Free-Body Diagrams

Read from **Lesson 2** of the **Newton's Laws** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/newtlaws/u2l2b.html
http://www.physicsclassroom.com/Class/newtlaws/u2l2c.html

MOP Connection: Newton's Laws: sublevel 5

Construct free-body diagrams for the following physical situations. Label all forces (e.g, F_{grav}, F_{norm}, F_{app}, F_{frict}, F_{air}, F_{tens}, etc.).

a. A physics book rests upon a level table.

b. A skydiver is falling and has reached a terminal velocity.

c. A large crate is being pushed leftward at a constant velocity.

d. A sledder has reached the bottom of a hill and is coasting rightward while slowing down.

e. A ball is moving upwards towards its peak. Ignore air resistance.

f. An air track glider moves rightward at constant speed.

g. The brakes are applied to a rightward moving car and it skids to a stop.

h. A spider is slowly descending a thin silk thread at constant speed.

i. A projectile is moving upwards and rightwards towards the peak of its trajectory.

j. An elevator is rising at a constant velocity; it is not touching the elevator shaft.

k. An upward rising elevator is slowing down; it is not touching the elevator shaft.

l. A force is applied to accelerate a crate across a rough horizontal surface.

Newton's Second Law

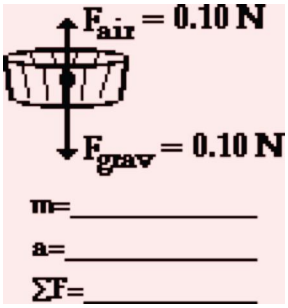
Read from **Lesson 3** of the **Newton's Laws** chapter at **The Physics Classroom**:

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

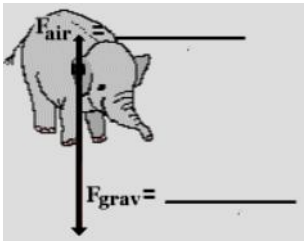
Free-body diagrams are shown for a variety of physical situations. Use Newton's second law of motion ($\sum F = m \bullet a$) to fill in all blanks. Use the approximation that g = ~10 m/s/s.

a.



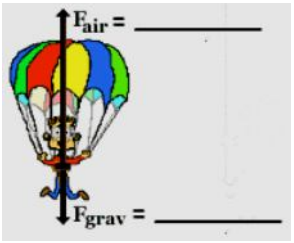
m=_____
a=_____
ΣF=_____

b.



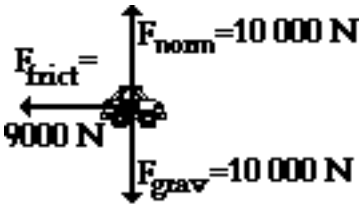
m=10000 kg
a = 8.0 m/s/s, down
ΣF = _____

c.



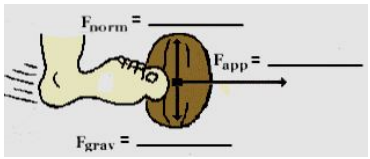
m=800 kg
a = 6.0 m/s/s, up
ΣF = _____

d.



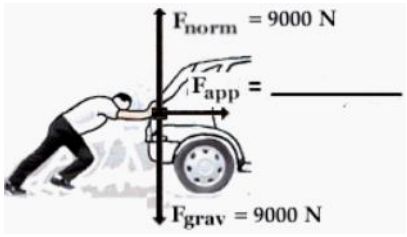
m=_____
a=_____
ΣF=_____

e.



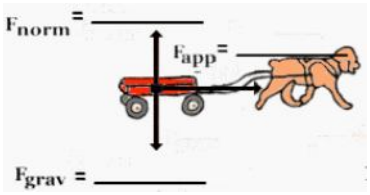
m=0.500 kg
a = _____
ΣF = 124 N, right

f.



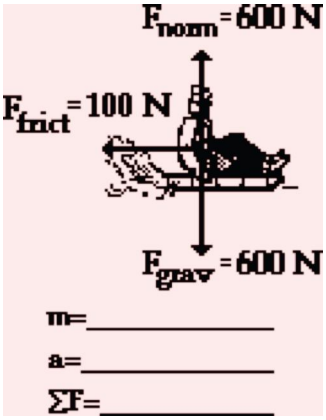
m= _____
a = 1.50 m/s/s, right
ΣF = _____

g.



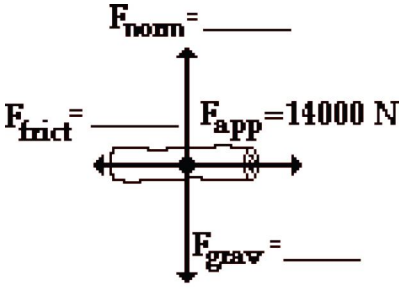
m=15.0 kg
a = 0.50 m/s/s, right
ΣF = _____

h.



m=_____
a=_____
ΣF=_____

i.



m=2000 kg
a= 2.0 m/s/s, right
ΣF=_____

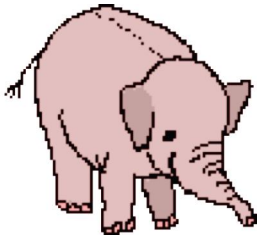
Air Resistance and Terminal Velocity

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

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

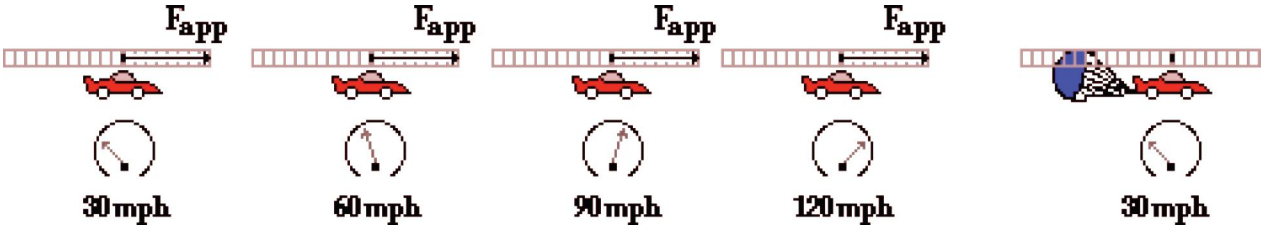
MOP Connection: Newton's Laws: sublevel 11

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

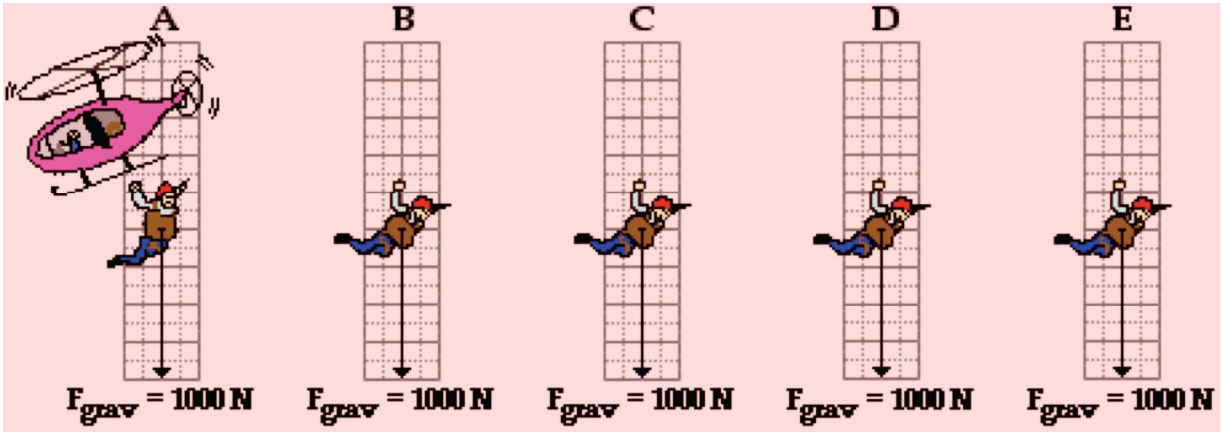


2. Which of the following variables will have a direct effect upon the amount of air resistance experienced by an object? (That is, for which of these quantities will an increase lead to a resulting increase in the air resistance force?)
   a. speed b. air density c. cross-sectional area

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, decreases) until a state of terminal velocity is reached. Once terminal velocity is reached, the force of air resistance is _____ (greater than, less than, equal to) the force of gravity. Hence, the object will _____ (continue to accelerate, stop its motion, stop its acceleration, move back up to its starting position).

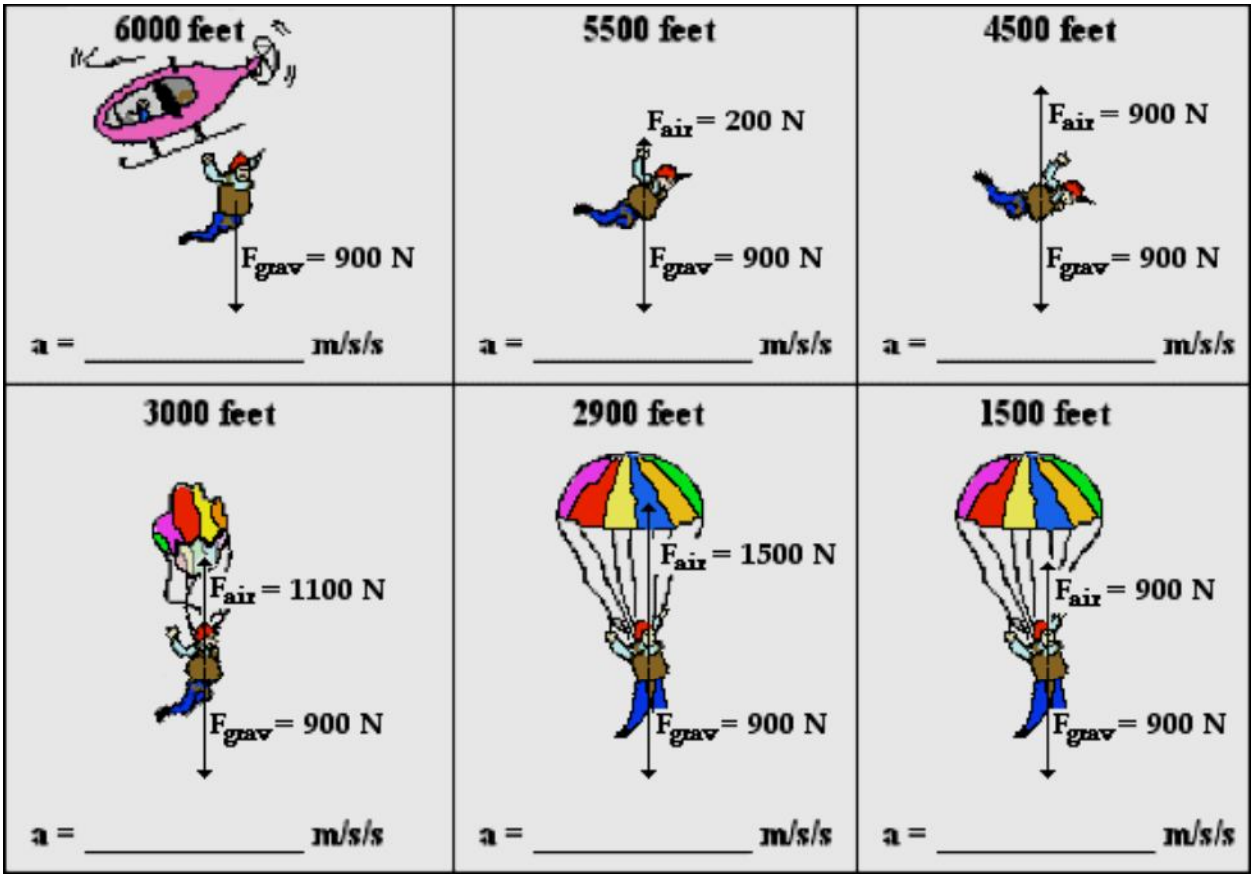
Skydiving

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.



1. At which two altitudes has the skydiver reached terminal velocity? _____
2. At which altitude(s) is the skydiver in the state of speeding up? _____
3. At which altitude(s) is the skydiver in the state of slowing down? _____
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.

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

