Name: ____________________

Newton's Second Law of Motion

Read from **Lesson 3** of the **Newton's Laws** chapter at **The Physics Classroom:**

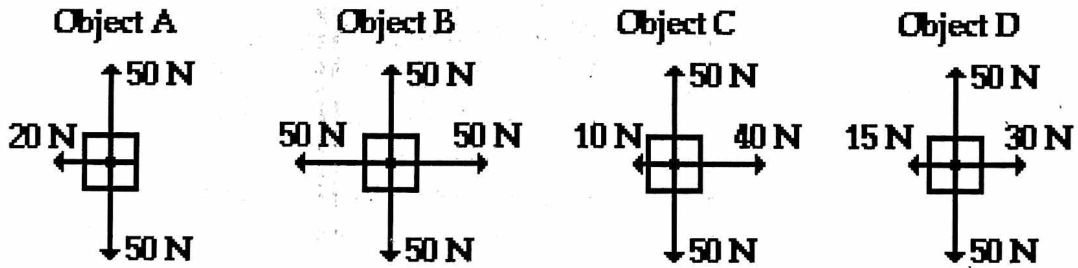
http://www.physicsclassroom.com/Class/newtlaws/u2l3a.html
http://www.physicsclassroom.com/Class/newtlaws/u2l3b.html

MOP Connection: Newton's Laws: sublevel 7

1. The acceleration of an object is __DIRECTLY__ related to the net force exerted upon it and __INVERSELY__ related to the mass of the object. In equation form: $a = F_{net} / m$.
   a. directly, inversely b. inversely, directly c. directly, directly d. inversely, inversely

2. Use Newton's second law to predict the effect of an alteration in mass or net force upon the acceleration of an object.
   a. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 2. The new acceleration will be __16__ m/s^2.
   b. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 4. The new acceleration will be __32__ m/s^2.
   c. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon decreased by a factor of 2. The new acceleration will be __4__ m/s^2.
   d. An object is accelerating at a rate of 8 m/s^2 when it suddenly has its mass increased by a factor of 2. The new acceleration will be __4__ m/s^2.
   e. An object is accelerating at a rate of 8 m/s^2 when it suddenly has its mass decreased by a factor of 4. The new acceleration will be __32__ m/s^2.
   f. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 2 and its mass decreased by a factor of 4. The new acceleration will be __64__ m/s^2.
   g. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 4 and its mass increased by a factor of 2. The new acceleration will be __16__ m/s^2.
   h. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 3 and its mass decreased by a factor of 4. The new acceleration will be __96__ m/s^2.

3. These force diagrams depict the magnitudes and directions of the forces acting upon four objects. In each case, the down force is the force of gravity. Rank these objects in order of their acceleration, from largest to smallest: __C__ > __A__ > __D__ > __B__



 Name: ____________________

Net Force and Acceleration

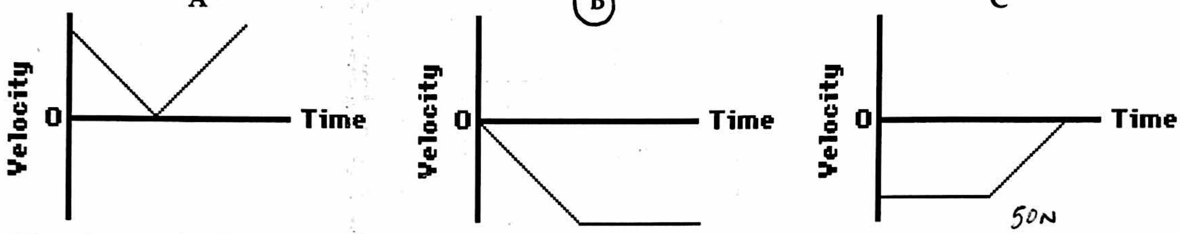
Read from **Lesson 3** of the **Newton's Laws** chapter at **The Physics Classroom**:

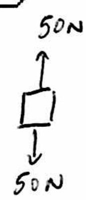
http://www.physicsclassroom.com/Class/newtlaws/u2l3a.html
http://www.physicsclassroom.com/Class/newtlaws/u2l3b.html
http://www.physicsclassroom.com/Class/newtlaws/u2l3c.html

MOP Connection: Newton's Laws: sublevels 3 (front), 8 and 9 (back)

1. Luke Autbeloe drops a 5.0 kg fat cat (weight = ~50.0 N) off the high dive into the pool below (which on this occasion is filled with water). Upon encountering the water in the pool, the cat encounters a 50.0 N <u>upward</u> restraining force. Which <u>one</u> of the velocity-time graph best describes the motion of the cat? __B__ Accompany your answer with a description of the cat's motion.

A B C





Description of cat's motion while falling through air:

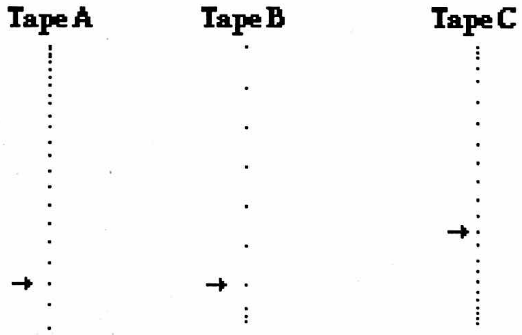
ACCELERATING AT $-10\ m/s^2$

Description of cat's motion after hitting the water:

NO NET FORCE, ∴ CONSTANT $\vec{v}$

2. Which <u>one</u> of the following dot diagrams best describes the motion of the falling cat from the time that they are dropped to the time that they hit the ground? __A__ The arrows on the diagram represent the point at which the cat hit the water. Support your answer with sound reasoning:

DOT'S SHOW $\vec{a}$ (LARGER GAPS) UNTIL HITS WATER, THEN CONSTANT $\vec{v}$ (GAPS SAME DISTANCE)



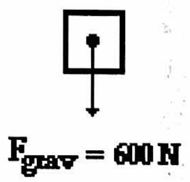
3 Several of Luke's friends were watching the motion of the falling cat. Being "physics types", they began discussing the motion and made the following comments. Indicate whether each of the comments are correct or incorrect? Support your answers.

Student Statement:	Correct? Yes or No
a. Once the cat hit the pool, the forces are balanced and the cat will stop. (CONSTANT) Reason: NO FNET = NO $\vec{a}$, ∴ WILL TRAVEL @ $\vec{v}$ IT HIT WATER	NO
b. Upon hitting the pool, the cat will accelerate upwards because the pool applies an upward force. Reason: UPWARD = DOWNWARD ∴ NO FNET & NO $\vec{a}$	NO
c. Upon hitting the pool, the cat will bounce upwards due to the upwards force. Reason: SAME AS b.	NO

↳ REMEMBER FNET WILL GIVE $\vec{a}$, <u>NOT</u> DIRECTION OF MOVEMENT

4. For each force diagram, determine the net or resultant force (ΣF), the mass and the acceleration of the object. Identify the direction (the second blank) of the two vector quantities. NOTE: F_{grav} stands for the weight of the object.

a.

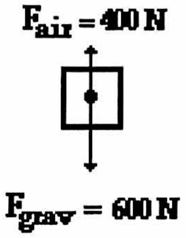


ΣF = 600 N, DOWN

m = 60 Kg

a = 10 m/s², DOWN

b.

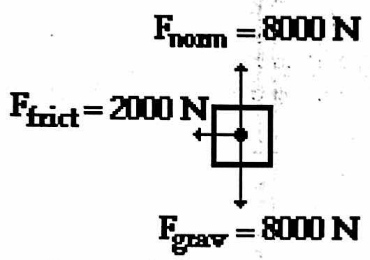


ΣF = 200 N, DOWN

m = 60 Kg

a = 3.33 m/s², DOWN

c.

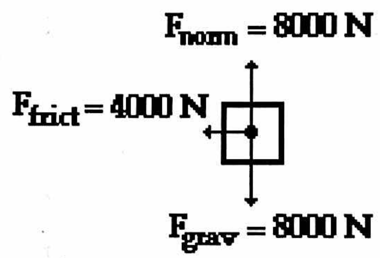


ΣF = 2000 N, LEFT

m = 800 Kg

a = 2.5 m/s², LEFT

d.

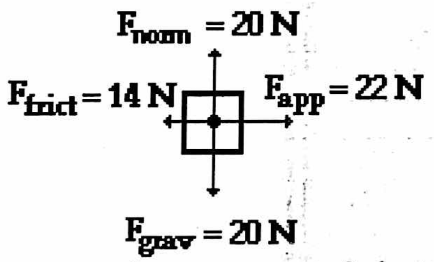


ΣF = 4000 N, LEFT

m = 800 Kg

a = 5 m/s², LEFT

e.

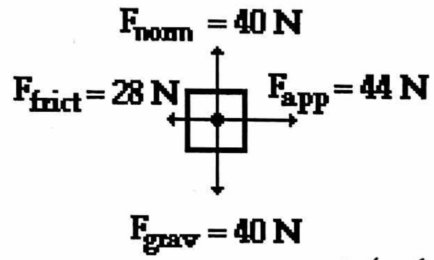


ΣF = 8 N, RIGHT

m = 2 Kg

a = 4 m/s², RIGHT

f.



ΣF = 16 N, RIGHT

m = 4 Kg

a = 4 m/s², RIGHT

 Name: ____________________

Newton's Second Law

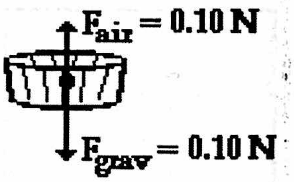
Read from **Lesson 3** of the **Newton's Laws** chapter at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/newtlaws/u2l3c.html
http://www.physicsclassroom.com/Class/newtlaws/u2l3d.html

MOP Connection: Newton's Laws: sublevels 8 and 9

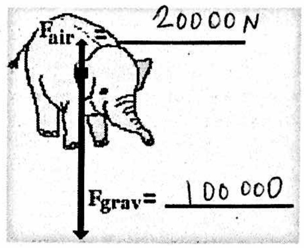
Free-body diagrams are shown for a variety of physical situations. Use Newton's second law of motion (ΣF=m•a) to fill in all blanks. Use the approximation that g = ~10 m/s/s.

a.



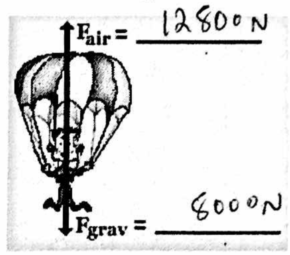
m= 0.01 Kg
a= 0 m/s²
ΣF= 0 N

b.



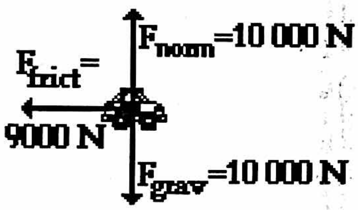
m=10000 kg
a = 8.0 m/s/s, down
ΣF = 80 000 N, DOWN

c.



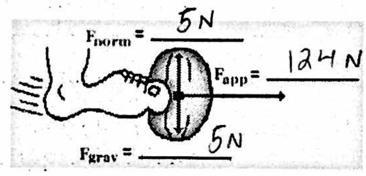
m=800 kg
a = 6.0 m/s/s, up
ΣF = 4800 N, UP

d.



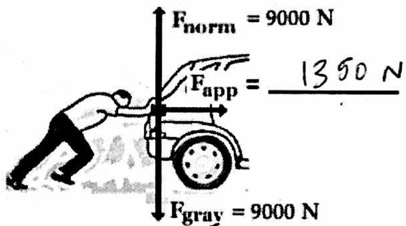
m= 1000 Kg
a= 9 m/s², LEFT
ΣF= 9000 N, LEFT

e.



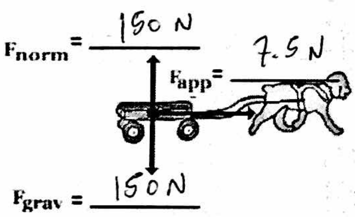
m=0.500 kg
a = 248 m/s²
ΣF = 124 N, right

f.



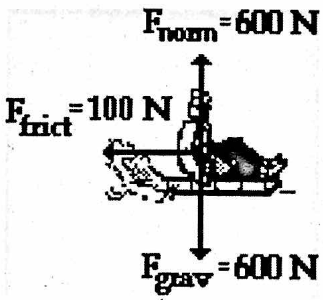
m= 900 Kg
a = 1.50 m/s/s, right
ΣF = 1350 N, RIGHT

g.



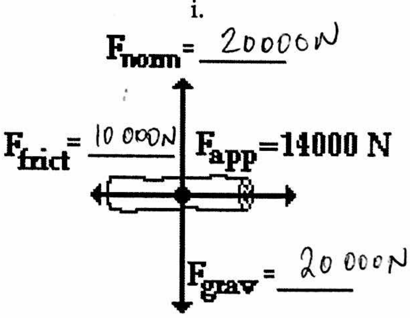
m=15.0 kg
a = 0.50 m/s/s, right
ΣF = 7.5 N, RIGHT

h.



m= 60 Kg
a= 1.67 m/s²
ΣF= 100 N, LEFT

i.



m=2000 kg
a=2.0 m/s/s, right
ΣF= 4000 N, RIGHT

 Name: ______________________

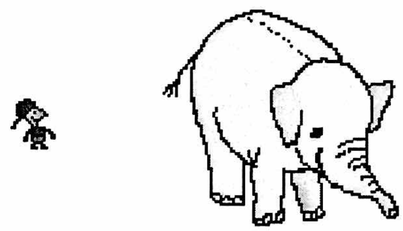
Air Resistance and Terminal Velocity

Read from **Lesson 3** of the **Newton's Laws** chapter at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/newtlaws/u2l3e.html

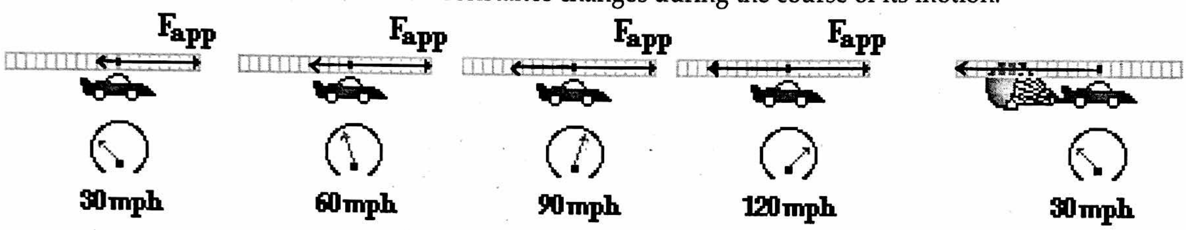
MOP Connection: Newton's Laws: sublevel 11

1. When falling under the influence of air resistance and dropped from the same height, which will fall to the ground at a faster rate?
   a. a mouse b. an elephant c. the same

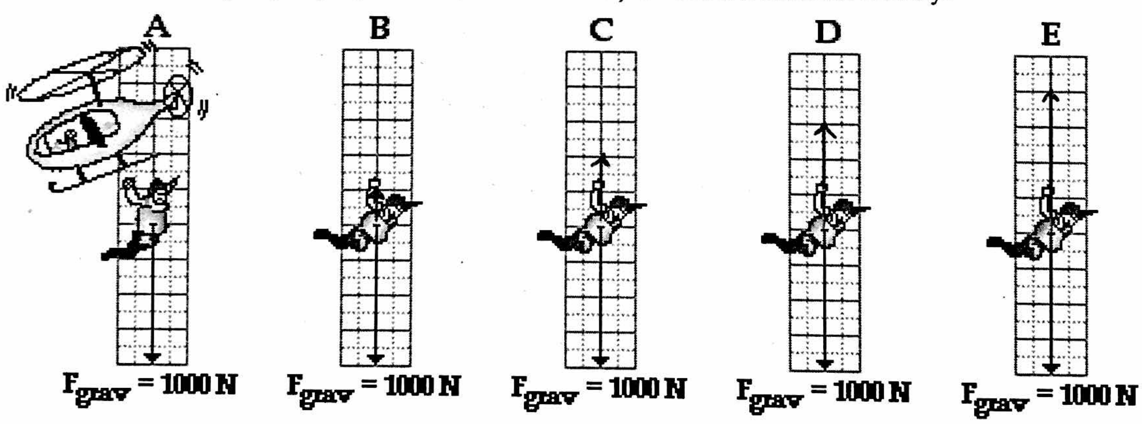


2. Which of the following variables will have a direct effect upon the amount of air resistance experienced by an object? (That is, for which of these quantities will an increase lead to a resulting increase in the air resistance force?)
   a. speed b. air density c. cross-sectional area

3. Consider the dragster's motion below. Speedometer readings and the forward propulsion force (F_{app}) are shown. The top (or terminal) speed is 120 mph. Draw F_{air} force arrows on each diagram to illustrate how the amount of air resistance changes during the course of its motion.



4. Draw F_{air} force arrows to show how the force of air resistance changes on the falling skydiver. At **A**, the diver has just jumped; and at **E**, the diver has just reached terminal velocity.



5. Fill in the blanks in the following paragraph.

   As an object moves faster and faster, the amount of air resistance INCREASES (increases, decreases) until a state of terminal velocity is reached. Once terminal velocity is reached, the force of air resistance is EQUAL TO (greater than, less than, equal to) the force of gravity. Hence, the object will STOP IT'S ACCELERATION (continue to accelerate, stop its motion, stop its acceleration, move back up to its starting position).

 Name: ______________________

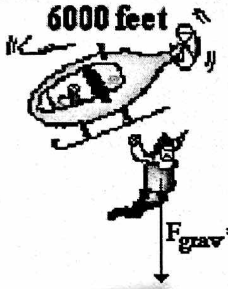
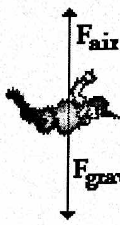
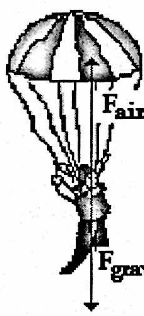
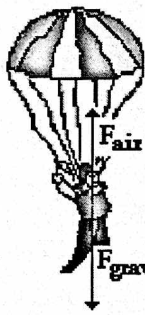
Skydiving

Read from **Lesson 3** of the **Newton's Laws** chapter at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/newtlaws/u2l3e.html

MOP Connection: Newton's Laws: sublevel 11

A 90-kg (approx.) skydiver jumps out of a helicopter at 6000 feet above the ground. As he descends, the force of air resistance acting upon him continually changes. The free-body diagrams below represent the strength and direction of the two forces acting upon the skydiver at six positions during his fall. For each diagram, apply Newton's second law ($F_{net} = m \bullet a$) to determine the acceleration value.

6000 feet  F_{grav} = 900 N a = 10 m/s/s, D	**5500 feet**  F_{air} = 200 N F_{grav} = 900 N a = 7.77 m/s/s, D	**4500 feet**  F_{air} = 900 N F_{grav} = 900 N a = 0 m/s/s
3000 feet  F_{air} = 1100 N F_{grav} = 900 N a = 2.22 m/s/s, UP	**2900 feet**  F_{air} = 1500 N F_{grav} = 900 N a = 6.66 m/s/s, UP	**1500 feet**  F_{air} = 900 N F_{grav} = 900 N a = 0 m/s/s

1. At which two altitudes has the skydiver reached terminal velocity? 4500 ft, 1500 ft
2. At which altitude(s) is the skydiver in the state of speeding up? 6000 ft, 5500 ft
3. At which altitude(s) is the skydiver in the state of slowing down? 3000 ft, 2900 ft
4. At 2900 feet, the skydiver is ___________. Choose two.
   a. moving upward (b) moving downward c. speeding up (d) slowing down
5. Explain why air resistance increases from 6000 feet to 4500 feet.

   AS YOU INCREASE $\vec{v}$, YOU HIT MORE AIR PARTICLES PER UNIT OF TIME & ∴ Fair ↑

6. Explain why air resistance decreases from 3000 feet to 1500 feet.

   AS THE PARACHUTE OPENS SURFACE AREA ↑, THUS ↑ Fair. THE SKYDIVER SLOWS DOWN AS A RESULT AS Fair > Fg. AS SKYDIVER SLOWS Fair ↓ UNTIL NEW TERMINAL $\vec{v}$ REACHED.

Newton's Second Law Problem-Solving

Study from **Lessons 3** of the **Newton's Laws** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/newtlaws/u2l3c.html
http://www.physicsclassroom.com/Class/newtlaws/u2l3d.html

For the following problems, construct a free-body diagram and show your work clearly.

A rightward force of 302 N is applied to a 28.6-kg crate to accelerate it across the floor. The coefficient of friction between the crate and the floor is 0.750. Determine the acceleration of the crate.

OMIT

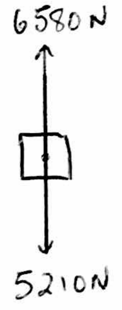
During a football workout, two linemen are pushing the coach on the sled. The combined mass of the sled and the coach is 300. kg. The coefficient of friction between the sled and the grass is 0.800. The sled accelerates at a rate of 0.580 m/s/s. Determine the force applied to the sled by the lineman.

OMIT

A 405-N rightward force is use to drag a large box across the floor with a constant velocity of 0.678 m/s. The coefficient of friction between the box and the floor is 0.795. Determine the mass of the box.

OMIT

4. A 6.58×10^3 N upward tension force is exerted on a 521-kg downward-moving freight elevator. Determine the acceleration of the elevator.

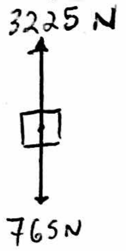


$F_g = 5210\ N$

$F_{NET} = 6580 N - 5210 N = 1370 N$, UP

$a = \frac{F_{NET}}{m} = \frac{1370 N, UP}{521 kg} = 2.63\ m/s^2$, UP

5. A basketball star exerts a force of 3225 N (average value) upon the gym floor in order to accelerate his 76.5-kg body upward. (a) Determine the acceleration of the player. (b) Determine the final speed of the player if the force endures for a time of 0.150 seconds.



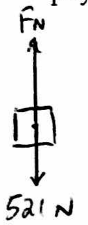
$F_g = 765\ N$

$F_{NET} = 2460\ N$, UP

a) $a = \frac{F_{NET}}{m} = \frac{2460 N, UP}{76.5\ kg} = 32.16\ m/s^2$, UP

b) $\vec{v} = \vec{a}t = (32.16\ m/s^2)(0.150 s) = 4.82\ m/s$, UP

6. At the end of the Giant Drop free fall ride, riders experience a large upward normal force to bring their falling bodies to a stop. Determine the normal force value required to accelerate a 52.1-kg physics student with an upward acceleration of 27.4 m/s/s.



$F_g = 521\ N$

$F_{NET} = m\vec{a} = (52.1\ kg)(27.4\ m/s^2) = 1427.54\ N$

$F_N = 1427.54\ N + 521\ N = 1948.54\ N$, UP

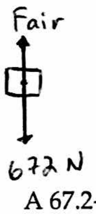
7. A hockey player accelerates a puck (m = 0.167 kg) from rest to a velocity of 50 m/s in 0.0121 sec. Determine the acceleration of the puck and the force applied by the hockey stick to the puck. Neglect resistance forces.

$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{50\ m/s}{0.0121 s} = 4132.23\ m/s^2$

$F_{NET} = F_{app} = m\vec{a} = (0.167\ kg)(4132.23\ m/s^2) = 690.08\ N$

8. A falling skydiver is accelerating in the downward direction at 3.29 m/s/s. The mass of the skydiver (including parachute gear) is 67.2 kg. Determine the air resistance force on the skydiver (and accompanying parachute).

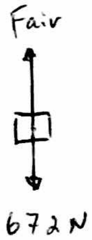
$F_g = 672\ N$



$F_{NET} = m\vec{a} = (67.2\ kg)(3.29\ m/s^2, D) = 221.09\ N$

$F_{air} = 672\ N - 221.09\ N = 450.91\ N$

9. A 67.2-kg falling skydiver opens his parachute and instantly slows down at a rate of 7.2 m/s/s. Determine the air resistance force on the skydiver (and accompanying parachute).



$F_{NET} = m\vec{a} = (67.2\ kg)(7.2\ m/s^2, UP) = 483.84\ N$, UP

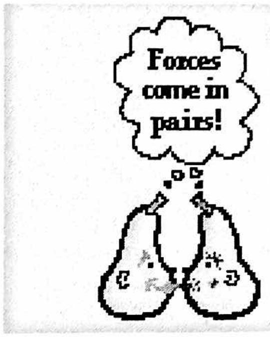
$F_{air} = 672\ N + 483.84\ N = 1155.84\ N$, UP

Newton's Third Law

Read from **Lesson 4** of the **Newton's Laws** chapter at **The Physics Classroom:**

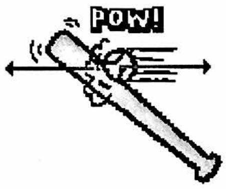
http://www.physicsclassroom.com/Class/newtlaws/u2l4a.html
http://www.physicsclassroom.com/Class/newtlaws/u2l4b.html

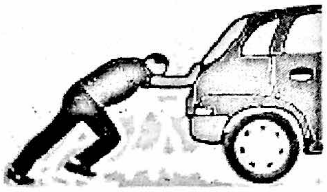
MOP Connection: Newton's Laws: sublevel 12

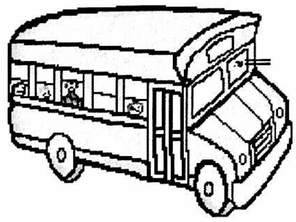


A force is a push or pull resulting from an interaction between two objects. Whenever there is a force, there are two objects involved - with both objects pushing (or pulling) on each other in opposite directions. While the direction of the pushes (or pulls) are opposite, the strength or magnitudes are equal. This is sometimes stated as Newton's Third Law of motion: *for every action, there is an equal and opposite reaction.* A force is a push or a pull and it always results from an interaction between two objects. These forces always come in pairs.

1. For each stated *action force,* identify the *reaction force.*

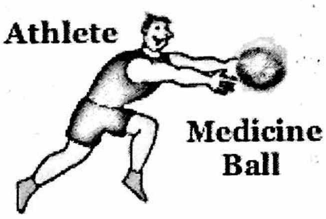
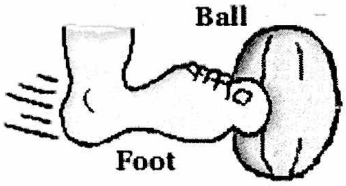






Bat hits ball.	Man pushes car.	Bus hits bug.
BALL HITS BAT	CAR PUSHES MAN	BUG HITS BUS

2. Identify by words the action-reaction force pairs in each of the following diagrams.

Athlete  **Medicine Ball**	**Foot**  **Floor**	**Ball**  **Foot**
ATHLETE PUSHES BALL BALL PUSHES ATHLETE	FOOT PUSHES FLOOR FLOOR PUSHES FOOT	FOOT KICKS BALL BALL KICKS FOOT

3. **TRUE** or **FALSE**:

As you sit in your seat in the physics classroom, the Earth pulls down upon your body with a gravitational force; the reaction force is the chair pushing upwards on your body with an equal magnitude.

If False, correct the answer.

FALSE ish - EARTH PULLS YOU, YOU PULL EARTH

4. Shirley Bored sits in her seat in the English classroom. The Earth pulls down on Shirley's body with a gravitational force of 600 N. Describe the reaction force of the force of gravity acting upon Shirley.

SHIRLEY PULLS WITH A FORCE OF 600N ON THE EARTH

5. Use Newton's third law (law of action-reaction) and Newton's second law (law of acceleration: $a = F_{net}/m$) to complete the following statements by filling in the blanks.

a. A bullet is loaded in a rifle and the trigger is pulled. The force experienced by the bullet is EQUAL TO (less than, equal to, greater than) the force experienced by the rifle. The resulting acceleration of the bullet is GREATER (less than, equal to, greater than) the resulting acceleration of the rifle.

b. A bug crashes into a high speed bus. The force experienced by the bug is EQUAL TO (less than, equal to, greater than) the force experienced by the bus. The resulting acceleration of the bug is GREATER (less than, equal to, greater than) the resulting acceleration of the bus.

c. A massive linebacker collides with a smaller halfback at midfield. The force experienced by the linebacker is EQUAL TO (less than, equal to, greater than) the force experienced by the halfback. The resulting acceleration of the linebacker is LESS THAN (less than, equal to, greater than) the resulting acceleration of the halfback.

d. The 10-ball collides with the 14-ball on the billiards table (assume equal mass balls). The force experienced by the 10-ball is EQUAL TO (less than, equal to, greater than) the force experienced by the 14-ball. The resulting acceleration of the 10-ball is EQUAL TO (less than, equal to, greater than) the resulting acceleration of the 14-ball.