MASENO UNIVERSITY

UNIVERSITY EXAMINATIONS 2016/2017

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR DEGREE OF BACHELOR OF SCIENCE IN COMPUTER SCIENCE & TECHNOLOGY

MAIN CAMPUS

SCS 413: OPTICAL DEVICES AND SYSTEMS

Date: 3rd December, 2016 Time: 12.00 - 3.00pm

INSTRUCTIONS:

- Answer Question ONE (Compulsory) and any other TWO.

Constants: h, Planck's constant = 6.62×10^{-34} W S^2

C, Velocity of light = 3×10^8 m/s

e, electron charge = 1.60×10^{-19} Coulombs

1 eV = 1.60×10^{-19} Joules

SECTION 1 (30 marks): Answer ALL questions in this section

Q1 (a) (i) State the laws of refraction at plane surfaces.

2 marks

(ii) Explain the meaning of critical angle and total internal reflection; and state the conditions necessary for total internal reflection to occur.

4 marks

(iii) Give brief account of a named natural phenomenon due to total internal reflection, and one practical application due to it

6 marks

(d) Explain the difference between stimulation and spontaneous emission of radiation in semiconductor materials / devices.

2 marks

(e) (i) The band gap energy for the material (Indium – Gallium – Arsenide, InGaAs) used as photo detector in optical fibre systems is 0.77 eV, determine its cut off wavelength and frequency

2 marks

(ii) An optical source generates 2.1μW of optical power. This power is coupled into an optical fibre at an angle of 12°. Determine the power coupled into the fibre, assuming that the active area of the optical source is larger than the optical fibre cross-sectional area.

4 marks

(f) State at least two differences between a convex mirror and a convex lens.

2 marks

A small object is placed at a distance of 30 cm from a converging lens of focal length 10 cm. Determine at what distances from this lens a second converging lens of focal length 40 cm must be placed in order to produce

(i) an erect image 4 marks

(ii) an inverted image, in each case of the same size as the object.

4 marks

SECTION II: ANSWER ANY TWO COMPLETE QUESTINS FROM THIS SECTION

Q2 (a) What is meant in optics by "Interference, and Diffraction"? ;. What part does each of the phenomena play in the production of spectra by a diffraction grating?

4 marks

(b) State the conditions that are necessary for light waves to interfere. Describe or explain an experiment illustrating how these conditions are realized in practice and show how the wavelength of sodium light may be determined from suitable measurements.

8 marks

(c) Parallel light consisting of two monochromatic radiations of wavelength

$\lambda_1 = 6 \, x \, 10^{-5}$ cm, and $\lambda_2 = 4 \, x \, 10^{-5}$ cm falls normally on a plane transmission grating with 5,000 lines per cm. What is the angular separation of the second order spectra of the two wavelengths?

8 marks

Q3 (a) (i) What is a spectrometer? 1 mark

(ii) Define / explain what is meant by dispersive power of a glass.

2 marks

(b) (i) Draw a diagram of the optical system of a spectrometer and describe the procedure you would use to measure the refractive index of the glass prism for a monochromatic light source, such as sodium.

8 marks

(ii) What additional observation would be necessary in order to determine the dispersive power of the glass?

2 marks

(c) The refractive index of the glass of a prism for red light is 1.514 and for blue light is 1.523. Calculate the difference in velocities of the red and blue light in the prism if the velocity of light in vacuum is 3.0×10^8 ms^{-1}

7 marks

Q4 (a) Swimmers, in particular, are aware that the bottom of a pool of water appears nearer the surface than is actually the case. Using a sketch diagram, explain the phenomenon.

4 marks

(b) A pond of depth, t, is filled with a liquid of refractive index μ. An object "0" is dropped into the pond and settles at the bottom.

(i) Using ray diagram show the position of the object in the pond as it appears to an observer standing at the edge of the pond, and that the displacement "d" is given by:

$$d = t\left(1 - \frac{1}{\mu}\right)$$

8 marks

(ii) How is the refractive index of the liquid related to the depths of the object in the liquid?

1 mark

(c) A small object is placed on the principal axis of a concave spherical mirror of radius of curvature 20 cm at a distance of 30 cm. By how much will the position and size of the image alter when a parallel sided slab of glass of thickness 6 cm and refractive index 1.5, is introduced between the centre of curvature and the object?

7 marks

Q5 (a) Define, in words and / or mathematically, Numerical Aperture, (NA), and Normalized frequency (V) of an optical fibre; and explain their significance.

6 marks

(b) Describe two methods of coupling light from a LEDs into the fibre, and state the advantages and challenges of each method.

6 marks

(c) Explain advantages and the challenges of using a laser source for optical fibre communication.

4 marks

d) A light source generating an optical power output equal to 1 μw is coupled into an optical fibre with a cross-sectional area larger than the active area of the light source. Determine the power coupled into the fibre with a fibre angle (θ) = 15^0

4 marks

END!