LAB MANUAL

Engineering Mechanics

ME 0713-2102

University of Global Village (UGV), Barishal

Department of Mechanical Engineering

Prepared by

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Lab Instructor

Department of Mechanical

COURSE INFORMATION			
Course Title	**Engineering Mechanics Sessional**	Lecture Contact Hours	85
Covered Lab	Solid Mechanics Sessional, Metallic materials Sessional	Credit Total Marks	01 50
PRE-REQUISITE			CIE 20 SEE 30
Course Code: ME 0713-2102		SEE exam time: 2 Hours	

Course Learning Outcomes (CLOs): After completion of this course successfully, the students will be able to……

CLO1	**Understand** the reactions at the support of simply supported beam.
CLO2	**Analyze** the law of machine of single purchase crab, double purchase crab and differential axle and wheel.
CLO3	**Apply skills to** the coefficient of friction of different surfaces at different angles using inclined plane set up and coil friction set up.
CLO4	**Evaluate** the tensile force and compressive force in the members of jib crane apparatus.

Sl. No.	Course Content	Hrs	CLOs
1	To determine law of machine for single purchase crab.	05	CLO1
2	To determine law of machine for double purchase crab.	10	CLO2, CLO3, CLO 4
3	To determine law of machine for differential axle and wheel.	15	CLO2, CLO3
4	Determination of reactions at the supports of a simply supported beam.	15	CLO2, CLO3, CLO 4
5	Determination of coefficient of friction using inclined plane set up.	10	CLO2, CLO3, CLO 4
6	Determination of coefficient of friction using coil friction set up.	10	CLO 2 CLO 4
7	Determination of forces in members of Jib Crane (Co-Planer Concurrent force system)	10	CLO 1 CLO 3
8	Determination of Moment of Inertia of a Fly Wheel.	10	CLO2, CLO3

ASSESSMENT PATTERN

CIE- Continuous Internal Evaluation (20 Marks) SEE-

Semester End Examination (30Marks)

SEE- Semester End Examination (50 Marks) (should be converted in actual marks (30)

Bloom's Category Cognitive	**Tests (20)**
Remember	**05**
Understand	**07**
Apply	**08**
Analyze	**07**
Evaluate	**08**
Create	**05**

Bloom's Category Psychomotor	**Practical Test (30)**
Imitation	10
Manipulation	5
Precision	5
Articulation	5
Naturalization	5

CIE- Continuous Internal be converted in actual

Evaluation (40 Marks) (should marks (20)

Bloom's Category Marks (out of 60)	Lab Report (10)	Continuous lab performance (10)	Presentation & Viva (10)	External Participation in Curricular/Co-Curricular Activities (10)
Remember			02	Attendance 10
Understand	05	04	03	
Apply		02		
Analyze		02		
Evaluate	05	02		
Create			05	

	Course Plan Specifying Content, CLOs, Teaching Learning Strategy and Assessment Strategy			
Week	Topics	Teaching Learning Strategy	Assessment Strategy	Corresponding CLOs
1,2	To determine law of machine for single purchase crab.	Lecture, Oral Presentation	Quiz	CLO1
3,4	To determine law of machine for double purchase crab.	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO3, CLO 4
5.6	To determine law of machine for differential axle and wheel.	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO3, CLO 4
7,8	Determination of reactions at the supports of a simply supported beam.	Group Discussion, Experiment Practice	Skill Development Test	CLO2, CLO3, CLO 4

9,10	Determination of coefficient of friction using inclined plane set up.	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO3
11,12	Determination of coefficient of friction using coil friction set up.	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO3
13,14	Determination of forces in members of Jib Crane (Co-Planer Concurrent force system)	Group Discussion, Experiment Practice	Skill Development Test	CLO2, CLO3
15,16,17	Determination of Moment of Inertia of a Fly Wheel.	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO3,

Lab Instructions:

- Students should come to the lab on time unless prior permission is obtained from the supervisor. As per department policy, a grace period of 10 minutes will be given to late students. Student arriving after 10 minutes of the starting time will be considered absent. Hence, he/she will automatically receive "zero" mark for the lab report.

- Students will be divided in to groups (preferably 2/3 students in a group). Each group will be given a handout. This will serve as a guide for them throughout the experiment.
- All students must have to submit the lab report just after the entrance and before the class start.

- Lab reports have to be submitted serially.

- Students have to complete the sample calculations and graphs in class and take sign from the course teacher. (In some experiment which require more times, should be completed as possible in class time.)

- Students should be very careful about any test. They should conduct the tests by taking maximum care of the equipment during test.
- Thoroughly clean your laboratory work space at the end of the laboratory session.
- Keep work area neat and free of any unnecessary objects.
- Never block access to exits or emergency equipment.
- Food and drink, open or closed, should never be brought into the laboratory.

Continuous Assessment Practical

Exp No	NAME OF EXPERIMENT	Date	Sign	Remark
1	To determine law of machine for single purchase crab.			
2	To determine law of machine for double purchase crab.			
3	To determine law of machine for differential axle and wheel.			
4	Determination of reactions at the supports of a simply supported beam.			
5	Determination of coefficient of friction using inclined plane set up.			
6	Determination of coefficient of friction using coil friction set up.			

7	Determination of forces in members of Jib Crane (Co-Planer Concurrent force system)			
8	Determination of Moment of Inertia of a Fly Wheel.			

CONTENTS

Experiment No. 1

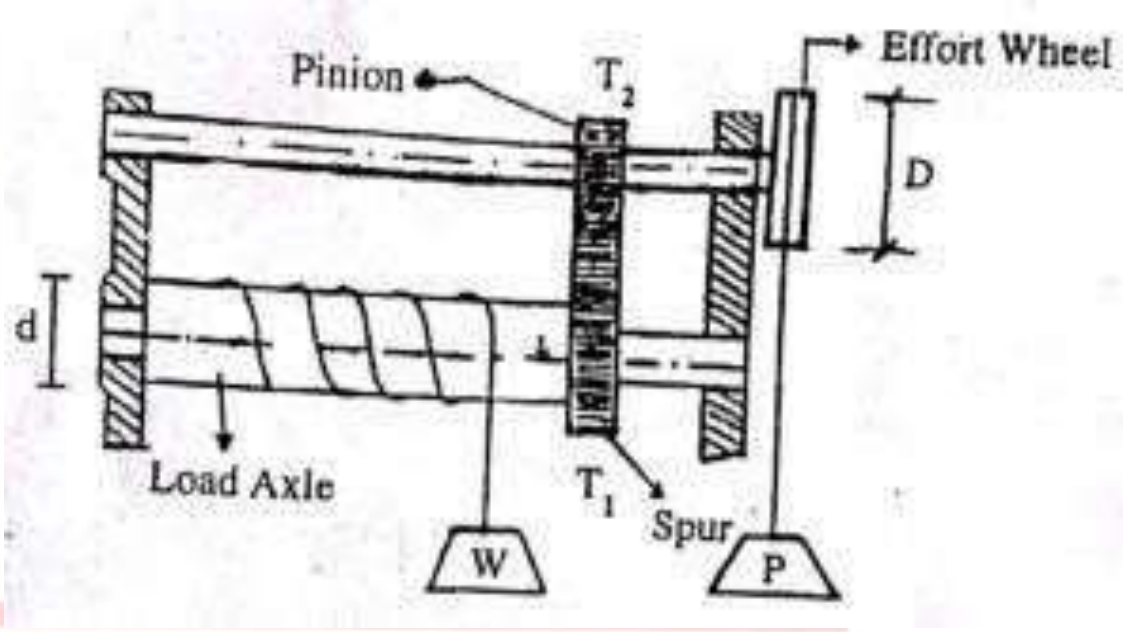
OBJECT:- To determine law of machine for single purchase crab.

APPARATUS: - Single purchase crab, weights, pansetc.

FORMULA:-

THEORY:-

FIGURE:-



Velocity ratio, V.R =[D/d]*[T_1 /T_2]

MechanicalAdvantage,M.A=load/effort=W/P

Efficiencyη= [M.A/V.R]*100%

Ideal effort, P_1 = W/V.R. Frictional effort , P_f=P- P_1

Max. Efficiency, η_{max} = 1/[m * V.R] * 100%

SINGLE PURCHASE CRAB

1. **SIMPLE MACHINE: -** It is a device which enables us to do some useful work at some point when an effort or force is applied to it at some other convenient point.

2. **LIFTING MACHINE: -** It is a device which enables us to lift a heavy load

3. MECHANICAL ADVANTAGE: -It is the ratio of load lifted to effort applied.

$$M.A = W/P$$

4. VELOCITY RATIO: -It is the ratio of distance moved by effort to the distance moved bythe load.

$$V.R. = y/x$$

5. EFFICIENCY OF MACHINE: - Ratio of workoutput to workinput is called efficiencyofmachine.

$$= Wx/Py$$

$$= W/P/(y/x)$$

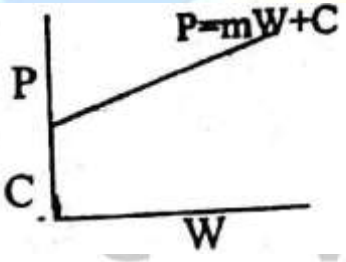
$$= M.A / V.R * 100\ \%$$

6. IDEAL MACHINE: - A machine is said to be ideal if its efficiency is 100% whichmaybeinabsenceoffriction.

$$M.A = V.R$$

7. LAW OFMACHINE: -It is defined as relationbetweenload lifted & effort applied.

P=mW+C



P- Effort applied to lift the load

m- Slope of line

W- Load lifted

C- It implies value of effort which is needed to overcome frictional force.

DERIVATION FOR V.R & η_{max}

Inonerevolutiondistancemovedbyeffort=πD No.ofrevolutionmadebypinion2 = 1

& no. ofrevolutionmadeby spur 1= T_2/T_1 No.ofrevolutionmadebyloaddrum=$T_2/T1$

Distancemovedbyload= πD* T_2/T_1

V.R = Distance moved by effort / Distance moved by load V.R=πD/ (π d* T_2/T_1)

V.R= (D/d)* (T_2/T_1)

SinceV.R. of machineis constantquantitytogetmaximumefficiencyM.A.shouldbe maximum.

M.A.= W/P P= mW+C

M.A = W/ (mW+C)

= 1/ (m+C/W) neglectingC/W Maximum M.A.= 1/m

Maximum efficiency = 1 / (m * V.R) * 100 %

PROCEDURE:-

1. Count the number of teeth on spur & pinion.
2. Note the diameter of load axle & effort wheel.
3. Wound the cord on load axle & effort wheel in such a fashion that wheneffort is applied load is lifted up.

4. Note the weight of effort pan & load pan.
5. Apply some load say 4Kg in the load pan
6. Apply some weight in effort pan such that load is just lifted up.
7. Note the weights.
8. Increase the load in steps of 1 kg & repeat steps 5, 6 & 7.

OBSERVATION:-

1) Teeth of spur wheel 1, T_1 =

2) Teeth of pinion wheel 2, T_2 =

3) Diameter of effort wheel, D =

4) Diameter of load axle, d =

5) Weight of effort pan =

6) Weight of load pan =

OBSERVATION TABLE:-

Sr. No.	Load W (kg) + wt. of pan	Effort P (kg) +wt.of pan	M.A.=W/P	V.R. =	Efficiency η%=M.A./V.R.*100
1.					
2.					
3.					
4.					
5.					

SAMPLE CALCULATION:-

MECHANICAL ADVANTAGE = M.A. = W /P = VELOCITY RATIO = V.R = [D/d] *

$[T_1/T_2]$ = EFFICIENCY = η=[M.A/V.R]* 100% =

GRAPH:-

Plot the graph between

I) Load & effort

2) Load & efficiency

RESULT :- The law of machines for single purchase crab is (P=mW+C) is

P =W +

CONCLUSION: - Since the graph of load vs effort is a straight line, law of machine is verified.

DISCUSSION:

1. What is law of machine Single Purchase Crab?
2. Explain Reversible and Non-Reversiblemachine.
3. IsSingle Purchase Crab machine reversible? Why?
4. What do you mean by output & input of a machine?

Experiment No. 2

OBJECT:- To determine law of machine for double purchase crab.

APPARATUS: -Double purchase crab, weights, pans etc.

FORMULA:-

1) Velocity ratio, $V.R=[D/d] * [T_1 /T_2] * [T_3 / T_4]$

2) Mechanical advantage, M.A = load/effort =W/P

3) Efficiency η = [M.A/V.R]*100%

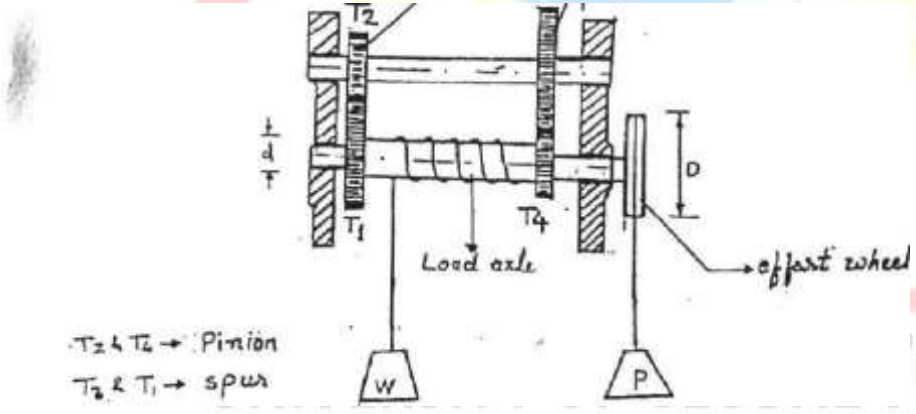
4) Ideal effort, P_I= W/V.R.

5) Frictional effort , $P_f=P-P_I$

6) Max. efficiency, η_{max} = 1/[m * V.R] * 100%

m:- Slope obtained from graph of load & effort

FIGURE:-



DOUBLE PURCHASE CRAB

THEORY:-

8. **SIMPLE MACHINE: -**It is a device which enables us to do some useful work at some point when an effort or force is applied to it at some other convenient point.

9. **LIFTING MACHINE: -** It is a device which enables us to lift a heavy load by applying acomparatively smaller effort.

10. **MECHANICAL ADVANTAGE: -**It is the ratio of load lifted to effort applied.

$$M.A = W/P$$

4. **VELOCITY RATIO: -**It is the ratio of distance moved by effort to the distance moved bythe load.

$$V.R = y/x$$

5. **EFFICIENCY OF MACHINE: -** Ratio of work output to work input is called efficiency of machine. i= Wx/Py

Ti=[W/P] Ty/xi M.A/V.R

6. **IDEAL MACHINE:-**A machine is said to be ideal machine if its efficiency is 100% which may be in absence of friction.

Mechanical advantage = Velocity ratio

7. **REVERSIBLE MACHINE: -** Sometimes machine is capable of doing some work in reverse direction after the effort is removed. Such a machine is called as reversible machine.

$$\eta > ½$$

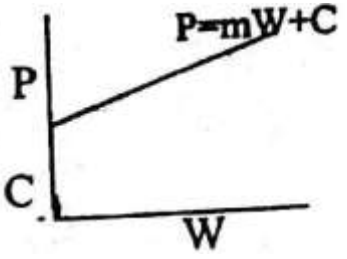
$$\eta > 50\%$$

If η<50% then it is called as self locking machine

LAW OF MACHINE: -It is defined as relation between load lifted and effort applied.

P=mW+c

P- Effort applied to lift the load



C- It implies value of effort which is needed to overcome frictional force

DERIVATION FOR V.R & η_{max}

In one revolution distance moved by effort = πD No of revolution made by pinion 4 =1

& no. of revolutions by spur 3 = T_4/T_3

No. of Revolution made by pinion 2 = T_4/T_3

No. of revolutions made by spur 1 = (T_2/T_1) x (T_4/T_3) Distance moved by load = π d * $[T_2/T_1]$ * $[T_4/T_3]$

$$V.R = \frac{\text{Distance moved by effort}}{\text{Distance moved by the}}$$

$$= [D/d] * [T_1/T_2] * [T_3/T_4]$$

Since V.R. of a machine is a constant quantity to get maximum efficiency, M.A should be maximum.

M.A = W/P P = mW+C

M.A = W/[mW+C]

M.A = 1/[m+(C/W)]

Neglecting C/W Maximum M.A=1/m

Maximum efficiency = 1/[m*V.R] *100 %

PROCEDURE

3) Wound the cord on load axle & effort wheel in such a fashion that when effort is applied load is liftedup.
4) Note the weight of effort pan and load pan.
5) Apply some load. (Say 2 kg)
6) Go on adding weights to effort pan such that load is just lifted up.
7) Note the weights.
8) Increase the load in steps of 1 or 2 kg and repeat steps 6 and 7.

OBSERVATIONS:-

1) Teeth of spur wheel 1, T_1 =
2) Teeth of spur wheel 3, T_3 =
3) Teeth of pinion 2, T_2 =
4) Teeth of pinion 4, T_4 =
5) Diameter of effort wheel, D =
6) Diameter of load axle, d =
7) Weight of effort pan =
8) Weight of load pan =

OBSERVATION TABLE:

Sr. No.	Load W (kg) +wt.of pan	Effort P (kg) +wt.of pan	M.A.=W/P	V.R.	Efficiency η%= M.A./V.R.*100
1					
2					
3					
4					
5					

SAMPLE CALCULATION:-

Mechanical Advantage = M.A. = W / P = Velocity Ratio = V.R = [D/d] * [T_1 /T_2] * [T_3 / T_4] = Efficiency = η = [M.A / V.R] * 100 % =

GRAPH:-

Plot the graphs between

1) Load and effort
2) Load and efficiency

RESULT: -

1) The law of machine for double purchase crab P = (mW+C) is P = W +C
2) Maximum efficiency of double purchasecrab is %.

CONCLUSION: -

Since graph of load vs. effort is a straight line, Law of machine is verified.

DISCUSSION:

5. What is law of machine of Double Purchase Crab?
6. What is maximum M.A. and maximum efficiency of the machine?
7. Is Double Purchase Crab machine reversible?Why?
8. Define Ideal machine and Ideal Effort.

Experiment No. 3

OBJECT:-To determine law of machine for differential axle and wheel.

APPARATUS: -Differential axle, weights, pans etc.

FORMULA:-

7) Velocity ratio, V.R=2D/[d_1-d_2]

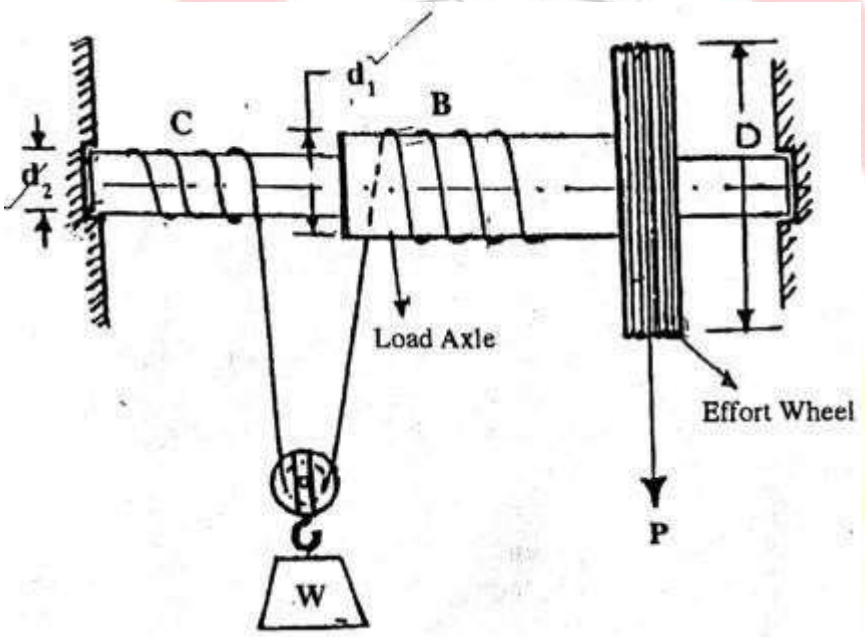
8) Mechanical advantage, M.A = load/effort =W/P

9) Efficiency η = [M.A/V.R]*100%

10) Ideal effort, P_I = W/V.R.

11) Max. efficiency, η_{max} = 1/[m * V.R] * 100%

FIGURE:-



DIFFERENTIAL AXLE & WHEEL

THEORY:-

11. **SIMPLEMACHINE: -**It is a devicewhichenablesus to dosome useful work at some point when an effort or force is applied to it at some other convenient point.

12. **LIFTING MACHINE:-** It is a device which enables us to lift a heavy load by applying acomparatively smaller effort.

13. **MECHANICAL ADVANTAGE: -**It is the ratio of load lifted to effort applied.

M.A= W/P

14. **VELOCITY RATIO: -**It is the ratio of distance moved by effort to the distance moved bythe load.

V.R y/x

15. **EFFICIENCY OF MACHINE: -** Ratio of work output to work input is called efficiency of machine.

η = [M.A / V.R] * 100 %

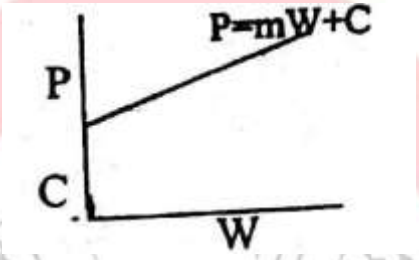
16. **IDEAL MACHINE:-** A machine is said to be ideal machine if its efficiency is 100% which may be in absence of friction.

Mechanical advantage = Velocity ratio

17. **REVERSIBLE MACHINE: -** Sometimes machine is capable ofdoing some work in reverse direction after the effort is removed. Such a machine is called as reversible

18.LAW OF MACHINE: -It is defined as relation between load lifted and effort applied.

P=mW+c



P- Effort applied to lift the load

m- Slope of line

W- Load lifted

C- It implies value of effort which is needed to overcome frictional force

DERIVATION FOR V.R & η_{max}

The effort string is wound round the wheel Another string is wound round the axle B which after passing round the pulley is wound round the axle C in opposite direction to that of the B care being taken to wind the string on the wheel A & axle C in same direction.

In the revolution of effort wheel A, displacement of the effort
=π D.

Length of string which will wound on the axle B in one revolution = πd1

Length of string which unwound from axle C in one revolution=πd2.

In one revolution the length of string which will wound = πd1- πd2 Displacement of weight = $1/2(\pi d_1 - \pi d_2)$

V.R = Distance moved by effort / Distance moved by load. & no. of revolutions by spur 3 = T_4/T_3

No. of Revolution made by pinion 2 = T_4/T_3

$$V.R = \frac{\pi D}{{}^{1}/_{2}(\pi d_1 - \pi d_2)}$$

$$V.R = \frac{2D}{\pi d1 - \pi d2}$$

PROCEDURE

9) Count the number of teeth on spur & pinion.

10) Note the diameter of load axle & effort wheel.

11) Wound the cord on load axle & effort wheel in such a fashion that when effort is applied load is liftedup.

12) Note the weight of effort pan and load pan.

13) Apply some load. (Say 2 kg)

14) Go on adding weights to effort pan such that load is just lifted up.

15) Note the weights.

16) Increase the load in steps of 500gm and repeat steps 6 and 7.

OBSERVATIONS:-

1) Diameter of effort wheel, D =

2) Diameter of greater axle, d_1 =

2) Diameter of smaller axle, d_2 =

OBSERVATION TABLE:-

Sr. No.	Load W (kg) + wt. of pan	Effort P (kg)+wt. of pan	M.A.=W/P	V.R. =	Efficiency η%= M.A./V.R.*100
1					
2					
3					
4					
5					

SAMPLE CALCULATION:-

MECHANICAL ADVANTAGE = M.A. = W/ P = VELOCITY RATIO = V.R = 2D/ $[d_1-d_2]$

=

EFFICIENCY =η = [M.A / V.R] * 100 % =

GRAPH:-

Plot the graphs between

1) Load and effort

2) Load and efficiency

RESULT: -

1)The law of machine for double purchase crab P = (mW+C) is P =_____W + C

2)Maximum efficiency of double purchasecrab is _____%.

CONCLUSION: -

Since graph of load vs. effort is a straight line, Law of machine is verified.

DISCUSSION:

1. Is Differential Axle and Wheel reversible?Why?
2. Define an Ideal Machine.
3. What is the application ofthe system?
4. Explain the various types of liftingmachin

Experiment No. 4

OBJECT: - Determination of reactions at the supports of a simply supported beam.

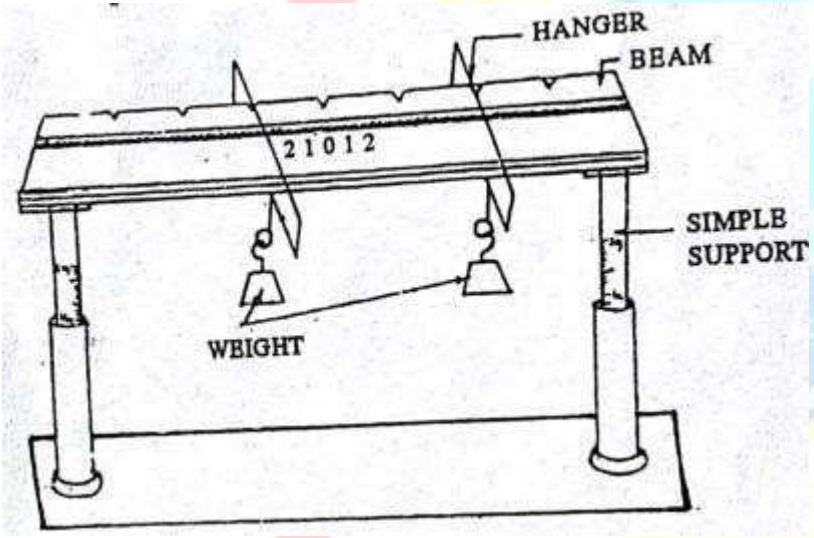
APPARATUS: -Simplysupported beam apparatus, hooks, weights, hanger etc.

FORMULA:-

1) $R_B = (W_1 * L_1 -- W_2 * L_2) / L$

2) $R_A = \sum W - R_B$

FIGURE:-



SIMPLY SUPPORTED BEAM APPARATUS

THEORY:-

1)SIMPLE BEAM: -A simple beam is a beam resting on two supports. The beam of this experimentrest on the supports which provide reactions only in vertical directions. The motion of beam in horizontal direction is not constrained.

2)FREE BODY DIAGRAM: -FBD is the isolated view of the chosen body with all the external forces acting on it including reactions due to removal of other body, surface or support in contact. The weight of free body should also be included in external forces since it represent attraction exerted by earth on the body.

3)EQUATION OF EQUILIBRIUM: - For coplanar non-concurrentforce system, the following equations areapplicable.

$\sum Fx = 0, \quad \sum Fy = 0, \quad \sum M = 0$

The force system in the experiment is coplanar parallel force system which is special case of coplanar non concurrent force system. Since there is no horizontal force following two equations is applicable.

$\sum Fy = 0 \quad \sum M = 0 \; Ma = 0$

$W1 * L1 + W2 * L2 = R_B * L$

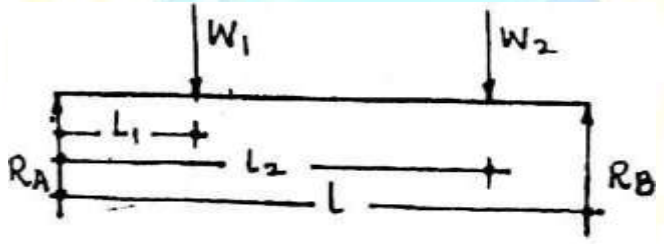
$$R_B = \frac{W1 * L1 + W2 * L2}{L}$$

$\sum Fy = 0$

$R_A + R_B - W_1 - W_2 = 0$

$R_A = W_1 + W_2 - R_B$

$= \sum W - R_B$



F.B.D. OF BEAM

PROCEDURE: -

9. Span of beam 'L' in meter is recorded
10. Beam is placed gently on two balances & initial reading of both balances are recorded.
11. Two hangers are placed at different points. Some weights are placed in hangers.
12. The distance of these hangers from left support A & weights including weight of hanger recorded.
13. Steps 3 & 4 are repeated for different procedure of weights & values of weights.

3. Initial reading at B = kg

OBSERVATION TABLE: -

Sr. No.	L_1 m	L_2 m	W_1 kg	W_2 kg	W	Final Reading		Experimental Reading		Theoretical Reading		% Deviation	
						R_A	R_B	R_A	R_B	R_A	R_B	R_A	R_B

Experimental R_A = Final reading at A - Initial reading at A Experimental R_B = Final reading at B - Initial reading at B

% Deviation in R_A = [Theoretical R_A – Exp. R_A] / Theoretical R_A

% Deviation in R_B = [Theoretical R_B – Exp. R_B] / Theoretical R_B

SAMPLE CALCULATION: -

RESULT: - Reactions at simple support for various loads and position are shown in the table.

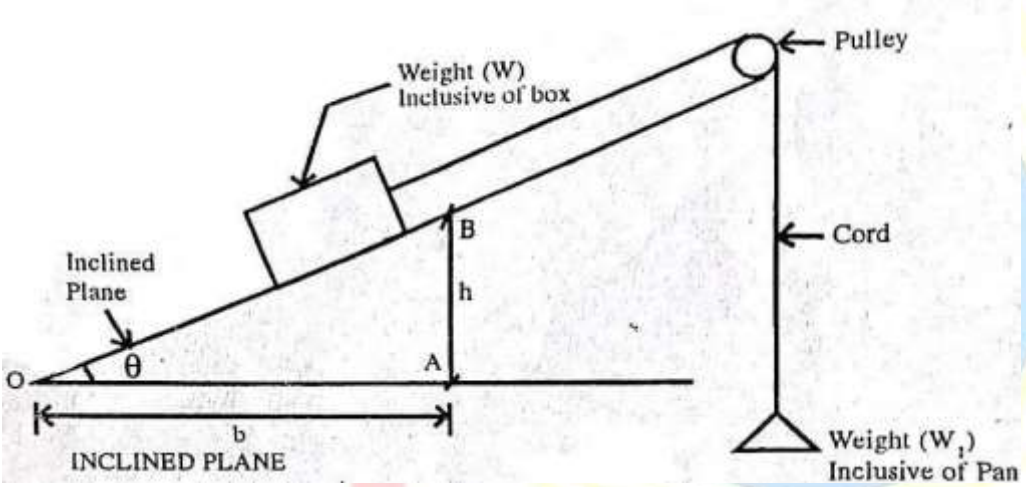
Experiment No. 5

OBJECT: -Determination of coefficient of friction using inclined plane set up.

APPARATUS: -Inclined plane, Wooden Box, Cord with pan, weights etc.

FORMULA:- $\mu s = \dfrac{W1 - W\sin\theta}{W\cos\theta}$

FIGURE:-



SIDE ELEVATION

THEORY:-

i) Laws of Friction :

The laws of dry friction (Sometimes called Coulomb friction) may be stated as follows

1) If friction is neglected, the reactions are always normal to the surface in contact.

2) Friction always acts to oppose the relative motion of thefree body (or its tendency to move) and it is tangent to the surfaces in contact.

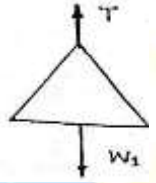
3) If static friction is acting, the value of the friction force may vary from zero to its maximum available value adjusting itself to the resultant force tending to causemotion.

4) The maximum available Value of static friction (i.e. the limiting friction when motion impends)is equal to 1.1.s N where 1..ts is the coefficient of static friction & N is the normal force:
5) It motion occurs, the kinetic friction force always acts at its constant value of 14 N where ilk is the coefficient of kinetic friction & N is the normal force.
6) The angle between the total reaction and its normal component when limiting friction is acting is called the angle of friction. The tangent of this angle is equal to the coefficient of friction.

i) <u>Laws of Friction</u> :

At a fixed angle of inclination θ, the suspended mass is increased until the block is at the verge of upward slippage, i.e. in the state of impending motion. Refer to the free-body diagram of the block at such a state as shown above for equilibrium.

FBD of pan:



$+\uparrow\sum F_y = 0 : \quad T = W1$ ..... (1)

FBD of block:

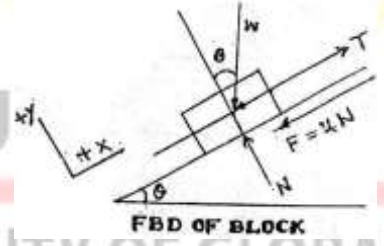
$+\uparrow\sum F_y = 0 : \quad N = W\cos\theta$ .....(2)

` $+\uparrow\sum F_x = 0 : T = \mu_S N - W\sin\theta = 0$ .....(3)

(1) and (2) in (3)gives

$W1 - \mu_S . W\cos\theta - W\sin\theta = 0$

$\mu_S = [\, W1 - W\sin\theta \,] / W\cos\theta$



FBD OF BLOCK

<u>PROCEDURE</u>:-

1) Set the incline plane of some suitable angle.
2) Note the weight of box and pan.
3) Put some weight say 50 gm in box and note W inclusive of weight of box.
4) Go on adding weights, in pan till the box just starts moving up on the incline.
5) Note W1 inclusive of weight of pan & weight added.

6) Increase weight W & repeat steps 4 & 5.

OBSERVATION:-

i) Weight of box =_____gm

ii)Weight of pan =__gm

Sr. No.	Weight (W)	Weight (W1)	Angle θ	$\mu s = \frac{W1 - Wsin\theta}{Wcos\theta}$
1				
2				
3				
4				
5				

SAMPLE CALCULATION:-

$\mu s = \frac{W1 - Wsin\theta}{Wcos\theta}$ _____=

Averageμs =

RESULT:- The coefficient of friction between wood (base of box) &glass (top of inclined plane) is, $\boldsymbol{\mu S}$ =

_____

CONCLUSION: - The critical angle of inclined plane, θcritical = $\tan^{-1}\{\mu S\}$ =

_____

Experiment No. 6

OBJECT: - Determination of coefficient of friction using coil friction set up.

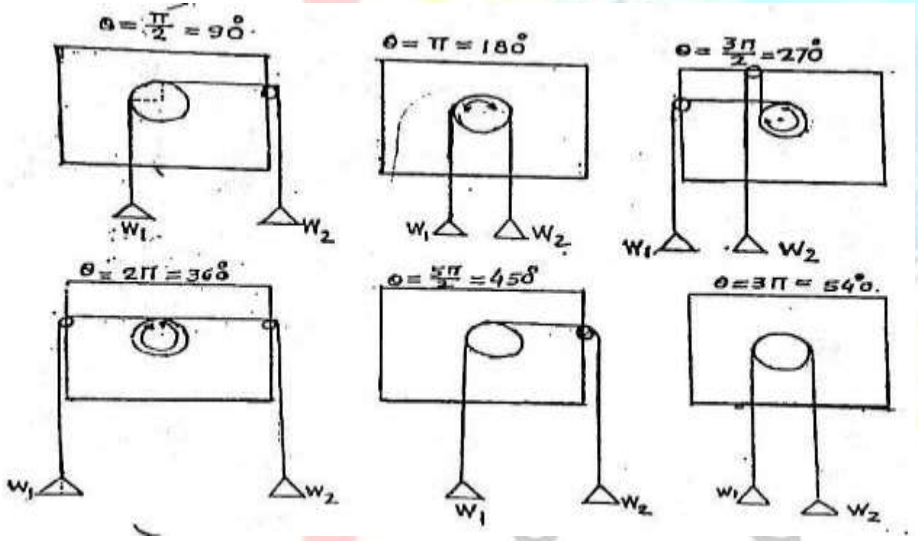
APPARATUS: - Coil friction setup, threads, pans, weight box etc.

FORMULA:- $\mu = \frac{loge\ (T2/T1)}{\theta}$

= Coefficient of friction between thread & drum.

= T_1 & T_2 = Tension at the two ends of thread

FIGURE:-



THEORY:-

COIL FRICTION: -The opposing force experienced by the coil (thread) when it slides over the drum is called coil friction.

If friction does not exist between drum & thread the tension throughout the belt will be constant & will have same value on both sides

of drum. But friction is always present when there is a relative motion or tendency of motion between the two surfaces in contact. So the tension in the belt will vary throughout the length of contact the difference in the belt tension being caused by incremental sum of frictional resistance.

If T1& T2 be the tension in the two ends of thread & motion of thread is in direction of T2 then T2> T1 because T2 has to overcome the opposite force T1& also the frictional force of the thread on the drum.

$$\mu = \frac{l}{\theta}(T2/T1)$$

PROCEDURE:-

1) Record the weights of pan 1 & 2.
2) Set the card for $\theta = 90^{o}$
3) Put some weight in pan 1 & note W_1 W_1 is inclusive of Wt of pan + W_t added
4) Add weights in pan 2 till it just starts moving down. Note W_2 & W_1 is inclusive of weight of pan 2 + weight added to start the motion.
5) Increase the weight in pan 1 & repeat steps 3 & 4. Repeat the above five steps for $\theta = \frac{\pi}{2}, \pi, \frac{3\pi}{2}, \pi$

OBSERVATION:-

Sr. No.	θ (rad)	$T_1 = W_1$	$T_2 = W_2$	$\mu = \frac{log\ e\ (T2/T1)}{\theta}$
1	π/2			
2	π			
3	3π/2			
4	2π			
5	5π/2			
6	3π			

Average μ =

SAMPLE CALCULATION:-

$\mu = \frac{log_e\ (T2/T1)}{\theta}$ =

Average μ =

RESULT:- The coefficient of friction between cord & drum is found to be μ=_____

PRECAUTION: - 1) Place the weights gently in the pan.

2)The angle of lap should be measured carefully.

3)The proper unit should be used for angle of lap.

Experiment No. 7

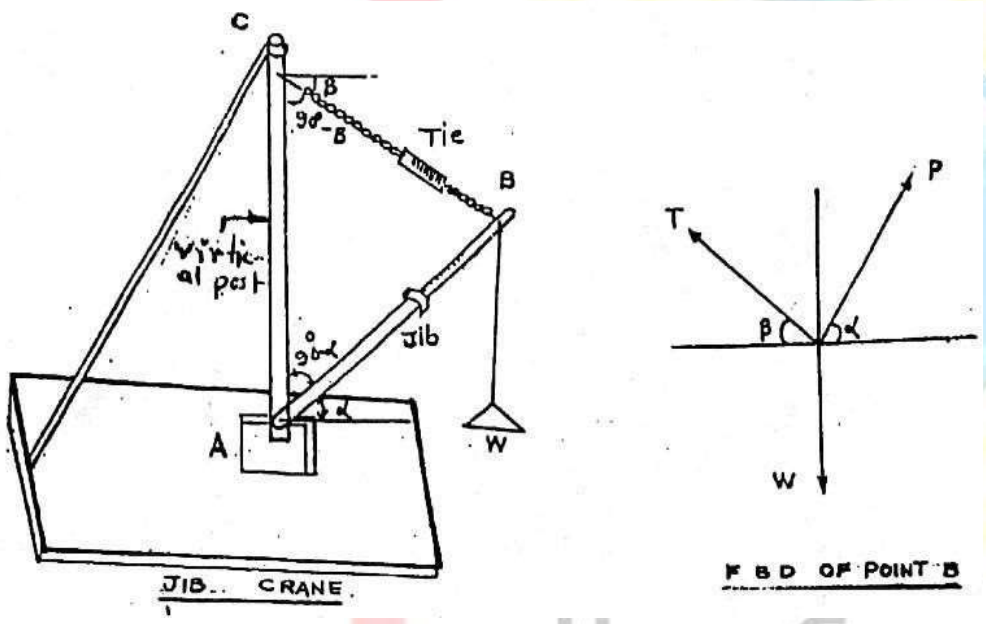
OBJECT: - Determination of forces in members of Jib Crane (Co-Planer Concurrent force system)

APPARATUS: - Jib Crane apparatus, meter scale, weight, thread etc.

FORMULA:-

$$\frac{T}{\sin(90+\alpha)} = \frac{P}{\sin(90+\beta)} = \frac{W}{\sin(180-\alpha-\beta)}$$

FIGURE:-



THEORY:-

1) **Coplanar Concurrent Forces:-**

The forces, which meet at one point and their lines of action also lie on the same plane are known as Coplanar Concurrent Forces.

In this apparatus Jib is a compression member, tie is tension member which take the load W applied. These forces meet at a single point lie in same plane.

2) Equation of Equilibrium:-

For coplanar concurrent force system, the following two equations are available for equilibrium.

$$\sum F_x = 0 \qquad \sum F_y = 0$$

3) Lami's theorem:-

It state that:-

"If three coplanar forces acting on at point be in equilibrium then each force is proportional to the sine of the angle between the other two."

$$\frac{T}{\sin(90+\alpha)} = \frac{P}{\sin(90+\beta)} = \frac{W}{\sin(180-\alpha-\beta)}$$

PROCEDURE:-

7) Attach the pan atB.
8) Measure the, length of AB,BC & CA with the help of string & scale.
9) Note the weight of pan & initial reading of spring balance in tie & in Jib.
10) Place some weight (say 0.5 kg) in the pan and note W (W is inclusive of weight of pan added).
11) Note the final reading at both the spring balances.
12) Increase the weight in pan (say by 0.5 kg) and repeat steps 4 & 5.

OBSERVATION:-

1) Length of Jib =
2) Length of Tie =
3) Length of Post =

OBSERVATION TABLE:-

Sr. No.	Weight	Initial Reading		Final Reading	
		Balance in Jib	Balance in Tie	Balance in Jib (kg)	Balance in Tie (kg)
1.					
2.					
3.					

Sr. No.	Experimental Values		Theoretical Values		% deviation	
	Force in Jib P (kg)	Force in Tie P (kg)	Force in Jib P (kg)	Force in Tie P (kg)	Jib	Tie
1.						
2.						
3.						
4.						
5.						

Sr. No.	Weight	Length in Jib	Length in Tie
1.			
2.			
3.			
4.			
5.			

SAMPLE CALCULATION:-

$$\cos(90-\beta) = AC^2 + CB^2 - AB^2 / (2*AC*CB)$$

$$\beta = \_\_\_\_\_$$

$$\cos(90-\alpha) = AC^2 + AB^2 - CB^2 / (2*AC*CB)$$

$$\alpha = \_\_\_\_\_$$

Applying Lami's theorem

$$\frac{T}{\sin(90+\alpha)} = \frac{W}{\sin(180-\alpha-\beta)}$$

T =_____**kg**

$$\frac{P}{(90+\beta)} = \frac{W}{sin(180-\alpha-\beta)}$$

P =_____**kg**

RESULT: -Theforce in Jib& Tie are found out for different loads applied at their commonjoint as shown in table

Experiment No. 8

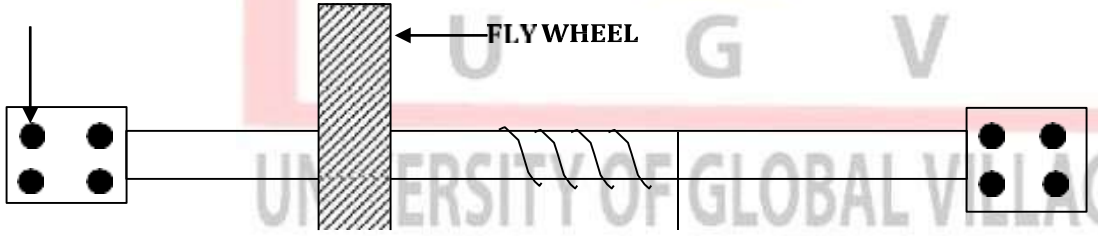
OBJECT: - Determination of Moment of Inertia of a Fly Wheel.

APPARATUS: - Apparatusof „Fly Wheel" , stopwatch, weights, scale, etc.

FORMULA:- $I = 2n_2(mgh - {}^1/_2\, mv^2)/(\omega^2(n_1+n_2))$ kg-m^2 or gm-cm^2

n_1= No. of turns of cord on axle.
= No. of rotations flywheel makes till detachment of falling mass.
n_2= No. of rotations which flywheel make after detachment of falling mass tillit stops.
h= Displacement of falling mass till detachment.
$=2 * \pi\, r\, n_1$
r = radius of Axle of flywheel.
ω=Angular velocity of flywheel at the instant of detachment.
$= 4 * \pi n_1/t$
t = Time taken by flywheel for n1 rotations.
v= linear velocity of falling mass at the instant of detachment.\
$= r\omega$

FIGURE:-



1)Kinetic & potential Energies of a body:

a)Kinetic Energy: - It is the energy possessed by a body by virtue of its motion.

i)If body undergoes translation:

$$K.E. = {}^{1}/_{2}mv^{2}$$

ii)If body undergoes rotation:

$$K.E. = {}^{1}/_{2}m\omega^{2}$$

b) **Potential Energy: -**It is the energy possessed by a body by virtue of its position. In mechanics, P.E. due to gravity (weight) and elastic spring is important.

2)Law of conservation of Energy: In mechanics, it is sometimes known as Law of conservation of mechanical energy. It states that during motion, sum of kinetic energy must be transformed to potential energy and vice versa.

3)Derivation of formula for I:-

Moment of inertia I represents measure of resistance of a body to angular acceleration. It is defined as the integral of second moment about an axis of all elements of mass dm.

The mass m falls through a vertical height of h and loses its potential energy mgh. This potential energy is converted in to:

a) Transnational K.E. = $^1/2\ mv^2$ of falling mass m.

b) Rotational K.E. = $^1/2 m\omega^2$ of flywheel where I is M.I. of flywheel about its axis of rotation.

c) Frictional energy loss n_1F is bearing where F is frictional energy loss in one revolution.

Law of conservation of energy implies:

$mgh = {}^1/_2mv^2 + {}^1/_2m\omega^2 + n_1F$ ..... (1)

Phase II:-

When falling mass is detached, the flywheel is having rotational K.E. equal to ${}^1/_2I\omega$. This energy is lost in friction. If no. of revolutions of flywheel after detachment of mass is n2, this frictional loss is equal to n_2F.

This means:

${}^1/_2I\omega^2 = n_2F$ ..... (2)

$F = I\omega^2/2\ n_2$ ..... (3)

(3) in (1) gives:

$mgh = {}^1/_2mv^2 + {}^1/_2I\omega^2 + n_1I\omega^2/2\ n_2$

${}^1/_2I\omega^2 + n_1\ I\omega^2/2\ n_2 = mgh - {}^1/_2mv^2\ {}^1/_2I\omega^2(1+ n_1/n_2) = mgh - {}^1/_2mv^2\ {}^1/_2I\omega^2((\ n_1/n_2)/n_2) = mgh -$

${}^1/_2mv^2$

$I = 2\ n_2/(\ mgh - {}^1/_2mv^2)/\ \omega^2(\ n_1/n_2)$ ..... (4)

Here $V = r\omega$ ..... (5)

But $\omega = \omega o + \alpha t$

$\omega = \alpha t$ (since $\omega o = 0$) ..... (6)

But $a = r\alpha$.....(7)

Also $s = vot + {}^1/_2\, at^2$

Here $s = h = (2\pi r)n_1$, $vo = 0$ $2\pi r n_1 = {}^1/_2 at^2$

$a = 4\pi r n_1/t^2$ .....(8)

(8) in (7) gives:

$4\pi r n_1/t^2 = r\alpha$

$\alpha = 4\pi n_1/t^2$ .....(9)

(9) in (6) gives:

$\omega = 4\pi n_1 t/t^2$

$\omega = 4\pi n_1/t$..... (10)

ωin (5) gives:

$v = 4\pi n_1/t$.....(11)

PROCEDURE:-

1. Record mass of pan & radius of axle of flywheel.
2. Take a cord of length less than the distance of axle from ground.
3. Make loop at one end and attach pan at other end.
4. Slip on the loop to small pin on axle of wheel.
5. Start wrapping string when pin is exactly horizontal by slowly turning flywheel. Give few turns say "n_1".
6. A short horizontal line is marked when pin is horizontal.
7. Put some mass say 100 gms in pan & record mass „m" inclusive wt of pan.
8. Release the pan & start stopwatch
9. Count no. of revolution till mass is detached (these should be n_1) stopwatch is stopped when mass is detached from fly wheel. Note time" t" required for 'n_1' revolution.
10. Record no. of revolution 'n_2' that fly wheel makes after mass is detached.

11. Repeat the experiment for different value of n_1& mass.

OBSERVATIONS:-

Radius of the axle = cm

OBSERVATION TABLE:-

Sr. No.	Mass in gram	No. of turns of cord on Axle n_1	$h = 2\pi r n_1$	Time for detachment „t" sec.	No. of revolution after detachment „n_2"	$\omega = 4\pi n_1/t$ Rad/sec	I gm-cm^2
1							
2							
3							
4							
5							
6							

SAMPLE CALCULATION: