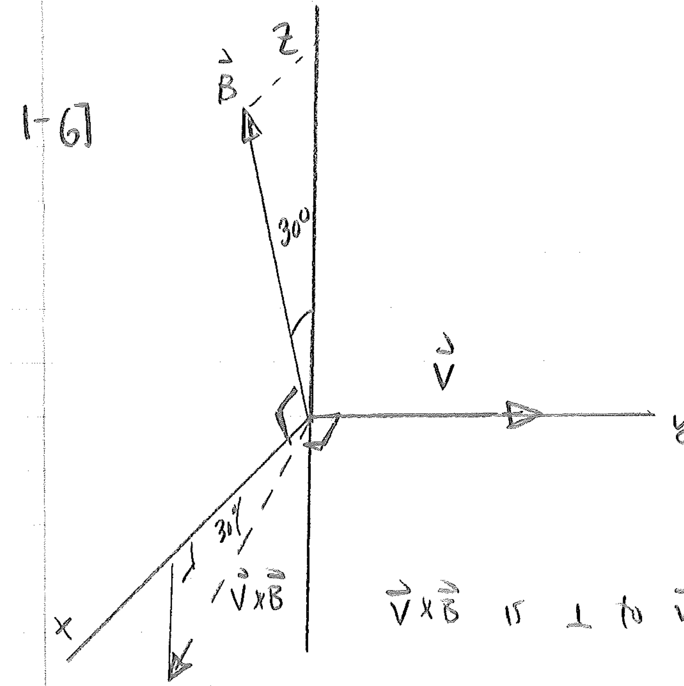
Solutions

1-6]



$\vec{V}\times\vec{B}$ is $\perp$ to $\vec{v}$, $\perp$ to $\vec{B}$

$F = |q\vec{v}\times\vec{B}|$. Here V happens to be $\perp$ to B.
(It need not be on the exam!)

$= qVB = 1.6\times10^{-19} \cdot 3\times10^{6} \cdot 2.4\times10^{5} = 1.15\times10^{-7}$ N.

$F_x = F\cos 30° = 10^{-7}$ N $= 100$ nN.

$F_z = F\sin 30° = 58$ nN.

$F_y = 0$.

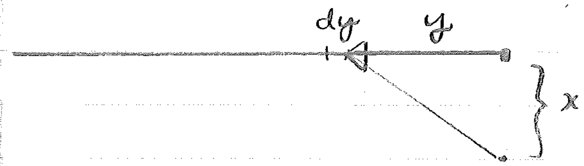
7] Motion in uniform B is a circle, EXCEPT if there is a component of V along B. Here, $V\perp B$, so CIRCLE, constant v.

8&9] Wire along z $F = I\vec{l}\times\vec{B} = IlB\sin\theta$
Here, $\theta = 30°$.

$F = 1\text{mA} \cdot 1\text{m} \cdot 2.4\times10^{5}\ \text{T} \cdot \frac{1}{2} = 120$ N.

10] Direction $= +y$.

[18.12] The magnetic field from a half-infinite wire can be found by integration



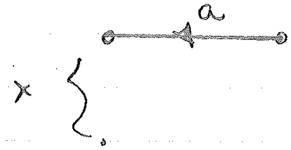
$$B = \left| \frac{\mu_0 I}{4\pi} \int \frac{d\vec{l} \times \hat{r}}{r^2} \right| \qquad \left(\sin\theta = \frac{x}{r} \right)$$

$$= \frac{\mu_0 I}{4\pi} \int_0^\infty \frac{x\,dy}{(x^2+y^2)^{3/2}}$$

see book p. 963

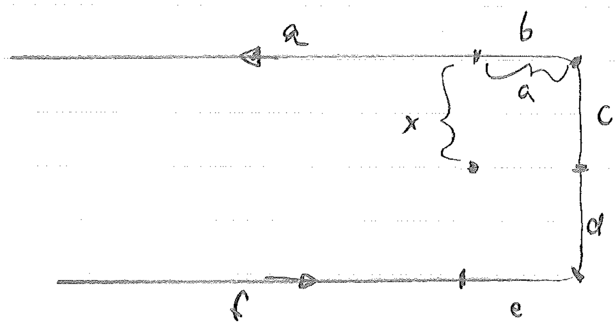
$$= \frac{\mu_0 I}{4\pi} \frac{1}{x}$$

For a short piece of wire, the same integral gives



$$B = \frac{\mu_0 I}{4\pi} \frac{a}{x\sqrt{x^2+a^2}}$$

For the problem given, segments a & f give equal contributions, as do b, c, d & e.



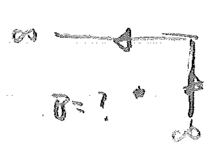
Note that $a = x = 1\,\text{m}$.

$$B = 2\left(\frac{\mu_0 I}{4\pi}\frac{1}{x}\right) + 4\cdot\frac{\mu_0 I}{4\pi}\cdot\frac{a}{x\sqrt{x^2+a^2}} = 2\cdot 10^{-7}\cdot\frac{20}{1} + 4\cdot 10^{-7}\cdot 20\cdot\frac{1}{\sqrt{1^2+1^2}}$$

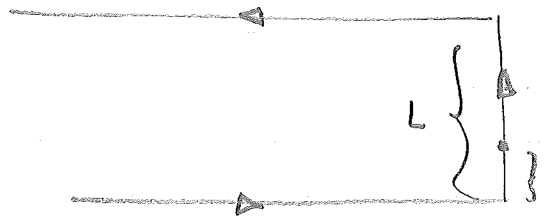
$$= 4\times10^{-6} + 5.66\times10^{-6}\ \text{T}$$

$$= 9.66\times10^{-6}\ \text{T} = 10\ \mu\text{T}.$$

Note: exam might be:



13 & 14] B at the right side, caused by the horizontal wires, is



$$B(x) = \frac{\mu_0 I}{4\pi}\left[\frac{1}{x} + \frac{1}{L-x}\right]$$

out of page.

$$dF = I\,dl \times B = I\,dl\,B \quad (B \perp dl)$$

$$F = \int I\,dl\,B = \int_0^L I\,dx \cdot \frac{\mu_0 I}{4\pi}\cdot\left(\frac{1}{x} + \frac{1}{L-x}\right)$$

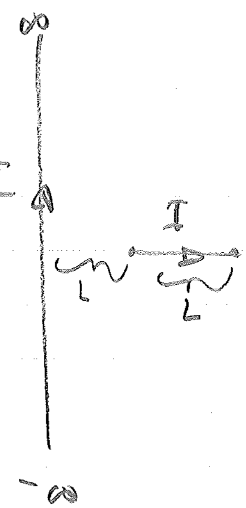
$$= \frac{\mu_0 I^2}{4\pi}\left[\ln x - \ln(L-x)\right]\Big|_0^L = \infty \ !$$

$\boxed{15}$ Force is to the right.

This divergence comes from the infinitely sharp corner.

Actual exam question will be:

What is force on horizontal segment at right?



Field from Ampere's law

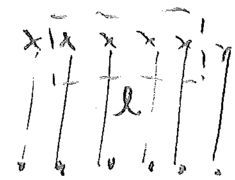
$$\oint B \cdot dl = \mu_0 I \qquad B = \frac{\mu_0 I}{2\pi r} \ \otimes$$

$$d\vec{F} = I\,d\vec{l} \times \vec{B} \qquad d\vec{l} \perp \vec{B} \ \text{so} \qquad dF = I\,dl\,B$$

$$F = \int_{r=L}^{r=2L} I \cdot dr\,\frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I^2}{2\pi}\ln 2$$

Direction? up.

16 & 17) See book p. 975



coil = solenoid

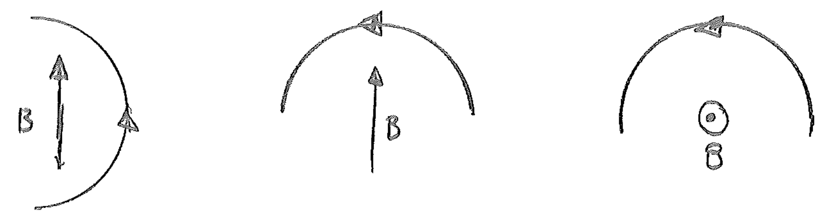
Ampere's law.

$$\oint \vec{B}\cdot d\vec{l} = B\cdot l = N\mu_0 I \qquad B = \frac{N}{l}\mu_0 I = \frac{2000}{1m}\cdot 4\pi\times10^{-7}\cdot 2A$$

$$= 5026\ \mu T.$$

Also may be on exam:

Rank the magnitudes of the magnetic force on the half-circle currents shown, & Find direction of force.



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