Problem # 22.1:

(a) In classical mechanics, Newton’s law can be written in the more familiar form \( F = ma \).

The relativistic equation, \( F = dp/dt \), cannot be so simply expressed. Show, rather, that

\[
F = \frac{m}{\sqrt{1 - u^2/c^2}} \left[ a + \frac{u(u \cdot a)}{c^2 - u^2} \right],
\]

where \( a = du/dt \) is the ordinary acceleration.

(b) Show that it is possible to outrun a light ray, if you’re given sufficient head start, and your feet generate a constant force.

Problem # 22.2:

Show that the ordinary acceleration of a particle of mass \( m \) and charge \( q \), moving at velocity \( u \) under the influence of electromagnetic fields \( E \) and \( B \), is given by

\[
a = \frac{q}{m} \sqrt{1 - u^2/c^2} \left[ E + u \times B - \frac{i}{c^2} u (u \cdot E) \right].
\]

*Hint:* Use the result of problem #22.1.

Problem # 22.3:

A parallel-plate capacitor, at rest in \( S_0 \) and tilted at a 45° angle to the \( x_0 \) axis, carries
charge densities $\pm \sigma_0$ on the two plates (see figure). System $S$ is moving to the right at speed $v$ relative to $S_0$.

(a) Find $E_0$, the field in $S_0$.
(b) Find $E$, the field in $S$.
(c) What angle do the plates make with the $x$ axis?
(d) Is the field perpendicular to the plates in $S$? Find $E_0$, the field in $S_0$.

Problem # 22.4:
In system $S_0$, a static uniform line charge $\lambda$ coincides with the $z$ axis.

(a) Write the electric field $E_0$ in Cartesian coordinates, for the point $(x_0, y_0, z_0)$.
(b) Use the transformation rules for the fields to find the electric field in $S$, which moves with speed $v$ in the $x$ direction with respect to $S_0$. The field is still in terms of $(x_0, y_0, z_0)$; express it instead in terms of the coordinates $(x, y, z)$ in $S$. Finally, write $E$ in terms of the vector $\mathbf{S}$ from the present location of the wire and the angle $\theta$ between $\mathbf{S}$ and $\hat{x}$. Does the field point away from the instantaneous location of the wire, like the field of a uniformly moving point charge?

Problem # 22.5:

(a) Charge $q_A$ is at rest at the origin in system $S$; charge $q_B$ flies by at speed $v$ on a trajectory parallel to the $x$ axis, but at $y = d$. What is the electromagnetic force on $q_B$ as it crosses the $y$ axis?
(b) Now study the same problem from system $\mathcal{S}$, which moves to the right with speed $v$. What is the force on $q_B$ when $q_A$ passes the $y$ axis? Do it two ways:

(i) by using your answer to (a) and transforming the force;
(ii) by computing the fields in $\mathcal{S}$ and using the Lorentz force law.