PHYS 408 Group Activities for Jan 6 2010

Please complete these exercises without opening the textbook. If you have questions talk with your group mates or raise your hand and Ellen or David will come to help

1. How many equations are collectively in Maxwell's Equations?

2. Write down Maxwell's Equations in a free space (vacuum) without any sources (no charge or current density). In this case use the H field, not the B field for the magnetic field.

3. Modify these equations to model electromagnetic waves propagating in simple dielectric media (linear, homogenous, nondispersive, isotropic) by including the polarization density

$$\vec{\mathcal{P}}(r,t)$$

4. In order to find an expression for an electromagnetic wave we need a wave equation. Using the vector identity

$$\nabla \times (\nabla \times \vec{U}) = \nabla(\nabla \cdot \vec{U}) - \nabla^2 \vec{U}$$

derive the electromagnetic wave equation from Maxwell's equations. Is this an equation for the electric or magnetic field? What is the speed of the wave?

5. Are there 1, 2, 3,4 or an infinite number of solutions to the wave equation you derived in question 4?

6. Check that is one solution to the wave equation is

$$\vec{\mathcal{E}}(r,t) = \mathrm{E}_o \hat{x} cos(kz - \omega t)$$

What is the speed of this wave? In your own words describe what k represents in the above solution.

see lectures notes for answers to these activities

complex amplitude lecture

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7. Find Maxwell's Equations in simple dielectric media using the complex amplitude form of **E** and **H** starting from

$$\nabla \times \mathcal{H} = \epsilon \frac{\partial \mathcal{E}}{\partial t}$$

$$\nabla \times \mathcal{E} = -\mu \frac{\partial \mathcal{H}}{\partial t}$$

$$\nabla \cdot \mathcal{E} = 0$$

$$\nabla \cdot \mathcal{H} = 0.$$

8. Find a wave equation for the complex amplitude form of **E** and **H** from your results of question 1 $\nabla \times (\nabla \times \vec{U}) = \nabla(\nabla \cdot \vec{U}) - \nabla^2 \vec{U}$

PHYS 408 Group Activities for Sept 14 2010

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7. Find Maxwell's Equations in simple dielectric media using the complex amplitude form of **E** and **H** starting from

$$\nabla \times \mathcal{H} = \epsilon \frac{\partial \mathcal{E}}{\partial t}$$
$$\nabla \times \mathcal{E} = -\mu \frac{\partial \mathcal{H}}{\partial t}$$
$$\nabla \cdot \mathcal{E} = 0$$
$$\nabla \cdot \mathcal{H} = 0.$$

$$\nabla \times \mathbf{H} = j\omega\epsilon\mathbf{E} = -i\omega\epsilon E$$
$$\nabla \times \mathbf{E} = -j\omega\mu\mathbf{H} = i\omega\mu H$$
$$\nabla \cdot \mathbf{E} = 0$$
$$\nabla \cdot \mathbf{H} = 0.$$

8. Find a wave equation for the complex amplitude form of **E** and **H** from your results of question 1 $\nabla \times (\nabla \times \vec{U}) = \nabla(\nabla \cdot \vec{U}) - \nabla^2 \vec{U}$

$$\nabla^2 \vec{E} + \frac{\omega^2}{c^2} \vec{E} = 0$$