Topic: Combination of pulleys

Please read the topic mentioned above from your text book and the attached notes. Then work out the exercises neatly with black ink in your big single lined (64pages) note book henceforth. Make the content page with the columns as shown below. Ensure neat and tidy work.
Mechanical Advantage:

Effort \( E = T_3 \)  

The two segments of the string passing over the pulley A supports the load \( L \)

Therefore, Tension \( T_1 \), is given by

\[
2T_1 = L
\]

Or, \( T_1 = L/2 \)  

Similarly, the two segments of the string passing over the pulley B supports the Tension \( T_1 \). So, Tension \( T_2 \) is given by

\[
2T_2 = T_1
\]

Or \( T_2 = T_1/2 = L/2^2 \) (from eg. ii)
Similarly, Tension $T_3$ in the string passing over the pulley C in
given as $2T_3 = T_2$
Or $T_3 = T_2 / 2 = L/2^3$ (from eg. iii) - - - (iv)

From eq (iv)
Load $L = 2^3 x T_3$

From eq (i) and (iv)
$E = L/2^3$

$\text{M.A.} = L/E = L/L/2^3 = 2^3$

In general, if there are $n$ movable pulleys with one fixed pulley, the mechanical advantage is
$\text{M.A.} = 2^n$

**Velocity Ratio**

If the load $L$ attached to pulley A moves up a distance $\alpha$ then
the string connected to the axle of pulley B moves up by a
distance $2\alpha$, the string connected to the axle of pulley C moves
up by a distance $2 \times 2\alpha = 2\alpha$ and as such

$V.R = \text{distance moved by the effort} / \text{distance moved by the load}$

$2^3 \alpha / \alpha = 2^3$

In general, if there are $n$ movable pulleys connected to a fixed
pulley, the velocity ratio

$V.R.2^n$

**Efficiency:**

Efficiency $= \text{M.A.} / V.R = 2^n / 2^n = 1$ or 100%

**Effect of weight of pulleys on M.A, V.R and Efficiency**
Let \( n \) be the number of pulleys and \( w \) be the total weight of the lower block along with the pulleys in it.

\[
E = T \quad \text{and} \quad L + w = n \ T
\]

Or \( L = n \ T - w = n \ E - w \)

M.A. = \( \frac{L}{E} \)

\[
= \frac{n \ E - w}{E} = n - \frac{w}{E}
\]

The velocity ratio doesn't change, it remains \( n \)

\( V.R = n \)

Efficiency = \( \frac{\text{M.A.}}{V.R} \)

\[
= \frac{n - w}{E} / n
\]

\[
= 1 - \frac{w}{En}
\]

For greater efficiency, the pulleys in the lower block should be as light as possible.

**Exercise**

1) A woman draws water from a well using a fixed pulley. The mass of bucket and water together is 6kg. The force applied by the woman is 70N . Calculate the mechanical advantage ( Take \( g = \text{ms}^{-2} \))

2) A fixed pulley is driven by a 180kg mass falling at a rate of 8.0m in 4.0s. It lifts a load of 75kgf. Calculate

   i) The power input to the pulley taking the force of gravity on 1kg as 10N .

   ii) The efficiency of the pulley.

3) A single fixed pulley and a movable pulley both are separately used to lift a load of 50kgf to the same height. Compare the efforts applied.
4) In a block and tackle system consisting of three pulleys, a load of 75kgf is raised with an effort of 25 kgf. Find
   i) the mechanical advantage
   ii) the velocity ratio
   iii) the efficiency.

5) A pulley system has a velocity ratio 3. Draw a diagram showing the point of application and direction of load (L), effort (E) and tension (T). It lifts a load of 150N by an effort of 60N. Calculate its mechanical advantage.

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