Motion and Forces

Speed

- Speed is an indicator of "how fast" something is moving.
- There are many possible units for speed:
  Km/h , miles/h , m/s ,
- We will use the symbol v to represent speed.

Distance

- Distance is the length of the path traveled.
- Some common units for distance are:
  km, m, miles, cm, lightyear
- Note: 1000 m = 1 km
- We will use the symbol d to represent distance.

Time difference

- Time difference is the amount of time elapsed. We sometimes call it the time interval.
- Some common units for time are:
  h, s, min
- Note: 1 h = 60 min, 1 min = 60 s, 1h = 3600s
- We will use the symbol Δt to represent time difference.

Speed, distance and time

- There is a relationship between speed, distance and time. It is represented by the following formula:

$$v = \frac{d}{\Delta t}$$

km, h, km/h

m, s, m/s

- Note: the units must MATCH!

Examples

- What is the speed of a dog that can run 40 m in 8.0 s?

v? d Δt

$$v = \frac{d}{\Delta t} = \frac{40\text{m}}{8.0\text{s}} = 5.0\text{m/s}$$

Examples

- How long will it take a car going 105 km/h to travel 250 km?

$v = \frac{d}{\Delta t} \rightarrow \frac{105\,km/h}{1} = \frac{250\,km}{x}$

$x = \frac{1 \times 250\,km}{105\,km/h}$

$= 2.38\,h$

Examples

- A cyclist rides his bike at a speed of 15 km/h. How far will this cyclist travel in 41 minute?

$\frac{41\,min}{60\,min} = 0.68\,h$

$v = \frac{d}{\Delta t} \quad \frac{15\,km}{1\,h} = \frac{x}{0.68\,h}$

$x = 15\,\frac{km}{h} \times 0.68\,h$

$= 10.2\,km$

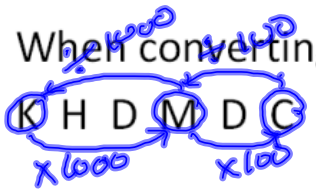
Summary of units

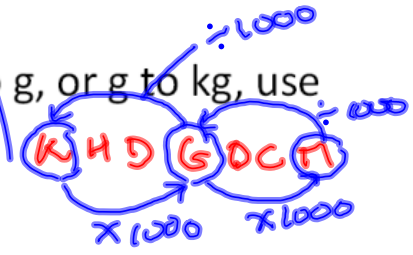
- Units of speed
  - m/s (meters per second)
  - Km/h (kilometers per hour)
- Units of time
  - h (hours)
  - min (minutes)
  - s (seconds)
- Units of distance
  - cm (centimeter)
  - km (kiloneter)
  - m (meters)

Converting units reminder

- When converting kg to g, or g to kg, use

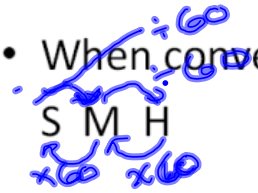
K H D M D C M





- When converting between s, min, h, use

S M H



Examples

① Convert 6.5kg to g.

$6.5\text{kg} \times 1000 = 6500\text{g}$

② Convert 250g to kg.

$250\text{g} \div 1000 = 0.25\text{kg}$

Examples

③ How many km in 750m?

$750\text{m} \div 1000 = 0.75\text{km}$

④ How many hours in 50 minutes?

$50\text{min} \div 60 = 0.833\text{h}$

⑤ Convert 4 min to s?

$4\text{min} \times 60 = 240\text{s}$

What is a force?

- A force is a pull or a push.
- A force must have a size and a direction.
- Force is measured in Newtons (N).
- The symbol for force is F.

↳ use subscripts to identify many forces

Weight (force due to gravity)

- All objects are subjected to the force of gravity. (on Earth)
- The symbol for the force due to gravity is

F_g

Mass vs. Weight

- Mass is the quantity of matter in an object

*does not change

- Weight is the force due to gravity acting on an object.

On another planet
- mass is the same
- weight does change (it would be different)

Calculating Weight

- There is a relation between mass and weight. → F_g
- The formula is:

$$F_g = m \times g$$

F_g = weight (in N)

m = mass (in kg)

g = gravitational constant

$g = 9.8 \frac{N}{kg}$ (on earth)

↑ units

More on the gravitational constant (g)

- On Earth g = 9.8 N/kg.
- Sometimes, we say that the acceleration is 9.8 m/s^2 .
- On other planets (or on the moon!) The gravitational constant is different.
  ex: on the moon, g = 1.6 N/kg

Examples:

1. What is the weight of a 50 kg box?

$F_g = ?$ mass

$F_g = mg$

$= (50kg)(9.8 \frac{N}{kg})$

$= 490N$

Examples

2. Gravity exerts a force of 200 N on a toy. What is the mass of the toy?

F_g

$m = ?$

$F_g = m \times 9.8 \frac{N}{kg}$

$200N = m \times 9.8 \frac{N}{kg}$

$m = \frac{200N}{9.8\ N/kg} = 20.4\ kg$

Examples:

3. On the moon, the gravitational constant is 1.6 N/kg. What is the weight of an 87 kg astronaut on the moon?

$F_g = ?$

$F_g = m \times 1.6 \frac{N}{kg}$

$= 87kg \times 1.6 \frac{N}{kg}$

$= 139.2N$

Examples:

$\frac{15.2\,N}{3.8\,N/kg} = \frac{x}{9.8\,N/kg}$

$x = (15.2)(9.8\,N/kg)/3.8\,N/kg$

4. A hammer has a weight of 15.2 N on Mars, where the gravitational constant is 3.8 N/kg. What would be the weight of this hammer on Earth? $= 37.2\,N$

Mars

$F_g = mg$

$15.2\,N = m(3.8\,N/kg)$

$m = \frac{15.2\,N}{3.8\,N/kg}$

$= 4.0\,kg$

Earth

$F_g = mg$

$= (4.0\,kg)(9.8\,N/kg)$

$= 39.2\,N$

Examples:

5. A probe has a weight of 53.9 N on earth. This probe is sent to Venus, where it has a weight of 48.95 N. What is the gravitational constant on Venus?

Earth

$\frac{53.9\,N}{9.8\,N/kg} = \frac{48.95\,N}{x}$

$x = \frac{(9.8\,N/kg)(48.95\,N)}{53.9\,N} = 8.9\,N/kg$

Simultaneous Forces

- Sometimes, multiple forces can be acting on an object at the same time.
- We must take the direction of forces into consideration when we combine forces.
- On diagrams, we use  to represent forces.

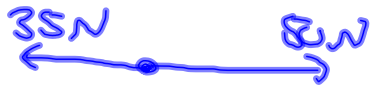
Net Force (F_{net})

- The net force is the combination (addition) of the forces applied to an object

- F_{net} is sum of forces.

Examples

1. Two dogs pull on a toy. One dog pulls to the right with 50 N, the other dog pulls to the left with 35 N. What is the net force applied to the toy?



$F_{net} = 50N - 35N$

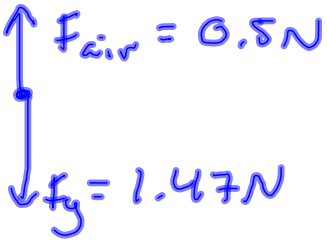
$= 15N$ Right

Examples

$F_g = (0.15kg)(9.8\frac{N}{kg})$

$= 1.47N$

2. A 150 g apple falls to the ground. Air resistance slows the apple down with a force of 0.5 N. What is the net force on the apple?



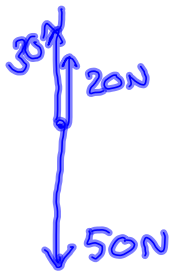
$F_{net} = 1.47N - 0.5N$

$= 0.97N$, down

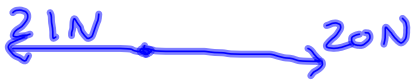
Equilibrium

- We say that an object is in equilibrium
  - The net force is zero
  - Force "cancel out"

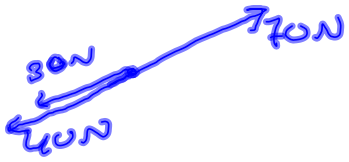
- For example:



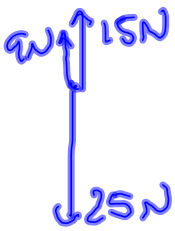
Are the following in equilibrium?

1) 

No!

2) 

Yes!

3) 

No!

The following are in equilibrium.
Find the missing force

1)

$F = 60N - 40N$
$= 20N$

2)

$F = (50N + 30N) - 20N$
$= 60N$

Quiz Monday
→ mass + weight ($F_g = mg$)
→ Fnet
→ Equilibrium

The effect of forces.

- On a moving object
  - → Slow down
  - → Speed up
  - → turn / change direction

  } changes the motion of object

- Forces can also deform (change the shape of) an object.
  ex: kicking a soccer ball

Other forces

1) Nuclear forces (hold the atom together)

2) Contact force
   - friction
   - push, pull
   -