Practical No. 6: Determine mechanical advantage and velocity ratio of Weston's differential pulley for different load and effort.

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. Weston's differential pulley block is used for lifting heavy loads in confined spaces. After conducting this experiment, a graduate engineer can evaluate the suitability of the Weston differential pulley block 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

Weston's Differential Pulley Block: This differential pulley block was invented by Thomas Aldridge Weston from king's Norton, England, in 1854. Hence, this simple machine is also called as Weston's differential pulley block. This is a special type of pulley system, which is normally used to hoist very large masses to small distance, for example, the pulley system is used for manually lifting car engines. This system consists of two fixed pulleys of unequal radii, which are coaxially attached to each other and can rotate together and are fixed to the support, a single pulley hanging at the bottom and holding load and an endless rope wrapped around the pulleys. In order to avoid slipping, generally rope is substituted by a chain and connected to pulleys by sprockets (i.e. tooth or cogs on pulleys). The displacement of the effort in one revolution of upper pulley block = πD. This is also equal to length of the chain pulled over the large pulley. Since the smaller pulley also turns with the larger one, therefore length of the chain released by the smaller pulley = πd. Net shortening of the chain = $\pi D - \pi d = \pi (D-d)$. This shortening of chain will be equally divided between the portion of the chain, supporting the load. Therefore, the distance the load moves up by a distance $\pi (D-d)/2$.

$$\text{Velocity Ratio (V.R.)} = \frac{2D}{D-d}$$

$$= \frac{2T_1}{T_1 - T_2}$$

7. Measure the radius or number of cogs of larger and smaller pulley.
8. Determine M.A., V.R., Efficiency, Ideal effort and Effort lost in friction for given Weston's Differential pulley block.
9. Plot graphs viz. load against effort and load against efficiency.

Observations and Calculations

$$V.R. = \frac{2D}{D-d} = \frac{2T_1}{T_1 - T_2} \quad \frac{2 \times 200}{200-150} = \frac{400}{50} = 8$$

1. T_1 = D = 200 ..... No.
2. T_2 = d = 150 ..... No.

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	50	28	1.78	8	22.25	6.25	21.75
2	100	44	1.85		28.12	12.5	41.5
3	150	104	1.44		18	18.78	85.25
4	200	128	1.56		19.5	25	1.4
5	250	150	1.66		20.75	31.25	118.25

Sample Calculations

$$M.A. = \frac{\text{Load}}{\text{Effort}} = \frac{W}{P} = \frac{50}{28} = 1.78$$

$$\text{Efficiency } (\eta) = \frac{M.A.}{V.R.} \times 100\% = \frac{1.78}{8} \times 100 = 22.75$$

$$P_i = \frac{W}{V.R.} = \frac{50}{8} = 6.25$$

$$P_f = P - P_i = 28 - 6.25 = 21.75$$

Law of Machine is P = mW + C

Where,

$$M = \text{Slope} = \frac{P2-P1}{W2-W1} = \frac{54 - 28}{100 - 50} = \frac{26}{50} = 0.52$$

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

XII. Results

1. The law of machine is P = (.0.52..) W + (...2.....) N

2. The average efficiency of machine is = 20.72 %

XIII. Interpretation of results

Machine is .non...reversible

Friction loss is (i.e. Y – intercept = ..2.....) reduced by ....2.... 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.....

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XIV. Conclusions and Recommendations

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The machine is used to light the heavy load lever.

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. Calculate the maximum MA and maximum efficiency.
2. State the given machine is reversible or not. Give reason.
3. Why effort is required for zero load?
4. Write use of snatch block in working of machine.
5. State the two situations in field where differential pulley block is used.

Space for answers

① Maximum MA = $\frac{1}{m}$ = $\frac{1}{0.82}$ = 1.92

η max = $\frac{1}{n \times V.R}$ x 100

= $\frac{1}{0.52 \times 800}$ x 100

= 24%

② The machine in non-reversible because efficiency is less than 50%.