CHAPTER 1

Force and Pressure

Introduction

Force is a familiar word in science. In our daily life we experience, the concept of force. When we push or pull an object, we exert a force on it. We exert a force when we throw or kick a ball. In these examples, the word force, is associated with the result of muscular activity and with some change in the state of motion of an object.

Force

Force is defined as a push or pull acting on a body. Whenever something moves, force must be involved.

The direction in which an object is pushed or pulled is called the direction of force. The SI unit of force is newton, denoted by the symbol N. In CGS system, the unit of force is dyne. 1 N = 10^5 dyne

DO YOU KNOW?

- The SI unit of force is newton (N). It was named after the scientist Sir Issac Newton.
- There only four fundamental forces : Gravitational force, Electromagnetic force, Weak force and Strong force.

Balanced and Unbalanced forces

If a set of forces acting on a body produces no acceleration in it, the forces are called balanced. If it produces a non-zero acceleration, the forces are said to be unbalanced.

When forces are applied on an object in the same direction, we get the net force by adding the magnitude of forces. When two forces are applied on an object in opposite directions, the net force is the difference in the magnitude of forces and acts in the direction of larger force.

(a) Forces in the same direction

(b) Forces in the opposite direction

A force can be described by stating its magnitude and the direction in which it acts.

When two forces act on an object in the same or opposite directions, the effect on the object is due to the net force acting on it. In this case it is the sum or difference of the two forces.

ACTIVITY CORNER

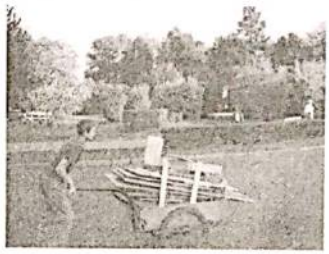
To study the net effect of two or more forces acting on a body in different directions.

- Observe a group of ants trying to pull a dead insect to their anthill. If all ants were to pull in the same direction, the forces would add up and their job would be easy.
- However, the ants do not pull in one direction, each ant pulls in a different direction.
- The insect moves in the direction of the net effect of all these forces. If the insect moves in the desired direction, the ants keep on pulling. But if it moves in another direction, they change their positions and pull again. They keep adjusting their positions until the net force acts in the desired direction and the insect moves towards their anthill.
- We conclude that when two or more forces act on an object in different directions, the effect is due to the magnitude and direction of the net force acting on it.

Effects of Force

Force can make a stationary object move

When you throw a ball, it moves. If you push a book lying on a table, it starts moving, *i.e.*, you make it move. When you pull a chair, it starts moving.



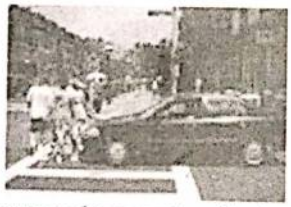
Force can make a stationary object move.

Force can change the direction of motion of a moving object

When a batsman hits a cricket ball with his bat, he applies force to change the direction of the moving ball.

Force can stop a moving object

If we apply brakes to moving car, it first slows down and then stops.



Force can make a moving object move slower.

Batsman hitting cricket ball, to show the change of direction after impact.

ILLUSTRATIONS

1 Given diagram shows a moving ping pong ball, hit by a player. What effect of the force is shown in the picture?

Ans.: The force changes the direction of the moving object.

2 The arrow in given diagram shows the direction of a sailing ship moves. What happens if a strong wind blows from the same direction?

Ans.: The sailing ship moves faster.

Force can change the shape of an object.

If you squeeze a lump of plasticise or sponge, its shape changes.

ACTIVITY CORNER

To study the effects of force.

- Some situations have been given in Column 1 of table in which objects are not free to move. Column 2 of the table suggests the manner in which a force can be applied on each object while Column 3 shows a diagram of the action.
- Try to observe the effect of force in as many situations as possible. You can also add similar situations using available material from your environment. Note your observations in Columns 4 and 5 of the table.

Table : Studying the effect of force on objects.

Description of situation	How to apply force	Diagram	Action of force	
			Change in state of motion	Change in shape
			Yes No	Yes No
A lump of dough on a plate	Pressing it down with your hands.			
Spring fixed to the seat of a bicycle.	By sitting on the seat.			
A rubber band suspended from a hook/nail fixed on a wall	By hanging a weight or by pulling its free end.			
A plastic or metal scale placed between two bricks.	By putting a weight at the centre of the scale.			

Types of Forces

Force is classified into two types :

Contact Forces

Forces that act only when there is physical contact between two interacting objects are known as contact forces.

Example : Muscular force and frictional force.

Muscular force : The force applied by the muscles of our body is called muscular force or biological force.

Frictional force : The frictional force is the opposing force exerted by one surface over other due to relative motion between two surfaces in contact.

Muscular force

The force of friction always acts on all the moving objects and its direction is always opposite to the direction of motion.

Non-contact forces

Force is being applied without touching the body. This is called action at a distance forces. It is also called non distance forces.

Example : Gravitational force, magnetic force and electrostatic force.

Gravitational force : Gravitational force is the force of attraction between particles of matter. Every object exerts this force on every other object. The magnitude of the force depends on the masses of the two objects and the distance between them.

The gravitational force exerted by the earth on all other bodies is called the force of gravity or simply gravity.

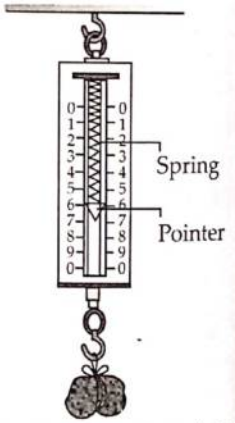
This gravitational force makes the earth move around the sun and also makes the moon go around the earth.

DO YOU KNOW?

- The value of the gravitational constant G was first determined experimentally by English Scientist Henry Cauendish in 1798.

Mass

- Mass is the amount of substance contained in a certain object. Substance that makes up an object is known as matter. Hence mass is the quantity of matter.
- The unit of mass is kilogram (kg), the smaller units are gram (g) and milligram (mg).
  1 kg = 1000 g
  1 g = 1000 mg.
- All object have mass. Every object on earth's surface is pulled towards its centre by gravitational forces. The gravitational force pulling, an object towards itself is said to be its weight.
  Weight (W) = mass (m) × gravity (g).
- On Earth, value of g_{earth} varies from place to place. The gravitational force at the poles is higher than at the equator. Hence an object appears to be heavier at the poles than at the equator. The gravitational force on earth is six times stronger than on the Moon. Therefore if your weight is 60 N on Earth, you will only be 10 N on the moon.
- The weight of an object can be measured by a spring balance or compressed balance. When we weight an object using a spring balance, we are actually measuring the earth's gravitational pull on that object. As weight is a force, its unit is newton.



Spring balance with a weight.

ILLUSTRATIONS

3 Mass of a body is 5 kg. What is its weight? [Take $g = 9.8$ m s^{-2}]

Ans.: Mass (m) = 5 kg
Acceleration due to gravity (g) = 9.8 m s^{-2}
We know that $W = m\,g = 5 \times 9.8 = 49$ N.

4 What is the mass of an object whose weight is 49 newton ? [Take $g = 9.8$ m s^{-2}]

Ans.: Weight (W) = 49 N
Acceleration due to gravity (g) = 9.8 m s^{-2}
Mass (m) = ?
We know that

$$W = mg \Rightarrow m = \frac{W}{g},\ m = \frac{49}{9.8} = 5 \text{ kg}.$$

Magnetic force : The force exerted by magnets (and some magnetic materials) on each other and on some metals like iron, nickel, cobalt and alloys such as steel, etc., is known as magnetic force. Two magnets attract or repel each other depending on which ends are facing each other. Like poles repel each other, whereas, unlike poles attract each other.

ACTIVITY CORNER

To show that magnetic force acts from a distance.

- Put some iron nails on a sheet of paper. Bring a small magnet near these iron nails.
- You will see that the iron nails are pulled towards the magnet even when they are a little distance away from it.
- This shows that magnetic force can act from a distance.
- Take two bar magnets. Bring them close together end to end, so that their north poles face each other. What happens? Do they attract or repel each other? Now bring the south pole of one of the magnets near the north pole of the second magnet and try again. What happens now? You will find that their behaviour is opposite to what you observed earlier.

Magnetic force acting from a distance.

Electrostatic force : Electrostatic charge can exert a force called electrostatic force. It is because of this force that the bits of paper move towards the comb. Electrostatic force, like magnetic force, also acts from a distance, and is a non-contact force.

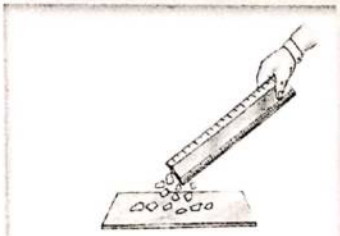
Electrostatic force is used to control pollution by separating solid pollutant particles from smoke given out from factories.

Electrostatic force acting from a distance.

ACTIVITY CORNER

To study electrostatic force.

- Take a plastic pen or ruler from your pencil box.
- Rub it vigorously on your hair (Make sure that your hair is dry).
- Bring the rubbed end near some tiny bits of paper or fluff.
- You can see the little bits of paper or fluff get attracted to the plastic ruler pen.
- This is because the pen acquires an electric charge while rubbing, this charge can exert a force called electrostatic force.



A ruler attracting bits of paper.

COMPETITION WINDOW

Newton's First Law of Motion

- A particle remains at rest or moves in a straight line with a constant speed unless it is compelled to change that state by an external unbalanced force. First law of motion gives the definition of inertia.

Inertia and mass : The inertia of an object is measured by its mass. A massive object has more inertia than a light object.

Inertia of rest : Tendency of a body to continue its state of rest.

- For example, when a bus starts suddenly, the passengers fall backwards. This is due to inertia of rest.

Inertia of motion : Tendency of a body to continue its state of motion.

For example a bicycle is observed to move forward even when pedaling is stopped, this is due to inertia of motion.

Newton's Second Law of Motion

- The rate of change of momentum of a particle is directly proportional to the force acting on it and takes place in the direction of applied force.

  Mathematically, $F \propto \frac{\Delta p}{\Delta t}$

  $\Rightarrow F = k\left[\frac{p_2 - p_1}{\Delta t}\right]$

  $\Rightarrow F = k\left(\frac{mv - mu}{\Delta t}\right) = km\left(\frac{v-u}{\Delta t}\right) = km\left(\frac{\Delta v}{\Delta t}\right)$

  $\therefore F = kma \quad \left(\because a = \frac{\Delta v}{\Delta t}\right)$

- The value of constant of proportionality, k can be taken as 1 when unit of force is so chosen (in S.I. units) that it produces unit acceleration in a unit mass then $F = ma$.
- The second law of motion gives us a method to measure the force acting on an object as a product of its mass and acceleration.

Linear Momentum (p)

- The total quantity of motion contained in a body is known as its momentum. It is a vector quantity.
- Momentum is measured as the product of mass and velocity.
- $p = mv$
- S.I. unit of momentum is kg m s^{-1}.

Impulse

- The product of force and time for which the force acts is called impulse.
- When a large force acts on a body for a very short duration of time then this large force is called impulsive force.

  Impulse = force × time = mat

  $= m\left(\frac{v-u}{t}\right)t = m(v-u)$

  Hence, impulse is also defined as change in momentum.
- The area under force (F) versus time (t) graph will give the change in momentum *i.e.*, impulse.
- It is a vector quantity. The SI unit of impulse is N s.

Newton's Third Law of Motion

- To every action there is an equal and opposite reaction.
- Whenever two bodies exert force on each other, the force exerted by first body on the second (action) is equal in magnitude but opposite in direction to the force exerted by second body on the first (reaction).
- Action – reaction forces act on different object and never on the same object.
- Even though the action and reaction forces are always equal in magnitude, these forces may not produce acceleration of equal magnitudes because each force acts on a different object that may have different masses.

Pressure

The effect that a force has when it acts on a surface depends on two factors :

(i) The amount of force applied.

(ii) The area in contact over which the force is applied.

Pressure is defined as the force acting per unit area.

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

It is clear from above expression, the smaller the area over which a force acts, the greater is pressure and therefore, the greater is the effect of force.

In the SI system of units, force is measured in newton and area in m^2. Therefore, the unit of pressure is N m^{-2}. However N m^{-2} is called Pascal (Pa) in honour of the French physicist Blaise Pascal.

Therefore, 1 N m^{-2} = 1 Pa.

All cutting instruments like knives, blades, axes, etc are sharpened (thin) at the cutting edge to decrease the area of intersection. This is done so as to increase the pressure exerted by these instruments for a given force.

DO YOU KNOW

- Wall of dams are specially thickened and broaden at the base than at the top to withstand the huge pressure of water.

Atmospheric Pressure

The pressure exerted by the atmosphere is known as atmospheric pressure. The earth is surrounded by a layer of air, about 120 km deep, the atmosphere. The atmosphere exerts an enormous pressure of around 100,000 N/m^2 on the earth.

A barometer is used to measure atmospheric pressure.

DO YOU KNOW

- We cannot dive more than about 120 m in water. The water pressure below this is enough to crash the human body.

Pressure Exerted by Liquids

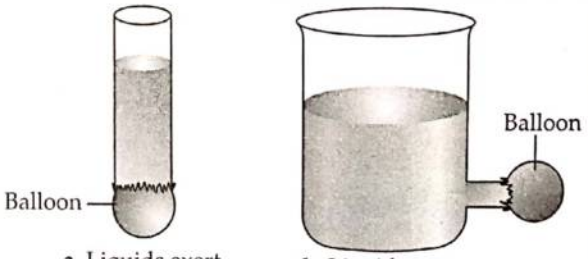
Like air, water and other liquids can also exert pressure.

Liquids exert pressure as we will learn from the following activity.

ACTIVITY CORNER

To show that liquids exert pressure on all sides.

- Take a wide glass tube open at both ends. Tie a rubber balloon to its lower end. Pour water into the tube (figure a). You will notice that the balloon bulges downwards.
- This shows that liquids exert pressure on the base of the container in which they are kept.



a. Liquids exert pressure downwards.

b. Liquids exert pressure sideways.

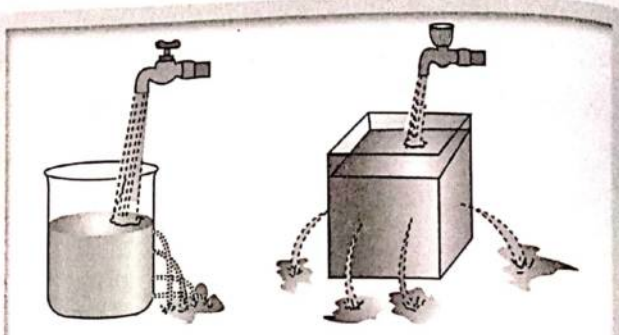
- Now take a vessel with a tap-like opening at its side. Tie a balloon to the opening and fill the vessel with water (figure b). You will notice that the balloon bulges outwards. This shows that liquids exert pressure not only on the base of the container but also sideways on the walls of the container. This sideways pressure is exerted by liquids but not by solids.

The pressure at the bottom of the sea is much greater than near the surface. This is the reason why deep-sea divers have to wear special suits to prevent their bodies from being crushed.

ACTIVITY CORNER

To show that liquid pressure varies with depth.

- Take a plastic container and make four holes in it at different heights. Fill the container with water, and let water keep flowing into it from a tap (figure a).
- Notice the force with which water comes out of the holes.
- You will find that water comes out with greater force from the holes at greater depth. Water from the bottom most hole will be spurted out the farthest from the container. This shows that the pressure in a liquid increases with increasing depth.



a. Water pressure increases with depth.

b. Pressure at the same depth is the same in all directions.

An instrument used to measure liquid pressure is called pressure gauge. The simplest form of pressure gauge is a manometer, which measure pressure difference.

COMPETITION WINDOW

Archimedes Principle

- It states that when a body is immersed wholly or partly in a liquid at rest, it loses some of its weight. The loss in weight of the body in the liquid is equal to the weight of the liquid displaced by the immersed part of the body.
- Determination of relative density of a body:

$$\text{Relative density} = \frac{\text{Weight of the body in air}}{\text{Loss of weight in water}}$$

$$= \frac{W_{air}}{W_{air} - W_{water}}$$

- Determination of relative density of liquid :

$$\text{Relative density} = \frac{\text{Loss of weight in liquid}}{\text{Loss of weight in water}}$$

$$= \frac{W_{air} - W_{liquid}}{W_{air} - W_{water}}$$

Floatation

- When a body of density ρ and volume V is completely immersed in a liquid of density σ, following two forces act on the body :
  - Weight of body, $W = V\rho g$ acting vertically downwards through the centre of gravity.
  - Buoyant force or upward thrust, $F_B = V\sigma g$ equal to weight of the liquid displaced, acting vertically upwards through the centre of buoyancy.
  - Depending upon relative magnitudes of above two forces, following three cases are possible:
    - If $W > F_B$, the body will sink to the bottom of the liquid. It will be so when the density of solid by (ρ) is greater than the density of liquid (σ) *i.e.* $\rho > \sigma$.
    - If $W < F_B$, the body will rise above the surface of liquid to such an extent that the weight of the liquid displaced by immersed part of the body (*i.e.* upward thrust) becomes equal to the weight of the body. The body then will float. In this case the density of solid body is less than the density of liquid *i.e.* $\rho < \sigma$.
    - If $W = F_B$, the body is at rest any where in the liquid. The body will float if its whole volume is just immersed in the liquid. In this case the density of body is equal to density of liquid *i.e.* $\rho = \sigma$.
- The law of floatation states that a body will float, if the weight of the liquid displaced by the immersed part of the body is equal to the weight of the body.

ILLUSTRATIONS

5 Calculate the pressure exerted by a brick, which applies a force of 2.5 N, when (a) it is placed upright on the soil, (b) when it is placed on its widest base. The dimensions of the brick are 25 cm × 10 cm × 5 cm.

Ans.: (a) When the brick is placed up right :

Area in contact with soil = 10 cm × 5 cm

$= \frac{10}{100}\text{ m} \times \frac{5}{100}\text{ m} = 0.005\text{ m}^2$

$\therefore$ Pressure exerted $= \frac{F}{A} = \frac{2.5\text{ N}}{0.005\text{ m}^2} = 500\text{ Pa}$

(b) When the brick is placed on its widest base :

Area in contact with soil = 25 cm × 10 cm

$= \frac{25}{100}\text{ m} \times \frac{10}{100}\text{ m} = 0.025\text{ m}^2$

$\therefore$ Pressure exerted $= \frac{F}{A} = \frac{2.5\text{ N}}{0.025\text{ m}^2} = 100\text{ Pa}$

6 Why is it easier to swim in sea water than in the river water ?

Ans.: The density of sea water is more than the density of river water, hence sea water gives more upthrust for the same volume of water displaced.

7 The dams of water reservoir are made thick near the bottom. Why?

Ans.: Pressure exerted by a liquid column = $h\rho g$ so as 'h' increases P increases. So to withstand high pressure dams are made thick near the bottom.

8 The blood pressure in human is greater at the feet than at the brain. Why?

Ans.: The height of blood column is quite large at feet than at the brain, hence blood pressure at feet is greater.

Applications of Pressure

(i) Pressure due to liquids in blood vessels helps blood to move throughout the body.

(ii) We use rubber suckers for installing hooks in the kitchen. As the air between wall and sucker is sucked out, it is held firmly against the wall.

(iii) We enjoy cold drinks with a straw. This happens when air of straw goes into lungs and forces liquid from straw to come out.

(iv) Vacuum cleaner - Low pressure is created inside the cleaner which sucks dirt into the device.

(v) Squeezing of tooth paste, lemon, spray bottle, perfume bottle, etc. are some activities which are not possible without understanding pressure.

CONCEPT MAP

FORCE AND PRESSURE

Force is a physical quantity that can be defined as a push or pull acting on an object which

- causes or tends to cause motion in an object.
- changes or tends to change the direction of motion of a moving object.
- changes or tends to change the size and shape of an object.
- changes or tends to change the speed of an object.

Physical contact during application of force

- **Muscular force :** The force applied by the muscles of our body.
- **Frictional force :** The opposing force exerted by one surface over other due to relative motion.

Force applied without touching the body

- **Gravitational force :** Force of attraction between any two particles / bodies.
- **Electric force :** Force acts between two charged particles/bodies.
- **Magnetic force :** Force exerted by a magnet on other magnet or magnetic materials.

The trolley moves along the direction we push it.

- **Weight :** It is the gravitational pull on an object.

Unit : kg f or newton.

- **Mass :** Quantity of matter present in an object.

Acceleration due to gravity $g = 9.8 \text{ m s}^{-2}$

- **Pressure :** Pressure is defined as the force acting per unit area,

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

- In the SI system of units, force is measured in newton and area in m^2. Therefore, the unit of pressure is $N\ m^{-2}$.
- The pressure exerted by a liquid depends upon the depth (height) of the liquid and density of the liquid.
- The pressure at any point under a liquid surface is due to the weight of the column of liquid above that point.

- **Manometer :** A device used for measuring liquid pressure.

- **Atmospheric pressure :** A layer of air called the atmosphere surrounds the earth. Air is matter and has weight. The weight of the atmosphere exerts a pressure on the surface of earth. This pressure is called atmospheric pressure.
- Atmospheric pressure reduces as height above the sea level increases.

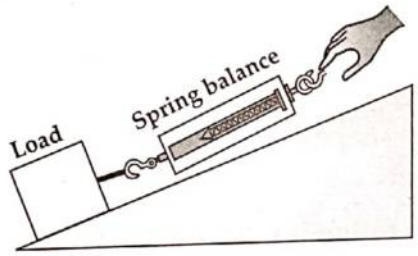
Solved Examples

1. How much would a 70 kg man weight on the moon? What will be his mass on the earth and on the moon? [g on moon = 1.7 m s^{-2}]

Ans.: Mass of the man, m = 70 kg
Acceleration due to gravity on moon. g_m = 1.7 m s^{-2}
Weight of the man on the moon, W = ?
From relation, $W = mg$
Putting values, we get, $W = 70 \times 1.7 = 119$ *i.e.* W = 119 N.

The weight of the man on the moon will be 119 N The mass will remain same (70 kg) on earth and the moon.

2. A student is pulling a load up an inclined plane. What are the forces the student has to overcome?



Ans.: (a) Frictional force
(b) Gravitational force

3. Why carts with rubber tyres are easier to ply, than those with iron tyres?

Ans.: The friction between rubber and road is less, than between iron and road. Therefore, it is easy to ply a cart with rubber tyres, than with iron tyres.

4. A person weight 600 N. He is wearing shoes with a total area of 0.02 m^2. What pressure do they exert on the floor?

Ans.: Pressure = $\frac{\text{Force}}{\text{Area}}$

Given, weight = $mg = F$ = 600 N.
and A = 0.02 m^2

$\therefore$ Pressure = $\frac{600}{0.02}$ = 30000 N

5. Why are all the things attract towards the earth?

Ans.: Because, the huge mass of the earth and its gravity.

6. What is the effect of force on the shape of an object?

Ans.: A force can change or try to change the shape of an object. When a force is applied on an object then change in shape takes place. It may be smaller or greater. At last we can say that the application of force on an object may change its shape.

7. If several forces act in different direction on a body, in which direction will the body move?

Ans.: When several forces act on a body in different directions, the effect on the object is due to the magnitude and direction of the net force acting on it.

8. Why do the school bags have broad shoulder straps?

Ans.: School bags and shopping bags have broad belts or straps as handles. Narrow handles cause pain in the hand because the weight of the bag acts on a small area, so the pressure will be higher.

9. What do you mean by state of motion of a body.

Ans.: The state of motion of a body is described by its speed and direction of motion. The state of motion of an object at rest is the state of zero speed.

10. What happens to the pressure when area on which it is applied increases?

Ans.: Pressure = Force/Area on which force acts. The pressure is inversely proportional to the area on which force is applied. As the area in which force is increases, the pressure decreases.

11. How do we feel force in our daily life?

Ans.: Various big or small actions make us feel the force. We hit or catch many objects in our daily life. We see that a moving ball stops of its own. The ball changes the direction of its motion when hits with a bat. These are many actions which help us to feel that a force is exerted.

12. What are the effect of force?

Ans.: A force changes or tries to change

(i) Speed of a moving body

(ii) Direction of motion of a body

(iii) Shape of a body.

13. A force 20 N acts over an area of 4 cm^2. Find the value of pressure? [in N m^{-2}]

Ans.: Pressure = $\frac{\text{Force}}{\text{Area}}$

Given F = 20 N

and $A = 4\ cm^2 = 4 \times 10^{-4}\ m$

$\therefore$ Pressure = $\frac{20}{4 \times 10^{-4}} = 50000\ N m^{-2}$

14. Can you separate two hemispheres, if all the air is suck out from them?

Ans.: If there is no air inside the two hemispheres, then only outer surface is in contact of atmospheric pressure and atmospheric pressure acts on it. We cannot separate them in that case.

NCERT Section

1. Give two examples of each situations in which you push or pull to change the state of motion of objects.

Ans.: (i) We apply brakes to a moving bicycle.

(ii) We pull a chair to change its position.

2. Give two examples of situations in which applied force causes a change in the shape of an object.

Ans.: (i) A lady making chapattis.

(ii) By pulling a rubber band suspended from hook/ nail fixed on a wall.

3. Fill in the blanks in the following statements.

(a) To draw water from a well we have to____ at the rope.

(b) A charged body ____ an uncharged body towards it.

(c) To move a loaded trolley we have to ____ it.

(d) The north pole of a magnet ____ the north pole of another magnet.

Ans.: (a) pull (b) attracts

(c) push (d) repels

4. An archer stretches her bow while taking aim at the target. She then releases the arrow, which begins to move towards the target. Based on this information fill up the gaps in the following statements using the following terms.

muscular, contact, non-contact, gravity, friction, shape, attraction

(a) To stretch the bow, the archer applies a force that causes a change in its ____.

(b) The force applied by the archer to stretch the bow is an example of ____force.

(c) The type of force responsible for a change in the state of motion of the arrow is an example of a ____ force.

(d) While the arrow moves towards its target, the forces acting on it are due to ____ and that due to ____ of air.

Ans.: (a) shape (b) muscular

(c) contact (d) gravity, friction

5. In the following situations identify the agent exerting the force and the object on which it acts. State the effect of the force in each case.

(a) Squeezing a piece of lemon between the fingers to extract its juice.

(b) Taking out paste from a toothpaste tube.

(c) A load suspended from a spring while its other end is on a hook fixed to a wall.

(d) An athlete making a high jump to clear the bar at a certain height.

Ans.: (a) The fingers are the agents, lemon is the object. The effect of force is the lemon juice being expelled by squeezing.

(b) The hand is the agent, toothpaste tube is object and the coming out of the paste from toothpaste tube is the effect of force.

(c) Suspended load is agent, spring is the object, the effect of force can be seen in the form of elongation of spring on suspension of load.

(d) Athlete is the agent, bar is the object. The force can be seen in the form of jump.

6. A blacksmith hammers a hot piece of iron while making a tool. How does the force due to hammering affect the piece of iron?

Ans.: The force is applied due to hammering causes, change in shape of iron and iron can be moulded in the shape of the required tool.

7. An inflated balloon was pressed against a wall after it has been rubbed with a piece of synthetic cloth. It was found that the balloon sticks to the wall. What force might be responsible for the attraction between the balloon and the wall?

Ans.: Electrostatic force.

8. Name the forces acting on a plastic bucket containing water held above ground level in your hand. Discuss why the forces acting on the bucket do not bring a change in its state of motion.

Ans.: Gravitational and muscular forces are acting on a plastic bucket. The forces acting on the bucket do not bring a change in its state of motion because muscular force acts upward direction and gravitational force acts downward direction. Hence net force on bucket is zero.

9. A rocket has been fired upwards to launch a satellite in its orbit. Name the two forces acting on the rocket immediately after leaving the launching pad.

Ans.: (i) Gravitational force.

(ii) Frictional force.

10. When we press the bulb of a dropper with its nozzle kept in water, air in the dropper is seen to escape in the form of bubbles. Once we release the pressure on the bulb, water gets filled in the dropper. The rise of water in the dropper is due to

(a) pressure of water.

(b) gravity of the earth.

(c) shape of rubber bulb.

(d) atmospheric pressure.

Ans.: (d) : Atmospheric pressure.

Exercise

Multiple Choice Questions

LEVEL - 1

1. Which of the following is not a correct statement?
   (a) A force can change the state of rest or motion of a body
   (b) A force can change the direction of a body
   (c) A force can change the chemical properties of a body
   (d) A force can change the dimensions of a body.

2. Which of the following forces is needed to pick up your school bag?
   (a) Muscular force
   (b) Gravitational force
   (c) Magnetic force
   (d) Electrostatic force.

3. You pick up your school bag by muscular force. The muscular force is also known as....
   (a) frictional force (b) magnetic force
   (c) biological force (d) all of these.

4. When a ball is dropped from a certain height the speed of the ball goes on increasing due to
   (a) gravitational force (b) biological force
   (c) magnetic force (d) all of these.

5. Force of friction is an example of
   (a) non-contact force (b) contact force
   (c) reactive force (d) none of these

6. If no external force acts on a body, it will
   (a) move with more speed
   (b) change its shape
   (c) break into pieces
   (d) either remain in its state of rest or uniform motion.

7. When the driver of a fast moving car suddenly applies brakes, the passengers in the car
   (a) fall backward (b) fall forward
   (c) are not affected (d) none of these

8. The impact which a body can produce due to the combined effect of mass and velocity is called
   (a) momentum
   (b) force
   (c) moment of force
   (d) pressure

9. _____ is a measure of the gravitational force acting on an object.
   (a) mass (b) weight
   (c) pressure (d) none of these.

10. Mass differs from weight because
    (a) weight is a force whereas and mass is not a force.
    (b) the mass of an object is always more than its weight
    (c) mass can be expressed only in the metric system
    (d) there is no difference.

11. Smooth surface has _____.
    (a) less frictional force
    (b) more frictional force
    (c) sometimes less and sometime more force
    (d) no frictional force at all.

12. If two equal forces act on the body in opposite direction, then the resultant force on the body will be
    (a) more (b) less
    (c) zero (d) none of these

13. A batsman hits a cricket ball which then rolls on a level ground. After covering a short distance, the ball comes to rest. The ball slows down to stop because
    (a) the batsman did not hit the ball hard enough
    (b) velocity is proportional to the force exerted on the ball
    (c) there is a force on the ball opposing the motion
    (d) there is no unbalanced force on the ball, so the ball would come to rest.

14. An object rests on a horizontal frictionless surface. A horizontal force of magnitude F is applied. This force produces an acceleration
(a) only if F is larger than the weight of the object
(b) only while the object suddenly changes from rest to motion
(c) always
(d) only if the inertia of the object decreases.

15. 1 tonne is equal to
(a) 1000 mg (b) 1000 g
(c) 1000 kg (d) 100 kg

16. A spaceship continues moving in space with constant speed because
(a) no force of friction due to air acts on it
(b) no force of gravitational acts on it
(c) its mass is zero in space
(d) none of these

17. What principle is used in a newton spring balance?
(a) The mass of an object depends on its density.
(b) The mass of an object depends on the gravity pulling it.
(c) The weight of an object is directly proportional to its mass.
(d) The extension of the spring is directly proportional to the weight pulling it, and weight depends upon mass.

18. Which of these is a contact force ?
(a) friction
(b) magnetic force
(c) gravitational force
(d) electrostatic force

19. The state of motion of a body is described by its _____ and direction of motion.
(a) force (b) pressure
(c) speed (d) none of these.

20. There is one force which is exerted by all matter on all other matter. Which force is this?
(a) Gravitational force
(b) Magnetic force
(c) Electrostatic force
(d) Frictional force

21. Which of the following is weakest force in nature?
(a) Gravitational force
(b) Electrostatic force
(c) Magnetic force
(d) All of these

22. In CGS system, the unit of force is
(a) newton (b) pascal
(c) dyne (d) metre

23. Equal forces $\vec{F}$ act on isolated bodies A and B as shown in figure. The mass of B is three times that of A. The magnitude of the acceleration of A is

(a) three times that of B
(b) 1/3 that of B
(c) nine times that of B
(d) 1/9 that of B

24. A coin flicked across a table will stop, because
(a) it is heavy
(b) no force is acting on it
(c) earth attracts the coin
(d) table exerts a frictional force.

25. Which of the following substance can be attracted by magnet ?
(a) Iron (b) Wood
(c) Glass (d) All of these.

26. The magnet is stronger near the
(a) poles of the magnet
(b) ends of the magnet
(c) centre of the magnet
(d) one quarter point from the poles of the magnet.

27. The space or region around a magnet in which a force is experienced by magnetic material is called
(a) electric field (b) magnetic force
(c) magnetic field (d) magnetic axis.

28. The pressure at the bottom of the sea is
(a) greater than at sea level
(b) lesser than at sea level
(c) same
(d) none of these

29. When a body is thrown up, the force of gravity is
(a) in upward direction
(b) in downward direction
(c) zero
(d) in the horizontal direction.

30. Which of the following effects cannot be produced by a force?
(a) changing the mass of an object
(b) changing the shape of an object
(c) changing the position of an object.
(d) changing the direction of movement of an object

LEVEL - 2

31. Pick the fundamental law of motion
(a) Newton's first law of motion
(b) Newton's second law of motion
(c) Newton's third law of motion
(d) All laws of motion

32. Equal and opposite forces acting on a body which do not change its state of rest or motion are called
(a) null forces
(b) unlike parallel forces
(c) balanced forces
(d) all of these

33. If a body is allowed to fall down a height freely, its speed increases continuously. It is because
(a) air does not exert frictional force
(b) magnetic force of earth increases its speed
(c) gravitational force of earth increases its speed
(d) pressure of air forces it downward.

34. A large truck and a car are moving with same velocity have a head on collision. Which of the following is an incorrect statement?
(a) Both vehicles experience equal force of impact.
(b) The car will experience greater force of impact.
(c) The truck will experience lesser acceleration.
(d) The car will experience greater acceleration.

35. A body is in the state of rest on the surface of earth. Which of the following is a correct statement?
(a) Frictional force acts on the body
(b) Only the weight of body acts on it
(c) Only the reaction of the earth acts on it
(d) The weight of body acting downward is equal and opposite to the reaction of the earth.

36. A truck and a car are moving with velocity v towards each other. They collide head in and stops after some time. If the time of collision is 1 sec, which vehicle will have maximum change in momentum?
(a) Car
(b) Truck
(c) Both will have same
(d) None of the above

37. The force of freely falling body is directly proportional to
(a) mass of body
(b) acceleration of body
(c) velocity of body
(d) both (a) and (b)

38. The acceleration due to gravity near the surface of moon is
(a) $\frac{1}{6}$ of the acceleration due to gravity of earth
(b) almost equal to acceleration due to gravity of earth
(c) 6 times the acceleration due to gravity of earth
(d) $\frac{1}{12}$ of the acceleration due to gravity of earth.

39. Frictional force is important for motor racing. This is because, frictional force
(a) can help a car slow down
(b) can help a car move faster
(c) can help a car move around the corners without skidding
(d) both (a) and (b)

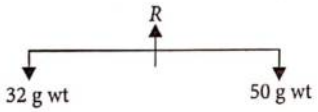
40. When a horse pulls a cart, the force which is responsible for the movement of cart is
(a) the force of the horse on the cart
(b) the force of the ground on the horse
(c) the force of the ground on the cart
(d) the force of the horse on the ground.

41. At the centre of earth the acceleration due to gravity is
(a) infinite (b) zero
(c) 9.8 m s^{-2} (d) all of these

42. An object is weighed in the following places using a spring balance. In which place will it weigh the heaviest?
(a) on the moon
(b) at the equator
(c) at the pole
(d) at the centre of earth

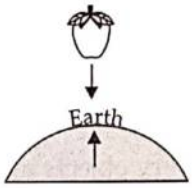
43. Why does an astronaut experience weightlessness in outer space?
(a) No gravitational force acts on him
(b) No frictional force acts on him
(c) There is no air resistance in outer space
(d) There is a vacuum in outer space

44. Two forces act on the either side of the rigid body of negligible mass suspended by string as shown in figure. If R is the force to balance then R will be



(a) 26 g wt (b) 41 g wt
(c) 82 g wt (d) 16 g wt

45. With the help of given figure, find which of the following options is correct?



(a) The apple pulls with greater force than the earth pulls the apple.
(b) The apple pulls with smaller force than the earth pulls the apple.
(c) The apple pulls the earth with the same force that the earth pulls the apple.
(d) All of these.

46. The mass of a body
(a) is slightly different at different places on earth
(b) is independent of the free-fall acceleration
(c) is the same for all bodies of the same volume
(d) can be measured most accurately on a spring scale.

47. An object placed on a equal-arm balance requires 12 kg to balance it. When placed on a spring scale, the scale reads 12 kg. Everything (balance, scale, set of weights and object) is now transported to the Moon where the free-fall acceleration is one-sixth that on Earth. The new readings of the balance and spring scale (respectively) are
(a) 12 kg, 12 kg
(b) 2 kg, 2 kg
(c) 12 kg, 2 kg
(d) 2 kg, 12 kg

48. When we press the bulb of a dropper with its nozzle kept in water, air in the dropper is seen to escape in the form of bubbles. Once we release the pressure on the bulb, water gets filled in the dropper. The rise of water in the dropper is due to
(a) Pressure of water
(b) Gravity of earth
(c) Shape of rubber bulb
(d) Atmospheric pressure

49. A car travels east with a certain constant velocity. The direction of the friction force on the car is
(a) due east
(b) due west
(c) up
(d) zero

50. When pressure is applied through a piston at the top of a closed tube containing water, the pressure is transmitted to
(a) Only the bottom of container
(b) All directions
(c) Only the side faces and the bottom of the container
(d) None of these

Match the Following

In this section each question has two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (a), (b), (c) and (d) out of which one is correct.

1.

List-I	List-II
(P) Magnetic force	1. Non-contact force
(Q) A physical quantity that determines the pressure in liquids	2. Depth
(R) Force	3. $N\ m^{-2}$
(S) Pressure	4. Newton.

(a) P–3, Q–2, R–4, S–1
(b) P–3, Q–4, R–2, S–1
(c) P–1, Q–2, R–4, S–3
(d) P–4, Q–3, R–1, S–2

2.

List-I	List-II
(P) Electrostatic force	1. Spring balance
(Q) Frictional force	2. Pascal
(R) Weight	3. Contact force
(S) Pressure	4. Non-contact force.

(a) P–3, Q–2, R–4, S–1
(b) P–3, Q–4, R–2, S–1
(c) P–1, Q–3, R–4, S–2
(d) P–4, Q–3, R–1, S–2

3.

List-I	List-II
(P) Contact force	1. A substance that can flow (both liquid and gasses).
(Q) Fluid	2. A force that acts upon another body through some material connecter.
(R) Manometer	3. A force that acts upon another body without the aid of a material connecter.
(S) Non contact force	4. A device used for measuring liquid pressure.

(a) P–2, Q–1, R–4, S–3
(b) P–3, Q–4, R–2, S–1
(c) P–1, Q–3, R–4, S–2
(d) P–4, Q–3, R–1, S–2

Assertion & Reason Type

Directions: In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of assertion.

(c) If assertion is true but reason is false.

(d) If assertion is false but reason is true.

1. **Assertion** : Force is defined as a push or a pull acting on a body.
Reason : CGS unit of force is newton.

2. **Assertion** : The weight of an object changes from place to place but not mass.
Reason : The weight of the object is independent of the value of g.

3. **Assertion** : The forces acting on a body can be replaced by the resultant force only as regards the motion of the body as a whole.
Reason : The resultant force can not replace the several forces acting on a body in other respects.

4. **Assertion** : The gravitational force makes the earth move around the sun and also makes the moon go around the earth.
Reason : Every objects in the universe exert a force on other objects.

5. **Assertion** : When we bring a magnet close to a pin lying on a smooth table, the pin starts moving (sliding) towards the magnet.
Reason : Magnetic force is a contact force.

6. **Assertion** : Friction always opposes the motion.
Reason : Whenever one surface moves or tries to move over another surface, the force of friction starts acting on the surfaces.

7. **Assertion** : The pressure at the bottom of the sea is lesser than that near the surface.
Reason : The pressure exerted by a liquid depends upon the depth of the liquid and density of the liquid.

8. **Assertion** : 1 dyne = 10^{-5} newton.
Reason : Dyne is the CGS unit of pressure while newton is the SI unit of pressure.

9. **Assertion** : We can live very happily if friction is not present in nature.
Reason : Aeroplane shape is streamlined to reduce the effort of frictional force.

10. **Assertion** : The weight of the atmosphere exerts a pressure on the surface of earth.
Reason : When we go upwards, the magnitude of atmospheric pressure decrease gradually.

Comprehension Type

PASSAGE-I : Ramu applied a force of 10 N on a body to move it from rest. He wants to express the applied force in terms of various system of units.

1. Express 10 N force in terms of dynes
(a) 10^5 dynes (b) 10^6 dynes
(c) 10^7 dynes (d) 10^8 dynes

2. Express 10 N force in terms of kgf
(a) 9.8 kgf (b) 56 kgf
(c) 100 kgf (d) 84 kgf

3. Express 10 N force in terms of g cm s^{-2}
(a) 10^5 g cm s^{-2} (b) 10^6 g cm s^{-2}
(c) 10^3 g cm s^{-2} (d) 10^4 g cm s^{-2}

PASSAGE-II : Two bricks each of same dimensions are placed on level ground. Surface area of end of each brick is 40 cm^2 and the surface area of base of each brick is 150 cm^2. Each brick weigh 40 N.

1. If both bricks are placed as shown then pressure exerted by both bricks on ground is
(a) 100 N m^{-2}
(b) 26 N m^{-2}
(c) 150 N m^{-2}
(d) 126 N m^{-2}

2. If both bricks are placed on standing position then, the total pressure exerted by the bricks on ground is
(a) 100 N m^{-2} (b) 200 N m^{-2}
(c) 300 N m^{-2} (d) 400 N m^{-2}

Subjective Problems

Very Short Answer Type

1. What is the direction in which an object is pushed or pulled is called?
2. Does a force acting on a body always cause a change in its state of motion?
3. What measures the earth's gravitational pull on an object, its weight or mass?
4. Which type of force is exerted by a static charge?
5. Which force tends to slow down objects or keep them from moving?
6. Name the force that acts on all bodies on the earth at all times.
7. What is the force per unit area?
8. Name the instrument used to measure liquid pressure.
9. How is pressure related to force and area ?
10. What do you call the force which can act from a distance?
11. What is the unit of pressure?
12. What is the requirement for a force to come into play?
13. What is the resultant force when two forces act in same direction?
14. What will be the resultant force when two forces act in opposite directions on an object?
15. What happens in tug of war when two teams pull equally hard?

Short Answer Type

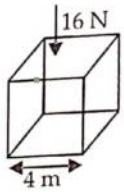
1. What is a force? Explain with the help of some examples.
2. Describe state of motion.
3. What do you understand about the force of friction?
4. What is electrostatic force? Why is it called non-contact force?
5. We observe that the wheels of buses and trucks are heavier than the wheels of car or scooter. Why?
6. What is atmospheric pressure?
7. If the area of your head is 15 cm × 15 cm, how much air (in weight) would you carry on your head?
8. Take a pencil sharpened at one end and press it between your fingers. Which end will hurt more and why?
9. Why do deep-sea divers wear special suits?
10. Why do some people suffer from nose bleeding at higher altitudes?

Long Answer Type

1. Prove that the pressure exerted by water at the bottom of the container depends on the height of its column.
2. What are contact forces? State different contact forces. What are non-contact forces? Explain different types of non-contact forces.
3. Show that air has pressure with the help of an experiment.
4. Explain that a liquid exerts pressure on the walls.
5. Explain that liquids exert equal pressure at the same depth.

Integer/Numerical Value Type

1. The mass of an object whose weight is 50 N is x kg. Find x. (Take $g = 10\ m\ s^{-2}$)
2. A force of 16 N is distributed uniformly on one surface of a cube of edge 4 cm. The pressure on this surface is $x \times 10^4$ Pa. Find the value of x.



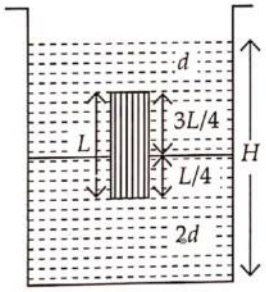
3. A horizontal force of 4 N is applied to a block of mass 2 kg resting on a frictionless table. What is the acceleration of the block in $m\ s^{-2}$?
4. The mass of the body is 60 kg, if value of acceleration due to gravity is $10\ m\ s^{-2}$ and weight of the body is $x \times 10^2$ N. Find x.
5. If two horizontal forces F_1 and F_2 act on a body of certain mass in opposite directions such that they are odd consecutive force then find the net force acting on the body.

Olympiad/HOTS Corner

1. A block of mass 4 kg and dimensions 10 cm × 20 cm × 30 cm rests on the floor. If $g = 10$ m s^{-2}, then the maximum pressure the block can exert on the floor is
   (a) 2000 N m^{-2} (b) 1000 N m^{-2}
   (c) 4000 N m^{-2} (d) 1333 N m^{-2}

2. A body of volume V and density d is completely immersed in a liquid of density ρ. Then the apparent weight of the body will be
   (a) Vdg (b) $V\rho g$
   (c) $V(\rho - d)g$ (d) $V(d - \rho)g$

3. In a container (cross-sectional area A) a homogeneous solid cylinder of length $L(L < H/2$ as shown in the figure), cross-sectional area $A/5$ is immersed such that it floats with its axis vertical at the liquid-liquid surface with length $L/4$ in the denser liquid as shown in the figure. The lower density liquid is open to the atmosphere. Then the density D of solid is given by



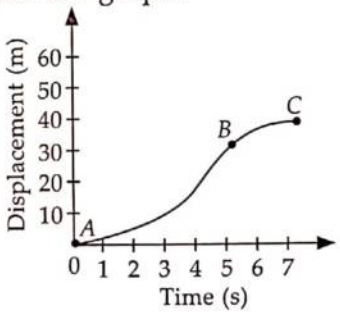
   (a) $\frac{4}{5}d$ (b) $4d$
   (c) $\frac{d}{5}$ (d) $\frac{5}{4}d$

4. A piece of wood is floating in water kept in a bottle. The bottle is connected to an air pump. Neglect the compressibility of water. When more air is pushed into the bottle from the pump, the piece of wood will float with
   (a) larger part in the water
   (b) lesser part in the water
   (c) same part in the water
   (d) will sink to the bottom

5. Kerosene of mass 100 g is mixed with 100 g of water. One of the under given options that well describes the reason for kerosene to float on water is
   (a) mass of displaced water is less than the mass of kerosene of equal volume
   (b) mass of kerosene is more than the mass of equal volume of water
   (c) mass of kerosene is less than the mass of displaced water
   (d) mass of kerosene is equal to mass of displaced water

6. A body when floats in water, 1/3rd of its volume remains outside water. When it floats in another liquid, 3/4th of its volume remains outside the liquid. Then the density of the liquid is
   (a) $\frac{9}{4}$ g/cc (b) $\frac{8}{3}$ g/cc
   (c) 4 g/cc (d) $\frac{3}{8}$ g/cc

7. The displacement- time graph of a lift climbing from the ground floor to the top of the building is given here. Which of the following statements are true about the graph?



   (i) At point A, the lift is stationary.
   (ii) Velocity of lift is decreasing from point B to C.
   (iii) At point C, the lift is at zero velocity.
   (iv) Velocity of lift is minimum at B.
   (a) (i) and (iii) only
   (b) (ii) and (iv) only
   (c) (i), (ii) and (iii) only
   (d) (ii), (iii) and (iv) only

8. A force of 16 N is distributed uniformly on one surface of a cube of edge 8 cm. The pressure on this surface is
   (a) 3500 Pa (b) 2500 Pa
   (c) 4500 Pa (d) 5500 Pa

9. A football has lesser inertia than a stone of the same size because
   (a) football has more air inside than the stone
   (b) football has less air inside than the stone
   (c) football has less mass than the stone
   (d) football has more mass than the stone

10. A machine gun of mass 10 kg fires 20 g bullets with speed of 500 m/s at the rate of 10 bullets per second. To hold the gun steady in its position how much force is necessary?
   (a) 200 N (b) 500 N
   (c) 100 N (d) 250 N

11. A 20 Pa pressure is applied on the head of a nail placed perpendicular to the surface of a wall. If the area of cross-section of the tip of the nail is (1/10) times the area of cross-section of the head, the pressure exerted at the wall is
   (a) 10 Pa (b) 20 Pa
   (c) 200 Pa (d) None of these.

12. An aluminium sphere is dipped into water. If B_I and B_{II} are the buoyancies in water at 0°C and 40°C respectively, then
   (a) $B_I < B_{II}$
   (b) $B_I > B_{II}$
   (c) $B_I = B_{II}$
   (d) $B_I >$ or $< B_{II}$ depending upon the radius of the sphere

13. A force acting on an object of mass 500 g changes its speed from 200 cm/s to 0.2 m/s. The change in momentum is
   (a) increase by 0.90 N s
   (b) decrease by 0.90 N s
   (c) increase by 90 g cm/s
   (d) decrease by 90 g cm/s

14. A block of ice is floating in a liquid of specific gravity 1.2 contained in a beaker. What will happen to the liquid level when ice completely melts?
   (a) Liquid level will increase
   (b) Liquid level will decrease
   (c) Liquid level will remain unchanged
   (d) Depends on the size of ice block

15. The weight of an empty balloon on a spring balance is W_1. The weight becomes W_2 when the balloon is filled with air. Let the weight of air itself be W. Neglect the thickness of balloon when it is filled with air. Also neglect the difference the density of air inside and outside the balloon.
   (a) $W_2 < W_1 + W$
   (b) $W_2 = W_1 + W$
   (c) $W_2 > W_1 + W$
   (d) $W_2 < W_1$