UNIVERSITY OF TORONTO

Faculty of Applied Science and Engineering

FINAL EXAMINATION, DECEMBER 2001

Fourth Year - Programs 5 and 7

ECE426H1F - Optical Engineering

Examination Type: A

Examiner - S. Dmitrevsky

All questions are of equal value and any five constitute a complete paper.
Write in ink!

1. An optical system consists of two thin lenses 15 mm apart. The focal length of one of them is 21 mm, that of the other -405 mm. Determine the location with respect to the 21 mm lens of the foci of the composite system.

2. A 0.058 mm thick oil film of 2.5 index of refraction is spread on flat surface of water. It is illuminated by sun the centre of which is 45° above horizon. The angular diameter of sun is 29 minutes of arc. How many red (λ = 0.600 μm) reflected fringes will be visible to an observer with eye focused at infinity?

3. Indices of refraction of uniaxial crystalline plate are $n_1 = 2.50$, $n_2 = u_3 = 2.51$. A linearly polarized input wave of λ_0 = 0.6 μm propagates in the plate in the x_3 direction. The input wave polarization has been established by a polarizer inclined at 45° to the positive x_1 axis.

   (i) What is the smallest thickness h of the plate for which the two propagating waves will be 90° out of phase at the exit from the plate?

   (ii) What is the polarization of the output signal assuming that reflection coefficients are independent of polarization?

   (iii) What would be the output polarization if the input polarizer were inclined at 45° to the negative x_1 axis?

4. A hawk flying at 150 m above ground can distinguish a 1 cm size prey. Assume that the wavelength of light is 0.55 μm and that index of refraction of the medium between the eye lens and hawk's retina is 1.5. What is the minimum size of hawk's pupil?

5. The indices of refraction of core and cladding of a multi-mode optical fibre are 1.505 and 1.500 respectively. The output of a light source feeding the fibre is a cone of 22½° cone angle (axis to edge) and uniform power density distribution. What fraction of the source power is trapped inside the fibre if all of the power is intercepted by the core section of the face of the fibre?

6. A simplified energy level scheme of a semiconductor material is given below:

$$E_v = 0eV,\ E_a = 15\ meV,\ E_d = 0.690\ eV,\ E_c = 0.700\ eV.$$

Levels of occupation of the above levels are:

v - valence band:	partially occupied
a - acceptor level:	fully occupied
d - donor level:	empty
c - conduction band:	partially occupied

Determine what wavelengths would be absorbed by the above material under the assumption that none of the relevant matrix elements are zero.

Note: E_v and E_c are <u>not</u> the top and bottom edges of their respective bands; they are sharp, highly degenerate levels representing the bands themselves.

Aids: $e = 1.6 \times 10^{-19}\ C$, $h = 6.63 \times 10^{-34}$ Joule second