(Knowledge for Development)

KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS - 2020/2021 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER
SPECIAL/SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF BSC (PHYSICS)

COURSE CODE: SPC 221

COURSE TITLE: PHYSICAL OPTICS

EXAM DURATION: 2 HOURS

DATE: 18/1/2022 **TIME:2-4PM**

INSTRUCTIONS: Answer question *ONE* and any other *TWO* questions.

Question one carries *30marks* and the rest *20marks* each

Take $h=6.626\times10^{-34}$JS, $c=3.0\times10^{8}$m/s

1. a) Distiquish between Fraunhofer and Fresnel diffraction. (2mks)

   b) State Huygens' Principle describing how waves propagate. Make a sketch illustrating this principle for a plane wave. (4mks)

   c) The work function of sodium is 4.4×10^{-19} J. What wavelength corresponds to f_o. (3mks)

   d) Deduce the Brewster's law and hence determine the polarizing angle for normal light incident from air to glass surface of refractive index 1.5. (5mks)

   e) Red light from a laser having wavelength 650nm is propagating inside an optical fibre with refractive index n_{fibre}=1.49 for red light. What is the wavelength of the red light in the fibre. (3mks)

   f) Explain the conditions that must be fulfilled to demonstrate interference of light. (3mks)

   g) Write down the Maxwells' equation in simple media. (4mks)

   h) With reference to lasers, differentiate between spontaneous and stimulated emission. (2mks)

   i) What is a wave front? (2mks)

   j) State any two applications of lasers. (2mks)

QUESTION TWO

2. a) Light ranges in wavelength roughly from violet at 3.9×10^{-7}m to red 7.8×10^{-7}m. Its speed in vacuum is about 3.0×10^{8}m/s. Calculate the light frequency range. (5mks)

   b) The light wavelength is written as:

   $\psi(t,t) = 10^3 \sin\pi(3\times10^6 x - 9\times10^{14} t)$

   Assuming SI units, calculate its (i) speed (ii) wavelength (iii) frequency (iv) period and (v) amplitude. (10mks)

   c) Describe the E(y,t) which results from the superposition of the disturbances;

   $E_z(y,t) = iE_{0Z}\cos k(y - vt)$ and $E_z(y,t) = -kE_{0Z}\cos k(y - vt)$ for E(0,t) at t=0, t=T/4 *and t=T/2 where T is the period. (5mks)*

QUESTION THREE

3. a) Derive expressions for the amplitude and reflection coefficients at oblique incidence for transverse electric (TE) and transverse magnetic ™. (12mks)

   b) Rewrite the above amplitude and reflection coefficients in terms of θ_i and θ_T and compute their numerical values at an air-glass interface where n_t=1.5. (8mks)

QUESTION FOUR

4. a) Verify that the harmonic wave function $\psi(x,t) = A\sin(kx - \omega t)$ is a solution of the one dimensional differential wave equation. (10mks)

   b) Given a harmonic plane electromagnetic wave whose E-field has the form:

   $E_z(y,t) = E_{0Z}\sin\left[\omega(t - \frac{y}{c}) + \varepsilon\right]$, determine the corresponding B-field and make a sketch of the wave. (10mks)

QUESTION FIVE

5. a) Write an expression for the irradiance as an explicit function of θ very far from a line source consisting of N identical emitters. (2mks)

   b) For what angles θ_m will maxima appear? (3mks)

   c) Compute I_{max} in terms of the irradiance of a single emitter I_o. (3mks)

   d) The Fraunhofer pattern of a double slit under λ=650nm illumination appears in the back focal plane of a lens having an 80cm focal length. The center to center separation between the bright fringes is observed to be 1.04mm and the fifth maximum is missing. Determine the width of each slit and the distance between them. (6mks)