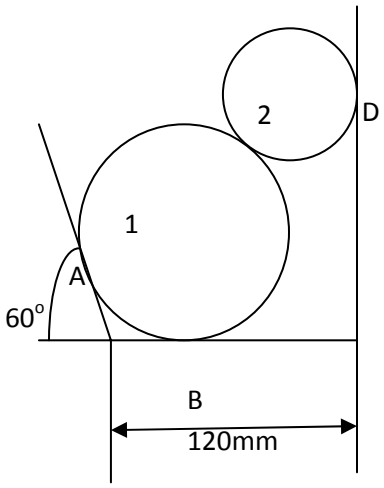
DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT: ENGINEERING MECHANICS (EME102/202) **Mr.Nurul Hssan**

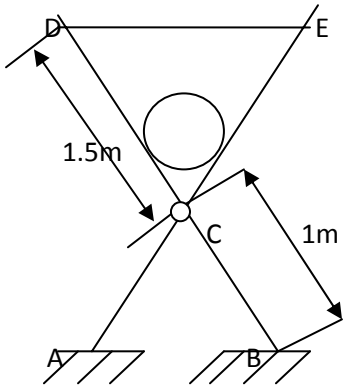
UNIT:1

Q.1.



Radius of ball 1=100mm and ball 2=50mm ;
Weight of ball 1=2000N and ball 2 =800N
Determine reactions at A, B, C, D

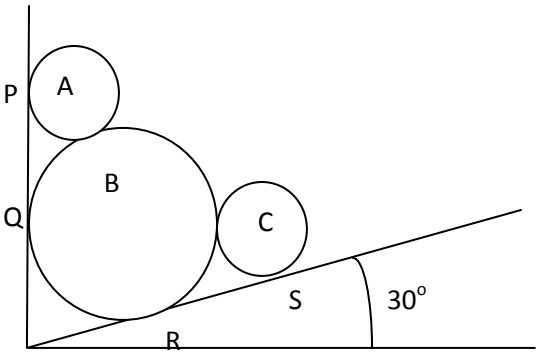
Q.4.



C is hinge joint

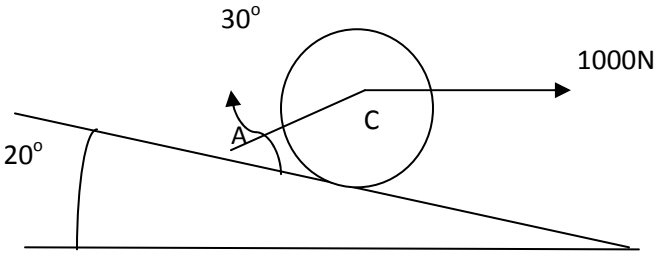
A Cylinder 1m diameter and 10kg mass is lodged between cross pieces that makes an angle of 60^0 with each other As shown in Fig. above. Determine the Tension in the horizontal rope DE.

Q.2.



Three uniform, homogeneous and smooth spheres A, B & C weighing 300N, 600N & 300N respectively and having diameters 800mm, 1200mm & 800mm respectively are placed in a trench as shown in Fig. above. Determine the reactions at the contact points P, Q, R and S

Q.3.A rigid circular roller of weight 5000N rest on a smooth inclined plane and is held in position by a chord AC as shown in Fig below. Find the tension in the chord if there is a horizontal force of magnitude 1000N acting at C.



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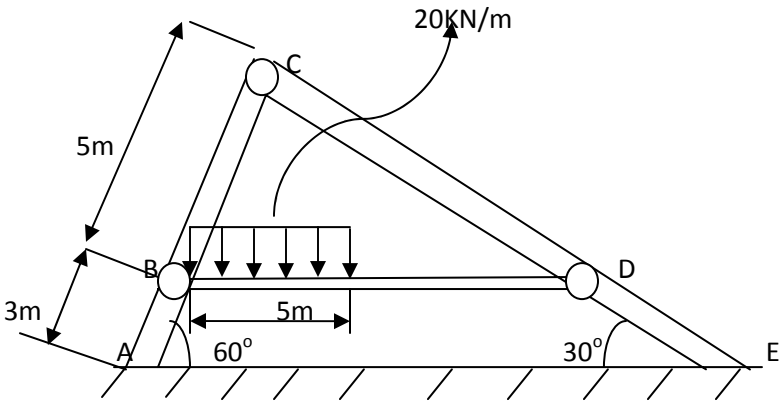
SUBJECT: ENGINEERING MECHANICS (EME102/202) **Mr.Nurul Hassan**

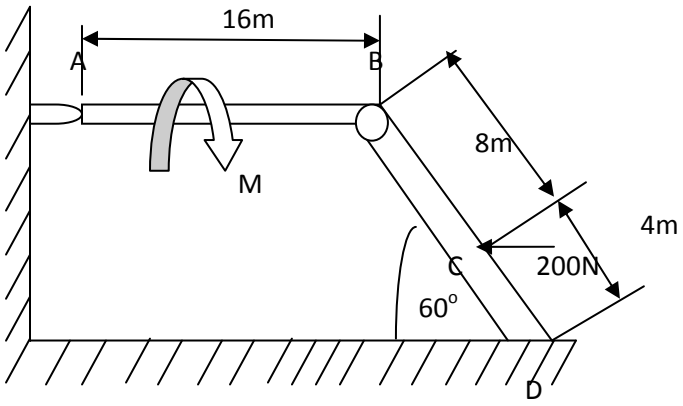
UNIT:1

Q.1.

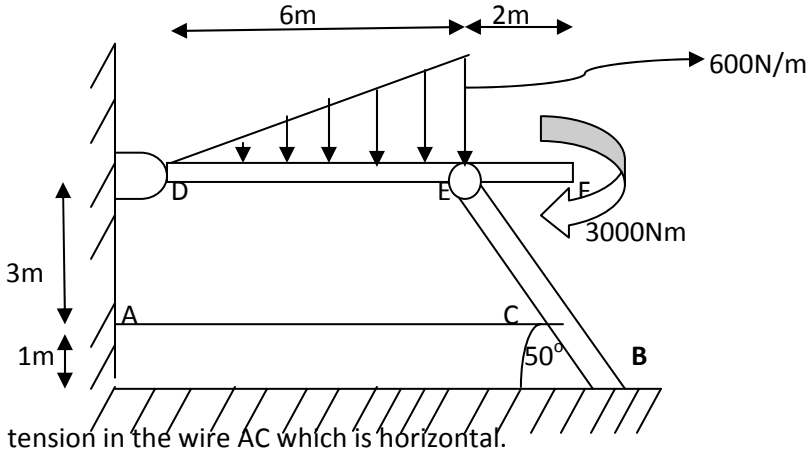


Determine the magnitude of pin reaction at B on the horizontal member BD. The smooth surface on which the structure rests is horizontal

Q.2. The horizontal force 200N in Fig is applied to the slopping member BCD whose bottom rests on a smooth horizontal plane. Its upper end is pinned at B to the horizontal member AB. What couple must be applied to the member AB to hold the system in equilibrium? What is the magnitude of the pin reaction at B



Q.3.



Determine the tension in the wire AC which is horizontal.

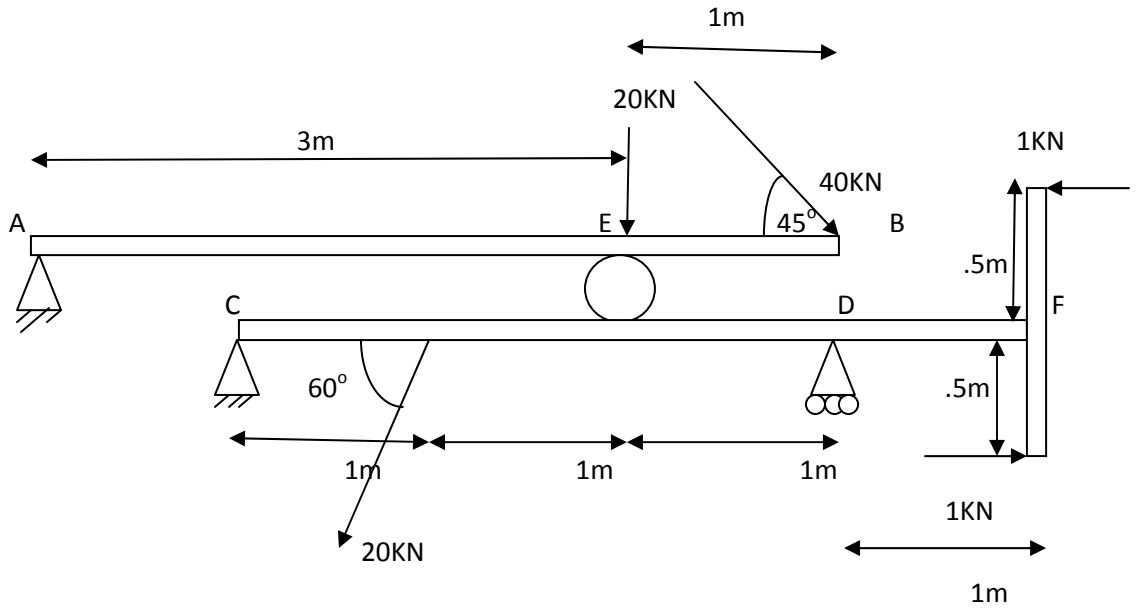
DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT: ENGINEERING MECHANICS (EME102/202)

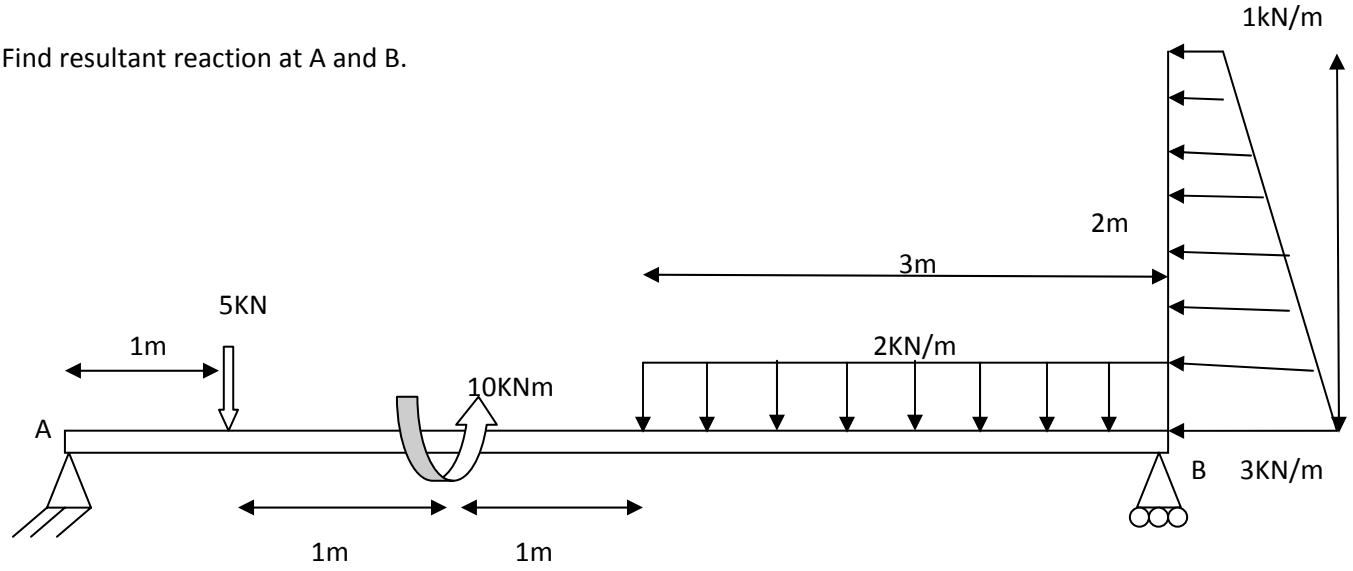
TUTORIAL: 01

Mr.Nurul Hassan

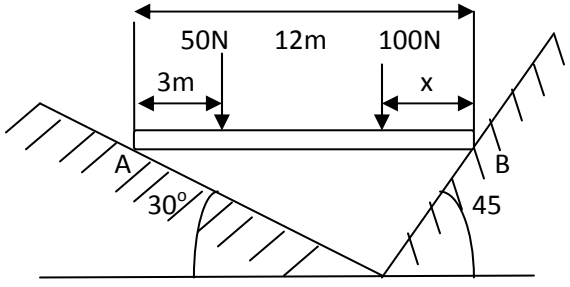
Q.1.Find support reactions at A,E,C& D



Q.2. Find resultant reaction at A and B.



Q.3.



Find x to keep the bar AB in equilibrium.

DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT: ENGINEERING MECHANICS (EME102/202)

UNIT:1 Mr.Nurul Hassan

Q.1. Determine the magnitude and direction of the resultant of the following set of forces acting on a body.

(i) 200N inclined 30 degree with east towards north

(ii) 250N towards the north

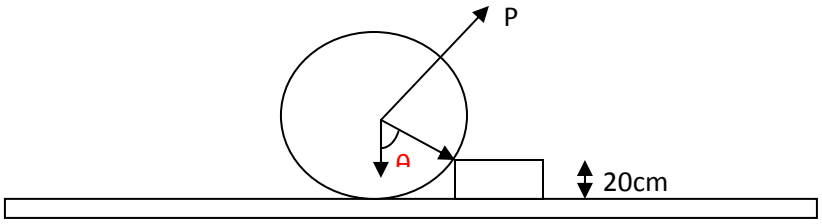
(iii) 300N towards North West

(iv) 350N inclined at 40 degree with west towards south.

What will be the equilibrant of the force system*?* ***(Ans: R=456N, 47.7 degree with X-axis in negative direction)***

Q.2. Find the resultant of forces 2, 3, 4, 5, 6 N that act at an angular point of a regular hexagon towards the other angular points taken in order.

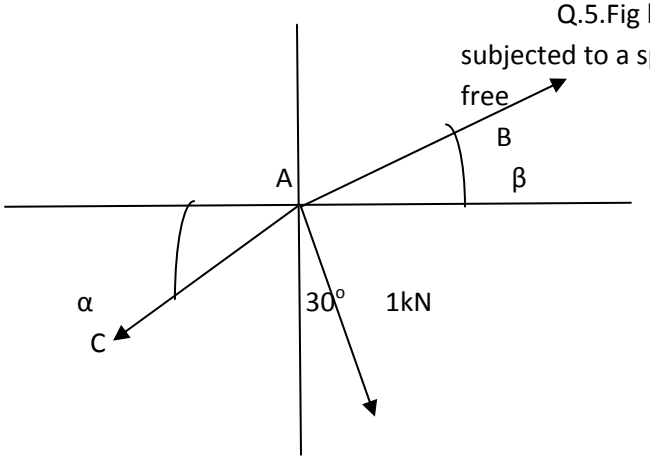
Q.3. A uniform wheel of 50cm diameter and 1kN weight rest against a rigid rectangular block of thickness 20 cm as shown in Fig.1. Considering all surfaces smooth, determine



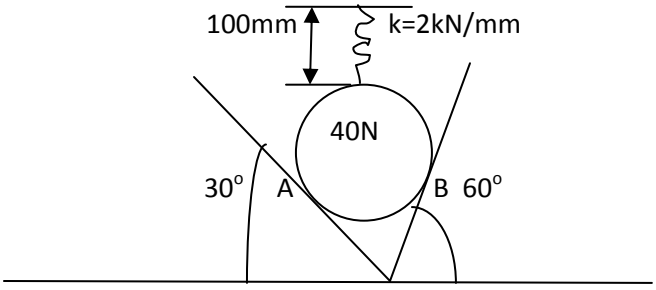
(a) Least Pull to be applied through the centre of wheel to just turn it over the corner of the block.

(b) Reaction of the block

Q.4.A 1kN force has been resolved into components along AB and AC directions in the x-y plane as shown in Fig.2.specified by the angles α and β as shown in Fig. If the component along is 2kN and along AB is 1.6kN, determine the angles α and β



Q.5.Fig below shows a sphere resting in a smooth V shaped groove and subjected to a spring force. The spring is compressed to a length of 100mm from its free Length of 150mm. If the stiffness of spring is 2KN/mm. Determine the contact reactions at A and B

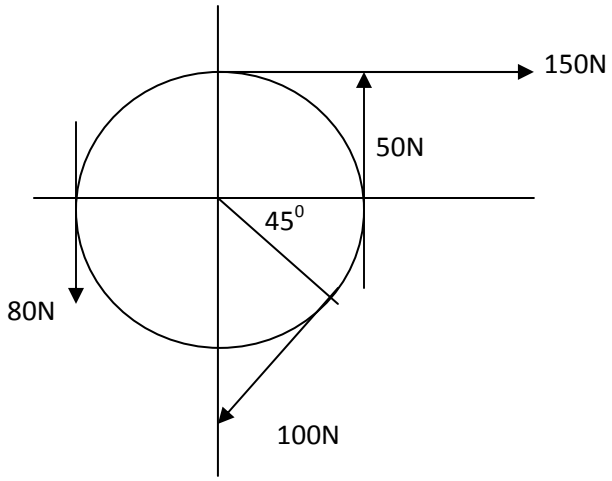


DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT: ENGINEERING MECHANICS (EME102/202)

TUTORIAL Mr.Nurul Hassan

Q.1. Determine the resultant of the forces acting tangential to the circle of radius 3m as shown in Fig given below. What will be its location with respect to the centre of the circle?



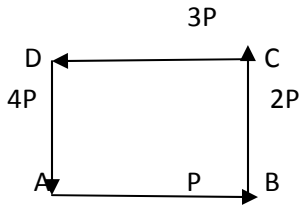
Q.2. A rigid bar is subjected to a system of parallel forces as shown in Fig given below.

Reduce this system to

(i) A single force (ii) a single force –moment system at A

(iii) A single force-moment system at B

Q.3.Forces equal to P, 2P, 3P and 4P act along the sides AB,BC,CD and DA of a square ABCD. Find the magnitude, direction and line of action of the resultant.



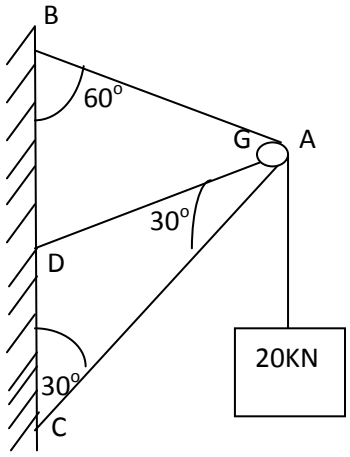
Q.4.Three forces equal to 1kn, 2kN and 3kN are respectively acting in order along the three sides of an equilateral triangle. Make calculation for the magnitude, direction and position of their resultant.

DEPARTMENT OF MECHANICAL ENGINEERING

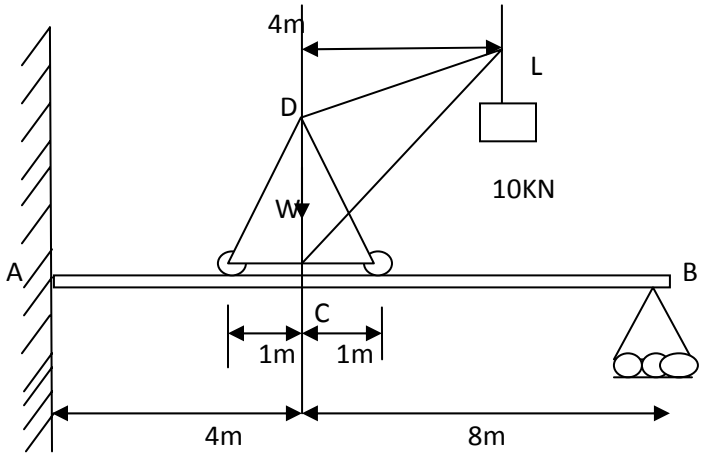
SUBJECT: ENGINEERING MECHANICS (EME102/202)

ASSIGNMENT Mr.nurul Hassan

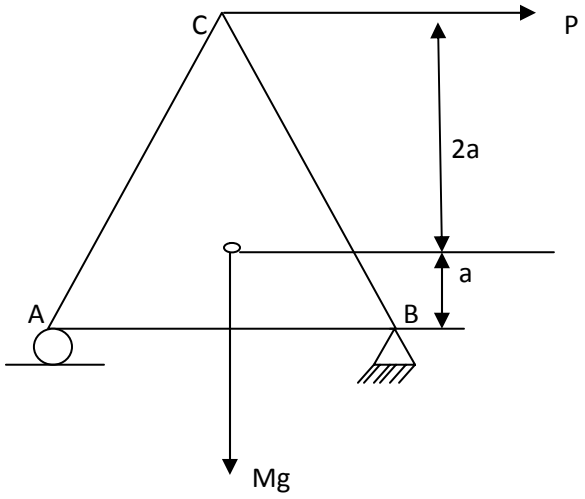
Q.1.The frictional less pulley A shown in Fig is supported by two bars AB and AC which are hinged at B and C to a vertical wall. The flexible cable DG hinged at D goes over the pulley and supports a load of 20KN at G. The angles between various members are shown in Fig. Determine the forces in AB and AC. Neglect the size of pulley



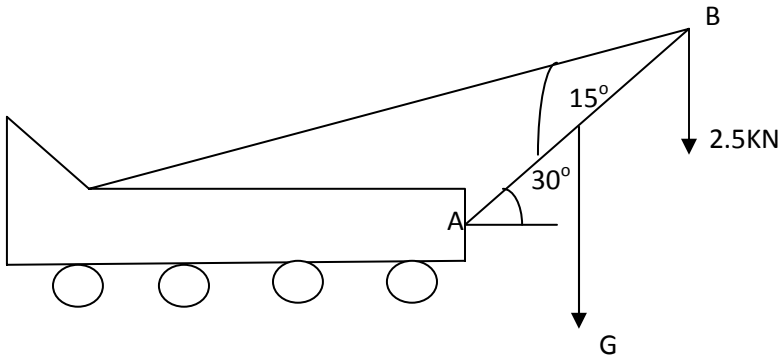
Q.2. One end of a split horizontal beam ACB is fixed into wall and the other end B rests on a roller support. A hinge is at point A.A crane of weight 50KN is mounted on the beam and is lifting a load of 10KN at the end L. The C.G of the crane acts along the vertical line CD and KL=4m.Neglect the weight of the beam, find the reaction / moments at A &B.



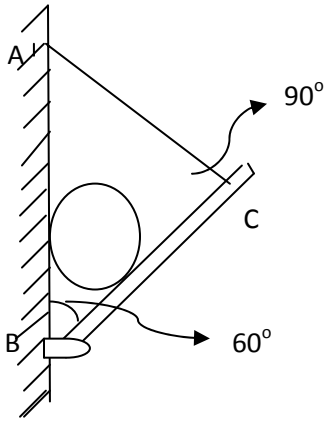
Q.3. The cross-section of a block is an equilateral triangle. It is hinged at A and rests on a rollerat B. It is pulled by means of a string attached at C. If the weight of the block is Mg and the string is horizontal, determine the force P which should be applied through string to just lift the block off the roller.



Q.4.A 12m boom AB weighs 1KN, the distance of the centre of gravity G being 6m from A. For the position shown, determine the tension T in the cable and the reaction at B



Q.5. A cylinder of weight 1000N and radius 40cm is in equilibrium as shown in Fig. Find the tension in the rope AC. Length of BC is 2m



DEPARTMENT OF MECHANICAL ENGINEERING
SUBJECT: ENGINEERING MECHANICS (EME102/202)

Mr.Nurul Hassan

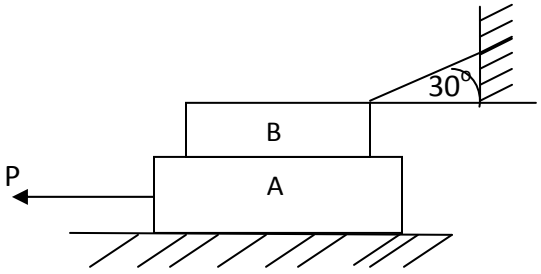
FRICTION

Q.1.A body of weight 100N rest on a rough horizontal surface (μ=03) and is acted upon by a force applied at an angle of 30 degree to the horizontal.
(a)What force is required to just cause the body to slide over the surface? (29.53N)
(b) Proceed to determine the inclination and magnitude of minimum force required to set the block in to impending motion (28.73N, angle=16.7 degree)

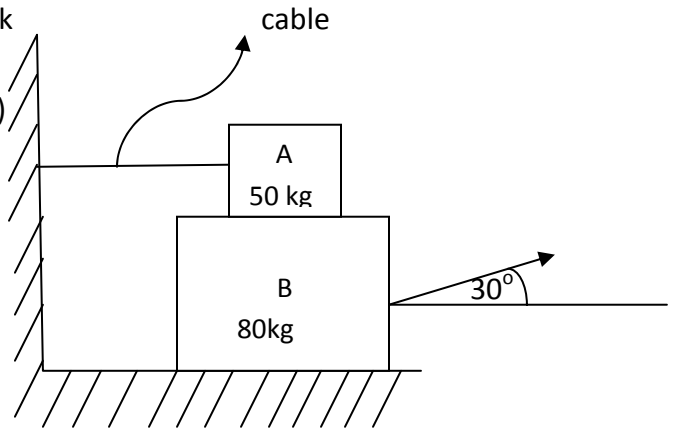
Q.2. A wooden block of weight 50N rest on a horizontal plane. Determine the force required to just (a) pull it and (b) push it. Take μ=04 between the mating surface. Comment on the result
(It is easier to pull the block than push it)

Q.3.A body resting on a rough horizontal plane required a pull of 24N inclined at 30 degree to the plane just to move it. It was also found that a push of 30N at 30 degree to the plane just enough to cause motion to impend. Make calculation for the weight of the body and the co-efficient of friction. (120.25N, 0.192)

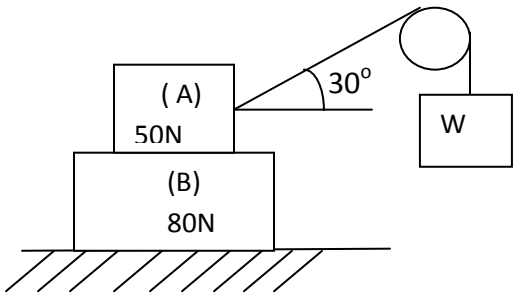
Q.4.Two blocks A & B of weight 4kN and 2 kN Respectively are in equilibrium as shown in Fig.1. Presuming that co-efficient of friction between the blocks as well as between block and floor is 0.25, make calculation for the force P required to move the block A (P=1.874N)



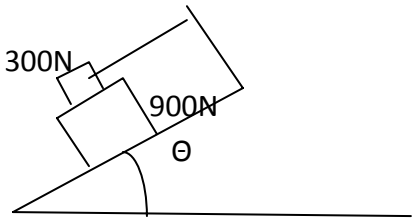
Q.5. Calculate the force P required to move the lower block B and tension in the cable. Take coefficient of friction at all the contact surfaces to be 0.3(P=521.4N, T=147.15N)



Q.6. State whether B is stationary with respect to ground and A or B is stationary with respect to A. Determine the minimum value of weight W in the pan so that motion starts .coefficient of friction between ground and block is 0.1 and between block A and B is 0.28

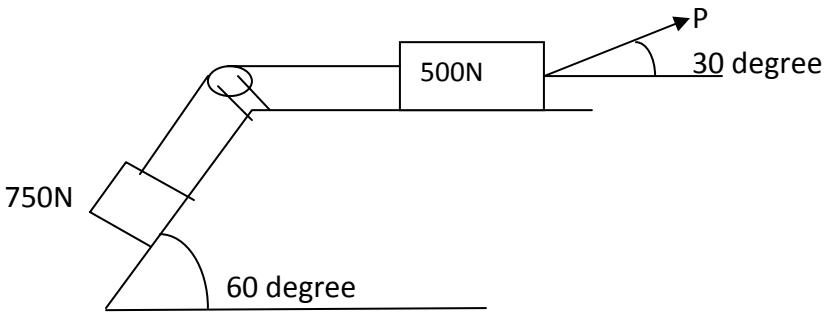


Q.7.What should be the value of θ in Fig given below which will make the motion of 900N block down the plane to impend? Coefficient of friction all contact surfaces is 1/3 (29.05 degree)



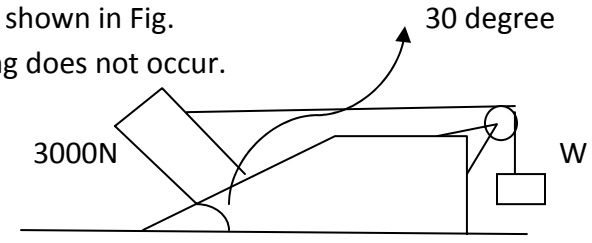
Q.8.A weight 500 N just starts moving down a rough inclined plane supported by a force of 200N acting parallel to the plane and it is at the point of moving up the plane when pulled by a force of 300N parallel to the plane. Find the inclination of the plane and the coefficient of friction between the inclined plane and the weight? (30degree, 0.11547)

Q.9.

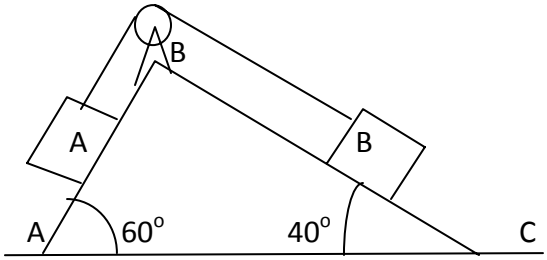


What is the value of P in the system as shown in Fig to cause the motion to impend? Assume the pulley is smooth and coefficient of friction between the other contact surfaces is 0.2 (853.52N)

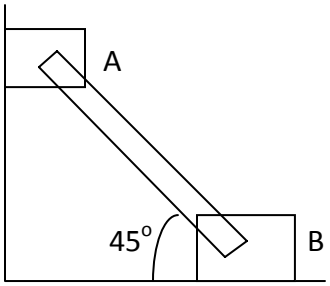
Q.10. A 3000N block is placed on an inclined plane as shown in Fig. find the maximum value of W for equilibrium if tipping does not occur. Assume coefficient of friction as 0.2. (1014.96 N)



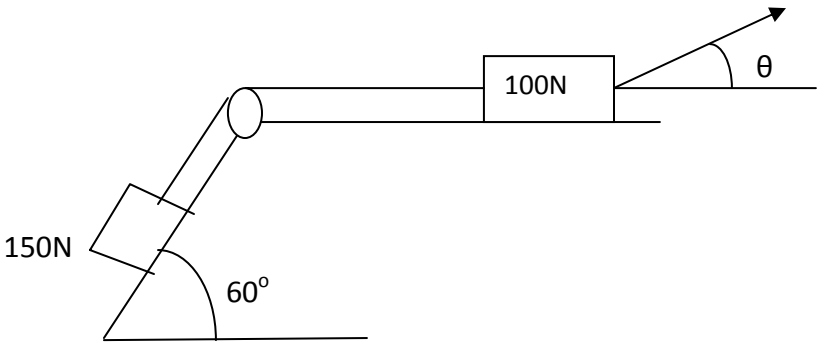
Q.11.Find whether block A is moving up or down the plane in Fig. for the data given below. Weight of block A and B are 300N and 600N respectively. Coefficient of friction between plane AB and block A is 0.2.Coefficient of friction between plane BC and block AB is 0.25.Assume the pulley is smooth.
(Block A moves up)



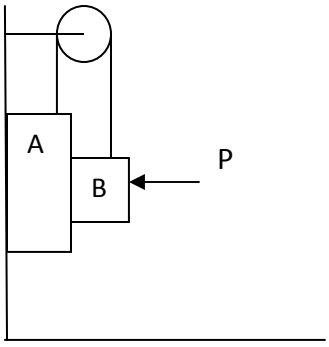
Q.12.Two identical blocks A and B are connected by a rod and they rest against vertical and horizontal planes respectively as shown in Fig. If sliding impends when θ=45 degree, determine the coefficient of friction, assuming it to be the same for both floor and wall.



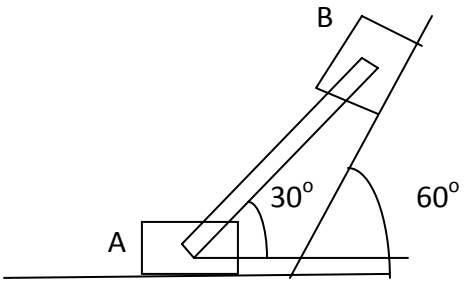
Q.13. What is the least value of P to cause motion to impend? Assume the coefficient of friction to be 0.20 (P=162N, 11.20°)



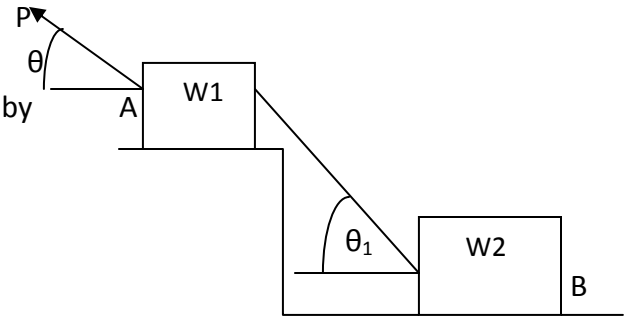
Q.14. Block A of mass 12kg and block B of mass 6kg are connected by a string passing over a smooth pulley. If μ =0.12 at all surfaces of contact find smallest value of P force to maintain equilibrium.(163.5N)



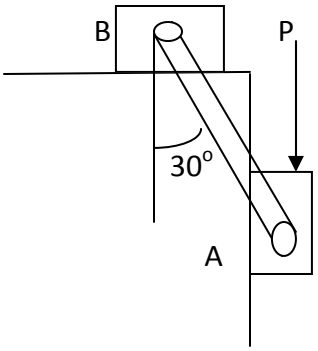
Q. 15. Two blocks are separated by a uniform strut attached to each block. Block A weighs 400N, block B weighs 300N and strut AB weighs 200N.I f μ_B=0.25, find coefficient of friction under A to prevent motion



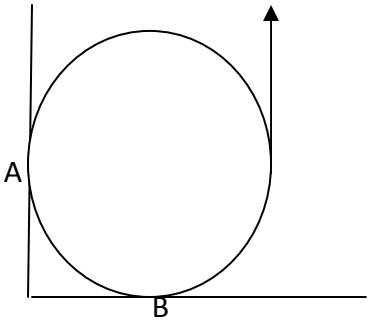
Q.16. Two block havimg weights W1 and W2 are connected by A string and rest on horizontal plane as shown in Fig. If the angle of friction for each block is ϕ, find magnitude and direction of least force P [Pmin=(W1+W2) sinθ]



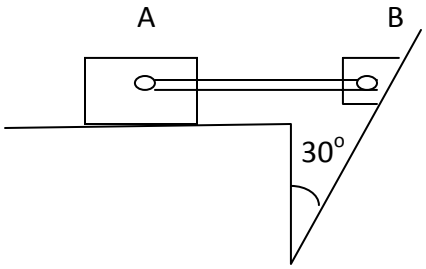
Q.17.two blocks A and B each of mass 100N are connected by A slender bar of negligible weight. If coefficient of friction at all Contact surfaces is 0.3, determine the largest value of P to maintain Equilibrium. (26.37N)



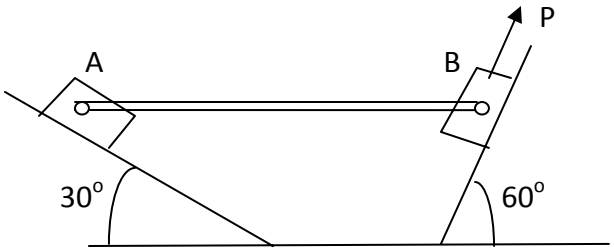
Q.18. Find whether a cylinder of 800N will slip or not under the action of a tangential force of 200N as shown in Fig. Take μ=0.5 at all contact surfaces.



Q.19.Two blocks connected by a horizontal link AB are supported on two rough planes as shown in Fig. The coefficient of friction for the block on the horizontal plane is 0.4. the limiting angle of friction for block B on the inclined plane is 20 degree. What is the smallest weight W of the block A for which equilibrium of the system can exist if weight of block B is 5kN. (10.49N)



Q.20. Two blocks A and B each weighing 1500N are connected by a uniform horizontal bar which weighs 1000N.If the angle of limiting friction under each block is 15 degree, find the force P directed parallel to the 60 degree plane that will cause motion impending to the right. (P=1856.40N)



THEORITICAL QUESTIONS

UNIT:1 & 2

Q.1.Define Mechanics .Explain Newton's laws of motion.

Q.2.What do you mean by force? What are the characteristics of a force? Explain different types of force with example.

Q.3.How will you define a particle and a rigid body?

Q.4.Explain: (a) Principle of transmissibility. (b) Triangle law (c) Parallelogram Law (d) Polygon law (e) Principle of moments (f) Lami's Theorem

Q.5.State and prove Varignon's theorem.

Q.6. Write note on (a) Resolution of force (b) Equilibrium of a body (c) Resultant (d) Equilibrant (f) Free body Diagram

Q.7. Explain the conditions of equilibrium of a body.

Q.8. what do you mean by moment, torque and couple.

Q.9.Explain various types of support and reactions developed on that support with diagram.

Q.10.What are the different types of load? What do you mean by UDL and UVL?

Q.11.Explain: Friction, Types of friction, Limiting friction, Static and dynamic friction, Sliding and rolling friction, Coefficient of friction, angle of friction, Cone of friction, angle of repose, Laws of friction, Advantage and disadvantage of friction, application of friction, Characteristics of friction

Q.12. Explain ladder friction and wedge friction.

Q.13.What do you mean by slip and creep of a belt. Show that for belt friction $T_1/T_2=e^{\mu\theta}$

Q.14.Define velocity ratio of a belt. Differentiate between flat belt and V-belt.

Q.15.Define shear force and bending moment. Explain the procedure to draw SFD and BMD of a beam.

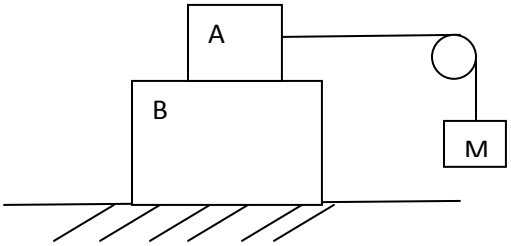
Q.16. Establish the relation between shear force, intensity of loading and bending moment.

Q.17. What is a beam? Explain different types of beam with fig.

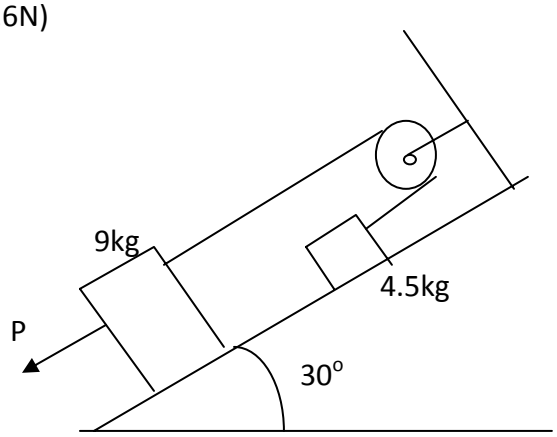
Q.18. What do you mean by point of contraflexture.

BELT FRICTION

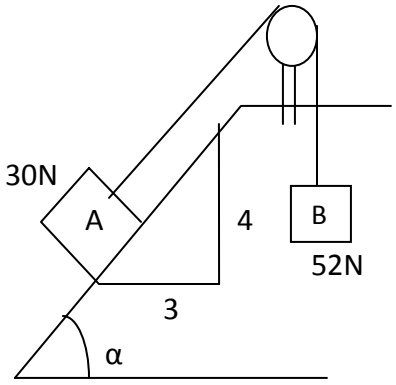
Q.1. The mass of A is 23 kg and the mass of B is 36kg.The coefficient of friction are 0.6 between A & B,0.2 between B and the plane and 0.3 between the rope and fixed drum. Determine the maximum mass of M before motion impends



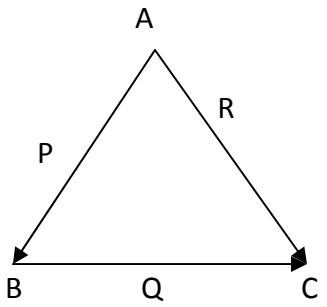
Q.2.Determine the force P to cause motion to impend.μ=0.25 at all contact contact surfaces. The pulley is frictionless.(P=6.6N)



Q.3. Determine the coefficient of friction between the rope and pulley if the coefficient of friction between the block A and the plane is 0.28

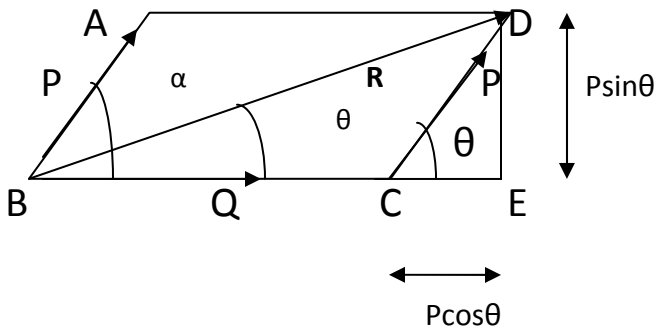


Triangle Law: If two sides of a triangle represent two forces taken in order then the third side will give the resultant taken in opposite order.



ABC is a triangle. Two forces P& Q acting along AB & BC in same order. The side AC will give the resultant in opposite order.

Parallelogram Law: If two forces acting simultaneously on a body at a point are represented in magnitude and direction by the two adjacent sides of a parallelogram, their resultant is represented in magnitude and direction by the diagonal of the parallelogram which passes through the point of intersection of the two sides representing the forces



ABCD is a parallelogram. P & Q are the two force acting along BA & BC. The diagonal BD will give the resultant(R).

$R=SQRT\ (P^2+Q^2+2PQ\cos\theta)$ & $\theta=\tan^{-}\{\ P\sin\theta\ /\ (Q+P\cos\theta)\ \}$

POLYGON LAW: If a number of concurrent forces acting simultaneously on a body are represented in magnitude and direction by the sides of a polygon taken in order then the resultant is represented in magnitude and direction by the closing side of the polygon taken in opposite order

FORCE: A "force" is an action that changes, or tends to change, the state of motion of the body upon which it acts. It is a vector quantity that can be represented either mathematically or graphically.

A complete description of a force MUST include its:

1. MAGNITUDE
2. DIRECTION and SENSE
3. POINT OF APPLICATION

Scalar and Vector: A quantity is said to be scalar if it is completely defined by its magnitude alone. Ex: length, area, time. A quantity is said to be vector if it is completely defined only when its magnitude and direction are specified. Ex: force, velocity, acceleration

Particle: It may be defined as an object which has only mass and no size. Such a body can not exist theoretically but when dealing with problems distances considerably larger when compared to the size of the body.

Rigid body: It may defined as a body in which the relative positions of any two particle do not change under the action of the forces.

Coplanar force: If all the forces lie in a single plane the system is called co-planar force system.

Non-Coplanar force: If all the forces do not lie in a single plane the system is called non co-planar force system.

Concurrent force: If the line of action of forces passes through a single point the system is called con-current force system.

Non-Concurrent force: If the line of action of forces does not pass through a single point the system is called non-concurrent force system.

Collinear forces: If the line action of all the forces acts along the same line it is called collinear forces (ex; Forces on a rope in a tug of war)

Moment of a force: Moment of a force about a point is its measure of its rotational effect. Moment is defined as the product of the magnitude of the force and the perpendicular distance of the point from the line of action of the force. The point about which the moment is considered is called moment centre and the perpendicular distance is called moment arm.

Couple: Two parallel forces equal in magnitude and opposite in direction and separated by a definite distance are said to form a couple. The sum of the forces forming a couple in any direction is zero which means the translator effect of the couple is zero.

Newton's Law of motion:

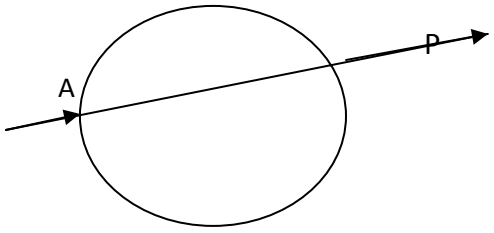
First Law: Every body continues in its state of rest or of uniform motion in a straight line unless it is compelled to change that state by forces acting on it.

Second Law: The rate of change of momentum of a body is directly proportional to the impressed force and it takes place in the direction in which the force acts. This law leads to the definition of force.

Momentum =mass × velocity
Rate of change of momentum=mass× rate of change of velocity
= mass × acceleration
Force is proportional to mass × acceleration

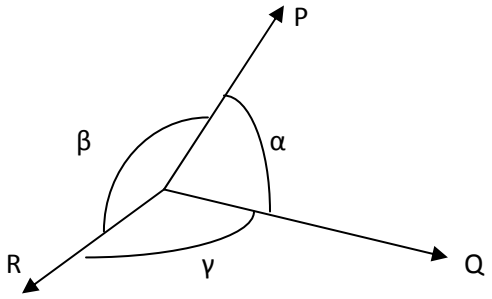
Third law: To every action there is an equal and opposite reaction

Principle of transmissibility of forces: The state of rest or of uniform motion of a rigid body is unaltered if a force acting on the body is replaced by another force of the same magnitude and direction but acting anywhere on the body along the same line of action of the replaced force.



FREE BODY DIAGRAM: In many engineering problems it is essential to isolate the body under consideration from the bodies in contact and draw all the forces acting on it. For this first the body is drawn and then applied forces, self weight and reactions at the point of contact with other bodies are drawn. Such a diagram of the body in which the body under consideration is freed from all the contact surfaces and all the forces acting on it (Including reactions at contact surfaces) are drawn is called a **Free Body Diagram**

Lami's Theorem: If a body is in equilibrium under the action of three forces each force is proportional to the sine of the angle between the other two forces.



From the Fig. above : $P/\sin\gamma = Q/\sin\beta = R/\sin\alpha$ (by Lami's theorem)

Equilibrium: A body is said to be in equilibrium when it is at rest or continues to be in steady linear motion. According to Newton's law of motion it means that the resultant of all the forces acting on a body in equilibrium is zero.

For concurrent force system the conditions of equilibrium are:

(i) **$\Sigma X=0$: Algebraic sum of the forces in X-direction is equal to zero.**

(ii) **$\Sigma Y=0$: Algebraic sum of the forces in Y-direction is equal to zero.**

For non concurrent force system the conditions of equilibrium are:

(i) **$\Sigma X=0$: Algebraic sum of the forces in X-direction is equal to zero.**

(ii) **$\Sigma Y=0$: Algebraic sum of the forces in Y-direction is equal to zero.**

(iii) **$\Sigma M=0$: Algebraic sum of the moments about any point is equal to zero.**

Equilibriant: A according to Newton's law of motion a body starts moving with uniform acceleration if it is acted upon by a force. Hence if another force equal in magnitude and opposite in direction to the force causing the motion is applied to the body, the body comes to rest. Such a force is equal and opposite to a given force is called Equlibriant

Reactions: These are self adjusting forces developed by the other bodies which come in contact with the body under consideration. According to Newton's third law of motion the reaction are equal and opposite to the action. The reactions adjust themselves to bring the body to equilibrium.

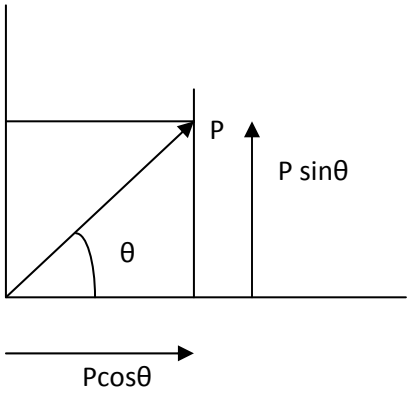
Resultant: It is possible to find a single force which will have the same effect as that of a number of forces acting on a body. Such a single force is called **Resultant.**

VARIGNON'S THEOREM: "It states that the algebraic sum of the moments of a system of coplanar forces about a moment centre in their plane is equal to the moment of their resultant force about the same moment centre."

Referring to the Fig. let R be the resultant of forces P_1 & P_2 and B the moment centre. Let d, d_1 & d_2 be the moment arm of the forces R, P_1 & P_2 respectively from the moment centre B. Then according to Varignon's theorem: $Rd=P_1d_1+P_2d_2$

Proof:

Resolution of Forces: It is the process of finding a number of component forces which will have the same effect on the body as the given single force. It is exactly the opposite process of composition of forces.



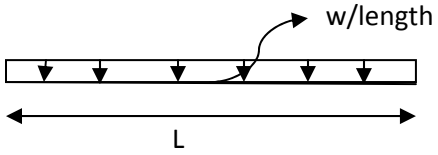
Types of load:

(i) Point Load: Load acting at a point. It is also called concentrated load.

(ii) Uniformly varying load(UDL):This load acts over a length with intensity w load /length

Total load = intensity of UDL × length over which the udl acts

This total load will act at the centre of the body

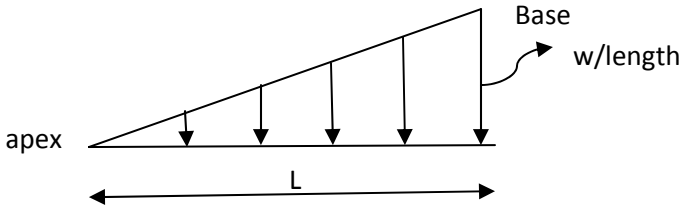


Total load =wL and it will act at L/2

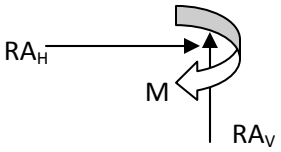
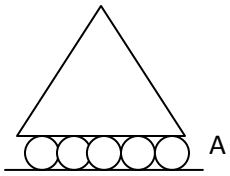
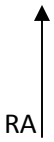
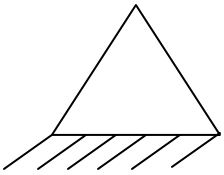
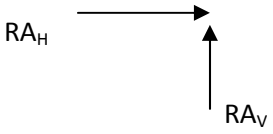
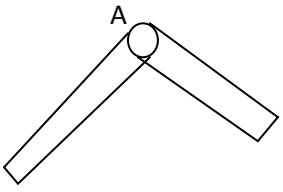
(iii) Uniformly varying load (UVL): This load act over a length starting from zero at one point and maximum at the other point with intensity w load/length. It is also called triangular load.

Total Load= area of the triangle

It will act at the centre of gravity



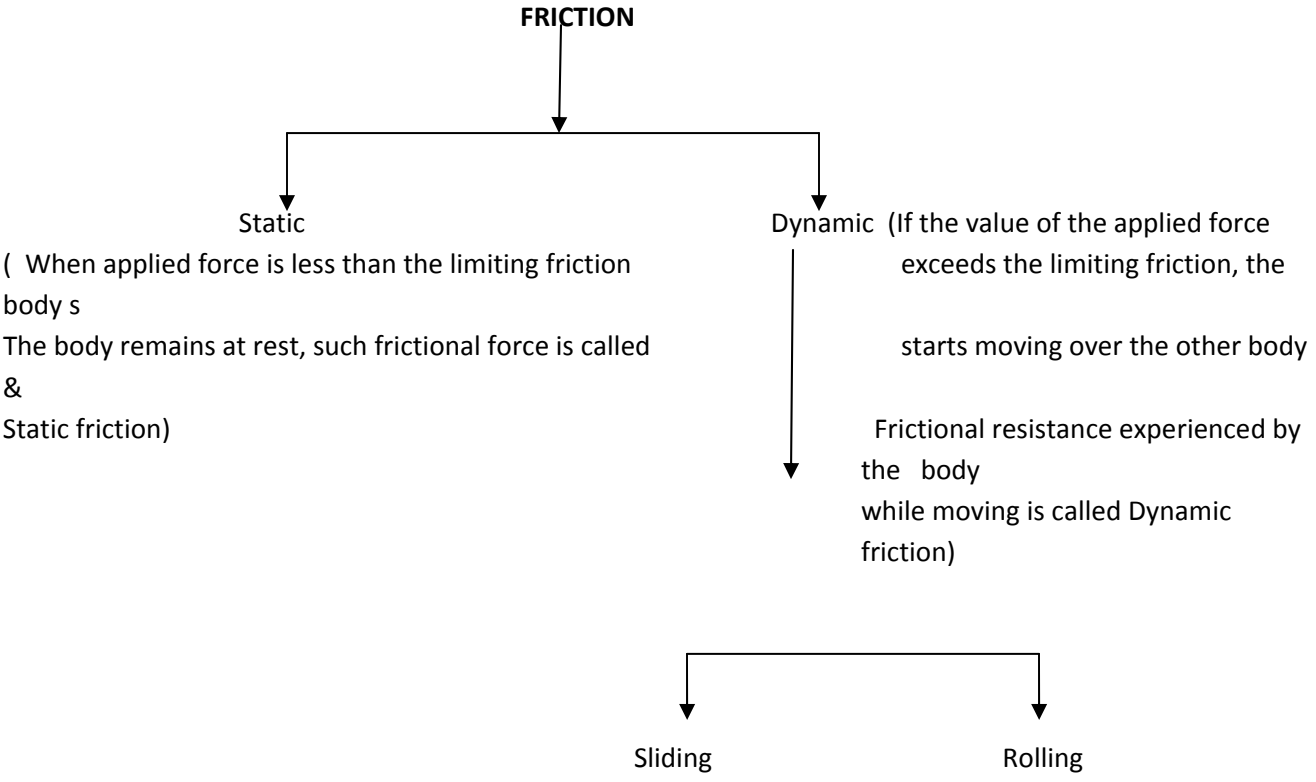
Total load = 1/2×w×L=wL/2 and it will act at $1/3^{rd}$ of L from base and $2/3^{rd}$ of L from apex

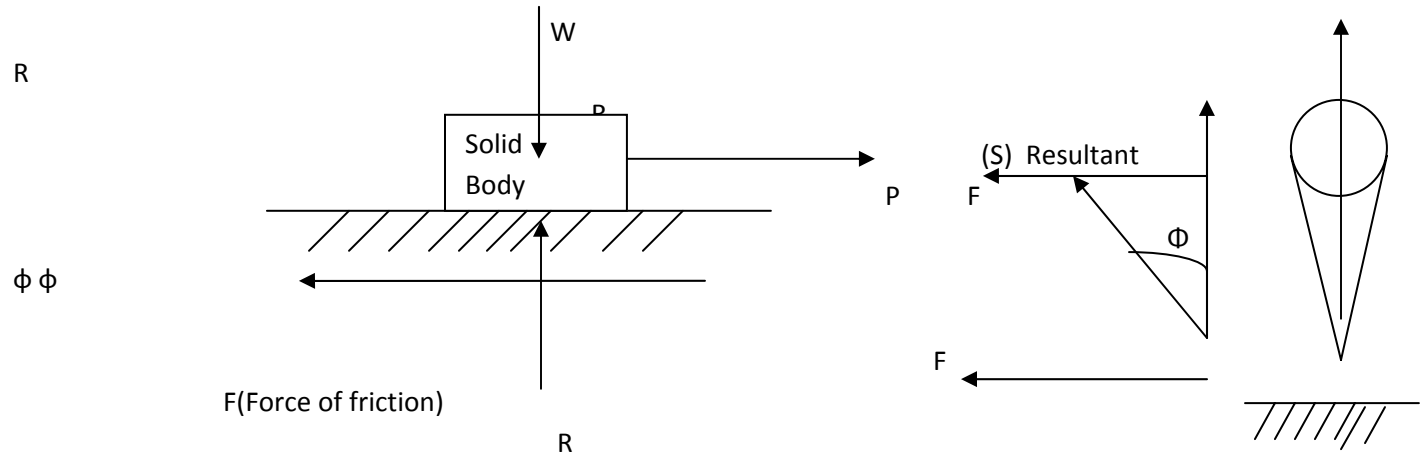
Types of support	Symbol	Reactions
1. Fixed		
2. Roller		
3. Hinge		
4. Pin joint		

FRICTION

FRICTION: When a body moves or tends to move over another body a force opposing the motion develops at the contact surfaces. This force which opposes the movement or the tendency of movement is called frictional force or simply friction. Friction occurs due to the resistance offered to motion by minutely projecting particles at the contact surfaces.

Limiting friction: Maximum value of frictional force which comes in to play when the motion is impending is called Limiting friction.





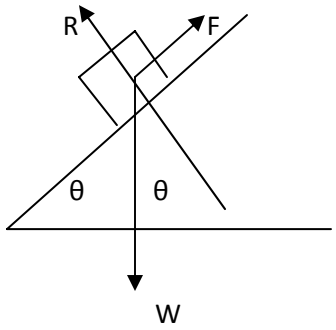
Coefficient of Friction (μ): It is defined as the ratio of the limiting force of friction (F) to the normal reaction ® between two bodies. μ= F/R

Angle of Friction (ϕ): It is defined as the angle made by the resultant of the normal reaction ® and the limiting force of friction (F) with the normal reaction R.

$$\tan\phi = F/R = \mu R/R = \mu$$

Cone of Friction: It is defined as the right circular cone with vertex at the point of contact of the two bodies (or surfaces) , axis in the direction of normal reaction (R) and semi vertical angle equal to angle of friction (ϕ).

Angle of Repose (θ): When a body is placed in a inclined plane then the minimum angle of inclination for which the body will start to impend motion is called angle of repose.



F=W sinθ or μR= Wsinθ----------(i)

R=Wcosθ----------(ii)

(i)/(ii): μ=tanθ= tanϕ

Or θ= ϕ

LAWS OF FRICTION:

1. The force of friction acts in the opposite direction in which the body moves or tends to move.

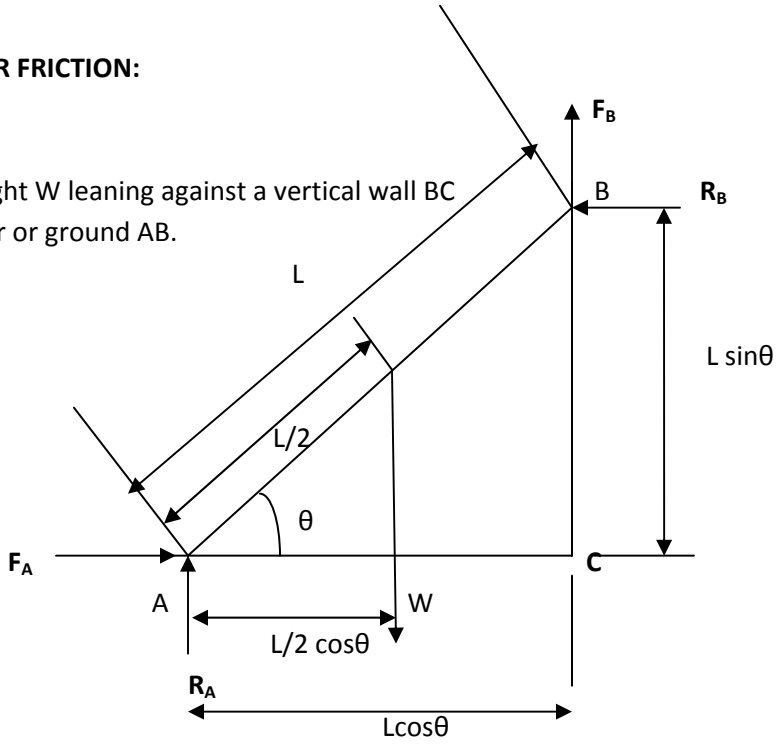
2. The limiting frictional force bears a constant ratio to the normal reaction between two surfaces.

3. The limiting frictional force does not depend upon the shape and areas of the surfaces in contact.

4. Coefficient of friction for static friction is slightly greater then that of dynamic friction.

ANALYSIS OF LADDER FRICTION:

AB is a ladder of weight W leaning against a vertical wall BC And resting on a floor or ground AB.



For the equilibrium of the system the algebraic sum of the horizontal and vertical forces must be equal to zero.

Also the moment of all the forces about any point is equal to zero.

WEDGE FRICTION:

A wedge is a relatively small sized and light weight element employed to raise or move the bodies of considerable weight. The wedges have one or two slipping surfaces which factilitate the lifting of a body through a small height by pushing it below the body with the application of force P on it. As wedges are subjected to concurrent force system, therefore the problems can be solved by using Lami's theorem.