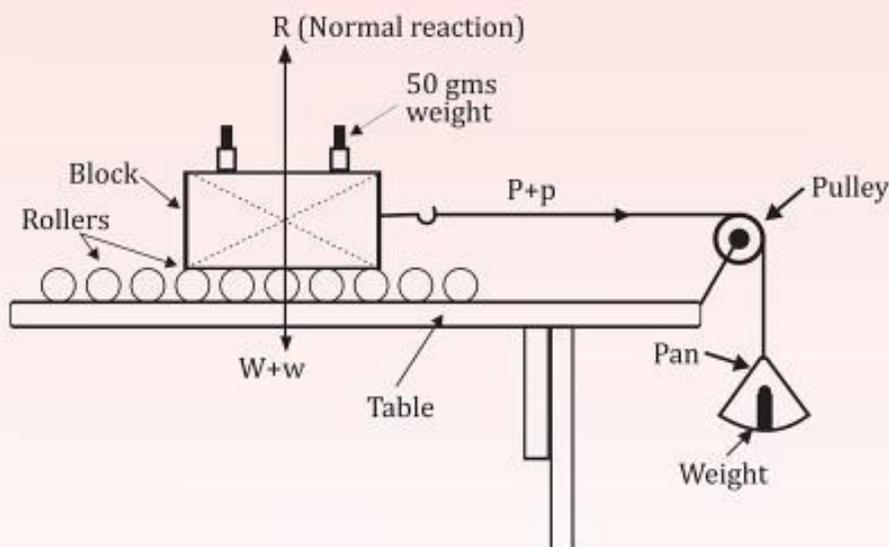# ACTIVITY

AIM

To measure the force of limiting friction for rolling of roller on a horizontal plane.

MATERIAL REQUIRED

A spring balance, a physical balance, set of weights, horizontal plane fitted with a frictionless pulley fitted at one end, thread, spirit level, wooden block with a hook on one side, weight box and lead shots (rollers).

DIAGRAM

THEORY

The force of friction which comes into play between the two bodies when one tends to roll over another surface is called rolling friction. Rolling friction is always less than sliding friction.

Let us consider, a block of weight 'w' has been placed over the lead shot spread on the horizontal surface as shown in figure. The block is tied with a scale pan with the help of thread after passing through the pulley. Here, the force which will tend to pull the block towards the pulley is applied by the weight of the scale pan (including the weight put in it). Thus, the force which pulls the block,

$$T = (P + p) g$$

Where, P and p are the weights put in the pan and the weight of the pan itself respectively. Due to the acceleration due to gravity, the downward force will also act on the block. It can be given as:

$$Downward\ force = W + w$$

Where, W and we are the weight of the block and the standard weight put over it respectively. Here, it can be concluded that:

(i) The downward force will be balanced by the reaction on the block. Thus,

$$R = W + w$$

(ii) The tension (T) will be balanced by the rolling friction (F_R) acting opposite to the motion of the block. Thus,

$$F_R = T = (W + w)\,g$$

PROCEDURE

Setting up the Apparatus

1. First, confirm whether the pulley is frictionless or not. If it is not, then lubricate it with the oil.
2. Now, with the help of a spirit level, check the horizontal surface and spread a layer of lead shots on it.
3. After checking the horizontal surface, measure the weight of the wooden block with the help of spring balance.
4. Determine the weight of the pan with the help of physical balance.
5. Place the block over the layer of lead shots.
6. Take a thread and tie one end to the hanger of the block and the other end with the scale pan after passing through the pulley.

Observe the Motion of the Block Towards the Pulley

7. Add a small weight to the pan and notice whether the wooden block kept on rollers starts moving or not.
8. If in case, the block does not start rolling, then from the weight box, add some more weights to the pan.
9. Repeat the step 7 till the block just starts moving.
10. When the block starts moving, note the total weight of the pan (including the weight put in it).
11. Now, put some suitable weight over the wooden block and repeat the above steps 8 to 10 and note the respective weights in the observation table.
12. Repeat the process and increase the weights in steps over the wooden block and pan and then note the value of weights in the observation table.
13. Calculate the mean value of total weight (force) pulling the block and weights and record it.

OBSERVATIONS

Mass of the wooden block, $m = $ _____ kg.

Weight of the wooden block, $w' = mg = $ _____ N.

Weight of the pan = (mass of the pan + weight put in it) × acceleration due to gravity (g)

$$= (W + w) \times g = \underline{\quad} \text{ N}$$

Table for the Measurement of Limiting Rolling Friction

S. No.	Weight of wooden block, w (N)	Total weight being pulled = $(W + w) \times g$ = Normal reaction, R (N)	Mass in pan, (P_1) (kg)	Mass of pan, (P_2) (kg)	Total weight (force) pulling the block and standard weights, $(W + w)\,g$ (N)
1.					$F_1 = $ .... N
2.					$F_2 = $ .... N
3.					$F_3 = $ .... N
4.					$F_4 = $ .... N
5.					$F_5 = $ .... N

CALCULATIONS

Mean value of total weight (force) pulling the block and standard weights,

$$F_R = \frac{F_1 + F_2 + F_3 + F_4 + F_5}{5} = \underline{\hspace{2cm}} \text{ N.}$$

RESULT

1. Since the total weight, which is being pulled increases, the limiting value of rolling friction increases.
2. The force of limiting friction of the roller, $F_R = (W + w) g = \underline{\hspace{2cm}}$ N.

PRECAUTIONS

1. With the help of physical balance, the mass of the scale pan should be accurately determined.
2. The scale pan should not provide the tension greater than the force of limiting friction.
3. The lead shots surface should be clean and dry.
4. The weights in the pan should be placed gently.
5. The portion of the string/thread between the pulley and hook should be horizontal.
6. Frictionless pulley should be used.
7. The scale pan should be tied in such a way that it does not touch the table.

SOURCES OF ERROR

1. Frictionless pulleys may not be used.
2. The string/thread between the hook and pulley may not be exactly horizontal.
3. The lead shots surface may not be clean and dry.

VIVA VOCE

Q1. What is the relation between the rolling friction and the radius of the wheel?

Ans. The force of rolling friction varies inversely with respect to the radius of the wheel.

Q2. What do you mean by limiting friction?

Ans. The maximum value of the opposing force which comes into existence when one body is just at the verge of moving over the surface of another body, is called the limiting friction.

Q3. "The force of friction is known as self-adjusting in nature". Explain this statement in brief.

Ans. The force of friction is known as self-adjusting in nature because it adjusts its magnitude and direction to keep itself always equal and opposite to the equal force applied to move the body at rest.

Q4. What can be the reason for keeping frictionless pulleys in this activity?

Ans. It is usually done to keep the weight of the pan and weights in it to be fully effective so friction in pulley reduces its effective value.

Q5. Differentiate between the sliding and rolling friction. Which one is greater either rolling friction or sliding friction?

Ans. Rolling friction comes into play when one object rolls over the surface of the other, while sliding friction is one which comes into play when one object slides over the surface of the other. Sliding friction is greater than rolling friction.

Q6. **What is one of the factors which causes the friction?**

Ans. Roughness of the surfaces is the cause of friction. It provides the interlocking between the two surfaces when the surfaces are in relative motion. So, when the body is pulled, elevations collide and provide friction.

Q7. **State the factors on which the force of limiting friction depends.**

Ans. Force of limiting friction depends upon the:
   (i) normal reaction
   (ii) nature of the two surfaces in contact

Q8. **State the laws of friction.**

Ans. Laws of friction are:
   (a) Friction is a self-adjusting force.
   (b) Value of limiting friction depends upon nature of surfaces in contact.
   (c) Magnitude of limiting friction is directly proportional to normal reaction.

Q9. **How does friction between surfaces depend on area of contact?**

Ans. The force of limiting friction is independent of the area of surfaces in contact.

Q10. **Which is greater-rolling friction or sliding friction?**

Ans. Sliding friction.