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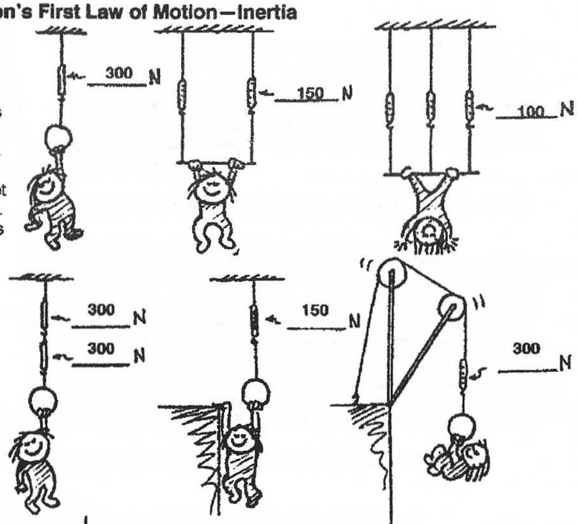
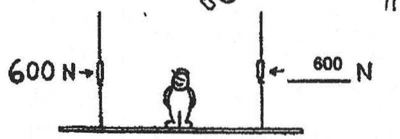
CONCEPTUAL Physics PRACTICE PAGE

Chapter 2 Newton's First Law of Motion—Inertia

Static Equilibrium

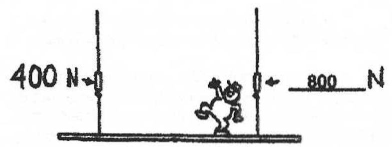
1. Little Nellie Newton wishes to be a gymnast and hangs from a variety of positions as shown. Since she is not accelerating, the net force on her is zero. That is, $\Sigma F = 0$. This means the upward pull of the rope(s) equals the downward pull of gravity. She weighs 300 N. Show the scale reading(s) for each case.



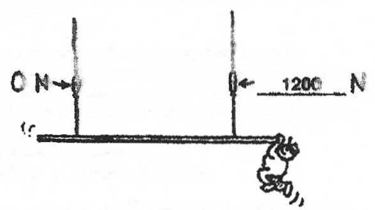


2. When Burl the painter stands in the exact middle of his staging, the left scale reads 600 N. Fill in the reading on the right scale. The total weight of Burl and staging must be

1200 N.



3. Burl stands farther from the left. Fill in the reading on the right scale.



4. In a silly mood, Burl dangles from the right end. Fill in the reading on right scale.

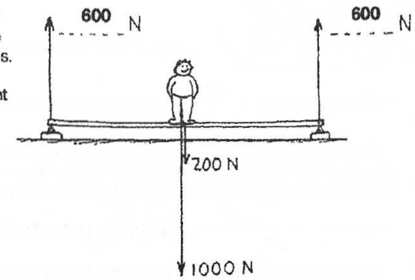
Hewitt Drew it!

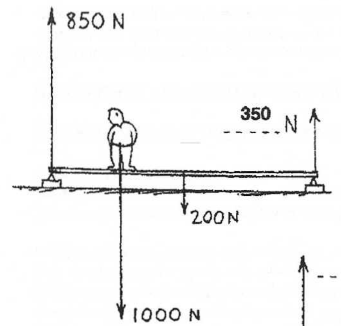
CONCEPTUAL Physics PRACTICE PAGE

Chapter 2 Newton's First Law of Motion—Inertia

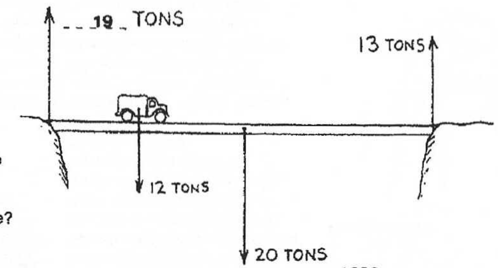
The Equilibrium Rule: $\Sigma F = 0$

1. Manuel weighs 1000 N and stands in the middle of a board that weighs 200 N. The ends of the board rest on bathroom scales. (We can assume the weight of the board acts at its center.) Fill in the correct weight reading on each scale.



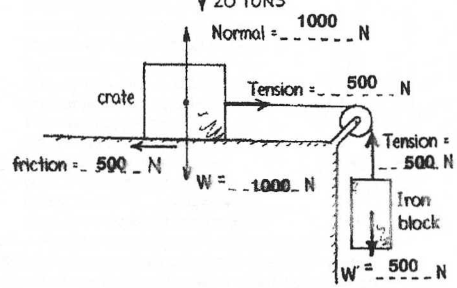


2. When Manuel moves to the left as shown, the scale closest to him reads 850 N. Fill in the weight for the far scale.



3. A 12-ton truck is one-quarter the way across a bridge that weighs 20 tons. A 13-ton force supports the right side of the bridge as shown. How much support force is on the left side?

4. A 1000-N crate resting on a surface is connected to a 500-N block through a frictionless pulley as shown. Friction between the crate and surface is enough to keep the system at rest. The arrows show the forces that act on the crate and the block. Fill in the magnitude of each force.



5. If the crate and block in the preceding question move at constant speed, the tension in the rope [is the same] [increases] [decreases].

The sliding system is then in [static equilibrium] [dynamic equilibrium].

Hewitt Drew it!

Name ______________________ Date __________

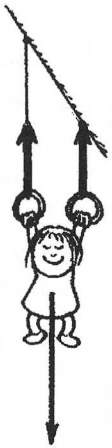
CONCEPTUAL Physics PRACTICE PAGE

Chapter 2 Newton's First Law of Motion—Inertia

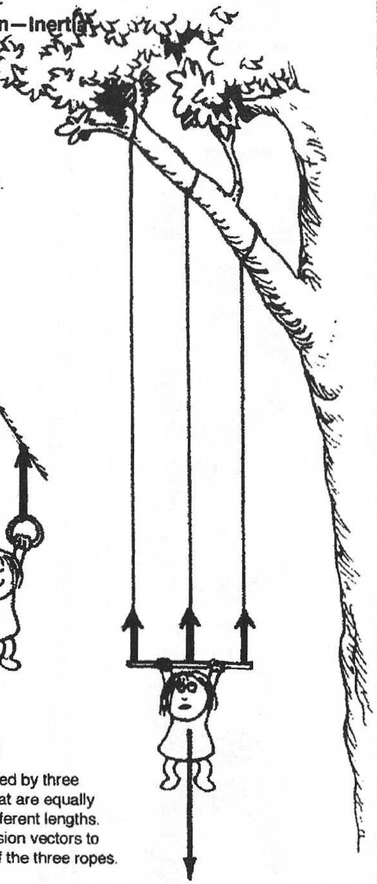
Vectors and Equilibrium

1. Nellie Newton dangles from a vertical rope in equilibrium: $\Sigma F = 0$. The tension in the rope (upward vector) has the same magnitude as the downward pull of gravity (downward vector).

2. Nellie is supported by two vertical ropes. Draw tension vectors to scale along the direction of each rope.



3. This time the vertical ropes have different lengths. Draw tension vectors to scale for each of the two ropes.



4. Nellie is supported by three vertical ropes that are equally taut but have different lengths. Again, draw tension vectors to scale for each of the three ropes.

Circle the correct answer.

5. We see that tension in a rope is [dependent on] [independent of] the length of the rope. So the length of a vector representing rope tension is [dependent on] [independent of] the length of the rope.

Rope tension does depend on the angle the rope makes with the vertical, as Practice Pages for Chapter 6 will show!

Hewitt Drew it!

Name ______________________ Date __________

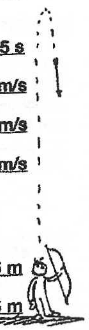
CONCEPTUAL Physics PRACTICE PAGE

Chapter 3 Linear Motion

Free Fall Speed

1. Aunt Minnie gives you \$10 per second for 4 seconds. How much money do you have after 4 seconds? \$40
2. A ball dropped from rest picks up speed at 10 m/s per second. After it falls for 4 seconds, how fast is it going? 40 m/s
3. You have \$20, and Uncle Harry gives you \$10 each second for 3 seconds. How much money do you have after 3 seconds? \$50
4. A ball is thrown straight down with an initial speed of 20 m/s. After 3 seconds, how fast is it going? 50 m/s
5. You have \$50, and you pay Aunt Minnie \$10/second. When will your money run out? 5 s
6. You shoot an arrow straight up at 50 m/s. When will it run out of speed? 5 s
7. So what will be the arrow's speed 5 seconds after you shoot it? 0 m/s
8. What will its speed be 6 seconds after you shoot it? 10 m/s

   Speed after 7 seconds? 20 m/s



Free Fall Distance

1. Speed is one thing; distance is another. How high is the arrow when you shoot up at 50 m/s when it runs out of speed? 125 m
2. How high will the arrow be 7 seconds after being shot up at 50 m/s? 105 m

3.a. Aunt Minnie drops a penny into a wishing well, and it falls for 3 seconds before hitting the water. How fast is it going when it hits? 30 m/s

b. What is the penny's average speed during its 3-second drop? 15 m/s

c. How far down is the water surface? 45 m

4. Aunt Minnie didn't get her wish, so she goes to a deeper wishing well and throws a penny straight down into it at 10 m/s. How far does this penny go in 3 seconds? 75 m

$$\bar{v} = \frac{v_0 + v}{2} = \frac{v_0 + (v_0 + 10t)}{2}$$

THEN $d = \bar{v}t$

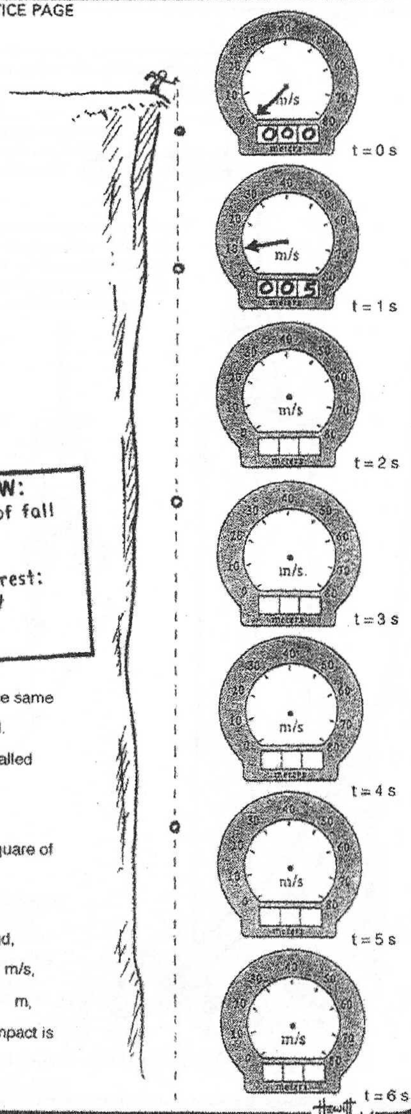
Distinguish between "how fast," "how far," and "how long"!

Hewitt Drew it!

CONCEPTUAL Physics PRACTICE PAGE

Chapter 3 Linear Motion
Acceleration of Free Fall

A rock dropped from the top of a cliff picks up speed as it falls. Pretend that a speedometer and odometer are attached to the rock to indicate readings of speed and distance at 1-second intervals. Both speed and distance are zero at time = zero (see sketch). Note that after falling 1 second, the speed reading is 10 m/s and the distance fallen is 5 m. The readings of succeeding seconds of fall are not shown and are left for you to complete. So draw the position of the speedometer pointer and write in the correct odometer reading for each time. Use $g = 10\ \text{m/s}^2$ and neglect air resistance.



YOU NEED TO KNOW:
Instantaneous speed of fall from rest:
$v = gt$
Distance fallen from rest:
$d = v_{average}t$
or
$d = \frac{1}{2}gt^2$

1. The speedometer reading increases the same amount, 10 m/s, each second.
   This increase in speed per second is called ACCELERATION.

2. The distance fallen increases as the square of the TIME.

3. If it takes 7 seconds to reach the ground, then its speed at impact is 70 m/s, the total distance fallen is 245 m, and its acceleration of fall just before impact is 10 m/s^2.

Name ______________________ Date __________

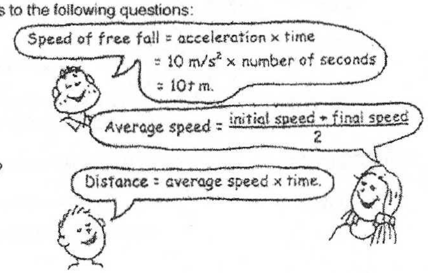
CONCEPTUAL Physics PRACTICE PAGE

Chapter 3 Linear Motion
Hang Time

Some athletes and dancers have great jumping ability. When leaping, they seem to momentarily "hang in the air" and defy gravity. The time that a jumper is airborne with feet off the ground is called hang time. Ask your friends to estimate the hang time of the great jumpers. They may say two or three seconds. But surprisingly, the hang time of the greatest jumpers is most always less than 1 second! A longer time is one of many illusions we have about nature.

To better understand this, find the answers to the following questions:

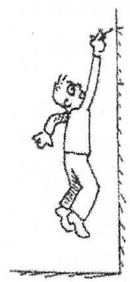
1. If you step off a table and it takes one-half second to reach the floor, what will be the speed when you meet the floor?
   $v = gt = 10\ \text{m/s}^2 \times \frac{1}{2} = 5\ \text{m/s}$



2. What will be your average speed of fall?
   $v = \frac{0 + 5\ \text{m/s}}{2} = 2.5\ \text{m/s}$

3. What will be the distance of fall?
   $d = vt = 2.5\ \text{m/s} \times \frac{1}{2}\text{s} = 1.25\ \text{m}$

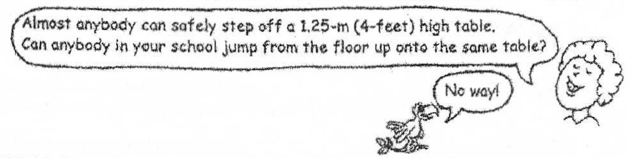
4. So how high is the surface of the table above the floor? 1.25 m

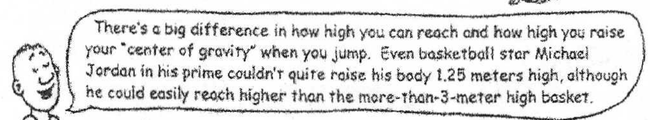


Jumping ability is best measured by a standing vertical jump. Stand facing a wall with feet flat on the floor and arms extended upward. Make a mark on the wall at the top of your reach. Then make your jump and at the peak make another mark. The distance between these two marks measures your vertical leap. If it's more than 0.6 meters (2 feet), you're exceptional.

5. What is your vertical jumping distance? (VARIES)

6. Calculate your personal hang time using the formula $d = 1/2\ gt^2$ (Remember that hang time is the time that you move upward + the time you return downward.)





Here we're talking about vertical motion. How about running jumps? We'll see in Chapter 10 that the height of a jump depends only on the jumper's vertical speed at launch. While airborne, the jumper's horizontal speed remains constant while the vertical speed undergoes acceleration due to gravity. While airborne, no amount of leg or arm pumping or other bodily motions can change your hang time.

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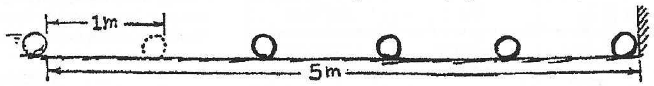
Chapter 3 Linear Motion
Non-Accelerated Motion

1. The sketch shows a ball rolling at constant velocity along a level floor. The ball rolls from the first position shown to the second in 1 second. The two positions are 1 meter apart. Sketch the ball at successive 1-second intervals all the way to the wall (neglect resistance).



a. Did you draw successive ball positions evenly spaced, farther apart, or closer together? Why?
EVENLY SPACED-EQUAL DISTANCE IN EQUAL TIME --> CONSTANT v

b. The ball reaches the wall with a speed of 1 m/s and takes a time of 5 seconds.

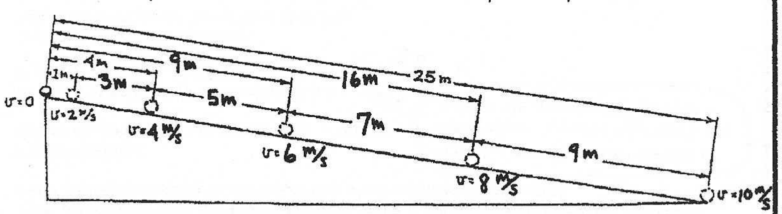
2. Table I shows data of sprinting speeds of some animals. Make whatever computations necessary to complete the table.

TABLE I

ANIMAL	DISTANCE	TIME	SPEED
CHEETAH	75 m	3 s	25 m/s
GREYHOUND	160 m	10 s	16 m/s
GAZELLE	1 km	0.01 h	100 km/h
TURTLE	30 cm	30 s	1 cm/s

Accelerated Motion

3. An object starting from rest gains a speed $v = at$ when it undergoes uniform acceleration. The distance it covers is $d = 1/2\, at^2$. Uniform acceleration occurs for a ball rolling down an inclined plane. The plane below is tilted so a ball picks up a speed of 2 m/s each second; then its acceleration $a = 2$ m/s². The positions of the ball are shown at 1-second intervals. Complete the six blank spaces for distance covered and the four blank spaces for speeds.



a. Do you see that the total distance from the starting point increases as the square of the time? This was discovered by Galileo. If the incline were to continue, predict the ball's distance from the starting point for the next 3 seconds.

YES; DISTANCE INCREASES AS SQUARE OF TIME; 36 m, 49 m, 64 m.

b. Note the increase of distance between ball positions with time. Do you see an odd-integer pattern (also discovered by Galileo) for this increase? If the incline were to continue, predict the successive distances between ball positions for the next 3 seconds.

YES; 11 m, 13 m, 15 m.

Hewitt Drew it!

Name ______________________ Date ________

CONCEPTUAL Physics PRACTICE PAGE

Chapter 4 Newton's Second Law of Motion
Mass and Weight

Learning physics is learning the connections among concepts in nature, and also learning to distinguish between closely-related concepts. Velocity and acceleration, previously treated, are often confused. Similarly in this chapter, we find that mass and weight are often confused. They aren't the same! Please review the distinction between mass and weight in your textbook. To reinforce your understanding of this distinction, circle the correct answers below.

Comparing the concepts of mass and weight, one is basic—fundamental—depending only on the internal makeup of an object and the number and kind of atoms that compose it. The concept that is fundamental is [mass] [weight].

The concept that additionally depends on location in a gravitational field is [mass] [weight]

[Mass] [Weight] is a measure of the amount of matter in an object and only depends on the number and kind of atoms that compose it.

It can correctly be said that [mass] [weight] is a measure of "laziness" of an object.

[Mass] [Weight] is related to the gravitational force acting on the object.

[Mass] [Weight] depends on an object's location, whereas [mass] [weight] does not.

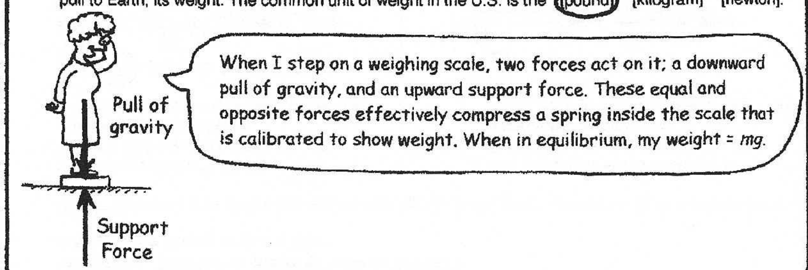
In other words, a stone would have the same [mass] [weight] whether it is on the surface of Earth or on the surface of the Moon. However, its [mass] [weight] depends on its location.

On the Moon's surface, where gravity is only about 1/6th Earth gravity [mass] [weight] [both the mass and the weight] of the stone would be the same as on Earth.

While mass and weight are not the same, they are [directly proportional] [inversely proportional] to each other. In the same location, twice the mass has [twice] [half] the weight.

The Standard International (SI) unit of mass is the [kilogram] [newton], and the SI unit of force is the [kilogram] [newton].

In the United States, it is common to measure the mass of something by measuring its gravitational pull to Earth, its weight. The common unit of weight in the U.S. is the [pound] [kilogram] [newton].



thanx to Daniela Taylor

Hewitt Drew it!

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CONCEPTUAL Physics PRACTICE PAGE

Chapter 4 Newton's Second Law of Motion
Converting Mass to Weight

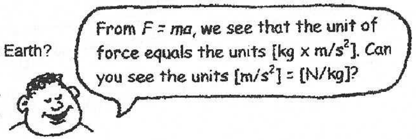
Objects with mass also have weight (although they can be weightless under special conditions). If you know the mass of something in **kilograms** and want its weight in **newtons**, at Earth's surface, you can take advantage of the formula that relates weight and mass.

Weight = mass × acceleration due to gravity
$W = mg$

This is in accord with Newton's 2nd law, written as $F = ma$. When the force of gravity is the only force, the acceleration of any object of mass m will be g, the acceleration of free fall. Importantly, g acts as a proportionality constant, 9.8 N/kg, which is equivalent to 9.8 m/s^2.

Sample Question:
How much does a 1-kg bag of nails weigh on Earth?

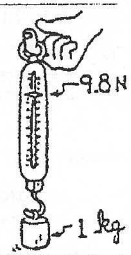
$W = mg = (1\text{ kg})(9.8\text{ m/s}^2) = 9.8\text{ m/s}^2 = 9.8\text{ N}$.
or simply, $W = mg = (1\text{ kg})(9.8\text{ N/kg}) = 9.8\text{ N}$.



Answer the following questions:
Felicia the ballet dancer has a mass of 45.0 kg.

1. What is Felicia's weight in newtons at Earth's surface? 441 N
2. Given that 1 kilogram of mass corresponds to 2.2 pounds at Earth's surface, what is Felicia's weight in pounds on Earth? 99 LB
3. What would be Felicia's mass on the surface of Jupiter? 45.0 kg
4. What would be Felicia's weight on Jupiter's surface, where the acceleration due to gravity is 25.0 m/s^2? 1125 N

Different masses are hung on a spring scale calibrated in newtons.
The force exerted by gravity on 1 kg = 9.8 N.



5. The force exerted by gravity on 5 kg = 49 N.
6. The force exerted by gravity on 10 kg = 98 N.

Make up your own mass and show the corresponding weight:
The force exerted by gravity on * kg = * N.
***ANY VALUE FOR kg AS LONG AS THE SAME VALUE IS MULTIPLIED BY 9.8 FOR N.**

By whatever means (spring scales, measuring balances, etc.), find the mass of your physics book. Then complete the table.

OBJECT	MASS	WEIGHT
MELON	1 kg	9.8 N
APPLE	0.1 kg	1 N
BOOK		
A FRIEND	60 kg	588 N

Name ______________________ Date __________

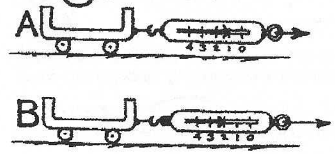
CONCEPTUAL Physics PRACTICE PAGE

Chapter 4 Newton's Second Law of Motion
A Day at the Races with a = F/m

In each situation below, Cart A has a mass of **1 kg**. *Circle the correct answer* (A, B, or Same for both).

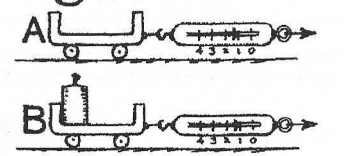
1. Cart A is pulled with a force of **1 N**.
Cart B also has a mass of **1 kg** and is pulled with a force of **2 N**.
Which undergoes the greater acceleration?

[A] [B] [Same for both]



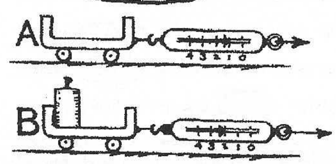
2. Cart A is pulled with a force of **1 N**.
Cart B has a mass of **2 kg** and is also pulled with a force of **1 N**.
Which undergoes the greater acceleration?

[A] [B] [Same for both]



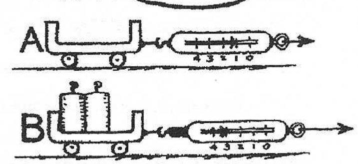
3. Cart A is pulled with a force of **1 N**.
Cart B has a mass of **2 kg** and is pulled with a force of **2 N**.
Which undergoes the greater acceleration?

[A] [B] [Same for both]



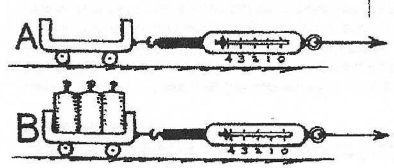
4. Cart A is pulled with a force of **1 N**.
Cart B has a mass of **3 kg** and is pulled with a force of **3 N**.
Which undergoes the greater acceleration?

[A] [B] [Same for both]



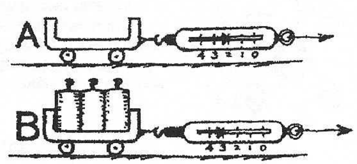
5. This time Cart A is pulled with a force of **4 N**.
Cart B has a mass of **4 kg** and is pulled with a force of **4 N**.
Which undergoes the greater acceleration?

[A] [B] [Same for both]



6. Cart A is pulled with a force of **2 N**.
Cart B has a mass of **4 kg** and is pulled with a force of **3 N**.
Which undergoes the greater acceleration?

[A] [B] [Same for both]



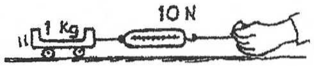
thanx to Dean Baird

Chapter 4 Newton's Second Law of Motion

Dropping Masses and Accelerating Cart

1. Consider a 1-kg cart being pulled by a 10-N applied force. According to Newton's 2nd law, acceleration of the cart is

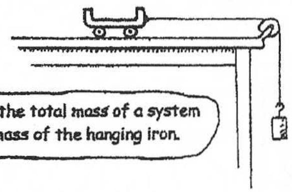
$$a = \frac{F}{m} = \frac{10\text{ N}}{1\text{ kg}} = 10\text{ m/s}^2.$$



This is the same as the acceleration of free fall, g—because a force equal to the cart's weight accelerates it.

2. Consider the acceleration of the cart when the applied force is due to a 10-N iron weight attached to a string draped over a pulley. Will the cart accelerate as before, at 10 m/s^2? The answer is no, because the mass being accelerated is the mass of the cart *plus* the mass of the piece of iron that pulls it. Both masses accelerate. The mass of the 10-N iron weight is 1 kg—so the total mass being accelerated (cart + iron) is 2 kg. Then,

The pulley changes only the direction of the force.

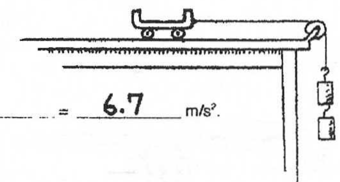


$$a = \frac{F}{m} = \frac{10\text{ N}}{2\text{ kg}} = 5\text{ m/s}^2.$$

Don't forget: the total mass of a system includes the mass of the hanging iron.

Note this is half the acceleration due to gravity alone, g. So the acceleration of 2 kg produced by the weight of 1 kg is $g/2$.

a. Find the acceleration of the 1-kg cart when two identical 10-N weights are attached to the string.



$$a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{20\text{ N}}{3\text{ kg}} = 6.7\text{ m/s}^2.$$

Here we simplify and say $g = 10\text{ m/s}^2$.

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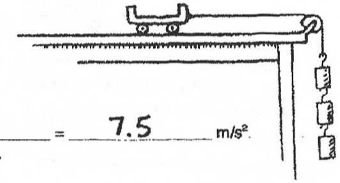
Chapter 4 Newton's Second Law of Motion

Dropping Masses and Accelerating Cart—continued

b. Find the acceleration of the 1-kg cart when the three identical 10-N weights are attach to the string.

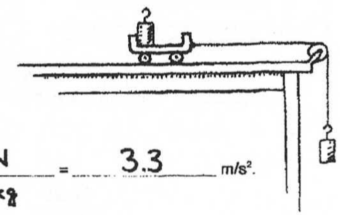


$$a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{30\text{ N}}{4\text{ kg}} = 7.5\text{ m/s}^2.$$

c. Find the acceleration of the 1-kg cart when four identical 10-N weights (not shown) are attached to the string.

$$a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{40\text{ N}}{5\text{ kg}} = 8\text{ m/s}^2.$$

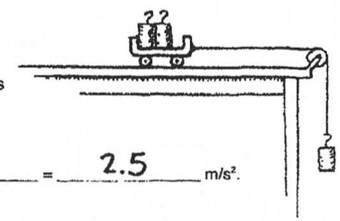
d. This time 1 kg of iron is added to the cart, and only one iron piece dangles from the pulley. Find the acceleration of the cart.



$$a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{10\text{ N}}{3\text{ kg}} = 3.3\text{ m/s}^2.$$

The force due to gravity on a mass m is mg. So gravitational force on 1 kg is (1 kg)(10 m/s^2) = 10 N.

e. Find the acceleration of the cart when it carries two pieces of iron and only one iron piece dangles from the pulley.



$$a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{10\text{ N}}{4\text{ kg}} = 2.5\text{ m/s}^2.$$

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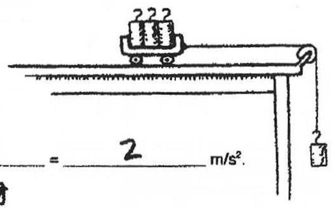
CONCEPTUAL Physics PRACTICE PAGE

Chapter 4 Newton's Second Law of Motion

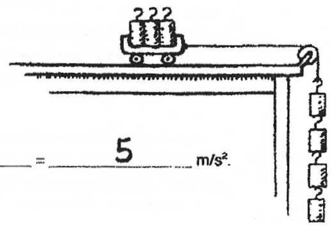
Dropping Masses and Accelerating Cart*—continued*

f. Find the acceleration of the cart when it carries 3 pieces of iron and only one iron piece dangles from the pulley.

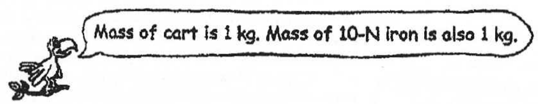


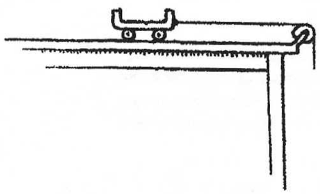
$a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{10\text{ N}}{5\text{ kg}} = 2\ \text{m/s}^2.$

g. Find the acceleration of the cart when it carries 3 pieces of iron and 4 pieces of iron dangle from the pulley.



$a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \frac{40\text{ N}}{8\text{ kg}} = 5\ \text{m/s}^2.$





h. Draw your own combination of masses and find the acceleration.

$a = \frac{F}{m} = \frac{\text{applied force}}{\text{total mass}} = \underline{\qquad\qquad} = \underline{\qquad\qquad}\ \text{m/s}^2.$

Name ____________________ Date ________

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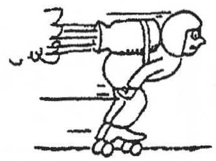
Chapter 4 Newton's Second Law of Motion

Force and Acceleration



1. Skelly the skater, total mass 25 kg, is propelled by rocket power.

a. Complete Table I (neglect resistance).

TABLE I

FORCE	ACCELERATION
100 N	4 m/s
200 N	8 m/s
250 N	10 m/s²

$a = \frac{F}{25\text{ mg}}$

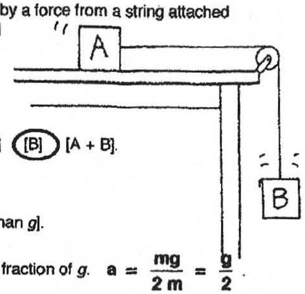
b. Complete Table II for a constant 50-N resistance.

TABLE II

FORCE	ACCELERATION
50 N	0 m/s²
100 N	2 m/s
200 N	6 m/s

$a = \frac{F - 50\text{ N}}{25\text{ kg}}$

2. Block A on a horizontal friction-free table is accelerated by a force from a string attached to Block B of the same mass. Block B falls vertically and drags Block A horizontally. (Neglect the string's mass).



Circle the correct answers:

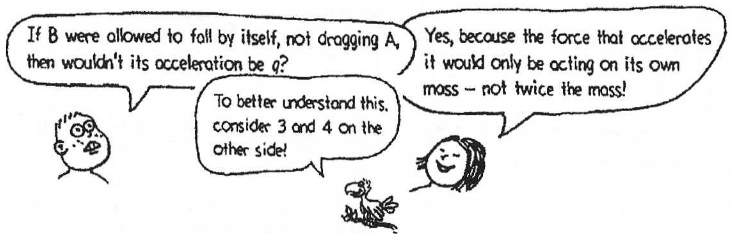
a. The *mass* of the system (A + B) is [*m*] [2 *m*].

b. The *force* that accelerates (A + B) is the weight of [A] [B] [A + B].

c. The weight of B is [*mg*/2] [*mg*] [2 *mg*].

d. Acceleration of (A + B) is [less than *g*] [*g*] [more than *g*].

e. Use $a = \frac{F}{m}$ to show the acceleration of (A + B) as a fraction of *g*. $a = \frac{mg}{2\text{ m}} = \frac{g}{2}$.



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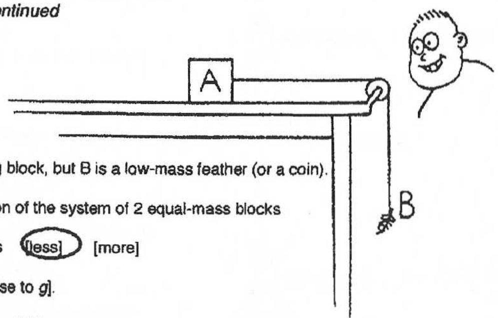
CONCEPTUAL **Physics** PRACTICE PAGE

Chapter 4 Newton's Second Law of Motion

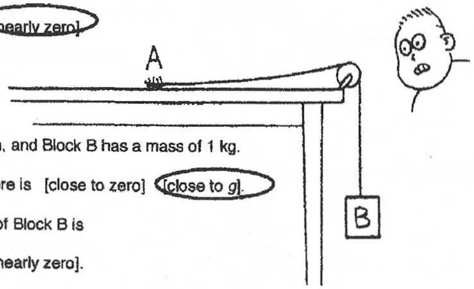
Force and Acceleration—continued



3. Suppose Block A is still a 1-kg block, but B is a low-mass feather (or a coin).

   a. Compared to the acceleration of the system of 2 equal-mass blocks the acceleration of (A + B) is [less] [more] and is [close to zero] [close to *g*].

   b. In this case, the acceleration of B is [practically that of free fall] [nearly zero].



4. Suppose A is the feather or coin, and Block B has a mass of 1 kg.

   a. The acceleration of (A + B) here is [close to zero] [close to *g*].

   b. In this case, the acceleration of Block B is [practically that of free fall] [nearly zero].

5. Summarizing we see that when the weight of one object causes the acceleration of two objects, the range of possible accelerations is between [zero and *g*] [zero and infinity] [*g* and infinity].

6. For a change of pace, consider a ball that rolls down a uniform-slope ramp.

   a. Speed of the ball is [decreasing] [constant] [increasing]

   b. Acceleration is [decreasing] [constant] [increasing].

   c. If the ramp were steeper, acceleration would be [more] [the same] [less].

   d. When the ball reaches the bottom and rolls along the smooth level surface, it [continues to accelerate] [does not accelerate].

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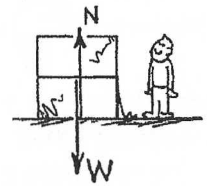
Chapter 4 Newton's Second Law of Motion

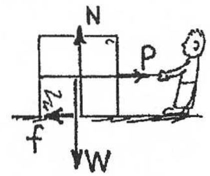
Friction



1. A crate filled with delicious junk food rests on a horizontal floor. Only gravity and the support force of the floor act on it, as shown by the vectors for weight **W** and normal force **N**.

   a. The net force on the crate is [zero] [greater than zero].

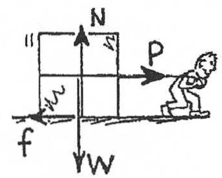
   b. Evidence for this is **NO ACCELERATION**



2. A slight pull **P** is exerted on the crate, not enough to move it. A force of friction *f* now acts,

   a. which is [less than] [equal to] [greater than] **P**.

   b. Net force on the crate is [zero] [greater than zero].

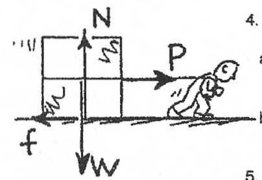


3. Pull **P** is increased until the crate begins to move. It is pulled so that it moves with constant velocity across the floor.

   a. Friction *f* is [less than] [equal to] [greater than] **P**.

   b. Constant velocity means acceleration is [zero] [more than zero].

   c. Net force on the crate is [less than] [equal to] [more than] zero.



4. Pull **P** is further increased and is now greater than friction *f*.

   a. Net force on the crate is [less than] [equal to] [greater than] zero.

   b. The net force acts toward the right, so acceleration acts toward the [left] [right].

5. If the pulling force **P** is 150 N and the crate doesn't move, what is the magnitude of *f*? **150 N**

6. If the pulling force **P** is 200 N and the crate doesn't move, what is the magnitude of *f*? **200 N**

7. If the force of sliding friction is 250 N, what force is necessary to keep the crate sliding at constant velocity? **250 N**

8. If the mass of the crate is 50 kg and sliding friction is 250 N, what is the acceleration of the crate when the pulling force is 250 N? **0 m/s²** 300 N? **1 m/s²** 500 N? **5 m/s²**

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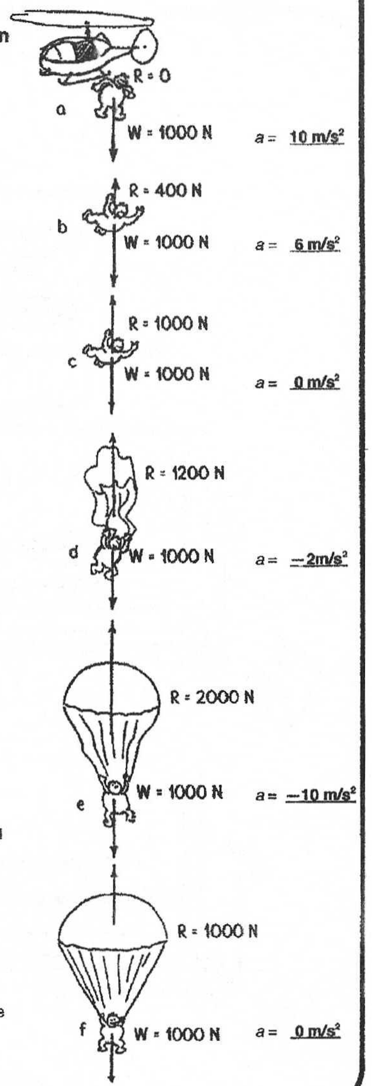
Chapter 4 Newton's Second Law of Motion
Falling and Air Resistance

Bronco skydives and parachutes from a stationary helicopter. Various stages of fall are shown in positions *a* through *f*. Using Newton's 2nd law,

$$a = \frac{F_{net}}{m} = \frac{W - R}{m}$$

find Bronco's acceleration at each position (answer in the blanks to the right). You need to know that Bronco's mass *m* is 100 kg so his weight is a constant 1000 N. Air resistance *R* varies with speed and cross-sectional area as shown.



Circle the correct answers:

1. When Bronco's speed is least, his acceleration is

   [least] [most]

2. In which position(s) does Bronco experience a downward acceleration?

   [a] [b] [c] [d] [e] [f]

3. In which position(s) does Bronco experience a upward acceleration?

   [a] [b] [c] [d] [e] [f]

4. When Bronco experiences an upward acceleration, his velocity is [still downward] [upward also].

5. In which position(s) is Bronco's velocity constant?

   [a] [b] [c] [d] [e] [f]

6. In which position(s) does Bronco experience terminal velocity?

   [a] [b] [c] [d] [e] [f]

7. In which position(s) is terminal velocity greatest?

   [a] [b] [c] [d] [e] [f]

8. If Bronco were heavier, his terminal velocity would be

   [greater] [less] [the same].

Hewitt Drew it!

Name ______________________________ Date __________

CONCEPTUAL Physics PRACTICE PAGE

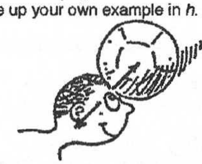
Chapter 5 Newton's Third Law of Motion
Action and Reaction Pairs

1. In the example below, the action-reaction pair is shown by the arrows (vectors), and the action-reaction described in words. In *a* through *g*, draw the other arrow (vector) and state the reaction to the given action. Then make up your own example in *h*.

Example:

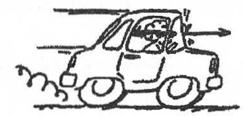
Fist hits wall.

Wall hits fist.



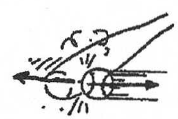
Head bumps ball.

a. **BALL BUMPS HEAD.**



Windshield hits bug.

b. **BUG HITS WINDSHIELD.**



Bat hits ball.

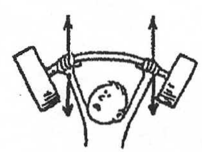
c. **BALL HITS BAT.**

Hand touches nose.

d. **NOSE TOUCHES HAND.**

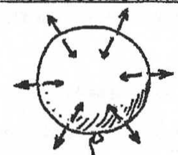
Hand pulls flower.

e. **FLOWER PULLS ON HAND.**



Athlete pushes bar upward.

f. **BAR PUSHES ATHLETE DOWNWARD.**



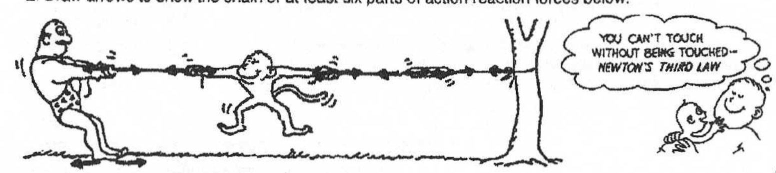
Compressed air pushes balloon surface outward.

g. **BALLOON SURFACE PUSHES COMPRESSED AIR UPWARD.**

STUDENT DRAWING (OPEN)

h. **THING *A* ACTS ON THING *B*. THING *B* ACTS ON THING *A*.**

2. Draw arrows to show the chain of at least six parts of action-reaction forces below.



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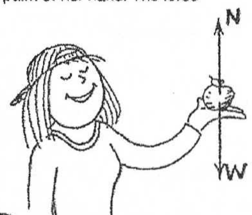
Name ______________________ Date __________

CONCEPTUAL Physics PRACTICE PAGE

Chapter 5 Newton's Third Law of Motion

Interactions

1. Nellie Newton holds an apple weighing 1 newton at rest on the palm of her hand. The force vectors shown are the forces that act on the apple.



a. To say the weight of the apple is 1 N is to say that a downward gravitational force of 1 N is exerted on the apple by [Earth] [her hand].

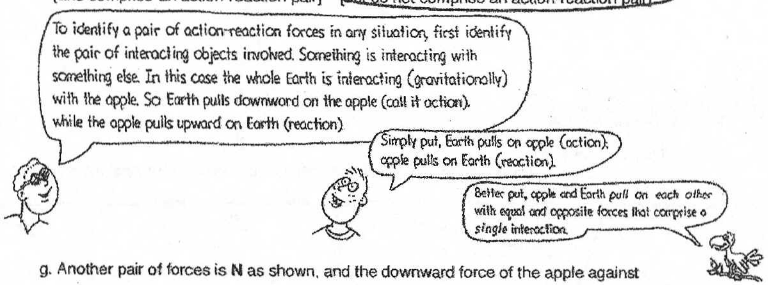
b. Nellie's hand supports the apple with normal force **N**, which acts in a direction opposite to **W**. We can say **N** [equals **W**] [has the same magnitude as **W**].

c. Since the apple is at rest, the net force on the apple is [zero] [nonzero].

d. Since **N** is equal and opposite to **W**, we [can] [cannot] say that **N** and **W** comprise an action-reaction pair. The reason is because action and reaction always [act on the same object] [act on different objects], and here we see **N** and **W** [both acting on the apple] [acting on different objects].

e. In accord with the rule, "If ACTION is A acting on B, then REACTION is B acting on A," if we say *action* is Earth pulling down on the apple, then *reaction* is [the apple pulling up on Earth] [**N**, Nellie's hand pushing up on the apple].

f. To repeat for emphasis, we see that **N** and **W** are equal and opposite to each other [and comprise an action-reaction pair] [but do not comprise an action-reaction pair].



g. Another pair of forces is **N** as shown, and the downward force of the apple against Nellie's hand, not shown. This force pair [is] [isn't] an action-reaction pair.

h. Suppose Nellie now pushes upward on the apple with a force of 2 N. The apple [is still in equilibrium] [accelerates upward], and compared to **W**, the magnitude of **N** is [the same] [twice] [not the same, and not twice].

i. Once the apple leaves Nellie's hand, **N** is [zero] [still twice the magnitude of **W**], and the net force on the apple is [zero] [only **W**] [still **W** - **N**, a negative force].

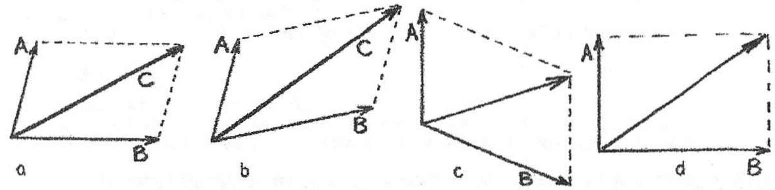
Hewitt Drew it!

CONCEPTUAL Physics PRACTICE PAGE

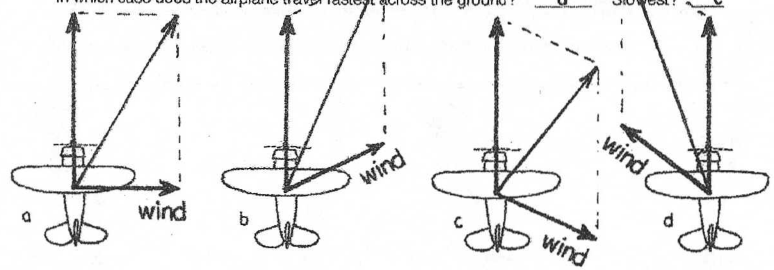
Chapter 5 Newton's Third Law of Motion

Vectors and the Parallelogram Rule

1. When two 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 resultant **C** in diagrams *c* and *d*. Note that in diagram *d* you form a rectangle (a special case of a parallelogram).



2. 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? __d__ Slowest? __c__



3. To the right we see the 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?

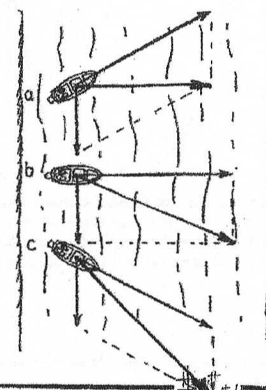
__a__

b. Which boat reaches the opposite shore first?

__b__

c. Which boat provides the fastest ride?

__c__



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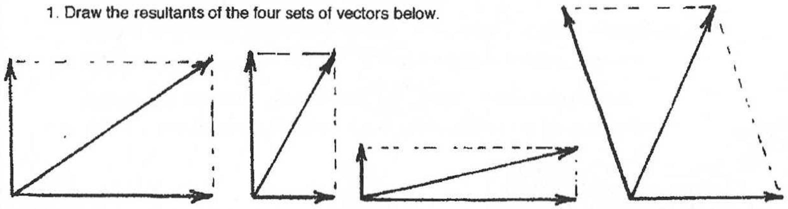
CONCEPTUAL **Physics** PRACTICE PAGE

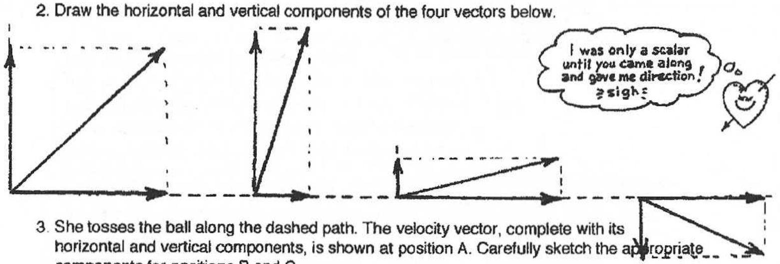
Chapter 5 Newton's Third Law of Motion

Velocity Vectors and Components

1. Draw the resultants of the four sets of vectors below.



2. Draw the horizontal and vertical components of the four vectors below.

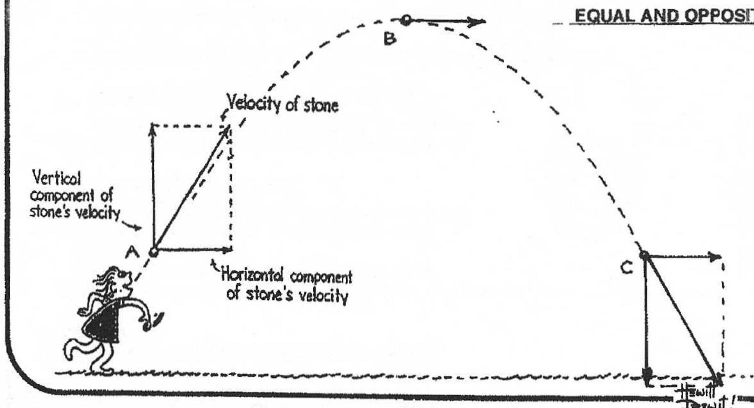


3. She tosses the ball along the dashed path. The velocity vector, complete with its horizontal and vertical components, is shown at position A. Carefully sketch the appropriate components for positions B and C.

   a. Since there is no acceleration in the horizontal direction, how does the horizontal component of velocity compare for positions A, B, and C? **SAME**

   b. What is the value of the vertical component of velocity at position B? **0 m/s**

   c. How does the vertical component of velocity at position C compare with that of position A? **EQUAL AND OPPOSITE**



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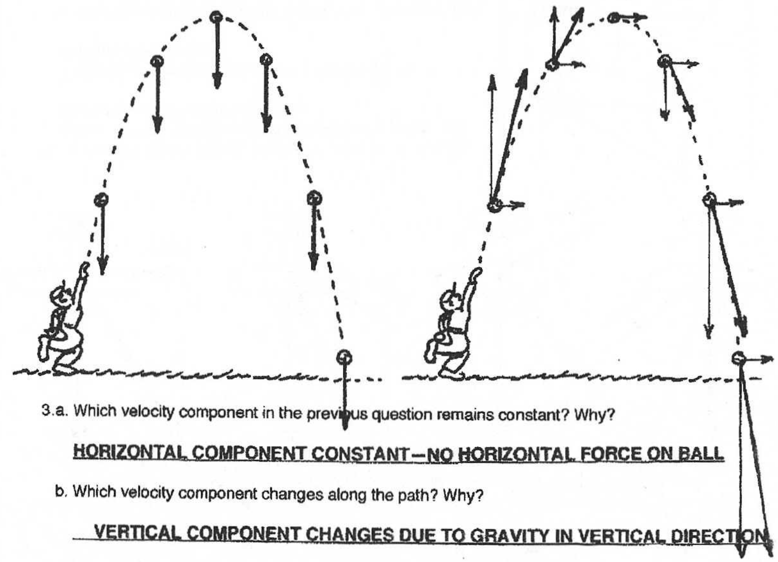
CONCEPTUAL **Physics** PRACTICE PAGE

Chapter 5 Newton's Third Law of Motion

Force and Velocity Vectors

1. Draw sample vectors to represent the force of gravity on the ball in the positions shown below after it leaves the thrower's hand. (Neglect air resistance.)

2. Draw sample bold vectors to represent the velocity of the ball in the positions shown below. With lighter vectors, show the horizontal and vertical components of velocity for each position.



3.a. Which velocity component in the previous question remains constant? Why?

HORIZONTAL COMPONENT CONSTANT—NO HORIZONTAL FORCE ON BALL

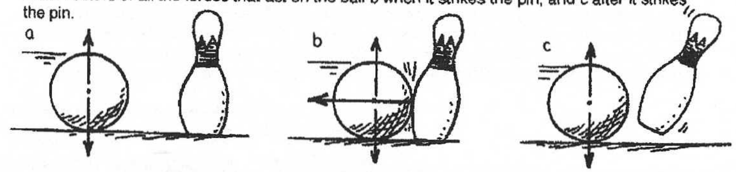
b. Which velocity component changes along the path? Why?

VERTICAL COMPONENT CHANGES DUE TO GRAVITY IN VERTICAL DIRECTION

4. It is important to distinguish between force and velocity vectors. Force vectors combine with other force vectors, and velocity vectors combine with other velocity vectors. Do velocity vectors combine with force vectors?

   NO

5. All forces on the bowling ball, weight (down) and support of alley (up), are shown by vectors at its center before it strikes the pin *a*.
   Draw vectors of all the forces that act on the ball *b* when it strikes the pin, and *c* after it strikes the pin.



thanx to Howie Brand

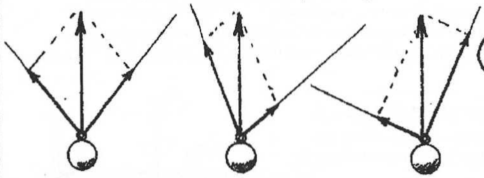
Hewitt Drew it!

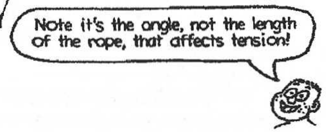
CONCEPTUAL Physics PRACTICE PAGE

Chapter 5 Newton's Third Law of Motion

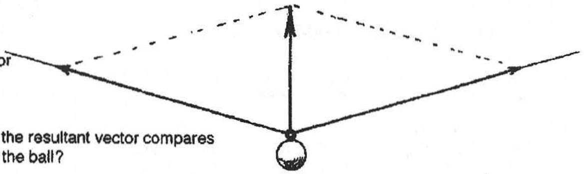
Force Vectors and the Parallelogram Rule

1. The heavy ball is supported in each case by two strands of rope. The tension in each strand is shown by the vectors. Use the parallelogram rule to find the resultant of each vector pair.





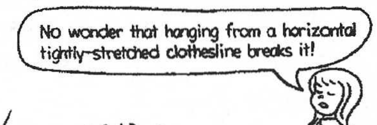
a. Is your resultant vector the same for each case?
   YES

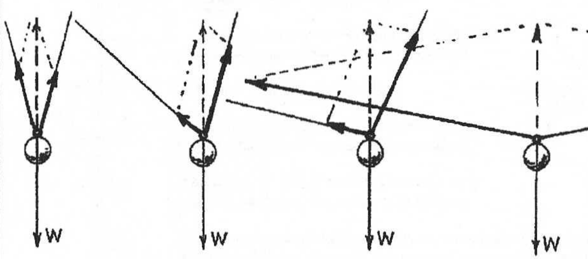


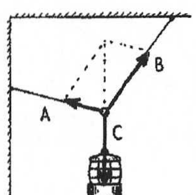
b. How do you think the resultant vector compares with the weight of the ball?
   SAME (BUT OPPOSITE DIRECTION)

2. Now let's do the opposite of what we've done above. More often, we know the weight of the suspended object, but we don't know the rope tensions. In each case below, the weight of the ball is shown by the vector **W**. Each dashed vector represents the resultant of the pair of rope tensions. Note that each is equal and opposite to vectors **W** (they must be; otherwise the ball wouldn't be at rest).

a. Construct parallelograms where the ropes define adjacent sides and the dashed vectors are the diagonals.
b. How do the relative lengths of the sides of each parallelogram compare to rope tension?
c. Draw rope-tension vectors, clearly showing their relative magnitudes.







3. A lantern is suspended as shown. Draw vectors to show the relative tensions in ropes A, B, and C. Do you see a relationship between your vectors **A** + **B** and vector **C**? Between vectors **A** + **C** and vector **B**?
   YES: A + B = −C   A + B = −B

Hewitt Drew it!

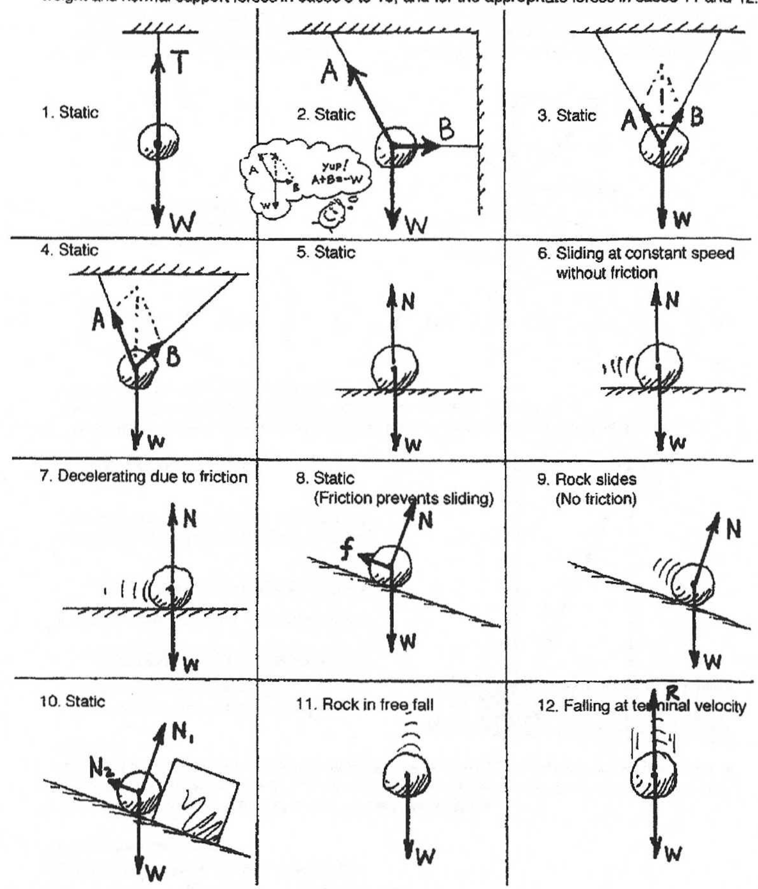
Name ______________________ Date __________

CONCEPTUAL Physics PRACTICE PAGE

Chapter 5 Newton's Third Law of Motion

Force-Vector Diagrams

In each case, a rock is acted on by one or more forces. Using a pencil and a ruler, draw an accurate vector diagram showing all forces acting on the rock, and no other forces. The first two cases are done as examples. The parallelogram rule in case 2 shows that the vector sum of **A** + **B** is equal and opposite to **W** (that is, **A** + **B** = -**W**). Do the same for cases 3 and 4. Draw and label vectors for the weight and normal support forces in cases 5 to 10, and for the appropriate forces in cases 11 and 12.

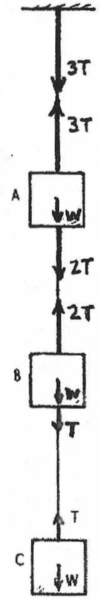


thanx to Jim Court

Hewitt Drew it!

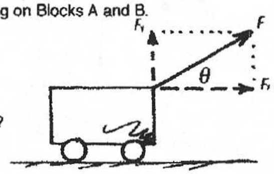
CONCEPTUAL Physics PRACTICE PAGE

Chapter 5 Newton's Third Law of Motion
More on Vectors



1. Each of the vertically-suspended blocks has the same weight ***W***. The two forces acting on Block C (***W*** and rope tension ***T***) are shown. Draw vectors to a reasonable scale for rope tensions acting on Blocks A and B.

2. The cart is pulled with force ***F*** at angle θ as shown. F_x and F_y are components of ***F***.



a. How will the magnitude of F_x change if the angle θ is increased by a few degrees?

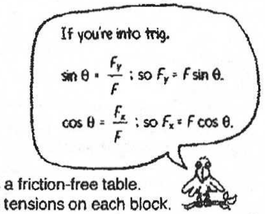
[more] [less] [no change]

b. How will the magnitude of F_y change if the angle θ is increased by a few degrees?

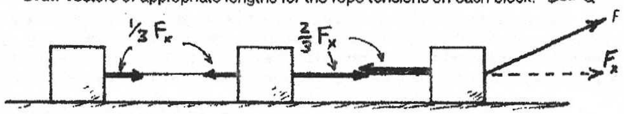
[more] [less] [no change]

c. What will be the value of F_x if angle θ is 90°?

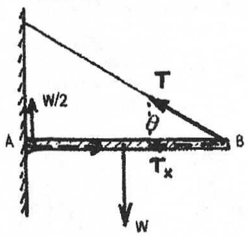
[more than ***F***] [zero] [no change]



3. Force ***F*** pulls three blocks of equal mass across a friction-free table. Draw vectors of appropriate lengths for the rope tensions on each block.



4. Consider the boom supported by hinge A and by a cable B. Vectors are shown for the weight ***W*** of the boom at its center, and ***W***/2 for vertical component of upward force supplied by the hinge.

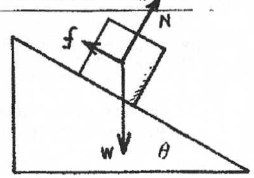


a. Draw a vector representing the cable tension ***T*** at B. Why is it correct to draw its length so that the vertical component of ***T*** = ***W***/2?

SAME LENGTH AS W/2 GIVES $\Sigma F_Y = 0$.

b. Draw component T_x at B. Then draw the horizontal component of the force at A. How do these horizontal components compare, and why **EQUAL AND OPPOSITE SO $\Sigma F_X = 0$.**

5. The block rests on the inclined plane. The vector for its weight ***W*** is shown. How many other forces act on the block, including static friction? **2** . Draw them to a reasonable scale.



a. How does the component of ***W*** parallel to the plane compare with the force of friction? **SAME SO $\Sigma F_X = 0$.**

b. How does the component of ***W*** perpendicular to the plane compare with the normal force?

SAME SO $\Sigma F_Y = 0$.

Hewitt Drew it!

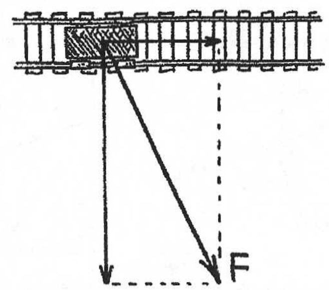
Name ______________________ Date ________

CONCEPTUAL Physics PRACTICE PAGE

Appendix D More About Vectors
Vectors and Sailboats

(Please do not attempt this until you have studied Appendix D!)

1. The sketch shows a top view of a small railroad car pulled by a rope. The force ***F*** that the rope exerts on the car has one component along the track, and another component perpendicular to the track.



a. Draw these components on the sketch. Which component is larger?

PERPENDICULAR COMPONENT

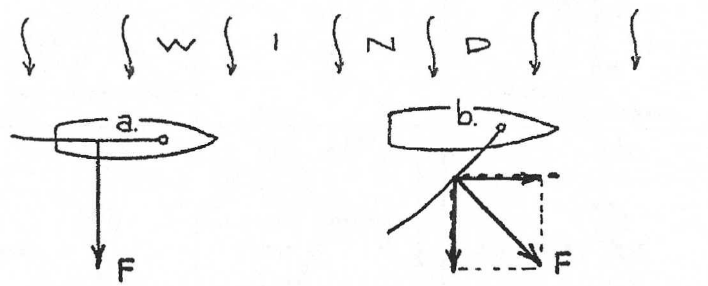
b. Which component produces acceleration?

COMPONENT PARALLEL TO TRACK

c. What would be the effect of pulling on the rope if it were perpendicular to the track?

NO ACCELERATION

2. The sketches below represent simplified top views of sailboats in a cross-wind direction. The impact of the wind produces a FORCE vector on each as shown. (We do NOT consider *velocity* vectors here!)



a. Why is the position of the sail above useless for propelling the boat along its forward direction? (Relate this to Question 1.c above where the train is constrained by tracks to move in one direction, and the boat is similarly constrained to move along one direction by its deep vertical fin—the *keel*.)

AS IN 1.c ABOVE, THERE'S NO COMPONENT PARALLEL TO DIRECTION OF MOTION.

b. Sketch the component of force parallel to the to the direction of the boat's motion (along its keel), and the component perpendicular to its motion. Will the boat move in a forward direction? (Relate this to Question 1.b above.)

YES, AS IN 1.b ABOVE, THERE IS A COMPONENT PARALLEL TO DIRECTION TO MOTION.

Hewitt Drew it!