A long straight wire carries a current of 20 A. A particle of mass $m$ and charge $q = 10 \mu C$ is 5 cm below the wire and traveling with a velocity of $3 \times 10^4$ m/s.

(a) Find the magnitude and direction of the magnetic field that the particle feels.

Right hand rule with thumb along the wire $\Rightarrow$ field lines loop around and at $m$ point into the paper.

$$B = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7} \text{T} \cdot \text{m/A})(20 \text{A})}{2\pi \cdot (0.05 \text{m})} = 8.0 \times 10^{-5} \text{T}$$

(b) Find the magnitude and direction of the force on the particle if it is moving in the $+x$ direction.

Direction: fingers along $v$, curl to $B$ (into paper) $\Rightarrow$ thumb points upward $(+y)$

$$F = qvB \sin \theta = (10^{-5} \text{C})(3 \times 10^4 \text{ m/s})(8 \times 10^{-5} \text{T}) = 2.4 \times 10^{-5} \text{ N}$$

(c) Find the magnitude and direction of the force on the particle if it is moving in the $+y$ direction.

Direction: fingers along $+y$, curl into paper $\Rightarrow$ force is to the left $(-x$ direction)

$$F = qvB \sin \theta = \text{same as (b)} = 2.4 \times 10^{-5} \text{ N}$$

(d) Find the magnitude and direction of the force on the particle if it is moving into the paper.

Here $v$ and $B$ are parallel, $\theta = 0$, $\sin \theta = 0$

$$F = 0$$