AUROUS ACADEMY

Contact Forces.

All the contact forces are the reaction forces arising due to unnoticeable or noticeable deformations produced in the bodies in contact.

Most common contact forces are tensile force of a string, force of normal reaction, friction, spring force etc.

Tensile Force of Strings:

A string or similar flexible connecting link such as a thread or a chain etc. are used to transmit a force from one end to the other.

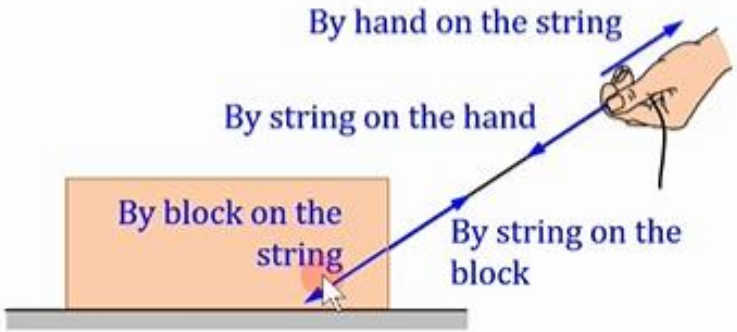
Due to flexibility, a string can only pull a body connected to it by applying a force always along the string.

This pulling force of a string is known as the tensile force of the string or mor commonly tension in the string. It is developed due almost negligible (unnoticeable) extension produced in the string.

In the figure, various forces between a string and a body connected to it are shown.

Question 01.

Identify the action-reaction pairs.



Ans.

Force by hand on the string and the force by string on the hand.

Force by string on the block and the force by block on the string.

Ideal String:

A string is used to pull an object connected at one end by transmitting the applied force from the other end.

An ideal string must have the following characteristics.

Inextensible: The pulled object must shift by the same amount as the end being pulled.

For this, length of the string must be a constant irrespective of the forces applied i.e. the string must be inextensible.

A string cannot be perfectly inextensible. In actual practice, extensions produced in the string must be negligible as compared to the length of the string.

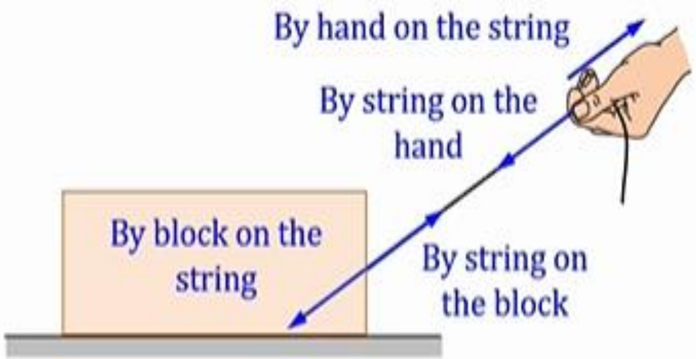
Massless: The applied force must be transmitted undiminished to the other end.

For this the string must be massless.

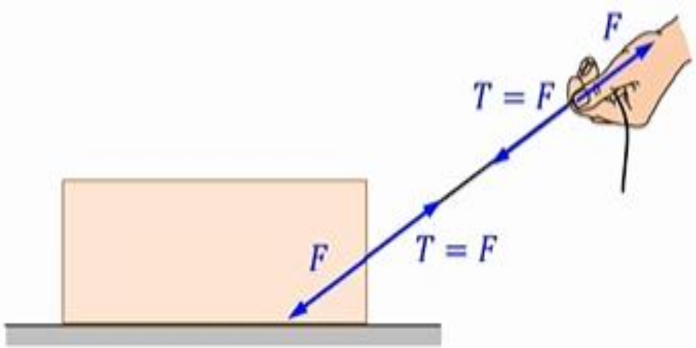
A material object cannot be massless so a string. In actual practice, mass of the string must be negligible as compared to the mass of the object being pulled.

Question 02.

If the force applied by the hand is F, show magnitude of all the forces considered in the following setup.



Ans.



Note:

A string must be assumed ideal, until it is not specified to be a non-ideal one i.e. having mass or being extensible or both.

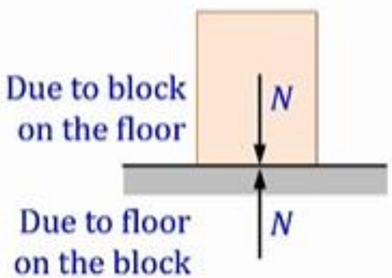
Force of Normal Reaction:

Two bodies in contact, when press each other, apply equal and opposite forces on each other. These forces constitute an action-reaction pair.

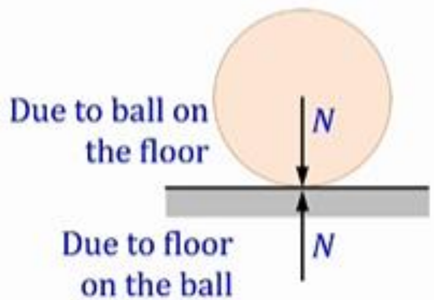
If surfaces of the bodies in contact are frictionless, the contact force acts along normal to the surfaces at the point of contact and known as the force of normal reaction or simply normal reaction.

If surfaces of the bodies are not frictionless, in addition the normal reactions, frictional forces also act.

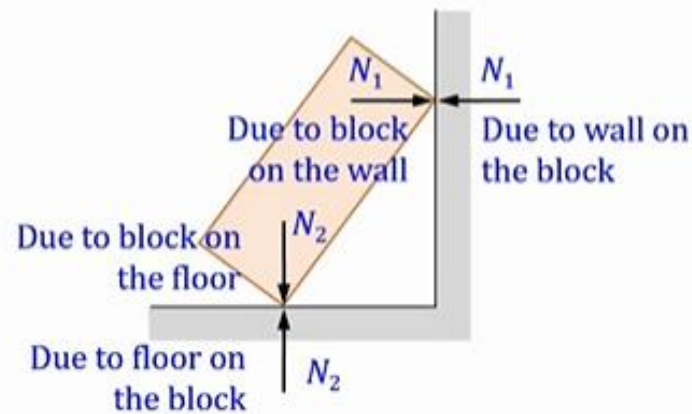
In the following figures, forces of normal reactions in some common situations are shown.



Block on a horizontal floor



Ball on a horizontal floor



Block on a corner

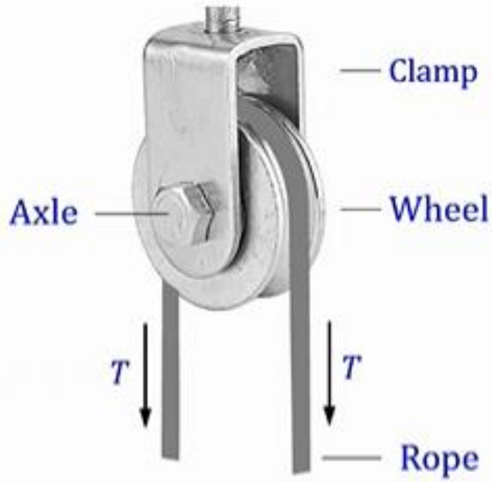
Pulley:

A pulley consists of a wheel free to rotate about an axle that is attached to a clamp.

The wheel rotates about an axle that may be a part of the clamp or of the wheel.

A pulley is used to change direction on force.

An ideal pulley must change direction of force undiminished.

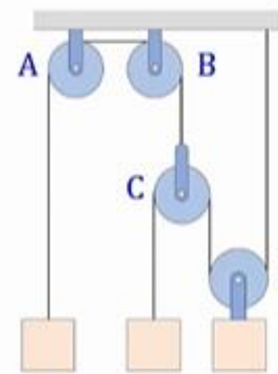


An ideal pulley must have the following characteristics.

Massless: For fixed pulleys, the wheel must be massless.

In case of a movable pulley, the entire pulley must be massless. Actually its mas must be negligible as compared the load on the pulley.

Frictionless: There must no friction between the axle and wheel, but between the rope and wheel, there must be sufficient friction to prevent the rope from slipping on the wheel.



In case of fixed pulleys as A and B, only the wheel must be massless.

In case of movable pulleys as C and D.

Necessity of Free Body Diagram (FBD):

A force is a two-body interaction. Therefore, in every situation, where forces are involved, there must be two or more bodies.

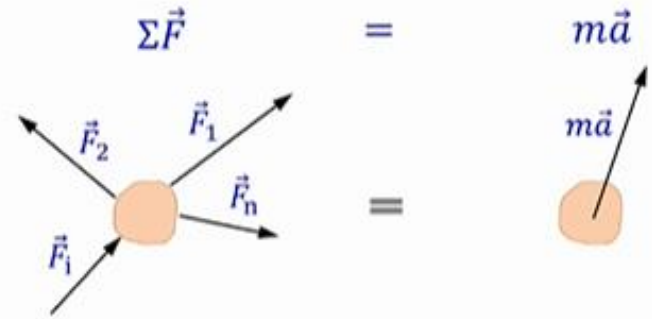
For quantitative description of motion of a body, we have to use Newton's second law.

Therefore, to analyze a given problem, we have to consider each of the bodies separately one by one.

This idea lads us to the concept of free body diagram.

Free Body Diagram (FBD):

A free body diagram is a pictorial representation in which the body under study is assumed free from rest of the system, then it is drawn in its actual shape and orientation showing all the forces acting it.



Free Body Diagram (FBD) **Kinetic Diagram (KD)**

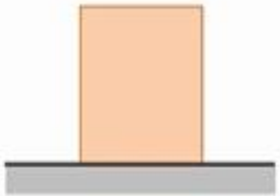
I. Separate the body under consideration from the rest of the system and draw it separately in actual shape and orientation.

II. Show all the forces whether known or unknown acting on the body at their respective points of application.

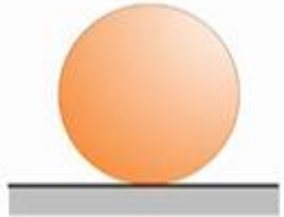
For the purpose, count every contact where we separate the body under study from other bodies. At every such contact point, there may be a contact force. After showing, all the contact forces show all the field forces.

Example 01.

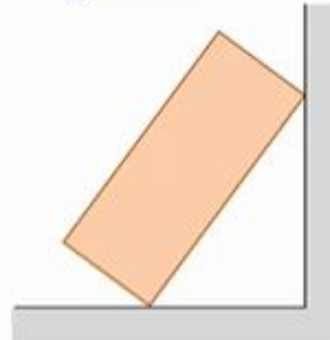
Denoting weight of the body by W, draw FBD in the following cases.



Block on a horizontal floor

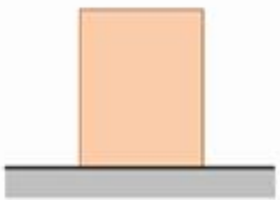


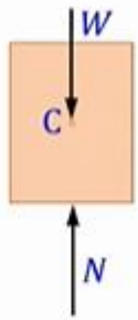
Ball on a horizontal floor



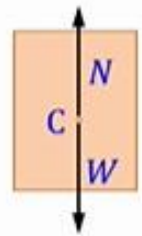
Block on a corner

Solution. **Block on a horizontal floor**





OR

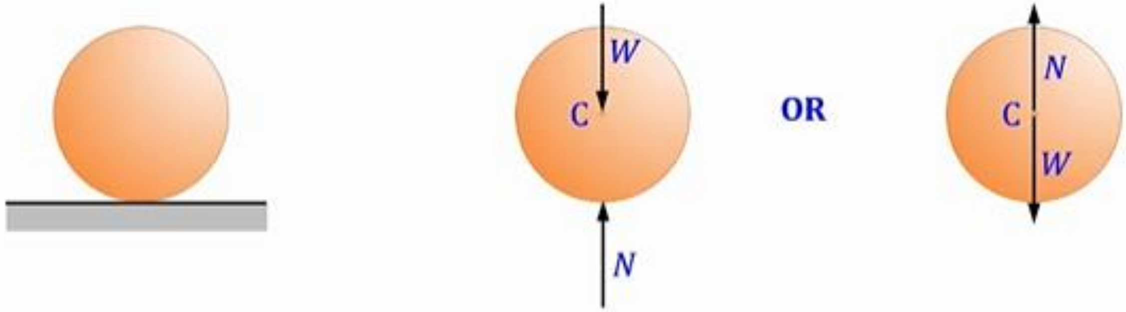


Note:

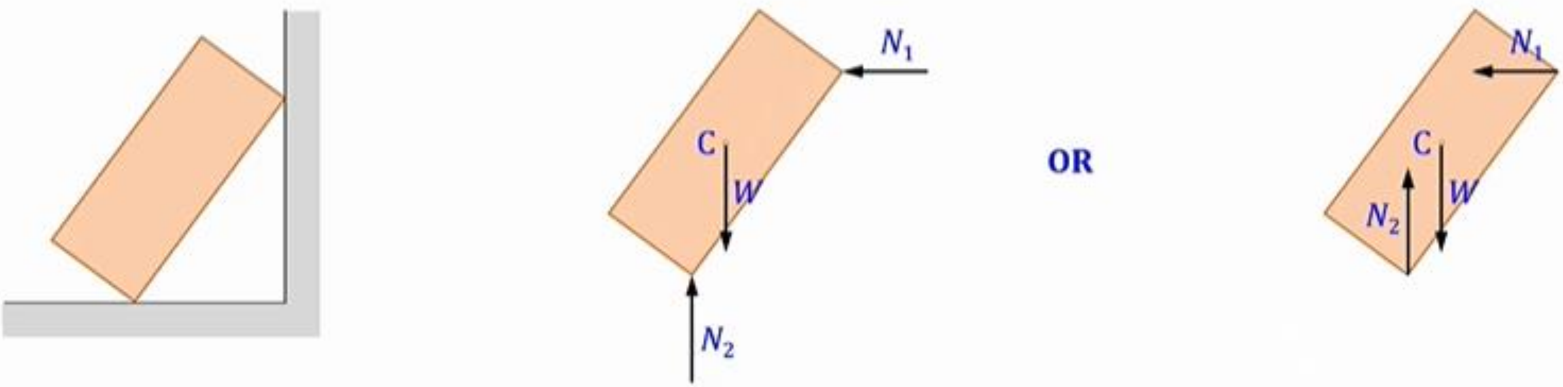
Weight is assumed to act at the mass center of the body.

In analyzing motion, a force can be shifted anywhere on its line of action.

Ball on a horizontal floor

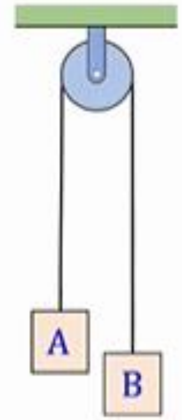


Block on a corner



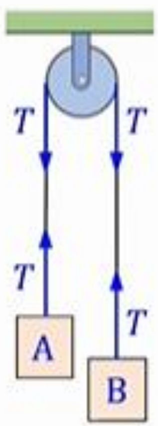
Example 02.

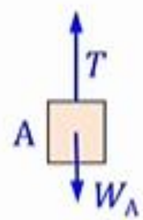
Draw FBD of the blocks and the pulley. Weight of the blocks B (W_B) is more then that (W_A) of A.



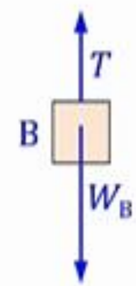
Solution.

First consider how tensile force is transmitted in the string.

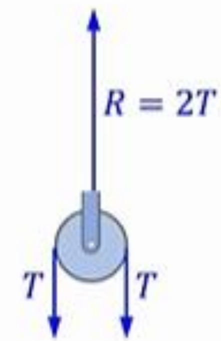




FBD of block A



FBD of block B

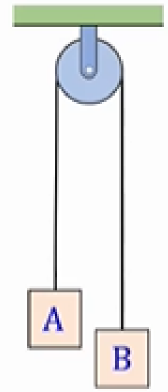


FBD of the pulley

Here forces by the string are shown.

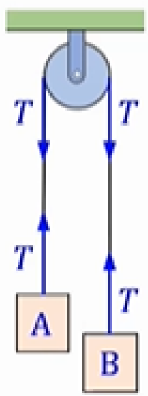
Example 03.

Draw FBD of the pulley, if weight of the pulley is W_P.

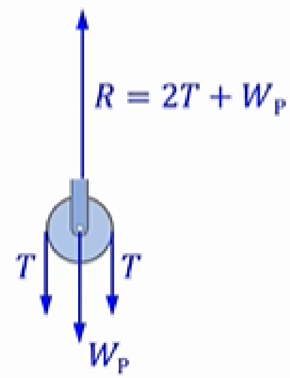


Solution.

First consider how tensile force is transmitted in the string.



Here forces by the string are shown.



FBD of the pulley

Note:

A pulley and a string must be assumed ideal, until it is not specified to tread any one of them nonideal.

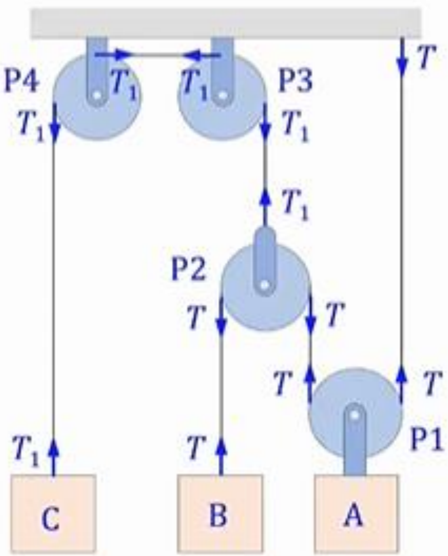
Thus, be the term string we mean an ideal string and by the term pulley we mean an ideal pulley .

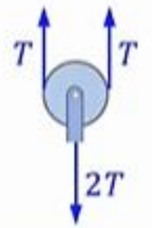
Example 04.

Draw FBD of the blocks and the pulleys. Weight of the blocks A, B and C are W_A, W_B and W_C respectively.

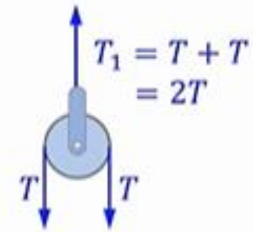
Solution.

Tensile forces in the strings.

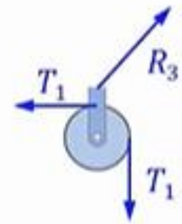




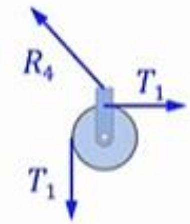
FBD of P1



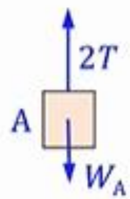
FBD of P2



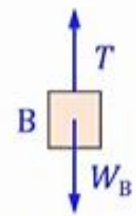
FBD of P3



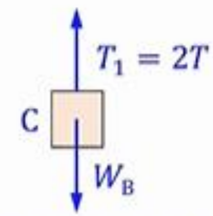
FBD of P4



FBD of block A



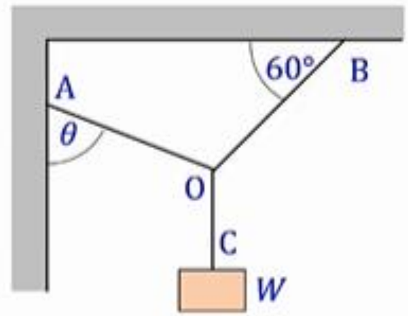
FBD of block B



FBD of block C

Example 05.

A box of weight W is held in equilibrium with the help of three strings OA, OB and OC as shown in the figure. Draw FBD of the box and the knot O.

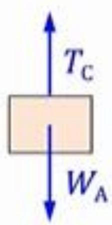


Note:

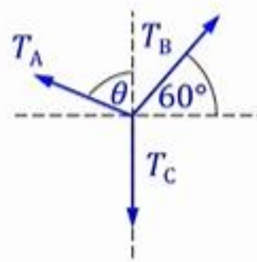
A knot of ideal strings is massless.

Solution.

Let the tensile forces in the strings OA, OB and OC be T_A, T_B and T_C.



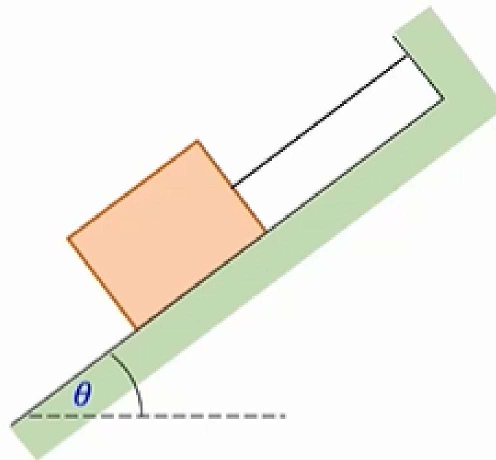
FBD of box



FBD of the knot O.

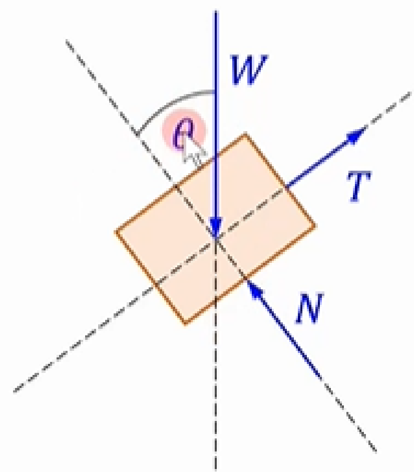
Example 06.

A box of weight W is held in equilibrium on a fixed frictionless inclined plane with the help of a string. Draw FBD of the box.



Solution.

Let tensile force in string be T and force of normal reaction from the inclined plane be N.



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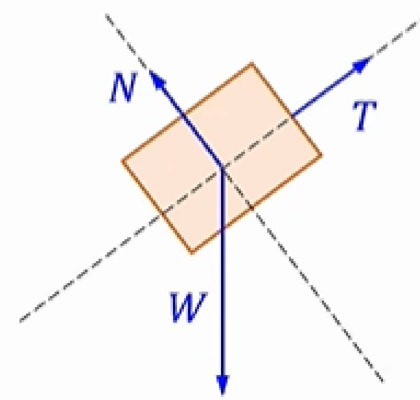
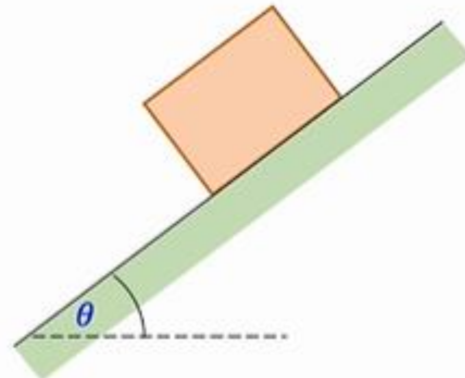


Example 07.

A box of weight W is sliding down a fixed inclined plane. Draw FBD of the box.

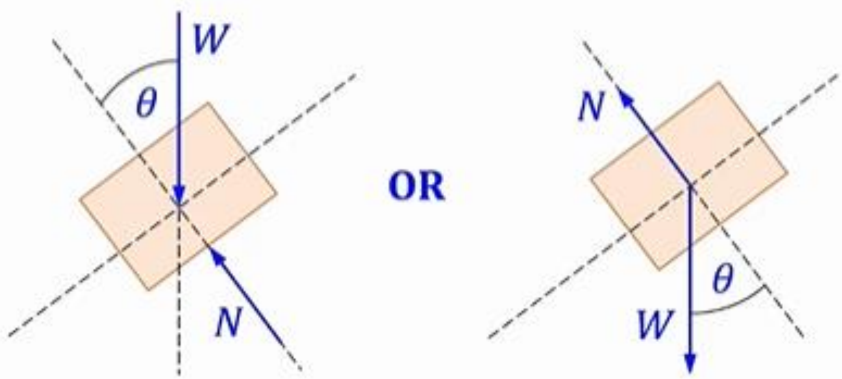
(a) Inclined plane is frictionless.

(b) Inclined plane is not frictionless.



Solution.

(a) Inclined plane is frictionless.



(b) Inclined plane is not frictionless.

Let f be the frictional force.