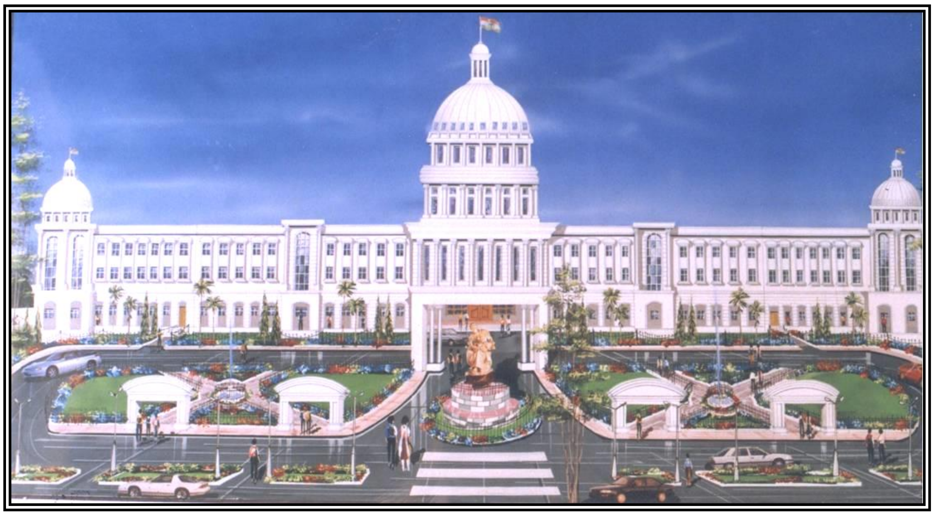
SESHADRI RAO GUDLAVALLERU ENGINEERING COLLEGE

(An Autonomous institute with permanent affliation to JNTUK Kakinada)

***SESHADRI RAO KNOWLEDGE VILLAGE*::GUDLAVALLERU**



DEPARTMENT

OF

CIVIL ENGINEERING

APPLIED MECHANICS LAB

APPLIED MECHANICS LABORATORY

Name : ………………………………………………………………..

Regd. No :………………………………………………………………

Year & Semester: …………………………………………………………..

Academic Year : ………………………………………………………….

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EXPERIMENT - 1

CALCULATION OF MOMENT OF A FORCE USING WEIGHT BALANCING TECHNIQUE

Aim:

Calculation of moment of a force by using balancing technique.

Apparatus Required:

1. Bell crank lever setup
2. Weighing pans
3. Weights
4. Measuring Tape
5. Pulleys and supporting stand
6. Set –square

Theory:

The moment of a force is a measure of its tendency to cause rotation of a body about a specific point or axis. This is different from the tendency of a body to translate in the direction of the force. In order for a moment to develop, the force must act up on the body in such a manner that the body would tend to rotate about a centre. A moment is due to a force acting that is not in the line of resultant. A couple is also moment due to two equal and opposite forces separated by a distance.

Moment is a vector quantity and conventionally anti clock – wise moments are taken as positive and clock – wise moments are taken as negative. The magnitude of the moment of force acting about a point or axis is directly proportional to the distance of the force from moment centre and the magnitude of the force. Moment is measured as the product of the force (F) and the arm length (d). Hence the unit is N.m. The moment arm or lever arm is the shortest (perpendicular) distance of the line of action of force from the centre of rotation.

$$M = d \times F$$

$$M = \text{Force (N)} \times \text{Arm Length (m)} \quad \text{N.m}$$

Procedure:

1. Measure the distance of bar perpendicular to the centre of edges.
2. Place the rigid beam on the knife edge such that it is horizontal.
3. Place a random weight in one of the pans (either left or right).
4. Place sufficient weights in the other pan till the balancing bar is horizontal.
5. Calculate the left and right (positive and negative) moments by multiplying weight with corresponding arm length.
6. Repeat the procedure with different weights at least three times.
7. The right side moment must be equal to the left side moment when the bar is horizontal.

S. No	Distance measured from one end (m)		Force (N)		Moment of a force (N-m)		Error in %
	Left	Right	Left	Right	Left	Right	
1							
2							
3							

Precaution:

1. Length of the bar must be measured carefully.
2. Weight should be handled very carefully.

Result:

The moment of force for the given system is calculated theoretically and compared with the practically observed values.

CALCULATION OF MOMENT OF A FORCE USING SYSTEM OF PULLEYS

AIM: -

To verify the law of moment by rotating disc apparatus.

APPARATUS REQUIRED:-

1. Mirror scale (adjustable)
2. No. of adjustable small pulleys is two
3. Moment disc with integrated holes (adjustable)
4. Four pans
5. Slotted weight
6. Plumb line

THEORY:-

The law of moment's states that if a number of coplanar forces acting on a rigid body keep it in equilibrium then the algebric sum of their moments about any point in their plan is zero.

In the moments disc apparatus, we use the hollow disc, pulleys, threaded pan, mirror scale, plumb line. All these things are adjustable. Due to use these apparatus make to ensure that the level of fixing threaded pan in a hollow disc should be equal. Requirement of plumb line to adjusting the apparatus at equal level in any positions.

The hollow disc & pulleys are moving either clockwise or anti-clockwise direction. All parts are adjusting on the straight beam which should be rigidly fixed on the base of the apparatus.

PROCEDURE:-

1. To find the nearest moment in disc and far distance moment in disc in this apparatus.

2. Firstly, rotating disc should be placed at a centre point note the thread are showed at zero on the scale and inserted all necessary pulleys and pans (as shown in fig.).
3. To initialize the apparatus, Put weights in the two far pans from centre plumb A & B. Such that $\mathbf{W_1}$ is the weight of the pan A and added weights in the pan.

4. Same do here as step 1, put weight in the pan B. Such that $\mathbf{W_2}$ weight of the pan B and added weights in the pan. Note down the total weights of $\mathbf{W_1}$ & $\mathbf{W_2}$.
5. Note down the distance $\mathbf{X_1}$ and $\mathbf{X_2}$.
6. Now ($\mathbf{W_1 * X_1}$) will be equal to ($\mathbf{W_2 * X_2}$) that is both the clockwise and anticlockwise and anticlockwise moments will be equal.
7. Take different sets of reading and find out the value of both the moments.
8. If both the moment is not equal then find out the percentage error between the clockwise moment and the anti-clockwise moment.

NOMENCLATURE:-

$\mathbf{W_1}$ = Weight in the pan A (far left from centre plumb)

$\mathbf{W_2}$ = Weight in the pan B (far right from centre plumb)

$\mathbf{W_A}$ = Total weight in the pan A

$\mathbf{W_B}$ = Total weight in the pan B

$\mathbf{X_1}$ = Distance from the centre point of the apparatus to the end of thread shadow show in the mirror scale of far pan A.

$\mathbf{X_2}$ = Distance from the centre point of the apparatus to the end of thread shadow show in the mirror scale of far pan B.

OBSERVATION TABLE:

S. No.	Weight of pan + Weight in pan (W_A)	Weight of pan + Weight in pan (W_B)	Distance from Centre to Pan A, X_1 (cm)	Distance from Centre to Pan B, X_2 (cm)	%age Error
1.					
2.					
3.					

(Note: Reading should be taken as higher grades to get better results)

PRECAUTIONS:-

1) Weights should be placed in the pans gently.

2) Reading should be noted in mirror only.

3) Additional weights and Pan Weights take simultaneously.

4) Distance should be noted down carefully form mirror.

5) Lubricate only necessary for hooks to tighten.

Result:

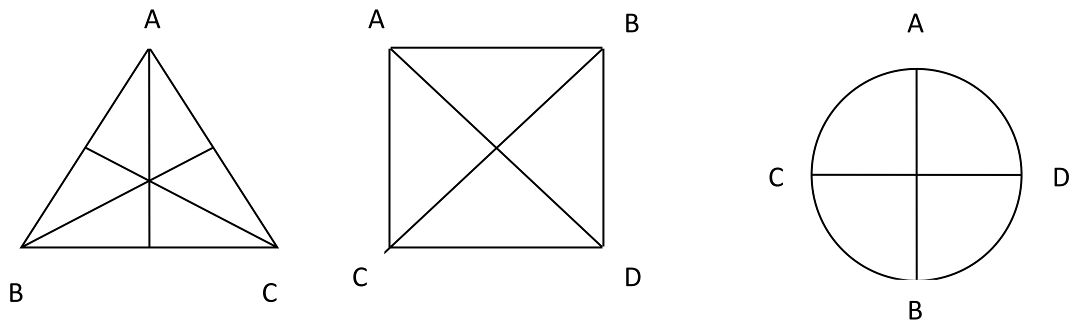
The moment of force for the given system is calculated theoretically and compared with the practically observed values.

EXPERIMENT - 2

CALCULATION OF CENTROID OF THE PLANE LAMINA

Aim:

To determine the centroid of regular and irregular plane lamina



Apparatus Required:

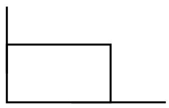
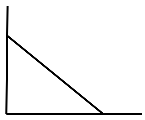
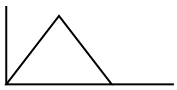
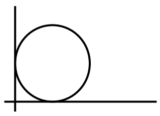
1. Supporting Stand
2. Square, triangular and Irregular Plane Laminas
3. Measuring Tape
4. Divider

Theory:

Centre of gravity is defined as an imaginary point at which the whole weight of the body (i.e., Resultant of all gravity force) is considered to be concentrated. But in case of areas (since area is a two dimensional fig) do not have weights. Gravity force is not to be considered, however, the point at which the whole area is considered to be concentrated is named as centroid, centre of gravity for masses and centroid for areas.

For regular bodies and areas, the centroid is at the geometric centre. However, for irregular areas, the centroid is to be determined experimentally or analytically. If an area has a line of symmetry, the centroid lies on the line of symmetry, but if an area has more than one line of symmetry, then the centroid lies on the point of intersection of those lines of symmetry.

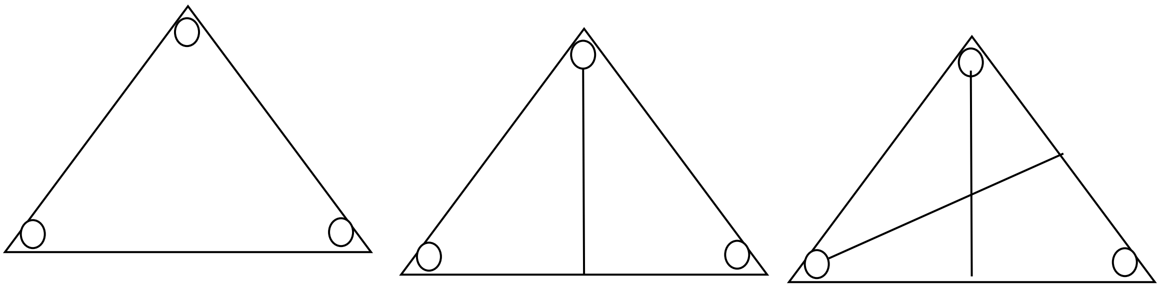
Centroids of different areas

Name of the section	Shape	Area	Centroidal coordinates	
			X	Y
Rectangle		bh	b/2	h/2
Right Angled Triangle		bh/2	b/3	h/3
Isosceles Triangle		bh/2	b/2	h/3
Circle		πr^2	r	r

Procedure:

The centroid of a uniform plane lamina, such as (a) below may be determined experimentally. By using a plumb and a pin to find the centroid. It is assumed that the thin body is of uniform density throughout the plate (lamina) is

1. Held by the pin inserted at a point near the body‘s perimeter as shown in the fig.
2. The plate hangs in such a way that it can freely rotate around the pin and the plumb line is dropped from the pin (b).
3. The position of the plumb line is traced on the body.
4. The experiment is repeated by hanging the plate from different points as shown in the fig and tracing the plumb line.
5. The experiment is repeated by hanging the plate from different points as shown in the fig and tracing the plumb line.
6. The intersection of at least two plumb lines is the centroid of the fig (c).



(a) (b) (c)

Observation Table:

S. No	Shape of the plane Lamina	Centroid				Error %	
		From Experiment		From formula			
		X_c	Y_c	X_c	Y_c	X_c	Y_c
1							
2							

Precaution:

1. Length of bar must be measured carefully.

Result:

The centroid of regular and irregular plane lamina has been found out for various reference points.

EXPERIMENT - 3

DETERMINATION OF AXIAL FORCE IN MEMBERS OF A LOADED TRUSS

Aim:

To find the axial force in all the members in a triangular truss and also to find out the type of force.

Apparatus Required:

1. Triangular truss
2. Weights Hangers
3. Weights
4. Measuring Tape
5. Divider for measuring angles

Theory:

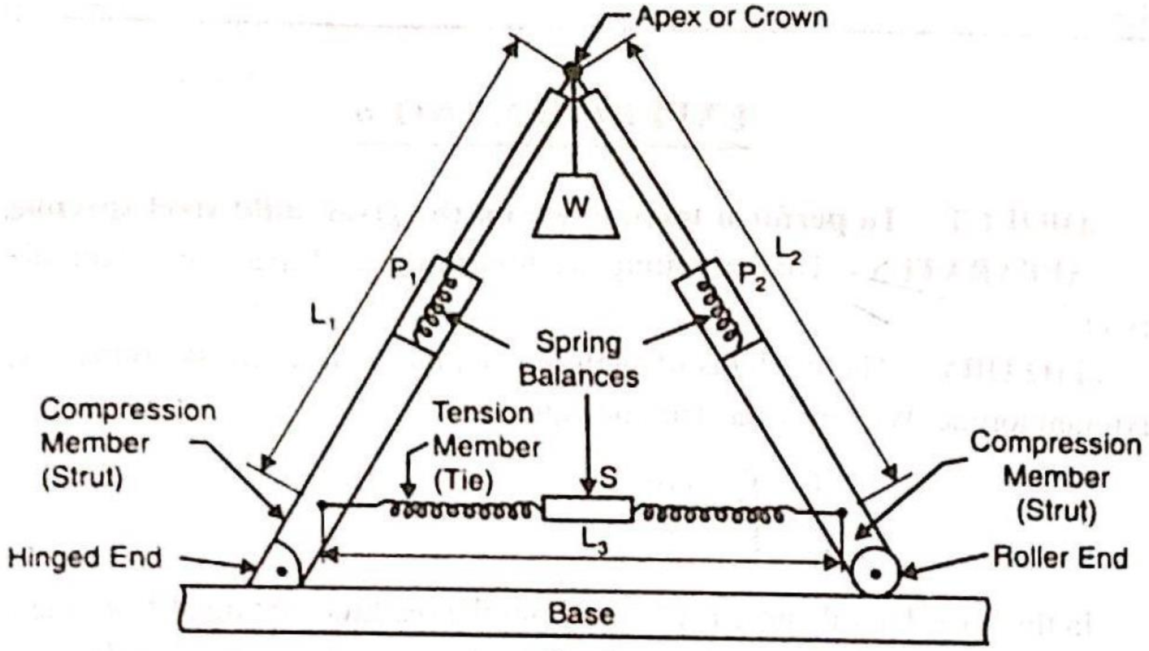
A truss is defined as a structure that is made of straight rigid bars joined together at their end by pins or riveting and subjected loads only at joints or nodal points. The assumptions made are

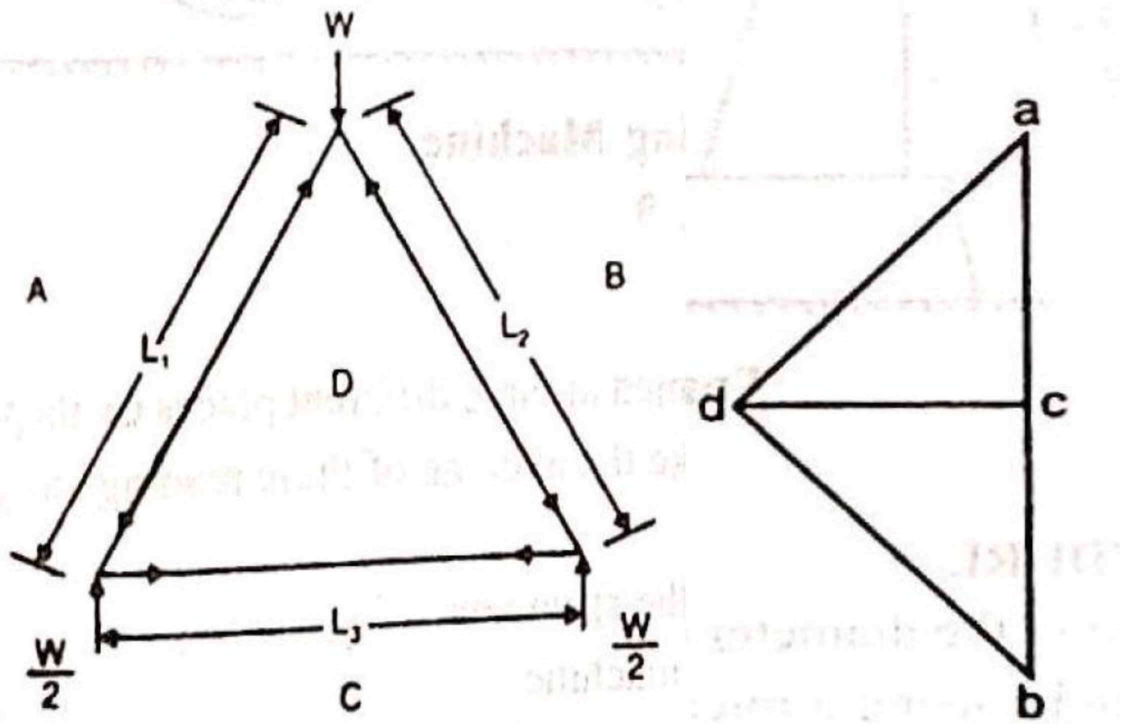
i) The truss is statically determine
ii) The loads are applied only at joints
iii) Members are two force members
iv) The weights of the members are negligibly small compared to the loads carrying by the whole truss

Procedure:

1. Note down the initial readings of spring balances P_1, P_2 and S
2. Place the load 'W' on the hook.
3. Note down the initial readings of spring balances P_1, P_2 and S again.
4. Difference between the initial and final readings gives the values of forces.
5. Note down the lengths of L_1, L_2 and L_3.
6. Repeat the experiment with different loads.
7. Determine the forces values by graphically.
8. Compare the two set of forces.

Diagram:





Space Diagram and Vector Diagram

Observations:

Initial reading of spring balance P_1 =

Initial reading of spring balance P_2 =

Initial reading of spring balance S =

S. No	Member	Spring balance readings		Force (N)
		Initial (I)	Final(F)	F - I
1	P_1	0		
2	P_2	0		
3	S	0		

Graphical Method:

P_1 = da = ……………… (Compression)

P_2 = db = ……………… (Compression)

S = cd = ……………… (Tension)

Result:

Forces in the members have been found and compared.

EXPERIMENT - 4

VERIFICATION OF LAMIE'S THEOREM

Aim:

Verification of lamie's theorem by finding magnitude of unknown weight.

Apparatus Required:

1. Weighing pans
2. Weights
3. Measuring Tape
4. Pulleys and supporting stand
5. Tri -square
6. Protractor

Theory:

Lamie's theorem is useful for finding resultant of two coplanar concurrent forces and three non-parallel concurrent forces are in equilibrium i.e., verification of theorem of three forces.

Triangle Law of Vector:

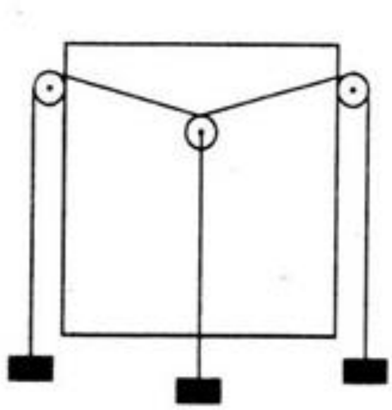
If two vectors can be represented both in magnitude and direction by the two sides of a triangle taken in same order, then their resultant is represented both in magnitude and direction by the third side of a triangle taken in positive direction. Suppose we have two vectors A and B then their resultant vector is the sum of these two.

$$R=A+B$$

Lamie's Theorem :

Lamie's Theorem is an equation relation the magnitude of three coplanar. Concurrent and non- collinear force. Which keep's an object in static equilibrium. Which the angles directly opposite to the corresponding forces. A.B.C

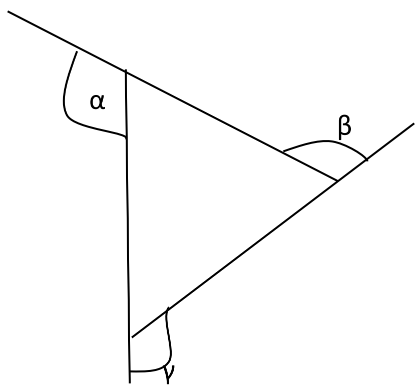
Where A, B and C are the magnitude s of three coplanar, concurrent and non – collinear forces, which keep the objection static equilibrium, and α, β, and γ are the angle directly opposite to the forces A,B and C respectively.



Lami’s theorem is applied in static analysis of mechanical and structural systems. The theorem named after Bernard Lamy.

Proof of lami’s Theorem :

Suppose there are three coplanar, concurrent and non-collinear forces. Which keeps the object static equilibrium. By the triangle law. We can re-construct the diagram as follow. By the law of sines.



Procedure:

1. Fix the sheet of paper on the board of pins after setting the board in a vertical plane.
2. Take a long thread and pass it over the two pulley fixed on the board, the ends of the thread are to be attached to the weights.
3. Take another thread and tie it to the middle of the previous thread. The end of this thread is also to be attached to the weights.
4. Attach different weights to the three ends of the thread such that the small Knot comes in the center of the paper. Note these weights.

5. Displace them from their position and note if they come to their original position and note they come to their original positional to ensure that the pulley have minimum friction.
6. Remove the sheet and produce these three lines to meet at a point o.
7. Place plain mirror below each string and mark two points of each thread. Measure the angle formed between the weights.
8. Calculate the angle caused by multiplying weight with corresponding arm length.
9. Repeat the procedure with different weights at least three times.
10. The right side moment must be equal to the left side moment when the bar is horizontal.

S.No	Weight A (N)	Weight B (N)	Unknown weight C (N)	Angle of Line of action of force			Magnitude of weight C (N)		Error in %
				A	B	C	Theorem	Experiment	
1			X						
2			X						
3			X						

Precaution:

1. Length of bar must be measured carefully.
2. Weight should be handled very carefully.

Result:

The magnitude of force for the given system is calculated theoretically and compared with practically observed values.

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EXPERIMENT - 5

ANALYSIS OF TRAPEZOIDAL TRUSSES FOR DIFFERENT LOADS

Aim:

To find the axial force in all the bars of the trapezoidal truss and to find out the type of force.

Apparatus Required:

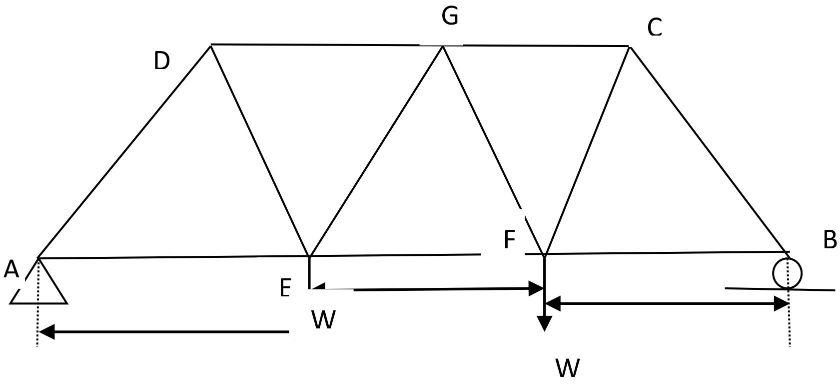
1. trapezoidal truss
2. Weights Hangers
3. Weights
4. Measuring Tape
5. Divider for measuring angles

Theory:

Truss is a structure which is having two or more bars in which loads are applied at the joints. Generally trusses are placed on the both sides of the bridges. The analysis of the trusses can be done in two ways by method of joints and method of section. In this experiment the analysis is done by the method of joints.

Procedure:

1. Measure the length of all members.
2. Calculate all the required angles.
3. Name all the joints.
4. Number all the members.
5. Check redundancy of the truss.
6. Assume tension in all the members.
7. Determination of all reaction forces.
8. Now start with a joint where there is at least one known force and not more than two unknown force.
9. Write down the ROUTE.
10. Proceed as per ROUTE to determine the axial force in all the members.



Results Table:

S.No	Magnitude of force	Nature of force

Precaution:

1. Length of bars must be measured carefully.
2. Angle of bar must be measured carefully.
3. Weight should be handled very carefully.

Result:

The analysis of the trapezoidal truss is done and type of force in each bar is stated in the tabular form.

EXPERIMENT - 6

UNDERSTANDING THE VECTOR AND VECTOR QUANTITIES

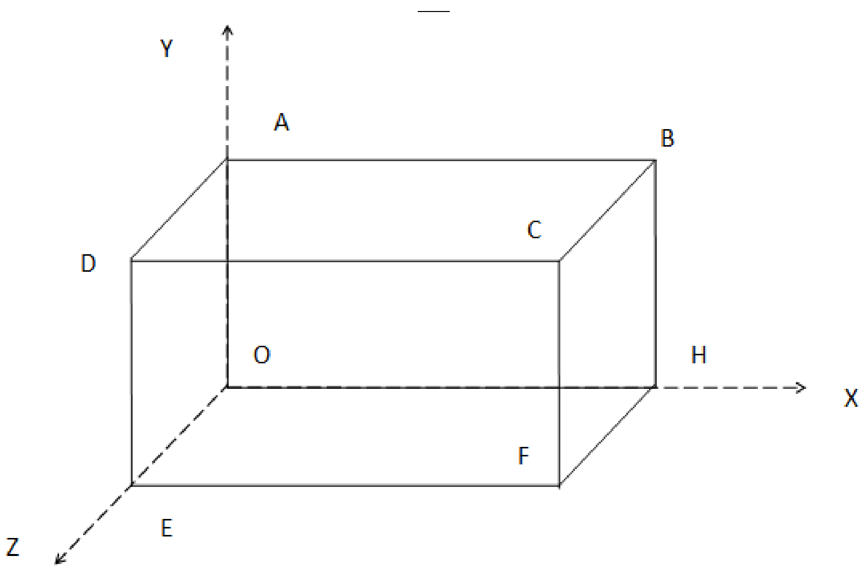
Aim:

To find out the length of the body diagonal of the cuboid by using application of spatial coordinate systems both theoretically and practically and compare them.

Apparatus Required:

1. Cuboid
2. Measuring tape

Diagram:



Procedure:

1. First measure the lengths of all side along x,y and z-axes of the cuboid.
2. To find out length of body diagonal OC initially write the vector of OE by measuring the length OA, OC and OD.
3. Treat O as origin and then the lengths OA. OD and OC respectively become the X,Y and Z coordinates of E.

4. Write the vector OE using the coordinates of O and BC the general from of vector OE is F=ai+bj+ck were a=OE, b=OD and c=OC
5. Magnitude of F is calculated which is equal to the length of the diagonal.
6. After finding the length of the diagonal. Now measure the length by using measuring tape and compare both measured length and calculated length.
7. In the same manner we can calculate all the diagonal lengths on all the faces.

Observation Table:

S.No	Section Name	Length of the Bar			Magnitude (mm)	
		X	Y	Z	Theoretical	practical
1						
2						
3						
4						
5						
6						

Precaution:

1. Length of bars must be measured carefully.
2. We should be carefully while writing vector equation.
3. We should be careful while writing co-ordinates of the cuboid.

Result:

The length of the diagonal of cuboid is found theoretically and compared practically.

EXPERIMENT - 7

DETERMINATION OF ANGLE OF DEFLECTION OF T – BAR DUE TO ECCENTRIC LOADING

Aim:

To find the angle of deflection of a T shaped bar from the vertical theoretically when a weight is applied at one end of horizontal portion and comperes it with experimental value.

Apparatus Required:

1. T- shaped bar with weight balancing
2. Weighing pans
3. Weights
4. Measuring Tape
5. Protractor

Theory:

The moment of a force is a measure of its tendency to cause rotation of a body about a specific point or axis. This is different from the tendency of a body to translate in the direction of the force. In order for a moment to develop, the force must act up on the body in such a manner that the body would tend to rotate about a centre. A moment is due to a force acting that is not in the line of result ant. A couple is also moment due to two equal and opposite forces separated by a distance.

Moment is a vector quantity and conventionally anti clock – wise moments are taken as positive and clock – wise moments are taken as negative. The magnitude of the moment of force acting about a point or axis is directly proportional to the distance of the force from moment centre and the magnitude of the force. Moment is measured as the product of the force (F) and the moment arm (d). Hence the unit is N.m. The moment arm or lever arm is the shortest (perpendicular) distance of the line of action of force from the centre of rotation.

$$M = F \times D$$

M = Force (N) x Arm Length (m) N.m

Procedure:

1.Measure the length of each arm of the T – shaped rod.

2.Find the weight of each arm taking the linear density of round steel rod from the table.

3.Load the T – shaped bars horizontal end (eccentrically) with some know Weight.

4.Now the bar swings to one side such that vertical portion is no more Vertical.

5.Calculate the angle of tilt "α" using moment equation for equilibrium.

6.Measure the angle of tilt with a protractor and compare the experimental Value.

Observations:

Length of the rod S1 =

Length of the rod S2 =

Weight of the rod (W1) =

Weight of the rod (W2) =

S.NO	**Weight of Rod (N)**		**External weights (N)**		**Angle of rotation**		**Error**
	W1	W2	P1	Q1	Theoretical "α"	Ptactical "α" (by moment equation)	
1							
2							
3							

Precaution:

1 Length of bar must be measured carefully.
2 Weight should be placed very carefully.

Result:

The angle of moment of force for the given system is been calculated theoretically and compared with the practical observations.

EXPERIMENT-7

DETERMINE THE COEFFICIENT OF FRICTION FOR MOTION

Aim:

To determine the coefficient of friction between the plane and block

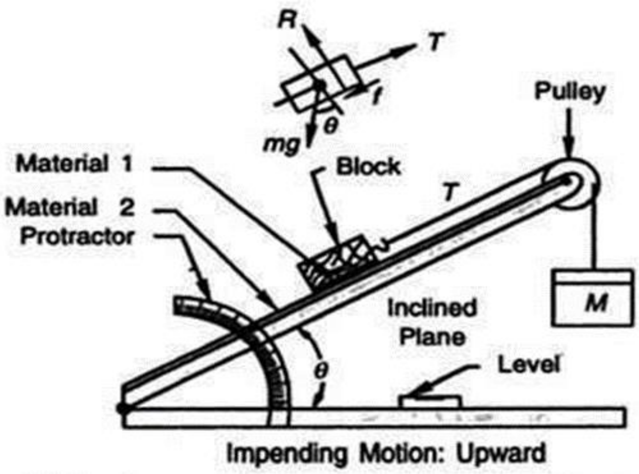
Apparatus:

1. Adjustable inclined plane
2. Block
3. Standard weights
4. Inextensible spring with pan

Theory:

Friction force is developed whenever there is a motion or tendency of motion of one body with respect to the other body involving rubbing of the surfaces of contact. Friction is therefore a resistance force to sliding between two bodies produced at the common surfaces of contact.

Friction occurs because no surface is perfectly smooth, however flat it may appear. On every surface there are microscopic hills and valleys (i.e., irregularities) and due to this the surfaces get interlocked making it difficult for one surface to slide over the other. During static state the friction force developed at the contact surface depends on the magnitude of the disturbing force. When the body is on the verge of motion the contact surface offers maximum frictional force called as 'Limiting Frictional Force'.



Procedure:

1. Set the apparatus at any desired angle.
2. Weigh the block then add some weight to it and record its mass.
3. Wipe the surfaces of the plank and block with a moist paper towel. Make sure both are free at dirt and grit.
4. Clamp the pulley at the end of the plank and place the plank at the edge of a lab table. Place the block on the far end of the plank and attach a length of string to it. Drape the string over the pulley and hang the mass hanger from its end. The string should be short enough so that the block can slide the length of the plank before the mass hanger hits the floor.
5. Determine what weight must be added to the hanger so that the system moves at constant speed.
6. Add a little mass to the hanger. Give the block a slight push to start it moving. If the block accelerates, take a little mass off and try again.
7. If the block moves the length of the plank at roughly the same speed, you have found the necessary mass.
8. Record the total hanging mass and its weight (P).
9. Record the total mass of and on the block and its weight (W).
10. Repeat the above process, adding 100 grams on top of the block for each new trial.

Observations:

S. No.	**Surfaces in contact**	**Inclination of pane (θ)**	**Load W (N)**	**Effort P (N)**	**Sin θ**	**Cos θ**	**Coefficient of Friction μ**	**Average μ**

Calculations:

Body just sliding down the inclined plane.

$\mu = W \sin \theta - P/(W \cos\theta)$

Body just sliding up the incline plane.

$\mu = P - W \sin \theta /(W \cos\theta)$

Precautions:

1. The reading must be note down carefully.
2. The load and effort should move slowly.
3. Effort must be applied gradually.
4. There should be no knot in the string.
5. The hanger should not move fast enough to bang the floor below.

Result:

The average value of the coefficient of friction for surface in contact is