tutorial #5 [magnetic fields & magnetic forces] .quiz

1) André-Marie Ampère, as shown in fig. 1, puts four parallel wires perpendicular to the plane (parallel to z-axis), in a square pattern with side length $a = 10$ cm. The current passing through these wires are $I = 1$ A with directions shown in the figure.

a) Show the direction of the magnetic field produced by each wire at point A.
b) Add these vectors and find the magnetic field at point A.
c) If there is an electron at point A moving with the velocity $v = 2.0 \times 10^6$ m/s in x direction, what is the magnetic force vector on this electron?
d) If there is another wire in z direction, sitting at point A, with current $I_0 = 5$ A and length $l = 25$ cm, what would be the force acting on this wire by the magnetic field?

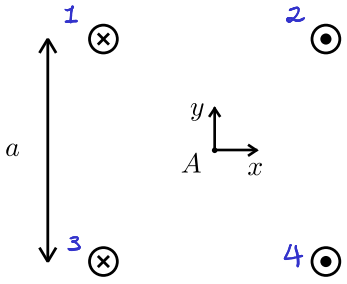
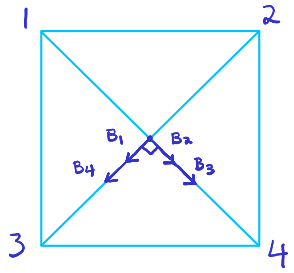


Figure 1: Wires in a square pattern.

a)

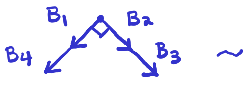


magnitudes

$B_1 = B_2 = B_3 = B_4$

$= \dfrac{\mu_0 I}{2\pi\left(a\frac{\sqrt{2}}{2}\right)}$

b)



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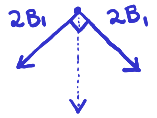

$B_A = 2B_1 \cos\frac{\pi}{4} = 2B_1\sqrt{2}$

$\vec{B}_A = (-\hat{y})\, 2B_1\sqrt{2} = -\dfrac{2\mu_0 I}{\pi a}\hat{y}$

$= -8\ \mu T\ \hat{y}.$

c) $\vec{F} = q\vec{v} \times \vec{B}_A = -e\left(2.0 \times 10^6 \frac{m}{s}\ \hat{x}\right) \times (-8\ \mu T\ \hat{y})$

$= 26 \times 10^{-19}\ N\ \hat{z}$

for right-handed coordinates,

$\hat{x} \times \hat{y} = \hat{z}$
$\hat{y} \times \hat{z} = \hat{x}$
$\hat{z} \times \hat{x} = \hat{y}$

d) $\vec{F} = \vec{I}_0 \vec{l} \times \vec{B}_A = (1.25\ Am\ \hat{z}) \times (-8\ \mu T\ \hat{y})$

$= 10\ \mu N\ \hat{x}$