Practical No. 2: Determine mechanical advantage and velocity ratio of differential axle and wheel for different load and efforts.

I. Practical Significance

There is often a need to lift loads and different lifting machines are used depending on the type of load, intensity of the load and other site conditions. Differential axle and wheel machines are used to lift smaller loads in confined spaces. After conducting this experiment, a graduate engineer will be able to assess the suitability of the differential axle and wheel based on the given load lifting situation.

II. Industry/Employer Expected Outcomes

Apply the principles of engineering mechanics to analyze, design and automation the prototypes and equipment's of various industries.

III. Course Level Learning Outcome(s)

CO1-Select the suitable machine under given loading condition.

IV. Laboratory Learning Outcome(s)

Verify law of machine under the given condition.

V. Relevant Affective Domain related Outcome(s)

a. Follow safety practices and precautions.
b. Demonstrate working as a leader/a team member.
c. Maintain tools and equipment.

VI. Relevant Theoretical Background

Differential axle and wheel: It is different from simple axle and wheel machine because of its axle configuration. Instead of prismatic single axle in simple wheel and axle, step down axles is used in differential axle and wheel. This machine has a better mechanical advantage as compared to single axle and wheel. Two axles of different diameters are coaxially fitted with the spindle with which a wheel is also coaxially attached. The effort is applied through a wrapped string wound around this wheel. Another string is wound over two axles and carries load with the help of movable pulley. The rope on the wheel and smaller axle are wound in the same direction, whereas that on the larger axle is in opposite direction. When an effort is applied through the wheel, the rope on the wheel and smaller axle get sun wound but gets wound on the larger axle, thus lifting the load.

$$\text{Velocity Ratio (V.R.)} = \frac{\text{Distance Travalled by Effort}}{\text{Distance Travalled by Load}}$$

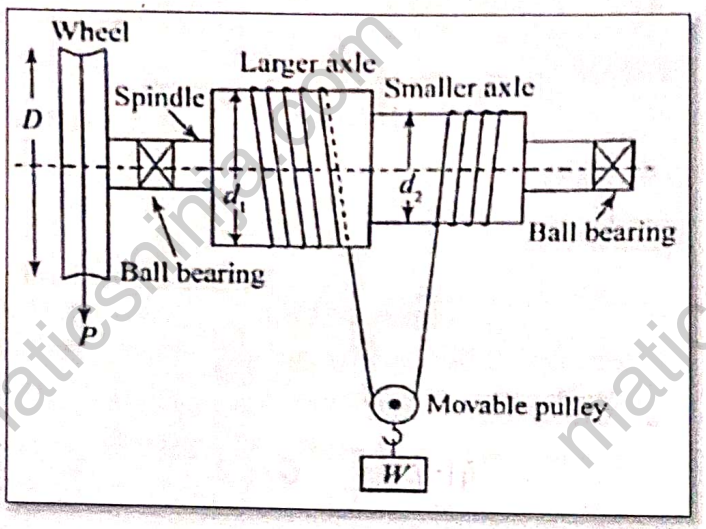
$$= \frac{\pi D}{\frac{\pi (d1-d2)}{2}}$$

$$\text{V.R.} = \frac{2D}{d_1-d_2}$$

Where,

D =Diameter of effort wheel.
d_1 =Diameter of larger axel.
d_2 =Diameter of smaller axle.

VII. Actual diagram used in laboratory with equipment specifications.



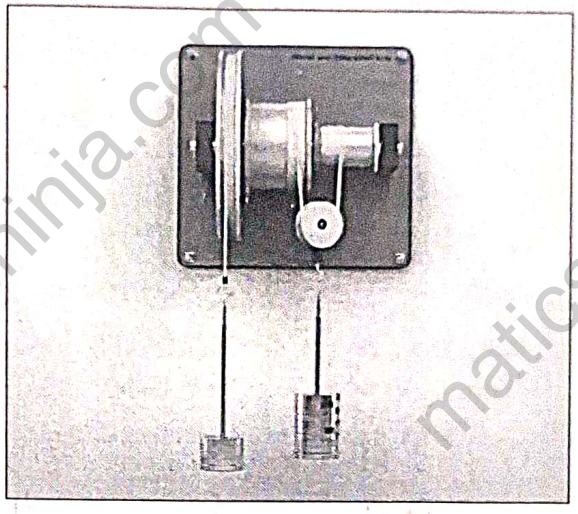


Fig. 2.1 Differential Axle and Wheel

VIII. Requires Recourses/Apparatus/Equipment with Specifications

Sr. No.	Broad Specifications	Quantity	Remarks (If Any)
1	Differential Axle and Wheel	Differential Axel and wheel(wall mounted unit)with wheel of 40 cm diameter andaxelsareinstepsof20cmand10cm reducing diameter	01for Group of 4 to 5students.

IX. Precautions to be followed

1. The reading must be taken and noted down carefully.
2. The load and effort should move slowly.
3. Effort must be applied gradually.
4. Any overlapping of the string must be avoided.
5. There should be no knot in the string.
6. Only light weights must be used during the course of experiment.

X. Procedure

1. Observe the machine carefully and identify the various components of machine.
2. Set the machine and check the reversibility of machine.
3. Calculate friction in the machine at zero load.
4. Apply the load starting with smaller magnitude.
5. Apply the effort for each corresponding load.
6. Record the observations of load and effort in observation table.

7. Take at least five readings.
8. Determine M.A., V.R., Efficiency, Ideal effort and Effort lost in friction,
9. Plot graphs viz. load against effort and load against efficiency.

Observations and Calculations

$$V.R. = \frac{2D}{d_1 - d_2} = \frac{2 \times 400}{200 - 100} = \frac{800}{100} = 8$$

1. D = 400 .....mm
2. d_1 = ..200.....mm
3. d_2 = ...100.....mm

XI. Observations Table

Sr. No.	Load W (N)	Effort P (N)	M.A.	Velocity Ratio	Efficiency η (%)	Ideal Effort Pi(N)	Effort Lost in Friction Pf (N)
1	5 N	1.5	3.33	8	41.62	0.625	0.875
2	10 N	2.5	4		50	1.25	1.25
3	15 N	3.5	4.28		53.5	1.875	1.625
4	20 N	4.5	4.44		55.5	2.5	2
5	25 N	5.5	4.54		56.75	3.125	2.375

Sample Calculations

$$M.A. = \frac{\text{Load}}{\text{Effort}} = \frac{W}{P} = \frac{5}{1.5} = 3.33, \frac{10}{2.5} = 4, \frac{15}{3.5} = 4.28$$

$$\text{Efficiency } (\eta) = \frac{M.A.}{V.R.} \times 100\% = \frac{3.33}{8} \times 100 = 41.62, \frac{4}{8} \times 100 = 50$$

$$P_i = \frac{W}{V.R.} = \frac{5}{8} = 0.625, \frac{10}{8} = 1.25, \frac{15}{8} = 1.875, \frac{20}{8} = 2.5, \frac{25}{8} = 3.125$$

$P_f = P - P_i = 1.5 - 0.625 = 0.875$, $2.5 - 1.25 = 1.25$, $3.5 - 1.875 = 1.625$

Law of Machine is $P = mW + C = 1.5 = 0.2 \times 5 + C$

$= 1.5 = 1 + C$

Where, $C = 1.5 - 1 = 0.5$

$$M = \text{Slope} = \frac{P2 - P1}{W2 - W1} = \frac{2.5 - 1.5}{10 - 5} = 0.2$$

C = Y intercept (i.e. Machine Friction) = 0.5 N

XII. Results

1. The law of machine is P = (.0.2.....) W + (.0.5.....) N

2. The average efficiency of machine is = 51.47 %

XIII. Interpretation of results

Machine is reversible

Friction loss is (i.e.Y– intercept = 0.5) reduced by the machine.

The graph between Load and effort is a straight line which indicates.....

The graph between load and efficiency is a curve which indicates.....

XIV. Conclusions and Recommendations

Analysed machine is reversible.

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.

1. Is Differential Axle and wheel reversible? Why?
2. Identify the effort required for zero load?
3. Whether the given machine is reversible or not? Give reason.
4. Why the graph of load versus ideal effort passes through the origin?
5. Determine the effort required to lift the load of 400kN from law of machine.

Space for answers

Q1 ——— ?

Ans:- yes differential axle and wheel is reversible because its efficiency is more than 50%.

Q.2 ⟶ ?

Ans:- Law of Machine

$P = 0.2W + 0.5$

put $W = 0$

$P = 0.2 \times 0 + 0.5$

$P = 0.5\ N$

Q: 5 ⟶ ?

Ans:- W = 400 kN = 400000 N

We know that

$P = 0.2\,W + 0.5$

$= 0.2 \times 400000 + 0.5$

$P = 80,000\ N$

$\boxed{P = 80\ kN}$

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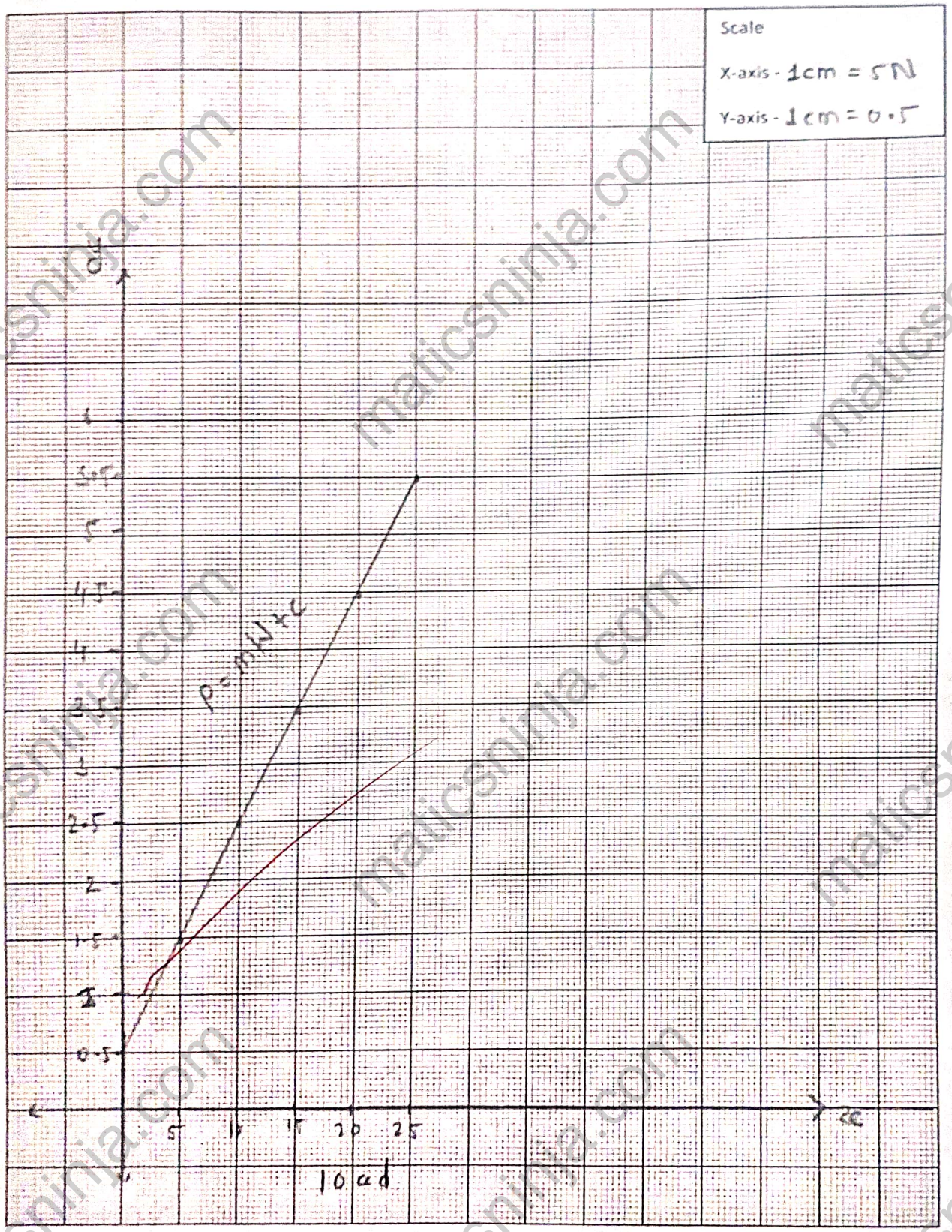
Scale
X-axis - 1cm = 5N
Y-axis - 1cm = 0.5
P=mW+c
Load