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*Problem 13-96

The forked rod is used to move the smooth particle of weight *W* around the horizontal path in the shape of a limacon $r = a + b\cos\theta$. If $\theta = ct^2$, determine the force which the rod exerts on the particle at the instant $t = t_1$. The fork and path contact the particle on only one side.



Solution: $t = t_1$ $\theta = ct^2$ $\theta' = 2ct$ $\theta'' = 2c$

Find the angel ψ using rectangular coordinates. The path is tangent to the velocity therefore.

$$x = r\cos(\theta) = (a)\cos(\theta) + b\cos(\theta)^{2} \qquad x' = \left[-(a)\sin(\theta) - 2b\cos(\theta)\sin(\theta)\right]\theta$$
$$y = r\sin(\theta) = (a)\sin(\theta) + \frac{1}{2}b\sin(2\theta) \qquad y' = \left[(a)\cos(\theta) + b\cos(2\theta)\right]\theta$$
$$\psi = \theta - \operatorname{atan}\left(\frac{y'}{x'}\right) \qquad \psi = 80.5410 \operatorname{deg}$$

Now do the dynamics using polar coordinates

$$r = a + b\cos(\theta)$$
 $r' = -b\sin(\theta)\theta'$ $r'' = -b\cos(\theta)\theta'^2 - b\sin(\theta)\theta'$

Guesses F = 1 lb $F_N = 1$ lb

Given
$$F - F_N \cos(\psi) = \left(\frac{W}{g}\right)(r\theta' + 2r'\theta)$$
 $-F_N \sin(\psi) = \left(\frac{W}{g}\right)(r'' - r\theta^2)$
 $\begin{pmatrix} F\\F_N \end{pmatrix} = \operatorname{Find}(F, F_N)$ $F_N = 0.2666 \, \text{lb}$ $F = 0.1630 \, \text{lb}$