TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering & Technology

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

DIPLOMA IN INSTRUMENTATION & CONTROL ENGINEERING (DICE 5)

ECI 2307: OPTICAL INSTRUMENTATION

END OF SEMESTER EXAMINATION
SERIES: APRIL 2014
TIME ALLOWED: 2 HOURS

Instructions to Candidates:
You should have the following for this examination
  -    *Answer booklet*
This paper consists of **FIVE** questions. Answer any **THREE** questions

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All questions carry equal marks
Maximum marks for each part of a question are as shown
This paper consists of **FOUR** printed pages
Question One

a) (i) With the aid of a diagram, describe the construction of a photoconductive detector.

(ii) State any TWO applications of photo conductive detectors.

(iii) Explain TWO ways in which temperature effects are overcome in the photoconductor defect.

b) (i) For the ac bride circuit of figure 1, derive the expression for the output voltage Vo in terms of R_1, R_2, R_3 and R_4.

Figure 1

(ii) In the bridge circuit of figure 1, $R_3 = R_4 = 1K\,\Omega$ R_1 and R_2 are photoconductive detectors. Initially the intensity on R_1 and R_2 was set at 400 lumen/m^2 and $R_1 = R_2 = 1K\,\Omega$ when light intensity on R_1 was reduced to 100 lumen/m^2 the resistance of R_1 increased to $2K\,\Omega$. The supply is 10V, determine the output offset voltage. **(7 marks)**

c) A photovoltaic cell produces 0.37V open circuit when illuminated by 20W/m^2 radiation intensity. A current of 1.5mA is delivered into a 200 Ω load at that intensity. Calculate:
   (i) The internal resistance of the cell
   (ii) The open circuit voltage at intensity of 35N/m^2 **(4 marks)**

Question Two

a) Distinguish between the following:
   (i) Spontaneous emission
   (ii) Stimulated emission **(2 marks)**

b) (i) Explain what is meant by population inversion as applied to lasers.

(ii) What are the precautions to be taken when handling laser devices

(iii) With the aid of diagram, explain the operation of Ruby Lasers

(iv) State any TWO advantages of semiconductor lasers over the Ruby Laser **(4 marks)**

c) The beam from a 1mW He – Ne Laser (633nm, w_o = 1.0mm) is brought to a focus on the retina of the Human eye (focal length 35mm. Determine:
   (i) The diameter of the focal point
   (ii) The power density in the focused spot **(4 marks)**

Question Three

a) Define the following terms as applied to optical fibre: **(2 marks)**
   (i) Numerical aperture
   (ii) Acceptance angle

b) (i) State and explain any THREE advantages of optical fibres advantages of optical fibres when used for instrumentation.

(ii) With the aid of labeled diagram, explain the operation of a monomode fibre **(10 marks)**

c) (i) Distinguish between intrinsic and extrinsic fibre optic sensors.

(ii) Figure 2 shows a typical fibre optic sensor for temperature measurements. Explain its operation
   Figure 2

(iii) State any ONE limitation of the above sensor. **(5 marks)**

d) A silica optical fibre has a core index of 1.52 and cladding refracture index of 1.45. Determine:

Take refraction index of air = 1
   (i) Critical angle at the core cladding interface
   (ii) Numerical aperture
   (iii) Acceptance angle **(3 marks)**

Question Four

a) (i) State any THREE ways n which the light intensity of an optical fibre sensor may be varied.

(ii) Explain any TWO reasons why plastic fibre cables are preferred to glass fibres in making fibre sensors.

(iii) State ONE limitation of the plastic fibres **(6 marks)**

b) (i) With the aid of a diagram, describe the operation on optical level sensor.

(ii) With the aid of a diagram, describe the operation of a fotonic sensor for displacement
    measurement. **(10 marks)**

c) A laser Doppler system for flow measurement uses two beams from a Gas Laser ($\lambda = 514\eta m$) at an
   angle of 4° tot eh viewing direction to illuminate the test field. If the beat frequency signal is 415KHz,
   find the velocity of a particular moving across the test field at right angles to the viewing direction in
   the plane of the illuminating beams find:
   (i)   The velocity of the particle
   (ii) The beat frequency produced for a speed of 2m/s **(4 marks)**

Question Five

a) Distinguish between the following:
   (i)   Constructive interference
   (ii) Destructive interference **(4 marks)**

b) (I) State the functions of each of the following optical devices:
   (i)   Beam splitter
   (ii)   Diffraction grating
   (iii) Collimator

   (II) With the aid of a diagram, describe the operation of a Mach-Zehnder interferometer and state any

       TWO of its applications.

   (III) State any TWO applications of extrinsic fibre sensors. **(14 marks)**

c) A Rayleigh Interferometer uses collimating and imaging lens with a focal length of 520mm . The
   centres of the two apertures that define the beams are separated by 10mm. If a white light source
   bused with a narrowband filter, $\lambda = 560nm$. Determine the spacing of the fringes. **(2 marks)**