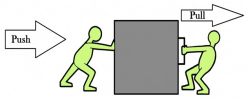
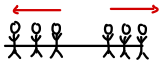
Force and Motion

What is **Force**?
Force is the push or pull acting on an object.

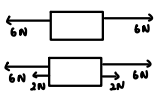


example: pushing and pulling of an object with both same and different directions.

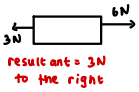


In the game tug of war (also known as tarik tambang, in Bahasa Indonesia), played on Independence day celebration, people pull the rope to the direction where they are standing. This is also an example of force in real life.

What are **Balanced** and **Unbalanced Forces**?
- Balanced Force: When two forces acting on an object are equal in size but act in opposite directions.
- Unbalanced Force: When two forces acting on an object are not equal in size.



When the forces acting on an object are equal (resultant = 0), this is called balanced force.



resultant = 3N to the right

When the forces acting on an object are NOT equal (resultant ≠ 0), this is called unbalanced force.

What is **Motion**?
Motion is the movement of an object

a car is moving, this means the car has motion

Meanwhile, the box doesn't move at all. It stands still. This means the box has no motion.

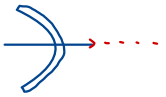
What do **Stationary Objects** mean?
Stationary Objects are objects which remain fixed at its place. These objects do not move.

A box which is NOT moving is called a Stationary object because there isn't any force applied on it.

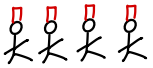
When you are standing still, you are also Stationary because you have No motion.

What are the **4 types of Motion?**

1. **Rectilinear** Motion
   Rectilinear motion is motion in a **straight line**.



when you fire an arrow, the arrow will go on a straight path. This is an example of a rectilinear motion.

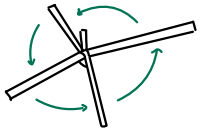


when soldiers march, they also move on a straight path, another example of rectilinear motion.

For Example:
- When you fire a bullet, it goes through a straight line.
- The motion of a cyclist racing on a straight road.
- Soldiers marching forward.
- The motion of a sprinter running on a straight track.

2. **Circular** Motion
   Circular motion is motion along a **circular path**.

The satellites above the earth move around the earth along a circular path. They are not stationary, so they move all the time.



A ceiling fan's blades moves along a circular path, so it has a circular motion.

A merry-go-round in a carnival moves along a circular path, so it has circular motion.

For Example:
- Movement of satellites around the Earth.
- Movement of all planets around the Sun.
- The motion of mixing flour when making a bread.
- The motion of a ceiling fan.
- The motion of a merry go round.

3. **Periodic** Motion
   The motion which repeats itself after regular intervals of time, is called **periodic motion**.

metronome

pendulum clock

For Example:
- The motion of a metronome. (moves left and right every 1 second (for example))
- The motion of an old pendulum clock. (the pendulum moves left and right after one second)
- The rotation of the Earth, because the Earth always takes the same time to rotate once on its axis.

4. **Rotational** Motion
   When an object turns (or spins) about a fixed axis, it is called **rotational motion**.

For Example: Spinning Top, the spinning of Earth on its axis, and turning of bicycle wheel.

The difference between **Circular and Rotational** Motion:
In circular motion, an object as a whole travels along a circular path.
But in rotational motion, the object spins on its axis.

Objects that have **more than one type of Motion:**

1. **Earth (Circular, Periodic, Rotational)**
   The Earth moves along the Sun, so it has circular motion. The Earth also goes around the sun after regular intervals of time (same amount of time which is 365 days), so it has periodic motion. Finally, the Earth rotates on its axis, so it has rotational motion.

2. **Bicycle (Rotational and Rectilinear)**
   A bicycle is moving on a straight road, so it has rectilinear motion. The wheel of a bicycle is also moving on an axis, so it also has rotational motion.

3. **Sewing Machine (Rotational and Periodic)**
   The sewing machine has a wheel which rotates on an axis, so it has rotational motion. The sewing machine also goes up and down continuously with the same interval, so it also has periodic motion.

Newton's 3 Laws of Motion:

1. **First Law**: An object at rest stays at rest unless a force acts on it, and an object in motion stays in motion unless a force acts on it.

(net force = 0)
no change in motion

A box will not move until you push or pull or apply any force to it. It will remain stationary unless a force is applied.

A car that is moving will keep moving unless it is stopped.

Usually, a person brakes the car so that it slows down and eventually stop.

2. **Second Law**: An object's acceleration (change in speed) depends on the mass of the object and the amount of force applied on it.

(net force ≠ 0)
acceleration is present

A car that goes faster every second has acceleration.

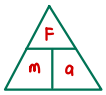
Usually, when you start a car from 0 km/h to 40 km/h will have an acceleration.

Acceleration depends on distance (m) and time (s), that is why the unit of acceleration is m/s^2.

$$F = m \times a$$

F = force (measured in N or newtons)
m = mass (measured in kg or kilograms)
a = acceleration (measured in m/s^2 or meters per second squared)

Triangle to memorize formula:



$F = m \times a$

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

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

3. **Third Law**: Every action has an equal and opposite reaction.

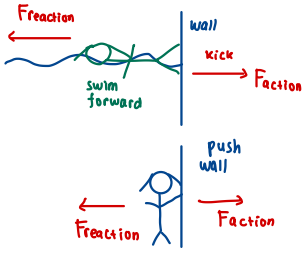
(net force ≠ 0)
opposite direction of force

$F_{action} = -F_{reaction}$
or
$F_{action} = F_{reaction}$

(the minus sign only tells you that the Freaction is moving the opposite direction, so you don't need to worry, they are the same.

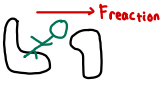
When you swim and kick the wall, you apply force to the wall (Faction).

You will get the reaction force which is the push that helps you swim forward (Freaction) which is the opposite direction.



When your car goes too fast and you hit the brake suddenly, you apply force to the car

the reaction force is you are going to suddenly feel a push to the front of the car.



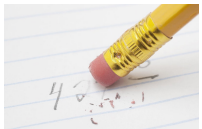
What is **Inertia**?
Inertia is the tendency of an object to resist changes in its state of motion.

Why will the coin drop into the glass when a force accelerates the card?

when the paper is pulled, the coin falls into the glass. This is because the inertia of the coin maintains its state at rest and it falls down into the glass due to gravity.

- When you flip a coin in a high-speed airplane, it behaves as if the airplane were at rest.
- The coin keeps up with you.

What is **Friction**?
Friction is a force that is created when two surfaces move or try to move across each other. Friction is the resistance to motion of one object moving relative to another.



When you erase on a paper, there will be friction between the eraser and the paper.

→ Running

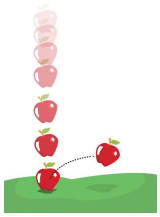
Why don't we slip when running?
Because there is friction preventing us from falling

BUT! when we run on ice without ice skating boots, we will slip and fall.
Why does this happen?
Because, ice almost has no friction!

Cars' wheel has friction between them and the ground

What is **Gravity**?
Gravity, also known as Gravitational force, is a force that attracts any two objects with mass. It is the universal force of attraction acting between all matter.

For example, the Earth is attracted to the Sun by the gravitational force. Another example is that humans are attracted to the center of the earth, that is why there exists gravity.



The apple is falling down to the ground because the apple is attracted to the center (core) of the earth due to gravitational force.

The gravity of Earth is 9.81 or usually rounded to 10 $\frac{m}{s^2}$

What is **Speed**?
Speed is how fast an object is moving. It is the distance travelled per unit of time.
When you ask: "How fast do you run?", you are asking about speed.

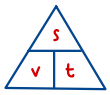
speed is only a number : for example you run 5 kilometers per hour, but it doesn't tell the direction (to the left / right / north / east / etc)

remember! speed and acceleration is DIFFERENT! speed is measured in m/s while acceleration is measured in m/s^2.

What is the **formula for speed**?
The formula for speed is speed = distance travelled / time elapsed.

$v = \frac{s}{t}$ or $s = v \times t$ or $t = \frac{s}{v}$

where v is velocity (measured in m/s) - meters per second.
s is distance (measured in m) - meters
t is time (measured in s) - second



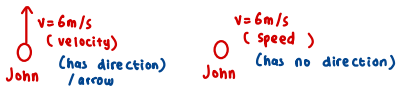
memorize the formula!!!

What is **Velocity**?
Velocity is the speed of an object with its direction. It is the quickness of motion or action.
Remember! Velocity and Speed are almost the same.
The formula for velocity is the same as speed's, but don't forget to add the direction!

The standard unit of measurement for speed and velocity is m/s (meters/second).

What is the **difference between velocity and speed**?
Velocity has direction. However, Speed only has value/magnitude. Speed doesn't have direction.

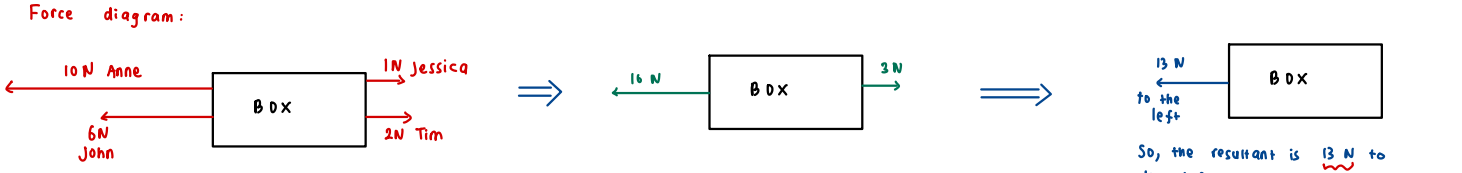
For example:
John is running 6 meters per second with direction North. (Velocity)
John is running 6 meters per second. (Speed)



What is **Net Force** or **Resultant Force**?
Net force or Resultant Force is the sum of all forces acting on an object.

For example: A box is being pulled by 4 people. John is pulling 6 N to the left. Anne is pulling 10 N to the left. Tim is pulling 2 N to the right. Jessica is pulling 1 N to the right. What is the resultant force?

Force diagram:



So, the resultant is 13 N to the left
number / magnitude
direction

Formula for pressure force

$P = \frac{F}{A}$ or $A = \frac{F}{P}$ or $F = P \times A$

where:
P is the pressure, measured in Pascal (Pa).
A is the area, measured in meters squared (m^2).
F is the force, measured in newtons (N).

What is **Pressure Force**?
Pressure force is how much force is acting upon an area. It is the physical force exerted on an object.
When a force is acting over a smaller area, it will create more pressure.

For Example: When you squeeze a play dough with your whole hand, you give pressure (LESS) to the whole dough. But, when you pinch a small area of the play dough, you will give more pressure to that area of the play dough.

squeezing dough with whole hand (less pressure)

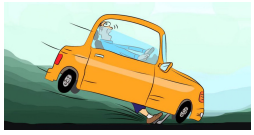
pinching dough with fingers (more pressure)

What is **Acceleration**?

Acceleration is the rate of change of velocity.

For Example: When a car gets faster, it means it **accelerates**, or its velocity/speed becomes larger. When this happens, there is a **positive acceleration**.

when the car accelerates, this means its speed is not constant / doesn't stay the same at, for example, 40 km/h. But, it gets faster and faster. 40 km/h → 50 km/h → 60 km/h and so on.



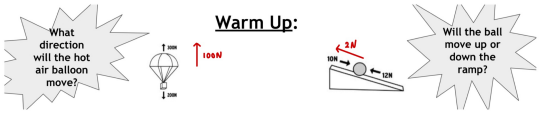
However, when a car is trying to stop (the driver pushes the brakes), the car gets slower over time. This means the car decelerates. 60 km/h → 40 km/h → 20 km/h and so on.

When a car gets slower, it means it **decelerates**, or its velocity/speed becomes smaller. When this happens, there is a **negative acceleration**.

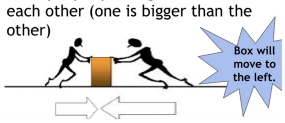
When you press down on the gas pedal in a car, the car surges forward going faster and faster. This change in velocity is acceleration.

The standard unit of measurement for acceleration is meters per second squared or m/s^2 (meters per second squared).

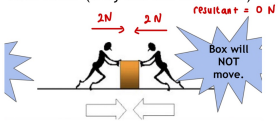
Warm Up:



Ex: 2 people pushing a box towards each other (one is bigger than the other)



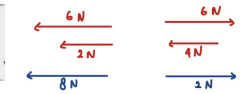
Ex: 2 people pushing a box towards each other (they are the same size)



The net force would be 5N to the left.

Vector (arrow): Shows the magnitude (number) and direction of a force

Remember: If vectors are pointing in same direction, add the forces together. If vectors are pointing in opposite directions, subtract.



Practice:

Calculate the net force of the box in each problem. Be sure to include the direction of the force as well (left or right).

1.

Net Force: 4 N to the left

2.

Net Force: 5 N to the left

3.

Net Force: 4-4 = 0 N
no resultant / net force

4.

Net Force: 9 N to the right

Exercise

1. The formula for average speed is equal to …
a. distance/time
b. time/distance
c. distance + time
d. distance x time

2. What does Newton's first law of motion state?
a. An object in motion stays in motion unless a force acts on it.
b. An object's acceleration (change in speed) depends on the mass of the object and the amount of force applied on it.
c. An object at rest stays at rest unless a force acts on it.
d. Every action has an equal and opposite reaction.
e. Both A and C

"When two forces acting on an object are equal in size but act in opposite directions." Which type of force is this?
a. Balanced Force
b. Unbalanced Force
c. Light Force
d. Rectilinear Force

What does Newton's third law of motion state?
a. An object in motion stays in motion unless a force acts on it.
b. An object's acceleration (change in speed) depends on the mass of the object and the amount of force applied on it.
c. An object at rest stays at rest unless a force acts on it.
d. Every action has an equal and opposite reaction.
e. Both A and C

What does Newton's second law of motion state?
a. An object in motion stays in motion unless a force acts on it.
b. An object's acceleration (change in speed) depends on the mass of the object and the amount of force applied on it.
c. An object at rest stays at rest unless a force acts on it.
d. Every action has an equal and opposite reaction.
e. Both A and C

A(n) … is a push or pull.
a. Acceleration
b. Force
c. Motion
d. Velocity

John is walking to school. It took her 2 minutes to walk 100 meters. How fast was she walking?
a. 100 meter per kilometer
b. 50 meter per minute
c. 50 meter per kilometer
d. 100 meter per hour

If John is pulling a rope to the left with a force of 30 N, while Michael is pulling to the right with a force of 45 N, the rope will move right with a force of 15 N.
a. True
b. False

The force resulting form the pull of Earth on an object is called …
a. Mass
b. Gravity
c. Weight
d. Acceleration

The tendency of an object to remain at rest or in motion is …
a. Friction
b. Velocity
c. Acceleration
d. Inertia

What is the type of force that affects two objects that are touching each other?
a. Net Force
b. Friction
c. Gravity
d. Newtons

Forces that delete/neglect the effect of each other are called … forces.
a. Unbalanced
b. Balanced
c. Zero
d. Many

If gravitation is suddenly stopped in the solar system, the Earth would move …
a. In orbit with the Sun
b. In the opposite direction
c. Nowhere
d. In a straight line

In order for an object to begin to move, stop moving, or change direction, which of the following must be present?
a. Unbalanced force
b. Friction force
c. Balanced force
d. None of the above

Velocity is a measure of speed that takes into account the …
a. Weight of an object
b. Direction of movement
c. Force of the movement
d. Acceleration of an object

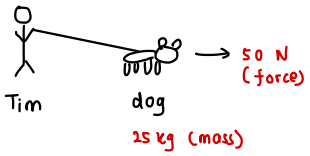
To describe the motion of an object, you need to know …
a. The unit of mass
b. A reference point
c. The unit of temperature
d. Its size

Two forces working in opposite directions, each with a force of 20 N, are …
a. Balanced
b. Unbalanced
c. Uneven
d. Different

In order to calculate speed, you need to know distance and area.
a. True
b. False

Pressure results from a force pressing on an area.
a. True
b. False

1. Tim's dog is pulling Tim with a force of 50 N. His dog's mass is 25 kg. Find the acceleration produced by the dog.



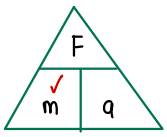
$F = m \times a$

force (N) = mass (kg) x acceleration (m/s^2)

$50 = 25 \times a$ equation

$a = \frac{50}{25} = 2\ m/s^2$

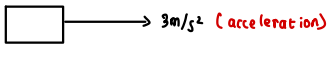
2. Marco is pushing a box of 15 kg with an acceleration of 3 meters per second squared. Find the force applied on the box.



$F = m \times a$

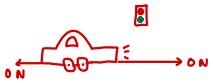
$F = 15 \times 3$

$F = 45\ N$



3. A car is stopped at a red light. Which claim about the forces acting on the car must be true?

a. There is not enough information
b. There is no net force on the car
c. There is a net force on the car
d. The car is accelerating.

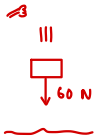


4. A truck slows down. Which claim about the forces acting on the truck must be true?

a. There is not enough information
b. There is no net force on the car
c. There is a net force on the car
d. The truck is accelerating.

5. A heavy box is dropped from the roof of a small building and is traveling to the ground. Which claim about the forces acting on the box must be true?

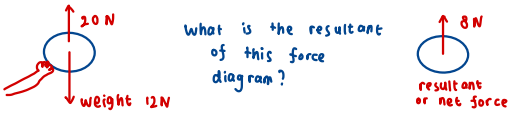
a. There is no enough information
b. There is no net force on the box
c. There is a net force on the box
d. The box is flying
e. There are no forces on the box



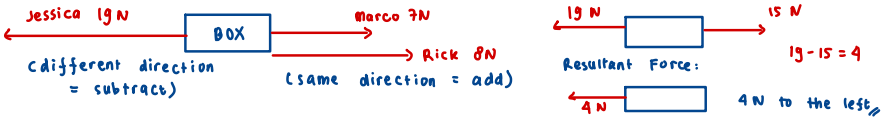
6. A basketball is resting on the ground. Which claim about the forces on the ball must be true?

a. There is not enough informstion
b. There are no forces on the ball
c. There is a net force on the ball
d. The ball is decelerating

7. A rock weighs 12 N. You are lifting it with a force of 20 N. Will the rock raise? If yes, what is the resultant force?



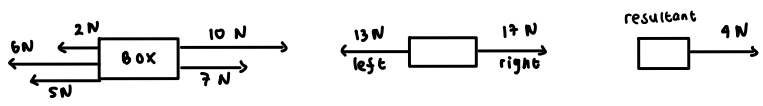
8. Marco is pushing a box with a force of 7 N from the left. Rick is also pushing from the left with a force of 8 N. Meanwhile, Jessica is pushing the box from the left with a force of 19 N. Will the box move to the left or right? What is the resultant or net force of the box?



9. Samuel is pushing a box with a force of 12 N from the left. Lory is also pushing from the left with 2 N. Meanwhile, Shaun is pushing the box from the right with 14 N. Will the box move to the right or left? What is the resultant of the box? Draw the force diagram.

10. Find the resultant force from the force diagram. Do not forget to indicate the direction and magnitude (number).

a.



b.