



Malla Reddy Engineering College (Autonomous)



(An Autonomous institution, Autonomy granted by UGC and affiliated to JNTUH, Accredited by NAAC with 'A' Grade, Accredited by NBA (2008-11) & Recipient of World Bank Assistance under TEQIP phase – II S.C.1.1 for the period (2011-14))
Maisammaguda, Dhulapally (Post. Via. Kompally), Secunderabad – 500 100.



LAB MANUAL

ENGINEERING MECHANICS

I B. TECH- I SEMESTER

Subject Code: 80305

Academic Year 2018-19

Regulations: MR18

NAME: _____

USN : _____

BATCH: _____ **SECTION:** _____

2018-19 Onwards (MR-18)	MALLA REDDY ENGINEERING COLLEGE (Autonomous)	B.Tech. I Semester		
Code: 80305	ENGINEERING MECHANICS LAB	L	T	P
Credits: 1.5		-	-	3

Prerequisites: Engineering Physics

Course Objectives: Student will be able to learn and understand the various basic concept and principles of Mechanics like Force & Resultant.

List of Experiments

1. Triangle law and polygon law of forces apparatus.
2. Support reaction for a beam apparatus.
3. Coefficient of friction apparatus.
4. Flywheel apparatus.
5. Moment of disc apparatus.
6. Jib Crane
7. Equilibrium of non concurrent forces apparatus.
8. Universal force table.
9. Screw jack apparatus.
10. Compound pendulum.
11. Worm and worm wheel apparatus.
12. Differential wheel and axle apparatus.

Course outcome:

At the end of the course, students should be able to:

	Course Outcome	Level of learning	Bloom's Taxonomy Level
CO1	Verify law of Force Polygon and law of Moments using Force Polygon and bell crank lever apparatus and also study Parallel Force apparatus.(Simply supported type).	3	Analyzing
CO2	Determine mechanical advantage, Velocity ratio and efficiency of	2	Analyzing

	a screw jack.		
CO3	Evaluate co-efficient of friction between trolley (slider) and an inclined plane.	3	Analyzing
CO4	Verify the error percentage for the universal force table.	3	Analyzing
CO5	Determine the moment of inertia of the fly wheel.	2	Analyzing

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Sl. No	Name of the Experiments	Dates			Manual Marks	Record Marks	Signature(Student)	Signature(Faculty)
		Conduction	Repetition	Submission of Record				
Average								

Note: If the student fails to attend the regular lab, the experiment has to be completed in the same week. Then the manual/observation and record will be evaluated for 50% of maximum marks.

General Instructions to Students

- Students are informed to present 5 min before the commencement of lab.
- Students must enter their name in daily book before entering into lab.
- Students must leave Foot wares before entering lab.
- Students must not carry any valuable things inside the lab.
- Students must inform lab assistant before He/She uses any computer.
- Do not touch anything with which you are not completely familiar. Carelessness may not only break the valuable equipment in the lab but may also cause serious injury to you and others in the lab.
- For any software/hardware/ Electrical failure of computer during working, report it immediately to your supervisor. Never try to fix the problem yourself because you could further damage the equipment and harm yourself and others in the lab.
- Students must submit Record book for evaluation before the commencement of lab.
- Students must keep observation book (if necessary).
- Students must keep silent near lab premises.
- Students are informed to follow safety rules.
- Students must obey lab rules and regulations.
- Students must maintain discipline in lab.
- Do not crowd around the computers and run inside the laboratory.
- Please follow instructions precisely as instructed by your supervisor. Do not start the experiment unless your setup is verified & approved by your supervisor.

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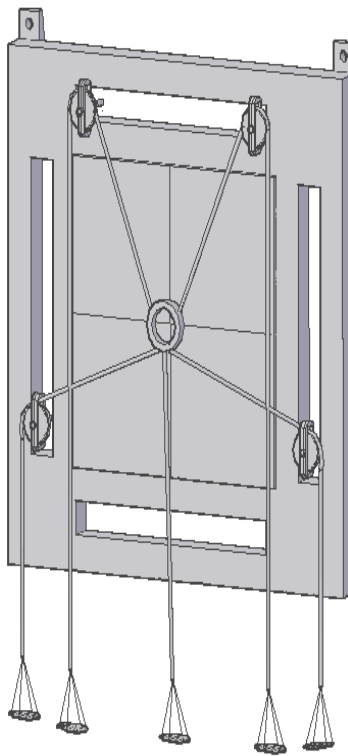
Title

1. Triangle law and polygon law of forces apparatus.
2. Support reaction for a beam apparatus.
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Polygon Law of Forces

ENGINEERING MECHANICS LAB

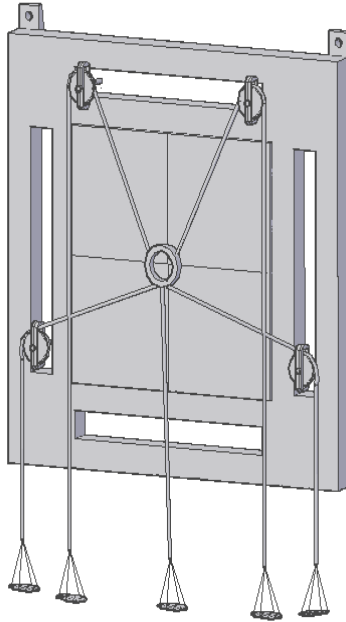
I SEM



Instruction Manual

Aim :-

To verify the polygon law of forces.



Apparatus :-

1. Gravesand's Apparatus,
2. Paper Sheet,
3. Weight Box,
4. Thread,
5. Drawing pins & Pencil,
6. Mirror Strip Pins.

Theory :-

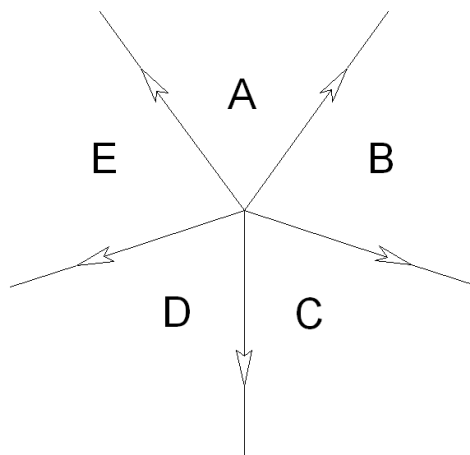
“**Polygon law of apparatus**” states that if a number of forces acting on a particle are represented in magnitude & direction by sides of a polygon taken in *same orde*, then their resultant is represented in magnitude and direction by the closing side of the polygon taken in the opposite direction.

S. NO.	FORCES (total weights of pans)	CALCULATED RESULTANT T_1	PERCENTAGE ERROR $\frac{T - T_1}{100} \times 1000$
--------	------------------------------------	-------------------------------	---

Procedure :-

1. Set the board in a vertical plane & fix the paper sheet with drawing pins
2. Pass a thread over two pulleys
3. Take a second thread & tie the middle of this thread to the middle of first thread
4. Pass the ends of second thread over the other set of two pulleys
5. Take a third thread & tie its one end to the point of first two threads
6. Attach pans to the free ends of the threads
7. Place the weights in the pans in such a manner that the knot comes approximately in the centre of the paper.
8. Mark the line of forces & write down the magnitude of forces
9. Remove the paper from the board & produce the line to meet at centre point O
10. Select a suitable scale & draw the vector diagram by moving in one direction. draw a b parallel to A B & cut it equal to force P; draw b c parallel to B C & cut it equal to Q; draw c d parallel to C D & cut it equal to force R; draw d e parallel to D E & cut it equal to force S. vector a e will be the resultant force T_1 taken in the opposite direction & should be equal to force T which proves the law of polygon forces. If a e is not equal to T then percentage error is found as follows.

Observations :-



	P	Q	R	S	T		
1.							
2.							
3.							

Precautions :-

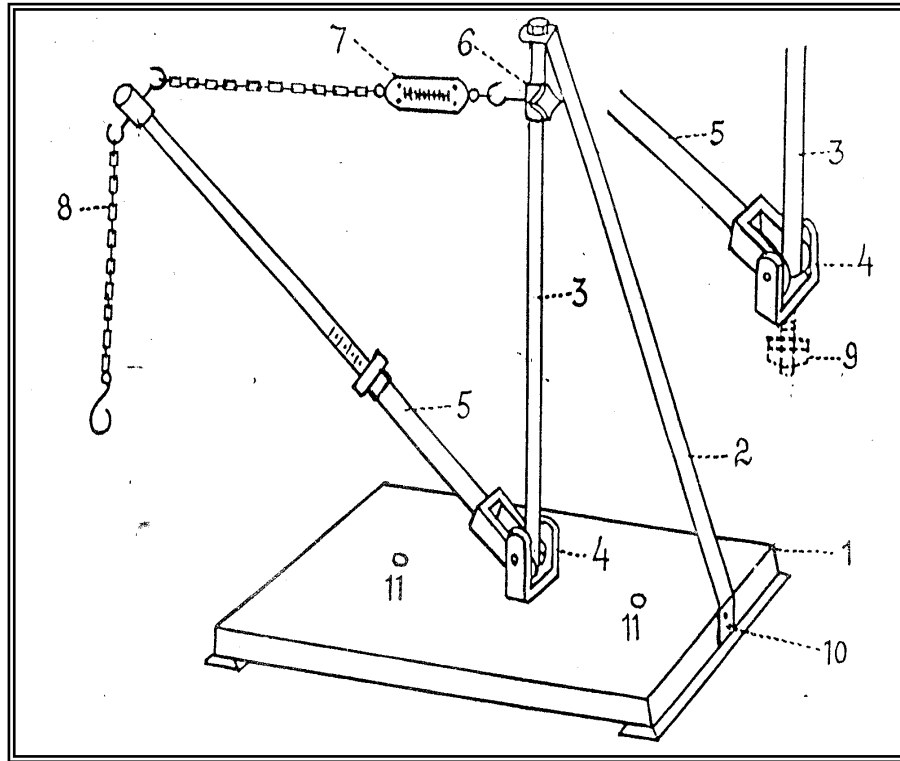
1. Pans/weights should not touch the board
2. There should be only one central knot on the thread which should be small
3. While calculating the total force in each case the weight of the pan should be added to the weight onto the pan
4. Make sure that all pans are at rest when the lines of action of force are marked
5. All the pulleys should be free from friction

JIB CRANE APPARATUS



I N S T R U C T I O N M A N U A L





Parts Details

1	Wooden Base	6	Sliding Hook Brackets
2	Iron Strip		Extinction Balance With
3	Upright Bar	7	Chain
4	Cast Aluminum Bracket	8	Hanging Chain With Hook
	Tie Bar With Compression	9	Nut & Washer
5	Balance		Screw For Fixing The Iron
		10	Strip

AIM : To calculate the stresses in various member of the jib crane and find the % age error between the calculated and the observed values.

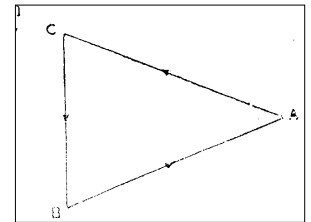
Things required ::

- Jib Crane Apparatus
- Weights

Procedure ::

1. Note the zero error in the compression balance and the spring balance.

2. Suspend a wt (w) from the pt. A. Then measure AB, BC, AC, Draw the scale. Note. B is center of the compression balance and C s vertically above B. Fig.



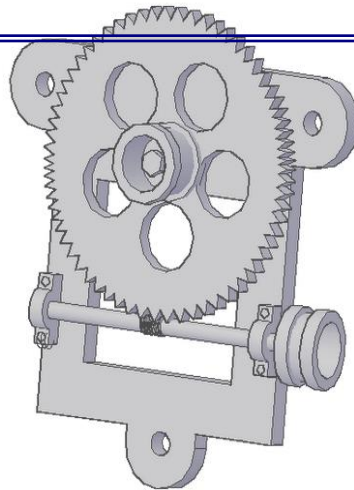
can serve as the vector or stress diagram also because it is a triangle (as any other triangle with sides parallel to it will be a similar triangle).

3. Let w be represented by CB. Then BA will be represent stress in the Arm AC (Tie). Thus these are the calculated values (Note, we can do without the scale diagram and simple measure AB, AC and BC)

4. Note the reading in the compression balance which will give the observed stress in the Arm AB, and tension in the spring balance given the observed force in the Arm AC. Find the %age error between the calculated and observed value.

5. We have to know whether arms AB and AC are in compression or in tension. Now the pt. A is in equilibrium acted upon by the forces exerted by arms AB AC and wt (w) as show in FIG 3. Lets first consider the nature of the force in the arm AB. The opposite force is exerted by the pt A on the member AB. As the member AB is in equilibrium another opposite force is exerted by the pt Bon the member AB. Thus AB is in compression. Similarly it can be show that the arm AC is in tension i.e. it is stretched.

SINGLE WORM WHEEL



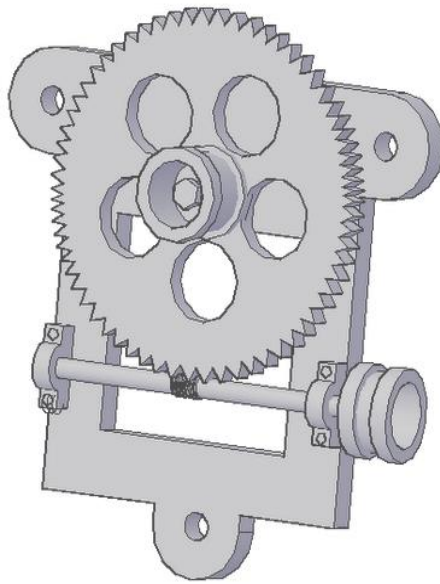
Working Manual

SINGLE WORM WHEEL APPARATUS

I N S T R U C T I O N M A N U A L

AIM:-

To determine the efficiency of a worm and worm wheel apparatus and plot a graph between W & P and W & η .



WORKING:-

As the pulley of the worm moves through n revolutions, n teeth of the wheel pass completely through the worm. If there are N teeth in the worm wheel, then N revolutions will have to be given to the pulley of the worm to rotate completely the worm wheel. So that if the effort applied at the pulley of the worm moves through N revolution the load is raised up by the a distance equal to the length of the circumference of the pulley of the worm wheel.

So that velocity ratio is

$$\frac{N \times \text{circumference of pulley of worm}}{\text{Circumference of pulley of worm wheel}}$$

SINGLE THREADED WORM :-

Specifications :

Starts : *Single*

Lead angle : $3^{\circ} 35'$

Pressure angle : 24°

Normal Axial Pitch : 8mm

Pitch of two continuous threads : 21.5mm

THEORY :-

If the worm is single threaded (i.e for one revolution of the wheel, the worm pushes the worm wheel through one teeth) then for one revolution of the effort pulley the distance moved by effort load = $2\pi l$

The load drum will move through $\frac{1}{T}$ revolution

Therefore, distance moved by the load on load drum = $\frac{2\pi r}{T}$

And velocity ratio(V.R) = **distance moved by P**
distance moved by W

$$V.R = \frac{2\pi l}{\frac{2\pi r}{T}} = \frac{lT}{r}$$

Mechanical advantage = $\frac{W}{P}$

Efficiency, $\eta = \frac{M.A}{V.R}$

PROCEDURE:-

1. Wrap the string round the pulley of the worm the free end of which is to be tied to the effort.
2. Wrap another string to carry the load round the pulley the worm wheel in such a manner that as the effort is applied the load is lifted up.
3. Suspend a small weight (w) through the free end of the second string and suspend another weight (p) through the free end of the first string which should just move the load upward.
4. Note w and P , so that mechanical advantage is given by $\frac{W}{P}$
5. Increase the load (w) gradually and increase the effort (p) correspondingly and take in this way about seven readings.
6. Measure the circumference of the pulley of the worm and also that of the worm wheel.
7. The percentage efficiency is given by $\frac{W}{PV} \times 100$
8. Plot a graph between w and p and w and.

OBSERVATION:-

1. Circumference of pulley of the worm ($2\pi R_1$) = 39.25 cm.

2. Circumference of pulley of the worm wheel ($2\pi R_2$) = 43.96 cm.

3. No of teeth in the worm wheel (N) = 120

4. Velocity ratio = $\frac{N \times 2\pi R_1}{2\pi R_2}$ = 107.14

OBSERVATION TABLE

S. No.	Weight Lifted (W)	Effort Applied (P)	Mech. Adv. = W/P	Velocity Ratio	% Efficiency W/PV x 100
1	2	180		107.14	
2	3	200		107.14	
3	4	250		107.14	
4	5	300		107.14	
5	6	350		107.14	

PRECAUTIONS:-

1. Lubricate the apparatus.
2. There should be no overlapping of the strings.
3. W should move slowly and in upward direction.
4. Effort should be applied carefully on sides of hangers.

BAR PENDULUM

INSTRUCTION MANUAL

Aim:

To determine:

- The acceleration g of gravity using a compound pendulum.
- The radius of gyration k_G of the compound pendulum about an axis perpendicular to the plane of oscillation and passing through its centre of mass.
- The moment of inertia I_G of the compound pendulum about an axis perpendicular to the plane of oscillation and passing through its centre of mass.

Apparatus:

- Bar Strip Length: 1 mtr
- Bracket Weight (Black colour): 600 gm
- Bar Pendulum Weight: 1.5 kg

- Width: 5 mm
- Thickness: 2.5 cm

Theory:

In Fig. 1, O is the point of suspension of the compound pendulum and G is its centre of mass; we consider the force of gravity to be acting at G. If h is the distance from O to G, the equation of motion of the compound pendulum is

$$I_O \ddot{\theta} = -Mgh \sin \theta$$

Where I_O is the moment of inertia of the compound pendulum about the point O.

Comparing to the equation of motion for a simple pendulum

$$Ml^2 \ddot{\theta} = -Mgl \sin \theta$$

We see that the two equations of motion are the same if we take

$$\frac{Mgh}{I_O} = \frac{g}{l} \quad (1)$$

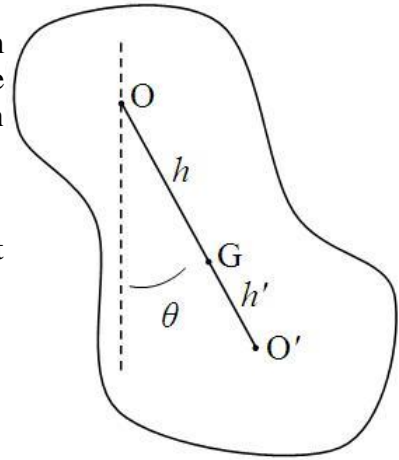


Figure 1

It is convenient to define the radius of gyration k_O of the compound pendulum such that if all the mass M were at a distance k_O from O,

the moment of inertia about O would be I_O , which we do by writing $I_O = Mk_O^2$

Substituting this into (1) gives us

$$k_O^2 = hl \quad (2)$$

The point O', a distance l from O along a line through G, is called the center of oscillation. Let h' be the distance from G to O', so that $l = h + h'$. Substituting this into (2), we have

$$k_O^2 = hl = h^2 + hh' \quad (3)$$

If I_G is the moment of inertia of the compound pendulum about its centre of mass, we can also define the radius of gyration k_G about the centre of mass by writing $I_G = Mk_G^2$.

The parallel axis theorem gives us

$$k_O^2 = h^2 + k_G^2$$

Comparing to (3), we have,

$$k_G = \sqrt{hh'} \quad (4)$$

If we switch h with h' , equation (4) doesn't change, so we could have derived it by suspending the pendulum from O'. In that case, the center of oscillation would be at O and the equivalent simple pendulum would have the same length l . Therefore the period would be the same as when suspended from O. Thus if we know the location of G, by measuring the period T with suspension at O and at various points along the extended line from O to G, we can find O' and thus h' .

Then using equation (4), we can calculate k_G and $I_G = Mk_G^2$.

Knowing h' gives us $l = h + h'$, and since for small angle oscillations the period

$$T = 2\pi \sqrt{\frac{l}{g}}$$

We can calculate g using

$$g = \frac{4\pi^2 l}{T^2}$$

The minimum period T_{\min} , corresponds to the minimum value of l . Recall that $l = h + h'$ and that $k_G = hh'$ is a constant, depending only on the physical characteristics of the pendulum.

Thus, $l = h + k_G^2/h$, and the minimum l occurs when,

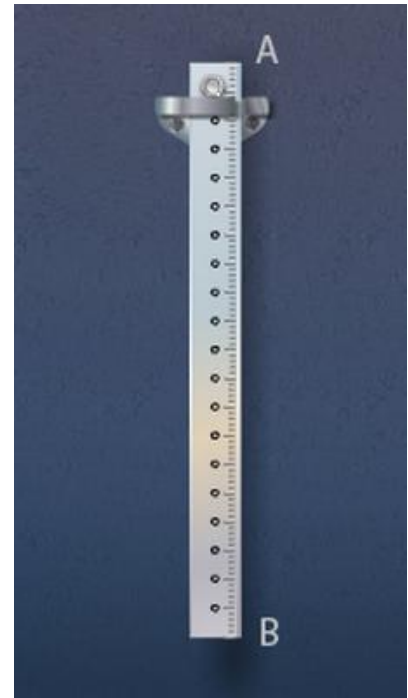
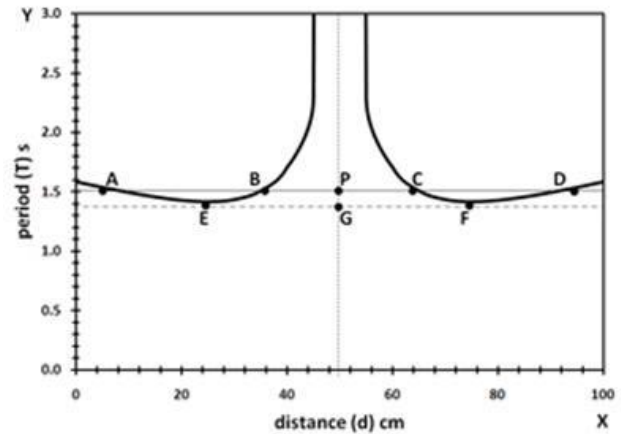
$$\frac{\partial l}{\partial h} = 1 - k_G^2/h^2 = 0$$

i.e, when $h^2 = k_G^2$, $h = h'$ and $l = 2h = 2k_G$.

Thus, at T_{\min} , $l = 2k_G$.

Performing the real lab:

- The compound bar pendulum AB is suspended by passing a knife edge through the first hole at the end A. The pendulum is pulled aside through a small angle and released, whereupon it oscillates in a vertical plane with a small amplitude. The time for 10 oscillations is measured. From this the period T of oscillation of the pendulum is determined.
- In a similar manner, periods of oscillation are determined by suspending the pendulum through the remaining holes on the same side of the centre of mass G of the bar. The bar is then inverted and periods of oscillation are determined by suspending the pendulum through all the holes on the opposite side of G. The distances d of the top edges of different holes from the end A of the bar are measured for each hole. The position of the centre of mass of the bar is found by balancing the bar horizontally on a knife edge. The mass M of the pendulum is determined by weighing the bar with an accurate scale or balance.
- A graph is drawn with the distance d of the various holes from the end A along the X-axis and the period T of the pendulum at these holes along the Y-axis. The graph has two branches, which are symmetrical about G. To determine the length of the equivalent simple pendulum corresponding



to any period, a straight line is drawn parallel to the X- axis from a given period T on the Y- axis, cutting the graph at four points A, B, C, D. The distances AC and BD, determined from the graph, are equal to the corresponding length l . The average length $l = (AC+BD)/2$ and l/T^2 are calculated. In a similar way, l/T^2 is calculated for different periods by drawing lines parallel to the X-axis from the corresponding values of T along the Y- axis. l/T^2 should be constant over all periods T , so the average over all suspension points is taken. Finally, the acceleration due to gravity is calculated from the equation $g = 4\pi^2(l/T^2)$.

- T_{\min} is where the tangent EF to the two branches of the graph crosses the Y-axis. At T_{\min} , the distance $EF = l = 2k_G$ can be determined, which gives us k_G , the radius of gyration of the pendulum about its centre of mass, and one more value of g , from $g = 4\pi^2(2k_G/T_{\min}^2)$.
- k_G can also be determined as follows. A line is drawn parallel to the Y -axis from the point G corresponding to the centre of mass on the X-axis, crossing the line ABCD at P. The distances $AP = PD = AD/2 = h$ and $BP = PC = BC/2 = h'$ are obtained from the graph. The radius of gyration k_G about the centre of mass of the bar is then determined by equation (4). The average value of k_G over the different measured periods T is taken, and the moment of inertia of the bar about a perpendicular axis through its centre of mass is calculated using the equation $I_G = Mk_G^2$.

Performing The Simulation:

- Suspend the pendulum in the first hole by choosing the length 5 cm on the **length** slider.
- Click on the lower end of the pendulum, drag it to one side through a small angle and release it. The pendulum will begin to oscillate from side to side.
- Repeat the process by suspending the pendulum from the remaining holes by choosing the corresponding lengths on the length slider.
- Draw a graph by plotting distance d along the X-axis and time period T along the Y-axis. (A spreadsheet like Excel can be very helpful here.)
- Calculate the average value of l/T^2 for the various choices of T , and then calculate g as in step 2 above.
- Determine k_G and I_G as outlined in steps 3 and 4 above.
- Repeat the experiment in different gravitational environments by selecting an environment from the drop-down **environment** menu. If the pendulum has been oscillating, press the **Stop** button to activate the environment menu.

Observations:

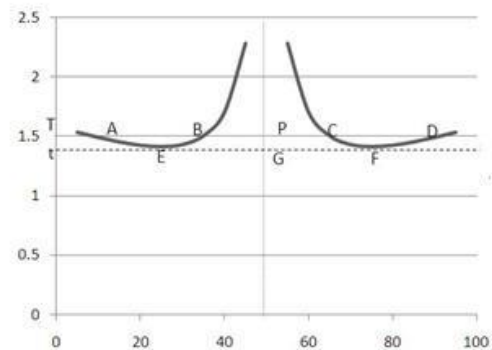
To draw graph:

No. of holes from A	Distance of knife edge from A: (cm)	Time for 10 oscillations (s)			Time period T (s)
		1	2	Mean (s)	



1. To find the value of 'g' :

SI.No	Length of equivalent simple pendulum(cm)			Time period, T (s)	g (cm/s ²)
	AC (cm)	BD (cm)	Mean l		



2. To find the radius of gyration and the acceleration of gravity (step 3 above):

- Radius of gyration about the centre of mass $k_G = EF/2 = \dots\dots\dots$
- Acceleration of gravity, $g = 4\pi^2(2k_G/T_{\min}^2) = \dots\dots\dots$

3. To find the radius of gyration (step 4 above):

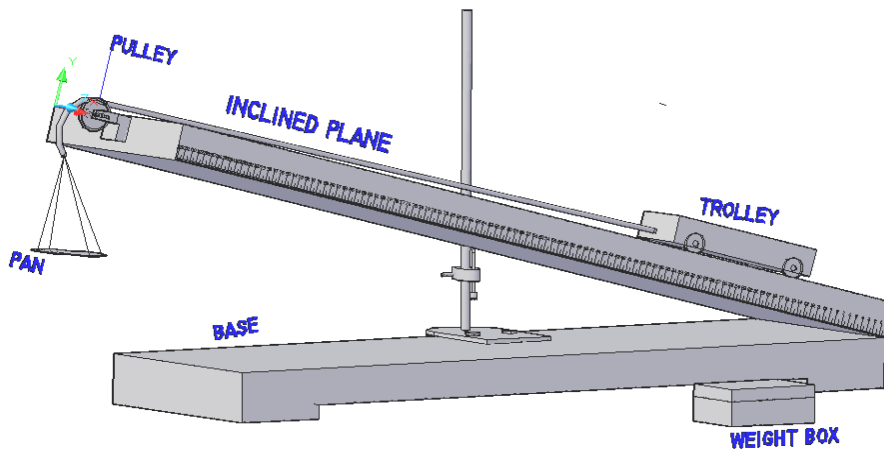
SI.No	$h=AD/2$	$h'=BC/2$	$k_G=(hh')^{1/2}$

Results:

- Average acceleration of gravity, $g= 4\pi^2(l/T^2) = \dots\dots\dots$ m/s²
- Average radius of gyration of the pendulum about its centre of mass, $k_G = \dots\dots\dots$ m
- Mass of the pendulum $M = \dots\dots\dots$ Kg
- Moment of inertia of the pendulum about its centre of mass, $I_G=Mk_G^2 = \dots\dots\dots$ Kgm²

COMBINED INCLINED PLANE & FRICTION SLIDE

APPARATUS



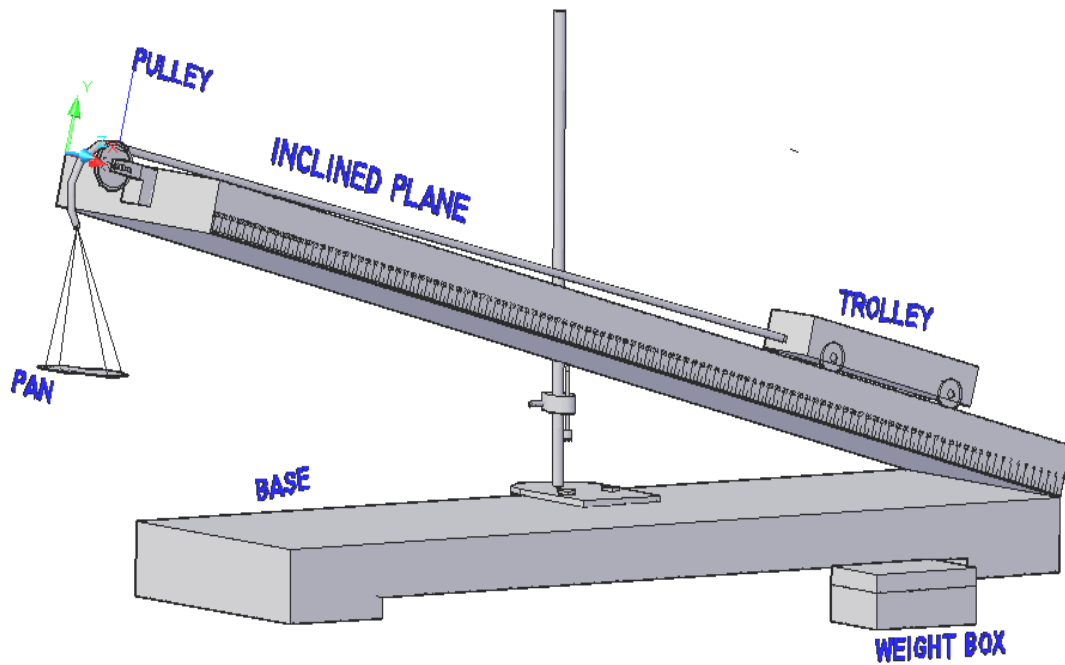
Working Manual

COMBINED INCLINED PLANE & FRICTION SLIDE APPARATUS

S T R U C T I O N M A N U A L

AIM:-

Determination of Coefficient of friction by the inclined plane apparatus.



APPARATUS:-

1. Inclined plane
2. Sliding boxes with different surfaces
3. String
4. Pan
5. Thread

THEORY:-

When a body slides upon another body, the property by virtue of which the motion of one relative to the other is related is called friction. The frictional force is directly proportional to the normal reaction '**N**'.

$$F \propto N$$

$$\mathbf{F = \mu N \quad or \quad \mu = \frac{F}{N}}$$

Suppose a body of weight W is to be lifted by inclined plane & this requires effort P . when this load just move upward a frictional force F acts downward which oppose its motion.

Component of load W parallel to the plane = $W \sin\alpha$

Component of load W perpendicular to the plane = $W \cos\alpha$

Considering equilibrium parallel to the plane

$$\mathbf{P = F + W \sin\alpha}$$

$$\mathbf{F = P - W \sin\alpha} \quad \text{.....(i)}$$

Considering equilibrium perpendicular to the plane

$$\mathbf{N = W \cos\alpha} \quad \text{.....(ii)}$$

From (i) & (ii)

Co – efficient of friction,

$$\mu = \frac{F}{N} = \frac{P - W \sin\alpha}{W \cos\alpha}$$

$$\text{Mechanical advantage (M.A.)} = \frac{W}{P}$$

$$\text{Velocity ratio (V.R.)} = \frac{\text{distance moved by effort}}{\text{Distance moved by load}}$$

Let effort P comes down through one centimeter, movement of the load along the plane = **1 cm**

$$\text{Vertical uplift of load} = 1 \times \sin\alpha$$

$$\text{V.R.} = \frac{1}{1 \times \sin\alpha} = \text{cosec}\alpha$$

$$\% \text{ efficiency} = \frac{\text{M.A.}}{\text{V.R.}} \times 100$$

PROCEDURE:-

- 1. Take the inclined plane apparatus & keep it first horizontal and put the slider on it.**
- 2. Increase the inclination of inclined board gradually till the slider just begins to slide downwards on it.**
- 3. Note the angle in this position. This is called angle of repose.**
- 4. Place the slider on the plane with the desired angle α .**
- 5. Tie the slider to the pan with the help of thread passing over the pulley.**
- 6. Put the weight in the pan till the slider just start moving. note down the weight.**
- 7. Measure the angle of inclination from the scale provided & finds the value of μ .**
- 8. Calculate M.A., V.R., efficiency.**

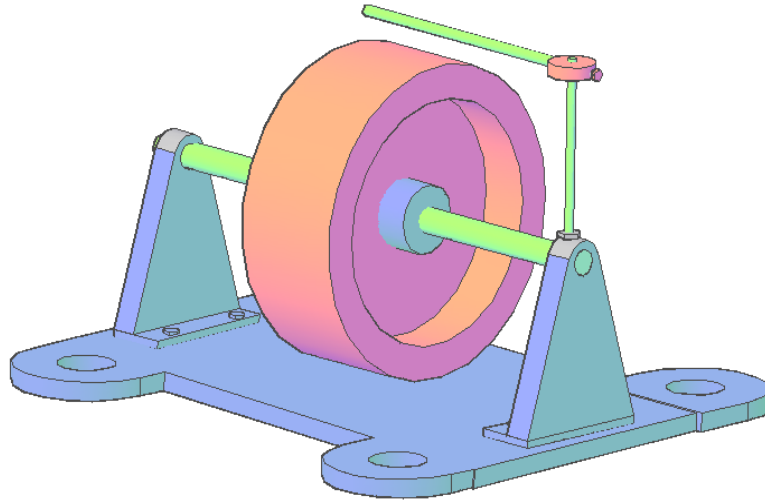
OBSERVATIONS:-

S. No.	Total weight of the slider W (grams)	Weight of pan + weight in the pan P (grams)	$\mu = \frac{P - W \sin\alpha}{W \cos\alpha}$	M.A. = $\frac{W}{P}$	V.R. = cosecα	% Efficiency
1.	125	40	0.15	3.125	5.75	54.34
2.	125	65	0.35	1.92	5.75	33.39
3.	125	115	7.65	1.08	5.75	18.72
4.	150	80	0.37	1.87	5.75	32.6
5.	200	110	0.38	1.81	5.75	31.62
6.	150	67	0.28	2.23	5.75	38.93
7.	200	115	0.41	1.73	5.75	30.24
8.	350	155	0.27	2.25	5.75	39.27
9.	150	62	0.24	1.73	5.75	30.24

PRECAUTIONS:-

- 1.** The plane should be clean & smooth.
- 2.** The guide pulley should move freely. It should be lubricated to make it frictionless.
- 3.** Weight should be added gently in pan.
- 4.** The slider should just begin to move slowly, it should not move abruptly.
- 5.** The direction of thread should be parallel to the inclined plane.

MOMENT OF INERTIA OF FLYWHEEL



Working Manual

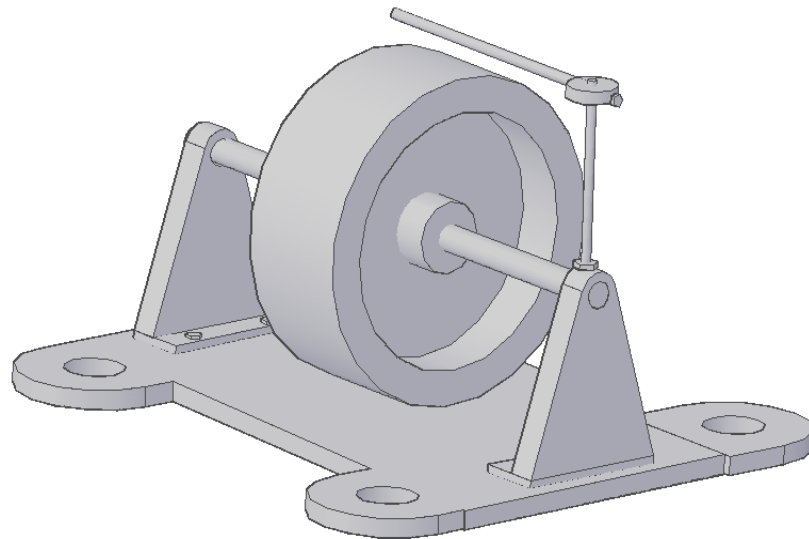
MOMENT OF INERTIA OF FLYWHEEL APPARATUS

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MOMENT OF INERTIA OF FLY WHEEL

I N S T R U C T I O N M A N U A L

AIM: - To find the moment of Inertia of a Fly Wheel.



APPARATUS USED:-

1. Fly wheel
2. Meter scale
3. Vernier calipers
4. Stop watch
5. Weight

DESCRIPTION OF APPARATUS:-

A flywheel is a large heavy wheel, through the center of which passes a long cylindrical axle. The center of gravity lies on its axis of rotation so that when it is mounted over ball bearing, it comes to rest any desired position.

To increase the moment of inertia, it is usually made thick at the rim.

To count the number of revolution made by the wheel, a lime is marked on the circumference. A string is wound on the axle, attached to the peg carries a mass M .

THEORY :

When a weight is suspended to the free end of a cotton string which is wrapped round tin: shaft and the other end of which is tied to the shaft and it is allowed to fall to touch the ground then P.E. energy possessed by the falling weight has partly been used to give motion to the fly wheel and partly used in overcoming frictional resistance present in the bearings.

1. Initial Potential Energy (P.E.) = $W \times h$ when h is the height of the weight from the level ground.
2. Initial Kinetic energy (K.E.) = 0. Final P.E = 0.
3. Final (K.E) = $\frac{1}{2} (w/g) v^2 + \frac{1}{2} I (w^2 / g)$ where $\frac{1}{2} (w/g) v^2$ is the K. E of the falling wt. And $\frac{1}{2} I (w^2/g)$ is the K. E. of the fly wheel and shaft combined and w is the final angular velocity of the wheel or of the shaft.
4. Work done due to frictional resistance = $F \times h$ where F is the force of friction acting tangentially to the shaft.

From law of conservation of Energy we can write

$$W \times h = \frac{1}{2} (w/g) v^2 + \frac{1}{2} I (w^2 / g) + F \times h$$

$$\Rightarrow 2g(W - F) \times h = W v^2 + I v^2$$

$$\Rightarrow I = \frac{(W - F) \times 2gh - W v^2}{w^2}$$

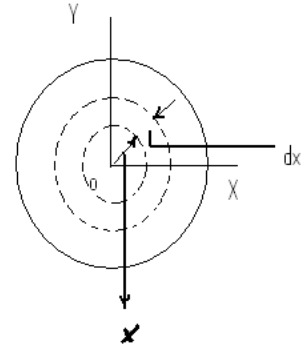
But v (final velocity) is given by the formula $(u+v)/2 = h/t$ where t is the time taken for the weight to fall a distance h so that h/t is the average velocity.

PROCEDURE:-

1. Attach a mass M (about 500 grams) to one end of the thin thread and loop is made at the other end which is fastened at the peg.
2. The thread is wrapped evenly round the axle of wheel.
3. Allow the mass to descend slowly & count the number of revolutions N_1 during descent.

4. When the thread has unwound itself & detached from the axle after N_1 turns, start the stop watch. Count the number revolution before the flywheel comes to rest & stop the stop watch. Thus N_2 are known.

5. With the help of vernier calliper, measure the diameter at several point. Thus find R.



6. Repeat the experiment with three different masses.

7. Calculate the value of I using the given formula.

MATHEMATICAL CALCULATIONS :

Moment about axis ox,

Consider an elementary ring of radius 'x' and thickness dx

Moment of inertia of this elementary ring about axis OX

$$= \frac{\text{mass} \times (\text{radius})^2}{2}$$

$$= \frac{\pi r^2 dx}{2}$$

Taking mnt of inertia about OX ie integrating the above equation

$$I_{ox} = \frac{Mr^2}{2}$$

4

By symmetry $I_{oy} = \frac{M(r)^2}{4}$

Similarly for axis OZ

M.O.I = mass x (radius)²
 Taking mnt about OZ

$$I_{oz} = \frac{\pi r^4}{2}$$

$$= \frac{Mr^2}{2}$$

OBSERVATIONS:-

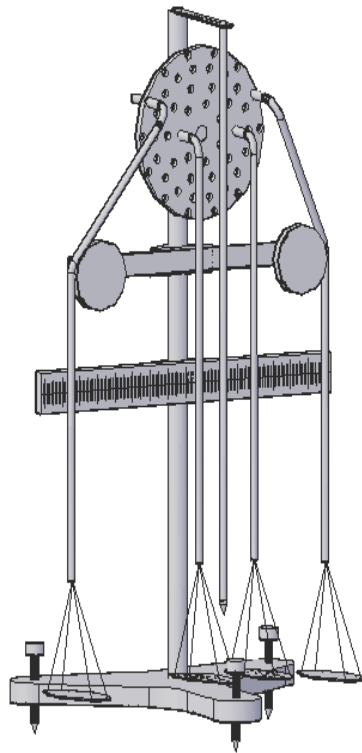
S.n	Total load applied M (k.g.)	No. of revolutions of flywheel before the mass deattached N ₁	No. of revolutions of flywheel to come to rest after mass deattached N ₂	Mean N ₂	Times of N ₂ revolution T seconds	Mean T sec.
1.	0.5	12	53 59 62	58	1.25 1.37 1.38	1.33
2.	1	12	107 120 121	116	2.05 2.12 2.23	2.13

3.	2	12	157 161 158	158	2.17 2.23 2.20	2.20
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PRECAUTIONS:-

1. Note the time accurately to the fraction of a second
2. Note the value of F when the motion just begins and the fly wheel does not move with any acceleration
3. Oil the bearings to reduce friction
4. Overlapping of the string should be avoided
5. Note the time thrice for the same weight (W)

MOMENTS DISC APPARATUS



Working Manual

MOMENTS DISC APPARATUS

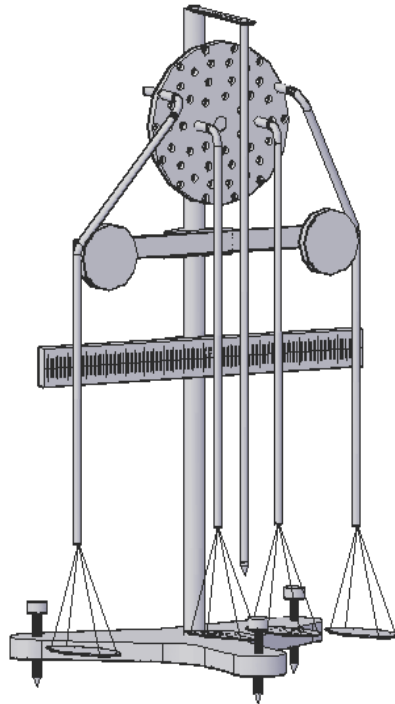
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MOMENTS DISC APPARATUS

I N S T R U C T I O N M A N U A L

AIM: -

To verify the law of moment by rotating disc apparatus.



APPARATUS REQUIRED:-

- 1. Mirror scale (adjustable)**
- 2. Two small pulley (adjustable)**
- 3. Hollow disc (adjustable)**

4. Four pans
5. Slotted weight
6. Plumb line

THEORY & FORMULA USED:-

The law of moment's states that if a number of coplanar forces acting on a rigid body keep it in equilibrium then the algebraic 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) Put weights in the two pans A and B. such that W^1 is the weights in the pan A plus weight of the pan & W^2 weight in the pan B plus weight of pan B. Note down W^1 & W^2 .
- (2) Rotating disc should be placed at a centre point note the thread are showed at zero on the scale
- (3) Note down the distance X^1 and X^2 .
- (4) Now ($W^1 \times X^1$) will be equal to ($W^2 \times X^2$) that is both the clockwise and anticlockwise and anticlockwise moments will be equal.
- (5) Take different sets of reading and find out the value of both the moments.

(6) If both the moment is not equal then find out the percentage error between the clockwise moment and the anti clockwise moment.

OBSERVATIONS:-

W^1 = weight in the pan A

W^2 = weight in the pan B

X^1 = distance from the centre point of the apparatus to the end of thread shadow show in the mirror scale of which pan A

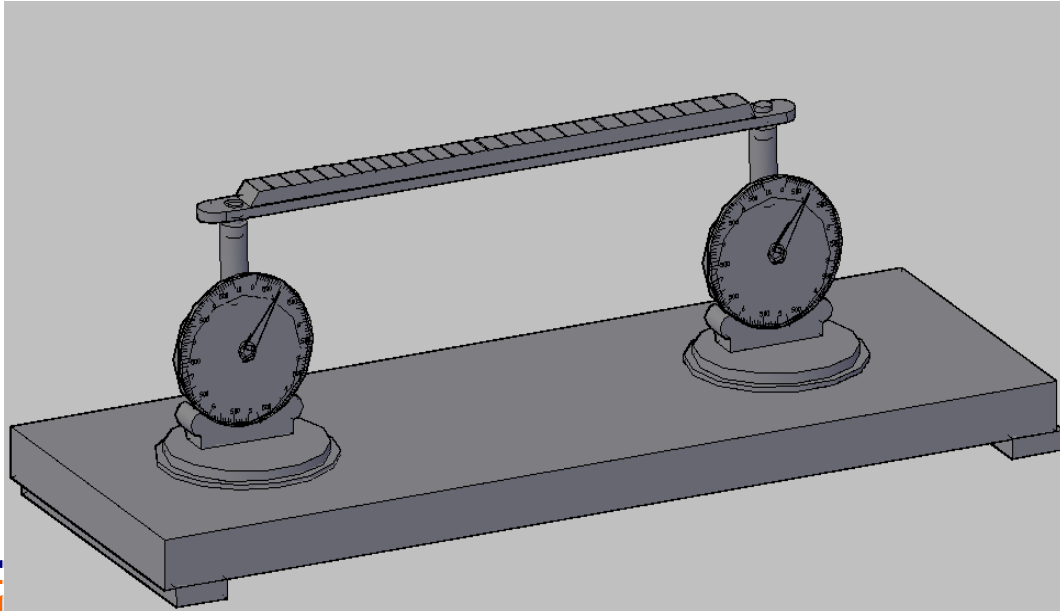
X^2 = distance from the centre point of the apparatus to the end of thread shadow show in the mirror scale of which pan B

S. No.	Weight of pan + Weight in pan (W^1)	Weight of pan + Weight in pan (W^2)	X^1 (c.m.)	X^2 (c.m.)	Percentage Error
1.	225	225	17	17	0
2.	225	225	17	16.6	0.4
3.	525	525	17	16.6	0.4

PRECAUTIONS:-

- (1) Weights should be placed in the pans A and B gently.
- (2) Take in to the account the weights of the pan.
- (3) Lubricate the apparatus.
- (4) Distance should be noted down carefully.

Parallel Force Apparatus



Working Manual

PARALLEL FORCES APPARATUS

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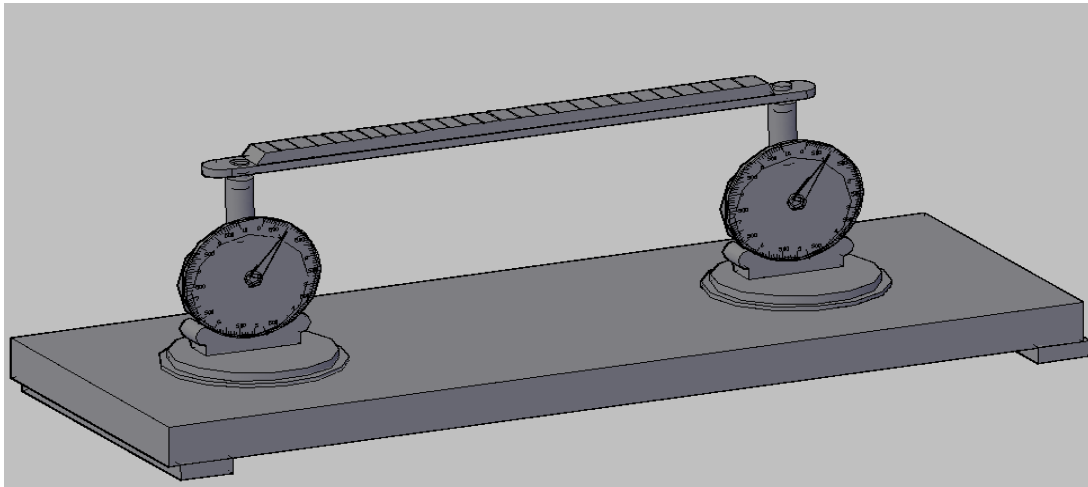
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Parallel Force Apparatus

I N S T R U C T I O N M A N U A L

AIM:

To verify the principle of forces in beam of Parallel Forces Apparatus with the help of beam supported at its ends.



Things required:

Parallel Forces Apparatus 10 Kg Dial Type, Conical Weights, and Aluminum hangers for hanging weights.

Appratus :

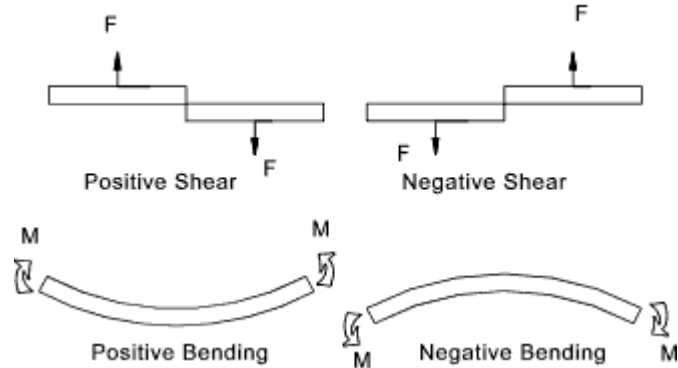
The apparatus comprising of two dial type weight gauges of 10 kg, one straight wooden beams of 150cm, a wooden platform for the support of the dial gauges, Two weight hangers for hanging the weights on the wooden beams, Two weights weighing 2 kg aggregate. The beam is provided with angular slots on them in order to place the hanger in it, the distance between each groove is 5cms. The weight of each hanger will be neglected.

The whole apparatus is well designed & painted.

Theory:

If a system of coplanar forces acting on a rigid body keep it in equilibrium then the algebraic sum of their moments about any point in their plane is zero. Normally a beam is analysed to obtain the maximum stress and this is compared to the material strength to determine the design safety margin. It is also normally required to calculate the deflection on the beam under the maximum expected load. The determination of the maximum stress results from producing the shear and bending moment diagrams.

The sign convention used for shear force diagrams and bending moments is only important in that it should be used consistently throughout a project. The sign convention used on this page is as below.



Nomenclature :

e = strain

σ = stress (N/m²)

E = Young's Modulus = σ / e (N/m²)

y = distance of surface from neutral surface (m).

R = Radius of neutral axis (m).

I = Moment of Inertia (m⁴ - more normally cm⁴)

Z = section modulus = I/y_{\max} (m³ - more normally cm³)

M = Moment (Nm)

w = Distributed load on beam (kg/m) or (N/m as force units)

W = total load on beam (kg) or (N as force units)

F = Concentrated force on beam (N)

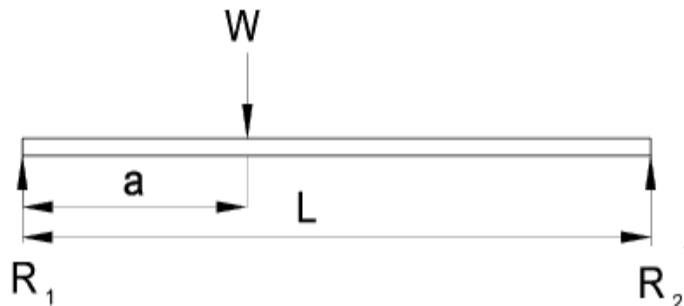
S = Shear Force on Section (N)

L = length of beam (m)

x = distance along beam (m)

Procedure:

1. First of all arrange the apparatus by placing the beams on the given dial gauges as shown in the figure. Note the zero error in the compression balances. When the beams are supported at it ends.
2. Suspend three different weights from the sliding hook against any division marked on the beam.
3. Note the reaction on the beam given by the readings of compression balances and takes into account the zero error from each reading.
4. Find the some of clockwise moment about the mid points of the beam and find also the sum of anti-clockwise moment about its each reading.
5. Find the % age error between clockwise and anti-clockwise moment.



- Suspend three or four weights at different graduated division of the beam and find %age error between clockwise and anti –clockwise moments as before.

Observations:

- Zero error in compression balance No. 1= -----
- Zero error in compression balance No. 2= -----

TABLE:

S.no	Weight W1	Weight W2	Reaction R1	Reaction R2	Reaction R3	Distance x1	Distance X2

Take in this manner about seven readings.

Precautions :

- Zero error of the compression balances must be taken in to account,
- Weights should not be put on the beam with a jerk.
- Slightly press h beam in to remove any frictional resistance at the supports before taking readings.

SCREW JACK APPARATUS



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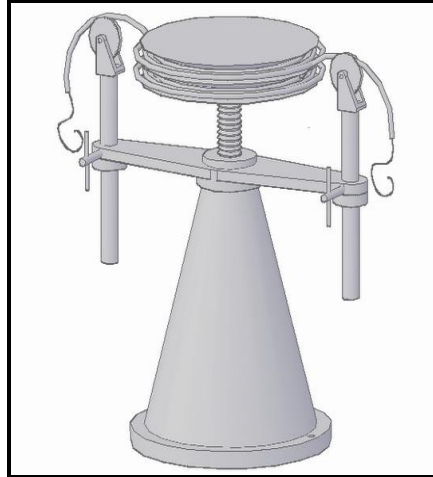
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Instruction Manual

SCREW JACK APPARATUS

AIM:-

- To determine the mechanical advantage, velocity ratio and efficiency of a screw jack.



ACCESSORIES REQUIRES:-

- ✓ Screw Jack
- ✓ Thread/Rope
- ✓ Load Weight (5kgs)
- ✓ Weight Set (50gms -2, 100gms-2)
- ✓ 1 measuring Ruler/Inch Tape

PRINCIPLE:

Basically screw jacks are mechanical devices consisting of a heavy bottom metallic base or stand through which a screw mechanism is allowed to slide up and down through a circular path over a central axis. The load that is to be lifted is placed over the top "head" of the screw mechanism. The lifting movement or operation is made functional by applying an external physical force (using human hands) through a radial motion. A careful inspection of the screw movement (unwinding) through a single thread shows that the elevating movement follows the principle of an inclined plane.

Primarily two major factors are involved with the functioning of a screw jack, viz. the *weight* lifted and the *effort* applied.

THEORY:-

Screw Jacks are devices used for raising and lowering heavy objects (weights) through external small manual labor. The article discusses the various calculations involved and explains the relation between weight which is to be lifted and the applied external force associated with these devices. Screw jacks were especially developed with the aim of solving the issue of raising and lowering large and heavy objects over ground levels easily through relatively smaller magnitudes of external effort. Screw jack works on the principle of screw & nut. It is used for raising heavy loads through small efforts.

A simple screw jack consists of a nut, a screw square threaded and a handle fitted to the head of the screw. The nut also forms the body of the jack. The load to be lifted is placed on the head of the screw. Here the axial distance between corresponding points on two consecutive threads is known as pitch. If 'p_s' be the pitch of the screw and 't' is the thickness of thread, then $p_s = 2t$.

PROCEDURE:-

Step 1 Wrap on string round of the flanged table and take it over a small pulley P₁. Effort load P₁ is tied to the free end of this string.

Step 2 Wrap another string around of the flanged table in the same direction in which the above string is wounded and take it over the other small pulley P₂.

Step 3 Place a load 'W' on the flanged table.

Step 4 Suspend weights over P₁ and P₂ to the free ends of both the strings coming over the two small pulleys. This load P₁ and P₂ should be increased gradually suitable to give a just upward motion to the load 'W' placed on the screw head.

Step 5 Note down 'W' and 'P' to determine the M.A. i.e W/P. in this case effort weight would be added and it consider as total effort P; P₁+P₂.

Step 6 Note down the distance fall down to lift the load l, measure by ruler.

Step 7 Note down the distance covered by flanged table from initial to final, measure by ruler.

Step 8 P₁ and P₂ should be noted down carefully.

Step 9 Take 3-4 reading by the variation of the Loads and Efforts.

FORMULA'S:

1. Circumference of the screw thread, $= \pi * D$
 $= 3.14 * 3.05$ $(\pi = 3.14, D = 3.05 \text{ cm})$
 $= 9.5$

2. Mechanical Advantage = Load/Total Effort

$$M.A = \frac{W}{P}$$

3. Velocity Ratio = Distance moved by the effort/Distance moved by the load

$$V.R = \frac{2\pi l}{R}$$

4. Efficiency:

$$\% \eta = \frac{M.A}{V.R} \times 100$$

NOMENCLATURE:

- ✓ D : Diameter of Screw
- ✓ p_s : Pitch of the screw
- ✓ W : Load suspended on flanged table
- ✓ P : Total Effort Applied
- ✓ P₁ : Weight suspended pulley 1
- ✓ P₂ : Weight suspended pulley 2
- ✓ l : Distance fall down to lift the load, i.e to turn the screw.
- ✓ R : Distance covered by flanged table in upward direction while weight suspended via pulleys (By Ruler)

OBSERVATIONS:-

- Diameter of the rotational centre screw, D = 30.5 mm = 3.05 cm
- Pitch of the center long screw, p_s = 2.5 mm = 0.25 cm
- Diameter of flanged table, = 205 mm = 20.5 cm
- Thickness of the flanged table = 41 mm = 4.1 cm
- No. of Pulley's, P₁, P₂ = 2
- Diameter of pulley = 52.5 mm = 5.25 cm
- Thickness of pulley = 10 mm = 1 cm
- Circumference of the flanged table = 9.5
- Load Lifted, W = Weight lifts
- Total Effort, (P₁ + P₂), P = Efforts applied

Note: Take P₁ & P₂ as per applicant need.

CALCULATIONS:-

- M.A. = W/P
- V.R. = Distance moved by effort/Distance moved by load
- Efficiency,% = (M.A./V.R) X 100

Observations							Calculations		
Sr. No.	Load Lifted, W, Gms	Effort P ₁	Effort P ₂	Total Effort P ₁ +P ₂	R mm	l mm	M.A.	V.R	Efficiency
1.									
2.									

RESULTS: -

PRECAUTIONS:-

5. There will be no overlapping of the strings.
6. "W" should moves upward direction gently.

7. Load always place on flanged table.
8. Effort should be applied carefully on both sides of hangers.
9. Both the pulleys are in parallel direction meanwhile performing.
10. Lubricate the screw thread in every 3-4 weeks
11. Grease should be used as lubricant always.

SAMPLE READINGS:

Observations							Calculations		
Sr. No.	Load Lifted, W, Gms	Effort P ₁	Effort P ₂	Total Effort P ₁ +P ₂	R mm	l mm	M.A.	V.R	Efficiency
1.	5000	400	300	700	10	120	5.55	75.3	9.4
2.	5500	550	850	1400	10	130	3.62	81.68	4.37

(All measurements constructed in shortest units)

RESULTS: The relationship between the efficiency and the load, the effort against the load as shows that increase in load causes decrease in efficiency and increase in load causes increase in effort applied.

UNIVERSAL FORCE TABLE



INSTRUCTION MANUAL

UNIVERSAL FORCE TABLE

AIM:-

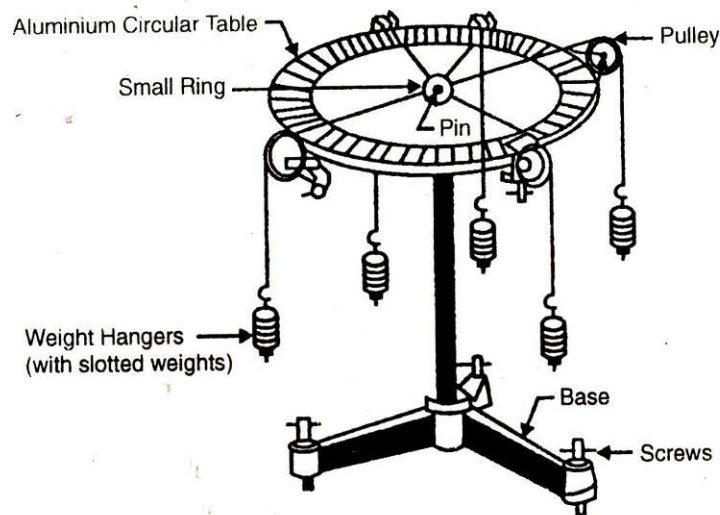
- To Verify The Universal Force Table.

APPARATUS – Universal force table apparatus complete with freely moving and **adjustable** guide pulleys (Fig. 1), a ring with five strings, weight hangers, weight etc.

COMPONENTS:-

- Thread Pulley
- Slotted Weight
- Thread/Rope
- Level Screw
- Central Ring

THEORY : Polygon law of forces states that if a number of coplaner forces acting on a particle are represented in magnitude and direction by the sides of a polygon taken in order, then their resultant is represented in magnitude and direction by the closing side of the polygen taken in order.



(FIG. 1 (f)) Universal Force Table

PROCEDURE (It can be done on Gravesand Apparatus also)

1. Clamp the pulleys to the graduated disc of the force table and make it horizontal by adjusting the screws at its base.
2. Tie each end of five strings to the circumference of a small ring and place it round the pin. Attach the other ends of the strings to the weight hangers, hanging over the pulley.
3. Put small weights on the weight hangers in such a manner that the ring is placed symmetrically round the axle and it does not touch the axle of the apparatus or the plane surface of the graduated disc.
4. Note the position of any one string on the disc and then find the angles between all the strings as $\theta_1, \theta_2, \theta_3, \theta_4$ and θ_5 .
5. Note down the magnitude of weights W_1, W_2, W_3, W_4 and W_5 acting on the ring.
6. Draw the space diagram of the forces $F_1 = W_1, F_2 = W_2, F_3 = W_3, F_4 = W_4$ and $F_5 = W_5$ as shown in Fig. 2 (a).
7. Draw the vector diagram abcde as shown in Fig. 2 (b). If the last force F_5 represented by the side ea falls short or is greater than the side which would complete the polygon, then measure the side which would complete the polygon and find the percentage error between the force F_5 and the force required to complete the polygon.

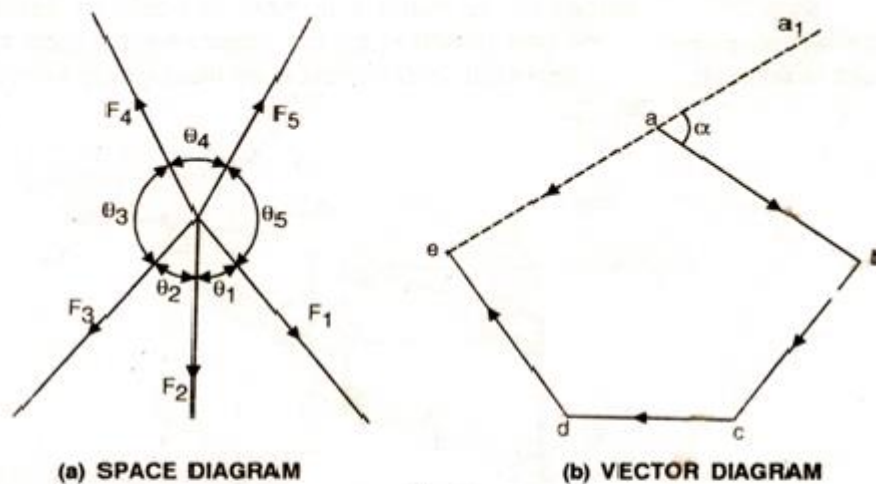


Fig. 2

8. Measure the angle $a'ab$ i.e. α which would be equal to θ_5 . If they are different, then find the percentage error between these angles taking any of them to be true angle.
9. Repeat the experiment with different set of weights.

PRECAUTIONS

1. The graduated disc should be made horizontal by adjusting the screws at its **base**. This can be checked with the help of a spirit level.
2. The ring should not touch the pin or the disc.
3. The pulleys should be frictionless i.e well lubricated.
4. The positions of the strings should be carefully noted only after the system **has come** to rest completely.

Observation Table:

Calculation Table:

Sr. No	Forces Or Weights Suspended (R1)					
	F=W1	F=W2	F=W3	F=W4	F=W5	F=W6
1	0	200	200	350	250	250

Sr. No	Angles(θ) And Distances Ring To Wheel (cm)										RESULTANT (R)
	θ_1	L1	θ_2	L2	θ_3	L3	θ_4	L4	θ_5	L5	PYTHA. THEROM
1	0	22.3	72	21	120	20.8	170	22.0	28.8	23.5	49.06

Sr. No.	(R1) AND (α)		Percentage Error In Resultant And Angles		TOTAL %ERROR IN
	F=SUM F	α	$A = \frac{R-F}{R} \times 100$	$B = \frac{\theta_5 - \alpha}{\theta_5} \times 100$	(B-A)
1	1.250 KG	72	97.45	75	22.45

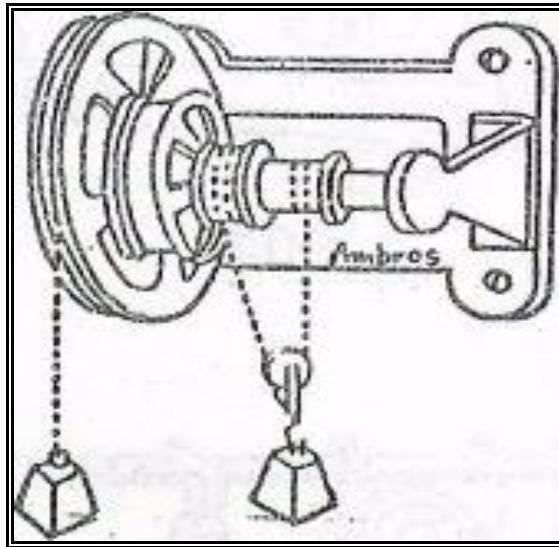
Differential Wheel And Axle Apparatus

INSTRUCTION MANUAL

Experiment: To determine the efficiency of a wheel and differential axle and to plot a graph between W and P and (w and n)

Things required:

1. Wheel & Differential Axle Apparatus
2. Weights
3. Cotton Thread



Theory:

When the wheel moves through n revolutions the bigger and smaller axles also move through “n” revolutions. But while the string carrying weight is wrapped round the bigger axle completely it is released completely from the smaller axle the same time if the radius of the bigger axle is r_1 and smaller axle is r_2 then the string of length nr ($2r_1$) is raised while a length nr ($2r_2$) is lowered so that weight (w) which is supported by two segments of string is raised through a distance $(2r_1 - 2r_2) \times n$: while distance moved by the effort is $2R \times n$

Velocity Ratio (v) is $\frac{2r \times n}{(2r_1 - 2r_2) \times n} = \frac{2(2r)}{(2r_1 - 2r_2)}$ in term of the circumferences

Procedure::

1. Wrap the string round the smaller and bigger axles in such a manner that as it is released from the smaller axle in such a manner that is it released from the

smaller axle it is wrapped round the bigger axle Tie another string round the wheel which will carry the effort applied.

2. Suspend a smaller weight (w) through the hook of a small pulley going in between the two segment of the string as show in the diagram.
3. Suspend another weight (p) is to act as effort to just raise the load (w)
4. Note the wt (w) and effort P so that mechanical advantage is w/p.
5. Increase the weight (w) by a small amount and go on increasing the effort P gradually till he load (w) is just raised. Take in this way about seven readings.
6. Measure the circumference of smaller and bigger axles and of the wheel also, so that velocity ratio (v) is determined.
7. The % age efficiency is given by $\frac{W}{PV} \times 100$

$$PV$$

Observations:

1. Circumference of smaller axle ($2\pi r_1$)= ----- cm
2. Circumference of bigger axle ($2\pi r_2$) =----- cm
3. Circumference of the wheel= ($2\pi R$) =----- cm
4. Velocity ratio = $\frac{2\pi R}{(2\pi r_1 - 2\pi r_2)}$ =-----

Table:

S. No.	Weight Lifted (W)	Effort Applied (P)	Mech. Adv. = W/P	Velocity Ratio	% Efficiency W/PV x 100
1					
2					
3					
4					
5					

Precautions:

1. Note the value of F when the motion just begins and the fly wheel does not move with any acceleration
 2. Oil the bearings to reduce friction.
 3. Overlapping of the string should be avoided.
-