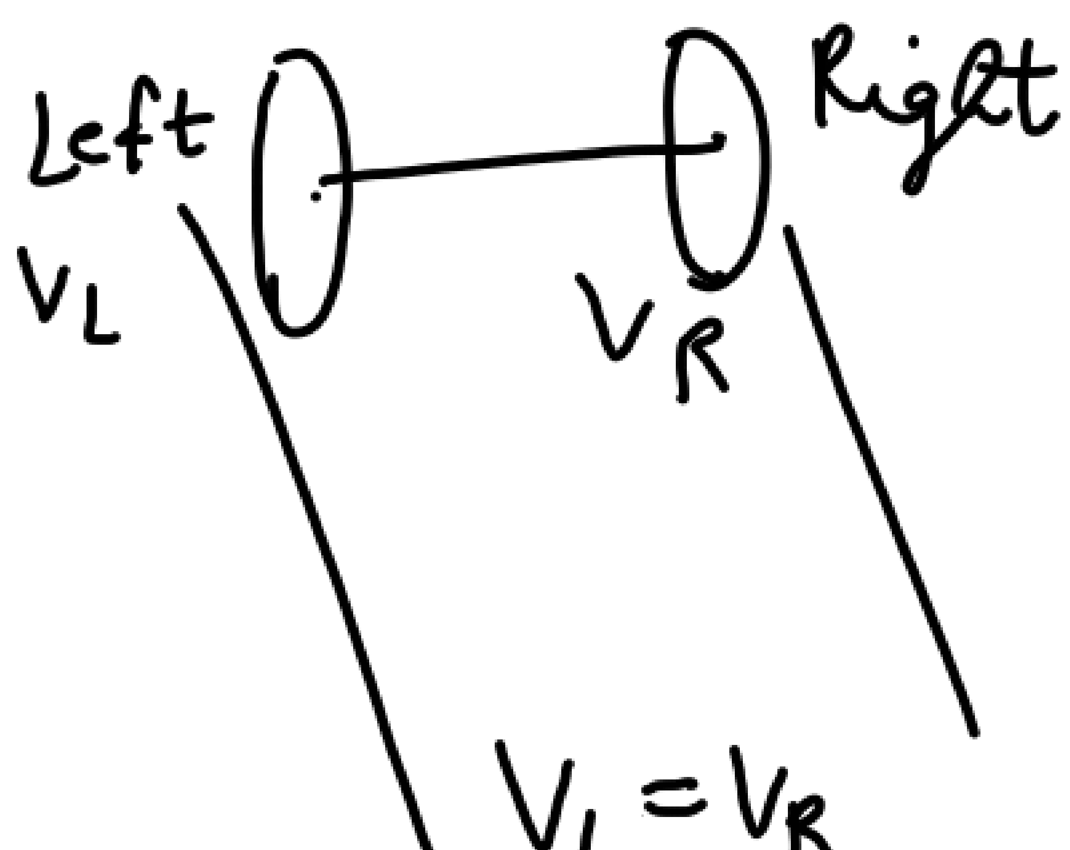
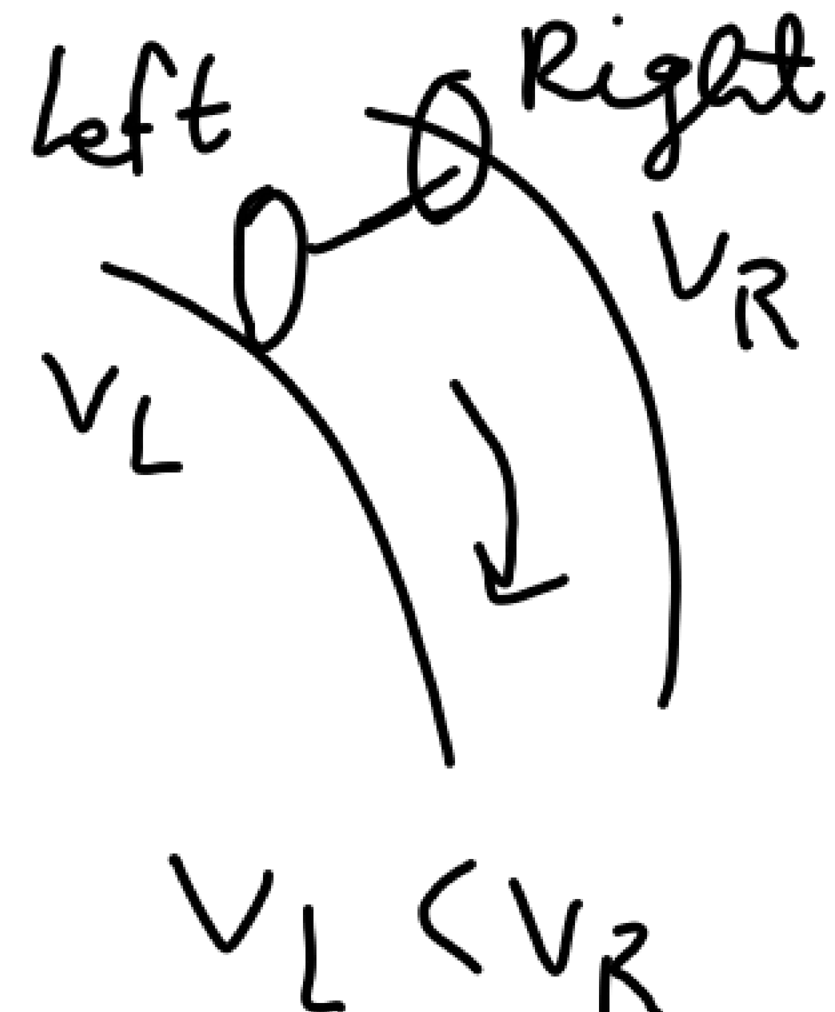
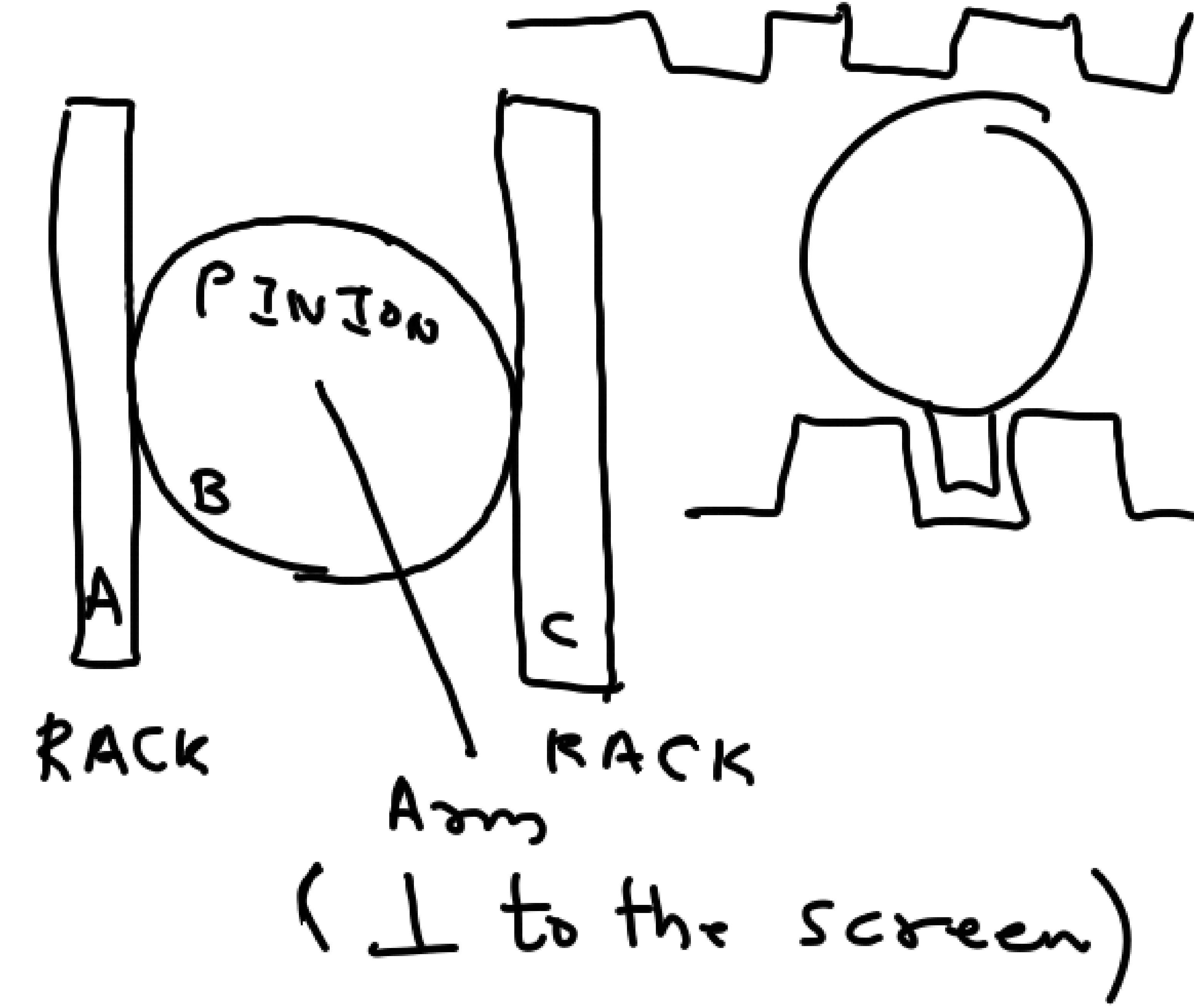
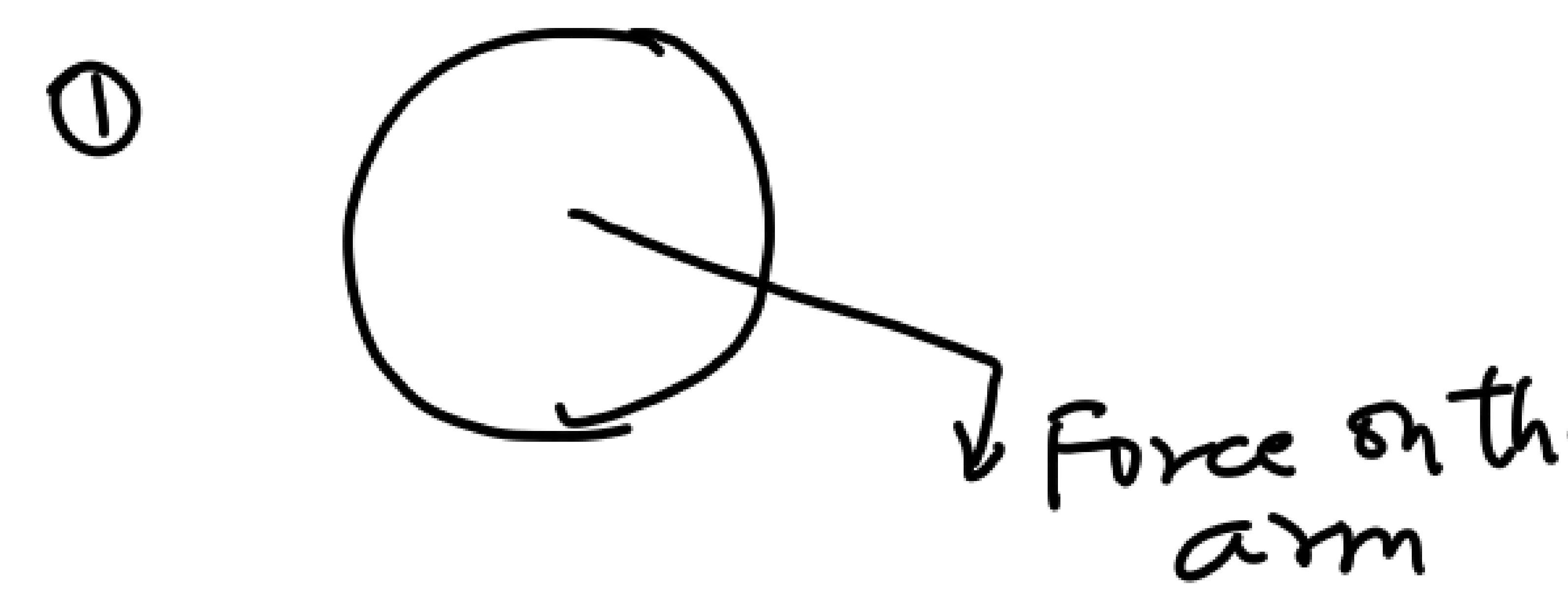
Application of Epicyclic gear train

Differential : Used in 4 wheelers to modify the speeds of rear wheels when the vehicle takes turn



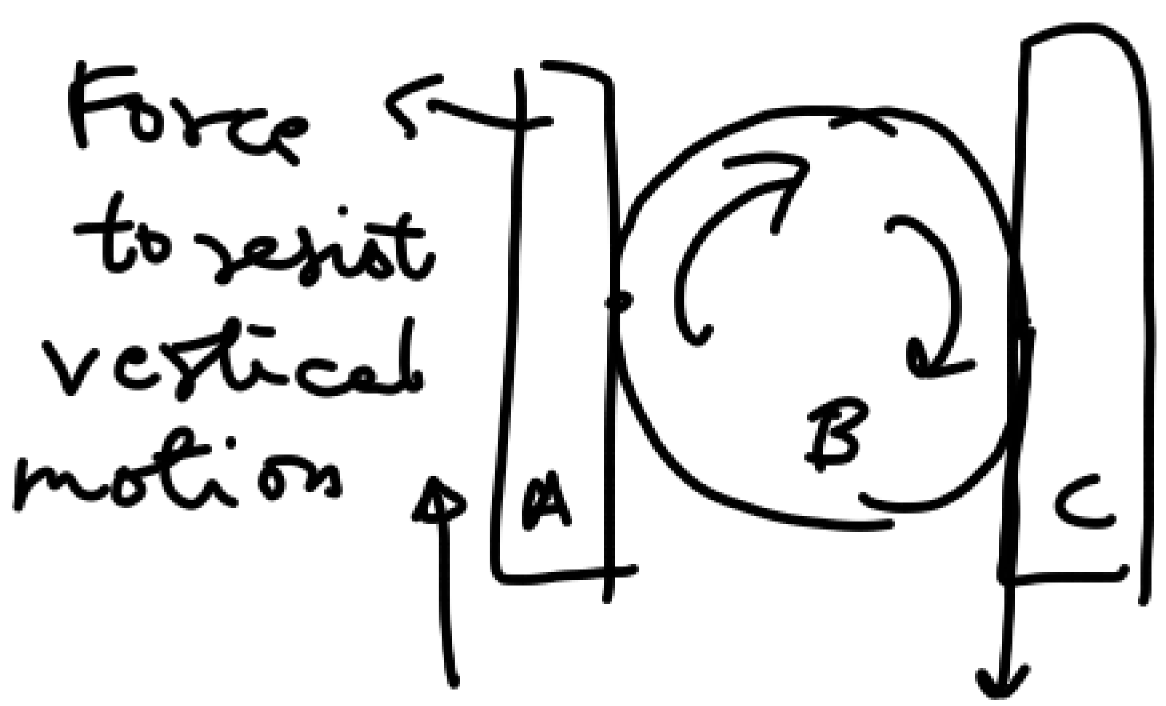






Since the teeth of rack & pinion are engaged, application of downward force on arm will also move the rack downward.

② Assuming right turn, if I hold A with a force such that its downward movement is resisted.



We can use superposition

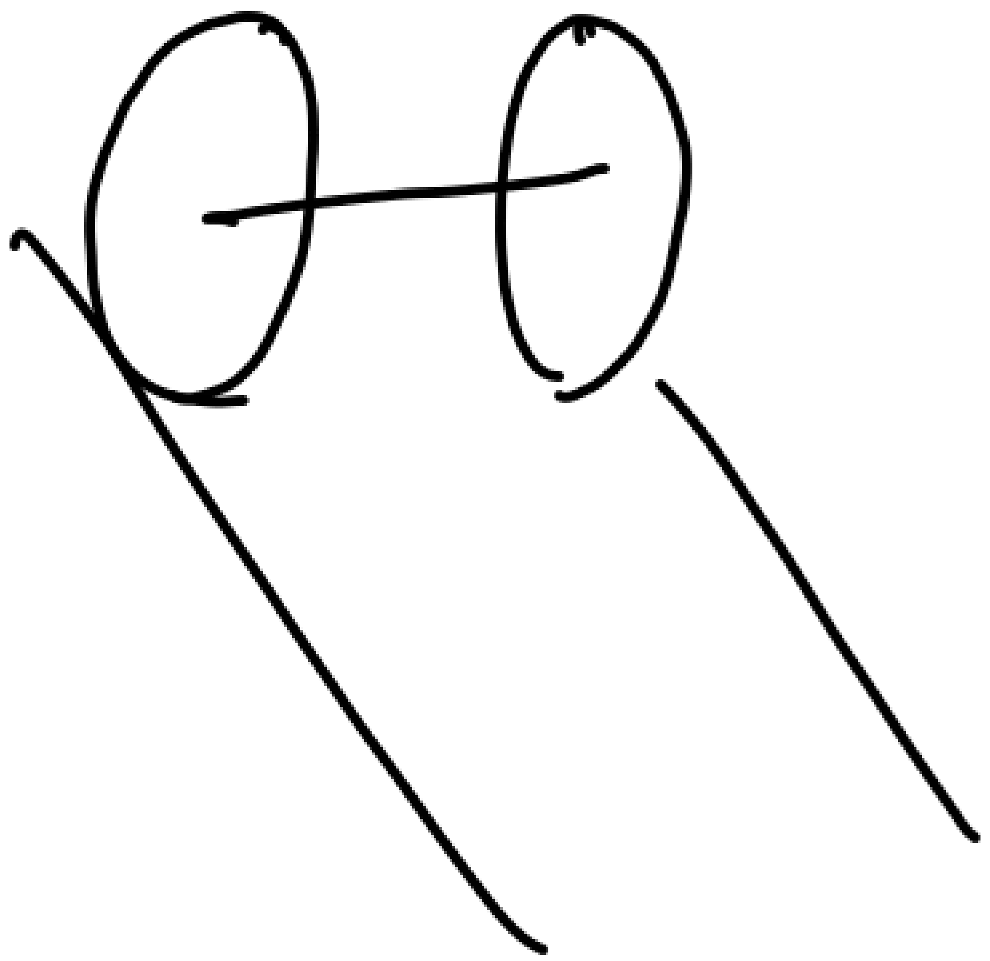
In the Ist step, with force on arm, {A, B, C} all move down

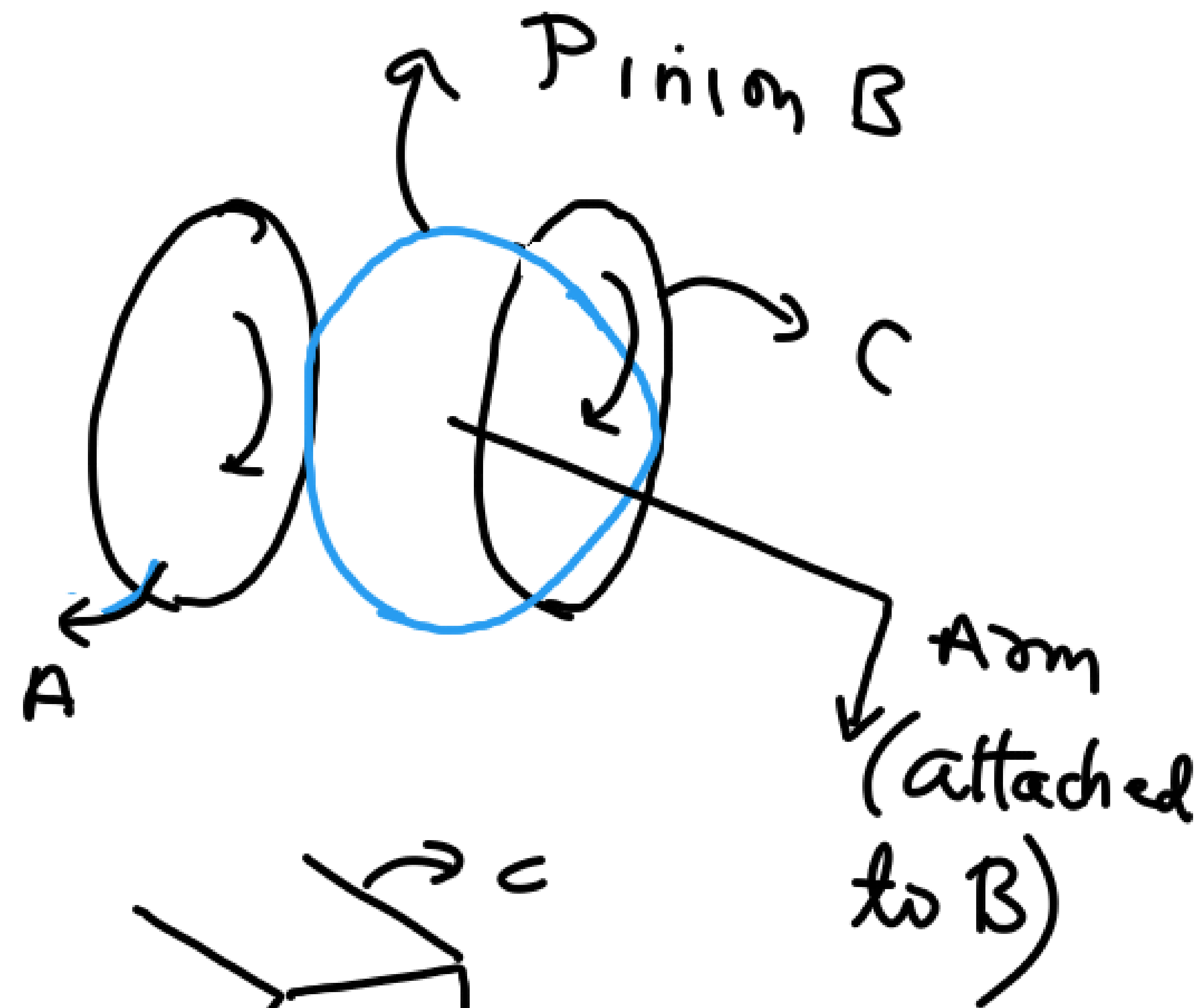
Since A shouldn't move down, we apply correction.

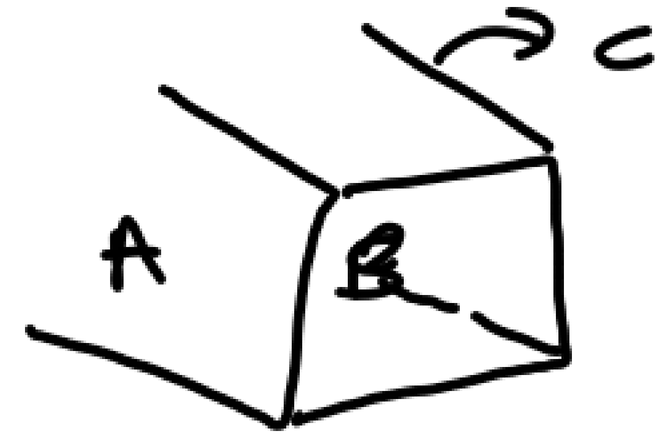
So we give upward vertical movement to A.

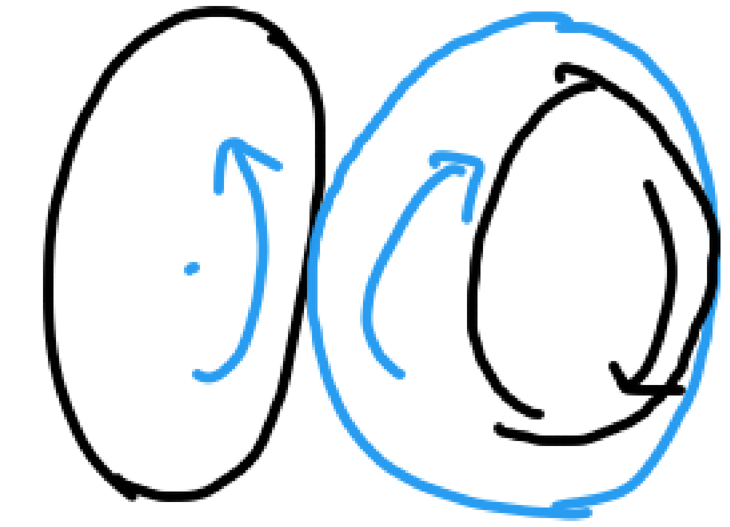
This causes clockwise rotation of pinion B

Consequently, C will move downward at a greater speed.









Correction / Anticlockwise rotation to A

This leads to clockwise rotation in pinion B.

Accordingly, C will rotate Clockwise at a greater speed.

Case (A): Travel on a straight line

Case (B): We arrest (resist) motion of gear A.

C will rotate in CW dir'n if looked along the arrow direction

In effect, C moves forward with a greater speed.

<u>Bevel gears.</u>

Unit # 4 : Rigid body dynamics

$\underbrace{\text{Kinematics}}$ + $\underbrace{\text{Kinetics}}$

Geometry, Displacement, Velocity, Acceleration

(Changes in size & shape) → If deformable

Forces, moments

<u>Newton's IInd law</u>

$$\underset{\text{Force}}{\Sigma} \underset{\sim}{F} = m \underset{\sim}{a}$$

→ Acceleration

→ vector

→ mass (Inertia)

→ Unbalanced force

Originally the law was given for a point mass

Euler extended the law (Leonhard) to massy bodies (in 2D, 3D)

Component form :

a) Cartesian : $\Sigma F_1 = m a_1$

$\Sigma F_2 = m a_2$

$\Sigma F_3 = m a_3$

1, 2, 3 can take values of (r, θ, z) in cylindrical (polar (2D)).

In curvilinear (2D), we can use tangent - normal to express $\underset{\sim}{F} = m\underset{\sim}{a}$

$F_t = m a_t = a \frac{dv}{dt}$ (Tangential)

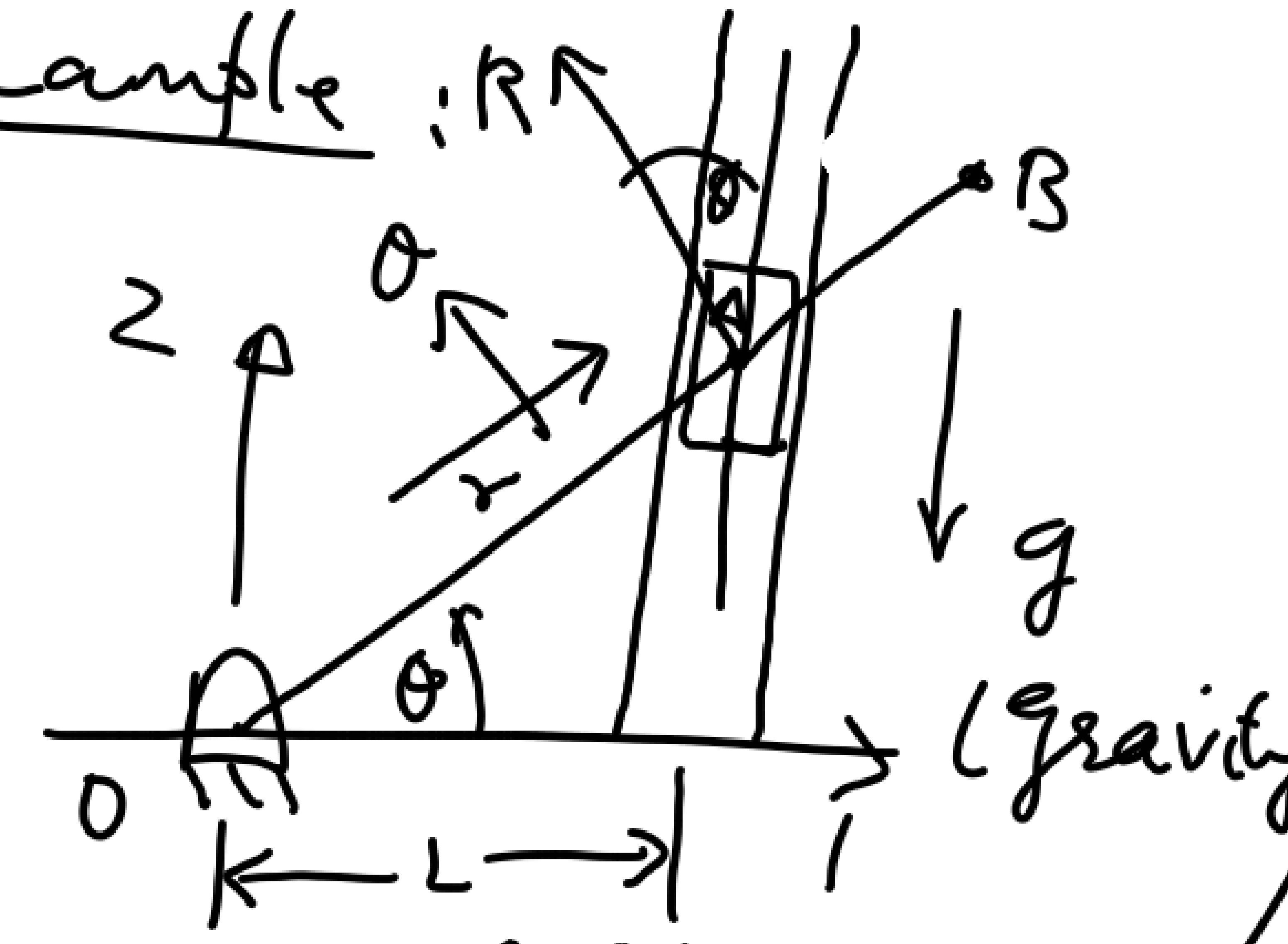
$F_n = m a_n = \frac{mv^2}{\rho}$ (Normal)

Free body diagram

Isolate the body from its surrounding.

Contact or joint should be replaced by forces (mostly unknown). This forces in turn ensure the constraint imposed by the joint

Example :



Given : $\theta, \dot{\theta}, \ddot{\theta}$; m (mass of slider)

To find : i) Force between rod OA and slider

ii) Slider A and wall

Kinematics: Co-ordinates of A

$$x_A = L \; ; \; y_A = L\tan\theta$$

Velocity:

$$V_x = \frac{dx}{dt} = 0;$$

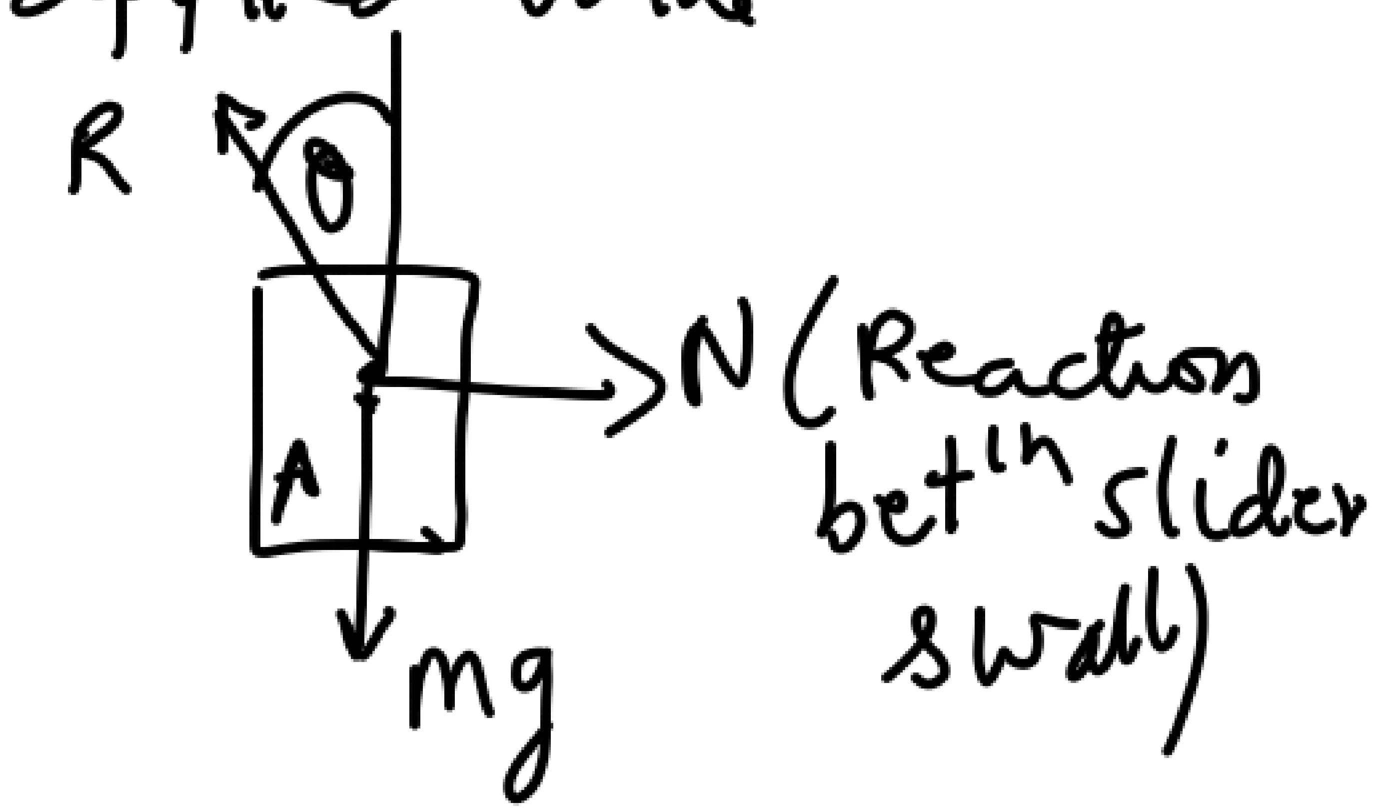
$$V_y = L\sec^2\theta\,\dot{\theta}$$

$$a_x = 0;$$

$$a_y = L\ddot{\theta}\sec^2\theta + 2L\sec^2\theta\tan\theta\,(\dot{\theta})^2$$

Newtons law applied to the slider A

F.B.D:



R is the reaction force between rod OB and slider.

It's orientation is $\perp$ to rod OB.

$$\Sigma F_x = N - R\sin\theta$$

$$\Sigma F_y = R\cos\theta - mg$$

$$\Sigma F_x = ma_x = 0$$

$$\Rightarrow \boxed{N = R\sin\theta}$$

$$\Sigma F_y = ma_y$$

$$R\cos\theta - mg = m\left[L\ddot{\theta}\sec^2\theta + 2L\sec^2\theta\tan\theta\,(\dot{\theta})^2\right]$$