Mass and Weight

- Mass m:

The quantity of matter in an object. It is also the measure of the inertia or sluggishness that an object exhibits in response to any effort made to start it, stop it, or change its state of motion in any way.

- Weight w:

Usually the force upon an object due to gravity.

Mass and Weight, Continued

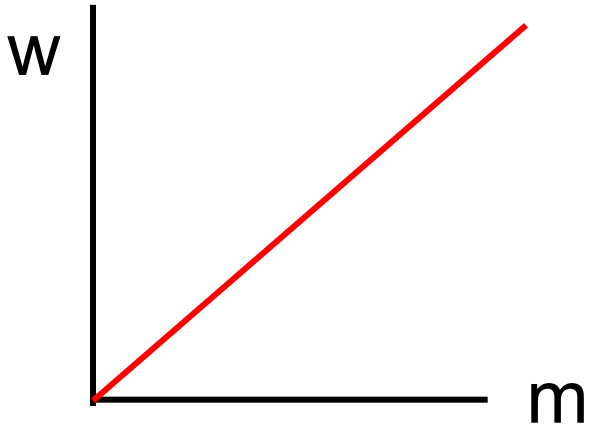
- Mass
  - A measure of the inertia of a material object
  - Independent of gravity
  - Greater inertia ⇒ greater mass
  - Unit of measurement is the kilogram (kg)

- Weight
  - Usually the **force** on an object due to gravity
  - Scientific unit of force is the newton (N)
  - Unit is also the pound (lb)

It is easy to confuse mass and weight because:

Weight and mass are directly proportional:

$w \sim m$



2x more mass means…

3x more mass means….

(1/4) as much mass means….

2x more weight…

3x more weight

(1/4)x as much weight

Mass—A Measure of Inertia
CHECK YOUR NEIGHBOR

If the mass of an object is halved, the weight of the object is

A. halved.
B. twice.
C. depends on location.
D. None of the above.

Mass—A Measure of Inertia
CHECK YOUR ANSWER

If the mass of an object is halved, the weight of the object is

A. halved.

Comment:

Weight and mass are directly proportional to each other.

Ex. Testing weight and mass:

To test which of 2 objects is heavier:

1st test: we hold them still in our hands.

This tests weight. Why?

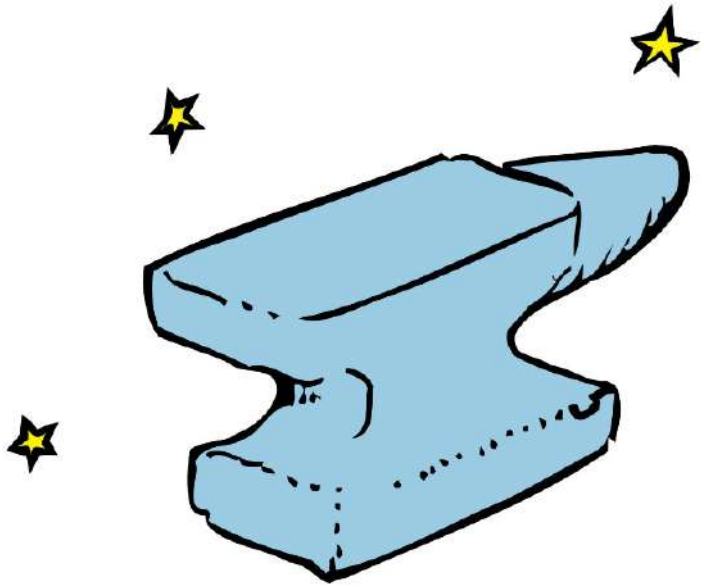
If the weights are very close, we apply the…

2nd test: gently move both side to side (or up and dosn). This is called *hefting*.

Hefting tests mass. Why?

Mass and Weight, Continued-1

- Mass and weight in everyday conversation are interchangeable.
- Mass, however, is different and more fundamental than weight.
- Mass versus weight
  - On the Moon and Earth:
    - Weight of an object on the Moon is less than on Earth.
    - Mass of an object is the same in both locations.



How to calculate weight w from mass m:

Weight w = mass m x the acceleration due to gravity

$$\mathbf{w = m \cdot g}$$

Where *w* is in newtons, *m* is in kilograms and $g = 9.8\ m/s^2$

Using $g \approx 10\ m/s^2$, it is easy to calculate weight of an object on Earth's surface:

$$\mathbf{w = m \cdot (10\ m/s^2)}$$

Ex. What is the weight in newtons of 2-kg text book?

$$\mathbf{w = m \cdot (10\ m/s^2)}$$

$$\mathbf{= (2\ kg)\ m/s^2)}$$

$$\mathbf{= 20\ kg \cdot m/s^2 = 20\ N}$$

Conversions:

- 1 kilogram weighs 10 newtons (9.8 newtons, to be precise).

- Relationship between kilograms and pounds:
  - 1 kg = 2.2 lb = 10 N at Earth's surface
  - 1 lb = 4.45 N

Ex. What is the weight in pounds of a 20-N textbook?

$$\mathbf{w = 20\ N} \times \frac{1\ lb}{4.45\ N} =$$

Examples:

36. Calculate the weight in newtons of a person who has a mass of 50 kg.

$$w = m \cdot (10\ m/s^2)$$

$$= (50\ kg)\ m/s^2)$$

$$= 500\ kg \cdot m/s^2 = 500\ N$$

Use 1 lb = 4.45 N to convert N to pounds.

$$w = 500\ N \times \frac{1\ lb}{4.45\ N} =$$

39. A small apple weighs about 1 N. What is its mass in kilograms? What is its weight in pounds?

$$w = m \cdot (10\ m/s^2)$$

$$1\ N = (m)\ (10\ m/s^2)$$

$$m = \frac{1\ N}{10\ m/s^2}$$

$$= 0.1\ \frac{N}{m/s^2}$$

$$= 0.1\ kg$$

Mass is the same everywhere
Weight depends on the strength of gravity

Ex. On the Moon, g_{moon} = (1/6) of Earth's g

So weights on the Moon are:

$$w = m \cdot g_{moon} = m \left(\frac{10\ m/s^2}{6}\right)$$

This is 1/6 of the weight on Earth

Ex. In space, far away from any gravity sources like stars, planets, galaxies, etc, the value of g is:

$$g_{space} = 0$$

So weights in space are:

$$w = m \cdot g_{space} = m\ (0) = ????$$

Ex. A 1-kg mass weighs 10 N on Earth's surface.

A) What is its mass on the Moon? **1-kg**

B) What is its mass in outer space? **1-kg**

C) Which changes, *mass* or *weight*? **weight**

D) Which is more fundamental, *mass* or *weight*?

mass

Mass, inertia, volume and weight:

1. Does a 2-kg iron brick have twice as much *inertia* as a 1-kg iron brick? Twice as much *mass*? Twice as much *volume*? Twice as much *weight*?

2. In which case would it be easier to lift a cement truck: on Earth's surface or on the Moon's surface?

Ex. Mass versus weight

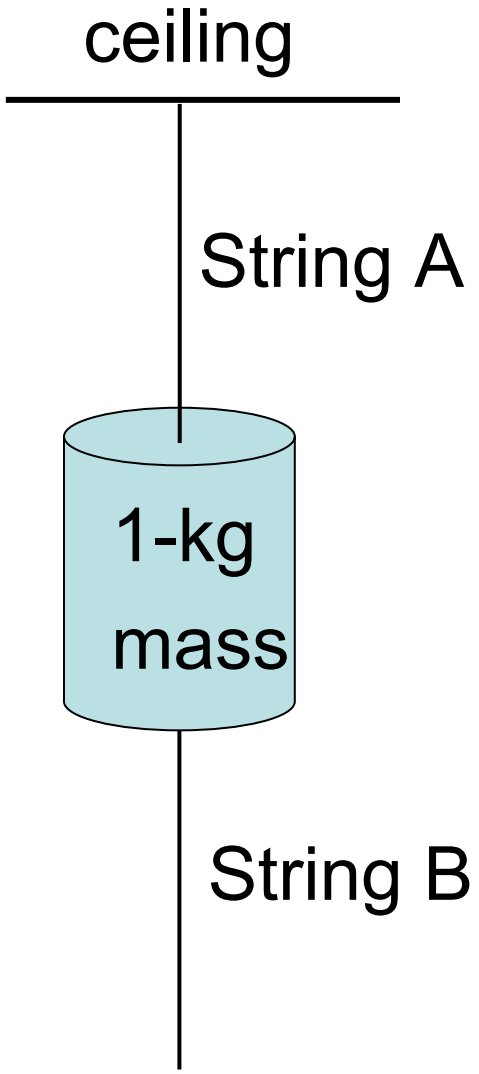
A 1-kg mass is hung from the ceiling with strings as shown here:

Which string is more likely to break if you pull down on B *quickly*?

Why?

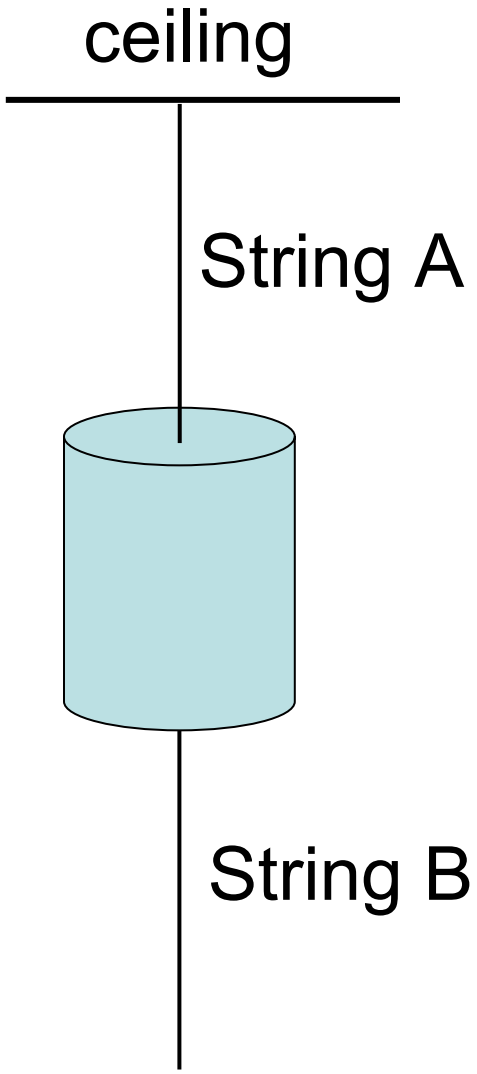
If you pull B down *slowly*?

Why?

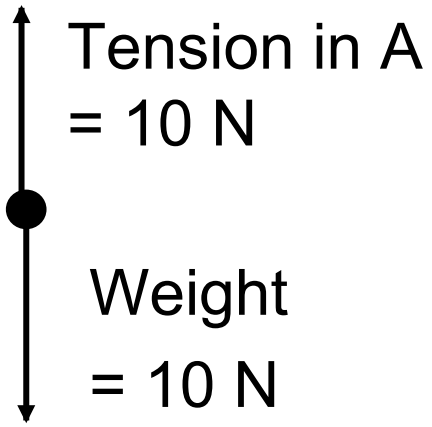


Slow pull on B:

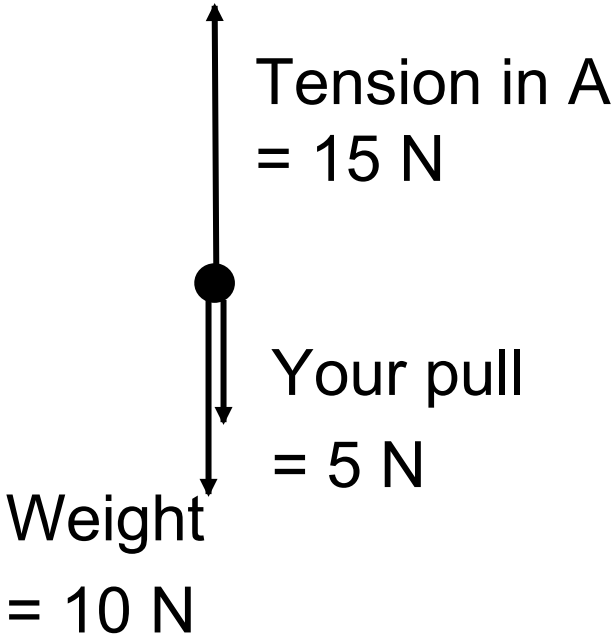
Look at the forces acting on the mass:



Before you pull down:



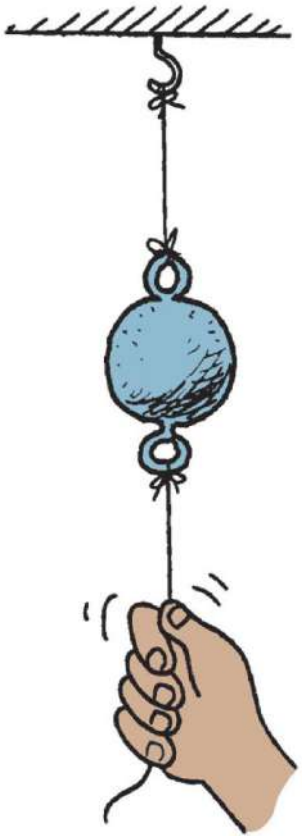
When you pull down:



Mass and Weight
CHECK YOUR NEIGHBOR

When the string is pulled down slowly, the top string breaks, which best illustrates the

A. weight of the ball.
B. mass of the ball.
C. volume of the ball.
D. density of the ball.



Mass and Weight
CHECK YOUR ANSWER

When the string is pulled down slowly, the top string breaks, which best illustrates the

A. weight of the ball.

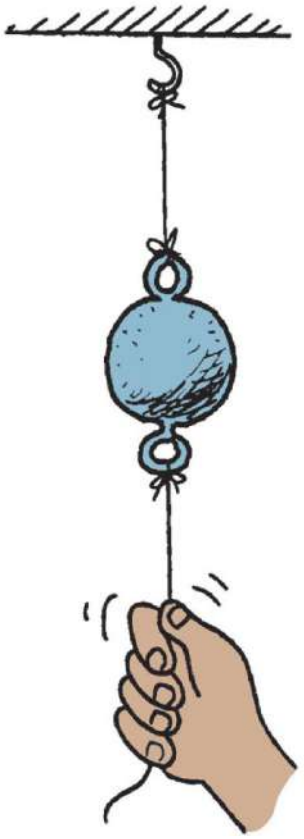
Explanation:

Tension in the top string is the pulling tension *plus* the weight of the ball, both of which break the top string.

Mass and Weight
CHECK YOUR NEIGHBOR, Continued

When the string is pulled down quickly, the bottom string breaks, which best illustrates the

A. weight of the ball.
B. mass of the ball.
C. volume of the ball.
D. density of the ball.



Mass and Weight
CHECK YOUR ANSWER, Continued

When the string is pulled down quickly, the bottom string breaks, which best illustrates the

B. mass of the ball.

Explanation:

It is the "laziness" of the ball that tends to keep it at rest, resulting in the breaking of the bottom string.

New homework: due Thursday @4 pm

On page 68, do #8-14

On page 69: do 37, 38 and 40

On these you must show your work to get credit.

This means:

A) copy the equation without numbers

B) Show how you substitute values with units

C) Show your answer with correct units.