? Explain.

(c) Does the angular velocity of the disc increase or decrease? Explain.

(d) Determine the initial and final rotational inertia of the system.

$I_0 = I =$

(e) Apply the conservation of angular momentum principle to this problem.

(f) Solve for the unknown final angular velocity.

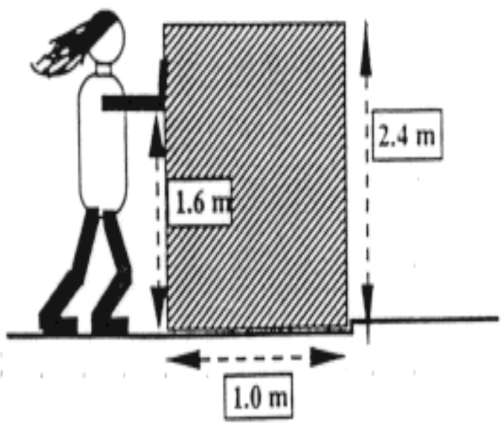
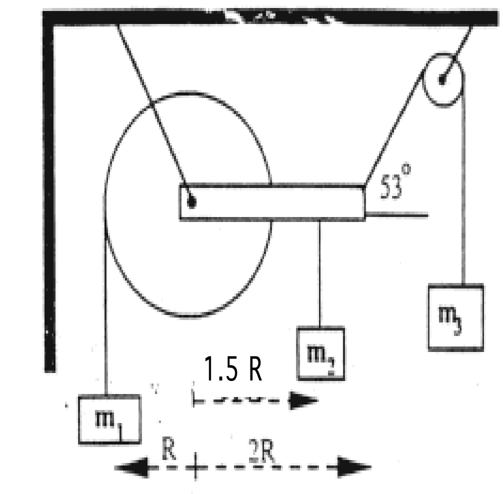
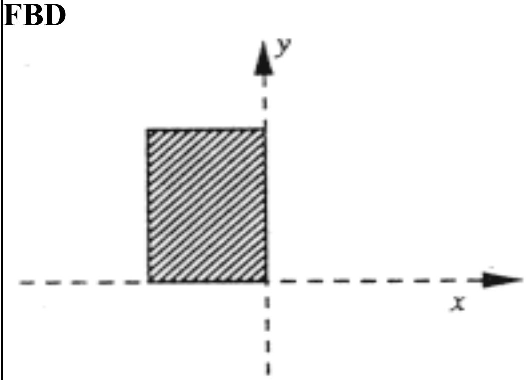
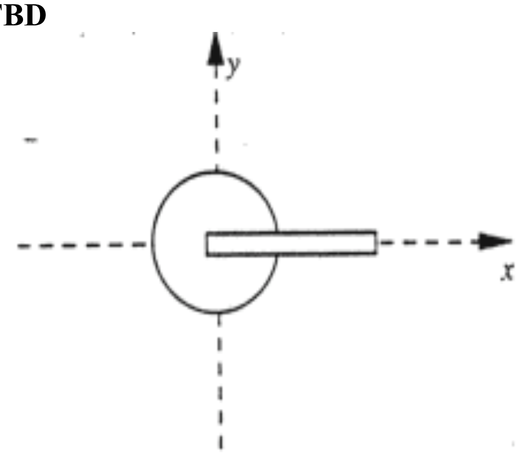
(g) Evaluation:

- Are units correct?

- Is the magnitude reasonable?
- Does the answer agree with qualitative analysis in (b) and (c) ?

Torque Caused by a Force 2

Construct a free-body diagram and determine the net torque acting on the objects below. Assume that g = 10 m/s^2.

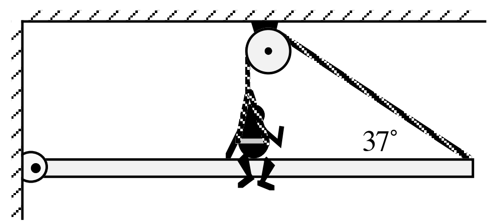
Person pushing a 100-Kg crate with 400N horizontal force.  (Assume the normal force on the crate is zero) The center of gravity is at the center of the crate.	 $m_1 = 14$ kg, $m_2 = 20$ kg, $m_3 = 10$ kg The system is stationary.
FBD  	**FBD** 
$\Sigma \tau =$ Is the crate rotationally stable?	$\Sigma \tau =$

Statics Problem Solving: A Lecturer Seat

You are asked to analyze a new lecture device that will be used nationwide to demonstrate the concepts of statics. The device supports a lecturer partly by a vertical rope secured to a harness that passes around the professor's waist and partly by a beam on which the professor "sits." Determine the tension in the rope and the force of the beam on an 80-kg professor. Ignore the weight of the beam and assume that $g = 10\ m/s^2$.

Pictorial Representation

- A sketch of the situation described in the problem is shown at the right.
- Label in the diagram the quantities involved in the problem and symbolically identify the unknowns.



Physical Representation

Construct separate free-body diagrams for both the professor and for the beam. Note: Be sure to include coordinate axes for each diagram.

Math Representation and Solution

- Apply one or more of the conditions of equilibrium for each free-body diagram shown above.
- Then, solve the problem.

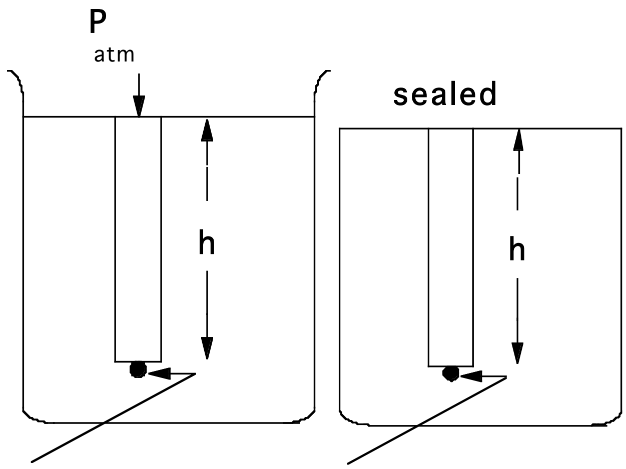
Evaluation

- Does the answer have the correct units?
- Does the answer have a reasonable magnitude?
- Does the sign of the answer make sense?

Workbook Chapter 10: Facts about Liquids

Density: r = Mass/Volume density of water rw = 62.4 lb/ft^3 = 1000 kg / m^3 = 1g/ml = 1g/cm^3
Pressure: P = Force/Area P atm = 1 atm = 14.7 lb/in^2 = 1.013 x 10^5 N/m^2 = 1 Pascal = 1Pa
Pascal's Law: Pressure applied to a liquid is transmitted equally throughout.
Archimedes Principle: Objects immersed in liquids are bouyed up by a force equal to the weight of the fluid displaced.
Torricelli's Law: Velocity of fluid from hole a depth h below the surface has same velocity as object dropped from height h.
Continuity Law: if A = cross-sectional area, and v = velocity of fluid particles, $A_1 v_1 = A_2 v_2$, leads to

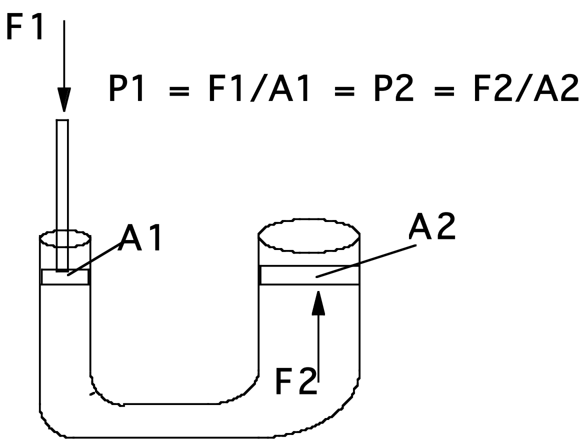
Bernoulli's Equation : P + .5rv2 + rgy = constant
Assumption: Liqiuds are incompressible



$P_{total} = P_{atm} + \rho gh$ $P_{total} = \rho gh$ only!

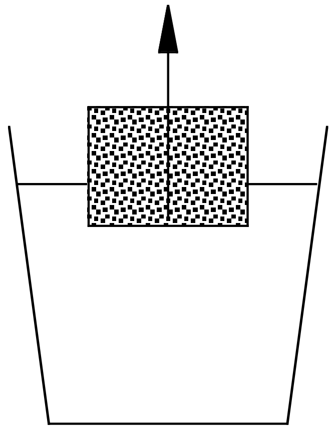
Pascal's Law : **Pressure applied to a <u>confined</u> liquid is transmitted eqully throughout the liquid.**

Example: If F1 = 20 lb and cylinder 1 was 1 inch in diameter, and cylinder 2 was 1 foot in diameter, would F2 be able to lift a 2000 lb car ?

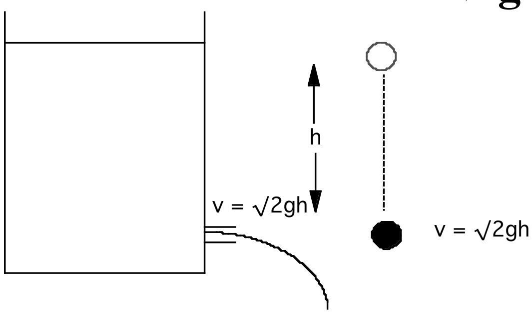


Archimedes Principle:

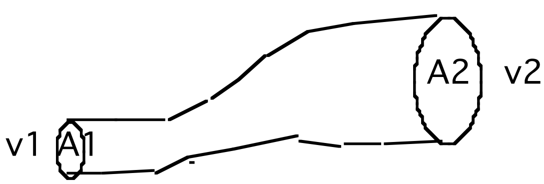
$$F_B = m_{\text{fluid displaced}}\, g$$



Torricelli's Law: $v = \sqrt{2gh}$

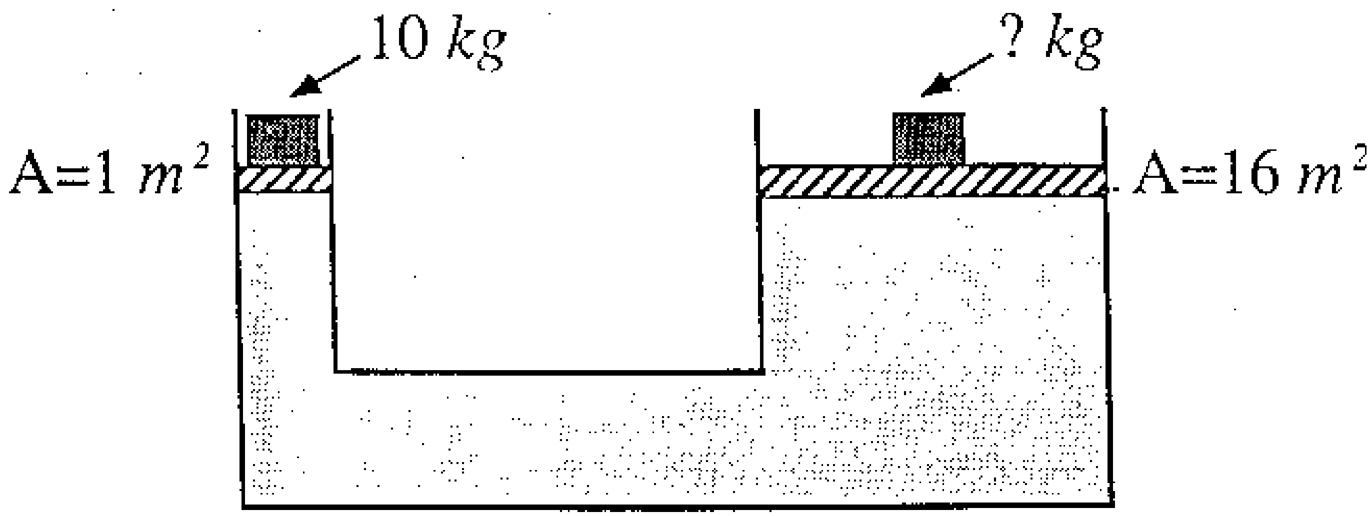


C ontinuity Law: $A_1 v_1 = A_2 v_2$



PB 1201-Q1

QUESTION: In the diagram below, the cross-sectional area of the left-hand piston is 1 m^2 and that of the right-hand piston 16 m^2. What size load on the right-hand piston will keep the fluid levels the same?



1. 16kg

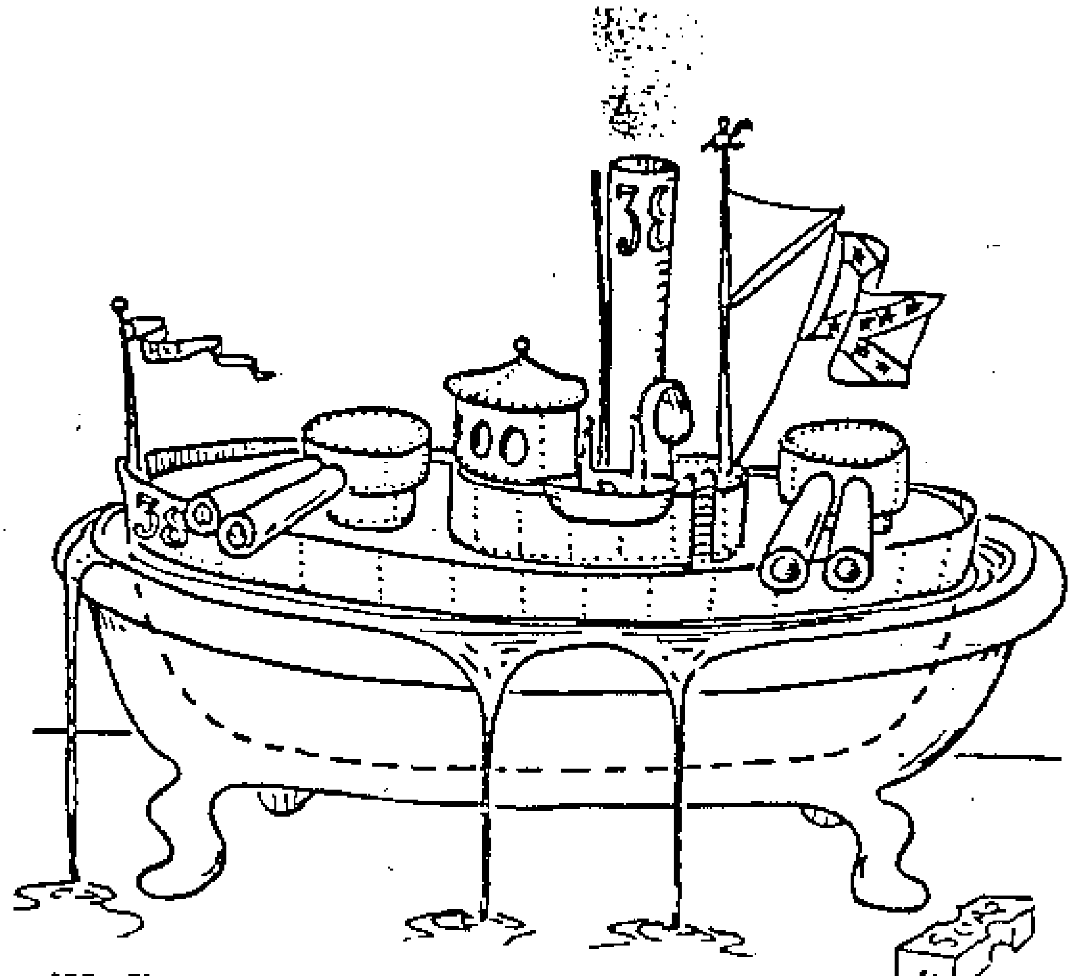
2. 1.6kg

3. 160 *kg*

4. insufficient information

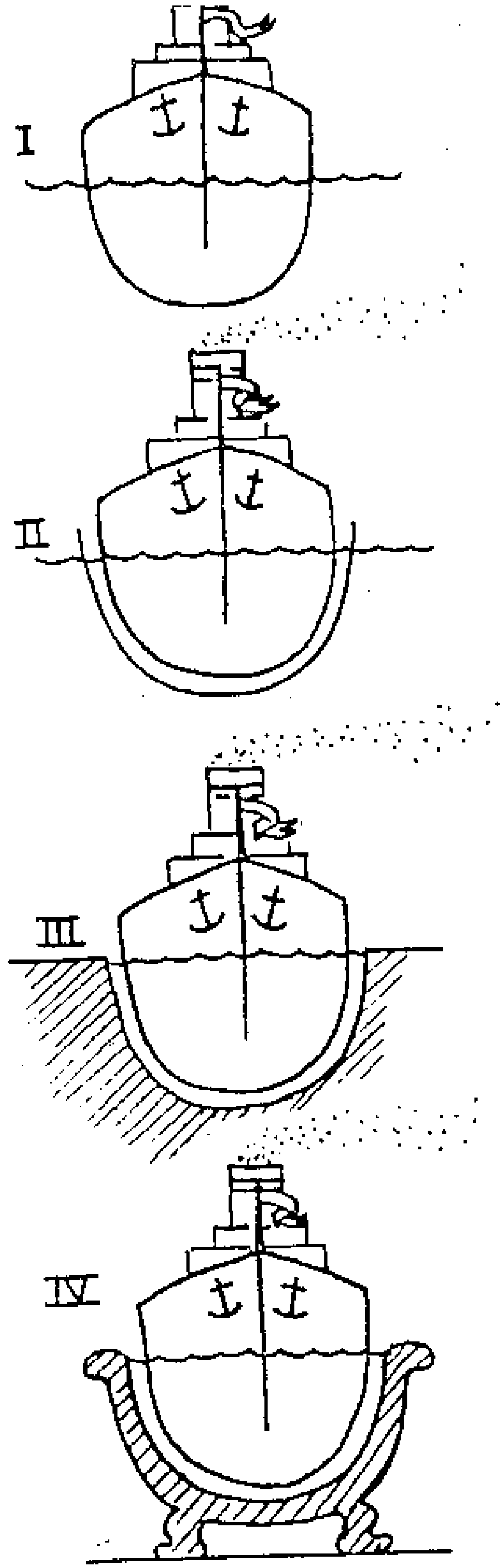
PC 1201-Q1

QUESTION 1: Can a battleship float in a bathtub? (imagine a very big bathtub and/or a small battleship; see figure) Suppose the ship weighs 100 tons and the water in the tub weighs 100 kg. There is just a little bit of water all around and under the ship. Will it float or touch the bottom?



1 . It will float if there is enough water to go all around it,

2. It will touch the bottom because the ship's weight exceeds the water's weight


I
II
III
IV

QUESTION 2: Which weighs more?

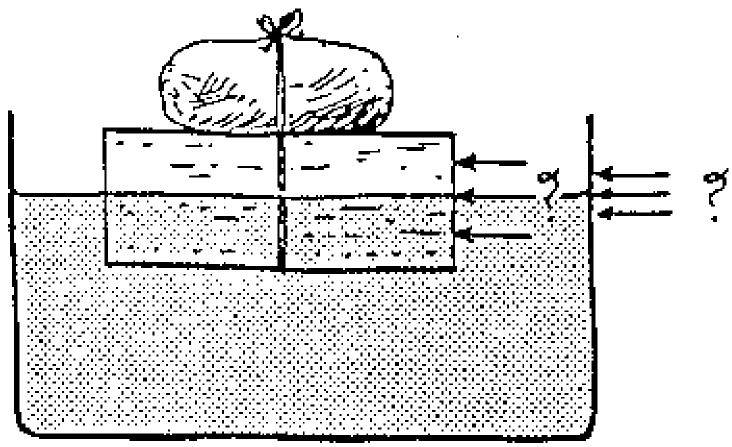
1. A bathtub brim full of water,

2. A bathtub brim full of water with a battleship floating in it,

3. Both weigh the same amount.

PC 1201-Q3

QUESTION 3: A block of balsa wood with a rock tied to it floats in water. When the rock is on top as shown, exactly half the block is below the water line. When the block is turned over so that the rock is underneath and submerged, the amount of block below the water line is



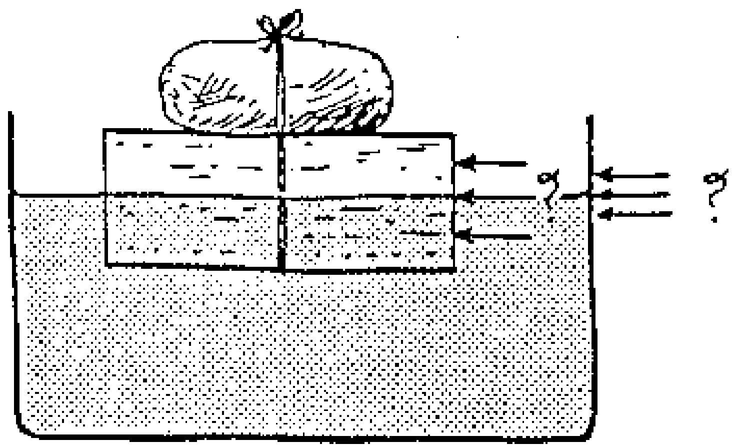
1. less than half

2. half

3. more than half

PC1201-Q4

QUESTION 4: Consider the balsa wood/rock system once again.



Again, the block is turned over so that the rock is underneath and submerged. When the block is overturned, the water level at the side of the container will

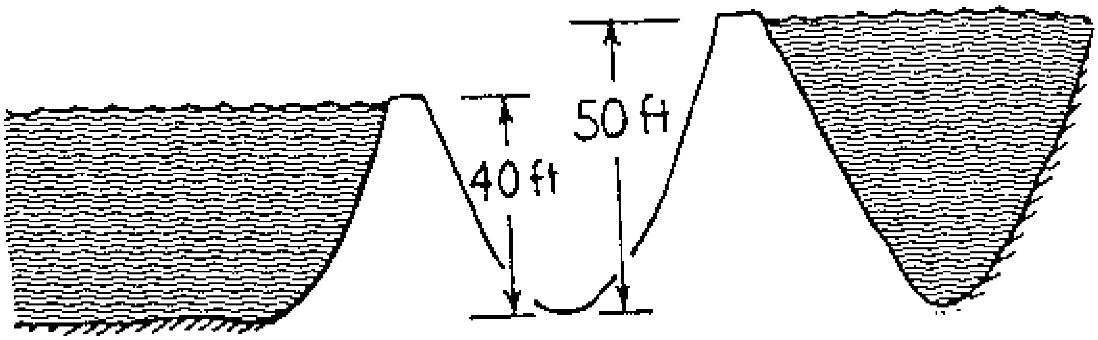
1. rise

2. fall

3. remain unchanged

PC 1201-Q5

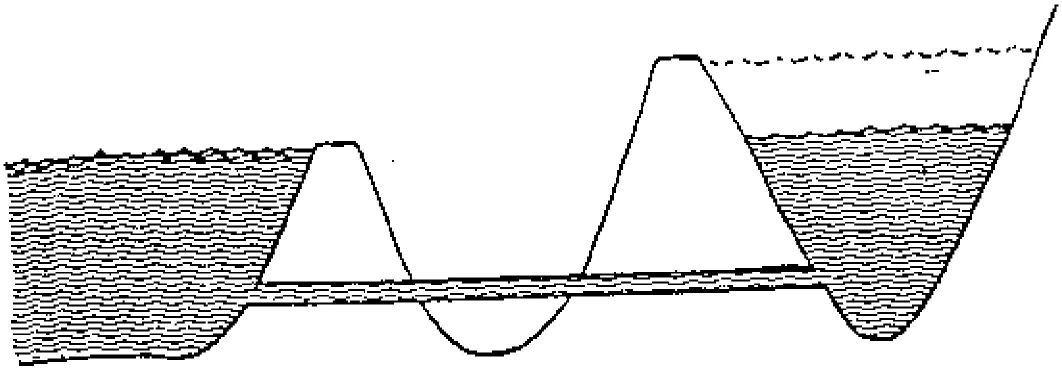
QUESTION 5: The Sierra Light and Power Company has a dam fifty feet high with a tiny lake behind it. Not far away the Department of Reclamation also has a dam—only forty feet high, but with a hugh lake behind it. Which dam must be strongest?



1. The Sierra Light and Power dam must be strongest

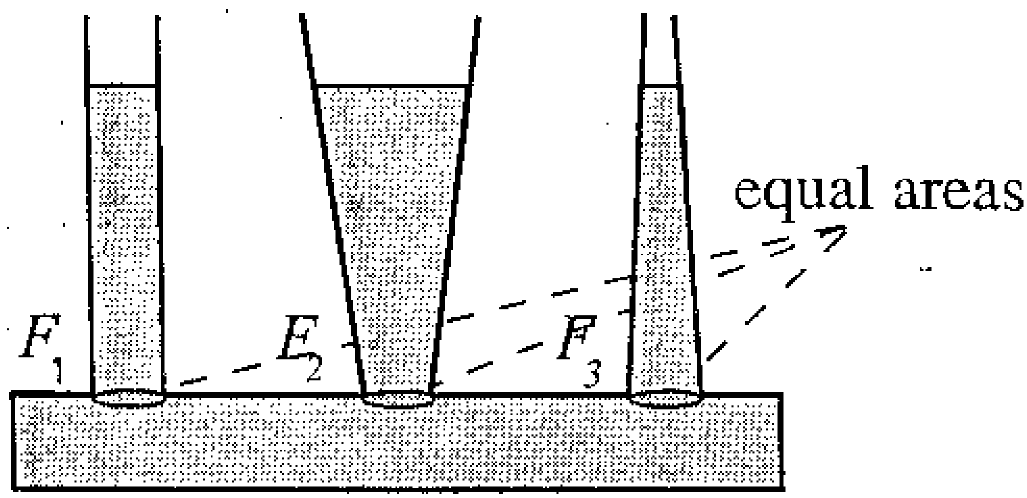
2. The Department of Reclamation dam must be strongest

3. Both must have the same strength



PC 1201-Q6

QUESTION 6: How do the forces Fl, F2, and F3 on the equal areas at the base of the columns compare?



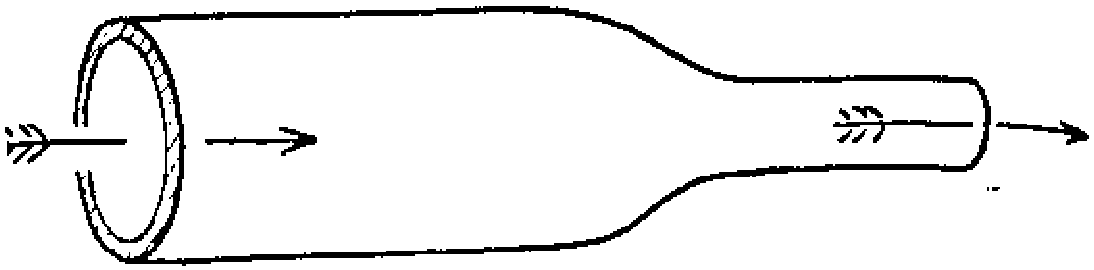
l.F2 > Fl > F3

2. Fl = F2 = F3

3. not enough information

PB 1203-Q1

BONUS QUESTION: Ten liters of water per minute is flowing through this pipe. Which is correct: The water goes



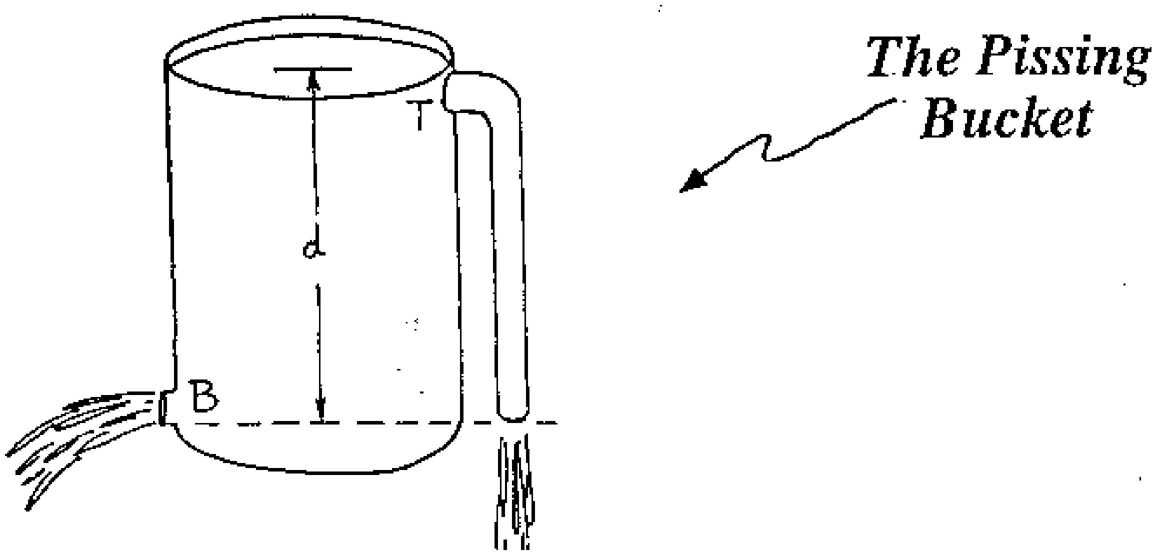
1. fastest in the wide part of the pipe

2. fastest in the narrow part of the pipe

3. at the same speed in both the wide and narrow parts

PC 1203-Q1

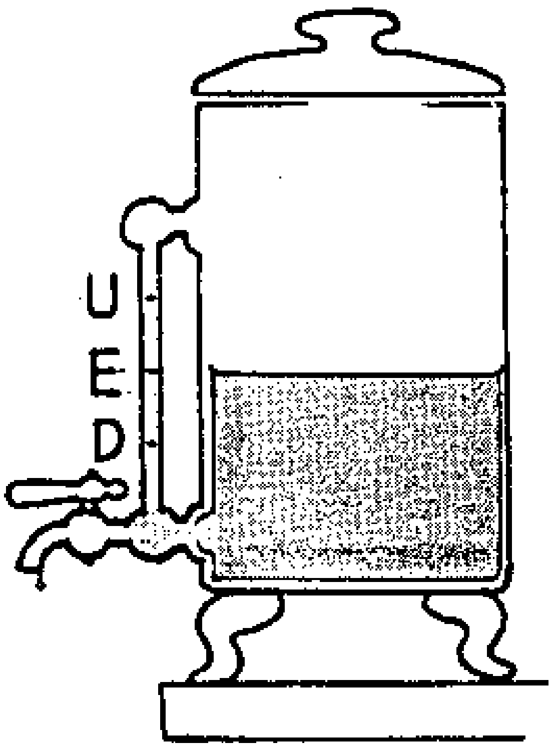
QUESTION 1: This was a favorite question of the noted hydrologist, George J. Pissing, and is still often asked of graduate students during oral exams. Consider a bucket of water with two holes through which water is discharged. Water can be discharged through a hole B at the bottom the bucket a distance d below the water surface, or it can be discharged through a downspout which starts at the top T and has its opening at the same distance d below the water surface. Neglecting any friction effects, compared with the water coming out o friction effects, compared with the water coming out of the downspout, the water coming out of hole B has



1. more speed
2. less speed
3. the same speed

PC 1203-Q2

QUESTION 2: Two fat pipes are attached directly to the bottom of a water tank. Both are bent up to make fountains, but one is pinched off to make a nozzle, while the other is left wide open. Water squirts



1. above the water level of the tank from the pinched pipe, below it for the wide open one

2. equal to the water level of the tank from both pipes

3. less than the water level of the tank from both pipes, but equal for both pipes

4. less than the water level of the tank from both pipes, but higher from the pinched pipe than the wide open one