

# Acceleration for falling objects

## **OBJECTIVES:**

- Apply  $F=ma$  law to explain why the acceleration of an object in free fall does not depend on the mass of the object.
- Describe what happens to the acceleration and the velocity of a falling object in the presence of air drag.



# Acceleration of Falling Objects

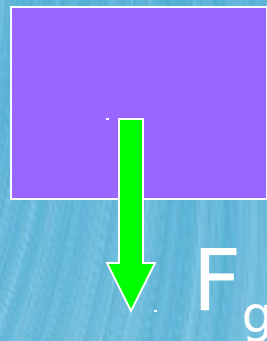
- ▲ Galileo Galilei proved "common sense" wrong when he showed that heavier objects do not fall faster than lighter objects.
- ▲ He showed this by experimenting.





# Acceleration of Falling Objects

- ▲ When an object is falling only under the influence of gravity, we say the object is in free fall.
- ▲ While in free fall, other forces such as air drag can be neglected.

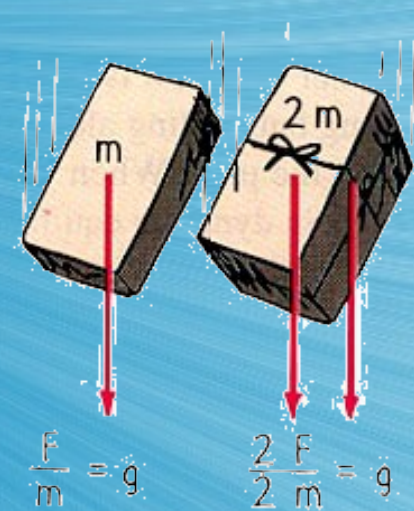


- ▲ Air drag, or air resistance, is a force of friction that usually opposes the motion of an object.



# Acceleration of Falling Objects

- ▲ Gravitational **force** (weight) is directly related to mass.
- ▲ Double the mass and the gravitational force will also be doubled.



- ▲ The acceleration of a falling object due to gravity can be calculated using  $\Sigma F = ma$ :

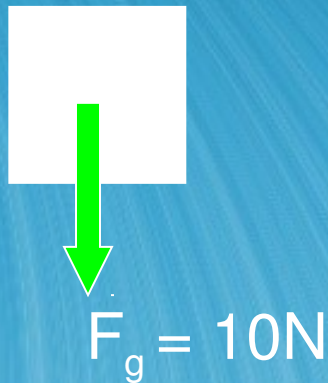
$$a = \frac{\Sigma F}{m}$$

- ▲ If no air drag is present, the answer is always  $a = \underline{9.8\text{m/s}^2}$  = the acceleration due to gravity
- ▲ In this class, we will round this to  $10 \text{ m/s}^2$



# Acceleration of Falling Objects

- ▲ Gravity pulls on a 1 kg object with a force of 10N. Assume there is no air drag.
- ▲ Draw a free body diagram for this object.



- ▲ Calculate the acceleration of the object due to this force.

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

# Acceleration of Falling Objects

- ▲ Gravity pulls on a 75 kg object with a force of 750N. Assume there is no air drag.
- ▲ Draw a free body diagram for this object.



$$F_g = 750\text{N}$$

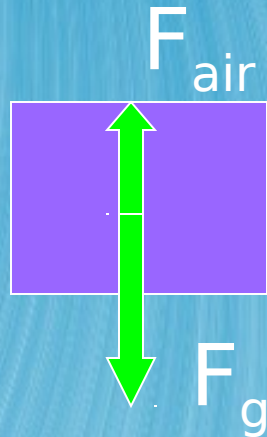
- ▲ Calculate the acceleration of the object due to this force.

$$a = \frac{\Sigma F}{m} = \frac{750\text{N}}{75\text{kg}} = 10 \text{ m/s}^2$$



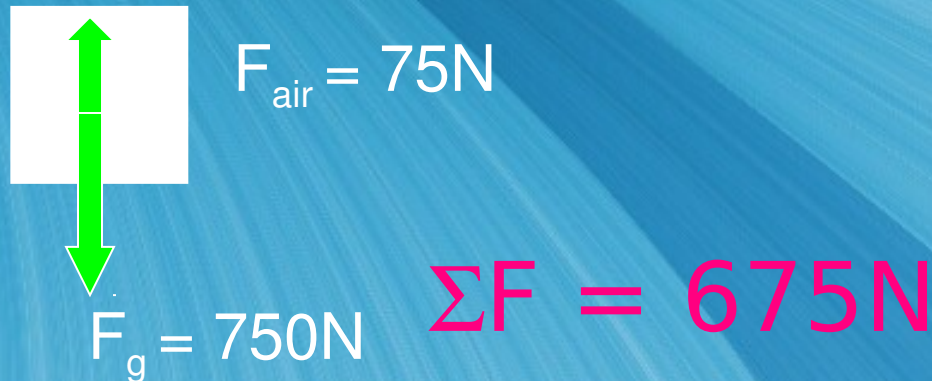
# Acceleration of Falling Objects

- ▲ Usually, the air drag on a falling object is not negligible.
- ▲ Because of this, the acceleration on a falling object is usually less than  $10\text{m/s}^2$ .



# Acceleration of Falling Objects

- ▲ Gravity pulls on a 75 kg object with a force of 750N. Air drag pushes on the object with a force of 75N.
- ▲ Draw a free body diagram for this object.



- ▲ Calculate the acceleration of the object due to this force.

$$a = \frac{\Sigma F}{m} = \frac{675\text{N}}{75\text{kg}} = 9 \text{ m/s}^2$$



# Acceleration of Falling Objects

▲ Air drag depends on two things:

▲ 1) The speed of the falling object

▲ 2) The surface area of the falling object



# Acceleration of Falling Objects

- ▲ When the force due to air drag is equal to the force due to weight, the object reaches a terminal velocity.
- ▲ At this time, the net force on the object is equal to zero and no acceleration occurs.
- ▲ Terminal velocity is a constant velocity.

