A charge \( Q \) moves on the \( x \) axis at constant relativistic velocity \(-v\hat{x}\). At the moment that the charge \( Q \) is at the origin, the fields at the point \((x, y, z) = (0, d, 0)\) are

\[
\mathbf{E} = \frac{Q}{4\pi\epsilon_0} \frac{\gamma}{d^2} \hat{y}, \\
\mathbf{B} = -\frac{Q}{4\pi\epsilon_0} \frac{v}{c^2} \frac{\gamma}{d^2} \hat{z},
\]

where

\[
\gamma = \frac{1}{\sqrt{1-v^2/c^2}}.
\]

A test charge \( q \) is moving parallel to the \( x \) axis on the line \( y = d, z = 0 \) at the same constant relativistic speed — but in the \textit{opposite} direction. It reaches the point \((0, d, 0)\) at the same time that charge \( Q \) is at the origin.

a) Find the force on \( q \) due to \( Q \) at the moment that \( Q \) is at the origin and \( q \) is at \((0, d, 0)\).

b) In the present frame of reference, the fields produced by \( Q \) obey the condition \( \mathbf{E} \cdot \mathbf{B} = 0 \). Will this condition remain true in all inertial frames?

**For the remaining problems consider the frame in which the charge \( q \) is at rest.**

c) Find the speed of the charge \( Q \) in the frame in which \( q \) is at rest.

d) Find the \( \mathbf{E} \) and \( \mathbf{B} \) fields at the position of test charge \( q \) due to charge \( Q \), at the moment that they have the same \( x \) co-ordinate in the frame in which \( q \) is at rest. You may either Lorentz transform the given fields, or use your result from part (c).

e) Find the force on \( q \) due to \( Q \), at the moment they have the same \( x \) co-ordinate in the frame in which \( q \) is at rest.

f) Should the forces in parts (a) and (e) be equal? If so, why? If not, why not?