

9.1: Introduction Newton's Second Law and Circular Motion

I shall now recall to mind that the motion of the heavenly bodies is circular, since the motion appropriate to a sphere is rotation in a circle.

Nicholas Copernicus

We have already shown that when an object moves in a circular orbit of radius r with angular velocity $\vec{\omega}$ it is most convenient to choose polar coordinates to describe the position, velocity and acceleration vectors. In particular, the acceleration vector is given by

$$\vec{\mathbf{a}}(t) = -r \left(\frac{d\theta}{dt} \right)^2 \hat{\mathbf{r}}(t) + r \frac{d^2\theta}{dt^2} \hat{\boldsymbol{\theta}}(t)$$

Then Newton's Second Law, $\vec{\mathbf{F}} = m \vec{\mathbf{a}}$ can be decomposed into radial ($\hat{\mathbf{r}}$ –) and tangential ($\hat{\boldsymbol{\theta}}$ –) components

$$F_r = -mr \left(\frac{d\theta}{dt} \right)^2 \quad (\text{circular motion})$$

$$F_\theta = mr \frac{d^2\theta}{dt^2} \quad (\text{circular motion})$$

For the special case of uniform circular motion, $d^2\theta/dt^2 = 0$, and so the sum of the tangential components of the force acting on the object must therefore be zero,

$$F_\theta = 0$$

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