$$\dot{\theta} = \frac{L}{mr^2} \Rightarrow \dot{\theta} = \frac{L}{m}\frac{1}{\left[r_0^2 - \left(\frac{-2\sigma}{m}\right)^{1/2}(t-t_0)\right]}$$

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$$\Rightarrow \theta - \theta_0 = \frac{L}{m}\int_{t_0}^{t}\frac{dt'}{\left[r_0^2 - \left(\frac{-2\sigma}{m}\right)(t'-t_0)\right]} \Rightarrow \tau \quad t' = \tau + t_0$$

$$\theta - \theta_0 = \frac{L}{m}\int_0^{t-t^0}\frac{d\tau}{\left[r_0^2 - \left(\frac{-2\sigma}{m}\right)^{1/2}\tau\right]} \Rightarrow$$

$$\boxed{\theta - \theta_0 = \frac{L}{m}\left[-\left(\frac{m}{-2\sigma}\right)^{1/2}\right]\log\left[r_0^2 - \left(\frac{-2\sigma}{m}\right)^{1/2}\tau\right]\Bigg|_0^{t-t_0}}$$