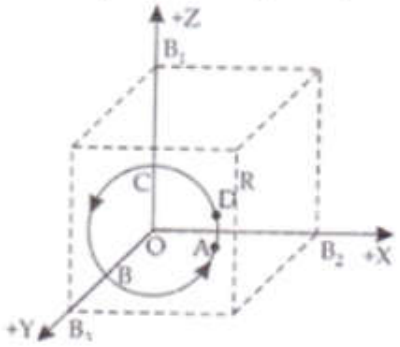
Q 4. A current-carrying loop consists of 3 identical quarter circles of radius R, lying in the positive quadrants of the X-Y, Y-Z and Z-X planes with their centers at the origin, joined together. Find the direction and magnitude of B at the origin.

Sol. Consider in the figure, 3 quadrants of conductors AB, BC, and CD along positive X-Y, Y-Z and Z-X planes respectively. A and D are connected to a battery which is responsible to flow current I through the three quadrants of radius R coordinate of A or D (R,0,0), B(0, R,0) and of C(0,0,R). Now the direction of the magnetic field by right-hand thumb rule due to quadrants AB, BC and CD are $+B_1$, B_2 and B_3 along +Z, +X and +Y directions respectively. So, in the centre of the quadrant.



$\because \vec{B} = \frac{\mu_0 I}{2\pi R} \cdot \frac{\frac{\pi}{2}}{2\pi}$

$B = \frac{\mu_0 I}{8\pi R}$

So Magnetic field due to quadrants AB, BC, and CD at their centre O are B_1, B_2, and B_3 respectively is given below:-

$B_1 = \frac{\mu_0 I}{8\pi R}\hat{k} \quad B_2 = \frac{\mu_0 I}{8\pi R}\hat{i}$ and $B_3 = \frac{\mu_0 I}{8\pi R}\hat{j}$

So-net magnetic field at origin due to three current-carrying loops B = B_1 + B_2 + B_3

$B = \frac{\mu_0 I}{8R}[\hat{i} + \hat{j} + \hat{k}]$, resultant magnetic field

The resultant of B_1, B_2 and B_3 will be diagonal OR of the cube of side B_1, B_2, B_3 as the $|B_1|=|B_2|=|B_3|$