

PHYS-2070 Exam 2 Form B (2pm) Corrected Problem 2(b).

★(b) An proton enters a velocity selector at its design speed v and velocity $\vec{v} = v\hat{i}$. If $\vec{E} = E\hat{k}$, find the work, $W = \int_a^b \vec{F} \cdot d\vec{s}$, done by the magnetic force on the proton as it moves from point a to point b .

$$\begin{aligned} \vec{v} &= v\hat{i}, \quad \vec{E} = E\hat{k}, \quad \vec{F}_E = q\vec{E} = qE\hat{k} \\ \vec{F}_B &= q\vec{v} \times \vec{B} = qvB(-\hat{k}) \\ W &= \int_a^b \vec{F} \cdot d\vec{s} \\ \vec{F}_B \cdot d\vec{s} &= F_B(-\hat{k}) \cdot dx\hat{i} = -F_B dx(\hat{k} \cdot \hat{i}) = 0 \\ \therefore W &= \int_a^b \vec{F}_B \cdot d\vec{s} = 0 \end{aligned}$$

(By definition of the cross-product, $\vec{F}_B \perp \vec{v}$, so $W = 0$.)