1) Find the velocity, acceleration, and speed of a particle with the given position function.

a) $\mathbf{r}(t) = \langle t^2 + 1, t^3, t^2 - 1 \rangle$

b) $\mathbf{r}(t) = \langle e^t \cos t, e^t \sin t, e^t \rangle$

a) $\boxed{\mathbf{v}(t) = \langle 2t, 3t^2, 2t \rangle,\ \|\mathbf{v}(t)\| = |t|\sqrt{9t^2 + 8},\ \mathbf{a}(t) = \langle 2, 6t, 2 \rangle}$

b) $\boxed{\mathbf{v}(t) = \langle e^t \cos t - e^t \sin t, e^t \sin t + e^t \cos t, e^t \rangle,\ \|\mathbf{v}(t)\| = e^t\sqrt{3},\ \mathbf{a}(t) = \langle -2e^t \sin t, 2e^t \cos t, e^t \rangle}$

2) Use the given acceleration function to find the velocity and position vectors. Then find the position at time $t = 2$.

a) $\mathbf{a}(t) = \mathbf{i} + \mathbf{j} + \mathbf{k},\ \mathbf{v}(0) = 0,\ \mathbf{r}(0) = 0$

b) $\mathbf{a}(t) = t\,\mathbf{i} + t^2\mathbf{j} + \cos 2t\,\mathbf{k},\ \mathbf{v}(0) = \mathbf{i} + \mathbf{k},\ \mathbf{r}(0) = \mathbf{j}$

a) $\boxed{\mathbf{v}(t) = \langle t, t, t \rangle,\ \mathbf{r}(t) = \left\langle \frac{t^2}{2}, \frac{t^2}{2}, \frac{t^2}{2} \right\rangle,\ \mathbf{r}(t) = \langle 2, 2, 2 \rangle}$

b) $\boxed{\mathbf{v}(t) = \left\langle \frac{1}{2}t^2 + 1, \frac{1}{3}t^3, 1 + \frac{1}{2}\sin 2t \right\rangle,\ \mathbf{r}(t) = \left\langle \frac{1}{6}t^3 + t, 1 + \frac{1}{12}t^4, \frac{1}{4} + t - \frac{1}{4}\cos 2t \right\rangle,\ \mathbf{r}(2) = \left\langle \frac{10}{3}, \frac{7}{3}, \frac{9}{4} - \frac{1}{4}\cos(4) \right\rangle}$

3) The position function of a particle is given by: $\mathbf{r}(t) = \langle t^2, 5t, t^2 - 16t \rangle$. When is the speed a minimum?

$\boxed{\sqrt{153} \text{ at } t = 4}$

4) What force is required so that a particle of mass m has the position function: $\mathbf{r}(t) = \langle t^3, t^2, t^3 \rangle$?

$$\boxed{\mathbf{F}(t) = \langle 6mt, 2m, 6mt \rangle}$$

5) Find the vector function for the path of a projectile launched at a height of 10 feet above the ground with an initial velocity of 88 feet per second and at an angle of $30°$ above the horizontal.

$$\boxed{\mathbf{r}(t) = \langle 44\sqrt{3}, 0, 10 + 44t - 16t^2 \rangle}$$

6) Find the tangential and normal components of the acceleration vector.

a) $\mathbf{r}(t) = \cos t\,\mathbf{i} + \sin t\,\mathbf{j} + t\,\mathbf{k}$

b) $\mathbf{r}(t) = t\,\mathbf{i} + t^2\,\mathbf{j} + 3t\,\mathbf{k}$

a) $\boxed{a_T = 0,\ a_N = 1}$

b) $\boxed{a_T = \dfrac{4t}{\sqrt{4t^2 + 10}},\ a_N = \dfrac{2\sqrt{10}}{\sqrt{4t^2 + 10}}}$