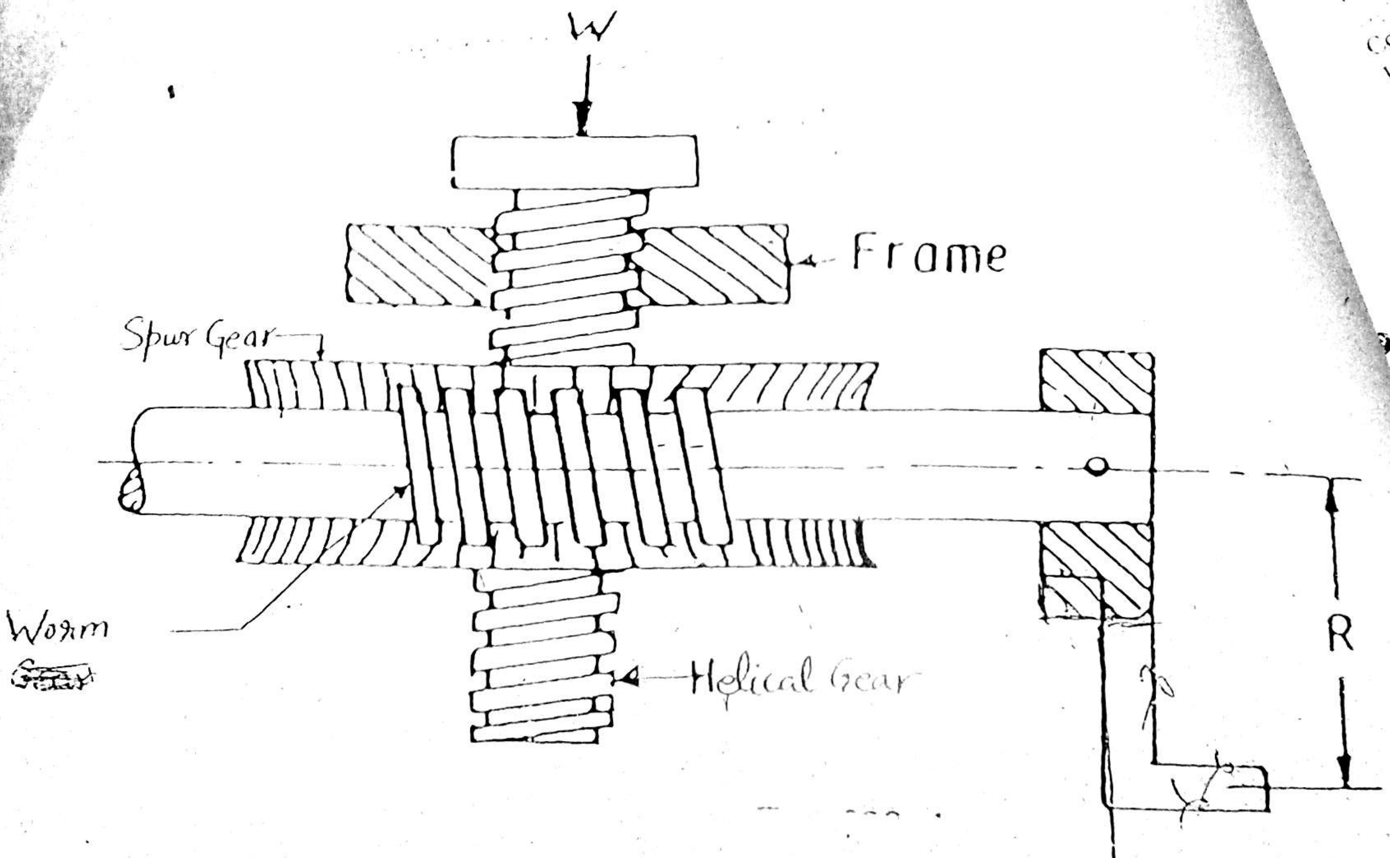

– WORM GEAR SCREW JACK

KNOMDCSM

EXPERIMENT NO. 6

AIM: To determine the Velocity Ratio, Mechanical Advantage and Efficiency and law of machines of worm- gear screw jack.

APPARATUS: worm- gear screw jack, weight box, and a meter scale.

Description: It is an improved form of screw jack in which the screw is lifted with the help of worm and gear wheel, instead of effort at the end of a pulley.

THEORY AND FORMULAE USED:

Consider a worm- geared screw jack.
Let

Circumference = 46
$\pi d = 46$
$d = \frac{46}{\pi}$

$2\pi r = 46$

p = pitch of screw (p = 4mm) → 4×10^{-3}
T = nb. of teeth in gear wheel (T = 40)

T — P
1 — x
$x = P/T$

∴ Number of revolutions made by the gear wheel and screw of jack = 1/T

Distance moved by load = p/T
Distance moved by effort = $2\pi R$

$\frac{2\pi R}{P/T}$

1) Velocity Ratio (V.R.) = $\frac{2\pi R}{p/T}$ where R is radius of effort pulley.

Effort = $2\pi R$
load = P/T

2) Mech. Adv. (M.A.) = $\frac{\text{Load lifted}}{\text{Effort applied}} = \frac{W}{P}$

1 rev —— P
$\frac{1}{T}$ " —— $\left(\frac{P}{T}\right)$

3) Efficiency (η) = $\frac{M.A}{V.R.}$

4) Ideal effort (P_i) = $\frac{W}{V.R.}$

5) Effort lost in friction P_f = Actual Effort – Ideal Effort = $P - P_i$

6) Ideal load (W_i) = Actual effort x Velocity ratio = P x V.R

7) Load lost in friction W_f = Ideal load - Actual load = $W_i - W$

8) Law of machine = P= mW+C (Y=mX+C)

where m = Slope of St. line. & C = Intercept of St. line on Y axis.

9) $M.A._{max} = \frac{1}{m}$ & Max.efficiency of machine = $\eta_{max} = \frac{1}{m \times V.R.}$

PROCEDURE:

1) Note down the diameter of effort pulley and pitch of screw jack
2) Known weight W was attested at loading point and effort P was applied at driving point and note down.
3) Determine the Velocity Ratio(V.R.)
4) Determine the M.A
5) Calculate effort lost in friction
6) Calculate load lost in friction
7) Calculate efficiency (η)

GRAPHS:

8) Plot curves for.
   a. Load Vs Effort
   b. Load Vs Mechanical Advantage
   c. Load Vs Efficiency
9) Calculate m & C from graph Load Vs Effort
10) Calculate law of machine
11) Max.efficiency of machine

OBSERVATION TABLE:

S.No.	LOAD W in Kg	EFFORT P in Kg	Ideal effort (P_i)	Effort lost in friction P_f	Load lost in friction W_f	Mechanical Advantage MA W/P	Efficiency η % MA/VR ×100
1.	10	0.160				62.5	1.35%
2.	9	0.120				75	1.63%
3.	8	0.100				80	1.73%
4.	7	0.090				77.7	1.68%
5.	6	0.080				75	1.64%
6.	5	0.075				66.66	1.44%

RESULTS:

1. The Velocity Ratio (VR) for the machine
2. The max. mechanical Advantage ($M.A._{max}$) for the machine
3. The max.efficiency (η_{max}) of the machine =
4. Law of machine =

PRECAUTIONS AND SOURCES OF ERROR:

1. The effort should be applied accurately at suitable situation.
2. The pitch of the screw jack should be measured accurately

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EXPERIMENT NO. 7.		
TITLE	WHEEL & AXLE	
DATE OF PERFORMING	DATE OF SUBMISSION	REMARKS
SIGNATURE OF PROFESSOR		

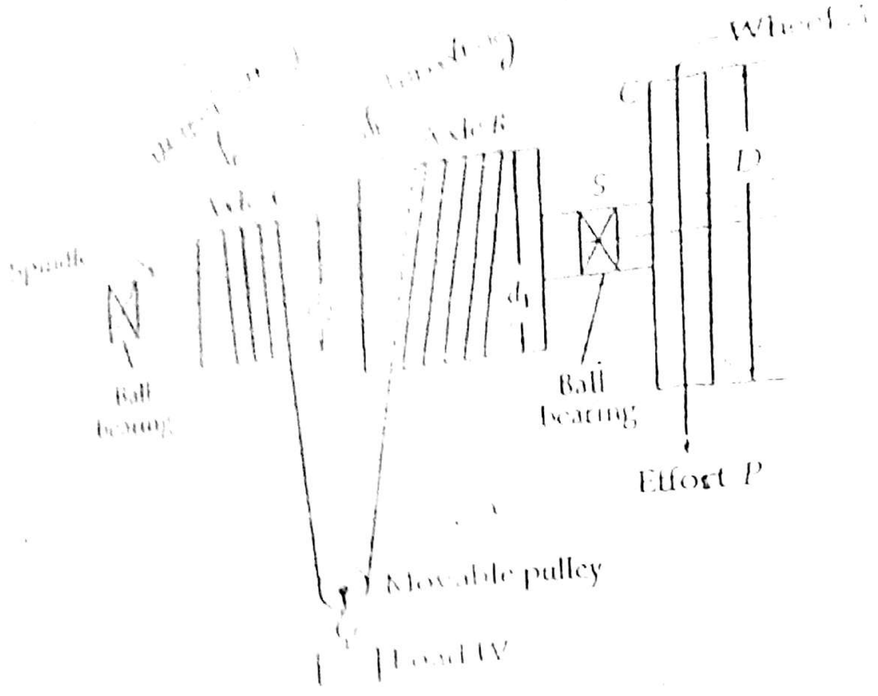

Fig 1 Differential wheel and axle

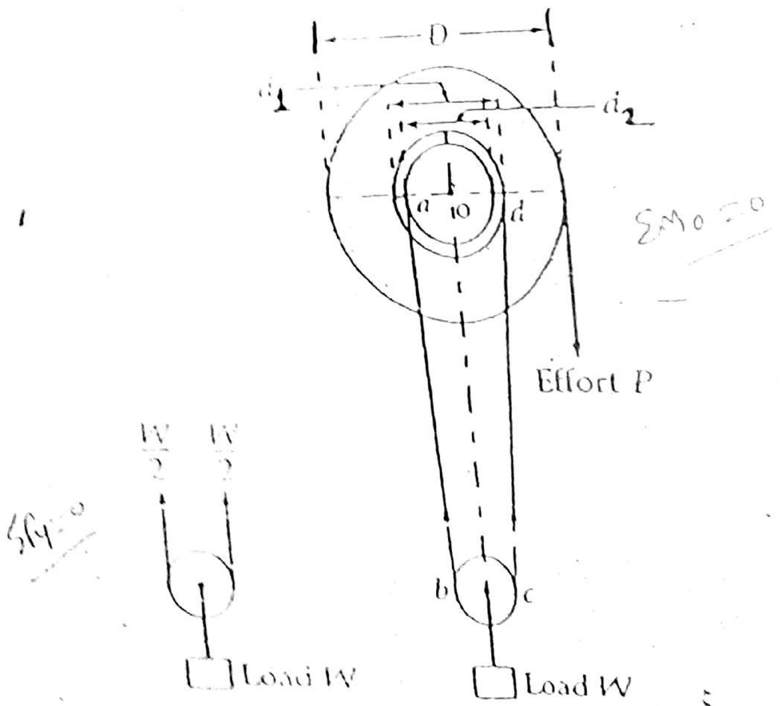

Fig 2

EXPERIMENT NO.7

AIM: To determine the Velocity Ratio, Mechanical Advantage and Efficiency of Differential wheel and Axle.

APPARATUS: One set of sloted weights, weight box, thread and a meter scale.

THEORY AND FORMULAE USED:

The unit consists of a wheel A and two axles B and C. The wheel and the two axles are keyed to the same shaft (spindle) which is supported in ball bearings. The effort is applied to the string which is wound round the wheel. Another string is wound on the two axles and it carries the load through a pulley. The strings on the wheel and smaller axle are wound in the same direction where as winding of string on the bigger axle is in the opposite direction.

When the effort P is applied in the downward direction, there is unwinding of the strings on the wheel and smaller axle. The string winds on the bigger axle at the same times and the load W is lifted upwards.

Let

distance moved by effort = πD (downward)

length of string that winds on bigger axle = πd_1

length of string that winds on ~~[illegible]~~ Smaller axle = πd_2

50%.

Therefore, Net length of string which will get wound on bigger axle = $\pi d_1 - \pi d_2$

Since the string caries the load through pulley, the load will get lifted by distance

$$\cancel{VR} = (\pi d_1 - \pi d_2)/2 = ½\, \pi(d_1 - d_2)$$

46
25
21

Therefore, Velocity ratio (VR) = distance moved by effort/distance moved by load

$$VR = \pi D / ½\, \pi(d_1 - d_2) = 2D/(d_1 - d_2)$$

Biggest Circle

$\frac{2D}{(d_1 - d_2)}$

For a larger velocity ratio, d_1 and d_2 are made nearly equal.

Neglecting friction at the contact surfaces, the forces acting on the system are shown in Fig. Let it be assumed that segments ab and cd of the string supporting the load to be vertical. Then from equilibrium condition $\sum V = 0$, the tension in each of the segments equals W/2. Further, from moment equilibrium $\sum M = 0$.

Taking moments of all forces about o, we get

$$P \times D/2 - W/2 \times d_1/2 + W/2 \times d_2/2 = 0$$

or

$$P \times D = W/2(d_1 - d_2)$$

Therefore Mechanical advantage (MA) = W/P = 2D/(d_1-d_2)

The mechanical advantage is equal to velocity ratio. This has to be so because friction has been neglected. Obviously then efficiency of the system will be 100 per cent.

Effect of friction

Let P′ be the effort required to lift the load W when friction if taken into account. Then for one revolution of the wheel and axles,

Work input (work done by the effort) = P′ x πD

Work output (work done by the load) = W x π/2(d_1-d_2)

Efficiency of machine η = work output / work input

$$= \frac{W \times \pi/2(d_1-d_2)}{P' \times \pi D} = \frac{W}{P'} \times \frac{(d_1-d_2)}{2D}$$

From the above expression,

$$P' = W\frac{(d_1-d_2)}{2D} \times \frac{1}{\eta}$$

and MA (actual) = W/ P′ $= \frac{2D}{d_1-d_2} \times \eta$.

PROCEDURE:

1. Measure and note down the circumference of all drums in order to calculate their diameters.
2. Apply the measured load and slowly apply the effort weights on the larger drum. When the load starts to lift, note down the reading of the effort weight.
3. For taking next reading, increase the load and repeat step 2 again.
4. Tabulate the readings and calculate the results.

OBSERVATION TABLE:

Table - I

All readings are in cm

Circumference of wheel	94	Diameter of the wheel (D)	
Circumference of the bigger axle	47	Diameter of the bigger axle (d_1)	
Circumference of the smaller axle	22	Diameter of the smaller axle (d_2)	

Table - II

All readings of effort and load are in Kg

S No	LOAD W in Kg	EFFORT (P) in Kg	Mechanical Advantage MA	Efficiency η
1				
2				
3				
4				
5				

CALCULATIONS:

1. Write the calculations for any one set of readings.
2. Draw the graphs
(a) Load Vs Effort.
(b) Load Vs Mechanical Advantage
(c) Load Vs Efficiency

RESULTS:

1. The Velocity Ratio (VR) for the machine =
2. The Mechanical Advantage (MA) for the machine =
3. The Efficiency (η) of the machine =

PRECAUTIONS AND SOURCES OF ERROR:

1. The differential wheel and axle must be properly oiled so that friction is negligibly small.
2. Make sure that the strings on the wheel and smaller axle are wound in the same direction.
3. The string used should have negligible diameter.
4. The string should be wound tightly over the wheel and axle drums.

1.5 → 0.23

1 → $\frac{0.23}{1.5}$

1 → 0.17

1.5 0.17×60×

2 →

EXPERIMENT - 8

Title :- WORM AND WORM WHEEL

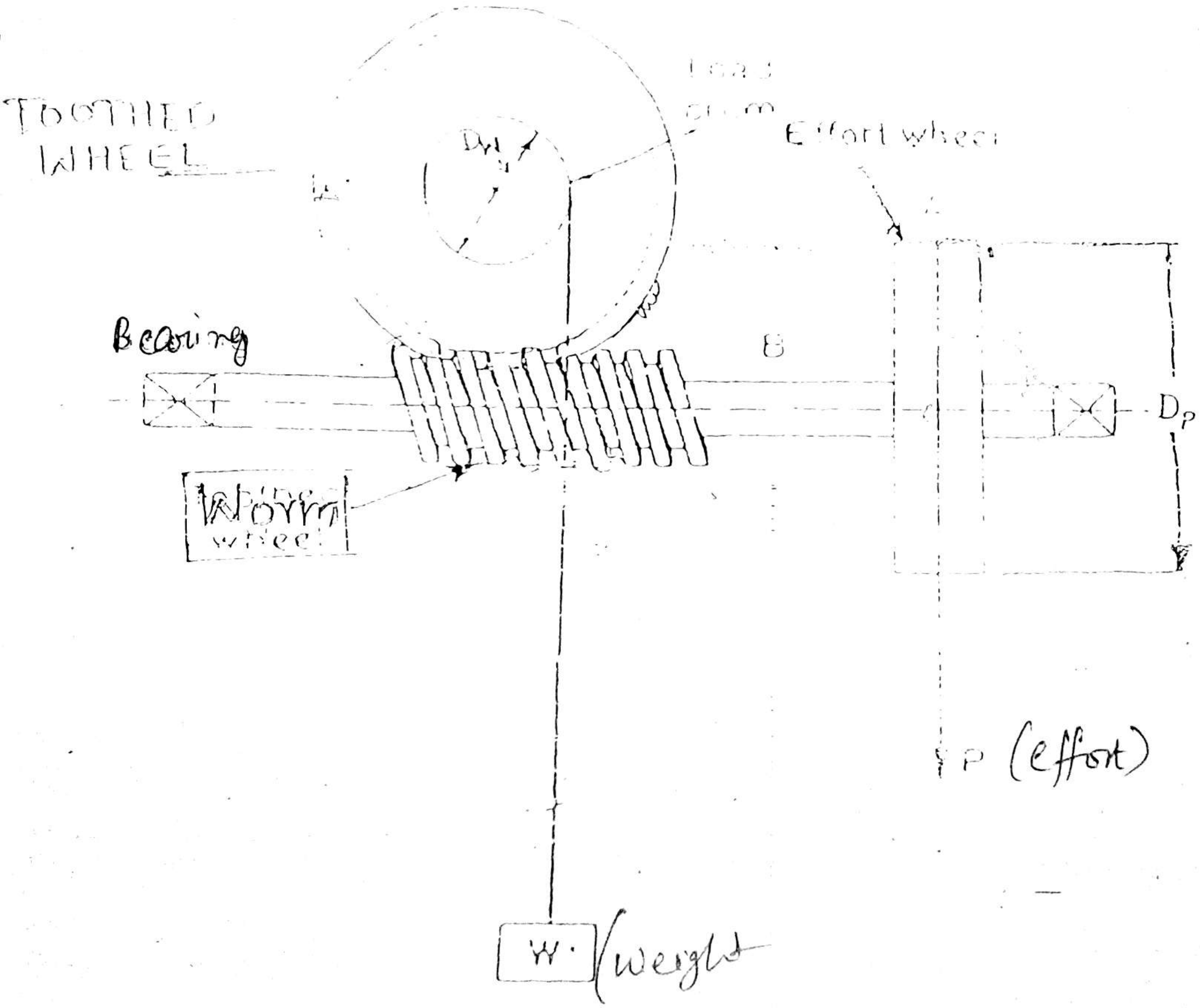

Fig:- WORM AND WORM WHEEL

9

EXPERIMENT NO

AIM: [illegible] the velocity ratio, mechanical advantage and efficiency of Worm and Worm wheel

APPRATUS: [illegible]

THEORY:

[illegible] square threaded screw ([illegible]) and [illegible] wheel (Worm wheel) is geared together and their axes at right angles to each other. A wheel or pulley is attached to worm over which rope passes. A load drum is securely mounted on worm wheel. To find the Velocity ratio of machine if D_p be the diameter of the effort pulley and D_w that of load drum and T be the number of teeth on worm wheel and P be the pitch of teeth then for one revolution of effort pulley the distance moved by effort = πD_p

Now worm has revolved through one revolution that is each teeth in the worm wheel has move through a distance of P and load [illegible] distance $\frac{1}{T}$ then

$$T = \frac{\pi D_p}{T}$$

NOTE: For three start apparatus in one revolution [illegible] distance traveled by worm wheel is three teeth.

For half start apparatus in one revolution of worm distance traveled by worm wheel is half teeth

$V \cdot R = \frac{\text{Effort}}{\text{Load}}$

FORMULA USED

1) For three start 2

$$V.R. = \frac{D_p \times T}{D_w \times 3}$$ 2

2) For half start

$$V.R. = \frac{D_p \times T \times 2}{D_w}$$

$\Rightarrow V \cdot R \Rightarrow \frac{D_p \times T \times 2}{D_w}$ $D_p \rightarrow$ Effort, $D_w \rightarrow$ Load

PROCEDURE

1) Measure and note the circumference of effort and load pulleys so as to calculate their diameters.
2) Load the machine and find the effort just enable to raise the load
3) Repeat the process for changing loads

dist moved by effort = πD_p

for 1 rev of effort wheel

rev. [illegible] by load wheel = $\frac{1}{T}$

$\frac{N_2}{N_1} = \frac{1}{T_2}$

$\frac{N_1}{1} = \frac{1}{T}$ (single purchase)

for 1 rev. of load wheel load dist moved = πD_w

$N_2 = \frac{1}{T}$

$\frac{1}{T}$ $\frac{\pi D_w}{T}$

$V.R. = \frac{\text{dist moved by eff}}{\text{[illegible]}} = \frac{\pi D_p}{\text{[illegible]}} = \frac{D_p \times T}{D_w}$

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70 →

1 → 7   1 → 70

1.5 → $\frac{7}{1}$ × 1.5   1.5 → $\frac{70}{1}$ × 1.5

(Weight) Circumference of

D_w ⇒ $40 = \pi d$

D_w $d = 12.73$

OBSERVATION TABLE

SR. NO.	LOAD(W) Kg	EFFORT(P) Kg	MECHANICAL ADVANTAGE(W/P)	%EFFICIENCY MA/VR X 100
1				
2	1 kg	~~0.70~~ 0.07	14.28	6.51%
3	1.5 kg	0.095	15.27	6.97
4	2 kg	0.115	17.39	7.93%
5	2.5 kg	0.125	20	9.12%
6	3 kg	0.140	21	~~10~~ 9.58%
7	3.5 kg			

GRAPHS:

Plot curves for

1. Load Vs Effort
2. Load Vs Mechanical Advantage.
3. Load Vs Efficiency.

(Effort)

Circumference of (Right one)

⇒ $36.5 = \pi d$

$d = \frac{36.5}{\pi}$

D_p $d = 11.62$

RESULTS:

Mention the values of M.A., V.R., and Efficiency of the machine

PRECATION AND SOURCE OF ERROR:

1. Movement of worm and worm wheel should neither be very smooth nor very hard
2. String used should be inextensible.

POSSIBLE QUESTION:

1. What is the difference between wheel and axle and worm and worm wheel mechanisms? Which one is more efficient ?
2. Give any two practical applications of both mechanisms ?
3. What is simple machine and compound machine?

EXPERIMENT NO 10 8 9

AIM: To find bending moment in a simply supported beam under loading and draw the SFD & BMD

APPARATUS

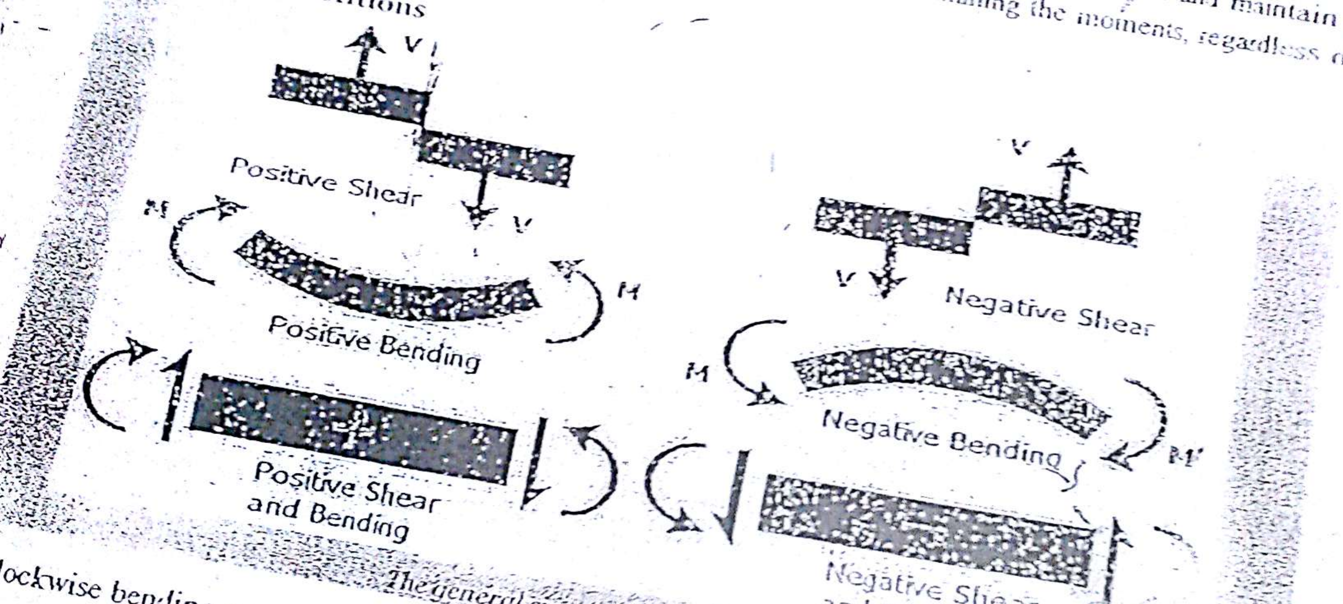
Simply supported beam, weights, scale

THEORY

A **bending moment** exists in a structural element when a moment is applied to the element so that the element bends. Moments and torques are measured as a force multiplied by a distance so they have as unit newton-metres (N m), or foot-pounds force (ft lbf)

The bending moment at a section through a structural element may be defined as "the sum of the moments about that section of all external forces acting to one side of that section". The forces and moments on either side of the section must be equal in order to counteract each other and maintain a state of equilibrium so the same bending moment will result from summing the moments, regardless of which side of the section is selected.

The Sign Conventions



The general sign convention of a beam.

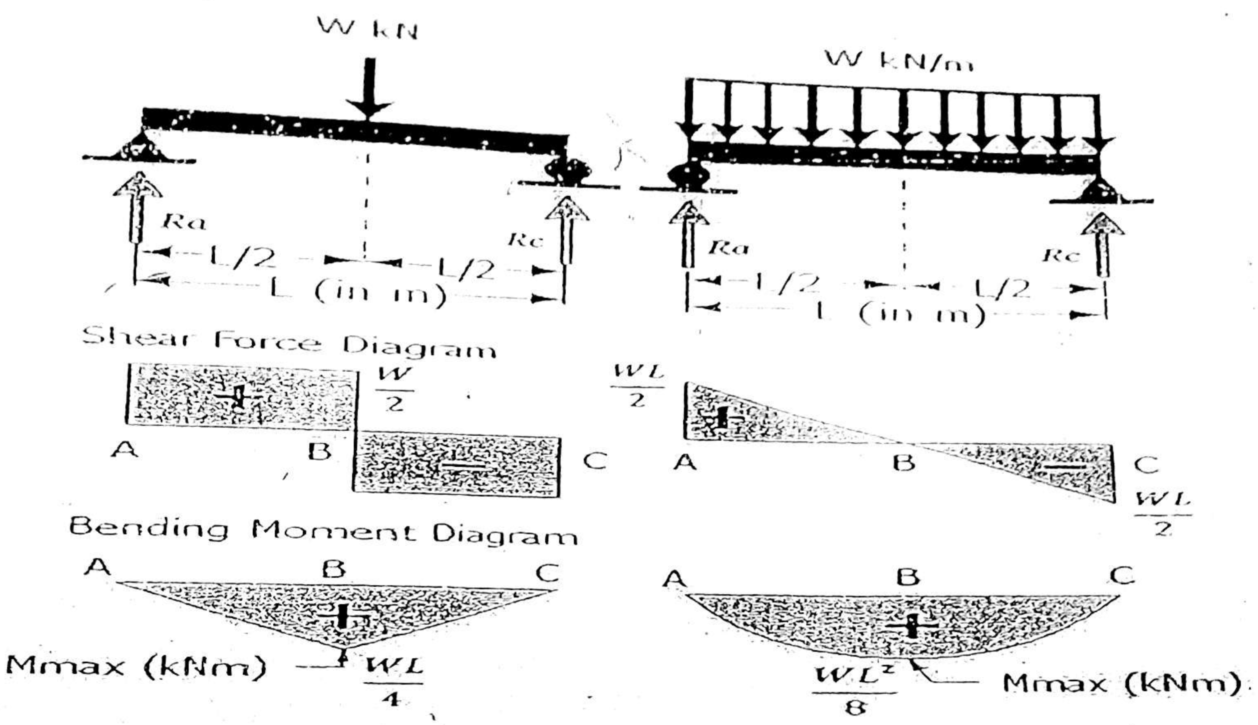
...lockwise bending moments are taken as negative, then a negative bending moment within ... ment ...cause "sagging", and a positive moment will cause "hogging". It is therefore clear the ... nt of ...bending moment within a beam is a point of contraflexure—that is the point of transition from ...g to sagging or vice versa.

...e common to use the convention that a clockwise bending moment to the left of the point under ...tion is taken as positive. This then corresponds to the second derivative of a function which, ...tive, indicates a curvature that is 'lower at the centre' i.e. sagging.

Critical values within the beam are most commonly annotated using a bending moment diagram, where negative moments are plotted to scale above a horizontal line and positive below. Bending moment varies linearly over unloaded sections, and parabolically over uniformly loaded sections.

Shear Force and Bending Moment in Simply Supported Beam

For a simply supported beam the reactions are generally simple forces. When the beam is built in the free body diagram will show the relevant support point as a reaction force and a reaction moment. It is normal practice to produce a free body diagram with the shear diagram and bending moment diagram position



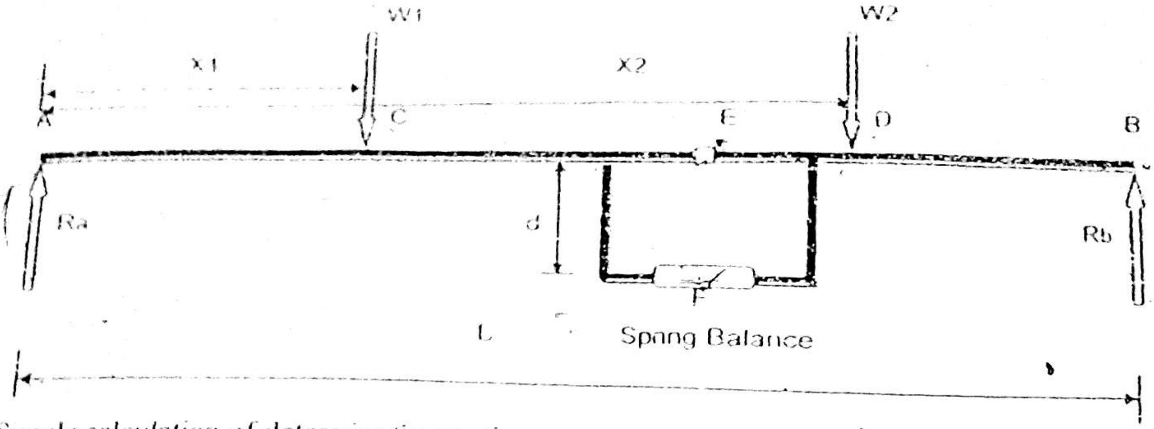
Shear Force and Bending Moment Diagrams in simply supported beam with two different loads.

The unknown forces (generally the support reactions) are then determined using the Equation of Equilibrium:

- Horizontal reaction respect to x-axis; $\Sigma Fx = 0$
- Vertical reaction respect to y-axis; $\Sigma Fy = 0$
- Bending reaction (clockwise or anti-clockwise), $\Sigma M = 0$

Shear Force and Bending Moment Diagrams

The shear force diagram indicates the shear force withstood by the beam section along the length of the beam. The bending moment diagram indicates the bending moment withstood by the beam section along the length of the beam



Simple calculation of determine the reactions
Taking $\Sigma F_y = 0$, we get
$R_A + R_B = W_1 + W_2$ ------------------------------ (i)

0.55

$\Sigma Ma = 0$ (taking clockwise as +ve at point A)
$(W_1 \times X_1) + (W_2 \times X_2) - (R_B \times L) = 0$ ------------------------------ (ii)

Using eqn. (i) and (ii), we find value of R_A and R_B.

The shear force diagram (SFD) is simply constructed by moving a section along the beam from the left origin and summing the forces to the left of the section. The equilibrium condition states that the forces on either side of a section balance and therefore the resisting shear force of the section is obtained by this simple operation.

SFD

$F_{A(left)} = 0$, $F_{A(right)} = +R_a$, $F_{C(left)} = +R_a$, $F_{C(right)} = +R_a - W_1$, $F_{E(left)} = +R_a - W_1$; $F_{E(right)} = +R_a - W_1$,
$F_{D(left)} = -R_b + W_2$, $F_{D(right)} = -R_b$, $F_{B(left)} = -R_b$, $F_{B(right)} = 0$.

On the other hand, bending moment diagram (BMD) is obtained in the same way except that the moment is the sum of the product of each force and its distance of x from the section either left or right. Distributed loads are calculated buy summing the product of the total force (to the left of the section) and the x distance of the distributed load centroid.

$M_A = 0$, $M_C = +R_A \times X_1$, $M_E = +R_A \times AE - W_1 \times CE$, $M_D = +R_B \times BD$, $M_B = 0$
(all in Nm)
Also $M_E = F \times d$ (Spring balance reading x length of arm)
The basic procedure for determining the shear and moment is to determine the values of Shear Force and Bending Moment at various sections along the beam and plotting the results from point to point. By doing so, we will be able to determine critical sections within the beam where a critical or maximum stress might occurs.

- Section of Maximum Shear – Since the shear, at any transverse section of the beam is the algebraic sum of the transverse forces to the left of the section, the shear, in most cases can be estimated at a glance.
- Section of Maximum Moment – It can be obtained mathematically, that when the shear force is zero or changes sign, the bending moment, M will be either a maximum or relative maximum.

PROCEDURE

1. Bring the unloaded beam to the horizontal position by adjusting the screw on the spring balance
2. Place the two loads at some distance on the beam.
3. Again bring the beam to horizontal position by adjusting the screw on spring balance
4. Note down the distance of the loads on the beam from any end and the reading on spring balance
5. Repeat step 2 to 4 for taking five readings.

3.84
3.70
0.14

OBSERVATION TABLE

Initial ⇒ 21 N

S.No.	Distance of W1 from left end X1 (m)	Distance of W2 from left end X2 (m)	Load W1 (N)	Load W2 (N)	Reading in spring balance (N)	Length of arm d (m)	Experimental Bending Moment (Nm)	Analytical Bending Moment (Nm)
1.	.40	1.60	9.8	9.8	30	0.32	2.88	
2.	.50	1.50	9.8	9.8	33	0.32	3.84	

28 → ...
22
24
17
15

RESULTS AND CALCULATIONS

$(33-21)\times 0.32$

R_A R_B

DISCUSSION

Comment on sources of error and random variation in recorded data.
Comment on possible explanation of differences between recorded data and theoretical predictions.

$R_A + R_B = W_1 + W_2$

~~$R_A + R_B = W_1 + W_2$~~

$(W_1 \times x_1) + (W_2 \times x_2) = (9.8)2$

$(9.8 \times 0.40) + (9.8 \times 1.60) = (9.8)L$

$9.8(0.50 + 1.50) =$

19.6
10.8
8.8

9.8
0×2
19.6