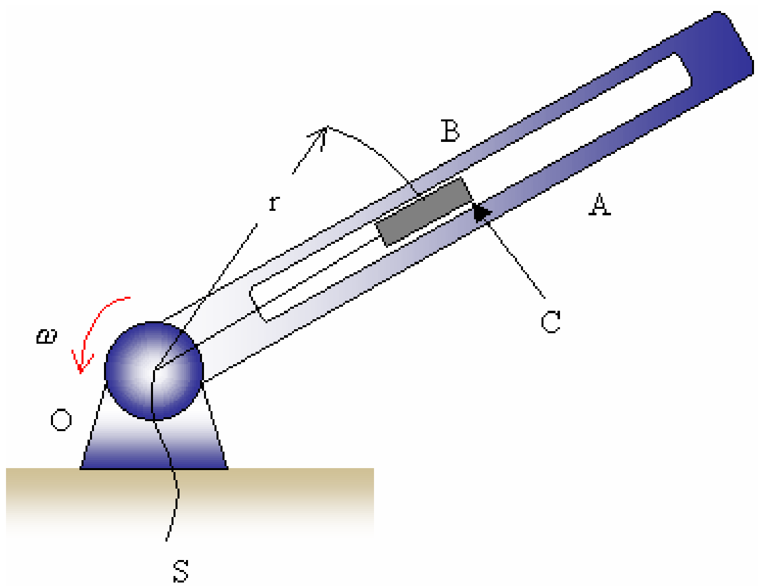
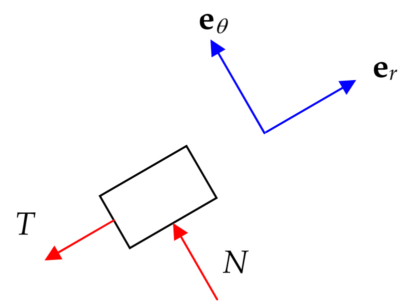
Example 7.5

The slotted arm revolves in a horizontal plane about the fixed vertical axis through point *O*. The 3-lb slider *C* is drawn toward *O* at the constant rate of 2 in/s by pulling the cord *S*. At the instant for which r = 9 in, the arm has a counterclockwise angular velocity $\omega = 6$ rad/s and is slowing down at the rate of 2 rad/s². For this instant, determine the tension *T* in the cord and the magnitude *N* of the force exerted on the slider by the sides of the smooth radial slot. Indicate which side, *A* or *B*, of the slot contacts the slider.



Solution:

The free-body diagram of the block and the coordinate system used are shown in the figure below:



In the figure above T is the tension in the string and N is the normal force exerted by the slot on the slider. From Newton's second law and Eqs. (7.4) we can write:

$$-T = ma_r = m\left(\ddot{r} - r\dot{\theta}^2\right)$$

$$N = ma_\theta = m\left(r\ddot{\theta} + 2\dot{r}\dot{\theta}\right)$$

From the given data for the instant shown we have: $r = 9$ in, $\dot{r} = -2$ in/s, $\ddot{r} = 0$ (since $\dot{r}$ is constant), $\dot{\theta} = 6$ rad/s, and $\ddot{\theta} = -2$ rad/s^2. Substituting these values in the equations above we obtained the required forces as:

$$T = mr\dot{\theta}^2 = \frac{3}{386.4}(9)(6)^2 = 2.52 \text{ lb}$$

$$N = m\left(r\ddot{\theta} + 2\dot{r}\dot{\theta}\right) = \frac{3}{386.4}\left[(9)(-2) + 2(-2)(6)\right] = -0.326 \text{ lb}$$

Since the sign of N comes out negative its direction is the opposite of what is shown in the figure above. Consequently the slider contacts the slot on the B side.