FRICTION

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If the switch off the engine of car it will stop after moving a certain distance. It means that some retarding force is acting on the car which stops it. The force opposing the motion of the car is called "force of friction".

- The frictional force is tangential to the surface in contact and always in a direction opposite to the direction of motion of the object.

- Frictional force is a force opposing the relative motion between two surfaces which are in contact with each other.
- The force of friction arises due to the interlocking of irregular projections on the two surfaces and is called as "force of contact".

Types of Friction

(A) Static friction :

The frictional force that exists between the body and the surface so long as they are relatively at rest even when the external force acts, is called the static friction.

(B) Limiting friction :

- When there is no external force acting on the body, the frictional force is zero.
- If we increase the magnitude of the external force, the static friction also increases.
- At one pt, when there is a slight increase in the magnitude of the external force, the body just starts sliding over the surface.
- The force of friction at the limiting stage is called the 'limiting friction.'
- The limiting friction depends upon the nature of the two surfaces in contact.

(C) Kinetic or Sliding friction :

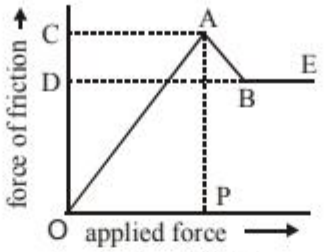
- When the external force exceeds the limiting friction, the body just starts sliding.
- The minimum force required to maintain the motion of the body over the other surface is called the "kinetic friction".
- The frictional force that exists between the two surfaces when there is a uniform relative motion between them is called the "dynamic friction" or "sliding friction".
- Kinetic friction is smaller than the limiting friction.

(D) Rolling friction :

- The frictional force that exists between the two surfaces when a body rolls over the other is called the "rolling friction".
- It deforms the surface over which it rolls.
- Rolling body it-self gets deformed at the pt of contact over the surface.

◈ Variation of frictional force with applied forces :

- The part OA of the graph shows that the static friction increases with the increase in applied force.



- The force of friction is maximum at a pt A which is equal to AP.
- If the applied force is increased further, the body will continue to be in motion but the force of friction is slightly lesser.
- After this the force of friction remains constant.

Note : Rolling friction is smaller than sliding friction which in turn is smaller than the limiting friction.

◈ Factors affecting friction

The force of friction depends upon the following factors :

- Materials of the bodies in contact.
- Roughness of the surfaces in contact
- Force of friction is independent of the area of the two surfaces in contact.
- The limiting frictional force is directly proportional to the normal reaction.

◈ Coefficient of friction

- Coefficient of static friction (μ_s)

$$\mu_s = \frac{\text{limiting frictional force}}{\text{normal reaction}} = \frac{f_s}{R}$$

- Coefficient of kinetic friction (μ_k)

$$\mu_k = \frac{\text{force of kinetic friction}}{\text{normal reaction}} = \frac{f_k}{R}$$

Ex. A block of mass 2kg is placed on the floor. The coefficient of static friction is 0.4. A force F of 2.5 N is applied on the block, as shown, calculate the force of friction between the block and the floor. ($g = 9.8\ ms^{-2}$)

Sol. Let R be the normal reaction on the block exerted by the floor. The limiting (maximum) force of static friction is

$f_s = \mu_s R = \mu_s mg$

$= 0.4 \times 2kg \times 9.8\ ms^{-2} = 7.84\ N$

The applied force F is 2.5 N, that is less than then the limiting frictional force. Hence under the force F, the block does not move. So long the block does not move, the (adjustable) frictional force is always equal to the applied force. Thus the frictional force is 2.5 N

Ex. A heavy box of mass 20 kg is placed on a horizontal surface. If coefficient of kinetic friction between the box and the horizontal surface is 0.25, calculate the force of kinetic friction. Also, calculate acceleration produced under a force of 98 N applied horizontally ?

Sol. Here, m = 20 kg, μ = 0.25, F = ?, P = 98 N, a = ?

$F = \mu R = \mu mg = 0.25 \times 20 \times 9.8 = 49N$

Force that produces acceleration

$f = P - F = 98 - 49 = 49$ N

$a = \frac{f}{m} = \frac{49}{20} = 2.45$ m/s^2.

◈ Reducing friction

Frictional force can be reduced in the following ways :

- **Use of lubricants :** In machines, friction can be reduced by applying lubricants between the contact surfaces to fill the fine pores or depressions in the surfaces and make them smooth thereby reducing friction.
- **Polishing :** unevenness of the surfaces can be reduced by polishing, thereby reducing the friction.
- **Use of ball bearings :** In rotating machines, shafts are mounted on ball bearings. By doing so, rolling friction occurs lesser than sliding friction, thereby reducing the friction.
- **By streamlining :** Air friction is reduced by designing streamlined bodies of cars or aeroplanes. Similarly, if the bodies of boats and ships are streamlined, friction of water can be reduced.

◈ Disadvantages of friction :

- Wear and Tear : In machine parts like gears, brakes when they come in contact with each other continuously, they wear out gradually, which should be replaced time to time.
- Friction reduces efficiency of the machine.
- Friction in machine produces heat and undesirable noise which damages the machine. To avoid excessive heating, water is circulated in machines generally.

◈ Applications of frictional forces

- We would not be able to walk if there had been no friction b/w the soles of our shoes and the ground.
- If there had been no friction, the wheels of a car will slip instead of rotating and stop moving. For that we have to increase the friction by making the tyres corrugated to get better grip of tyres on the road. Also, the friction is increased.
- When brakes are applied, the vehicle stops due to the force of friction b/w the brakelining and the drum.
- In the absence of friction, we cannot write on a blackboard with a chalk stick because the chalk stick will slide off the board without leaving any mark on the board.

EXERCISE - 1

VERY SHORT ANSWER TYPE QUESTION

Q.1 Define friction.

Q.2 What is meant by sliding friction ?

Q.3 What is rolling friction ?

Q.4 What is meant by air resistance ?

Q.5 When does static friction come into play ?

Q.6 Which force is responsible for wear and tear of machinery ?

Q.7 Which is greater–rolling friction or sliding friction ?

Q.8 What are lubricants ?

Q.9 What are fluids ?

Q.10 Do fluids exert friction ?

Short Answer Type Question

Q.11 You spill a bucket of soapy water on a marble floor accidently. Would it make easier or more difficult for you to walk on the floor? Why

Q.12 Explain why sportsmen use shoes with spikes.

Q.13 Iqbal has to push a lighter box and Same has to push a similar heavier box on the same floor. Who will have to apply a larger force and why ?

Q.14 Explain why sliding friction is less than static friction.

Q.15 Explain why objects moving in fluids must have special shapes.

Q.16 Why are the soles of shoes grooved ?

Q.17 Give examples to show that friction is both a friend and a foe.

Q.18 Why does friction increase if the two surfaces are pressed ?

Q.19 A labourer has to push a heavy trunk. What should be do to reduce his effort in pushing it and why ?

Q.20 Why is friction essential ? Give three examples.

Long Answer Type Question

Q.21 Give five examples to show that friction is increased deliberately.

Q.22 Why are heat resistant tiles laid along the surface of spaceships ?

Q.23 What is meant by lubrication ? Why do we lubricate the moving parts of our vehicles? Name some lubricants and where they are used.

Q.24 What is meant by "streamlined shape" ? Where and why is this shape used ? To whom has nature provided streamlined body?

EXERCISE-2

SINGLE CORRECT ANSWER TYPE QUESTIONS

Q.1 Force of friction is directly proportional to
(A) size
(B) area
(C) weight
(D) all these factors of the moving body

Q.2 Which of the following is the least ?
(A) static friction
(B) sliding friction
(C) rolling friction
(D) limiting friction

Q.3 Friction between two flat surface can be reduced by,
(A) greasing
(B) painting
(C) using ball bearing
(D) decreasing the area

Q.4 The flying machine offering the least frictional force should be
(A) irregular
(B) tree-like
(C) symmetrical with many arms
(D) streamlined

Q.5 Frictional force increases with the increase in
(A) roughness of the surface
(B) smoothness of the surface
(C) distance between two bodies
(D) none of these

Q.6 Lubrication of moving surfaces
(A) removes friction
(B) reduces friction
(C) increases friction
(D) has no effect on friction

Q.7 Frictional force is due to ..... between two moving surfaces
(A) softness (B) roughness
(C) distance (D) none of these

Q.8 The maximum value of force required to make the body just to slide is known as
(A) dynamic friction
(B) static friction
(C) limiting friction
(D) rolling friction

Q.9 Rolling friction is always more than the
(A) dynamic friction
(B) static friction
(C) limiting friction
(D) none of these

Q.10 What can you use to reduce the force of friction on an object ?
(A) Lubricate the surface
(B) Streamline the body shape
(C) Reduce the surface area in contact of two bodies
(D) All of these

Q.11 Which of the statement is correct about rolling and sliding friction ?
(A) Rolling friction is greater than sliding friction
(B) Rolling friction is lesser than sliding friction
(C) Rolling and sliding frictions acting on a body are equal
(D) None of these

Q.12 A body will experience the minimum friction in –
(A) Vacuum (B) Air
(C) Fresh water (D) Sea water

Q.13 Ball bearings are used to
(A) increase surface area
(B) decrease surface area
(C) increase friction
(D) decrease friction

Q.14 Lubricants are used to
(A) reduce friction
(B) increase friction
(C) make a surface shiny
(D) make a surface oily

Q.15 SI unit of force of friction is
(A) N (B) kg wt
(C) kg ms^{-2} (D) Joule

Q.16 Ball bearings are used to
(A) increase friction
(B) decrease friction
(C) optimize friction
(D) remain same

Q.17 The use of lubricants makes the surface
(A) smooth (B) rough
(C) very rough (D) no effect

Q.18 The frictional force ..... with the ..... in roughness of the surfaces
(A) increases, increase
(B) decrease, decrease
(C) decrease, increase
(D) increases, decrease

Q.19 The maximum force of friction when the body is just beginning to move is known as the
(A) limiting friction (B) rolling friction
(C) static friction (D) none of these

Q.20 The friction that exists between a surface sliding on another surface is called the
(A) dynamic friction (B) rolling friction
(C) static friction (D) none of these

ANSWER KEY

EXERCISE-1

VERY SHORT ANSWER TYPE QUESTION

Sol.1 Friction is the force which resists the motion of a body, while moving on a surface.

Sol.2 When one surface is sliding over the other, sliding friction comes into play.

Sol.3 When one body rolls over the surface of another body, the resistance to its motion is called the rolling friction.

Sol.4 Threre is friction between a moving object and the air through which it moves known as air resistance.

Sol.5 Static friction comes into play to counter balance the applied force on the body.

Sol.6 Force of friction.

Sol.7 Sliding friction is greater than rolling friction.

Sol.8 The substances which reduce friction are called lubricants.

Sol.9 Fluids is the common name given to gases and liquids.

Sol.10 Yes, fluids also exert friction.

Short Answer Type Question

Sol.11 It would be more difficult to walk on the floor with soapy water because when we walk on a soapy floor, there is little friction between the floor and the feet, so it becomes difficult to walk.

Sol.12 Sportsman use shoes with spikes to increase the friction. In this way, the sportsman can run faster.

Sol.13 Seema will have to apply more force because the weight of the box increase and the friction increases. For a heavier box the ridges of the surfaces get interlocked more.

Sol.14 Sliding friction is less than static friction because it comes into play once the body has started sliding. To make the body slide more force is required to overcome the irregularities in the surface of the body.

Sol.15 Fluids also exert a frictional force on the body moving through them. Therefore, the shape of the body is streamlined to over the frictional force of fluids and to move smoothly through them.

Sol.16 Soles of shoes are grooved so as to provide better grip between the shoes and the ground.

Sol.17 Friction is friend in the following ways – it helps us to walk, to write on the blackboard and to apply the brakes of a car.Friction is foe in the following ways it causes wear and tear of machinery and shoes, it proudces heat in the machinery.

Sol.18 Since the friction is due to the interlocking of irregularities in the two surface which slide with respect to each other, it increases when the two surfaces are pressed harder.

Sol.19 The labourer should put some cylindrical logs of wood under the trunk. In this way the area of contact between the two surfaces is reduced. Rolling friction is less than sliding friction.

Sol.20 Friction is necessary between the soles of our feet and ground so that we can walk without slipping.

Friction helps us in writing on paper.

Friction makes it possible to light a match stick, by rubbing it along the rough surface of the match box.

Long Answer Type Question

Sol.21 (a) Athletes wear spiked shoes to help them run fast.

(b) Mountaineers wear spiked shoes while walking on snow.

(c) The tyres of vehicles are grooved.

(d) The roads are made rough.

(e) The blackboard is made rough.

Sol.22 The spaceships are sent into the space from the rockets with a very high speed. This create a very high frictional force between the air and spaceship. As result, the spaceship gets heated to red hot. The heat resistant tiles save the spaceship from burning.

Sol.23 Lubrication means oiling the machines from time. Lubrication of the moving parts is done to reduce friction between them. We can use oil or grease in machines. Graphite can be used in machines which reach a very high temperature.

Sol.24 Streamlined shape means they are narrow in front and broader at the back. The bodies of aeroplanes, missiles and rockets are streamlined to reduce friction with air. Ships and boats have a streamlined shape to reduce friction with air. Nature has given birds and fish streamlined bodies.

EXERCISE-2

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	D	C		D	A	B	B	C	D	D	B	A	B	A	A
Ques.	16	17	18	19	20										
Ans.	B	A	A	A	A										