AN ION OF (NEGATIVE) CHARGE -10^{-7}C MOVES WITH VELOCITY $\vec{v} = (10^7\hat{i} + 10^7\hat{j})$ m/s THROUGH A MACHINE THAT IS CAPABLE OF PRODUCING A 1.0T MAGNETIC FIELD IN THE $\hat{i}$, $\hat{j}$ AND $\hat{k}$ DIRECTION. WHAT IS THE FORCE ON THE PARTICLE IF THE MACHINE IS TURNED ON TO PRODUCE (a) $\vec{B} = 1.0T\,\hat{i}$? (b) $\vec{B} = 1.0T\,\hat{j}$? (c) $\vec{B} = 1.0T\,\hat{k}$ (d) ALL THREE OF (a), (b) AND (c) ARE APPLIED AT ONCE? IN EACH CASE, SKETCH THE DIRECTION OF $\vec{v}$, $\vec{B}$, $\vec{v}\times\vec{B}$ AND THE FORCE, $\vec{F}$

(a), (b) AND (c) (i) WRITE DOWN THE MATRIX FORMULATION FOR $\vec{v}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & k \\ V_x & V_y & V_z \\ B_x & B_y & B_z \end{vmatrix}$

(ii) DETERMINE THE COMPONENTS OF $\vec{v}\times\vec{B}$ (iii) MULTIPLY BY q TO FIND $\vec{F} = q\vec{v}\times\vec{B}$. WHAT WAS THE POLARITY OF q? WHAT ARE THE RELATIVE DIRECTIONS OF $\vec{F}$ AND $\vec{v}\times\vec{B}$?

(iv) SKETCH THE DIRECTIONS OF $\vec{v}$, $\vec{B}$, $\vec{v}\times\vec{B}$ AND $\vec{F}$ BASED ON THEIR $\hat{i}$, $\hat{j}$, $\hat{k}$ COMPONENTS

(d) (i) YOU HAVE TWO CHOICES, HERE. BOTH FIELDS AND FORCES OBEY SUPERPOSITION SO YOU COULD EITHER FIND THE SUM (VECTOR SUM!) OF THE FORCES YOU FOUND IN PARTS (a), (b) AND (c) OR YOU CAN USE THE VECTOR SUM OF THE B-FIELD $\vec{B} = (1.0\hat{i} + 1.0\hat{j} + 1.0\hat{k})$ T TO FIND $\vec{F} = q\vec{v}\times\vec{B}$ USING THE FORMALISM FROM PARTS (a), (b) AND (c). (ii) AFTER SKETCHING $\vec{v}$, $\vec{B}$, $\vec{v}\times\vec{B}$ AND $\vec{F}$, IT SHOULD BE A USEFUL EXERCISE TO ASK YOURSELF THIS: WHY IS YOUR SKETCH FOR THIS QUESTION (PART (d)) SO SIMILAR TO YOUR SKETCH FOR PART (c)?
