1. (25%) Pin B is attached to the rotating arm AC and moves at a constant speed $v_0 = 2.875$ m/s. Knowing that pin B slides freely in a slot cut in arm OD, Let the length $\overline{AB}$ be denoted by R.

(a) Show that, when arm AC rotates, at any instant angle θ can be expressed in terms of ϕ as

$$\tan\theta = \frac{R\sin\phi}{0.375 + R\cos\phi}. \tag{1}$$

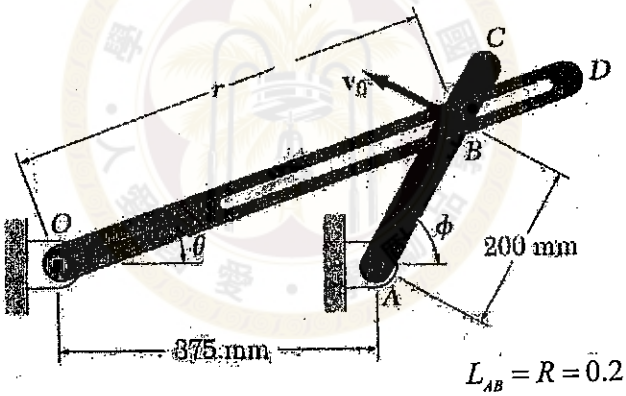
(b) Show that at any instant the rates $\dot{r}$ and $\dot{\theta}$ in terms of r, θ, ϕ, and $\dot{\phi}$ are

$$\dot{r} = R\dot{\phi}\left(\cos\phi\sin\theta - \sin\phi\cos\theta\right) = R\dot{\phi}\sin\left(\theta - \phi\right), \tag{2}$$

$$\dot{\theta} = \frac{R\dot{\phi}\left(\cos\phi\cos\theta + \sin\phi\sin\theta\right)}{r} = \frac{R\dot{\phi}\cos\left(\theta - \phi\right)}{r}. \tag{3}$$

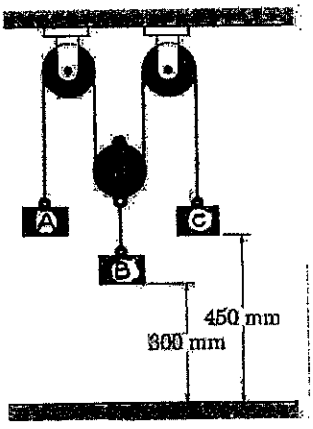
(c) Determine the rates $\dot{r}$ and $\dot{\theta}$ at the instant where $\phi = 0$.

(d) Determine the rates $\dot{r}$ and $\dot{\theta}$ at the instant where $\phi = 90^\circ$.



$L_{AB} = R = 0.2$ m

2. (25%) Referring to the following figure and knowing that blocks B and C strike the ground simultaneously and exactly 1 s after the system is released from rest. Determine m_B and m_C in terms of m_A.



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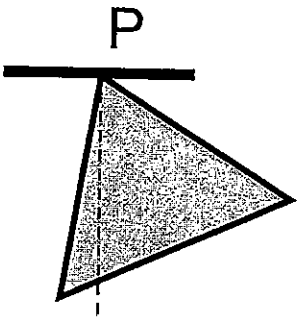
3. (25%) Shown in the plot is an equilateral triangular plate of lateral length L with the point **P** fixed. The pendulum is allowed to oscillate in the plane depicted under a constant gravitational field g. The plate is assumed to be homogeneous and the total mass is M.

(a) Calculate the principal moment of inertia with respect to P that is relevant to the oscillation.

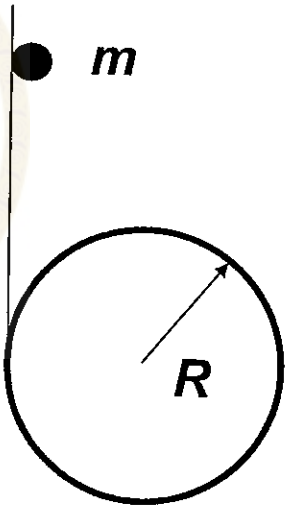
(b) For the case of small oscillation, calculate the oscillation period.



4. (25%) A point mass m rolls without friction down a ramp and through a vertical circular loop of radius R in a constant gravitational field g. If the particle is released from rest, find:

(a) The minimum release height such that the particle can travel all the way around the loop.

(b) The force exerted on the track by the particle when it is at the lowest point of the loop.



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