ELECTROMAGNETISM – MC1 ANSWERS

MC1.1 $\underline{E}(\underline{r}_2) = \dfrac{q\,\hat{\underline{r}}_{12}}{4\pi\epsilon_0 |\underline{r}_2 - \underline{r}_1|^2}$ ← unit vector pointing from source (1) to field (2) point.

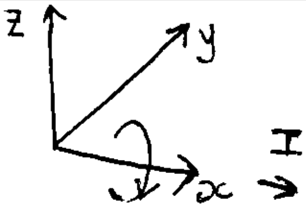
$\hat{\underline{r}}_{12}$ is in direction of $\underline{r}_2 - \underline{r}_1 = \begin{pmatrix}-1\\1\\2\end{pmatrix} - \begin{pmatrix}5\\-2\\5\end{pmatrix} = \begin{pmatrix}-6\\3\\-3\end{pmatrix} \equiv \begin{pmatrix}-2\\1\\-1\end{pmatrix}$ direction

but charge is −ve so $\underline{E}$ is in $\begin{pmatrix}2\\-1\\1\end{pmatrix}$ direction – answer c)

MC1.2 $|\underline{E}| = \dfrac{|q|}{4\pi\epsilon_0 |\underline{r}_2 - \underline{r}_1|^2} = \dfrac{1.6\times10^{-19}}{4\pi\times 8.85\times10^{-12}\times 54} = 2.7\times10^{-11}\ \mathrm{V\,m^{-1}}$ (2 s.f.'s)

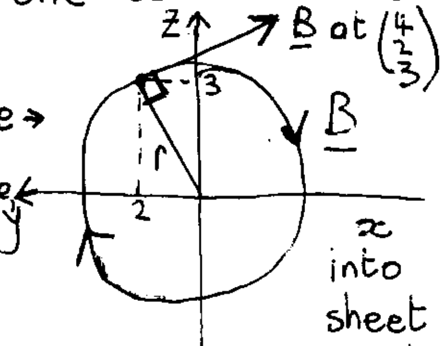
– answer a)

MC1.3



$\underline{B}$ is "circulating" around the x axis as shown.

In any yz plane we have →



$\underline{B}$ is tangential to circle. Here ← y in direction of $\begin{pmatrix}0\\-3\\2\end{pmatrix}$. Radius of circle, r, is $r = (3^2 + 2^2)^{\frac{1}{2}}$ m

answer a)

$\underline{B}$ has no x component.

MC1.4 The standard expression for $B(r)$ at a distance r from an infinite straight wire is:

$$B(r) = \frac{\mu_0 I}{2\pi r} = \frac{4\cancel{\pi}\times10^{-7}\times1}{2\times\cancel{\pi}\times\underset{\substack{\uparrow\\ \text{in this case}}}{\sqrt{13}}} = 5.5\times10^{-8}\ \mathrm{T}\ \text{(2 s.f.'s)}$$

answer d)

MC1.5

e.m.f. $\displaystyle\oint \underline{E}\cdot d\underline{l} = -\frac{\partial}{\partial t}\int_{\text{inside loop}} \underline{B}\cdot d\underline{a}$

Area of loop $= \pi r^2 = \pi \times 0.2^2$

$$= -\frac{\partial}{\partial t}\left[1.5\times\cos(10^6 t)\times\pi\times0.2^2\right]$$

$$= 1.5\times10^6\times\pi\times0.2^2\times\sin(10^6 t)\quad \mathrm{V}$$

Thus, the amplitude is just given by (put sin = 1)

$1.5\times10^6\times\pi\times0.2^2 = 1.9\times10^5\ \mathrm{V}$ (2 sig. figs)

answer b)