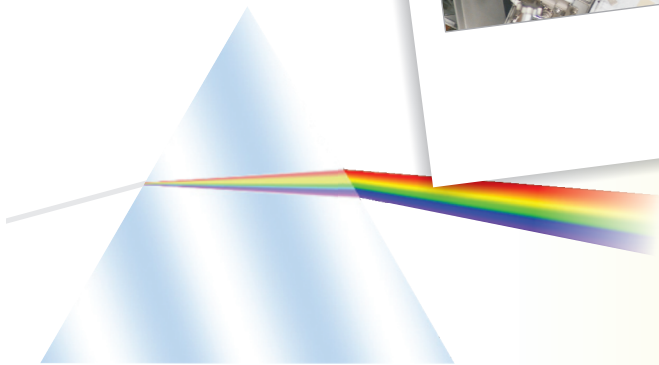




PHYSICS





Chapter 13

Force and Motion



“Sare jahan se achcha,” replied Wing Commander Rakesh Sharma when asked by the then Prime Minister, Mrs. Indira Gandhi, about how India looked from space.

These famous words of poet Iqbal were once again etched in the memories of millions of Indians who witnessed the launch of the space station Salyut-7 in 1984. On board was an Indian Air Force pilot, the first ever Indian to venture into space. From a fighter pilot to an astronaut, the journey had been awesome indeed. Rakesh Sharma had been trained for one and a half years for this eight-day trip into space. A mission like this requires a lot of self-discipline to face the tough training to live in the space station and to stay focused on the job. Responding to a question on space travel Rakesh Sharma said, “the training ensured that our speed, strength and endurance characteristics improved significantly.”

There are various physical factors such as force, mass and gravity that govern the motion of fighter planes or commercial aircrafts. The knowledge of various types of forces and motion is essential for a pilot to be able to fly these machines.



Captain Jammie Jamieson
Fighter Pilot



Rakesh Sharma
Pilot and Astronaut

Pilots

- ❖ Fly airplanes and helicopters carrying passengers or cargo
- ❖ Are proficient in air navigation and interpretation of meteorological reports
- ❖ Operate sophisticated electronic and mechanical control equipment
- ❖ Lead crew members and passengers during weather changes and emergency situations

What you already know... >>>

Force is a push or a pull that is experienced by a body. Force gives an object the energy to move, stop or change direction. Force needs to be applied in almost all day-to-day activities. For example, when you write with a pen or a pencil, pedal your bike, chew gum or swim in a pool, you exert force on different objects. Thus, it can be said that you cannot do anything without exerting some kind of force.

List five instances where force results in the movement of an object.

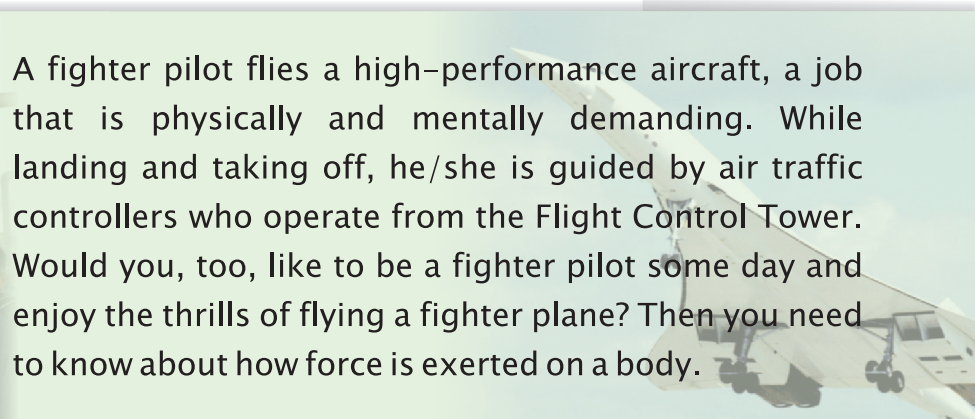


Force applied while swimming

What you need to know... >>>



A fighter pilot flies a high-performance aircraft, a job that is physically and mentally demanding. While landing and taking off, he/she is guided by air traffic controllers who operate from the Flight Control Tower. Would you, too, like to be a fighter pilot some day and enjoy the thrills of flying a fighter plane? Then you need to know about how force is exerted on a body.



Force

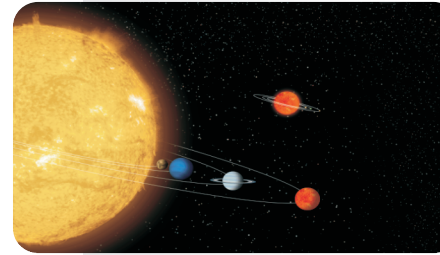
You must have observed planes standing on an airstrip. Do you know why they do not move on their own? Well, some kind of force needs to be applied to move them. Similarly, a football lying on the ground will not move all by itself. Force needs to be applied by another body to make it roll. Sir Isaac Newton, the famous mathematician and physicist, stated that an object will continue to remain at rest or move in a straight line at a constant speed until it is acted upon by a force exerted by another object.

Moreover, forces do not work alone. A change in motion is always due to a relationship between two forces. Any object that exerts force on another object must itself also experience some force during the interaction. For example, when we kick a ball, the force that makes it move is exerted by the foot. But the foot, upon contact with the ball, also experiences a jerk during the interaction.



A ball moves only when force is exerted on it

Whenever we see that an object has changed its direction and speed, we infer that there must be some force acting upon it, even if we cannot see the source of that force. For example, the motion of the earth's revolution around the sun is due to the gravitational force that acts upon the Sun and the Earth. This force is responsible for keeping the Earth in continuous motion in a fixed orbit around the Sun.



Gravitational force causes planetary motion

Effects of Force

Force is a physical quantity that cannot be seen. However, its effects can be observed in the changes in motion and the shape of objects.

a. Force results in the motion of objects

Since force is exerted when there is an interaction between two bodies, it is often called a push or pull. The push or pull may come from direct contact such as when objects collide or from non-contact forces such as magnetism or gravity that can operate even from a distance. Force can cause an object to start moving, speed up (accelerate), slow down (decelerate), stop moving or change the direction of motion.

When a force results in motion, the following three parameters are important:

- i. The direction in which the force acts
- ii. The strength of the force applied, i.e. the magnitude of force
- iii. The mass of the object on which the force is applied

For example, if a car needs to be pushed, force needs to be applied in the direction in which the car is required to move. In addition, the minimum force needed to move the car needs to be calculated on the basis of the mass of the car.

Interesting Fact

Can you guess what would happen if only the Sun exerted a force on the Earth? The Sun would simply pull the earth towards itself and destroy it.



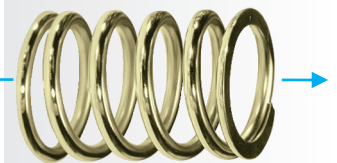
Pushing force

b. Force results in change of shape of objects

Have you ever observed what happens when tomatoes are put in the blender? The tomatoes are reduced to pulp instantly. The force of the rotating blades is such that it changes the shape of the tomatoes. Similarly, we can stretch, squeeze or twist a lump of clay to mould it into various shapes. The change in the shape or size of an object due to the application of force is known as **deformation**. This can be the result of tensile (pulling) forces, compressive (pushing) forces and bending or torsion (twisting) forces.



Bending force



Tensile force

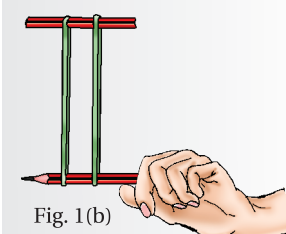
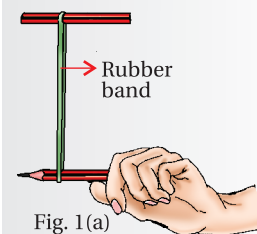


Compressive force

What you need to do... >>>

1. Take a rubber band and connect it to a rigid support, as shown in Fig. 1(a). Measure the length of the rubber band. Now, insert a pencil in the loop of the rubber band and pull it downwards. Measure the deformation when force is applied to the rubber band. Now, place another similar rubber band parallel to the first one, as shown in Fig. 1(b). Pull them downwards again. Compare the change in the length with the previous reading when force was applied on a single rubber band.
2. Take a square piece of foam. Draw a small square on it with a sketch pen. Now, apply different types of forces like pull, push and compression and observe the changes in the shape of the square.

Discuss your findings in class.



What you need to know... >>>



A pilot is granted permission for take off only after the aircraft maintenance engineers have checked the aircraft. During ground operations such as taxiing and take-off or landing, the friction between the tyres and the surface of the runway affects the motion of a plane. Once airborne, forces such as air resistance also affect the speed of the plane. The pilot needs to overcome such forces to steer the aircraft to the desired destination. However, in some situations a pilot may need to use a parachute to increase the air resistance and thus slow down the speed of the plane.

Let us find out more about the different types of forces.

Types of Forces

Following are the two types of forces:

- a. Contact forces
- b. Non-contact forces

Contact forces

Contact forces are exerted between two objects that are in direct contact with each other. Muscular force, frictional force and tensional force are examples of contact forces.

Muscular force is the force exerted by the elongation and contraction of muscles. A boy dragging a toy behind him exerts muscular force. You too are able to move around, lift an object and do various other activities by exerting muscular force.



Muscular force

You might be thinking that a contact force can only make an object start moving. However, there is another force that opposes motion and is very beneficial to us.

This force is termed **friction**. It acts in a direction opposite to the object's direction of motion. It helps control the speed of an object and stops motion. Without friction, an object would continue to move at a constant speed forever. For example, walking would be impossible if there was no friction between the ground and the soles of the feet or shoes.

There are basically two types of friction that we come across frequently. They are sliding friction and rolling friction.



Rolling friction

Sliding friction is exerted when two surfaces slide over one another. A snow boarder is able to slide over snow-covered slopes because of sliding friction. When an object rolls over another surface, then the friction between them is called **rolling friction**. Skaters and skiers are able to glide so fast because the friction between the wheels or blades and surface is very less. On the other hand, the tread on the tyres of

a vehicle increases friction between the road and the tyres, thus preventing the vehicle from skidding.



Sliding friction

What you need to do... >>>

1. Place a coin on an inclined plane, say a ruler. Tilt the plane and observe the angle of tilt when the coin starts sliding. Use inclined planes made of different materials and observe the time taken for the coin to slide down. On which kind of plane did the coin slide fastest?
2. Take a tennis ball and a lead ball. Attach the two balls using a rubber band. Pull the two balls apart, stretching the rubber band. Does the rubber band pull with the same force on both balls? Now release the rubber band and observe what happens to the balls. Which ball moves faster and farther? Record and discuss your observations.



Coin on an inclined plane

What you need to know... >>>



The engines of a plane provide the thrust necessary to counter the gravitational forces that can pull an aircraft down to the earth. On 15 January 2009, a United States jetliner stuck a flock of geese which resulted in an immediate and nearly complete loss of thrust from both engines of the aircraft. The pilot Captain Chesley Sullenberger masterfully landed the crippled aircraft in New York's Hudson River saving all 155 lives on board. The pilot's quick thinking and skill thus averted a catastrophe. He proved to be a true leader to his crew and passengers during a crisis.

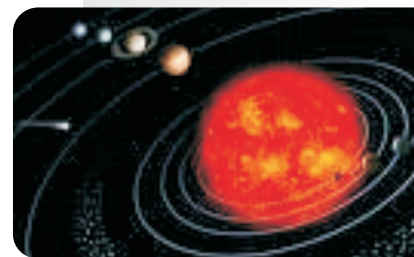
Force and Motion

Non-contact forces

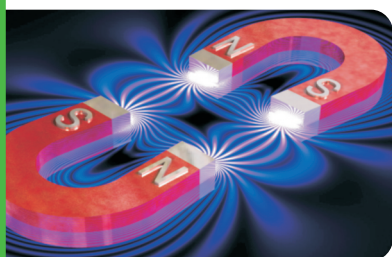
When a force is exerted on an object by another body that is not in direct contact with it, it is called a non-contact force.

Non-contact forces generally fall into the following categories:

Gravitational force: It is defined as a non-contact force exerted between two objects that possess mass. Gravitational force is attractive in nature and pulls objects together. As already said, the huge gravitational force of the Sun holds together all the planets and other heavenly bodies of the solar system. The planets revolve around the Sun at speeds that just balance the Sun's gravitational pull. So, they are locked in a permanent orbit around the Sun. Gravitational force is the weakest of all fundamental forces.



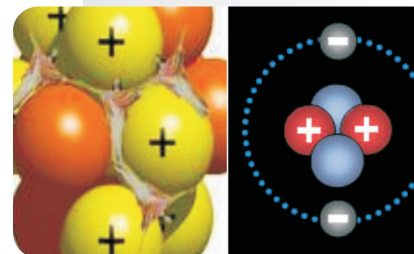
Gravitational force



Magnetic force

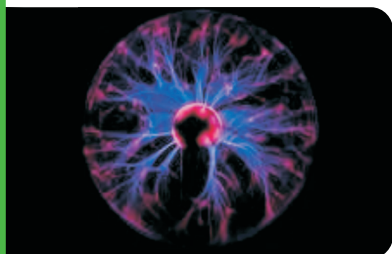
Magnetic force: It is a non-contact force similar to gravitational force and acts on objects present even at smaller distances. Magnetism can produce a force acting towards or away from a magnet. Magnets have two poles, north (N) and south (S). Two magnets attract each other if their opposite poles are brought closer and repel if their like poles face each other.

Nuclear force: Nuclear force is the force that holds together the subatomic particles such as protons and neutrons present in the nucleus of an atom. It is the strongest of all the forces in nature. However, nuclear force also has the shortest range. In other words, the particles must be extremely close before its effects can be felt. It acts equally between two protons, two neutrons, or a proton and a neutron.



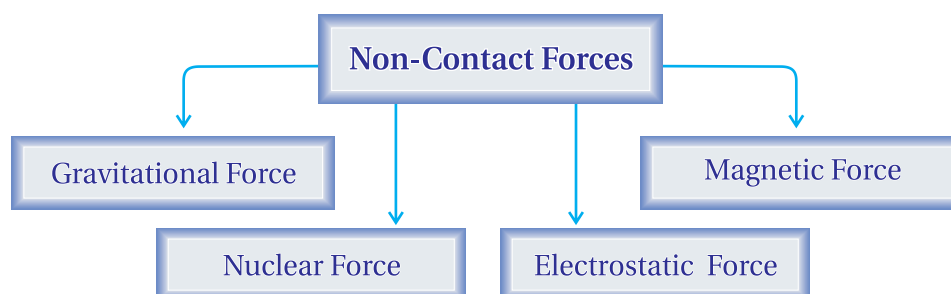
Nuclear force

Electrostatic force: It is a non-contact force exerted between two charged particles or objects. Electrostatic force is either attractive or repulsive in nature. When the charged particles or objects are of the same polarity, i.e. both are positively charged or both are negatively charged, they repel each other. If the particles or objects are of opposite polarity, i.e. one is positively charged while the other is negatively charged, they attract each other. In short, we can say, like charges repel and unlike charges attract each other.



Electrostatic force

It is the electrostatic force that keeps the electrons in an atom moving in a circular path called orbit.



What you need to do... >>>

1. Place a bar magnet on a table. Place a sheet of paper over the magnet. Sprinkle some iron filings on the paper and tap it gently. Observe what happens. Now, place another magnet under the paper, ensuring that the like poles of the two magnets face each other. Tap the paper and record what happens. Change the position of the magnets, so that now the unlike poles face each other. Again tap the paper and record what happens. Draw the patterns formed by the iron filings in each case.
2. Make a magnetic picture. Place a file card over a magnet. Sprinkle some iron filings on the card. The filings will form a design because of the magnetic field. Spray the cards with hair spray. Dry and spray again before removing the magnet. Draw the pattern formed.
3. Take a magnet in a cup. Place it in the pan on one side of a balance. Beneath the pan attach another magnet. Place some washers on the other pan of the balance. Observe what happens. State the type of force experienced by the magnet in the cup.

Interesting Fact

Black holes are large, dead stars whose gravitational pull is so strong that it crushes the star to zero volume. Nothing can escape from them, not even light. So, they cannot be viewed. The closest known black hole near Earth is Cygnus X-1, located about 8000 light years away.

What you need to know... >>>



At high altitudes, air pressure decreases. Hence, pilots are required to use special pressure suits. Oxygen is circulated within these suits at a suitable pressure to help the pilots breathe. Sometimes, the word pressure is also used in other contexts. Does the phrase 'pressure of studies' sound more familiar to you? Let us find out what pressure means in Physics.

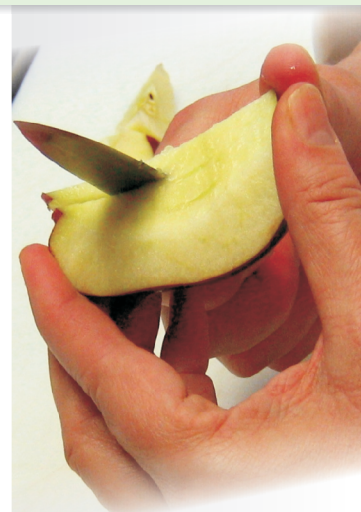
Pressure

Pressure is an effect that occurs when force is applied on a surface. It is the force applied per unit area of the surface.

$P = \frac{F}{A}$, where P is pressure, F is the force exerted and A is the surface area where force is applied.

The SI unit of measuring pressure is **Pascal**.

Pressure is the most important variable to be kept in mind while performing various activities. For example, if we try to cut a fruit with the flat side of a knife, we cannot insert the knife easily. However, if we use the sharp edge of the knife, the fruit can be cut easily. The reason is that for a given force, if the surface area is larger, the force gets spread out, so less pressure is exerted.



The lesser the surface area, the more the pressure exerted

Thus, it is difficult to cut something using the blunt edge of a knife. For the same reason, it is better to have a sharp needle for an injection since a smaller area of contact implies that less force will be required to push the needle through the skin.

Different Types of Pressure

Pressure plays an important role in our lives. The football that you play with or the tyres of your bicycle, both use the principle of air pressure.

Pressure exerted by a solid

Let us consider an example from your classroom scenario. While putting up a chart on the soft board, you place the board pin with its pointed end towards the board. It goes right inside the board when you give a slight push with your thumb. Since the pointed end of the pin has a small surface area, the pressure applied is more and so it pierces the board with greater ease.

If you place a solid object on the floor, the pressure exerted on the floor over the area of contact is the weight of the object divided by the area of the floor it covers. A good example of how force on a small area can result in a very high pressure is seen in a woman's high, spiked heels. The weight of the whole body exerts force on a very small area resulting in huge pressure on the floor. On the other hand, a camel can walk easily in a sandy desert because its feet have a large surface area and so, the weight of the body is evenly spread out. So, the pressure exerted is less and the feet do not sink into the soft sand.



Pressure exerted by a liquid

You must have felt the pressure of water around when you go for swimming.



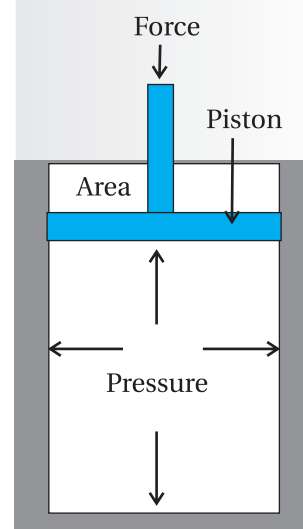
Deep sea diver

If you dive deeper into the pool or in the sea, the pressure of water on you goes on increasing with the depth. This is the reason why dams have thicker walls at the base, so that they can withstand the high pressure exerted by the water at a greater depth. Similarly, deep-sea divers make use of special clothing to withstand the high pressure exerted by water at that depth.

If a liquid or gas is confined in a container or cylinder, the pressure can be increased by applying force with a solid piston. The pressure created in the cylinder equals the force applied divided by the area of the piston, i.e. $P = \frac{F}{A}$, as shown in Fig. 2.

Pressure exerted by gas

In our daily life, we come across numerous examples where we can feel and experience the effect caused by the pressure exerted by gases. You all know that pressure is exerted on our bodies by the atmosphere that, in turn, is made up of layers of gases. Usually, human lungs are also adapted to exchange of gases at atmospheric pressure at sea-level. But when we climb a



Cylinder
Fig. 2

mountain breathing becomes extremely difficult. This happens because at higher altitude, the atmosphere becomes thinner and air pressure decreases.

Another practical example of air pressure is when you use a foot pump to inflate a bicycle tyre or a football. The air from the foot pump is pumped at a pressure to inflate the tyre.

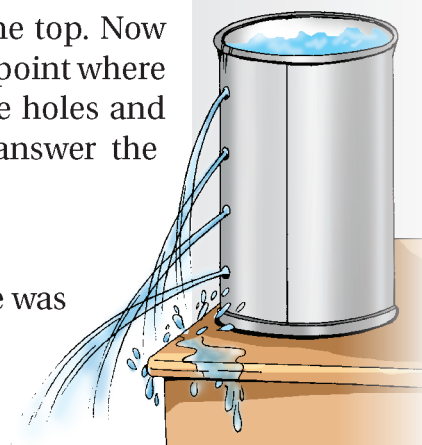


Foot pump

What you need to do... >>>

Take a can made of tin. Make four holes with the help of a screwdriver. The holes should be in a straight line from top to bottom. Cover the holes with the help of adhesive tape. Pour water in the can till it is filled to the top. Now remove the tape from one of the holes and measure the farthest point where the water falls. Similarly, remove the tape from the other three holes and measure the distance again. Record your observations and answer the following questions:

1. What happened when the tape was removed?
2. Which hole had the strongest stream of water when the tape was removed? Why?
3. Which hole had the weakest stream of water when the tape was removed? Why?
4. Water from which hole reached the farthest? Why?
5. Why was there a difference in the strengths of the four streams of water?



A tin can filled with water

What you know now... >>>

- Force is exerted due to interaction between two objects.
- Force can cause a body to be in motion or change the speed and direction of motion of an object.
- Deformation can be defined as the change in the shape or size of an object due to the application of force.
- The different types of forces that can cause deformation are compressive, tensile and torsion forces.
- Muscular force, rolling friction and sliding friction are contact forces.
- Gravitational force, magnetic force, nuclear force and electrostatic force are non-contact forces.
- Pressure is the force exerted per unit area. The SI unit of pressure is Pascal.
- Pressure is exerted by solids, liquids as well as gases.

Time to chat... >>>

http://blog.themillenniumschoools.com



Welcome to educhat

Web screen for 'Force and Motion'

- Neha:** Hi friend, long time no see! I happened to visit your house on Sunday, but a big lock greeted me.
- Umbar:** Oh, I am so sorry. We had gone to see a village fair.
- Neha:** Must've left early, because I came around eight.
- Umbar:** Actually, we had left early, but we got stuck on the highway as we ran out of petrol.
- Neha:** Tough luck! What did you do?
- Umbar:** We had to push the car to the nearest petrol pump.
- Neha:** Good that you have a muscular body! So, how was the fair?
- Umbar:** There were many stalls. In one of the stalls, we saw a potter at his wheel applying force to shape pots out of clay.
- Neha:** Yah, they do make amazing pots! Did you buy any?
- Umbar:** No, I was more fascinated by the person lying on a bed of nails.
- Neha:** That's because his weight was distributed uniformly over the large number of nails.
- Umbar:** Bulls eye! How did you know?
- Neha:** Elementary, my dear Umbar! Any other interesting stuff?
- Umbar:** I enjoyed the breaking of the structure made of tumblers. Believe me, I was able to make all the tumblers fall with just a single throw.
- Neha:** You seem to have had a good time! Maybe, I will also visit the fair sometime.

Done

B I U

Arial

12 pt

Catch you later at

<http://blog.themillenniumschoools.com>

Send



Time to workout... >>>

1. Identify the types of forces (contact or non-contact) in each of the following.
 - a. A ball that is thrown up falls down
 - b. Formation of molecules
 - c. Iron particles attracted towards a magnet
 - d. Wrestlers fighting in a ring
 - e. Falling down of raindrops
2. In which of the following cases is greater pressure applied?
 - a. A person lying on a bed of nails
 - b. An elephant moving on sand
 - c. A woman wearing high, spiked heels
3. A ball has a weight of 250 gm. How much pressure do you experience when you balance it on the tip of your finger that has an area of 1 cm square (1 cm²)?
(Hint: Use $P = \frac{F}{A}$ to calculate the pressure.)
4. Choose the correct option.
The pressure exerted by a liquid
 - a. increases with depth.
 - b. decreases with depth.
 - c. does not change with depth.
 - d. is different in different directions at the same depth.
5. List five situations where low pressure is applied, say by a camel's feet and five situations where high pressure is applied, such as while writing with a pointed pencil or cutting with a blade.
6. 'Force is exerted due to the interaction between two objects'. Give two examples to support your answer.
7. What are the different types of contact forces? Illustrate each with examples.
8. Name the different types of non-contact forces. Give an example of each type.
9. Is magnetic force a type of contact or non-contact force? Explain.
10. Define deformation and give the causes of deformation.
11. What do you understand by pressure? What is the SI unit for measuring pressure?
12. What are the different types of pressure? Give examples of pressure caused by a solid on a solid and a solid on a liquid.



For the Apprentice... >>>

As an apprentice to a pilot you need to find how much pressure do you exert when you stand on the floor by using the force-area relationship.

What you can aspire to be... >>>

Making sculptures of wood and clay

visiting amusement parks

Avoiding injuries during sports

Scoring points in games

Participating in sports events



Judging the magnitude of force needed for a task

A pilot

A sportsperson

An aeronautical engineer

Explore...

Know more about forces at:

<http://www.glenbrook.k12.il.us/gbssci/Phys/Class/newtlaws/u2l2b.html>

Know more about commercial pilots at:

<http://career.webindia123.com/career/institutes/index.asp>

Know more about fighter pilots at:

<http://careerairforce.nic.in>

Know more about deep-sea diving at:

<http://visualmagic.awn.com/archive/archive06.html>

http://www.encyclopedia.com/topic/deep-sea_diving.aspx#1E1-diving-d

Smart Class Module... 6-8_Force and Gravity_Friction

6-8_Work, Energy and the Simple Machine: Compound Machines

Tool Kit... rubber bands, foam, can, tennis ball, lead ball, bar magnet iron filings, hair spray, washers, a balance, a tin can, adhesive tape, ruler