MACHAKOS UNIVERSITY

University Examinations 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SPECIAL NEEDS)

BACHELOR OF EDUCATION (SCIENCE)

SPH 306: PHYSICAL OPTICS

DATE: 9/8/2021 **TIME: 2.00-4.00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

YOU MAY USE:

Plank's constant= $6.63 \times 10^{-34} m^2 kg/s$

Speed of light, c=$2.998 \times 10^8 m/s$

$\varepsilon_o = 8.85 \times 10^{-12} Nm^2C^2$, $\mu_o = 4\pi \times 10^{-7}$TmA

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

a) Describe the wave nature of light (3 marks)

b) Identify the two causes of phase change in wave propagation. (2 marks)

c) Define diffraction grating and identify any two devices where this phenomenon is used. (3 marks)

d) Define the following terms;

i. Wavefront (2 marks)

ii. Optical path length (2 marks)

e) Distinguish between the two types of polaroids (4 marks)

f) Under what conditions are two or more sources coherent? (2 marks)

g) In the white light spectrum obtained with a diffraction grating, the third order image of a wavelength coincides with the fourth order image of a second wavelength. Calculate the ratio of the two wavelengths. (4 marks)

h) State Huygens's principle (2 marks)

i) Identify the three types of wavefronts (3 marks)

j) Describe the principle of holography. (3 marks)

QUESTION TWO (20 MARKS)

a) Explain whether the Young's experiment is an experiment for studying interference or diffraction effects of light. (4 marks)

b) Show that the components of an electromagnetic wave are always perpendicular to one another (5 marks)

c) i Define resolving power of a laser (2 marks)

ii Rayleigh light source with a wavelength of 557nm has a numerical aperture (NA) of 0.9. Calculate its resolving power. (4 marks)

d) Define a laser and describe how it emits a light signal. (5 marks)

QUESTION THREE (20 MARKS)

a) Distinguish between guided and unguided waveguides. (2 marks)

b) Using relevant drawings, describe the four forms of interference. (8 marks)

c) Starting with the two components of a wave $\vec{E}_x(z,t) = iE_{ox}Cos(k.z - \omega t + \varphi_x)$ and $\overrightarrow{E_y}(z,t) = jE_{oy}Cos(k.z - \omega t + \varphi_y)$, show that for a circular polarization, $\vec{E}_x^{\,2} + \vec{E}_y^{\,2} = \vec{E}_o^{\,2}$ (10 marks)

QUESTION FOUR (20 MARKS)

a) A Young's double-slit interference experiment is carried out with blue-green argon laser light. The interference pattern formed on a screen 3.3 m away contains the first-order bright fringe 3.4 mm from the centre of the pattern. If the separation of the double slits is 0.50 mm, what is the wavelength of the argon laser light? (4 marks)

b) Differentiate between Fresnel and Fraunhoffer diffraction processes (6 marks)

c) Japheth has been handed a transmission grating by his supervisor who wants to know how widely the red light and blue light fringes (in second order) are separated on a screen one meter from the grating. Japheth is told that the separation distance between the red and blue colours is a critical piece of information needed for an experiment with a grating spectrometer. The transmission grating is to be illuminated at normal incidence with red light at λ = 632.8 nm and blue light at λ=420.0 nm. Printed on the frame surrounding the ruled grating, Japheth sees that there are 5000 slits (lines) per centimetre on this grating. Japheth decides that he must calculate:

   i. The distance between the slit centres. (2 marks)

   ii. The angular deviation θp in 2nd order for both the red and the blue light. (4 marks)

   iii. The separation distance on the screen between the red and blue fringes. (4 marks)

QUESTION FIVE (20 MARKS)

a) Describe the three phenomena that result from linear optics (9 marks)

b) A HeNe laser in air emits light at 632.8nm. The beam passes into a glass substance of index 1.35. Calculate;

   i. the speed (3 marks)

   ii. wavelength (2 marks)

   iii. frequency of the laser light in the glass substance? (2 marks)

c) Use the Jones matrix, to calculate the effect of a horizontal polarizer on light that is initially horizontally polarized and vertically polarized. (4 marks)