ECEN 466 Exam #1

Fall 2009
Nov. 12-17
Prof. Stephen M. Schultz – 422-1693

Name:________________________________

Instructions – Please Read

1. Closed book and closed notes
2. 3 hour time limit
3. **Graphing Calculator Allowed**
4. Ruler for drawing picture if you want
5. This exam consists of 7 problems + appendix. These are all work out problems so be sure to show your work.
    a. The first 5 problems are shorter and are worth 10 points each.
    b. The last 2 problems are worth 25 points each.
6. There are some equations that you might find useful at the end of the test.
7. Please make any standard class assumptions *unless otherwise indicated*. Some standard assumptions are that if $\mu_r>1$ then $\varepsilon_r=1$ and vice versa, propagation is in the z-direction, mks units, perfect conductors for metallic waveguides, charge free, lossless materials, linear, time invariant, etc… Any other assumptions should be stated.

Appendix

Imaging equation for a single spherical surface: $\frac{n_1}{S_1} + \frac{n_2}{S_2} = \frac{n_2 - n_1}{R_1}$

Thin Lens equation: $\frac{1}{S_o} + \frac{1}{S_i} = \frac{n_2 - n_1}{n_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \frac{1}{f}$

Camera field of view equation: $h = f\theta$

Gaussian beam equations:

$$E(\rho, z) = E_o \frac{W_o}{W} \exp\left[-\frac{\rho^2}{W^2}\right] \exp\left[-j\left(kz - \tan^{-1}\left(\frac{z}{z_o}\right) + k\frac{\rho^2}{2R}\right)\right]$$

$$I(\rho, z) = \frac{2PW_o}{\pi W^2} \exp\left[-2\frac{\rho^2}{W^2}\right]$$

$$W(z) = W_o\sqrt{1 + \left(\frac{z}{z_o}\right)^2}$$

$$R(z) = z\left[1 + \left(\frac{z_o}{z}\right)^2\right]$$

$$W_o = \sqrt{\frac{\lambda z_o}{\pi}}$$

$$\theta = \frac{\lambda}{\pi W_o}$$

Gaussian beam transmission through a thin lens
(The primed parameters are after going through the lens.)

$$\frac{1}{R'} = \frac{1}{R} - \frac{1}{f}$$

$$W_o' = \frac{W}{\sqrt{1 + \left(\frac{\pi W^2}{\lambda R'}\right)^2}}$$

$$z' = \frac{R'}{1 + \left(\frac{\lambda R'}{\pi W^2}\right)^2}$$

ABCD Matrices:

Free space propagation: $M = \begin{bmatrix} 1 & d \\ 0 & 1 \end{bmatrix}$

Refraction at a planar boundary: $M = \begin{bmatrix} 1 & 0 \\ 0 & \frac{n_1}{n_2} \end{bmatrix}$

Refraction at a spherical boundary: $M = \begin{bmatrix} 1 & 0 \\ \frac{n_1 - n_2}{n_2 R} & \frac{n_1}{n_2} \end{bmatrix}$

Transmission through a thin lens: $M = \begin{bmatrix} 1 & 0 \\ -\frac{1}{f} & 1 \end{bmatrix}$

Reflection from a planar mirror: $M = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

Reflection from a spherical mirror: $M = \begin{bmatrix} 1 & 0 \\ \frac{2}{R} & 1 \end{bmatrix}$

Gaussian beam relationship for an ABCD matrix:

$$\frac{1}{q_1} = \frac{1}{R_1} - j\frac{\lambda}{\pi W_1^2}$$

$$q_2 = \frac{A q_1 + B}{C q_1 + D}$$