position: $r(t)$

velocity: $r'(t) = V(t)$, $|V(t)| = S(t)$

accel.: $r''(t) = V'(t) = a(t)$

$$T = \frac{r'}{|r'|} = \frac{V}{S} \rightarrow V = TS$$

$$V' = T'S + S'T = a$$

$$a = S'T + KSNS = \underset{a_T}{\underbrace{\boxed{S'}T}} + \underset{a_N}{\underbrace{\boxed{KS^2}N}}$$

$$N = \frac{T'}{|T'|} \quad , \quad R = \frac{|T'|}{|r'|} = \frac{|T'|}{S}$$

$$T' = |T'|N \qquad |T'| = KS$$

$$= KSN$$

$f(t)$

$r(t) = \langle 3\cos 2t, 3\sin 2t \rangle$

Find a_T, a_N

$K S^2 = a_n$

$r'(t) = -6\sin 2t, 6\cos 2t$

$|r'(t)| = 6$

$S' = 0$

$K = \frac{1}{c}$ $K = \frac{1}{3}$

$\frac{36}{3} = 12$

$$a_N = KS^2 = \frac{|r' \times r''|}{|r'|}$$

$$a_T = S' = \frac{r' \cdot r''}{|r'|}$$

$$K = \frac{|r' \times r''|}{|r'|^3}, \quad |r'| = S$$

$$\frac{|r' \times r''|}{|r'|^3} \cdot |r'|^2$$

$$|r'| = \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2}$$

$$|r'|' = \frac{1}{2\sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2}} \cdot \frac{d}{dt}\left(\left(\frac{dx}{dt}\right)^2 + \frac{dy^2}{dt}\right)$$

$$\frac{\cancel{2}\frac{dx}{dt}\frac{dx^2}{d_2t} + \cancel{2}\frac{dy}{dt}\frac{dy^2}{d_2t}}{\cancel{2}\sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2}} \Leftarrow$$

$$2\frac{dx}{dt}\frac{dx^2}{d_2t} + 2\frac{dy}{dt}\frac{dy^2}{d_2t}$$

$$\frac{r' \cdot r''}{|r'|}$$

$$r' = \frac{dx}{dt}, \frac{dy}{dt} \quad r'' = \frac{dx^2}{d_2t}, \frac{dy^2}{d_2t}$$