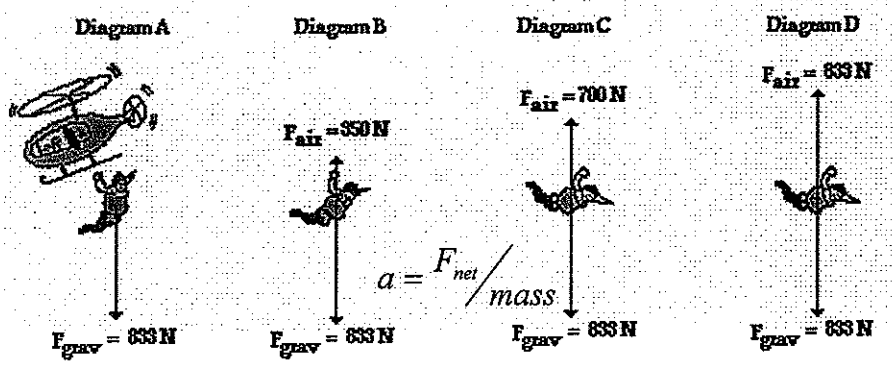
Terminal Velocity

The fastest something can move because of the resistance it encounters.

Why does an object that encounters air resistance eventually reach a terminal velocity? To answer this questions, Newton's second law will be applied to the motion of a falling skydiver.

In the diagrams to the right, free-body diagrams showing the forces acting upon an 85-kg skydiver (equipment included) are shown. For each case, use the diagrams to determine the net force and acceleration of the skydiver at each instant in time.



$a = F_{net} / mass$

$a = \frac{-833N}{85kg} = -9.8m/s^2$

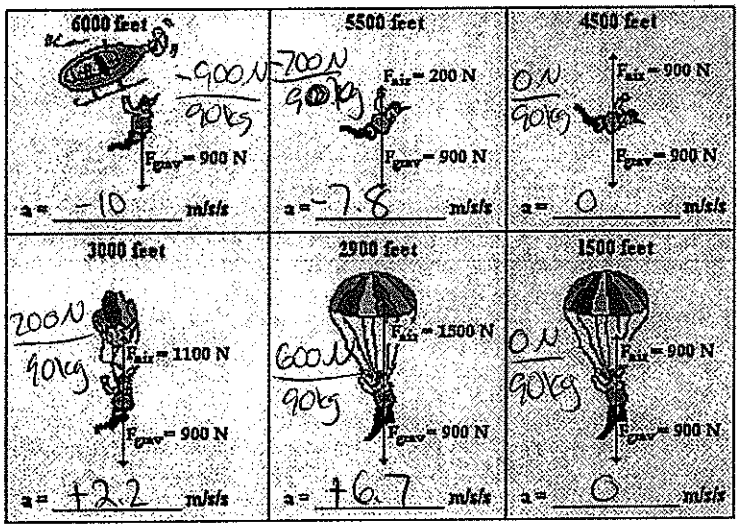
$a = \frac{-833N + 700N}{85kg} = -1.6m/s^2$

$a = \frac{-833N + 350N}{85kg} = -5.7m/s^2$

$a = \frac{-833N + 833N}{85kg} = 0m/s^2$

The diagrams illustrate a key principle. As an object falls, it picks up speed. The increase in speed leads to an increase in the amount of air resistance. Eventually, the force of air resistance becomes large enough to balances the force of gravity. At this instant in time, the net force is 0 Newton; the object will stop accelerating. The object is said to have reached a **terminal velocity**. The change in velocity terminates as a result of the balance of forces. The velocity at which this happens is called the terminal velocity.

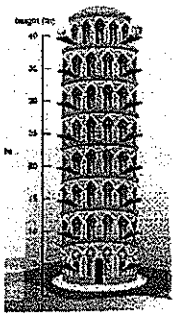
A 90-kg (approx.) skydiver jumps out of a helicopter at 6000 feet above the ground.
As he descends, the force of air resistance acting upon him continually changes.
For each diagram, apply Newton's second law (Fnet = m•a) to determine the acceleration value.

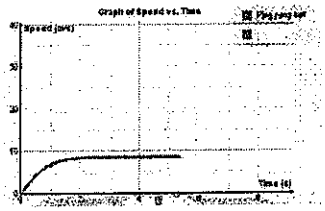


1. At which two altitudes has the skydiver reached terminal velocity?
   6000 Ft & 1500 Ft
2. At which altitude(s) is the skydiver in the state of speeding up?
   6000 Ft & 5500 Ft
3. At which altitude(s) is the skydiver in the state of slowing down?
   3000 Ft & 2900 Ft
4. At 2900 feet, the skydiver 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.
   Speed increases
6. Explain why air resistance decreases from 3000 feet to 1500 feet.
   area of chute increases

Galileo dropped a ping pong ball and a golf ball off of the Tower of Pisa. Each of the balls have parachutes that can be deployed at any time.

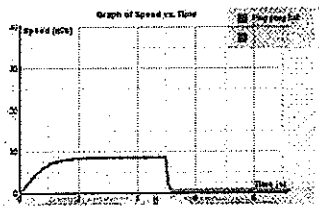
Using your knowledge of freefall and graphs, answer the following questions.





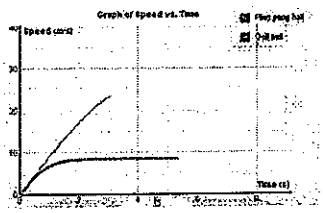
The Ping pong ball, only, was dropped.

1. What is the ball's terminal velocity?
   ≈ 9m/s



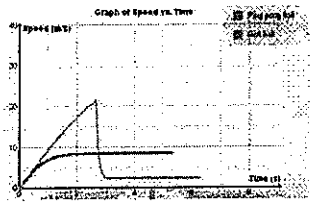
The Ping pong ball, only, was dropped.

2. By inferring from the graph, what happened to the ping pong ball to change it's terminal velocity?
   Parachute engaged



The Ping pong ball, and golf ball were both dropped.

3. Which has the greater terminal velocity?
   Golf Ball
4. Why
   Heavier object, takes longer for air resistance to equal



The Ping pong ball, and golf ball were both dropped.

5. By making inferences from the graph, what happened to the two balls after they were dropped?
   Parachute where engaged