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Mechanical Engineering

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1. Given that $F = x^2 i + (3x+2) j + \sin x k$; Find (a) $\frac{dF}{dx}$ (b) $\frac{d^2F}{dx^2}$ (c) $\left| \frac{dF}{dx} \right|$ (d) $\frac{d}{dx}(F \cdot F)$ at $x=1$.

Solution

~~1~~ $F = x^2 i + (3x+2) j + \sin x k$

a) $\frac{dF}{dx} = 2x i + (3) j + \cos x k$
 $\therefore \frac{dF}{dx} = 2x i + 3 j + \cos x k$

b) $\frac{d^2F}{dx^2} = 2 i - \sin x k$

c) $\left| \frac{dF}{dx} \right| = \sqrt{(2x)^2 + (3)^2 + (\cos x)^2}$
 $= \sqrt{4x^2 + 9 + \cos^2 x}$
At $x=1 \Rightarrow \sqrt{4(1)^2 + 9 + \cos^2(1)}$
 $= \sqrt{4 + 9 + 0.999} = \sqrt{13.999} = 3.74$

d) $\frac{d}{dx}(F \cdot F) \Rightarrow (F \cdot F) = [x^2 i + (3x+2) j + \sin x k] \cdot [x^2 i + (3x+2) j + \sin x k]$
 $= x^4 + (9x^2 + 6x + 6x + 4) + \sin^2 x$
 $= x^4 + 9x^2 + 12x + 4 + \sin^2 x$
 $\therefore \frac{d}{dx}(F \cdot F) = 4x^3 + 18x + 12 + 2 \sin x \cos x$

$\frac{d}{dx}(F \cdot F) \Rightarrow 4(1)^3 + 18(1) + 12 + 2 \sin(1) \cos(1)$
at $x=1$

$= 4 + 18 + 12 + 2(0.0175)(0.999)$
 $= 4 + 18 + 12 + 0.035$
 $= 34.035$