

Physics 110B Fall 2012

Practice Questions for Final Exam

1. A plane wave $U_0 \cos(kz - \omega t)$ is incident normally on a screen. Fraunhofer conditions apply. The diffracted wave is observed from $z \rightarrow \infty$ at various angles ψ with respect to the z axis.

(a.) Assume that the screen has three long parallel slits with equal spacing b and equal negligible width. Compute the irradiance ratio $I(\psi)/I(\psi = 0)$.

(b.) Instead assume that the screen has five long parallel slits with equal spacing b . The slit widths are still negligible; however, they are a function of the slit location, so that the five slit areas vary according to the ratio 1:2:3:2:1. Compute the irradiance ratio $I(\psi)/I(\psi = 0)$.

2. A plane electromagnetic wave is described by $E(z, t) = \text{Re}(\tilde{E} \cdot e^{i(kz - \omega t)})$, where $\tilde{E} = E_0((2 - i)\hat{x} + (1 - 2i)\hat{y})$, and E_0 , k , and ω are real constants. A linear polarizer is placed in the beam, and oriented so that the largest possible fraction of the original beam's irradiance is transmitted. What is that fraction?

3. Write down a master equation that is equivalent to the pair of Maxwell's equations in vacuum that involve sources. You need not prove this equivalence. Your equation must be manifestly covariant, with no gauge condition imposed. Any four-tensors that you use must further be defined in terms of four-vectors. Correspondingly, any four-vectors that you use (either in the master equation or in defining any four-tensors) must further be defined in terms of three-vectors and scalars.

4. Silver is an excellent conductor, but it's expensive. Suppose you were designing a microwave experiment to operate at a frequency of 1010 Hz. How thick would you make the silver coatings? Assume that silver response is dominated by free electrons with a concentration at $10^{23}/\text{cm}^3$, and a scattering rate (in terms of angular frequency) of $200 \cdot 10^{12}$ Hz.

5. Consider a rectangular wave guide with dimensions 2.28 cm x 1.0 cm. What TE modes will propagate in this wave guide, if the driving frequency is 1.70×10^{10} Hz? Suppose you wanted to excite only one TE mode; what range of frequencies could you use? What are the corresponding wavelengths (in open space)?

6. When a charged particle approaches (or leaves) a conducting surface, radiation is emitted, associated with the changing electric dipole moment of the charge and its image. If the particle has mass m and charge q , find the total radiated power, as a function of its height z above the plane.

7. Example 10.1 of Griffith.

8. When a glass plate with $n=1.517$ is placed in one of the arms of a Michelson interferometer, 18.5 fringes are displaced. What is the glass thickness if the laser wavelength is 589.3 nm?

9. A grating is ruled at 1000 lines/min. How wide must it be in order to resolve the spectral content of an HeNe laser (wavelength centered at 632.8 nm)? The frequency content of the HeNe laser consists of three very narrow emission lines: one at 632.8 nm with two others spaced 450 MHz on either side of the 632.8 nm line. Would there be a better instrument to resolve this spectrum?

10. A molecule absorbs 10^{-12} of incident photons with a 1 mm diameter beam. To enhance the molecular absorption, one can focus the laser beam, and put the molecule inside a resonant cavity. Assume we can have a resonant cavity with center beam diameter of 0.1mm, and two end mirrors with reflectivity of 0.9999.

(1) What is the Finesse of the the cavity?

(2) What fraction of light will the molecule absorb if a laser beam is incident from the left mirror?

(2) How will the molecule absorption change if the right mirror has perfect reflectivity of 1?

11. We have a laser with a gain media inside of a Fabry-Perot cavity. The gain media has a round trip gain of $0.1*(P_{\text{sat}}-P)$, where $P_{\text{sat}}=1000\text{W}$ is the saturating power, and P is the actual power inside the cavity. The Fabry-Perot cavity is composed a high reflection mirror ($R=1$) and a slightly transmitting mirror ($R<1$). A portion of the cavity power will leak out from the transmitting mirror, which produces the laser beam. If we want to maximize the output laser power, what reflectivity shall we design the end mirror to have?

Practice questions for last week's lecture.

1. Griffith Problem 12.47.

2. Griffith Problem 12.50.

3. Griffith Problem 12.60.

4. Work out Lorentz transformation of E and B based on field tensor $F^{\mu\nu}$.