NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 4270 - APPLIED OPTICS II

BSc HONOURS PART IV: MAY 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) List five lasers used in material processing. Give your preference in selecting lasers for metal cutting. State reasons for your choice. [5]

(b) A CO_2 laser beam operating at 10.6nm has a beam diameter of 2.5mm. A convex lens of focal length 150mm focuses the beam. If 15% variation in w(2) can be tolerated, calculate the depth of focus. Explain what you understand by the term "depth of focus". [5]

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

Give your choice in selecting the laser power and its duration so as to increase these parameters. [5]

(d) Briefly explain the following terms meaning the industries that use the lasers for the purposes:
(i) Laser drilling
(ii) Laser scribing
(iii) Laser marking [6]

(e) (i) State and describe two military applications of lasers.
(ii) Briefly explain how a Police Laser (LIDA) work? [6]

(f) How can you avoid a laser speeding ticket. [4]

(g) Give a brief description of how a laser room monitoring system work. How can you protect your room from monitoring? [5]

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

SECTION B

2. (a) Describe in detail how you can measure flatness of a test surface by Fizeau Interferometer. [6]

(b) It is required to drill 0,5mm diameter hole in a nickel sheet 1mm thick using a Nd - YAG laser with a 5kW peak power. Estimate the pulse length required. [4]

(c) (i) Distinguish between a co operative target and a non co operative target. Give one example of each. [4]

(ii) For a non co operative target with diameter $d_{tar} = 0.2$m and reflectivity 0.5. Calculate the received power P_r given that; $P_t = 10$kW, $O_t = 10^{-2}$ radians, $R = 10^3$m, $d_{ta} = 10$cm $d_{ra} = 10$cm, T = 0.8 and $\lambda = 1.06 \times 10^{-4}$cm (Nd - YAG laser). [2]

(iii) What will be the received power P_r if a co-operative target with a cube corner reflector of diameter 3cm is subjected to the same conditions as in (ii) above. [2]

(iv) Comment on the difference in your answers. [2]

3. (a) Describe the method used to treat
(i) Malignant tumors,
(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 a tissue. The penetration depth is $\alpha = 1\,000\text{cm}^{-1}$. If the beam is fully absorbed in a volume $V = 4 \times 10^{-5}\text{cm}^3$, calculate ablation threshold density. Take $L = 4/\alpha$. [5]

(c) Explain briefly the principle of holography. What are the advantages of holographs over ordinary photographs. [4]

(d) In laser remote sensing; state the main physical properties which are usually measured. What are the common areas of its applications. [3]

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

(b) What is Lawson's criteria for sustaining fusion reaction? 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 = $10^{-25}\text{m}^3\text{s}^{-1}$. Derive the formula you will use. [8]

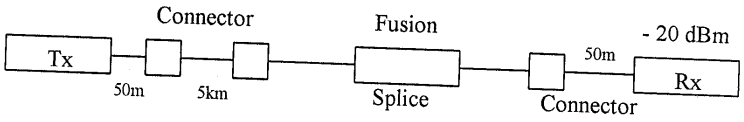
(c) How will you achieve the temperature of the central core of the sun in a laboratory. Give necessary reactions. Describe the inertial confinement technique used to generate electrical power. [8]

5. (a) Define the following:
   (i) Wave length division multiplexing (WDM)
   (ii) Time division multiplexing (TDM)
   (iii) LAN, MAN and WAN, and
   (iv) Fibre distributed data interface (FDDI) [7]

   (b) (i) Why is WDM preferred over the TDM?
   (ii) What are the fundamental limitations in utilising the band width offered by the optical fibre? Explain the techniques that could be employed to utilise the full band width. [7]

   (c) Obtain an expression for the threshold current for a double heterojunction semi-conductor. [2]

   (d) Determine the minimum power of the transmitter used in the system shown below:



   If rise times for the transmitter and receiver are 2ns, and 4ns respectively and the fibre band width is 300 MHz km, calculate usable bandwidth. [4]

6. (a) What do you understand by the 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 a nitrogen laser to track crude oil spillage in a river? [5]

END OF PAPER