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$x = \cos t + t\sin t$
$y = \sin t - t\cos t$

an expression for the radius of curvature (R) in terms of t

Ans

$x = \cos t + t\sin t$

$\frac{dx}{dt} = -\sin t + t\cos t + \sin t = t\cos t$

$dy = \sin t - t\sin t$

$\frac{dy}{dt} = \cos t + t\sin t - \cos t = t\sin t$

$\frac{dy}{dx} = \frac{dy}{dt} \times \frac{dt}{dx}$

$= \frac{t\sin t}{t\cos t}$

$\frac{dy}{dx} = \frac{\sin t}{\cos t}$

$\frac{d^2y}{dx^2}$ $\quad U = \sin t, \quad V = \cos t$

$\frac{du}{dt} = \cos t \qquad \frac{dv}{dt} = -\sin t$

$\frac{V\,du/dx - U\,dv/dx}{V^2}$

$\frac{\cos t(\cos t) - (\sin t)(-\sin t)}{(\cos t)^2} \times \frac{1}{t\cos t}$

$$\frac{\cos^2 t + \sin^2 t}{\cos^2 t} \times \frac{1}{t \cos t}$$

$$\frac{1}{\cos^2 t} \times \frac{1}{t \cos t} = \frac{1}{t \cos^2 t}$$

$$\frac{d^2y}{dx^2} = \frac{1}{t \cos t}$$

$$R = \frac{\left(1 + (dy/dx)^2\right)^{3/2}}{d^2y/dx^2}$$

$$R = \frac{\left(1 + \left(\frac{\sin t}{\cos t}\right)^2\right)^{3/2}}{d^2y/dx^2}$$

$$R = \frac{\left(1 + \frac{\sin^2 t}{\cos^2 t}\right)^{3/2}}{\frac{1}{t} \cos^3 t}$$

$$R = \frac{\left(\frac{\cos^2 t + \sin^2 t}{\cos^2 t}\right)^{3/2}}{1/t \cos^3 t}$$

$$R = \frac{(1/\cos^2 t)^{3/2}}{1/t \cos^3 t}$$

$$R = \frac{1}{\cos^3 t} \times t \cos^3 t$$

$$R = t$$

Expressessions for the Coordinate (h, k) or the Centre of Curvature in terms of t

Ans

$h = x_1 - R\sin t$

$k = y_1 + R\cos t$

$R = t, \quad \theta = \tan^{-1}(dy/dx)$

$$\frac{dy}{dx} = \frac{\sin t}{\cos t} = \tan t$$

$$\therefore \theta = \frac{1}{\tan} \times \tan t$$

$\theta = t$

$h = x_1 - t\sin t$

$k = y_1 + t\cos t$

but $x = \cos t + t\sin t$

$y = \sin t - t\cos t$

$h = \cos t + t\sin t - t\sin t$

$h = \underline{\cos t}$

$k = \sin t - t\cos t + t\cos t$

$k = \sin t$

$(h, k) = (\cos t, \sin t)$

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