7. $\vec{r}(t) = t^4\vec{i} - (t^2-1)\vec{j}$

a) $\vec{r}'(t) = \boxed{4t^3\vec{i} - 2t\vec{j}}$

b) $\vec{r}''(t) = \boxed{12t^2\vec{i} - 2\vec{j}}$

c) $\vec{r}'(t) \cdot \vec{r}''(t)$

$= 4t^3(12t^2) + (-2t)(-2)$

$= \boxed{48t^5 + 4t}$

8. $\vec{r}(t) = \langle \cos(2t), \sin(2t), te^t \rangle$

$\vec{r}'(t) = \boxed{\langle -2\sin(2t), 2\cos(2t), e^t + te^t \rangle}$

$\vec{r}''(t) = \boxed{\langle -4\cos(2t), -4\sin(2t), 2e^t + te^t \rangle}$

$\underbrace{te^t}_{P}\ \underbrace{}_{Q}$

$P' = 1 \quad Q' = e^t$

$P'Q + PQ'$

$1 \cdot e^t + te^t$

$= e^t + te^t$

$D_t\left[e^t + te^t\right]$

$e^t + e^t + te^t$

$2e^t + te^t$

$\vec{r}'(t) \cdot \vec{r}''(t)$

$= 8\sin(2t)\cos(2t) - 8\sin(2t)\cos(2t) + (e^t + te^t)(2e^t + te^t)$

$= 2e^{2t} + te^{2t} + 2te^{2t} + t^2e^{2t}$

$= 2e^{2t} + 3te^{2t} + t^2e^{2t}$

$= \boxed{e^{2t}(2 + 3t + t^2)}$