Air Resistance and Terminal Velocity

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

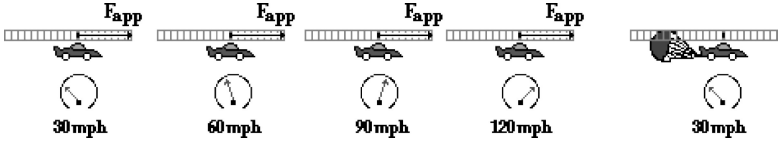
http://www.physicsclassroom.com/Class/newtlaws/u2l3e.html

MOP Connection: Newton's Laws: sublevel 11

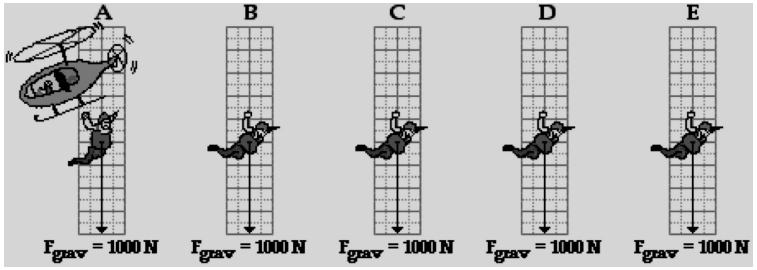
1. When falling under the influence of air resistance and dropped from the same height, which will fall to the ground at a faster rate?
   a. a mouse b. an elephant c. the same

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

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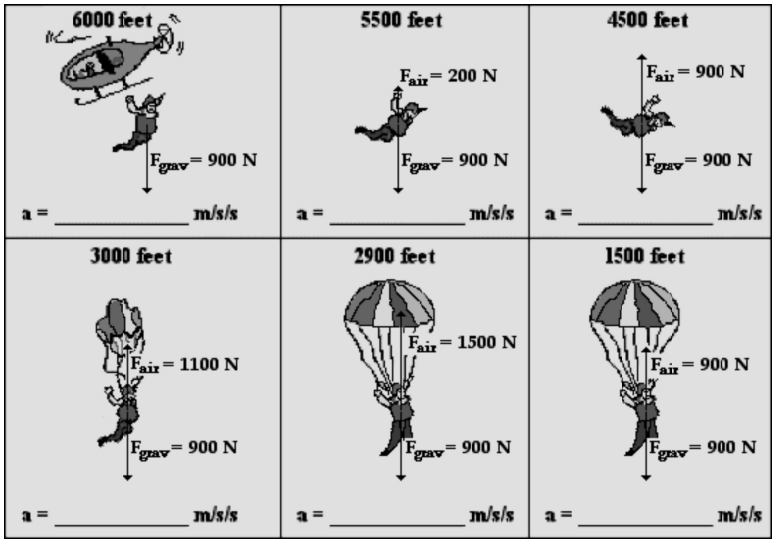
MOP Connection: Newton's Laws: sublevel 11

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.

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 an 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?

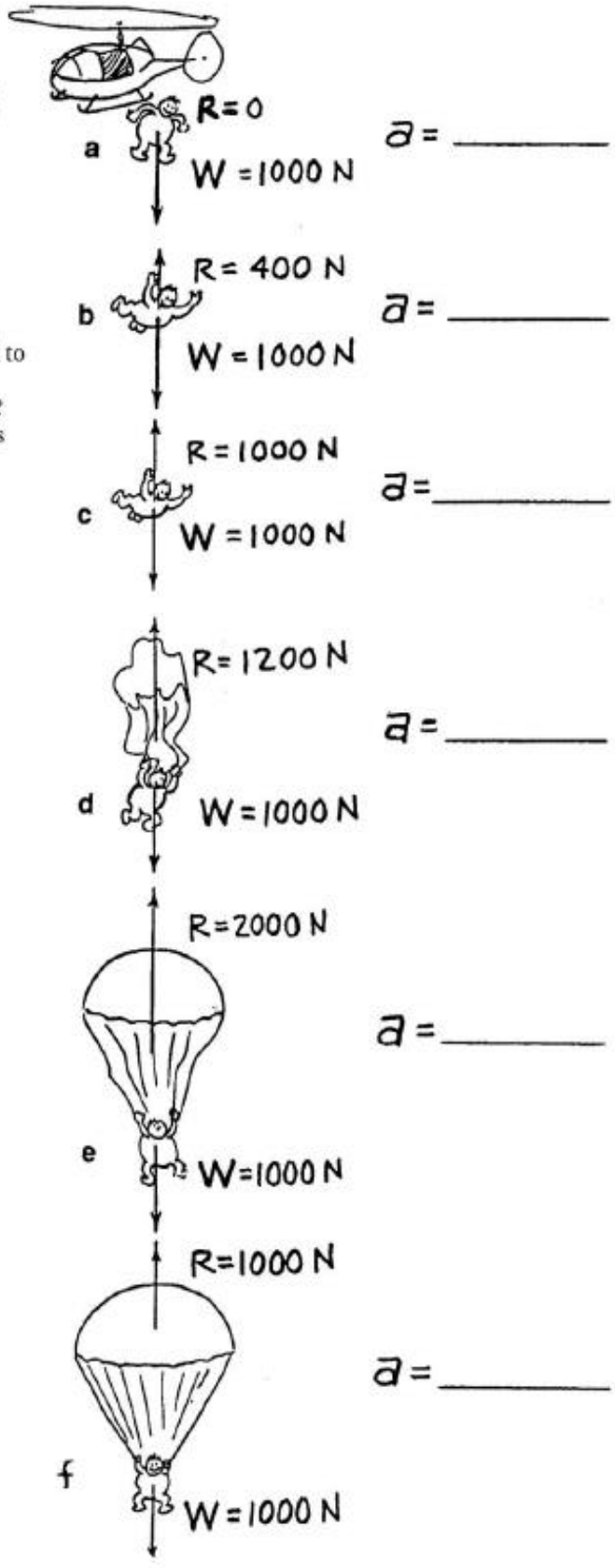
   (a) (b) (c) (d) (e) (f)

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).



Conceptual PHYSICS