

AN EXACTLY SQUARE WIRE LOOP OF AREA 1 m^2 HAS A CLOCKWISE CURRENT OF 1.0 A RUNNING THROUGH IT. (a) FOR $1 \mu\text{m}$ AT EACH OF THE 4 MIDPOINTS ALONG THE SIDES OF THE LOOP SKETCH THE MAGNETIC FIELD DIRECTION AT THE CENTER OF THE LOOP (b) CALCULATE THE MAGNETIC FIELD AT THE CENTER OF THE LOOP DUE TO THESE SAME 4 MIDPOINTS (c) WHAT IS THE TOTAL MAGNETIC FIELD AT THE CENTER OF THE LOOP DUE TO THE 4 MIDPOINTS?

i.e. A $1 \mu\text{m}$ SECTION OF THE WIRE

(a) (i) SKETCH A SQUARE CURRENT LOOP THAT IS 1 m BY 1 m . DRAW THE DIRECTION OF THE CURRENT (ii) DRAW A SMALL PART OF THE LOOP $d\vec{l} = 1 \mu\text{m}$ AT THE MIDPOINT OF ONE SIDE OF THE LOOP (iii) $d\vec{l}$ IS A VECTOR. MARK ITS DIRECTION ON YOUR SKETCH (iv) SKETCH THE DIRECTION OF \hat{r} , THE UNIT VECTOR IN THE DIRECTION FROM $d\vec{l}$ TO THE POINT WHERE WE NEED TO FIND THE MAGNETIC FIELD (i.e. TO THE CENTER OF THE LOOP) (v) WHAT IS THE BIOT-SAVART LAW THAT RELATES A SMALL LINE OF CURRENT $d\vec{l}$ TO THE MAGNETIC FIELD $d\vec{B}$ IT PRODUCES? (vi) IF THE DIRECTION OF $d\vec{B}$ IS GIVEN BY $d\vec{l} \times \hat{r}$, USE THE RIGHT-HAND RULE TO FIND THE DIRECTION OF $d\vec{B}$ AT THE CENTER OF THE SQUARE (vii) REPEAT PARTS (i-vi) FOR EACH OF THE 4 MIDPOINTS OF THE SQUARE

(b) (i) WRITE DOWN THE BIOT-SAVART LAW (ii) THE DEFINITION OF THE CROSS-PRODUCT STATES THAT $d\vec{l} \times \hat{r} = |d\vec{l}| |\hat{r}| \sin\theta$, WHERE θ IS THE ANGLE BETWEEN $d\vec{l}$ AND \hat{r} AND $|\hat{r}|$ AND $|d\vec{l}|$ MEAN THE MAGNITUDES OF THOSE QUANTITIES (iii) CHOOSE ONE OF THE 4 MIDPOINTS... WHAT IS θ ? WHAT IS $|\hat{r}|$? (iv) WRITE DOWN THE BIOT-SAVART LAW FOR YOUR CHOSEN MIDPOINT AND SUBSTITUTE IN THE GIVEN QUANTITIES TO FIND $d\vec{B}$ (v) REPEAT THE PROCESS FOR EACH OF THE 4 MIDPOINTS

(c) (i) MAGNETIC FIELDS OBEY SUPERPOSITION, SO $\vec{B} = \int d\vec{B}$. FOR OUR 4 MIDPOINTS $\vec{B}_{\text{TOTAL}} = \sum_{i=1}^{i=4} d\vec{B}_i$ (ii) FIND THE VECTOR SUM OF YOUR ANSWERS FOR THE 4 MIDPOINTS TO DETERMINE \vec{B}_{TOTAL}

i.e. PAY CAREFUL ATTENTION TO DIRECTION