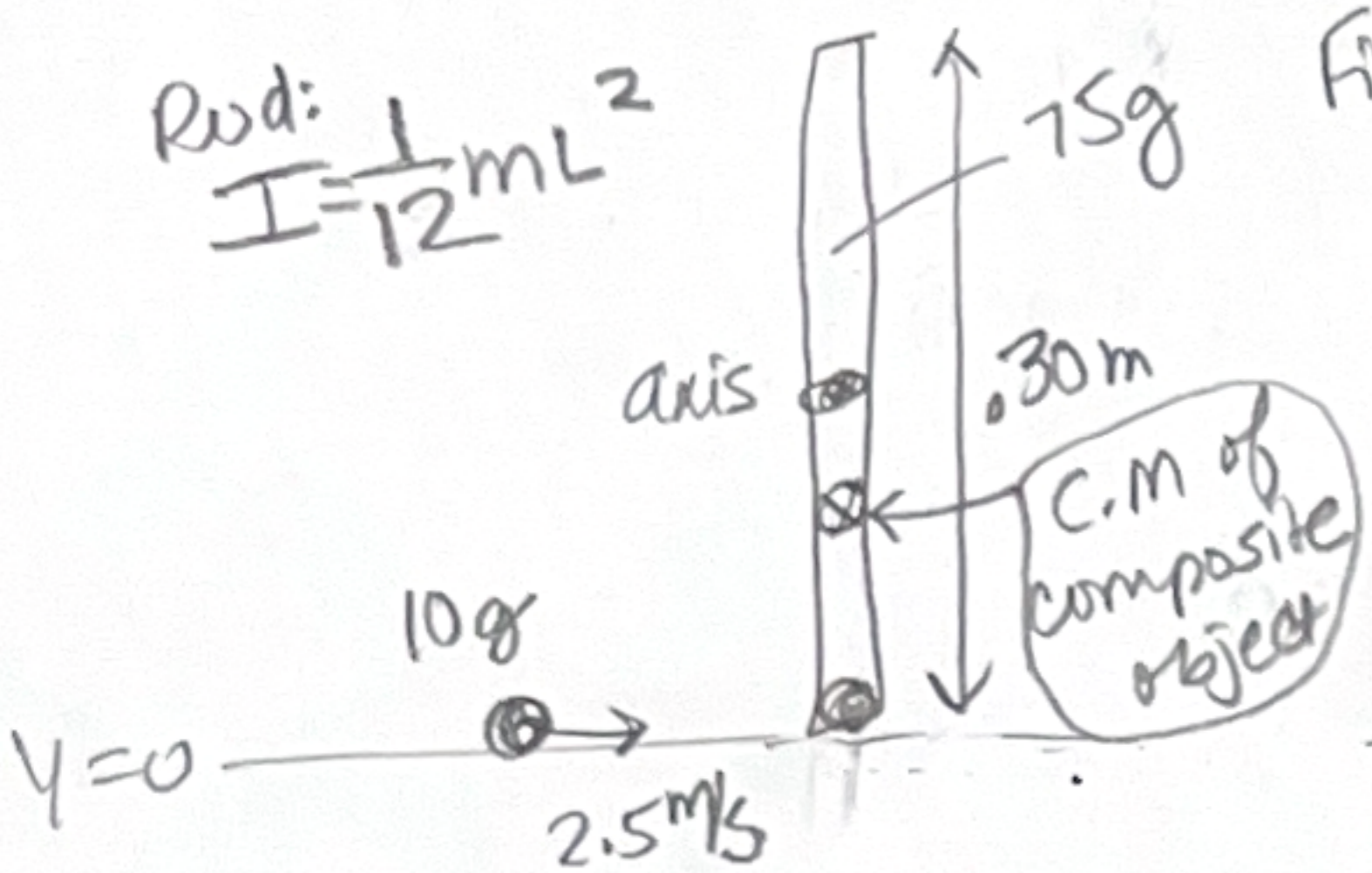


Rotational Practice 3

Name: _____
Date: _____

p.335 #90. Solve the problem by working through these steps:

a) Sketch and translate:



- m_R = rod mass
- m_C = clay mass
- l = rod length
- v_0 = clay initial velocity

b) How many parts (time intervals) would you divide this problem into? 2 Label the points in time at the boundaries of these time intervals with letters and a description. I've done the first one:

- A: Just before the ball of clay hits the rod
- B: Just after the collision of clay + rod
- C: At max angle after collision ($v=0$)

c) Decide whether or not each physics principle would be useful for analyzing each time interval, or under what conditions it would be useful. In each box, write "yes" or "no" and your reasoning. *(changed directions)*

**You should have the green boxes!*

Time interval	Newton's Laws	Conservation of Energy	Conservation of Angular Momentum
A to B <i>This is during the collision</i>	NO - We don't know anything about the forces between the clay and the rod.	Depends - This is an inelastic collision, so there is an increase in E_{th} . Energy is not useful <u>unless</u> we want to find E_{th} .	Yes - There are no angular impulses (external torques that act for some time), so $L_i = L_f$. if the system is the clay + rod.
B to C <i>as it rotates</i>	NO - As the object rotates, the torque from F_g is always changing. N2L is best for constant forces.	Yes - if we include Earth in the system, then there is no work done by external forces or torques, so $E_i = E_f$ for the system of rod, clay, earth.	NO - if system is rod, clay, then the F_g causes angular impulse, which is messy b/c it is not constant. If the system includes Earth, angular momentum is constant, but as the rod goes up, earth's angular momentum must change + we can calculate it.

d) Calculate the position of the center of mass of the composite object (rod and clay). Mark it on the diagram.

$$y_{cm} = \frac{m_1 y_1 + m_2 y_2}{m_1 + m_2}$$

$$= \frac{m_C y_C + m_R y_R}{m_C + m_R}$$

$$= \frac{(0.01 \text{ kg})(0) + (0.075 \text{ kg})(0.15 \text{ m})}{(0.01 \text{ kg} + 0.075 \text{ kg})} = \boxed{0.13 \text{ m}} \text{ (from bottom end of rod.)}$$

e) Calculate the rotational inertia of the composite object (rod and clay).

$$\begin{aligned}
 I_{rc} &= I_{rod} + I_{clay} \\
 &= \frac{1}{12} m_R l^2 + m_c r_c^2 \\
 &= \frac{1}{12} m_R l^2 + m_c \left(\frac{l}{2}\right)^2 \\
 &= \frac{1}{12} m_R l^2 + \frac{1}{4} m_c l^2 \\
 &= l^2 \left(\frac{1}{12} m_R + \frac{1}{4} m_c\right) \\
 &= (.3\text{m})^2 \left(\frac{1}{12} (.075\text{kg}) + \frac{1}{4} (.010\text{kg})\right) \\
 &= \boxed{7.875 \times 10^{-4} \text{kgm}^2}
 \end{aligned}$$

f) Calculate the angular speed of the composite object (rod and clay) just after the collision of the clay and the rod. Define system.

From A → B: Conservation of Ang. Mom.

Clay rod
Earth axis

$L_i = L_f$ b/c no external torques ~~are~~ to cause angular impulses

$$r_{\perp} m v_0 = I_{rc} \omega_B$$

$$\frac{r_{\perp} m v_0}{I_{rc}} = \omega_B$$

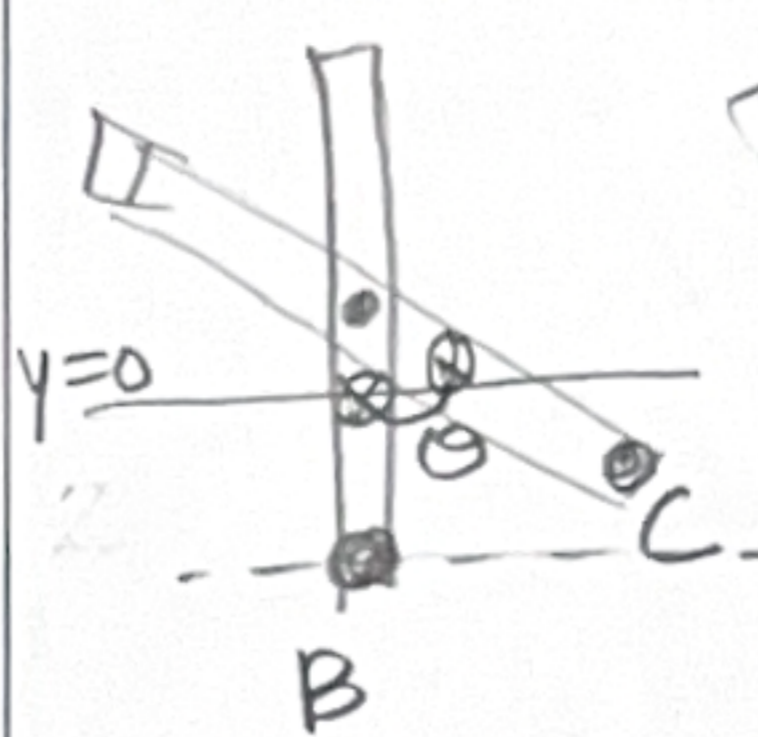
$$\frac{(.15\text{m})(.01\text{kg})(2.5\text{m/s})}{(7.875 \times 10^{-4}\text{kgm}^2)} = \omega_B$$

$$\boxed{4.76 \frac{\text{rad}}{\text{s}} = \omega_B}$$

This is the angular speed of the composite object at B, just after the collision.

note Since the C.M. of the rod doesn't change height, you can use just m_c for the U.G. Due to sig figs, you might get $\theta = 66^\circ$ or 67° .

g) Calculate the maximum angle, measured from the vertical, that the rod (with the attached ball of clay) reaches after the collision. Define system.



The center of mass of the composite object changes height. No transfers by work

$$E_B = E_C$$

$$K_{rot} = U_G$$

$$\frac{1}{2} I_{rc} \omega_B^2 = (m_R + m_c) g h_{cm}$$

$$(I_{rc}) \omega_B^2 = h$$

$$2g(m_R + m_c)$$

$$h = \frac{(7.875 \times 10^{-4} \text{kgm}^2)(4.76 \frac{\text{rad}}{\text{s}})^2}{2(10\text{N/kg})(.01\text{kg} + .075\text{kg})}$$

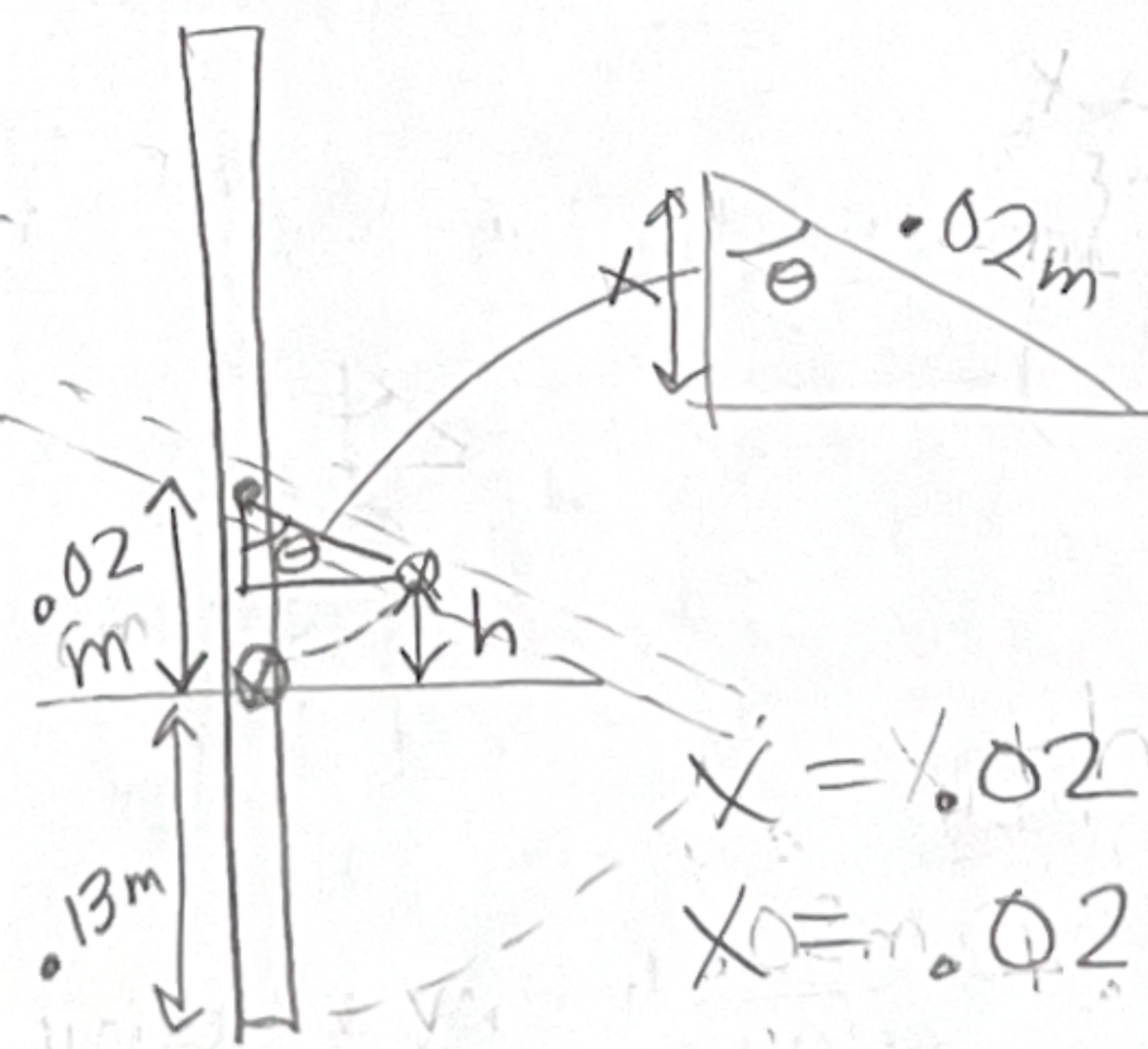
$$h = .0105\text{m}$$

h = height of C.M.

rod clay earth

y=0 is at lowest position of C.M.

h) For what system of objects is there an increase in thermal energy? During what time interval does it occur? Calculate the increase in thermal energy:



$$x = .02 - h$$

$$x = .02\text{m} - .0105\text{m}$$

$$x = .0095\text{m}$$

$$\cos \theta = \frac{x}{.02\text{m}}$$

$$\cos \theta = \frac{.0095}{.02}$$

$$\theta = 62^\circ$$

or if you carried more sig figs, θ might be closer to 66°