Unit Circle. Cooordinate System Identities.

\[ x = r \cos \theta = \rho \sin \phi \cos \theta \]
\[ y = r \sin \theta = \rho \sin \phi \sin \theta \]
\[ z = x \tan \theta \]
\[ r = \rho \sin \phi \]
\[ r^2 = x^2 + y^2 \]
\[ \rho^2 = x^2 + y^2 + z^2 \]

Projections and Angles. For any two vectors \( u \) and \( v \), the projection \( p_v(u) \) of \( u \) onto \( v \) is given by
\[ p_v(u) = \left( \frac{u \cdot v}{v \cdot v} \right) v \]
and the angle \( \theta \) between them satisfies
\[ \cos \theta = \frac{u \cdot v}{||u|| ||v||} . \]

Notions related to curves. Consider a curve \( r(t) \) in \( \mathbb{R}^2 \) or \( \mathbb{R}^3 \).

1. **Arclength.** The arclength of the curve from \( t = a \) to \( t = b \) is given by
\[ \int_a^b ||r'(t)|| \, dt. \]

2. **Unit Tangent Vector.** The unit tangent vector \( T \) at any time is given by
\[ T = \frac{r'}{||r'||} . \]

3. **Tangential Acceleration.** The tangential component of the acceleration \( a_T \) at any time is given by
\[ a_T = \frac{r' \cdot r''}{||r'||} \quad \text{or} \quad a_T = T \cdot r'' . \]

4. **Normal Acceleration.** The normal component of the acceleration \( a_N \) at any time is given by
\[ a_N = \frac{||r' \times r'||}{||r'||^3} \quad \text{or} \quad a_N = ||T \times r'|| \quad \text{or} \quad a_N = ||r'' - a_T T|| . \]

5. **Curvature.** The curvature at \( \kappa \) at any time is given by
\[ \kappa = \frac{||r' \times r''||}{||r'||^3} \quad \text{or} \quad \kappa = \frac{a_N}{||r'||^2} \quad \text{or} \quad \kappa = \frac{|x'y'' - y'x''|}{[(x')^2 + (y')^2]^{3/2}} . \]

6. **Unit Normal Vector.** The unit normal vector \( N \) at any time is given by
\[ N = \frac{1}{a_N}(r'' - a_T T) \quad \text{or} \quad N = \frac{T'}{||T'||} . \]

7. **Binormal Vector.** The binormal vector \( B \) at any time is given by
\[ B = T \times N . \]