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MECHATRONICS ENGINEERING
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① A particle moves along a curve, $x = t^2$, $y = -5t^2$, $z = t+7$, where t is time. Find its acceleration

$r = xi + yj + zk$

$r = t^2 i - 5t^2 j + (t+7)k$

$\frac{dr}{dt} = 2t i - 10t j + 1k$

$\frac{d^2r}{dt^2} = 2i - 10j$

② If $P = i - 9j - 4k$, $Q = 8i + 3j + 6k$, $R = i - 4j - 3k$
Find $(P \times Q) \cdot (R \times P)$

$$P \times Q = \begin{vmatrix} i & j & k \\ 1 & -9 & -4 \\ 8 & 3 & 6 \end{vmatrix} = i \begin{vmatrix} -9 & -4 \\ 3 & 6 \end{vmatrix} - j \begin{vmatrix} 1 & -4 \\ 8 & 6 \end{vmatrix} + k \begin{vmatrix} 1 & -9 \\ 8 & 3 \end{vmatrix}$$

$= i(-54+12) - j(6+32) + k(3+72)$

$-42i - 38j + 75k$

$$R \times P = \begin{vmatrix} i & j & k \\ 1 & -4 & -3 \\ 1 & -9 & -4 \end{vmatrix} = i \begin{vmatrix} -4 & -3 \\ -9 & -4 \end{vmatrix} + j \begin{vmatrix} 1 & -3 \\ 1 & -4 \end{vmatrix} + k \begin{vmatrix} 1 & -4 \\ 1 & -9 \end{vmatrix}$$

$i(16-27) - j(-4+3) + k(-9+4)$

$-11i + j - 5k$

$(P \times Q) \cdot (R \times P) = -42x - 11 - 38x1 + 75x - 5$

$= 462 - 38 - 375$

$= 49$

(3) Given $F = 5\cos 7t\, i - 2e^{3t} j - 4t^3 k$, find the integral of F with respect to t

$$\int F = 5\int \cos 7t\, i\, dt - 2\int e^{3t} j\, dt - 4\int t^3 k\, dt$$

$u = 7t$

$\frac{du}{dt} = 7$

$dt = \frac{du}{7}$

$$\therefore \int F = 5\int \frac{\cos u\, i\, du}{7} - 2\int e^{3t} j\, dt - 4\int t^3 k\, dt$$

$$\int F = \frac{5}{7}\int \sin u\, i - \frac{2}{3} e^{3} - t^4 + C$$