NATIONAL OPEN UNIVERSITY OF NIGERIA
14/16 AHMADU BELLO WAY, VICTORIA ISLAND, LAGOS
SCHOOL OF SCIENCE AND TECHNOLOGY
MARCH/APRIL 2014 EXAMINATION

COURSE CODE: PHY 306
COURSE TITLE: OPTICS II
TIME ALLOWED: 3 HOURS
INSTRUCTION: ANSWER ANY FOUR QUESTIONS.

1. (a) (i) Briefly explain the phenomenon of interference of two waves and give one physical example of it.
3 marks

(ii) Two waves of the same frequency and different amplitudes are superposed. Show that the resultant intensity I is given in terms of the I_1, I_2 and constant phase difference δ by

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\delta$$

6 marks

(b) (i) State the principle of superposition of two waves.
2 marks

(ii) Two waves of same frequency and constant phase difference have intensities in the ratio 81:1. They produce interference fringes. Deduce the ratio of the maximum to minimum intensity. **6 ½ marks**

2. (a)(i) With a suitable diagram, explain Young's double-slit experiment and obtain the relevant equations for bright and dark fringes.
5 ½ marks

(ii) Monochromatic light passes through two narrow slits 0.40 mm apart. The third-order bright fringe of the interference pattern, observed on a screen 1.0 meter from the slits, is 3.6 mm from the centre of the central maximum. What is the wavelength of the light? **4 marks**

(b)(i) If y_n and y_{n+1} denote the n^{th} and $(n+1)^{th}$ bright fringes, in Young's double-slit experiment, show that the fringe width β is given as $\beta = \frac{D}{d}\lambda$, where d is the separation between the two slits, D the distance of the plane of the slits from the screen and λ the wavelength of the light used. **5marks**

(ii) In a two slit interference pattern with $\lambda = 6000\,\mathring{A}$, the zero-order and the tenth-order maxima fall at 12.34 mm and 14.73 mm respectively. Find the fringe width. **3 marks**

3. (a) (i) Show that the average intensity distribution for the interference fringes from two waves of the same frequency is $I_{average} = 2a^2$ where a, the amplitude is the same for the two waves. **4 ½ marks**

(ii) A column of transparent material $50\,mm$ long was initially positioned in front of one of the two slits in Young experiment. The column was removed and on comparing the fringe patterns corresponding to the column with that due to argon, it was found that the entire fringe pattern on the observation screen was displaced 40 bright bands away from the side containing the column. Given that the wavelength of the light source is $5893\,\mathring{A}$ for which argon has the refractive index $n_a = 1.00025$, determine the refractive index of the material of the medium. **5 marks**

(b)(i) show that for the Fresnel's biprism, the minimum angle of deviation is

$\delta_m = (n-1)\alpha$ **3 marks**

where α angle of prism and n the refractive index.

(ii) In a Fresnel's biprism experiment, the eyepiece is at a distance of 100 cm from the slit. A convex lens inserted between the biprism and the eyepiece gives two images of the slit in two positions. In one case, the two images of the slit are 4.05 mm apart, and in the other case 2.10 mm apart. If sodium light of wavelength 5893 Å is used, find the thickness of the interference fringes. **5 marks**

4. (a)(i) Explain the origin of colours seen in thin films such as the soap bubbles. **3 ½ marks**

(ii) White light is reflected normally from a uniform oil film (μ = 1.33). An interference maximum for 6000 Å and a minimum for 4500 Å, with no minimum in between, are observed. Calculate the thickness of the film. **5 marks**

(b)(i) Briefly discuss two practical applications of the principles of interference in thin films. **4 marks**

(ii) A beam of light of wavelength $6500\,\mathring{A}$ is incident at an angle of $30°$ on a film of thickness $1.25\times10^{-6}m$ of refractive index 1.60. If the beam is split into two rays, calculate the optical path difference introduced in traversing the film. (Hint: the film is immersed in air). **5 marks**

5. (a) (i) With a suitable diagram, explain how Newton's rings are observed. **4 ½ marks**

(ii) If in a Newton's ring experiment, the air in the interspace is replaced by a liquid of refractive index 1.33, in what proportion would the diameters of the ring change? **4 ½ marks**

(b)(i) Briefly describe the main features of Michelson interferometer and explain its working. **4 marks**

(II) When the movable mirror of Michelson's interferometer is shifted through 0.0589 mm, a shift of 200 fringes is observed. What is the wavelength of light used? Give the answer in Angstrom units. **4 ½marks**

6. (i) What is diffraction of waves? **2 marks**

(ii) Show that for a single slit diffraction, the intensity distribution is

$$I=I_0\frac{\sin^2\beta}{\beta^2}$$

The symbols have their usual meaning. **5 ½ marks**

(b)(i) Briefly distinguish between Fresnel and Fraunhofer diffraction. **4 marks**

(ii)) In an experiment a big plane metal sheet has a circular aperture of diameter 1 mm. A beam of parallel light of wavelength λ = 5000 Å is incident upon it normally. The shadow is cast on a screen whose distance can be varied continuously. Calculate the distance at which the aperture will transmit 1, 2, 3, ... Fresnel zones. **6 marks**