EE 894J - Spring Quarter 1999

Midterm Exam

May 3rd, 1999

Write your name below and sign the honor pledge “No aid given, received, or observed” if it applies.

There are 2 problems on this exam. Exam is open book and notes.

Please box or underline your final answers, and remember to include units.

Be sure to show all work clearly if you wish to obtain any partial credit.

Use the pages at the back of the exam for your work. Be sure to clearly indicate which problem is being worked on each page.

Name: _____

“The Pledge”: No aid given, received, or observed.

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Problem 1 (3 parts, 50 points)

Consider Rayleigh scattering from a lossless spherical particle for which $\sigma_S = \sigma_t = 0.01$ square meters. Using the coordinate system described in the handout "Phase matrix for Rayleigh scattering", the electric field of a plane wave impinging on this particle in free space is written as $(3j\hat{v}_i + 2\hat{h}_i)e^{i\bar{k}_i \cdot \bar{r}}$ (V/m), with $\hat{k}_i = \hat{x}$. The scattered field will be measured along direction $\hat{k}_s = \hat{y}$.

(a) Find the angles (θ_i, ϕ_i) (also sometimes notated as (θ', ϕ')) and (θ_s, ϕ_s) (also sometimes notated as (θ, ϕ)) which describe the incidence and scattering directions.

(b) Write the modified Stokes vector for the incident field (note units should be Watts per meter squared.)

(c) Write the modified Stokes vector for the scattered field. Classify the polarization of the scattered field and interpret your result. (Hint: remember definition of phase matrix.)

Problem 2 (3 parts, 50 points).

(a) Consider 1 GHz scattering from two spheres, both with radius 1.06 mm and relative permittivity $\varepsilon = 4 + i0.2$. The first sphere is located at position $\bar{r}_i$, while the second sphere is located at $\bar{r}_i + 0.2\hat{y}$ (units are meters). Write the bistatic scattering amplitude and radar cross sections obtained from this pair of spheres neglecting any multiple scattering effects. Incidence and scattering directions in the x-z plane should be considered, and the incident electric field is polarized in the $\hat{y}$ direction.

(b) A random medium is composed from these particles, i.e. for each sphere located at position $\bar{r}_i$ there is a second sphere located at position $\bar{r}_i + 0.2\hat{y}$. The $\bar{r}_i$'s are independent random variables uniformly distributed throughout a cubical volume 99.9 m on a side. Find the expected value of the backscattered scattering amplitude for a medium containing a 1% volume fraction of spheres (not two sphere pairs) and for a plane wave incident in the $\hat{z}$ direction. Neglect any extinction effects.

(c) Find the expected value of the backscattered radar cross section for a plane wave incident in the $\hat{z}$ direction. Does independent scattering theory apply in this problem (the expected total power is the sum of the scattered power from each sphere)? Interpret your results.