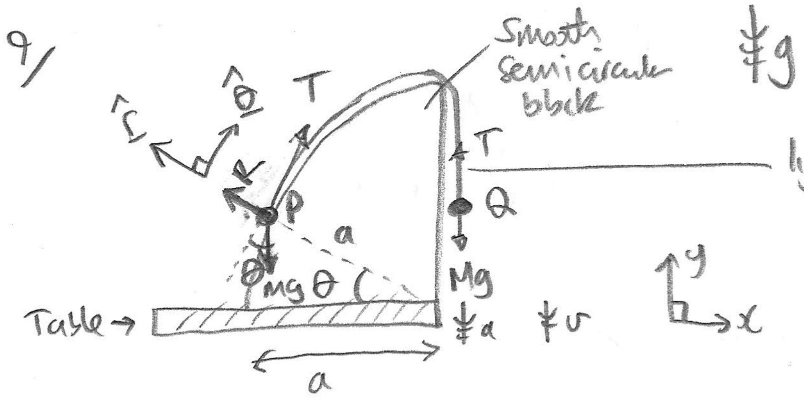
9/



Initially $\theta = 0$ ie mass P on the table.

Conservation of energy:

$$0 = \frac{1}{2}mv^2 + \frac{1}{2}Mv^2 + mga\sin\theta - \underbrace{Mga\theta}$$

Q moves down by the arc P moves up

$$\therefore \boxed{v^2 = \frac{2(Mga\theta - mga\sin\theta)}{m+M}}$$

Now Newton II in $\hat{r}$ direction (acceleration is radially inwards)

$$\frac{mv^2}{a} = mg\sin\theta - R \qquad // \hat{r}$$

$$\therefore \quad R = mg\sin\theta - \frac{mv^2}{a} \qquad \text{(Normal contact force)}$$

Using the v^2 expression above

$$R = mg\sin\theta - 2mg\frac{(M\theta - m\sin\theta)}{m+M}$$

$$R = mg\left(\frac{(m+M)\sin\theta - 2M\theta + 2m\sin\theta}{m+M}\right)$$

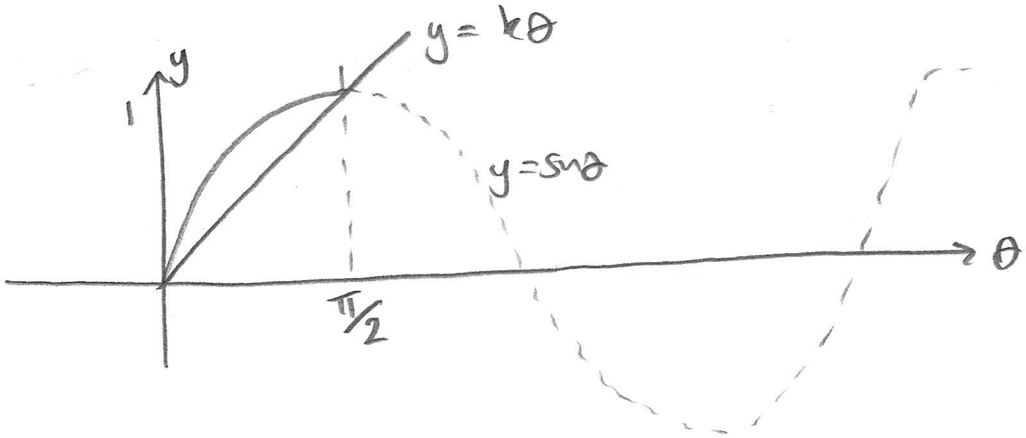
$$\boxed{R = mg\left(\frac{(3m+M)\sin\theta - 2M\theta}{m+M}\right)}$$

Now we are told that P remains in contact with the quarter-circular block for $0 \leq \theta \leq \frac{\pi}{2}$

This means $R \geqslant 0$ for this range.

$$\therefore \quad (3m+M)\sin\theta - 2M\theta \geqslant 0$$

$$\boxed{\sin\theta \geqslant \frac{2M}{3m+M}\theta} \qquad (+)$$



So if $k > \dfrac{1}{\pi/2}$

$k > \frac{2}{\pi}$ then $\sin\theta < k\theta$ over range $0 < \theta \leq \frac{\pi}{2}$

$\therefore$ So $(+)$ true for $0 \leq \theta \leq \frac{\pi}{2}$

if $\dfrac{2M}{3m+M} \leq \dfrac{2}{\pi}$

$$M \leq \frac{3m+M}{\pi}$$

$$M(\pi-1) \leq 3m$$

$$\boxed{\frac{\pi-1}{3} \leq \frac{m}{M}} \quad \text{as required.}$$