

$$\vec{r}(t) = \langle -t^2 + 3t - 1, -2t^3 + 2t^2 + 3t + 1, 2t - 4 \rangle = \langle -1, 1, -4 \rangle$$

$$\vec{v}(t) = \langle -2t + 3, -6t^2 + 4t + 3, 2 \rangle = \langle 3, 3, 2 \rangle$$

$$\vec{a}(t) = \langle -2, -12t + 4, 0 \rangle = \langle -2, 4, 0 \rangle$$

$$\vec{a}_T(t) = \frac{\vec{v} \cdot \vec{a}}{\|\vec{v}\|^2} \cdot \vec{v} = \frac{6}{22} \cdot \langle 3, 3, 2 \rangle = \left\langle \frac{9}{11}, \frac{9}{11}, \frac{6}{11} \right\rangle$$

$$\vec{a}_N(t) = \vec{a} - \vec{a}_T = \langle -2, 4, 0 \rangle - \left\langle \frac{9}{11}, \frac{9}{11}, \frac{6}{11} \right\rangle = \left\langle -\frac{31}{11}, \frac{35}{11}, -\frac{6}{11} \right\rangle$$