1. Speed: $v(t)=s^{\prime}(t)=\left\|\mathbf{r}^{\prime}(t)\right\|$

Velocity: $\mathbf{v}(t)=\mathbf{r}^{\prime}(t)$
Acceleration: $\mathbf{a}(t)=\mathbf{v}^{\prime}(t)=\mathbf{r}^{\prime \prime}(t)$
2. Find the velocity and acceleration functions for the position function $\mathbf{r}(t)=\left\langle t e^{-2 t}, 2 e^{-2 t},-3 t^{2}\right\rangle$.
3. Find the velocity and position functions if $\mathbf{a}(t)=\langle t, 0,-4\rangle, \mathbf{v}(0)=\langle 12,-4,0\rangle, \mathbf{r}(0)=\langle 5,0,2\rangle$.
4. Newton's Second Law of Motion: $\mathbf{F}=m \mathbf{a}$, where $\mathbf{F}$ is the net force vector acting on the object, $m$ is the mass, and $\mathbf{a}$ is the acceleration vector.
5. Projectile Motion: A projectile is launched with an initial speed of 49 meters per second from ground level at an angle of $\pi / 4$ to the horizontal. Assuming the only force acting on the object is gravity ( 9.8 meters per second per second), find the
(a) maximum altitude,
(b) horizontal range, and
(c) speed at impact of the projectile.
6. Tangential and Normal Components of Acceleration: Imagine an object moving along a curve determined by $\mathbf{r}(t)$. Recall that the tangent (velocity) vector is $\mathbf{v}(t)=\mathbf{r}^{\prime}(t)$, and the speed is $v(t)=\|\mathbf{v}(t)\|$. Then $\mathbf{v}(t)=v(t) \mathbf{T}(t)$, and the acceleration $\mathbf{a}(t)$ of the object is given by

$$
\mathbf{a}(t)=v^{\prime}(t) \mathbf{T}(t)+\kappa(t) v^{2}(t) \mathbf{N}(t)
$$

This says that the acceleration is always in the osculating $\mathbf{T}(t) \mathbf{N}(t)$-plane. The tangential and normal components of acceleration are then the coefficients $a_{\mathbf{T}}=v^{\prime}(t)$ and $a_{\mathbf{N}}=\kappa(t) v^{2}(t)$, respectively.

We may also write

$$
\mathbf{a}(t)=\left(\frac{\mathbf{a}(t) \cdot \mathbf{v}(t)}{\|\mathbf{v}(t)\|}\right) \mathbf{T}(t)+\left(\frac{\|\mathbf{a}(t) \times \mathbf{v}(t)\|}{\|\mathbf{v}(t)\|}\right) \mathbf{N}(t)
$$

Proof:
7. A particle moves through 3 -space such that its position vector at time $t$ is $\mathbf{r}(t)=\left\langle t, t^{2}, t^{3}\right\rangle$. Find the
(a) scalar tangential and normal components of acceleration at time $t$.
(b) scalar tangential and normal components of acceleration at time $t=1$.
(c) vector tangential and normal components of acceleration at time $t=1$.
(d) curvature of the path at the point at time $t=1$.

