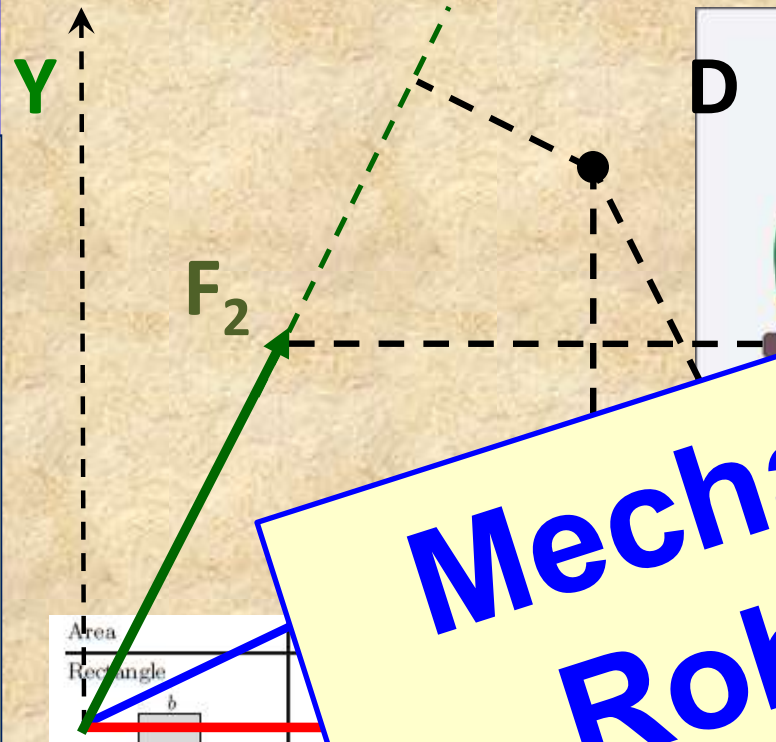
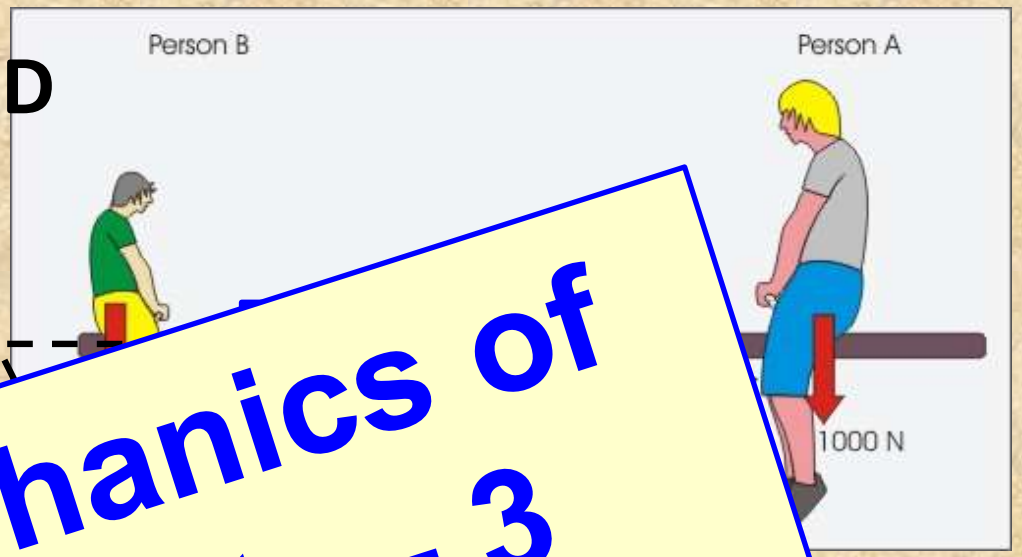
Vishwakarma Institute of Technology

FY - Department of Engineering, Sciences and Humanities





Mechanics of Robots - 3

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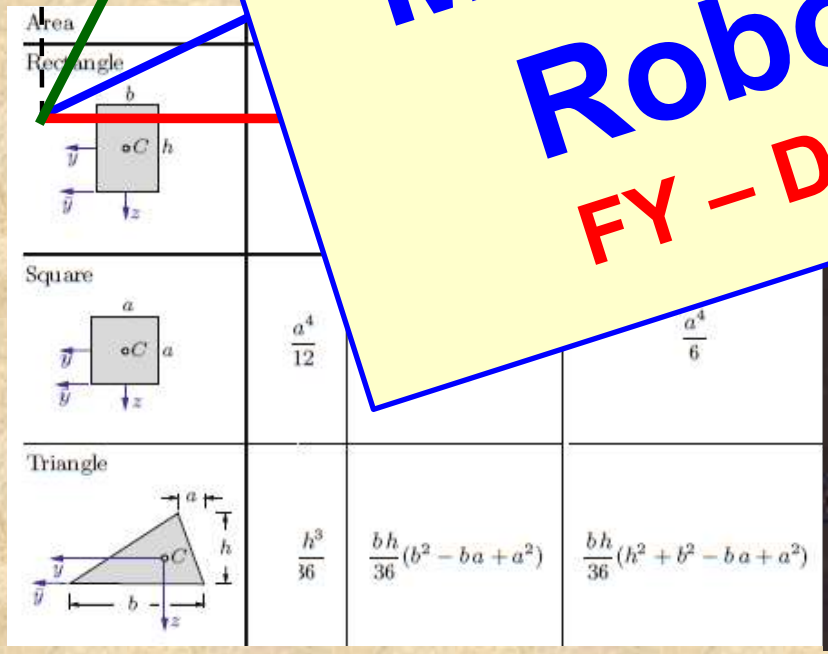
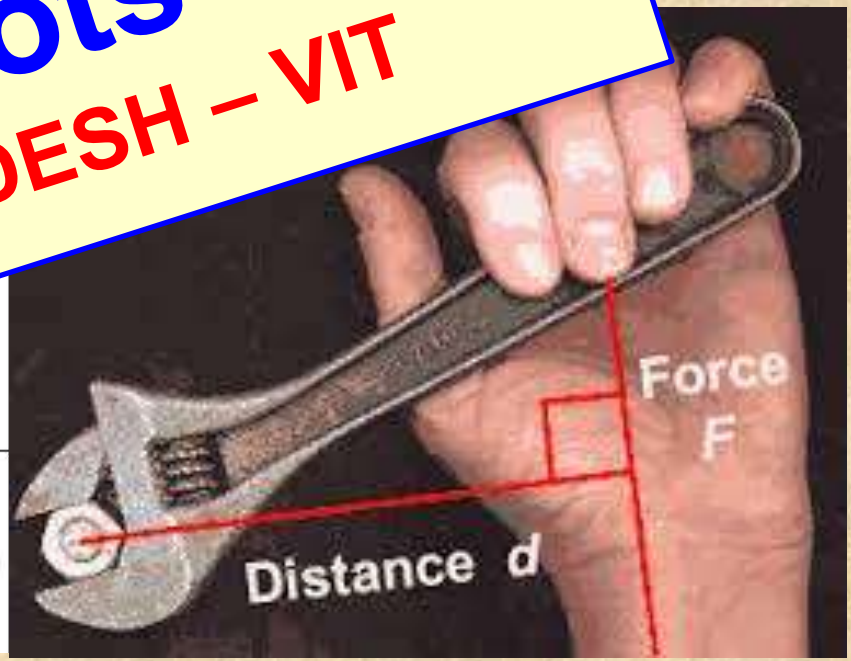
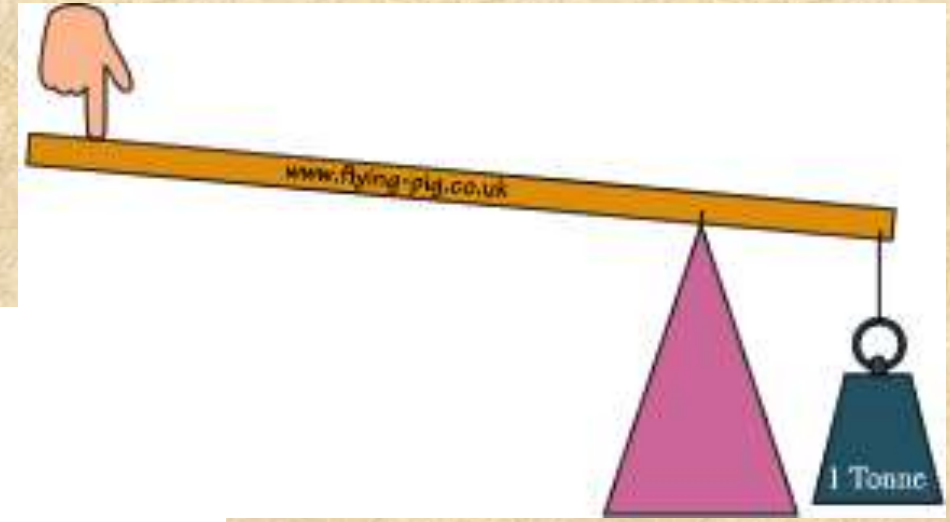
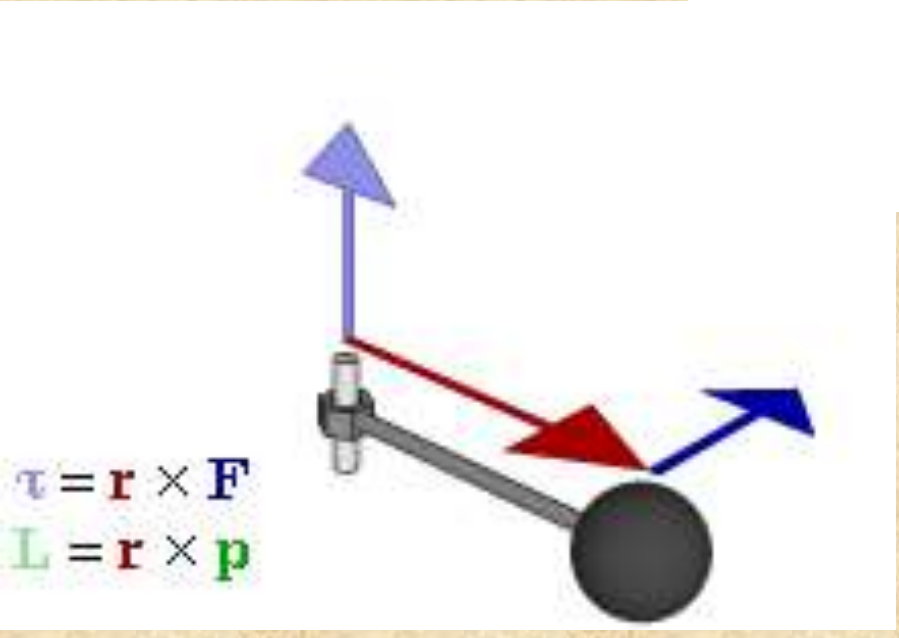
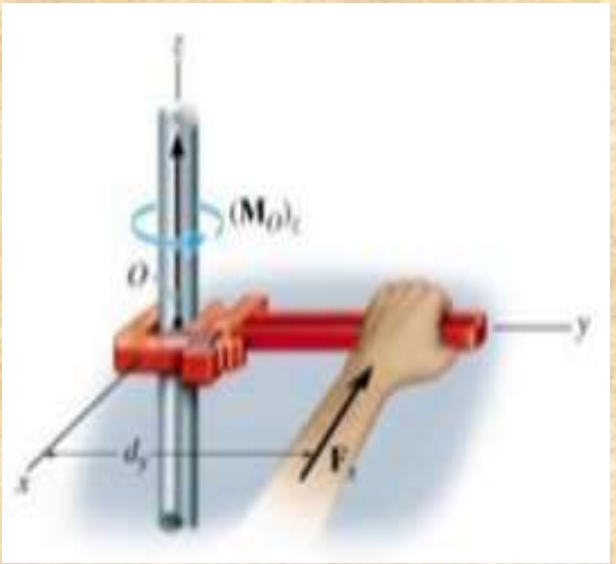




Observe these actions carefully -



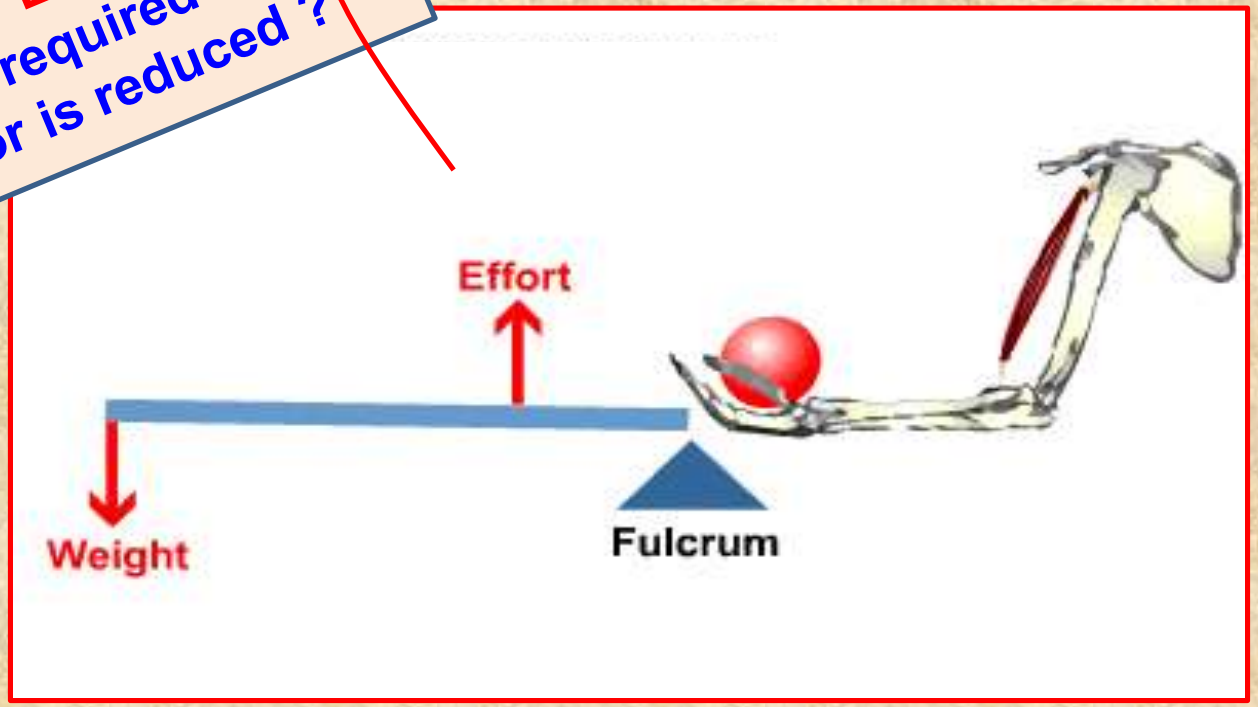




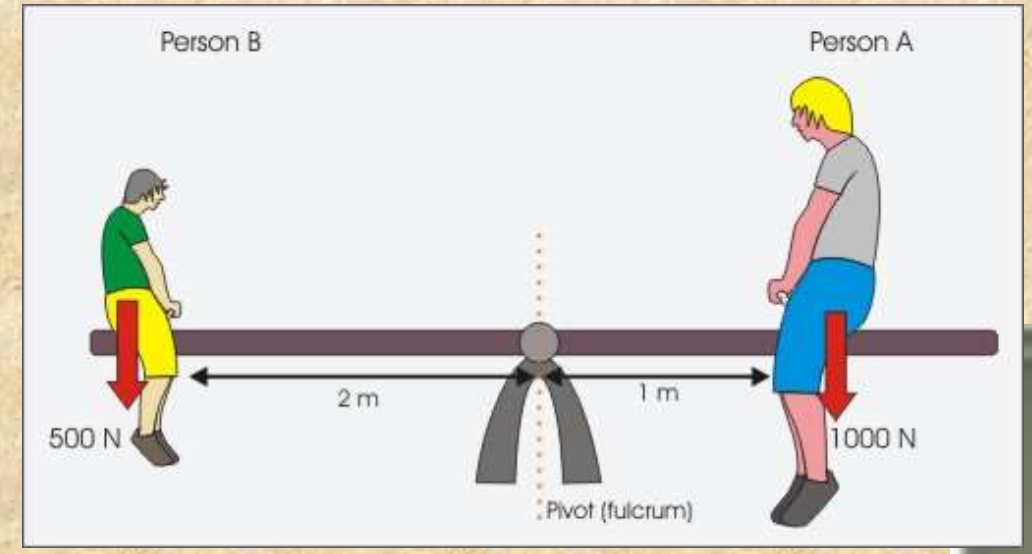
Observe these actions carefully -

In Robotics, this Effort is provided by an actuator for e.g. an electric motor or pneumatic actuator. The load), the different distances should be used to calculate the power of the actuator.

Can you suggest a better location for Effort so that the Power required by the Actuator is reduced ?



Observe these actions carefully -



Moment of a Force is ……..

…. the Turning effect produced by the force on the body.

…. a measure of its tendency to cause a body to rotate about a specific point or axis. (also known as Torque)

A moment is due to a force not having an equal and opposite force directly along it's line of action. Thus ….

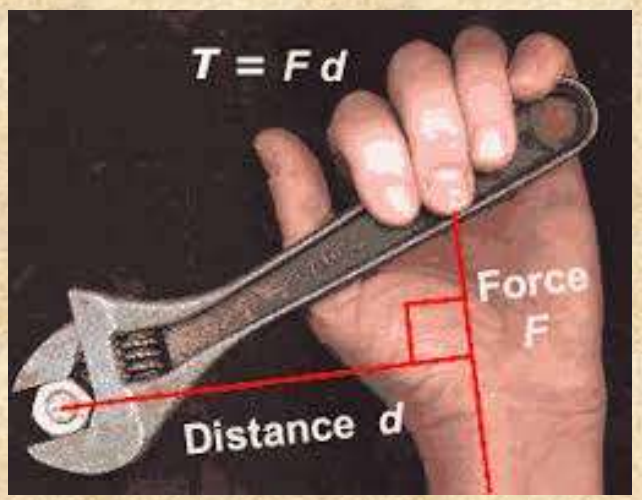
Torque = Force x Distance (⊥)

The moment of the force is zero when either …..

1) the force is zero

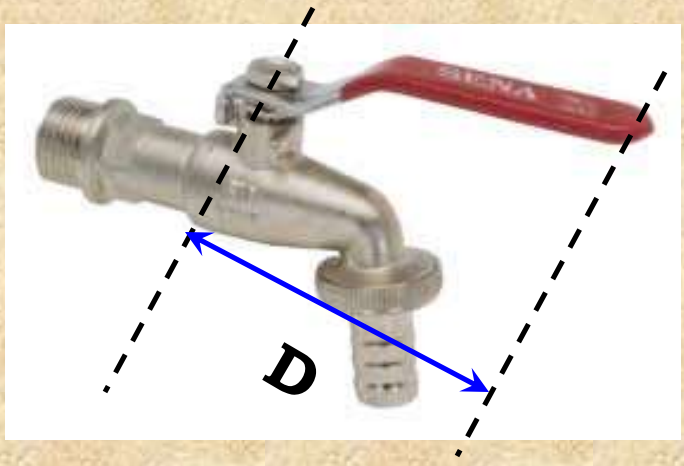
OR

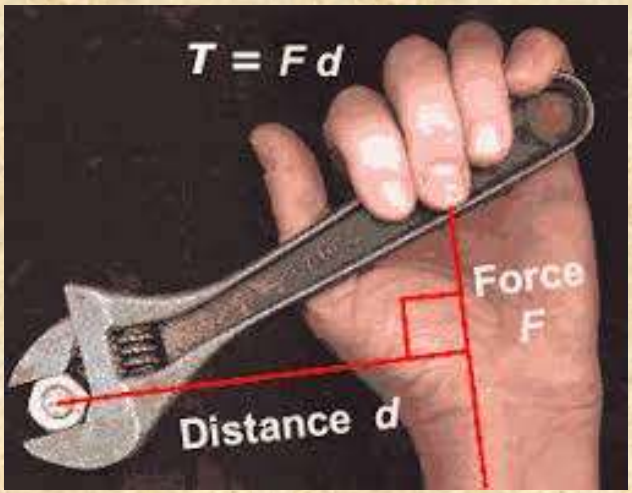
2) when the perpendicular distance is zero



Moment of a Force ……..

Which tap is EASY to operate ?





Moment of a Force ……..

Comment on these two photos ….

Couple -

Comment on the two steering positions in the above images.

Couple -

A couple is formed by two forces that are …..

a) equal in magnitude ,
b) opposite in direction and
c) parallel in action

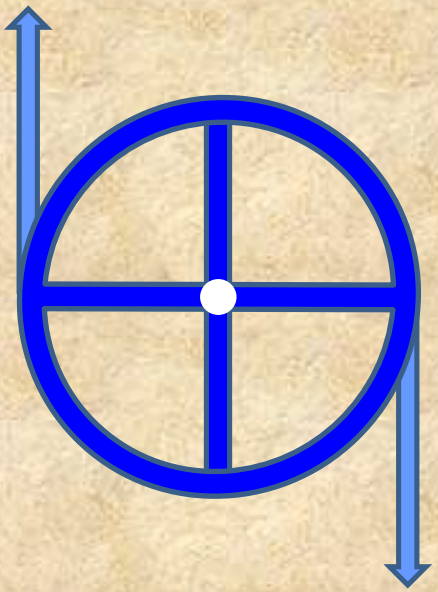
- The effect of a couple on the body is to produce **rotation**.

- **Moment of Arm of Couple -** The perpendicular distance between the two lines of action of forces forming the couple is called the " **Moment Arm**" of the couple.

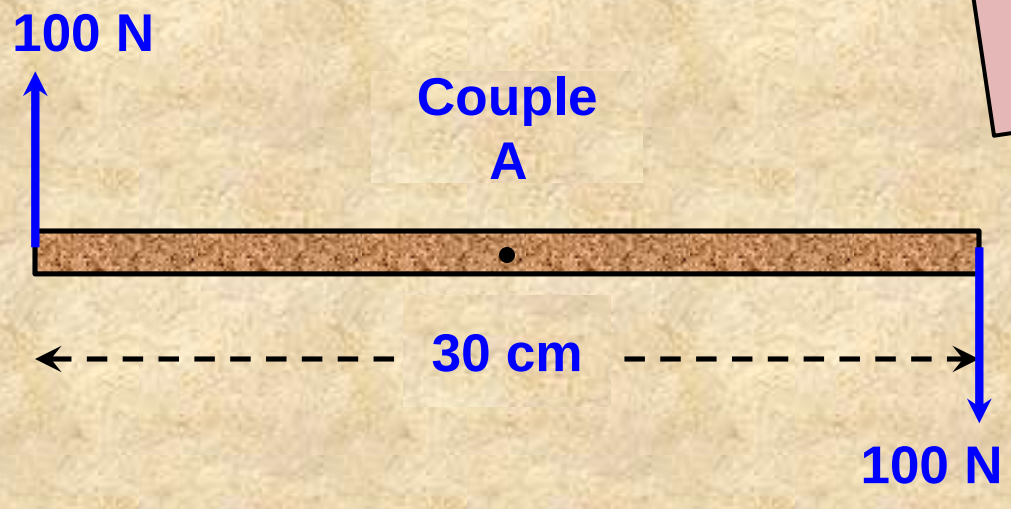
- The **magnitude** of couple is defined as the **product** of the **magnitude** of the force and the moment arm.

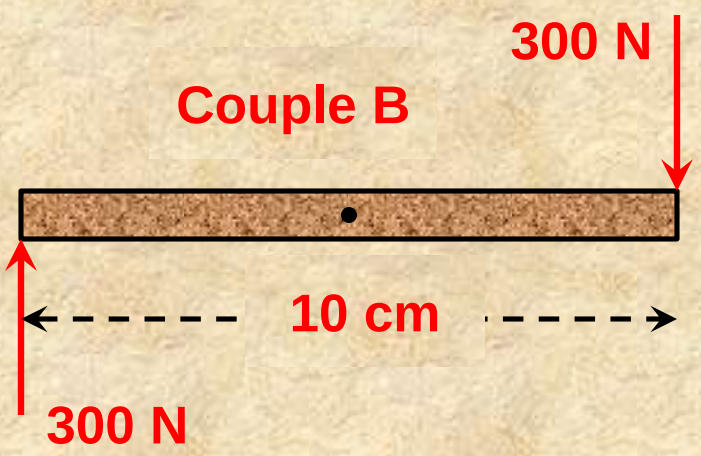
- The sense of the couple could be CW (**–ve**) or CCW (**+ve**). Couple is measured in "**N-m**".

Couple -



Couple -





Are both the couples Equivalent ...?

For equivalence ....

couples should have

1) Same magnitude

2) Same sense

Which one is easy to operate manually ? Why ?

Do both have the same sense ?

Moment of Inertia of a body

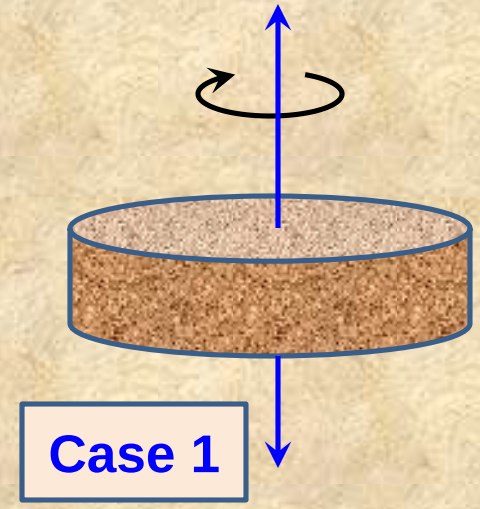
M.I. is a quantity which expresses a *tendency to resist angular rotation.*

It is just like …..
How much force is required to linearly accelerate a mass ?
How much torque is required to angularly accelerate a mass ?

The amount of torque needed to cause any given angular acceleration (the rate of change in angular velocity) is proportional to the moment of inertia of the body.

Moment of Inertia is also called as Second Moment of Area OR Area Moment of Inertia.

Moment of Inertia of a body -

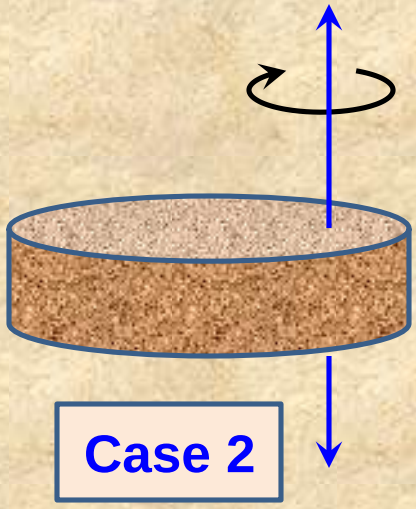


Case 1

The body rotates about a certain axis. If the axis changes, the moment of inertia of the body will definitely change.

Will the M.I. change ? ...Justify !

Which case will have higher M.I. ? ...Justify !



Case 2

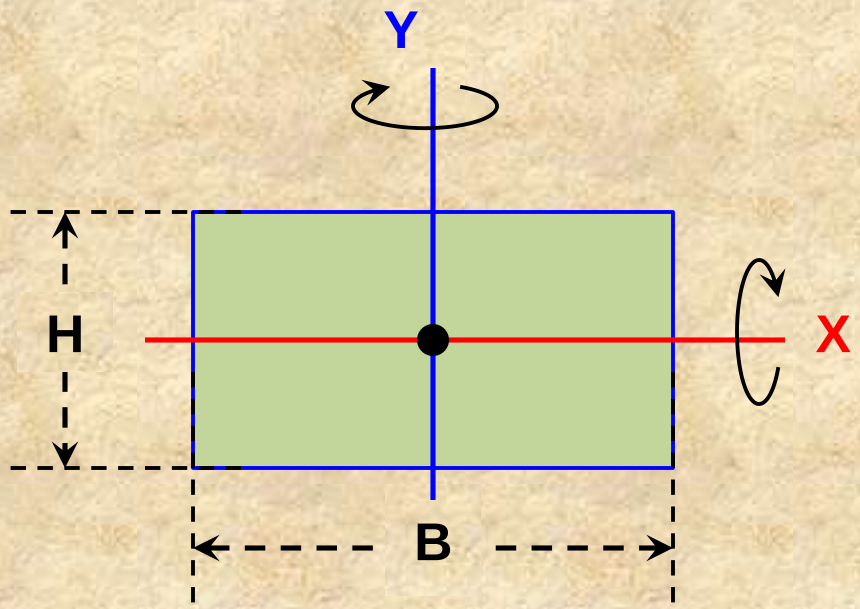
Moment of inertia is defined as the product of mass of section (m) and the square of the distance (r^2) between the reference axis and the Centroid of the section.

$$I_P = \sum_{i=1}^{N} m_i r_i^2$$

m_1 , m_2 , m_3 ..... are the masses of all particles.

r_1 , r_2 , r_3 ..... are the respective distances (squared) from the axis of rotation.

Moment of Inertia of a body – list of formulae



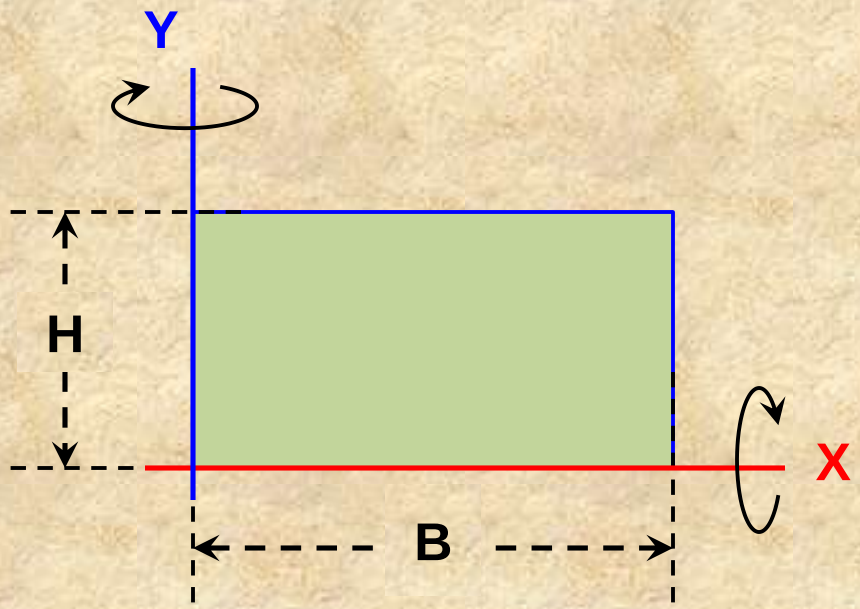
About	Formula
X	$\frac{B H^3}{12}$
Y	$\frac{B^3 H}{12}$

Point of confusion :- Which term to be cubed ? B or H ?

That length which is at right angles to the axis of rotation ……

Point to remember : axes are passing through the centre ….

Moment of Inertia of a body – list of formulae

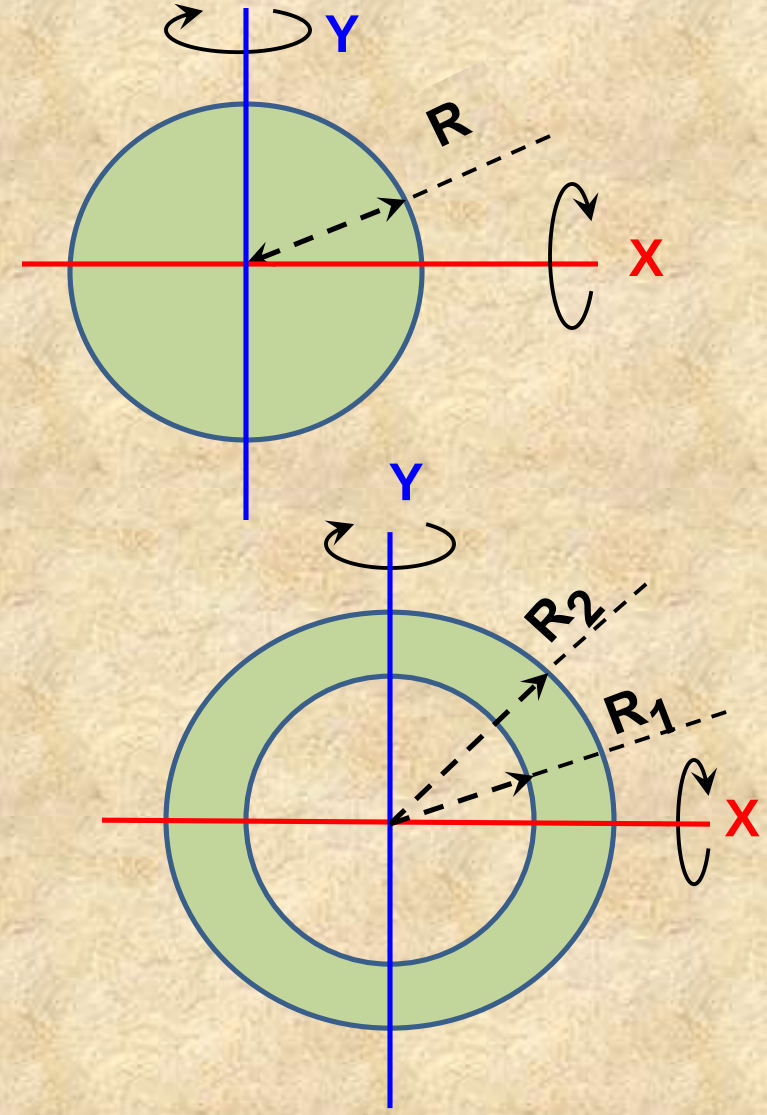


About	Formula
X	$\frac{B H^3}{3}$
Y	$\frac{B^3 H}{3}$

Why the M.I. is higher in this case ?

(axes are on the edges)

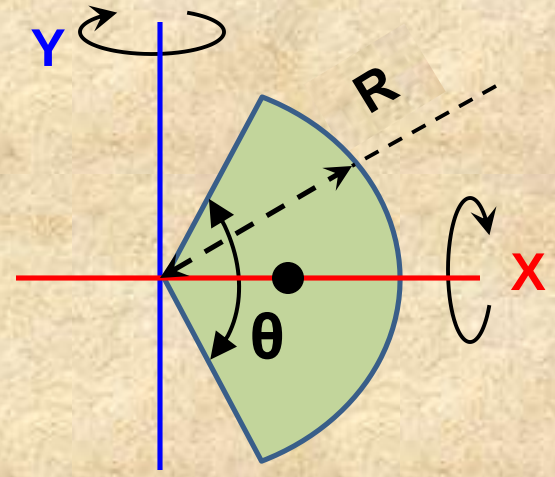
Moment of Inertia of a body – list of formulae



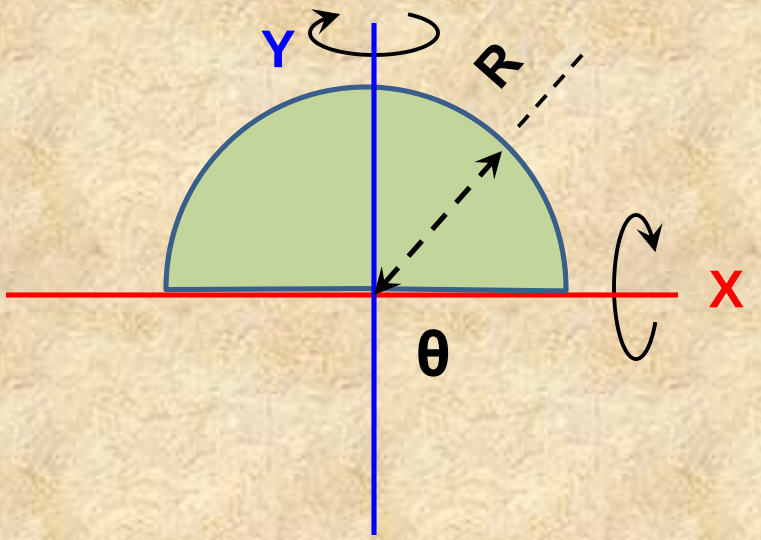
About	Formula
X	$\frac{\pi R^4}{4}$
Y	$\frac{\pi R^4}{4}$

X	$\frac{\pi (R_2^4 - R_1^4)}{4}$
Y	$\frac{\pi (R_2^4 - R_1^4)}{4}$

Moment of Inertia of a body – list of formulae

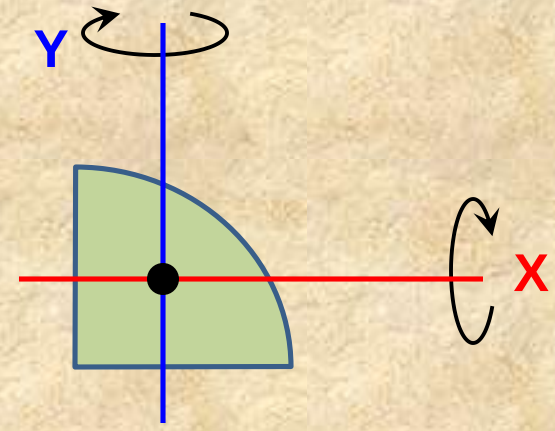


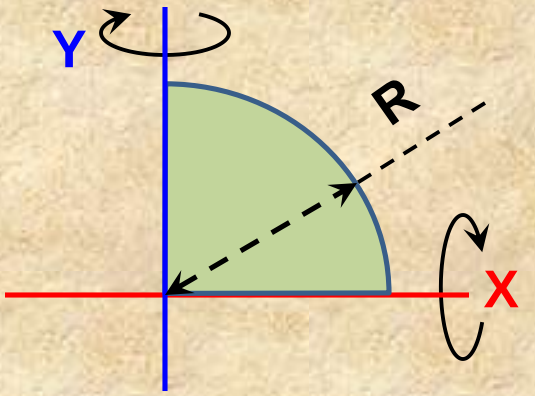
About	Formula
X	$\frac{(\theta - \sin\theta)\, R^4}{8}$
Y	$\frac{\pi R^4}{4}$



X	$\frac{\pi R^4}{8}$
Y	$\frac{\pi R^4}{8}$

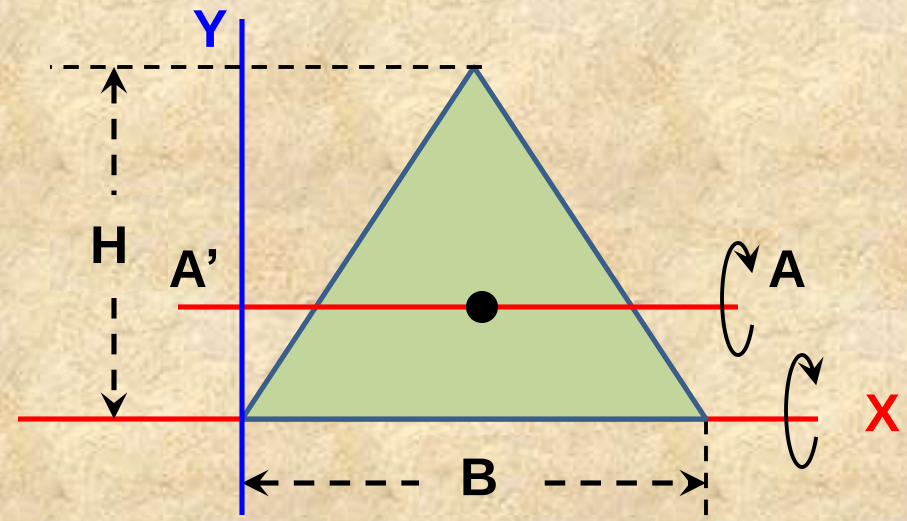
Moment of Inertia of a body – list of formulae



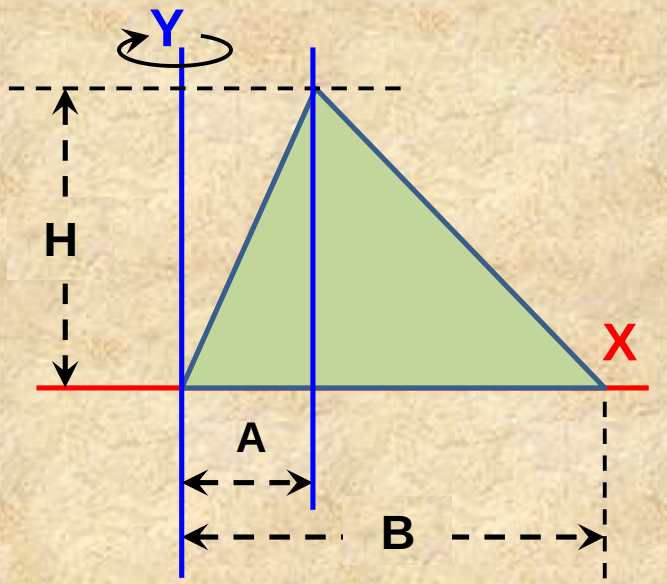


About	Formula
X Through Centroid	$0.0549\ R^4$
Y Through Centroid	$0.0549\ R^4$
X	$\frac{\pi R^4}{16}$
Y	$\frac{\pi R^4}{16}$

Moment of Inertia of a body – list of formulae



About	Formula
A-A' through centroid	$\frac{B H^3}{36}$
X	$\frac{B H^3}{12}$



About	Formula
Y	$\frac{H B^3 + H A B^2 + H A^2 B}{36}$

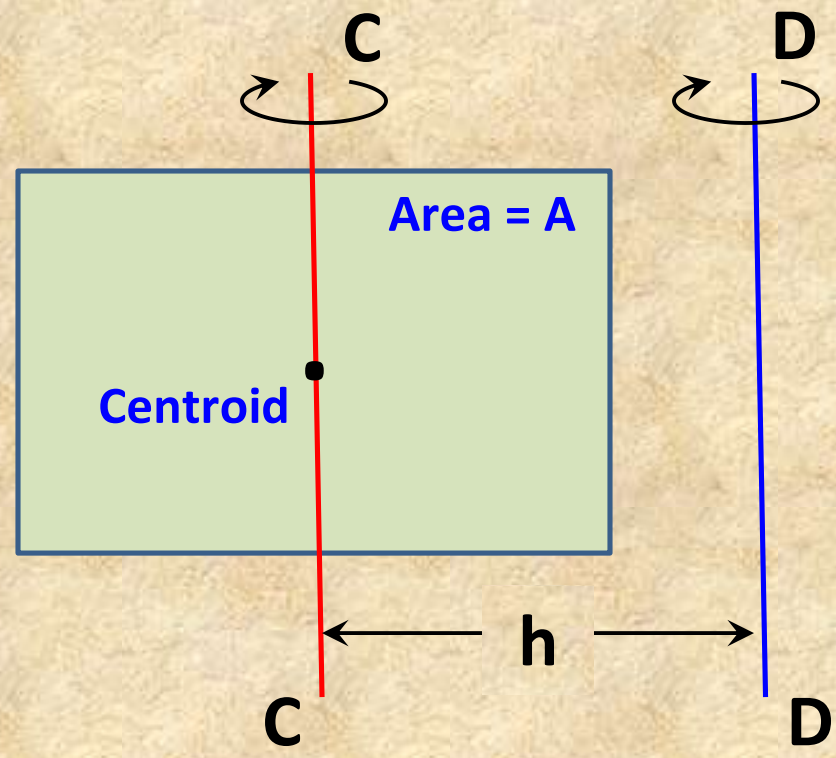
Parallel Axis Theorem -

Statement :- The moment of inertia of a plane area with respect to any reference axis in its plane is equal to the sum of moment of Inertia with respect to a parallel centroidal axis and product of total area and the square of the distance between the two axes.

$$I_{AB} = IG + Ah^2$$

Parallel axis theorem is used to find M. I. about an axis which is not passing through C.G. of the section.

Parallel Axis Theorem -



CC is centroidal axis.

CC is parallel to DD with distance = h

M.I. about DD = M.I. about CC + A*h²

$$I_{DD} = I_{CC} + A*h^2$$

Perpendicular Axis Theorem -

Statement :- The moment of inertia of an area with respect to an axis perpendicular to the x-y plane (z-axis) and passing through origin will be equal to the sum of moments of inertia of the same area about x-x and y-y axis.

$$I_{zz} = I_{xx} + I_{yy}$$

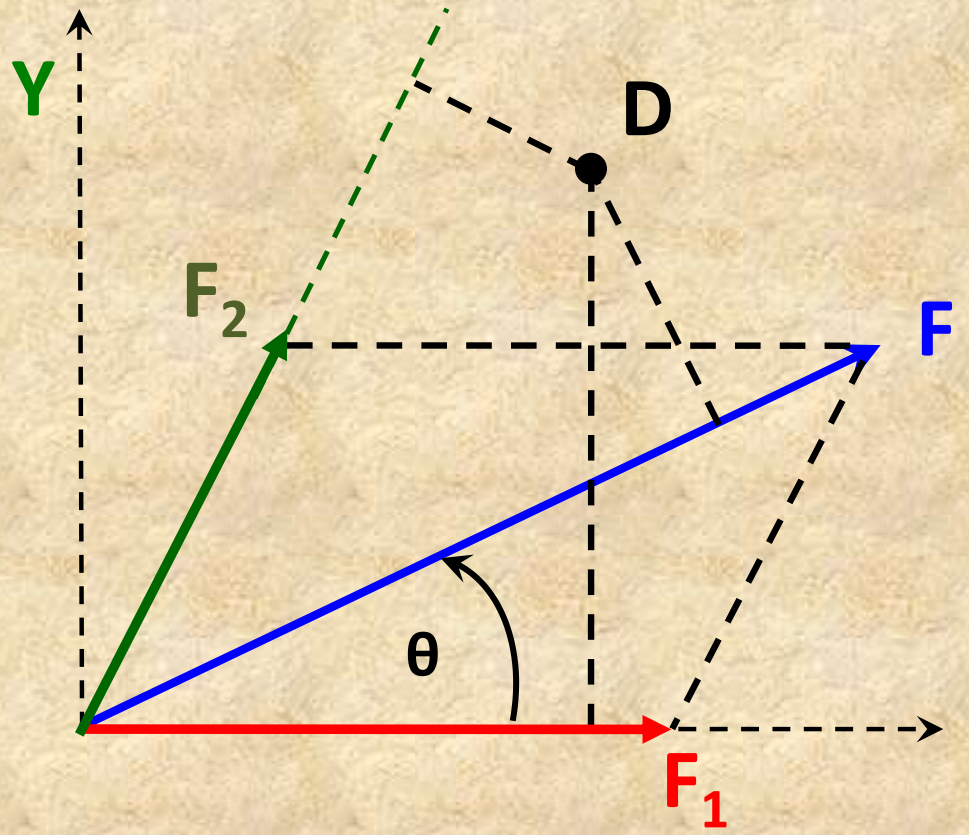
This theorem is kept for **SELF STUDY !**

You are supposed to study this topic of your own in all directions including numericals on it.

All the best wishes …!

- **Verignon's Theorem –** The algebraic sum of the moments of all forces about any point in their plane is equal to the moment of their resultant about the same point.
- **Verignon's Theorem –** Moment of Force about any point is equal to the sum of the moments of its components about the same point.
- **Verignon's Theorem –** It is used to determine the position of Resultant of Parallel force system.

Varignon's Theorem -



F_1 and F_2 are the two components of F

Moments of F about D = Moments of F_1 about D + Moments of F_2 about D

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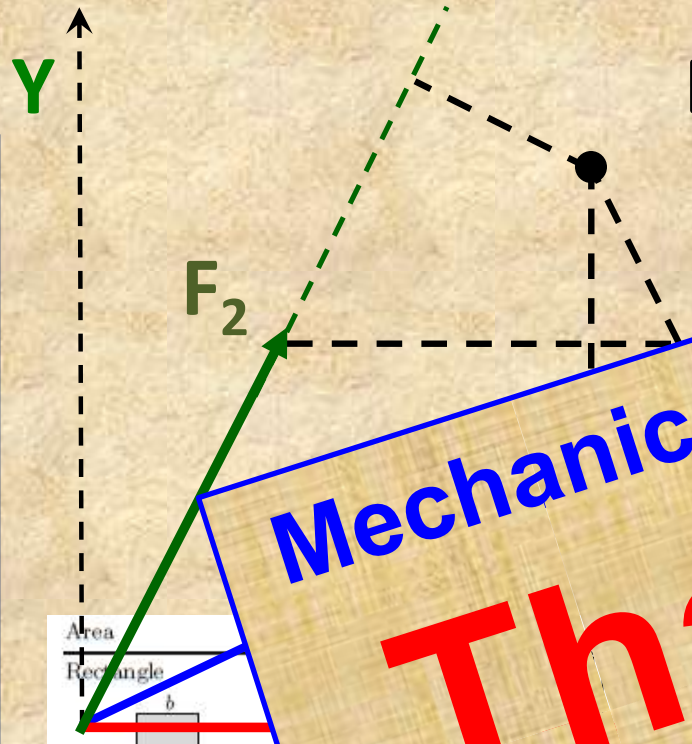

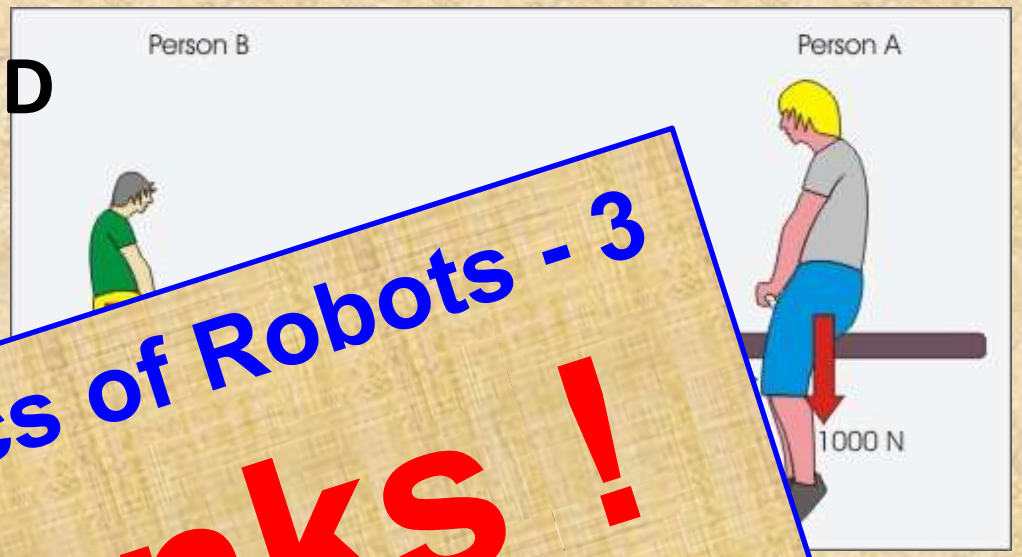

Mechanics of Robots - 3

Thanks !

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