

Midterm Exam No. 01 (2026 Spring)

PHYS 520B: ELECTROMAGNETIC THEORY

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Date: 2026 Feb 19

1. (20 points.) Given

$$\nabla^2(\mathbf{a} \cdot \mathbf{r})^2 = c, \quad (1)$$

where \mathbf{a} is a unit vector that is constant. Find c .

2. (20 points.) A monochromatic plane electromagnetic wave is described by electric and magnetic fields of the form

$$\mathbf{E} = \mathbf{E}_0 e^{i\mathbf{k} \cdot \mathbf{r} - i\omega t}, \quad (2a)$$

$$\mathbf{B} = \mathbf{B}_0 e^{i\mathbf{k} \cdot \mathbf{r} - i\omega t}, \quad (2b)$$

where \mathbf{E}_0 and \mathbf{B}_0 are constants. Assume no charges or currents.

- (a) Using Maxwell's equations show that

$$\mathbf{k} \cdot \mathbf{E} = 0, \quad (3a)$$

$$\mathbf{k} \cdot \mathbf{B} = 0, \quad (3b)$$

$$\mathbf{k} \times \mathbf{E} = \omega \mathbf{B}, \quad (3c)$$

$$\mathbf{k} \times \mathbf{B} = -\frac{\omega}{c^2} \mathbf{E}, \quad (3d)$$

where $\varepsilon_0 \mu_0 = 1/c^2$.

- (b) For non-trivial cases ($\mathbf{E}_0 \neq 0$ and $\mathbf{B}_0 \neq 0$), using Eqs. (3), show that we have

$$ck = \omega. \quad (4)$$

3. (20 points.) Consider the Green function equation

$$-\nabla^2 G(\mathbf{r}; \omega) = \delta^{(3)}(\mathbf{r}). \quad (5)$$

Derive the continuity condition by integrating around the source.

4. (20 points.) Show that two light-like vectors can not be orthogonal without also being parallel. That is, show that orthogonality of two light-like vectors imply that they are parallel.

5. (20 points.) [Problem 3.10 in Rindler's book on Relativity.]

In a given inertial frame, two particles are shot out simultaneously from a given point, with equal speeds v , in orthogonal directions. What is the speed of each particle relative to the other?