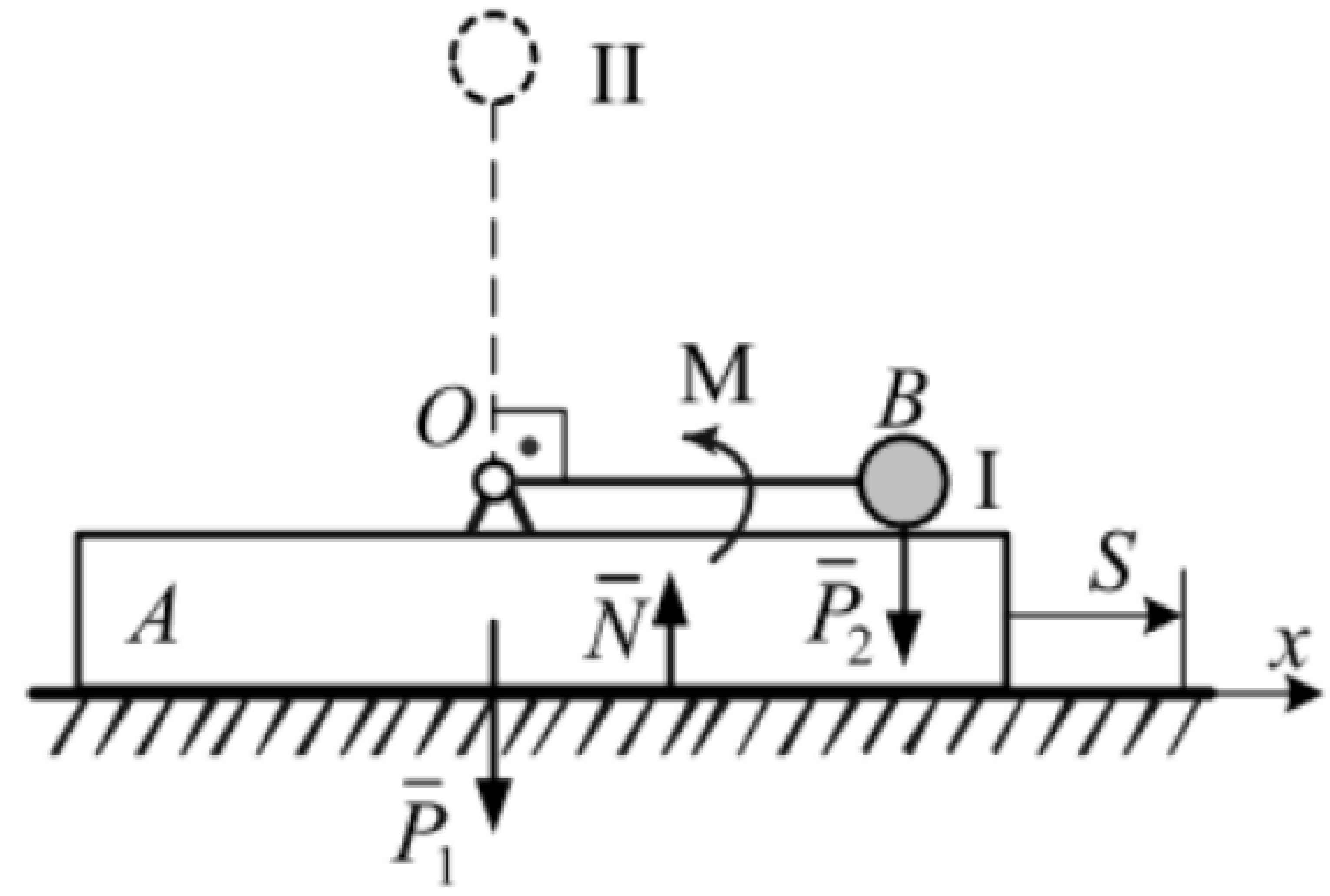
A system consist of body $A$ (a rectangular) with mass $m_1 = 2\ kg$. And a body $B$ (a ball) which connected to body $A$ by rotational joint. $OB = l = 0.2\ m$, $m_2 = 0.5\ kg$ - mass of B.
There are 2 subtasks:

1. We need to find $S$ (a distance), when the body $B$ moved from I position to the II with $M$ torque.

   *Answer*: $S = \frac{m_2 l}{m_1 + m_2} = 0.04\ m$

2. We know that $B$ has an angular velocity $\omega = \epsilon t$, where $\epsilon = const$. We need to find a velocity of body $A$, when the body $B$ reaches II position.




HINTS:
Theorem of the center of mass and linear momentum are the same, but the first help us to operate with positions easier, 2-nd - with velocities

$$m\bar{a}_c = \sum \bar{F}_i \Rightarrow m\bar{x}_c = \frac{\sum m_i \bar{x}_i}{\sum m_i}$$

$$m\frac{d\bar{V}_c}{dt} = \sum \bar{F}_i \Rightarrow \frac{d(m\bar{V}_c)}{dt} = \sum \bar{F}_i \Rightarrow \frac{d\bar{Q}}{dt} = \sum \bar{F}_i \Rightarrow \bar{Q} = \sum m\bar{v}_i$$

Research Object: System, consists of A body, B body

Motion: A - translatory, B - rotational

Conditions:

| "0" - Initial | "1" |
|---|---|
| $x_0 = 0$ | $x_1 - ?$ |
| $\dot{x}_0 = 0$ | $\dot{x}_1 - ?$ |
| $t = 0$ | $t - ?$ |

Force Analysis:

$\bar{P}_1 = m_1\bar{g}$; $P_2 = m_2 g$; $M$; $\bar{N}_1$

Solution:
1-st subtask

$$m\bar{a}_c = \bar{P}_1 + \bar{P}_2 + \bar{N}_1;\quad x:\ m\ddot{x}_c = 0 \Rightarrow m\dot{x}_c = C_1 \Rightarrow C_1 = 0 \Rightarrow m\dot{x}_c = 0$$

$m x_c = C_2 \overset{=0}{\Rightarrow} m x_c = 0 \longrightarrow$ It means, the position of a center of mass (not each part of system!) not changed

$$m\, x_c^{init} = m\, x_c^{final}$$

Let's write conditions for each body

"0" - Initial "1" - final

$x_1$ $\quad$ $x_1 + \Delta S$

$y_1$ $\quad$ $y_1$

$x_2$ $\quad$ $x_2 + \Delta S - l$

$y_2$ $\quad$ $y_2 + l$

$$\frac{\cancel{m_1 x_1} + \cancel{m_2 x_2}}{\cancel{m_1 + m_2}} = \frac{\cancel{m_1 x_1} + m_1 \Delta S + \cancel{m_2 x_2} + m_2(\Delta S - l)}{\cancel{m_1 + m_2}}$$

$$\Rightarrow 0 = m_1 \Delta S + m_2 \Delta S - m_2 l \Rightarrow \underline{\underline{\Delta S}}$$

2-nd subtask

We need to know the time, when B body will reach 90 degrees. Let's integrate angular velocity and find time

$$\omega = \varepsilon t \Rightarrow \varphi(t),\ \varphi = 90 \Rightarrow t_1$$

$$V_B^{rel} = \omega(t_1)\, l$$

$$\frac{d\bar{Q}}{dt} = 0$$ We know it from the first subtask $\Rightarrow x: \frac{dQ_x}{dt} = 0$

$$Q_x^{init} = Q_x^{final}$$

$$0 = m V_a^{abs} + m_B \underbrace{V_B^{abs}}_{(V_a^{abs} - V_B^{rel})} \Rightarrow V_a^{abs}$$