To Study the Relationship Between Force of Limiting Friction and Normal Reaction and to Find the Co-Efficient of Friction Between a Block and a Horizontal Surface

Aim

To study the relationship between force of limiting friction and normal reaction and to find the co-efficient of friction between a block and a horizontal surface.

Apparatus

Wooden block (with a hook on one side), 50 g or 20 g weights, horizontal plane (table top) fitted with a friction less pulley at one end, pan, spring balance, thread, spirit level.

Theory

Sliding friction. It is the friction between two surfaces of the bodies in sliding motion.
Force of sliding friction. It is the least force required to make a body start sliding over a surface.

Force of friction $F \propto R$ (1)

$F = \mu R$

where μ = co-efficient of friction, R is the normal reaction.

At equilibrium, $F = P + p$ ...(2)

and $R = W + w$ ...(3)

Diagram

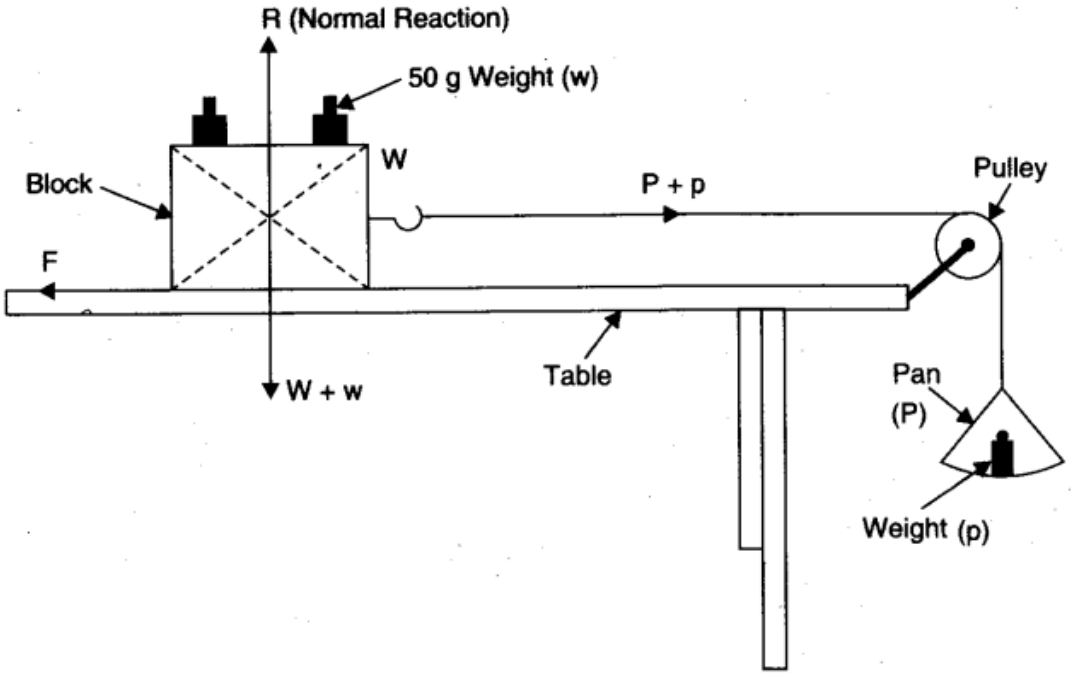

Fig. Study for force of sliding friction.

Procedure

1. Clean the horizontal table top and check the pulley to see that it is friction less (oil if necessary).
2. Weigh the wooden block and put it on the table top. (Check horizontality of table top by spirit level.)
3. Tie one end of a thread with the hook of the wooden block and pass it over the pulley.
   (The thread must be horizontal).
4. Find the weight of the pan.
5. Tie other free end of the thread with the pan and let the pan hang vertical. (The pan will pull the wooden block horizontally by a force equal to its weight).
6. Since the pan itself does not pull the block, put some weights in the pan (from weight box).
7. Tap the table top to make the block just slide.
8. Increase weights in pan little by little, till the block just starts sliding on tapping the table top.
9. Note the total weights put in the pan then record them in observation table (sum of weight of pan and weights in pan gives the force of sliding friction.)
10. Put one 50 g or 20 g weight over the wooden block and repeat steps 8 and 9.
11. Repeat steps 8, 9, 10, six times. Every time increase weight by 50 g or 20 g.
12. Record the observations in tabular form as given ahead.

Observations

Weight of wooden block, W = ……gwt
Weight of pan, P = ……g wt.
Table for additional weights

Serial No. of Obs.	*Weights on wooden block (w) (g wt)*	*Total weight being pulled (W + w) (g wt) = Normal reaction (R) (g wt)*	*Weight on pan (p) (g wt)*	*Total weight (force) pulling the block and weights (P + p) (g wt) = Limiting friction (F) (g wt)*
1.	...	...	...	...
2.	...	...	...	...
3.	...	...	...	...
4.	...	...	...	...
5.	...	...	...	...
6.	...	...	...	...
7.	...	...	...	...

Calculations

Total weight (force) pulling the block and weights gives the value of force of sliding

friction.
On horizontal surface, total weights being pulled give normal reaction R. Total weight (force) pulling these weights gives dynamic friction F.
Plot a graph between normal reaction R and limiting friction F, taking R along X-axis and F along Y-axis.
The graph comes to be a straight line as shown below.

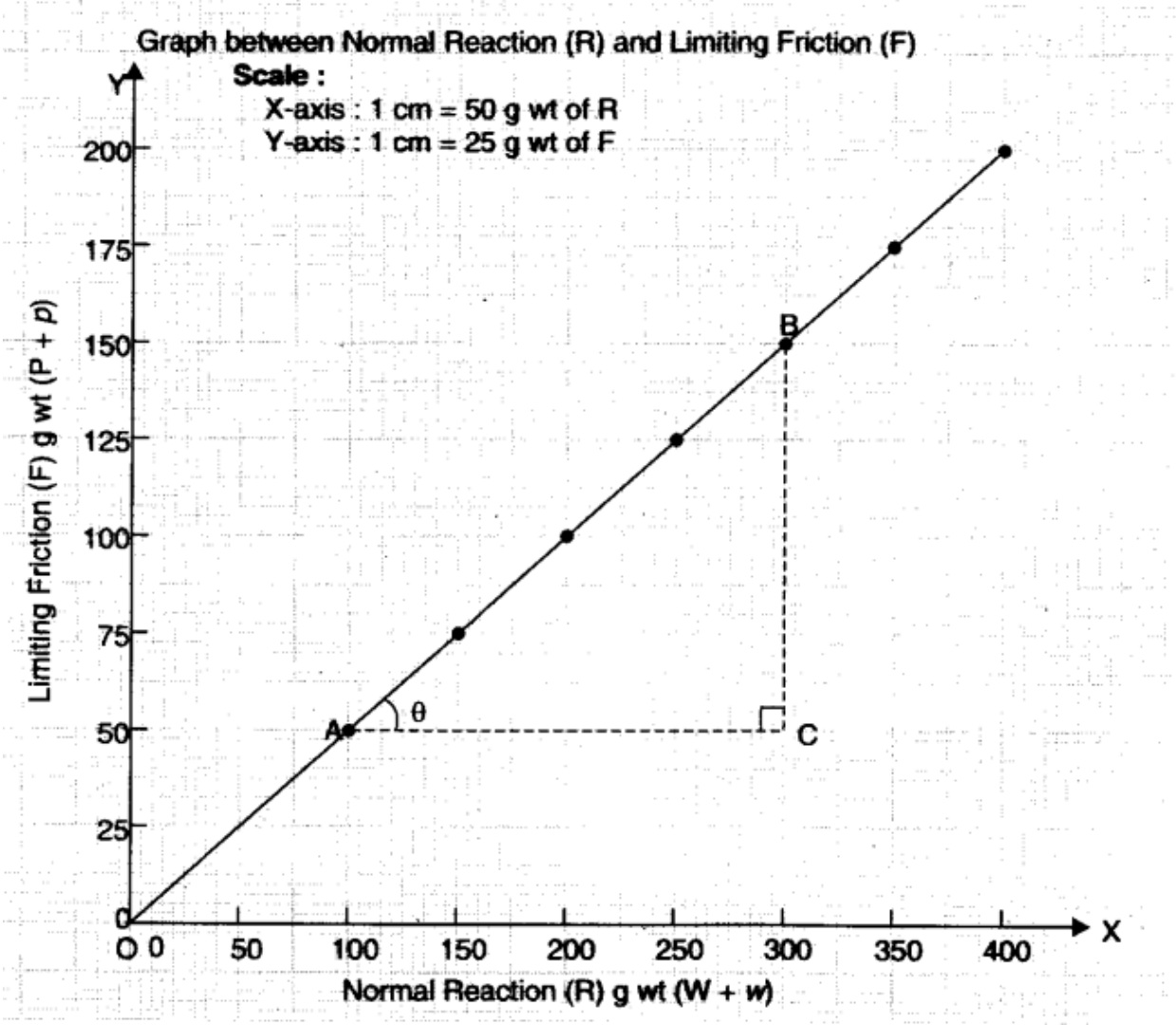

Fig. Graph between R and F.

Result

It is found that as the total weight pulled increases, force of limiting friction also increases. The increase is in direct proportion.
The graph shows that limiting friction F is directly proportional to the normal reaction R. It is an agreement with law of limiting friction. (This experiment may be taken as a verification of the law).

The constant ratio FIR, is called coefficient of friction (p). It can be calculated by finding slope of the graph.

In ΔABC

$$\text{Slope of straight line } AB = \tan\theta = \frac{BC}{AC} = \frac{F}{R} = \frac{150-50}{300-100}$$

$$\tan\theta = \frac{F}{R} = \frac{100}{200} = \frac{1}{2} = 0.5 \qquad ...(1)$$

But, $F = \mu R$

$$\frac{F}{R} = \mu \qquad ...(2)$$

From equation (1) and (2)

$$\mu = \tan\theta = 0.5$$

$$\mu = 0.5.$$

Precautions

1. The surface (table top) should be horizontal.
2. The thread part between block and pulley should be horizontal.
3. Weight in pan should be increased in small steps and pan should not oscillate or rotate.
4. Table top should be tapped gently each time.
5. Pulley should be friction less.

Sources of error

1. The table top may not be horizontal.
2. The thread part between block and pulley may not be horizontal.
3. Pulley may not be friction less.

Viva Voce

Note. Read all the Articles 7.01 to 7.10. (Every Article is a question.)

Question.1. Why thread part between block and pulley is kept horizontal ?
Answer. It makes total weight of pan and weights effective in pulling the block horizontally.

Question.2. Why is pulley kept friction less ?
Answer. It is done to keep the weight of pan and weights in it to be fully effective. Friction in pulley will reduce its effective value.

Question.3. Why roads become slippery after rains ?
Answer. Rain water forms a thin layer between our feet and road. It acts as a lubricant preventing interlocking of irregularities on the surface of wheel and road. Friction becomes less and causes slipping.

Question.4. Why brake surfaces are kept flat, though area of surface does not increase friction ?
Answer. Same force applied through more area reduces pressure. The surface being braked is not scratched.