Modern Optics: Class Exam II

9 November 2015

Name: _____ **Total:** **/50**

Instructions

- There are 5 questions on 6 pages.
- Show your reasoning and calculations and always justify your answers.

Physical constants and useful formulae

$$c = 3.0 \times 10^8\,\mathrm{m/s} \qquad \epsilon_0 = 8.85 \times 10^{-12}\,\mathrm{C^2/Nm^2} \qquad \mu_0 = 4\pi \times 10^{-12}\,\mathrm{Tm/A}$$

Question 1

A spherical mirror has a concave surface, whose radius of curvature is 5.0 cm. An object is placed at a distance of 4.0 cm from the surface of the mirror. Determine the location of the image *using equations* and also *using a ray tracing diagram*.

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Question 2

An object is located beyond the focal length of a converging lens which produces an image on a screen. The location of the object and the screen are fixed and the distance between them is D. The position of the lens can be adjusted. Let s_o be the distance from the lens to the object and f be the focal length of the lens. Determine a general expression for s_o in terms of D and f that will result in a clear image on the screen.

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Question 3

A thin film of soapy water ($n = 1.33$) is held vertically in air ($n = 1.00$). Light of wavelength 590 nm is incident perpendicularly to the surface of the soap film. Determine the minimum thickness of the film which results is strongly reflected light.

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Question 4

Two plane wave sources have the same linear polarization and oscillate in phase with the same wavenumber, k. The waves propagate along the x axis. One of the sources is located at x_1 and the other at $x_2 > x_1$.

a) Show that the time averaged irradiance at a detector located at $x > x_2$ is

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\left(k\Delta x\right)$$

where $\Delta x = x_2 - x_1$ and I_j is the intensity of source j in the absence of the other source.

Question 4 continued ...

b) Suppose that the distance between the sources can be varied. Determine the visibility of the resulting interference pattern if $I_1 = 4I_2$.

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Question 5

A wave pulse is represented in complex form via

$$\psi(t) = Ae^{-|t|/\tau}e^{i\omega_0 t}$$

where $\tau > 0$ and ω_0 are constants. Determine the Fourier transform of $\psi(t)$.

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