SOUTH EASTERN KENYA UNIVERSITY

UNIVERSITY EXAMINATIONS 2016/2017

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF BACHELOR OF SCIENCE (PHYSICS)

SPH 308: PHYSICAL OPTICS

DATE: 14TH DECEMBER, 2016 **TIME: 4.00-6.00 P.M**

INSTRUCTIONS TO THE CANDIDATES

(a) This paper consists of five questions

(b) Answer question **ONE** and **ANY OTHER TWO** questions

Question One (30 marks)

a) Given a disturbance travelling through a stationary medium;

i) Explain what happens after a given time t **(2 marks)**

ii) State the Huygens principle **(2 marks)**

iii) What happens to disturbance at $r = \infty$? **(2 marks)**

b) For interference to occur the sources of the waves have to be coherent

i) Give two properties of coherent source **(2 marks)**

ii) Two light bulbs placed closed to each do not form a coherent pair. Explain why **(2 marks)**

c) For interference of light monochromatic light is used

i) What is a monochromatic light **(1 mark)**

ii) State any other property of light necessary for interference **(1 mark)**

d) Given two waves described by $Y_1 = a\ sin\omega t$ and $Y_2 = a\ sin\omega t + \varphi$ travelling in the same medium

i) State the principle of superposition **(2 mark)**

ii) Write the expression for the resultant wave Y **(3 marks)**

iii) Derive the expression for intensity of the resultant wave I in terms of R where R is an arbitrary constant **(3 marks)**

e) In Young's double slit experiment;

i) Explain how two coherent sources of light can be created **(3 marks)**

ii) Derive expression of the path difference in terms of *a*, *d* and *D* where the symbols have their usual meaning **(3 marks)**

f) Diffraction is an important property exhibited by all types of waves

i) Define the term diffraction **(1 mark)**

ii) Differentiate between Fresnel's diffraction and Fraunhofer diffraction **(2 marks)**

g) Diffraction is usually applied in finding the resolving power of optical instruments

i) Define the term resolving power of an optical instrument **(1 mark)**

ii) Explain the Rayleigh's criterion **(2 marks)**

Question Two (20 marks)

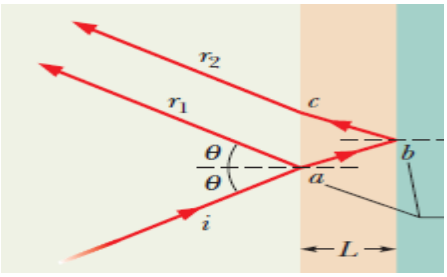
a) Interference by division of wavefront can be achieved using the Lloids mirror

i) By use of a suitable diagram explain how coherent sources can be achieved in Lloyd's experiment **(3 marks)**

ii) Derive the expression for the path difference and hence the fringe width **(3 marks)**

iii) Explain the nature of the central fringe **(3 marks)**

b) Light is incident at oblique angle on two parallel sided glass block as shown



i) Using trigonometric relations and given that refractive index of glass is denoted as η' show that the path difference is given by $PD = 2\eta' L cos\theta_r + \frac{\lambda}{2}$ where L is the thickness of the glass **(5 marks)**

ii) Explain how the fringes are achieved for both extended and point sources of light **(4 marks)**

iii) State two characteristics of fringes obtained in newton's rings experiment **(2 marks)**

Question Three (20 marks)

a) In fraunhofer double slit diffraction a maximum for diffraction occurs when;

$a\sin\theta_m = (2m+1)\frac{\lambda}{2}$ where the symbols have their usual meaning.

i) Explain each of the symbols used **(2marks)**

ii) What are the possible values of m? **(2 mark)**

iii) Give a similar expression for the maxima caused by interference effects **(2 mark)**

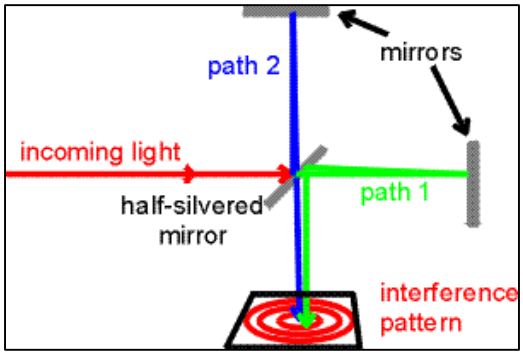
iv) Determine the angular separation for the diffraction and interference maxima for $m=1$ and $m=2$. **(6 marks)**

v) Using a graphical sketch explain the combined effect of diffraction and interference **(3 marks)**

b) By taking a slit width a equal to the slit separation b $(a = b)$ in fraunhofer double slit diffraction show that some orders may be lost. **(5 marks)**

Question Four (20 marks)

a) Both interference and diffraction are applied in optical instruments such the Michelson's interferometer shown below. Explain how the following can be measured



i) Distance **(3 marks)**

ii) Refractive index of material using the instrument **(3 marks)**

b) In the resolution of optical instruments

i) What do you understand by the term 'limiting angle of resolution" as used in Rayleigh's criterion? **(3 marks)**

ii) In a single slit fraunhofer diffraction, $b\sin\theta_R = n\lambda$ where the symbols have their usual meaning and considering the first minimum, $n = 1$, explain the conditions for a good resolution. **(2 marks)**

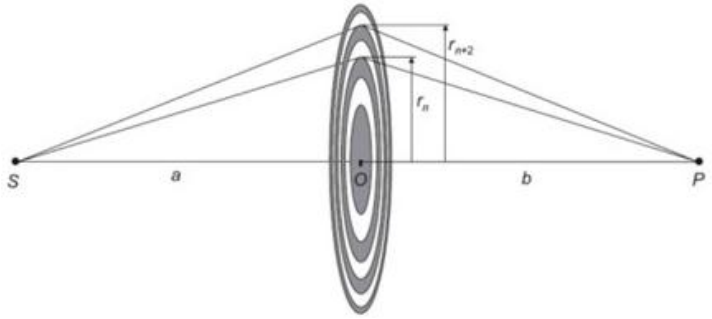
c) Two spectral lines must be separated by atleast $\Delta\theta$ in order to be resolved. Given that the grating equation is; $n\lambda = d\sin\theta$, where the symbols have their usual meaning,

i) Show that the wavelength is given by $\lambda = Nd(\Delta\theta)\cos\theta$ **(5 marks)**

ii) Show that the limit of resolution is given as $\frac{\Delta\lambda}{\lambda} = \frac{1}{Nn}$. **(4 marks)**

Question Five (20 marks)

a) In Fresnel's diffraction a point P on the screen receives spherical waves coming from a small aperture



i) What is a zone plate? **(2 marks)**

ii) Show that the intensity at P due to waves from all zones is given by $I = \frac{I_1}{4}$ where I_1 is the intensity of first zone **(6 marks)**

iii) Explain how a zone plate can be constructed **(5 marks)**

iv) From your zone plate show that $f_p = \frac{r_p}{p_\lambda}$ hence a zone plate cats as converging lens with many foci $f_1,\ f_2, f_3,\ f_4$, ... **(5 marks)**

v) State two advantages of using the zone plate **(2 marks)**