Physics prelim exam (Electromagnetism, Spring 2016)

Please pick two problems to complete and specify explicitly which two problems you pick.

Problem 1

At one instant, the electric and magnetic fields at one point of an EM wave are:

\[ \vec{E} = (200 \hat{x} + 300 \hat{y} - 50 \hat{z}) \text{ V/m} \]
\[ \vec{B} = B_0 (7.3 \hat{x} - 7.3 \hat{y} - a \hat{z}) \times 10^{-6} \text{ T} \]

- What are the values of \( a \) and \( B_0 \)?
- What is the Poynting vector at this time and position?

Problem 2

You have an imaginary device to measure any parameter you wish of both electric and magnetic fields (amplitude, phase, frequency, wavelength). You have a mystery thin sheet of material (thickness of 0.1 micron) on which a 1 MHz electromagnetic field is incident - how will you determine if it is a conductor or dielectric?

Your device cannot measure anything except the above. For a comparative measure, copper has a skin depth of 1 micron at 1 MHz.

Problem 3

A positively charged particle with charge \( q \) and mass \( m \), and with velocity \( \vec{v} = v_0 \hat{x} \) is injected at time \( t = 0 \) into a region of the x-y plane where there is a uniform magnetic field \( \vec{B} = B_0 \hat{z} \)

Assume that \( v \ll c \) and that any observer is far away.

(a) Find an expression for the radius \( R \) of the circular trajectory of the particle in terms of \( m \), \( q \), \( v_0 \), and \( B_0 \).
(b) What is the angular frequency \( \omega \) of the radiation?
(c) What is the acceleration of the particle at time \( t \)? Give the magnitude and direction
(d) Give the magnitude and direction of the electric field \( E \) detected by a distant observer at \( +r_0 \hat{z} \). What is the nature of the polarization? By “nature” explain if it is polarized at all, and if so, is it linearly polarized or circularly or elliptically polarized?