(Knowledge for Development)

KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2016/2017 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER
SPECIAL/SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF B.ED (SCIENCE)& BSC (PHYSICS)

COURSE CODE: SPH 214

COURSE TITLE: PHYSICAL OPTICS.

EXAM DURATION: 2 HOURS

DATE: 29TH SEPTEMBER 2017 TIME: 3 – 5 Pm

INSTRUCTIONS TO CANDIDATES

- Answer question one and any other two questions two (2) questions. Question one is compulsory and carries 30 marks, the other questions carry 20 marks each.

KIBU observes ZERO tolerance to examination cheating.

The following physical quantities may be useful.

- *Mass of an electron* = 9.11×10^{-31}Kg
- $e = 1.6 \times 10^{-19}$C
- $\varepsilon_0 = 8.85 \times 10^{-12} C^2/N.m^2$
- $\mu_0 = 4\pi \times 10^{-7} m/A$
- $\sin(\theta + \phi) = \sin\theta\cos\phi + \cos\theta \sin\phi$

Question ONE (30 marks)

a) Define the terms:

i) Geometrical optics

ii) Physical optics

iii) Wave front

iv) Monochromatic light

v) Coherent sources (5 marks)

b) State Huygens's Principle and use it to verify the law of reflection of light. (2 marks)

c) A wave is described by the equation $y(r,t) = y_0 \, Sin\left[\frac{2\pi}{\lambda}(r - vt)\right]$ where symbols have their usual meaning. Describe the wave when:

i) $\phi = \frac{\pi}{2}, \frac{\pi}{2} + 2\pi, \ldots.$

ii) $\phi = \frac{3\pi}{2}, \frac{3\pi}{2} + 2\pi, \ldots.$ (4 marks)

d) i) Two slits in Young's double slit experiments are illuminated by two different sodium lamps emitting light of same wavelength, do you observe any interference pattern on the screen? (2 marks)

ii) State the conditions which must be satisfied for two light sources to be coherent. (2 marks)

e) Give three differences between interferences and diffraction (3 marks)

f) Give two types of diffraction (2 marks)

g) Give conditions for maximum and minimum diffraction. (2 marks)

h) Calculate the wavelength range if the frequency if frequency of red light and violet light are 3.85×10^{14}Hz and 7.69×10^{14}Hz respectively (4 marks)

i)Give two uses of lasers. (4 marks)

Question TWO (20 marks)

a) State Maxwell's equations of electromagnetic waves in charge free vacuum. (4 marks)

b) i) Show that a one-dimensional wave equation $\Psi(x, t) = \text{Sin}(x - vt)$ is given by $\nabla^2.\Psi(x,t) = \frac{1}{v^2}\frac{\partial^2}{\partial t^2}\Psi(x, t)$, (6 marks)

ii) Using $\nabla \times \boldsymbol{E} = \frac{-\partial \boldsymbol{B}}{\partial t}$, show that $\nabla^2.\boldsymbol{E} = \mu_0\varepsilon_0 \frac{\partial^2 \boldsymbol{E}}{\partial t^2}$ where symbols have their usual meaning. (5 marks)

iii) Use the results in b(i) and b(ii) to determine velocity of light in free space. (2 marks)

c) State Malus law of polarization. (1 mark)

d)Determine the angle required so that the intensity of incident light I_0 incident on a polarizer is reduced by 60% (2 marks)

Question THREE (20 marks)

a) State two types of interference? (2 marks)
b) What are conditions to be fulfilled for interference to take place? (3 marks)
c) In Young's slits experiments, the separation between the first and fifth bright fringe is 2.5mm when the wavelength used is 620nm. The distance from the slits to the screen is 0.80m. Calculate the separation of the two slits. (3 marks)
d) In a Young's double slit experiment using red light state the effect of the following: (6 marks)
    i) The separation of the slits is decreased.
    ii) The screen is moved closer to the slits.
    iii) The source is moved closer to the slits.
    iv) Blue light is used instead of red.
    v) One of the slits is covered up
    vi) The source slit is made wider (4 marks)
e) A transparent oil index of refractive index 1.29 spills on the surface of water of refractive index 1.33 producing maximum reflection with normally incident range line of wavelength of 600nm. Assuming maximum order occurs in the first order, determine the thickness of the oil slick. (3 marks)
f) A certain metal surface has a work function of 3.31×10^{-19}J when illuminated with light of energy 4.31×10^{-19}J. Calculate the speed of photo electrons emitted from the metal surface. (3 marks)

Question FOUR (20 marks)

a) Define the term diffraction. (1 mark).
b) A parallel beam of sodium light is incident normally on a diffraction grating. The angle between thetwo first-order spectra on either side of the of the normal is $27^0 42'$. Taking wavelength of the light as 5.893×10^{-7}m, find:
    i) The number of rulings per mm on the grating
    ii) The greatest number of bright images obtained (6 marks)
c) The diffraction pattern from a single slit of width 0.02mm is viewed on the screen placed 1.2m from the slits and light of wavelength 430nm was used. Calculate the width of the central maximum. (4 marks)
d) Why can you easily hear sound around a corner but cannot see around the same corner? (2 marks)

e) Monochromatic light is incident on a single slit of width 0.3mm on a screen located 2.0m away. The width of the central bright fringe is 7.8mm. What is the wavelength of the incident light? (4 marks)

f) A slit of width W is illuminated with light of wavelength 650nm. For what value of W will the first dark fringe for red light be $\theta = 15^0$? (3 marks)

<u>Question FIVE (20 marks)</u>

a) Give conditions for formation of dark and bright fringes. (4 marks)

b) Distinguish between Fraunhoffer and Fresnel diffraction. (2 marks)

c) Unpolarised light in air is to be reflected off a glass surface (n = 1.5). In another instance internal unpolarised 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. (6 marks)

d) Determine the minimum thickness of an antireflective (AR) coat of M_2F_2 deposited on a glass substrate($n_s = 1.52$). If the coat is highly antireflective for the centre of white light spectrum of λ_{air} = 550nm (take refractive index of M_2F_2 = 1.38). (4 marks)

e) White light is incident normally on the surface of a soap bubble. A portion of the surface reflects green light of wavelength. λ_0 = 540nm. Estimate the thickness in nanometers of the soap bubble surface (taken_f = 1.33). (4 marks)