

# IMPULSE

$$F = \frac{dp}{dt}$$

$$\int_{p_i}^{p_f} dp = \int_0^{\Delta t} F \cdot dt$$

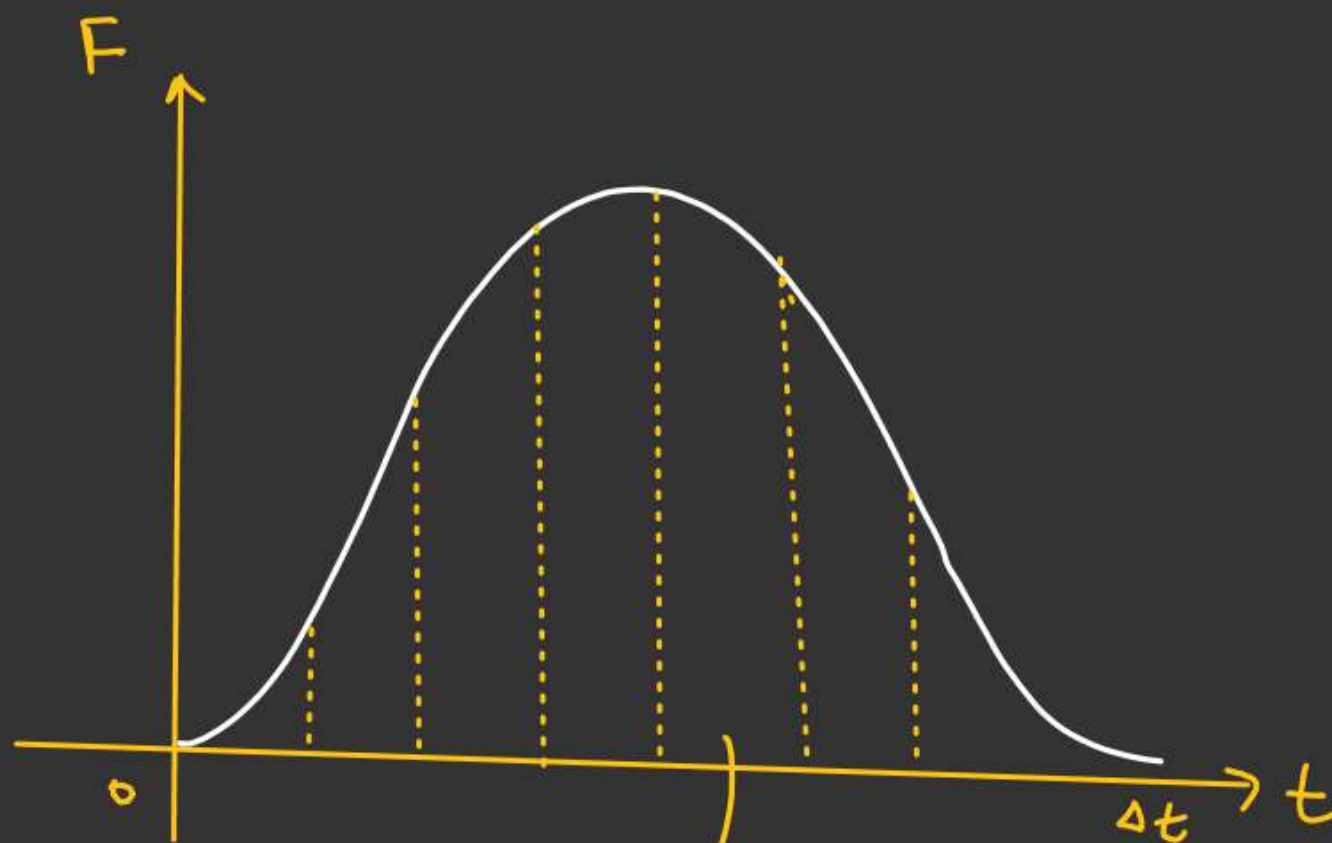
$$p_f - p_i = \underline{\Delta p} = \int_0^{\Delta t} F \cdot dt$$

If  $F$  is  
constant in  $\Delta t$   
time

$$J = F \int_0^{\Delta t} dt = \underline{(F \Delta t)}$$

$$J = \int_0^{\Delta t} F \cdot dt$$

Area under  
 $F$  vs  $t$  curve  
is Equal to  
Change in linear  
moment



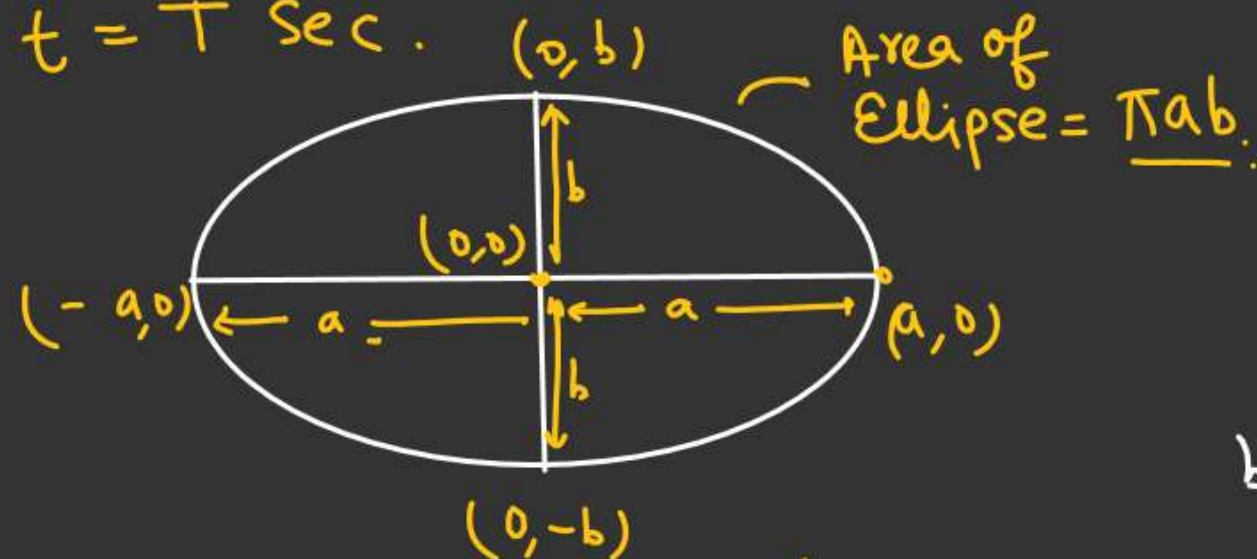
$J \rightarrow \text{unit} \rightarrow$

$$\text{Kg m/s}$$

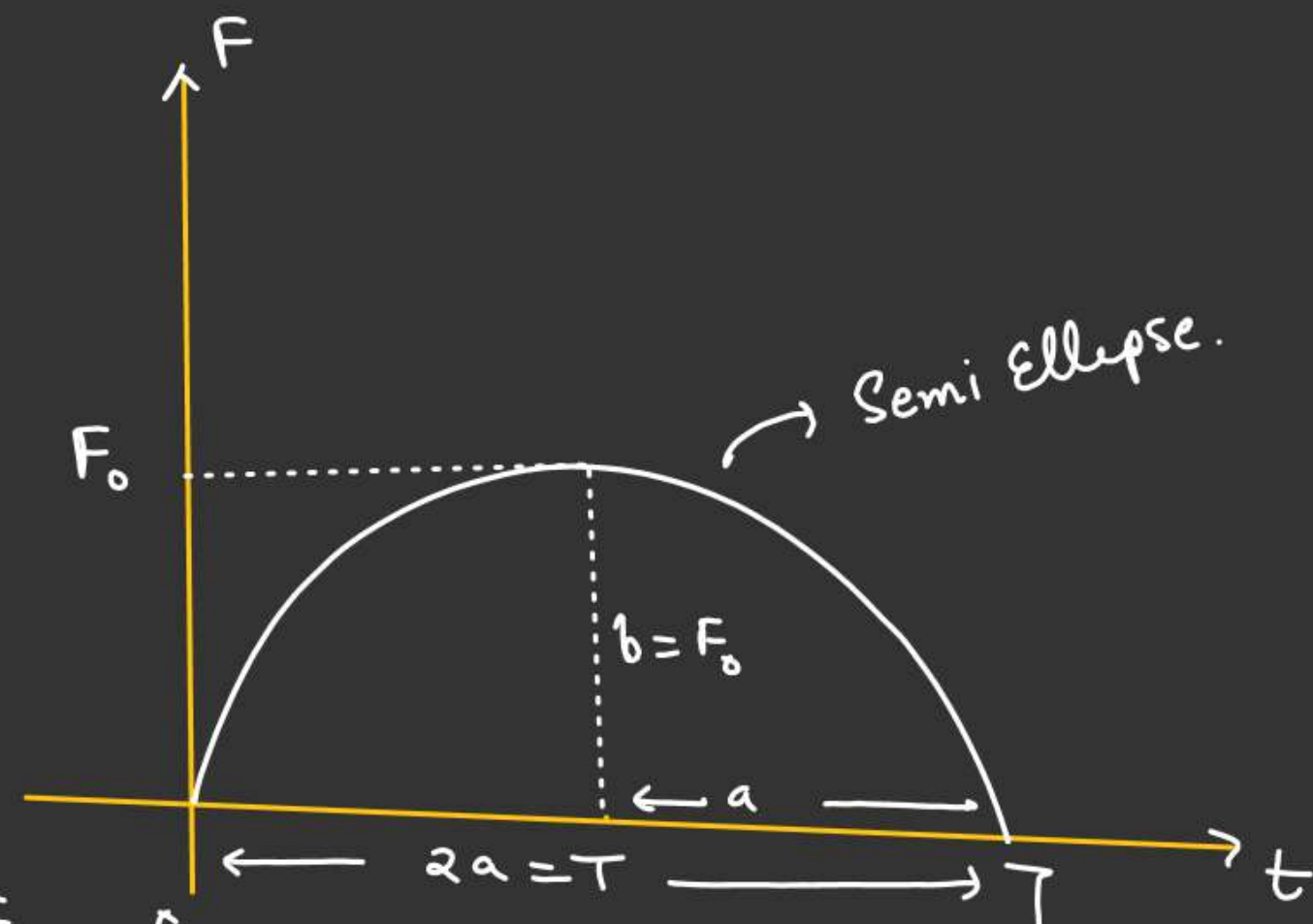
✖ A Force which varies with time  $t$  as shown in the graph. acts on a particle of mass  $m$ .

Initially particle at rest.  $\Rightarrow p_i = 0$

Find linear momentum of particle at  $t = T$  Sec.



$a > b$   
 $a$  = Semi Major axis  
 $b$  = Semi Minor axis



$$b = F_0$$

$$a = \frac{T}{2}$$

$\Delta p$  = Area of  $F$  vs  $T$  graph.

$$p_f - p_i = 0 \quad \Rightarrow \quad \pi \left( \frac{T}{2} \right) F_0 \times \frac{1}{2} = \left( \frac{\pi F_0 T}{4} \right) \checkmark$$

$$\left[ p_f = \frac{\pi F_0 T}{4} \right]$$



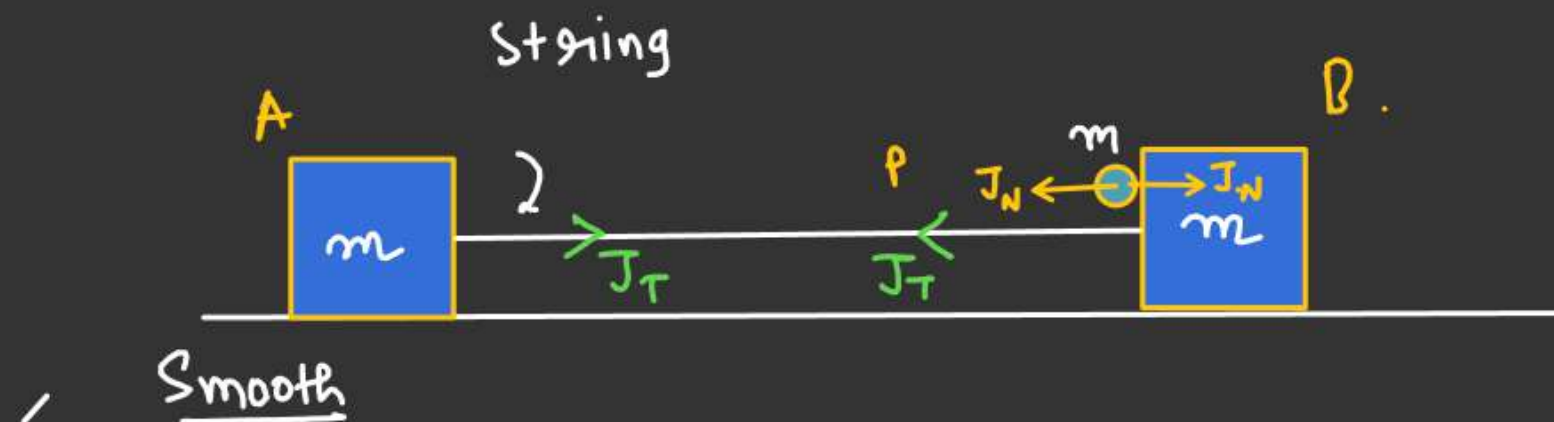
## Important points for Impulse

- Gravitational force & Spring force never be impulsive
- If String Suddenly taut then tension in the string impulsive in nature. and always acts along the string
- In Case of impulse we only see the change in linear momentum of the body just before impulse applied to just after impulse applied

Q.2: Two block system attached with string  $l$ . A mud-particle moving with velocity  $v_0$  stick to block B.

a) Find velocity of each block just after particle  $p$  stick to B.

b) Also find impulse due to tension



$$J_N = \underline{N} \Delta t = \text{Impulse due to Normal reaction}$$

$$J_T = \underline{T} \Delta t = \text{Impulse due to tension}$$

M-1

For whole system

$$J_{\text{net}} = 0$$

$$(\Delta p)_{\text{system}} = 0$$

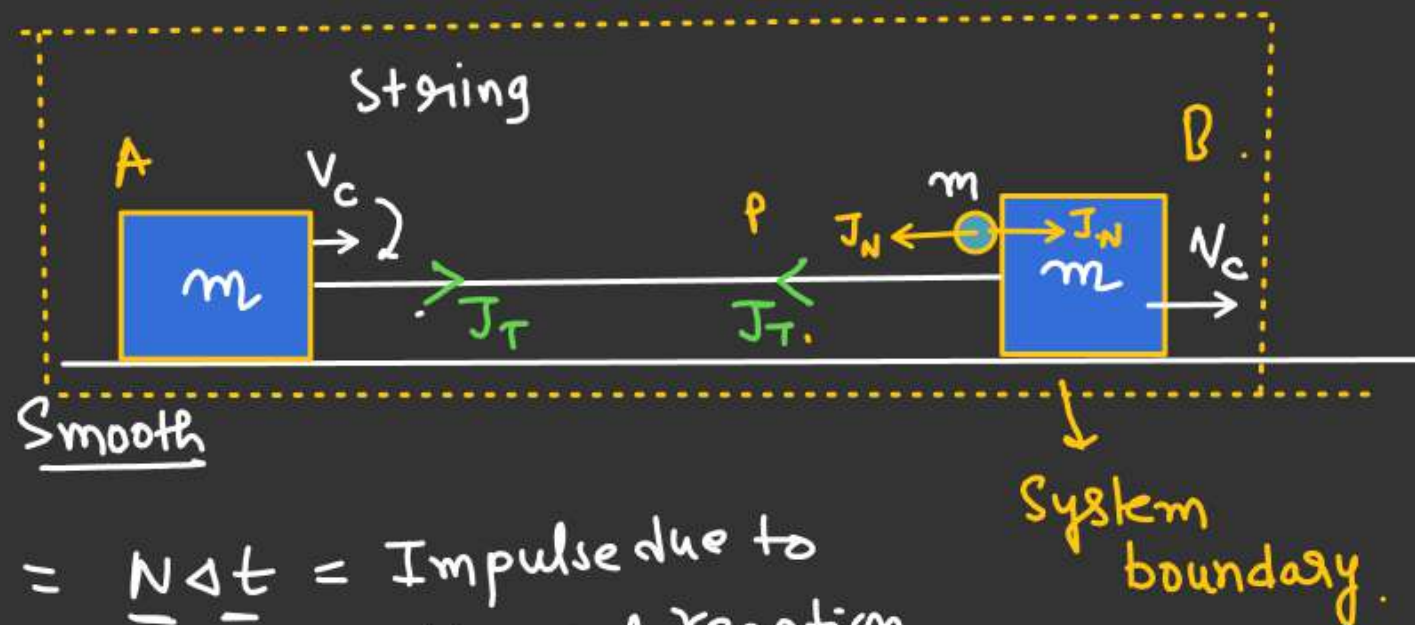
$$(\vec{p}_i)_{\text{system}} = (\vec{p}_f)_{\text{system}}$$

Just before collision  
of mud - particle

Just after  
collision of  
Mud - particle

$$m v_0 = 3m v_c$$

$$v_c = \frac{v_0}{3} \checkmark$$



$$J_N = \underline{N \Delta t} = \text{Impulse due to Normal reaction}$$

$$J_T = \underline{T \Delta t} = \text{Impulse due to tension}$$

$$J_T = ??$$



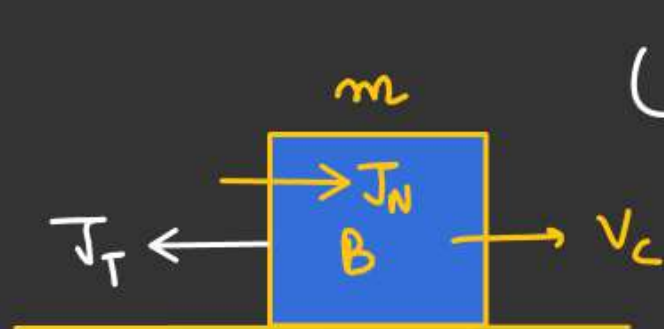
$$J_T = \underline{\left(m \frac{v_0}{3}\right) \text{ kg m/s}}$$

$$J_T = (\Delta p)_A$$

$$J_T = (\vec{p}_f)_A - (\vec{p}_i)_A$$

$$J_T = (m v_c) \hat{i} - 0$$

## Impulse due to Normal reaction



$$(\Delta \vec{p})_{\text{block B}} = (mv_c - 0) \hat{i} \\ = \left(\frac{mv_0}{3}\right) \hat{i}$$

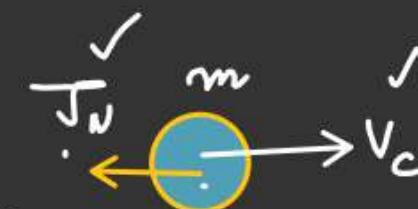
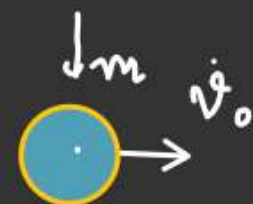
$$J_N \hat{i} - J_T \hat{i} = (\Delta \vec{p})_{\text{block B}}$$

$$J_N \hat{i} = J_T \hat{i} + (\Delta \vec{p})_{\text{block B}}$$

$$J_N \hat{i} = \frac{mv_0}{3} \hat{i} + \frac{mv_0}{3} \hat{i}$$

$$J_N = \left(\frac{2mv_0}{3}\right) \checkmark \checkmark$$

Before Collision



After Collision

$$-J_N \hat{i} = (\Delta \vec{p})_{\text{mud particle}}$$

$$-J_N \hat{i} = mv_c \hat{i} - mv_0 \hat{i}$$

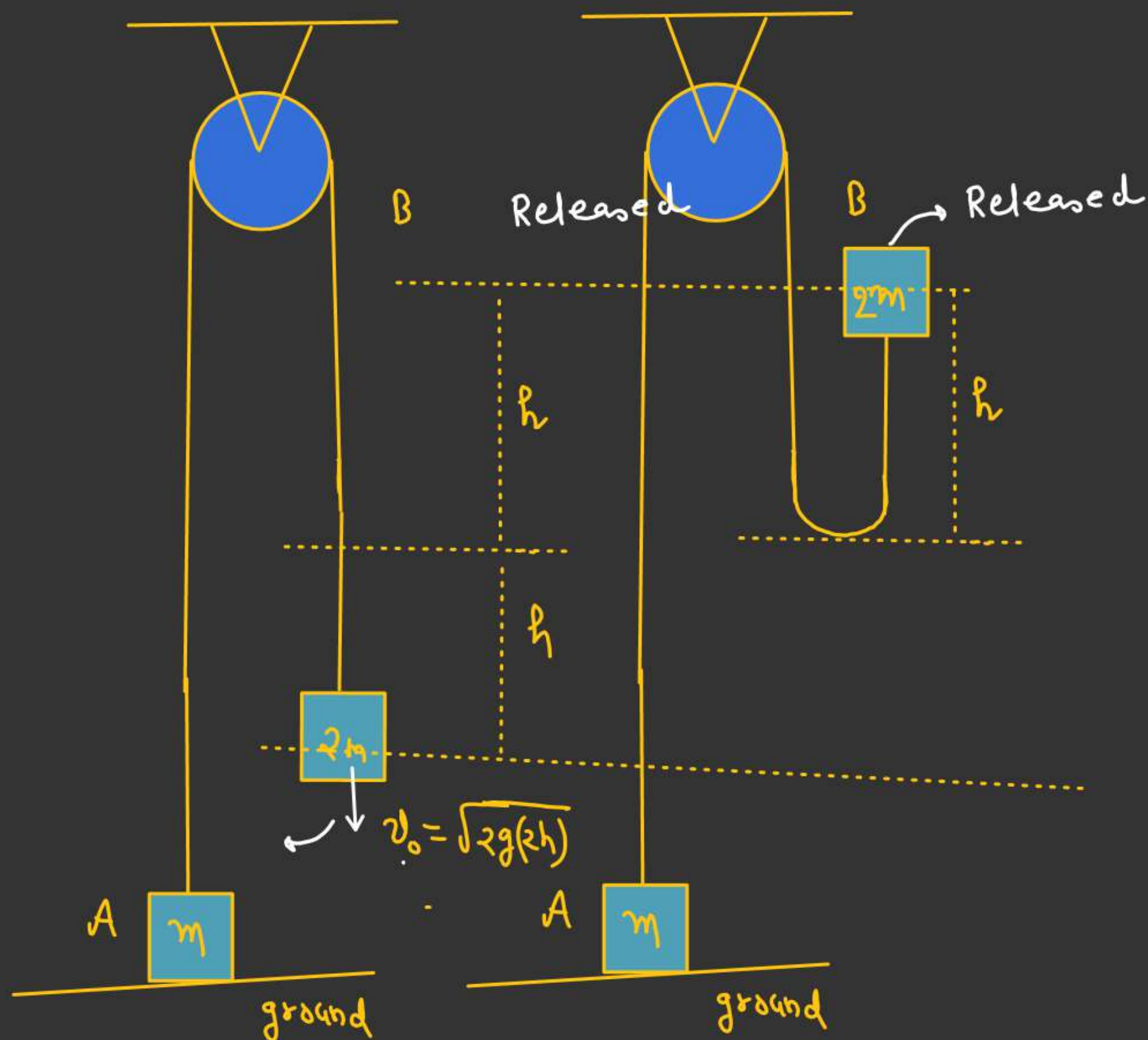
$$-J_N = (mv_c - mv_0)$$

$$J_N = mv_0 - mv_c \\ = \left(mv_0 - m\frac{v_0}{3}\right) \\ = \left(\frac{2mv_0}{3}\right) \checkmark$$

Block B is released from the position shown in the fig.

- Find velocity of both the blocks just after string is taut.
- Also find impulse due to tension

$$v_0 = \sqrt{2gh}$$

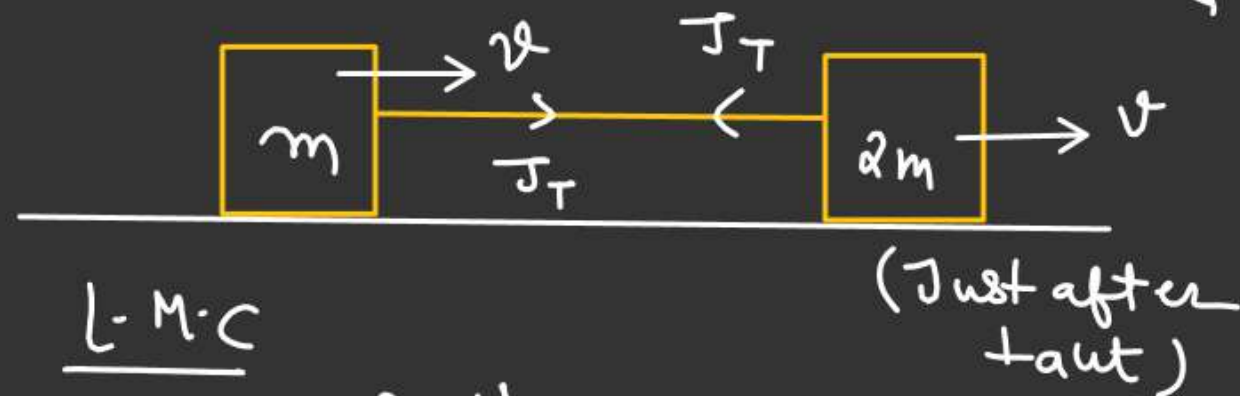


Note

$$v_0 = \sqrt{2g(2h)} = 2\sqrt{gh}$$

No Role of gravity in changing the linear momentum of block from just before taut to just after taut.

Initial state (Just before taut)

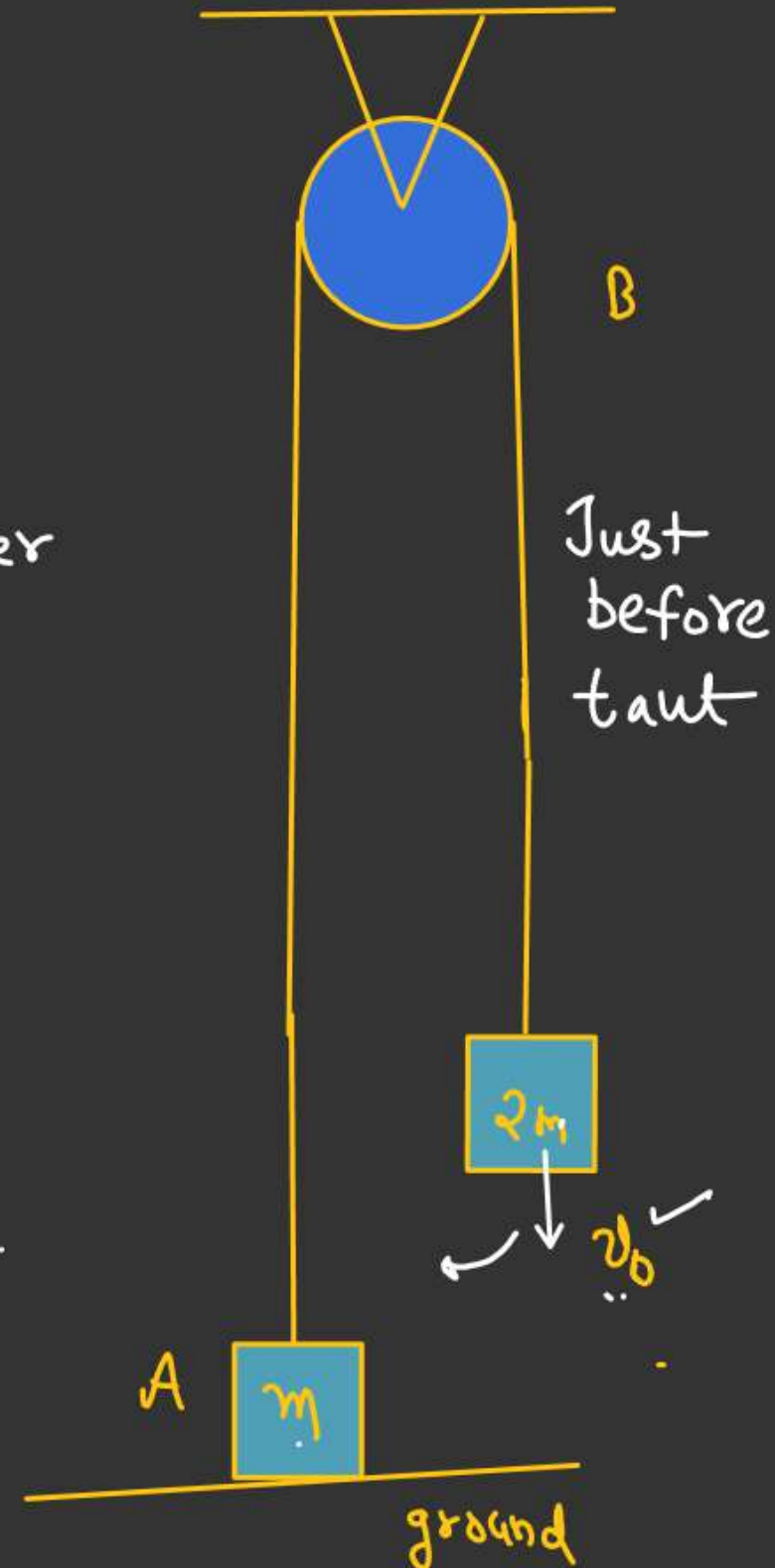
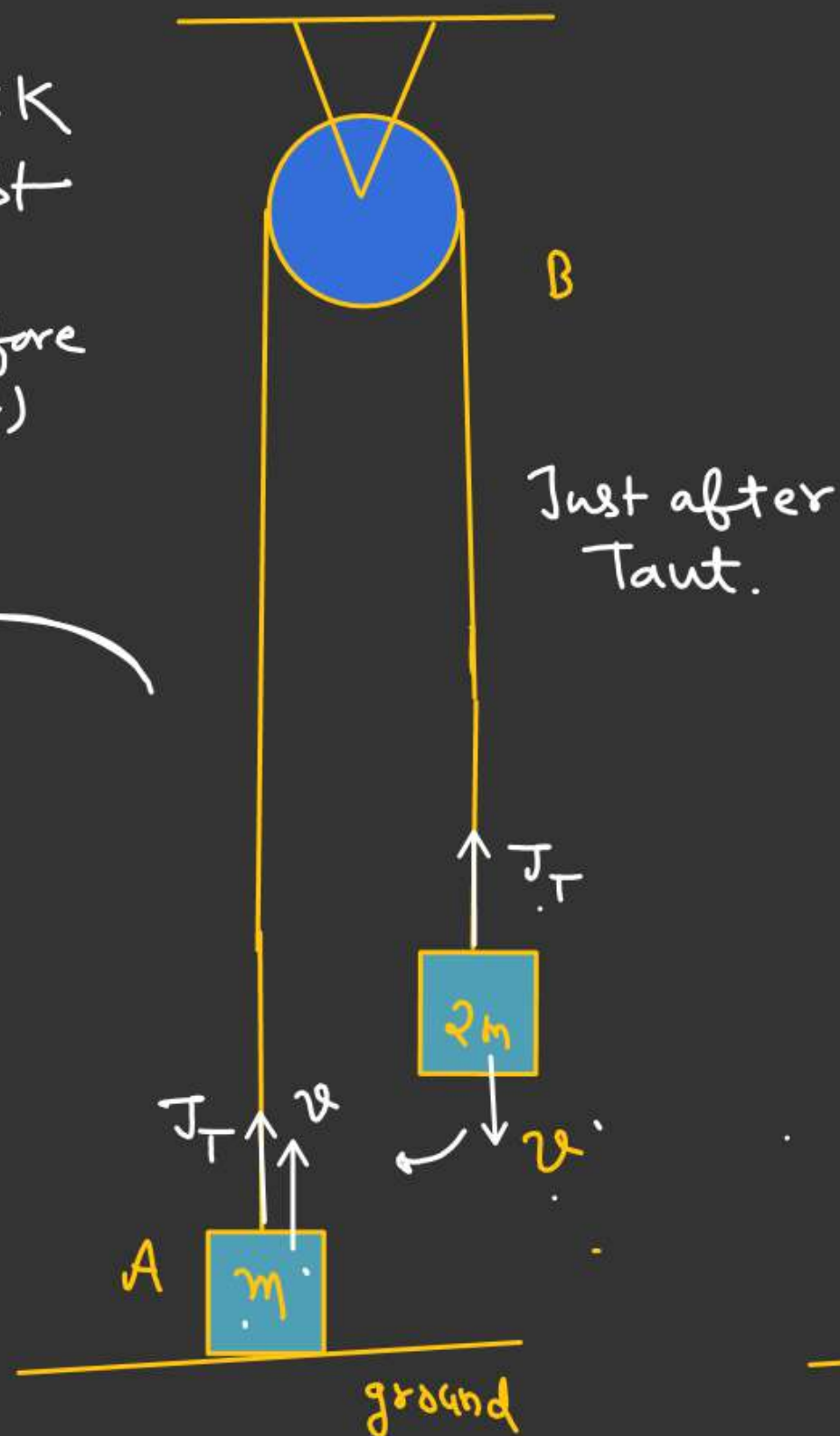


L-M-C

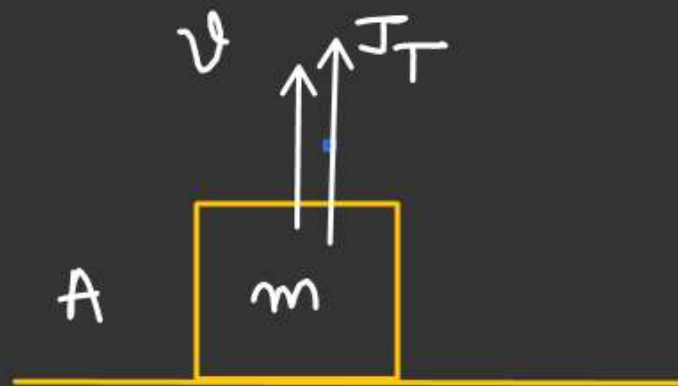
$$2m v_0 = 3m v$$

$$v = \left( \frac{2v_0}{3} \right) = \frac{2}{3} \times 2\sqrt{gh}$$

$$v = \left( \frac{4}{3} \sqrt{gh} \right) \checkmark$$



$$\underline{J_T = ??}$$



$$\vec{J_T} = (\Delta \vec{p})_A$$

$$J_T \hat{j} = (\vec{p}_f)_A - (\vec{p}_i)_A$$

$$J_T = mv$$

$$J_T = \frac{m 2v_0}{3} = \frac{2m}{3} \cdot (2\sqrt{gh}) = \left(\frac{4m}{3}\sqrt{gh}\right) \checkmark$$

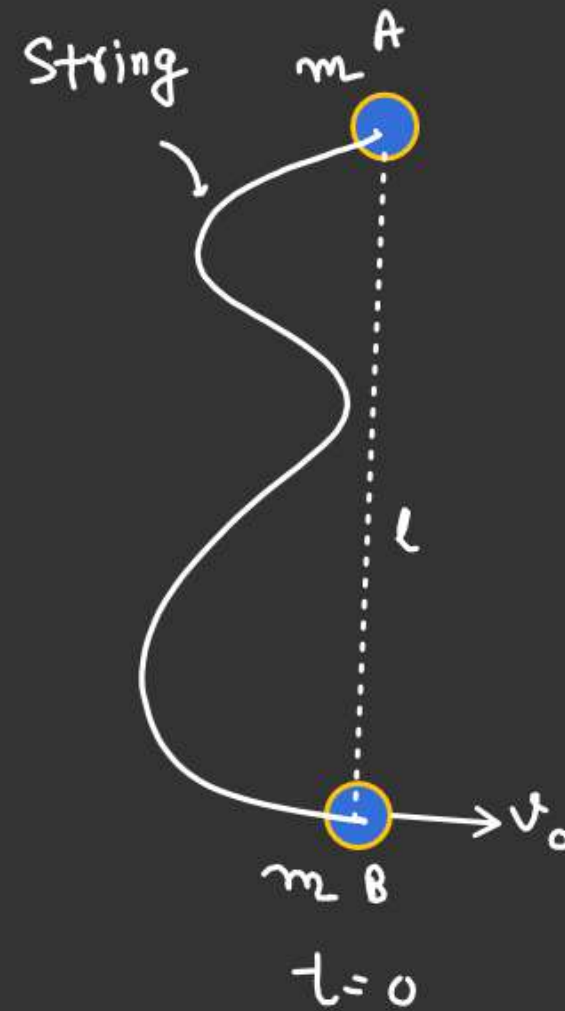
length of string is  $2l$ .

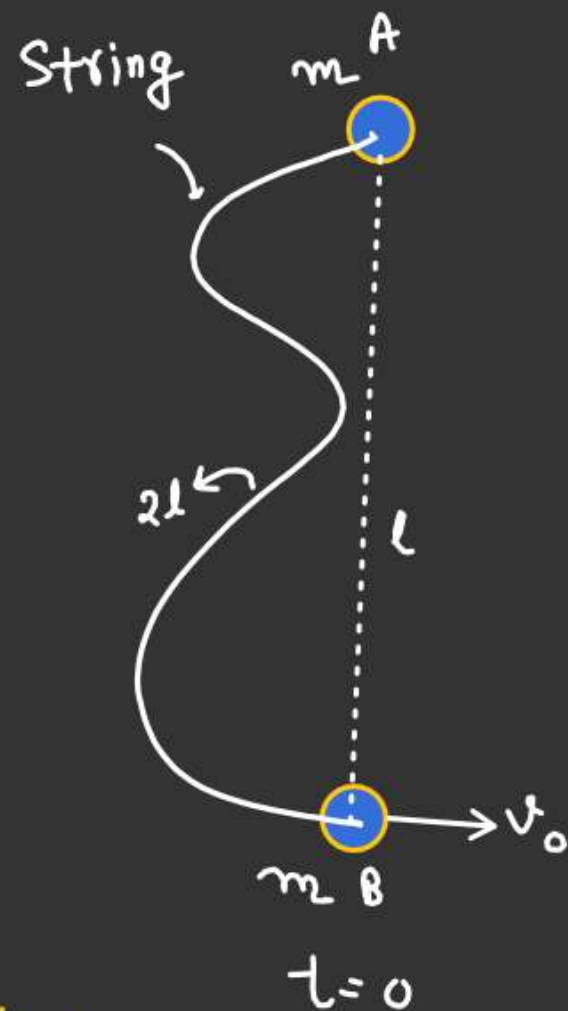
Whole system is on a smooth horizontal plane.

Ball B projected horizontally with velocity  $v_0$ .

Find :- 1) Speed of ball B & A just after string is taut.

2) Impulse due to tension.

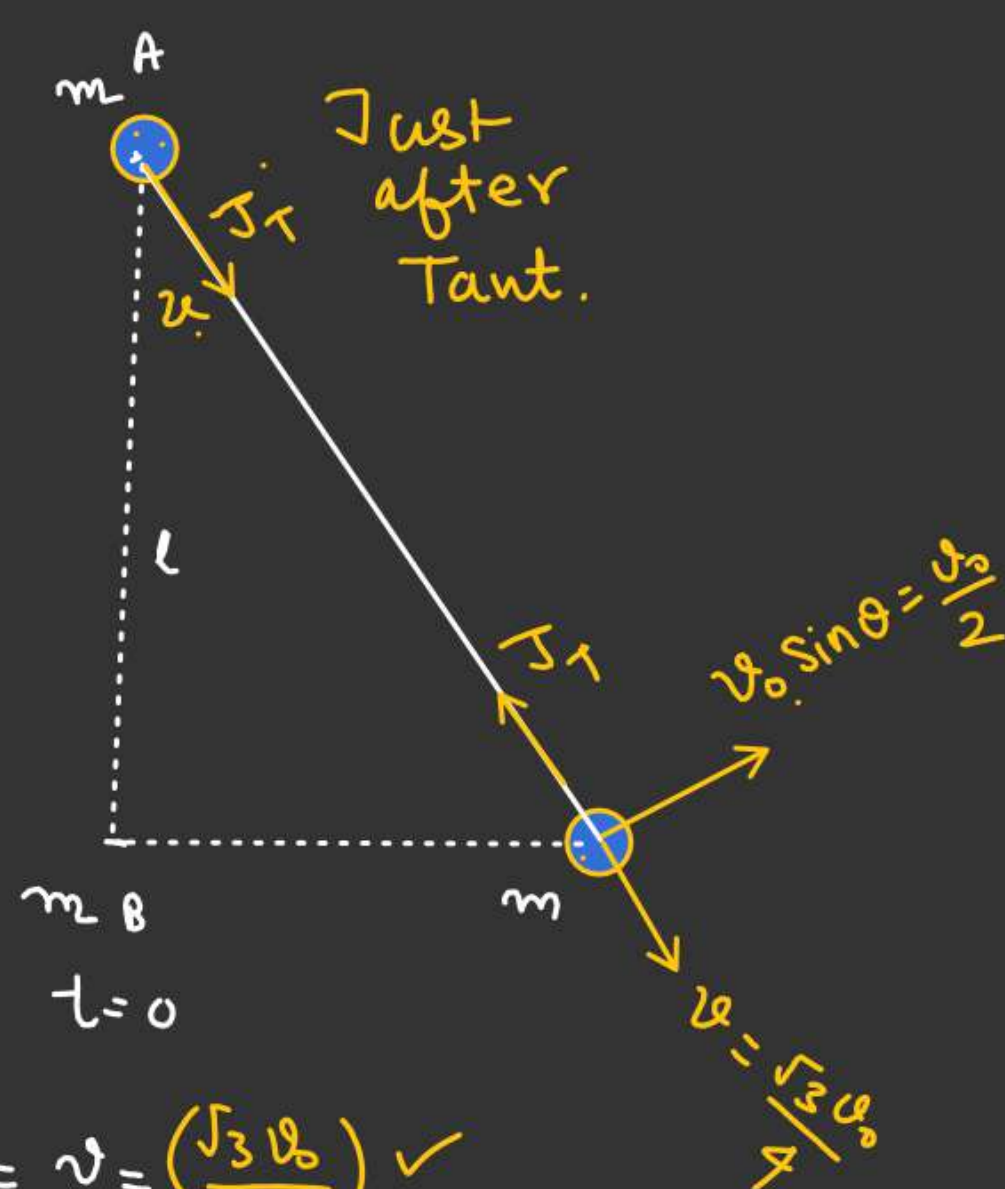
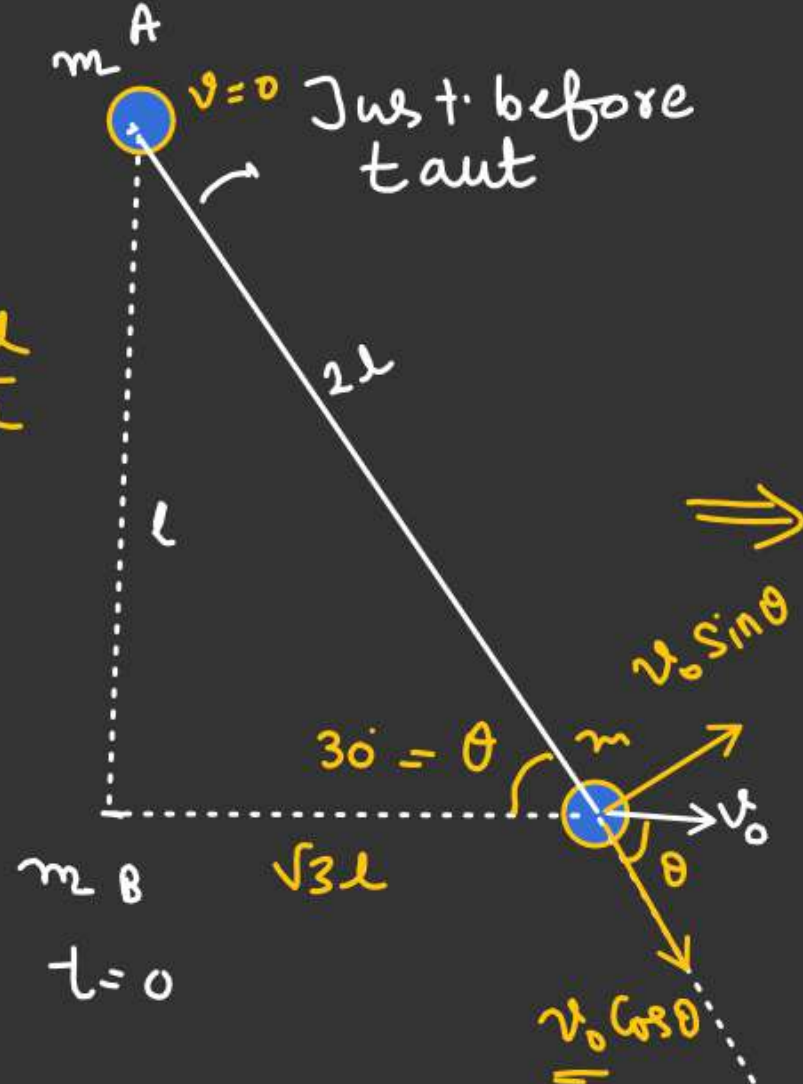




$\Rightarrow$

$$\cos \theta = \frac{\sqrt{3}l}{2l}$$

$$= \frac{\sqrt{3}}{2}$$



Along the string

$$(J_T)_{\text{net}} = 0$$

$$(\Delta p)_{\text{system along the string}} = 0$$

$$m v_0 \cos \theta = 2 m u$$

$$u = \frac{v_0 \cos \theta}{2} = \frac{\sqrt{3}v_0}{4}$$

$$\sin 30^\circ = \frac{1}{2}$$

$$\left[ \begin{array}{l} J_T = (\Delta p)_{\text{ball A}} \\ J_T = m u_A \\ = \left( m \frac{\sqrt{3}v_0}{4} \right) \text{ kg m/s} \end{array} \right.$$

$$\text{Speed of A} = v = \left( \frac{\sqrt{3}v_0}{4} \right) \checkmark$$

$$\text{Speed of B} = \sqrt{\left( \frac{\sqrt{3}v_0}{4} \right)^2 + \left( \frac{v_0}{2} \right)^2}$$

$$= \sqrt{\frac{3v_0^2}{16} + \frac{v_0^2}{4}} = \sqrt{\frac{7v_0^2}{16}} = \frac{\sqrt{7}v_0}{4}$$