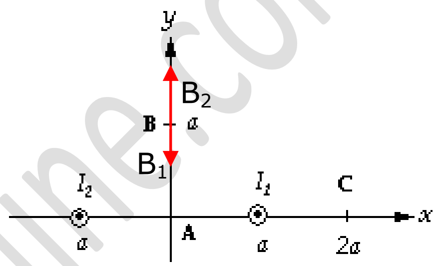
Q- Two infinite wires run parallel to the *z*-axis, which points out of the page. One wire carries a current I_1= 2 A and intersects the *x*-axis at *x* = *a* = 3 cm. The second wire carries current I_2= 5 A and intersects the *x*-axis at *x* = -*a*. Both currents flow in the +*z* direction.

(a) Calculate the net magnetic field due to I_1 and I_2 at Point *A* (the origin).

(b) Calculate the net magnetic field due to I_1 and I_2 at Point *B* a distance *a* above the origin on the *y*-axis.

(c) Calculate the net magnetic field due to I_1 and I_2 at Point *C* a distance 2*a* to the right of the origin on the *x*-axis.



(a) The magnetic field due to long straight wire carrying a current I at a distance r form it is given by

$$B = \frac{\mu_0 I}{2\pi r}$$

The direction of the magnetic field at a point is given by the right hand rule.

Now here the field at A due to the wire carrying current I_1 will be

$$B_1 = \frac{\mu_0 I_1}{2\pi a} = \frac{2*10^{-7}*2}{0.03} = 1.33*10^{-5} \text{ T}$$

According to right hand rule, the direction of this current is outward and at A the field will be downward means negative y direction and hence

$$\vec{B}_1 = -1.33 * 10^{-5} \, \hat{j} \text{ T} \qquad \text{------------------------------ (1)}$$

The field at A due to the wire carrying current I_2 will be

$$B_2 = \frac{\mu_0 I_2}{2\pi a} = \frac{2*10^{-7}*5}{0.03} = 3.33*10^{-5} T$$

According to right hand rule, the direction of this current is outward and at A the field will be upward means positive y direction and hence

$$\vec{B}_2 = 3.33 * 10^{-5} \, \hat{j} \text{ T} \qquad \text{------------------------------ (2)}$$

Hence the total field at A is given by

$$\vec{B} = \vec{B}_1 + \vec{B}_2 = \left(-1.33 * 10^{-5} + 3.33 * 10^{-5}\right) \hat{j} \text{T}$$

Hence the field at A is 2.0*10^{-5} T and in positive y direction

(b) Now here the distance of each wire is $r = \sqrt{a^2 + a^2} = a\sqrt{2}$ and hence field at B due to the wire carrying current I_1 will be

$$B_1 = \frac{\mu_0 I_1}{2\pi a\sqrt{2}} = \frac{2*10^{-7}*2}{0.03\sqrt{2}} = 9.43 * 10^{-6} \, T \qquad \text{T}$$

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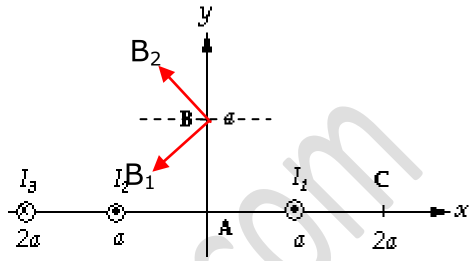
According to right hand rule, the direction of this current is outward and at A the field will be making 45^0 with negative x direction and hence in component form can be written as

$$\vec{B}_1 = 9.43 * 10^{-6}(-\cos 45^o\,\hat{\imath} - \cos 45^o\,\hat{\jmath}) = -6.67 * 10^{-6}\,(\hat{\imath} + \hat{\jmath})\ \text{T} \qquad \text{-------- (3)}$$

The field at B due to the wire carrying current I_2 will be

$$B_2 = \frac{\mu_0 I_2}{2\pi a\sqrt{2}} = \frac{2*10^{-7}*5}{0.03\sqrt{2}} = 2.36 * 10^{-5}\,T$$



According to right hand rule, the direction of this current is also outward and at B the field will be making 45^0 with positive y direction and hence

$$\vec{B}_2 = 2.36 * 10^{-5}(-\sin 45^o\,\hat{\imath} + \cos 45^o\,\hat{\jmath}) = 1.67 * 10^{-5}(-\hat{\imath} + \hat{\jmath})\ \text{T} \qquad \text{--------- (4)}$$

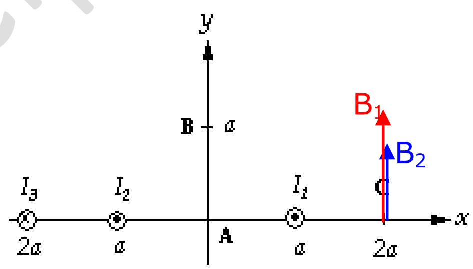
Hence using equation 3 and 4 total field at B is given by

$$\vec{B} = \vec{B}_1 + \vec{B}_2 = -6.67 * 10^{-6}\,(\hat{\imath} + \hat{\jmath}) + 1.67 * 10^{-5}(-\hat{\imath} + \hat{\jmath})$$

Or $\quad \vec{B} = -2.34 * 10^{-5}\,\hat{\imath} + \ 1.003\,\hat{\jmath}$

(c) The distance between the wire carrying current I_1 and point C is r_1 = 2a - a = a and hence the magnetic field due to this wire at C is given by

$$B_1 = \frac{\mu_0 I_1}{2\pi a} = \frac{2*10^{-7}*2}{0.03} = 1.33 * 10^{-6}\,T$$



According to right hand rule the current is outward and point C is to the right of the wire the field will be upward means to the positive y direction. Hence the field due to this wire is given by

$$\vec{\text{B}}_1 = 1.33 * 10^{-5}\ \hat{\jmath}\ \text{T} \qquad \text{----------- (5)}$$

The distance between the wire carrying current I_2 and point C is r_2 = 2a + a = 3a and hence the magnetic field due to this wire at C is given by

$$B_2 = \frac{\mu_0 I_1}{2\pi a} = \frac{2*10^{-7}*5}{3*0.03} = 1.11 * 10^{-5}\,T$$

According to right hand rule the current is outward and point C is to the right of the wire the field will be upward means to the positive y direction. Hence the field due to this wire is given by

$$\vec{\text{B}}_1 = 1.11 * 10^{-5}\ \hat{\jmath} \qquad \text{--------------------------- (6)}$$

Hence the resultant field at point C due the two wires using equations 5 and 6 is

$$\vec{\text{B}} = \vec{\text{B}}_1 + \vec{\text{B}}_2 = 1.33 * 10^{-5}\ \hat{\jmath} + 10^{-5}\ \hat{\jmath} = 2.44 * 10^{-5}\ \hat{\jmath}\ \ \text{T}$$

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