NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 4270 - APPLIED OPTICS II

SUPPLEMENTARY EXAMINATIONS

BSc HONOURS PART IV: JULY 2005 *DURATION: 3 HOURS*

ANSWER **ALL** PARTS OF QUESTION **ONE** IN SECTION A AND ANY **THREE** QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS

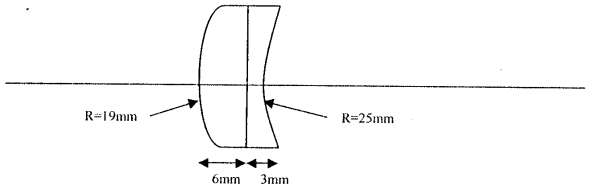
SECTION A

1. (a) A plano -convex lens 6 mm thick is placed in contact with a 3 mm thick plano-Concave lens as shown below. Both lenses have index of refraction, n = 1.5. The radius, R, of the convex surface is 19 mm and that of the concave surface is 25 mm.

i) Use your worksheet to trace a parallel axial ray forward through the two lens system. [5]

ii) Sketch the ray on the diagram shown and clearly indicate the location of the back focal point, F' and the back principal plane, H'. [5]

iii) Use your ray trace data to calculate the focal length and the location of H' and F'. [5]



(b) A CO_2 laser beam operating at 10,6μm has a beam diameter of 2,5mm. A convex lens of focal length 150mm focuses the beam. If 15% variation in *w(z)* can be tolerated, calculate the depth of focus. Explain what you Understand by the term "*depth of focus*". [5]

(c) What do understand by the terms:
(i) Case depth
(ii) Transition zone?

How would you increase these parameters? [5]

(d) Explain the following terms:
(i) Laser drilling [2]
(ii) Laser scribing [2]
(iii) Laser marking [2]

(e) Suggest and describe one application of lasers in remote sensing and monitoring. [5]

(f) Distinguish the following using the clear example:
(i) Circuit switched and,
(ii) Packet switched networks. [4]

SECTION B

2. (a) Given a step index fibre with core diameter of 9 μm, a core index of 1.460 and a and a cladding index of 1.455;
(i) Calculate the numerical aperture NA of the fibre [3]

(ii) Determine the longest wavelength that will guarantee single mode operation of this fibre. [5]

(iii) If you were using this fibre in a long- haul communications system, what wavelength would you choose for your transmitter? [2]
Give an argument to support your answer. [3]

(b) Given a 30 km long communications link using a fibre with $A_{dB} = 0.3$ dB/km, a Transmitter with $P_{T, dBm} = 5$ dBm, and a required received signal, $P_{r, dBm} = -14$ dBm.

(i) What will be the received power [3]
(ii) Determine the actual margin for this system [4]

3. (a) Describe the method used to treat
(i) Malignant tumours,
(ii) Blockage of arteries by atherosclerotic plague, and
(iii) Urinary stones. [8]

(b) A CO_2 laser of spot size A = 0,01mm^2 impinges on tissue. The penetration depth is $\alpha = 1\ 000 cm^{-1}$. If the beam is fully absorbed in a volume V = 4 x 10^{-5}cm. Calculate ablation threshold density. [5]

Briefly explain the principle of holography [4]

(c) In laser remote sensing; state the main physical properties which are usually measured. [3]

4. (a) Draw a graph of estimated energy consumption of the world for the next twenty years. [4]

(b) State Lawson's criterion for sustaining fusion reaction and hence calculate $n\tau$, given the following parameters:
The ignition energy = 44 keV, Energy yield per reaction = 17,6 MeV and the product of the cross-section and velocity of particle = $10^{-25}m^3s^{-1}$. Derive the formular you will use. [8]

(c) (i) How will you achieve the temperature of the central core of the sun in a laboratory. Give necessary reactions. [4]
(ii) Describe the inertial confinement technique used to generate electrical power. [4]

5. (a) Define the following:
(i) Wave length division multiplexing (WDM) [1]
(ii) Time division multiplexing (TDM) [1]

(b) Explain the following terms as applied to communications networks
(i) Local Area Network (LAN) [1]
(ii) Metropolitan Area Network (MAN) and, [1]
(iii) Wide Area Network (WAN) [1]
(iv) Fibre distributed data interface (FDDI) [2]

(c) (i) Why is WDM preferred as opposed to TDM. [2]
(ii) What are the fundamental limitations in utilising the band-width offered by the optical fibre? [3]
(iii) Explain the techniques that could be employed to utilise the full bandwidth. [4]

(d) Given that transmitter and receiver rise times are 2ns, and 4ns respectively, and the fibre bandwidth is 300 MHz km. Calculate usable bandwidth. [4]

6. (a) What do you understand by the following terms
(i) Primary atmospheric pollutants and
(ii) Secondary atmospheric pollutants. Give examples. [5]

(b) Describe
(i) Optical heterodyne detection technique and,
(ii) Differential Absorption Lidar used to monitor air pollution [10]

(c) How will you use nitrogen gas to track crude oil spillage in a river? [5]

END OF PAPER