UNIVERSITY EXAMINATIONS
2017/2018 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER SUPPLEMENTARY EXAMINATIONS

COURSE CODE: SPH 214

COURSE TITLE: PHYSICAL OPTICS

DATE: 19/10/2018 **TIME:** 3:00 – 5:00 PM

INSTRUCTIONS TO CANDIDATES

TIME: 2 Hours

Answer question ONE and any TWO of the remaining.

Symbols used bear the usual meaning.

QUESTION ONE (30 MARKS)

a) Differentiate between geometrical and physical optics. (1mark)

b) State the importance of studying physical optics (1mark)

c) Describe the following using diagrams (2marks)

   i) wave front

   ii) wavelength

d) State the conditions to be satisfied for two light sources to be coherent. (3marks)

e) Explain why no interference pattern is observed when two coherent sources are

   I. too close (2marks)

   II. very far apart (2marks)

f) Highlight the differences between interference and diffraction (6marks)

g) Show that for a single slit diffraction pattern the angle for the dark fringes formed is given by $\sin\theta = \frac{n\lambda}{\omega}$ for $n = 1,2, \dots\dots$ where symbols have their usual meaning. (3marks)

h) Coherent laser light of wavelength 633nm is incident on a single slit of width 0.25mm. The observation screen is 2.0m from the slit. Show that the width of the bright fringe between the 5^{th} and 6^{th} minima is about half the width of the central bright fringe(6marks)

i) A photonics technician is asked to produce a Fraunhoffer diffraction pattern when light from a HeNe laser (λ=633nm) passes through a pinhole of 150μm diameter. Determine the minimum distance between the pinhole to the screen that will give this diffraction (4marks)

QUESTION TWO (20 MARKS)

a) State and verify Malus law (5marks)

b) In one instance, unpolarized light in air is to be reflected off a glass ($n = 1.5$). In another instance, internal unpolarized light in a glass prism is to be reflected at the glass-air interface, where n for the prism is also 1.5. Determine the Brewster angle for each instance. (4marks)

c) Violet light of wavelength λ = 4.20 x 10^{-7} m is shone through two slits which are a distance d = 1.50 mm apart. The light lands on a screen a distance L = 4.50 m away.

   I. Determine the position of the first- and second-order bright fringes on the screen produced by the light passing through the slit. (4marks)

   II. Sketch the light intensity vs. screen position y, with the light intensity maximum at the location of the bright fringes. (3marks)

d) Briefly explain how thin film interference occurs (4marks)

QUESTION THREE (20 MARKS)

a) Show that Newton's corpuscular theory is in good agreement with the Snell's law of refraction . (4marks)

b) Write short notes on the following

   i) Wave theory of light (3marks)

   ii) Huygens principle (3marks)

   iii) Newton's corpuscular theory (3marks)

c) A light wave with amplitude E_i is travelling in optical material with refractive index n_o strikes at normal incidence an interface with another optical material with refractive index n_f

I. Write down the expression for the amplitude of reflected wave in terms of the incident wave. (1mark)

II. Explain the physical interpretation of three cases that may arise when the case in (I) above is considered. (6marks)

QUESTION FOUR (20 MARKS)

a) A physicist wants to know how widely the red light and blue light fringes are separated on a screen one metre from a grating. The transmission grating is illuminated at normal incidence with red light at λ=632.8mm and blue light at λ=420mm. If there are 5000 slits (lines) per centimeter on the grating

I. Determine the distance between the slit centers (1mark)

II. Determine the angular deviation in 2nd order for both the red and blue lights (4marks)

III. The separation distance on the screen between the red and blue fringes (3marks)

b) State some of the mechanisms through which light can be polarized (3marks).

c) Briefly but concisely describe how the interference pattern would change if we change each of the following. Explain your reasoning.

i. The distance between the slits is increased. (3marks)

ii. Red light is used instead of violet light. (3marks)

iii. The screen is moved to a distance $L = 9$ m away from the slits. (3marks)

QUESTION FIVE (20 MARKS)

a) Briefly explain how thin film interference occurs (4marks)

b) A light wave is incident on a thin soap bubble. Given the optical path difference due to the film is Δp and the optical path difference upon reflection is Δr,

i) Write down the expression for the condition for constructive interference to occur (1mark)

ii) If the thin film has a thickness t and refractive index n_f located in air, derive the expression for

I. Constructive interference at normal incidence (2marks)

II. Destructive interference at normal incidence (2marks)

c) Determine the minimum thickness of an anti-reflection coat of MgFe deposited on a glass substrate ($n_s = 1.52$) if the coating is to be highly anti-reflective for the center of the white light spectrum i.e. at $\lambda_{air} = 550nm$.(Refractive index of MgFe=1.38) (3marks)

d) Discuss the properties of laser light (8marks)