Main points:

In Physics 513 we covered relativistic kinematics and dynamics. We practiced the Loentz transformation of 4-vectors and specifically considered 4 different 4-vectors.

4-vector position: $x^\mu = (x_0, \mathbf{r})$
4-vector velocity: $u^\mu = (\gamma c, \gamma\mathbf{v})$
4-vector velocity: $p^\mu = (\gamma mc, \gamma m\mathbf{v}) = (E/c, \mathbf{p})$
4-vector wave vector: $k^\mu = (\omega/c, \mathbf{k})$

The dot product of any two 4-vectors, $(a_0, \mathbf{a})\cdot(b_0, \mathbf{b}) = a_0b_0 - \mathbf{a}\cdot\mathbf{b}$ is Lorentz invariant.

In relativistic E&M we encounter some additional 4-vectors.
4-vector current: $j^\mu = (c\rho, \mathbf{j})$
4-vector potential: $A^\mu = (\Phi/c, \mathbf{A})$

Note: j^μ and A^μ are in general function of position and time. For the transformed expressions to make sense in frame K', we also need to transform the position 4-vector, so that we have $j'^\mu(x'^\mu)$ and $A'^\mu(x'^\mu)$.

We also show that vector operators can transform as 4-vectors.

The electric and magnetic fields are NOT components of a 4-vector but of a tensor.

For the exam you need to be able to use the following transformation properties,
Assume reference frame K' moves with velocity v with respect to reference frame K.
$\mathbf{E}'_{||} = \mathbf{E}_{||}$, $\mathbf{B}'_{||} = \mathbf{B}_{||}$,
$\mathbf{E}'_\perp = \gamma(\mathbf{E} + \mathbf{v}\times\mathbf{B})_\perp$,
$\mathbf{B}'_\perp = \gamma(\mathbf{B} - (\mathbf{v}/c^2)\times\mathbf{E})_\perp$.
Here || and ⊥ refer to the direction of the relative velocity.

For the fields, we also have scalar quantities that is invariant under a Lorentz transformation.
$\mathbf{E}^2 - c^2\mathbf{B}^2$ and $(\mathbf{E}\cdot\mathbf{B})^2$ are invariant under a Lorentz transformation.

To calculate the electromagnetic force on a charged particle in two different reference frame we discuss two approaches.

(i) Transform the fields and use $\mathbf{F}' = q(\mathbf{E}' + \mathbf{v}\times\mathbf{B}')$.
(ii) Transform the momentum 4-vector and use $F' = d\mathbf{p}'/dt'$.

We review the Doppler shift formula and show that we can compare intensities by transforming the fields.