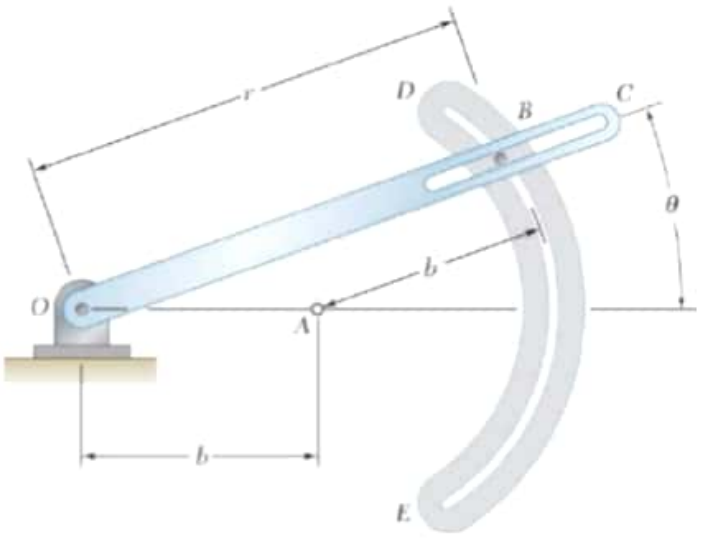
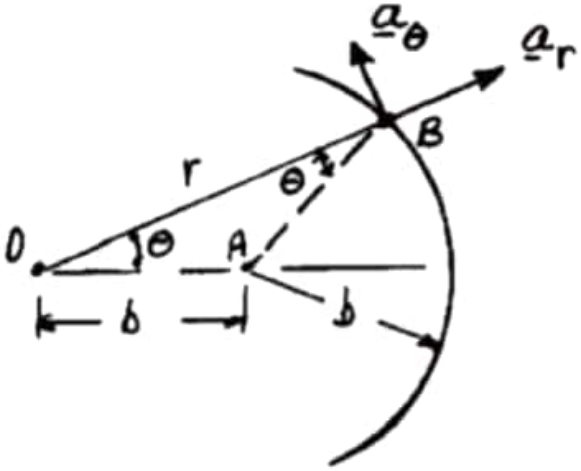
PROBLEM 11.166



The pin at B is free to slide along the circular slot DE and along the rotating rod OC. Assuming that the rod OC rotates at a constant rate $\dot{\theta}$, (*a*) show that the acceleration of pin B is of constant magnitude, (*b*) determine the direction of the acceleration of pin B.

SOLUTION



From the sketch:

$$r = 2b\cos\theta$$

$$\dot{r} = -2b\sin\theta\,\dot{\theta}$$

Since $\dot{\theta} = \text{constant}$, $\ddot{\theta} = 0$

$$\ddot{r} = -2b\cos\theta\,\dot{\theta}^2$$

$$a_r = \ddot{r} - r\dot{\theta}^2 = -2b\cos\theta\,\dot{\theta}^2 - (2b\cos\theta)\dot{\theta}^2$$

$$a_r = -4b\cos\theta\,\dot{\theta}^2$$

$$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = (2b\cos\theta)(0) + 2(-2b\sin\theta)\dot{\theta}^2$$

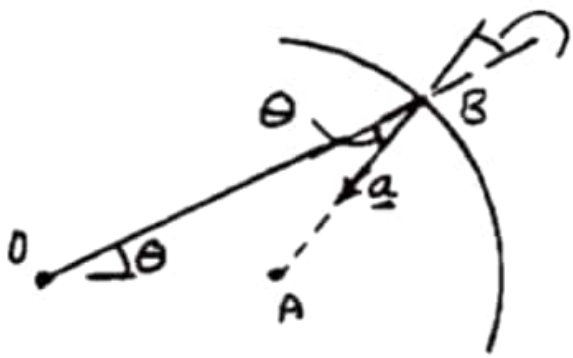
$$a_\theta = -4b\sin\theta\,\dot{\theta}^2$$

$$a = \sqrt{a_r^2 + a_\theta^2} = 4b\dot{\theta}^2\sqrt{(-\cos\theta)^2 + (-\sin\theta)^2}$$

$$a = 4b\dot{\theta}^2$$

Since both b and $\dot{\theta}$ are constant, we find that

$a = \text{constant}$ ◀

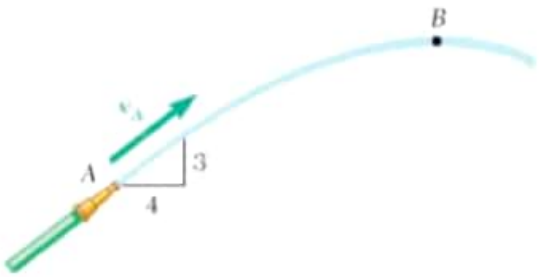


$$\gamma = \tan^{-1}\frac{a_\theta}{a_r} = \tan^{-1}\left(\frac{-4b\sin\theta\,\dot{\theta}^2}{-4b\cos\theta\,\dot{\theta}^2}\right)$$

$$\gamma = \tan^{-1}(\tan\theta)$$

$$\gamma = \theta$$

Thus, **a** is directed toward A ◀



PROBLEM 11.148

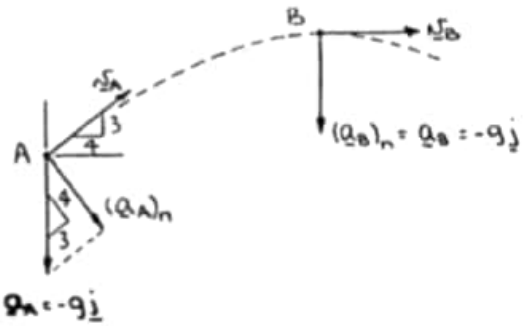
From measurements of a photograph, it has been found that as the stream of water shown left the nozzle at A, it had a radius of curvature of 25 m. Determine (a) the initial velocity $\mathbf{v}_A$ of the stream, (b) the radius of curvature of the stream as it reaches its maximum height at B.

SOLUTION

(a) We have $(a_A)_n = \dfrac{v_A^2}{\rho_A}$

or $v_A^2 = \left[\dfrac{4}{5}(9.81 \text{ m/s}^2)\right](25 \text{ m})$

or $v_A = 14.0071 \text{ m/s}$



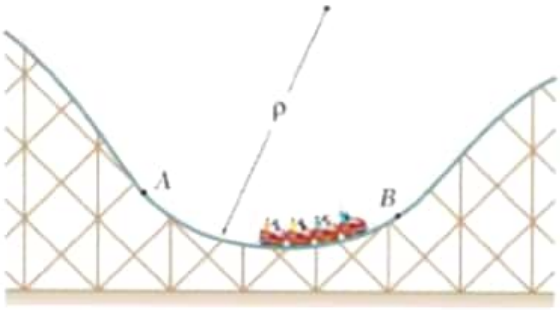
$\mathbf{v}_A = 14.01 \text{ m/s} \angle 36.9° \blacktriangleleft$

(b) We have $(a_B)_n = \dfrac{v_B^2}{\rho_B}$

Where $v_B = (v_A)_x = \dfrac{4}{5} v_A$

Then $\rho_B = \dfrac{\left(\frac{4}{5} \times 14.0071 \text{ m/s}\right)^2}{9.81 \text{ m/s}^2}$

or $\rho_B = 12.80 \text{ m} \blacktriangleleft$



PROBLEM 11.134

Determine the maximum speed that the cars of the roller-coaster can reach along the circular portion AB of the track if ρ is 25 m and the normal component of their acceleration cannot exceed 3 g.

SOLUTION

We have $$a_n = \frac{v^2}{\rho}$$

Then $$(v_{\max})_{AB}^2 = (3 \times 9.81 \text{ m/s}^2)(25 \text{ m})$$

or $$(v_{\max})_{AB} = 27.124 \text{ m/s}$$

or $$(v_{\max})_{AB} = 97.6 \text{ km/h} \blacktriangleleft$$