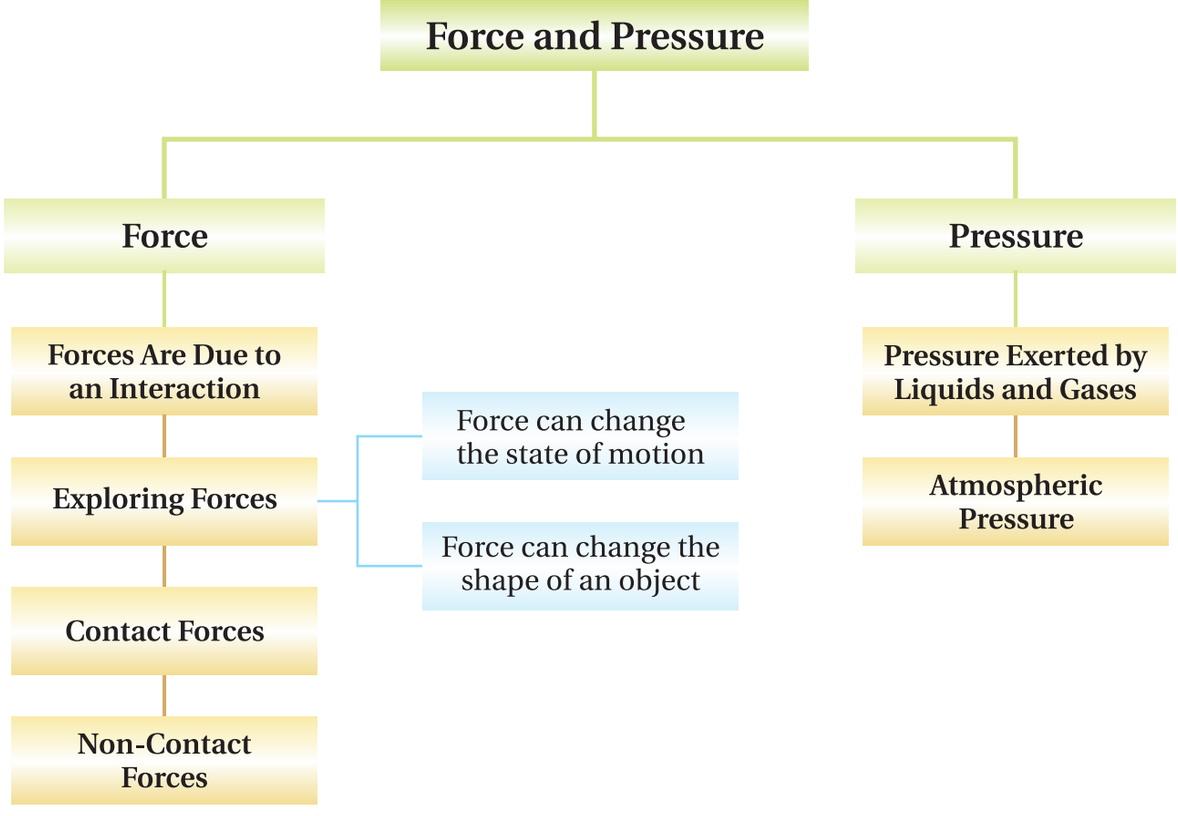
Chapter 1 Force and Pressure



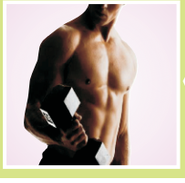
This chapter introduces one of the most important physical quantities called 'force' and gives fundamental knowledge about the same. Effects and applications of force in our day-do-day lives are discussed, followed by the different types of forces. Another important physical quantity, 'pressure', is also introduced here and an extended discussion about the same brings this chapter to an end.



Retrieve

Force can make an object start moving, change its speed or direction and stop a moving object. It can also change the shape of an object.

Different Types of Forces

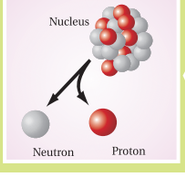


Muscular Force: It is the force exerted by the elongation and contraction of muscles.

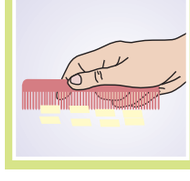
Frictional Force: It is the force that slows down or opposes the motion of an object.

Magnetic Force: It is the force by which magnets attract or repel objects.

Gravitational Force: It is the force of attraction between all objects in the universe.



Nuclear Force: It is the force that holds the subatomic particles in the nucleus of an atom.



Electrostatic Force: It is the force exerted between two charged particles or two bodies.

Pressure

Pressure is the force acting on a unit area. It is an effect that occurs when force is applied on a surface. The SI unit of pressure is pascal (Pa). Pressure is exerted by solids, liquids and gases.

1. What is meant by pressure?

   Ans. _____

   _____

2. What is nuclear force?

   Ans. _____

Upload / Force

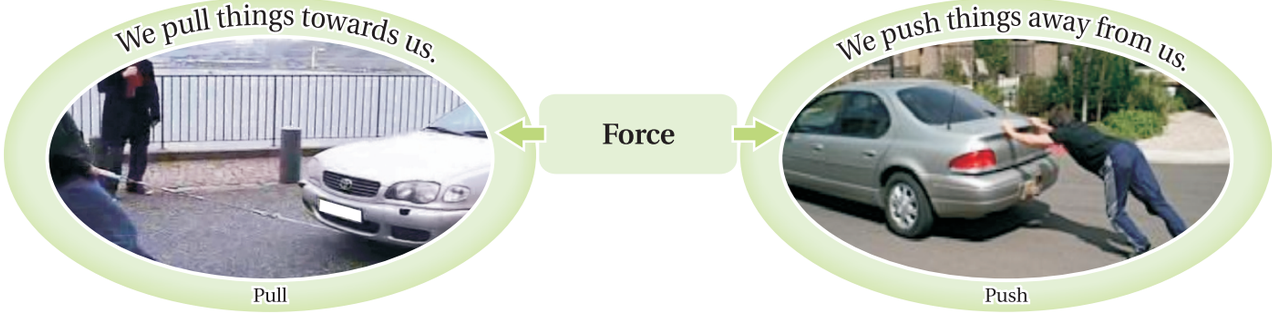
Force is simply a push or a pull. Force causes a body to move, to stop moving or to change its direction, speed or shape.

When a player kicks a ball, the force that he applies on the ball makes it move.

When a goalkeeper saves a goal, he applies force to stop the ball.

When a player deflects the ball, he applies force to change the direction of the ball.

Different actions like opening, throwing, hitting, picking, shutting are forms of pulling or pushing. A pull tends to bring objects towards us whereas a push tends to move objects away from us.



If there were no force, our day-to-day activities would not be possible. We apply force to perform various activities—to open a window, to push the mobile keypad, to run, to pull a chair, to open the door, etc.

Apps

Shown ahead are some activities performed by different people at different times. Identify the actions shown as push or pull.

Opening a closed drawer

Hitting a ball

Lifting the weight

Processing

1. What is meant by force?

   Ans. _____

   _____

2. Differentiate between push and pull.

   Ans. _____

   _____

   _____

   _____

   _____

3. Give two examples each of actions from your daily life where force is used to pull or push an object.

   Ans. _____

   _____

   _____

Forces Are Due to an Interaction

For a force to come into play, at least two objects or bodies must interact with each other. If they don't, a force can never come into play. A bull fight, tug of war, a man pushing a mower are some examples where force is due to an interaction between two bodies or objects.

Pushing a mower

Force is applied on the mower by the person holding it to make it move.

The two objects (hands holding the handle of the mower and the handle of the mower) involved here interact with each other.

Bullfight

In a bullfight, two bulls try to push each other to win the fight.

The two objects (heads of two bulls) involved here also interact with each other.

Tug of war

Two teams are involved in a tug of war, each trying to pull the other team to their side.

The objects (the two teams) involved here interact with each other through the rope.

Processing

1. Give two examples to show that two objects must interact for a force to come into play.

Ans._____

Exploring Forces

Force can be added or subtracted depending upon the situation. When more than one force acts on an object, then the overall force acting on that object is called the resultant force. The resultant force is also known as net force. The net force depends upon the magnitude and direction of the forces acting on an object.

Addition of Forces

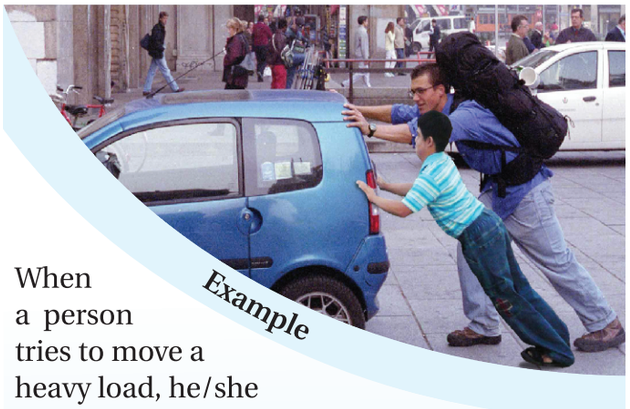
When two or more forces are applied on an object in the **same direction**, they **add up**. The magnitude of the net force is the sum of the magnitude of the individual forces.

The direction of the net force is the same as that of the individual forces acting upon the object.

Addition and Subtraction of Forces

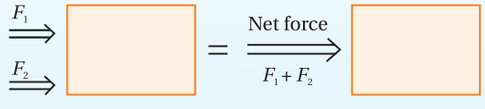
Subtraction of Forces

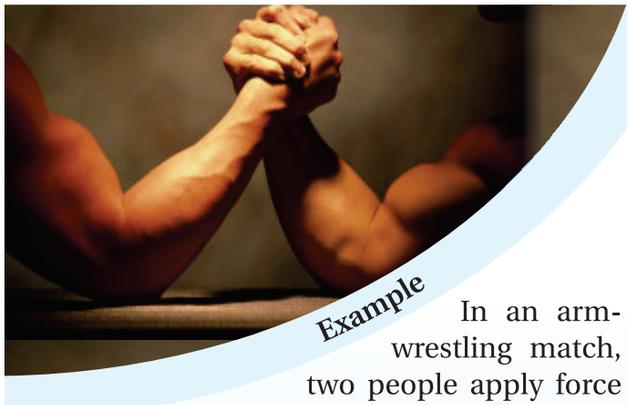
When two or more forces are applied on an object in **opposite directions,** the net force acting on the object is the **difference between the forces**. The direction of the net force is the direction in which the force with the higher magnitude acts upon the object.



Example

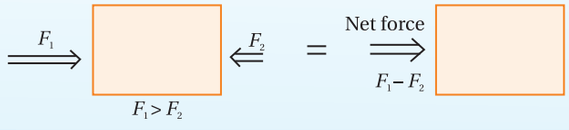
When a person tries to move a heavy load, he/she may find it difficult to move it. But when two people push the same load, it is comparatively easier to move it.





Example

In an arm-wrestling match, two people apply force in opposite directions. The one who applies a greater force wins the match by pushing the other person's arm down.



NOTE

When forces of equal magnitude act in opposite directions on an object, the net force on the object will be zero. Such forces are called balanced forces and they do not affect the state of the object, i.e., the state of motion or rest in which the object is in to begin with.
Example: In the tug of war, if both the teams pull the rope with equal force then there would be no motion of the rope. Both teams would remain in the positions they were in at the start.

Apps

Listed below are some actions where two or more forces come into play. Identify whether addition or subtraction of forces takes place in each case.

Action	Addition/Subtraction of Forces
Two friends pushing a loaded cart	
Two girls pulling each other	
A balloon suspended in the air	
Four workers carrying a heavy wooden log	
Two ants pushing a food particle in opposite directions	

Processing

1. Forces add up when applied in the _____ direction. (same/opposite)
2. Under which condition is the net force calculated by the subtraction of forces?

   Ans. _____

   _____
3. When is the net force acting on an object equal to zero? Explain with an example.

   Ans. _____

   _____

   _____

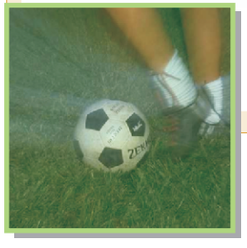
Force can change the state of motion

State of motion is the state of rest or movement of an object. It is also related to the speed and direction of the object. When an object is in motion, it has a certain speed and direction. When the object is at rest, its speed is zero.

When force is applied on a body at rest, it sets the body in motion. The body moves in the direction of the applied force. In other words, if the body is at rest it will move only if force is applied on it.

Example

When a football player kicks a football initially at rest, it travels some distance. In this case, he applies force on it which sets the stationary football into motion.



When a force is applied on a moving object along a direction other than the direction of its motion, the direction of motion of the moving object changes.

Example

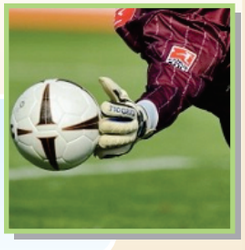
When a batsman plays a late cut to a delivery, the cricket ball deviates by a small angle and travels to the 'third man' position. The batsman applies force on the moving ball and the direction of motion of the ball changes.

A force can change the state of rest or motion of an object.

When force is applied on a moving object against the direction of its motion, its speed is significantly reduced or it may come to rest and if the force is applied along the direction of motion of a moving body, its speed increases.

Example

When a goalkeeper saves a goal, he applies a force against the direction of the moving ball and eventually prevents the goal.

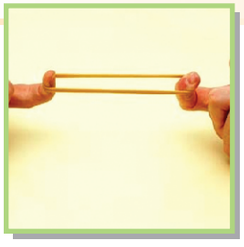


Direction of Force Applied	Speed	Example
Opposite to the direction of motion	Decreases	Speed of a car decreases when brakes are applied.
Along the direction of motion	Increases	Speed of a car increases when the accelerator is pressed.

A force can change the shape of an object

A force can change the shape of an object.

When the two ends of a rubber band are pulled in opposite directions, elongation of the same takes place due to the application of force.



When a deflated football is pumped, it regains its spherical shape as air enters inside it. This is due to the application of force.

When a lump of dough is rolled, it flattens and takes the shape of a roti. The flattening takes place due to the application of force.

Processing

1. Give two examples from your experience where application of force results in the following changes.

   a. Brings a moving object to rest.

   Ans. _____

   _____

   b. Changes the speed of a moving object.

   Ans. _____

   _____

AERONAUTICAL ENGINEER

Aircrafts flying at a low height have to face the force of high-speed winds. Strong winds can push the aircraft to change or deviate from its course and even cause change in its shape.

An aeronautical engineer is one who designs and constructs aircrafts. While designing them he/she needs to keep in mind the size, capacity, speed, weight, etc. of the plane as well as the height at which it will fly and force of the winds which it will have to face.

Contact Forces

A contact force is defined as the force exerted when two physical objects come in direct contact with each other.

Muscular Force

The force resulting due to the movement and action of muscles is called **muscular force**.

Humans and animals use muscular force for performing various activities. Example: pushing and pulling, running, dragging, jumping, etc.

Frictional Force

The force acting against the motion of a body which has a tendency to oppose the motion is called **friction** or **frictional force**.

Frictional force always acts in opposition to the direction of motion. Example: slowing down of a rolling ball, moving a box on a surface, running of vehicles on the road.

Muscular force and frictional force are contact forces because both require two bodies to be in direct contact with each other.

Processing

1. Define contact forces.

Ans. _____

_____

FITNESS INSTRUCTOR

Most people undergo rigorous training under fitness instructors to get in shape. Apart from building good muscular strength, good fitness levels improve the quality of our life and keep us healthy in the long run. Physical fitness makes our body more flexible and reduces the deposition of fat in our body. It increases lean body mass, resulting in a balanced and healthy body composition.

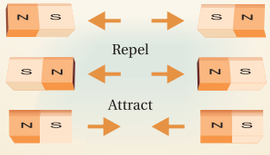
The professional who helps us attain perfect fitness levels is the fitness instructor. He/She also guides us on health and nutrition, lifestyle and personality development.

Non-Contact Forces

Non-contact forces are those which do not require any two bodies or objects to be in direct contact. Such forces can come into play from a distance.

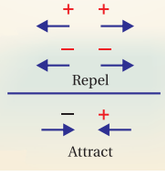
Magnetic Force

- The force by virtue of which a magnet attracts objects made of iron, nickel, etc.
- This force also enables a magnet to attract or repel another magnet.
- Like poles of magnets repel each other while unlike poles of magnets attract each other.



Electrostatic Force

- The force exerted by an electrically charged body on another electrically charged or neutral body.
- This force enables an electrically charged body to attract or repel another charged body.
- Similar charges repel each other while unlike charges attract each other.



Gravitational Force

- A force that exists between any two objects in the universe.
- The force by virtue of which Earth attracts all the objects towards itself is called **gravity**.
- Gravitational force is always attractive in nature and acts towards the centre of an object.

Magnetic and electrostatic forces can be attractive or repulsive in nature.
Gravitational force is always attractive in nature, it is never repulsive.
Nuclear force is an attractive force that holds protons and neutrons together in the nucleus of an atom. It is a non-contact force.

Apps

Take a bar magnet. Bring it close to a mixture of iron filings and sand particles. What happens? Do the iron filings get attracted towards the magnet? Does this process help in separating out iron filings from the sand particles?

Processing

1. Define non-contact forces.

Ans. _____

2. Compare magnetic and electrostatic force.

Ans. _____

_____

_____

_____

3. What is gravitational force?

Ans. _____

_____

Updates

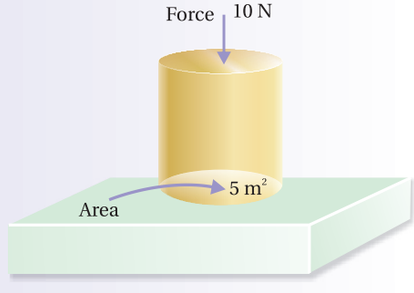
Astronauts become slightly taller in space because there is a decrease in the gravitational force of the Earth. Their bones become less compressed. This leads to an increase in their height.

Upload Pressure

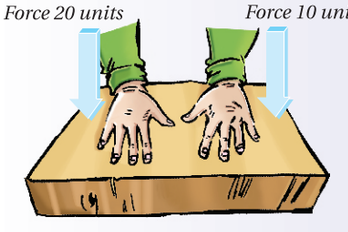
Pressure is the force acting per unit area of a surface.

Mathematically,

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

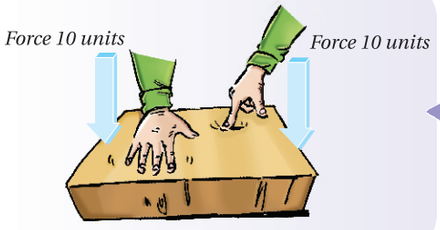


A force of 10 newton (N) acting on an area of 5 m^2 will exert 2 N/m^2 pressure.



For a given area, the higher the magnitude of the force the higher will be the pressure and vice versa.

In the above figure, pressure exerted by the right hand will be greater since it is exerting more force. (Note, both hands have the same area.)



For a given force, the smaller the area the higher the pressure and vice versa.

Pressure exerted by the finger will be more since it has a smaller area in comparison to the hand. (Note, both the hand and the finger are applying the same force.)

$$Pressure \propto Force,$$

$$Pressure \propto \frac{1}{Area}$$

Apps

Take a lump of wet clay and shape it into three cuboids as shown in the figures below. Now take two bricks. Place one of them in an upright position on one of the cuboid lumps (as in Fig. A). Remove the brick and see how deep an impression it leaves on the lump of clay. Now keep the brick on another lump horizontally (as in Fig. B). Is the impression of the brick in this case as deep? Now take the two bricks and place them in a horizontal position one over the other on the third lump of clay (as in Fig. C). How deep is the impression in this case? Note your observations and give reasons for them.

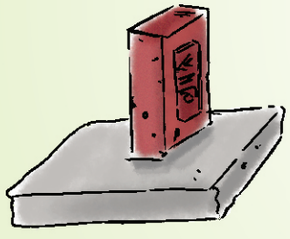


Fig. A

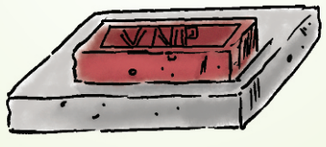


Fig. B

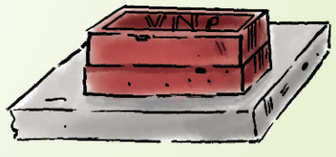


Fig. C

Processing

1. Define pressure. Write the mathematical expression of pressure.

Ans. _____

_____

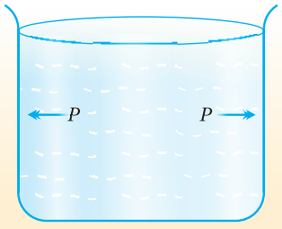
Pressure Exerted by Liquids and Gases

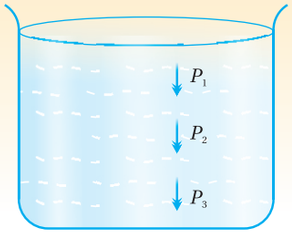
Liquids and gases exert pressure on the walls of the containers in which they are kept.

Pressure due to liquids and gases is related to the height of the liquid or gas.

In a container, liquids and gases exert equal pressure at the same depth.

(Note: This is also known as 'Pascal's law'.)





$P_3 > P_2 > P_1$

In a container, pressure exerted by liquids and gases increases with the depth.

Updates

The pressure exerted by water at the deepest point in the ocean is equivalent to one person trying to hold fifty aircrafts.

Apps

Take a tin container. Make four holes of the same size at the same height in it. Fill the container with water and continue to fill it with running water from the tap. As the container gets filled with water, you will observe that water comes out of the holes with the same pressure (as shown in Fig. A). This shows that pressure in liquids remains the same at the same height in all directions.

Now, take another container. Make four holes in it from top to bottom at equal intervals. As you fill the container with water, you will observe that the pressure of the water at the lowest hole will be maximum and minimum at the topmost point (as shown in Fig. B). This proves that pressure in liquids decreases with decreasing depth.

Fig. A

Fig. B

Processing

1. Gases _____ force on the walls of the container. (exert/do not exert)

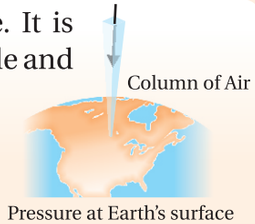
2. Liquids exert _____ pressure at the same depths. (equal/unequal)

Atmospheric Pressure

Earth is surrounded by a thin blanket of air (of about 100 km thickness) called the atmosphere. Because of the force of gravity, the air particles in the atmosphere exert force on us. This force is known as atmospheric pressure. On Earth's surface one square centimetre observes a force of 1 kilogram due to atmospheric pressure. The device used to measure atmospheric pressure is called a barometer.

Atmospheric pressure increases with decreasing altitude. It is due to the fact that air is more compressed at a lower altitude and thus exerts more pressure. It is

- Maximum at sea level.
- Minimum at the mountains.



Significance of Atmospheric Pressure

When you drink any liquid using a straw, the air inside the straw gets sucked. The atmospheric pressure forces the drink to move into your mouth.

Blood exerts pressure on the walls of the blood vessels. Atmospheric pressure from outside counterbalances this internal pressure. Otherwise, blood vessels could burst.

'Atmospheric pressure' is represented by the unit 'atm'.

PILOT

Thousands of people travel by air every day. All types of aircraft are carefully engineered to enable them to fly under low atmospheric pressure conditions prevailing in the higher altitudes and maintain cabin pressures that are comfortable for the passengers. The pilot who flies the aircraft is involved in making a series of intricate adjustments to take the aircraft to an altitude at which it can cruise and be most fuel efficient besides taking off and landing smoothly to take us to our destination safely.

Processing

1. Define atmospheric pressure.

Ans. _____

_____

Add to Favourites

Force and Pressure

Force

Examples

Forces Are Due to an Interaction

Example

Exploring Forces

Addition of forces

Subtraction of forces

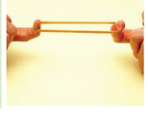
A force can change the state of motion

Case 1

Case 2

Case 3

A force can change the shape of an object



Contact Forces

Definition

Examples

Non-Contact Forces

Definition

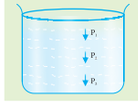
Examples

Pressure

Definition

Mathematical expression

Pressure Exerted by Liquids and Gases



Atmospheric Pressure

Definition

Significance

Scandisk

1. Define force.
2. Is it possible for a force to come into play when two bodies are not interacting with each other?
3. Complete the following table.

Pressure	Force	Area
a. 70 N m^2	35 N	
b.	50 N	2 cm^2
c. 5 N m^2		20 m^2
d. 200 N m^2	800 N	
e.	a^2 N	a cm^2
f. 45 Nm^2	90 N	

4. Which non-contact force is always attractive in nature?
5. What is the effect of application of force on a moving body?
6. Fill in the blanks.
   a. Force per unit area is known as _____.
   b. Atmospheric pressure _____ with increase in altitude.
   c. The smaller the area over which the force acts, the _____ is the pressure.
   d. Force can change the _____ and direction of motion of a moving body.
7. Which of the following is true for pressure exerted by a liquid in a cointainer?
   a. At the same depth, pressure is the same in all directions.
   b. Pressure increases with increase in depth.
   c. Pressure does not depend on depth.
   d. None of these.
8. Why does a cricket ball fly off after being hit by a cricket bat?

9. What is the significance of frictional force?
10. Under which condition is electrostatic force repulsive in nature?
11. An inflated balloon was pressed against a wall after it had been rubbed with a piece of synthetic cloth. It was found that the balloon got stuck to the wall. What may be the reason for this?
12. A force of x units and another force of $2x$ units are applied on an area A. Which force would exert higher pressure?
13. The deeper a diver dives in water the _____ will be the pressure on him. (greater/smaller). Give reasons for your answer.
14. List five instances of application of force by a person while driving a car.
15. Why do you think it is necessary to have a separate concept called 'pressure' despite having the concept of force?
16. Why does a boat come to rest when one stops rowing it?
17. You have thrown a ball upwards in the sky. Name the forces that act on the ball soon after it is thrown.
18. Keeping in mind the concept of atmospheric pressure, explain the working of a syringe.
19. How will your life get affected if there were no atmospheric pressure on Earth?

Explorer

You have studied atmospheric pressure and its importance. Aeronautical engineers design aircrafts for different purposes and conduct different experiments to make sure they are successful in their attempts.

Your task is to conduct an experiment and observe the impact of atmospheric pressure on a soft drink can.

Future Calling

I will design a faster aircraft than Jumbo 380 Airbus.

Aeronautical Engineer

Designs, develops and tests aircrafts and also constructs vehicles that can be used in space

Follow my instructions to get eight pack abs.

Fitness Instructor

Organises team and individual exercise programmes to help people improve their health and fitness levels

I will successfully fly an aircraft over Bermuda Triangle.

Pilot

Flies aeroplanes and helicopters using multifaceted electronic and mechanical control devices

smartclass modules

- Forces: An Introduction
- Effects Of Force
- Contact Forces
- Non-Contact Forces
- Pressure
- Liquid Pressure
- Atmospheric Pressure