UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	BIOMEDICAL OPTICS
COURSE CODE	:	BEU 41303
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2019/JANUARY 2020
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER ALL QUESTIONS ON THIS QUESTION BOOKLET

THIS QUESTION PAPER CONSISTS OF **THIRTEEN (13)** PAGES

Q1 (a) Name **TWO (2)** conditions required for Total Internal Reflection (TIR) to occur.
(4 marks)

(b) Light from a laser source of wavelength, λ=633 nm incident on a glass medium from air at an angle of 50°. Calculate the reflective index of the glass medium if TIR has occurred at this incident angle.
(4 marks)

(c) A single slit of width, d = 0.5 mm, is illuminated by monochromatic light (λ = 850 nm). A screen is placed at distance, y = 4.8 m, from the slit to observe the fringe pattern.

(i) Determine the angle between the second dark fringe (m=2) and the central maximum.
(3 marks)

(ii) Calculate the lateral displacement of the dark fringe mentioned in **Q1(c)(i)**.

(3 marks)

(iii) Predict changes in the lateral displacement calculated in **Q1(c)(i)** if $d = 1.0$ mm.

(3 marks)

Q2 (a) Mention **TWO (2)** conditions for real image formation.

(4 marks)

(b) List down **FOUR (4)** types of lens aberrations and briefly discuss their differences.

(8 marks)

(c) An object of height 20 mm is placed at a distance of $u = 3$ cm from a positive lens with focal length, $f = 5$ cm.

(i) Calculate the position and the size of the image.

(4 marks)

(ii) Compare your results in **Q2(c)(i)** using ray tracing method.

(4 marks)

(iii) Determine the position of the final image if u is increased to 5 cm.

(3 marks)

(d) Lens is made from glass of refractive index n, with radius of curvatures (R_1 and R_2). Estimate the focal length of the lens shown in **Figure Q2(d)** using Lensmaker formula given that $n = 1.5$, $R_1 = 2$ cm, $R_2 = 50$ mm.

(4 marks)

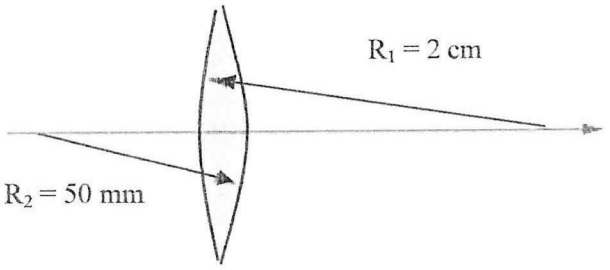

Figure Q2(d)

(e) A three lenses system shown in **Figure Q2(e)** consists of two thin lenses in contact (L_1 and L_2), while the third lens (L_3) is located at a distance, x = 10 mm, from L_2. The focal length, f, of these lenses is given by $f_{(L1)}$ = 3 cm, $f_{(L2)}$ = 5 cm and $f_{(L3)}$ = 4 cm. An object of is placed at 5 mm in front of L_1.

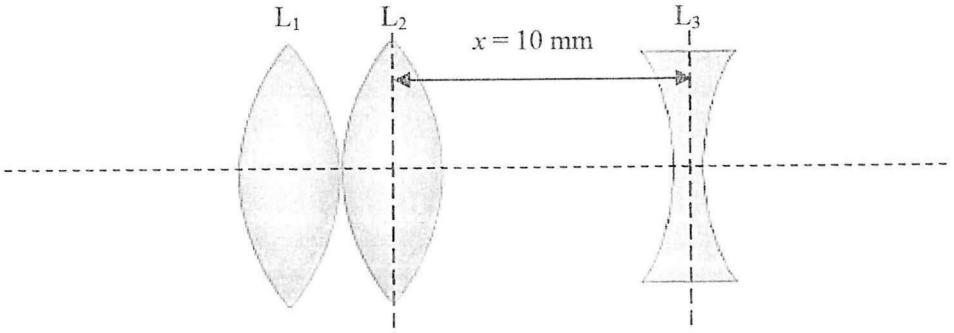

Figure Q2(e)

(i) Calculate the effective focal length of L_1 and L_2 system.

(2 marks)

(ii) Determine the position of the final image.

(7 marks)

(iii) Evaluate the total magnification of this three lenses system.

(4 marks)

Q3 (a) Compare between the technology of Complementary Metal Oxide Detector (CMOS) and Charge Coupled Detector (CCD).

(8 marks)

(b) Spectral responsivity of a photosensitive material is the relative efficiency of detection of light as a function of the frequency or wavelength of the signal.

(i) Compute the responsivity of a photosensitive material with a quantum efficiency of 5 % at 600 nm.

(3 marks)

(ii) Using the value calculated in **Q3(b)(i)**, determine the produced photocurrent if the incident light power is given by 3 mW.

(3 marks)

(c) A P-type intrinsic N-type (PiN) photodiode has quantum efficiency shown in **Figure Q3(c)**.

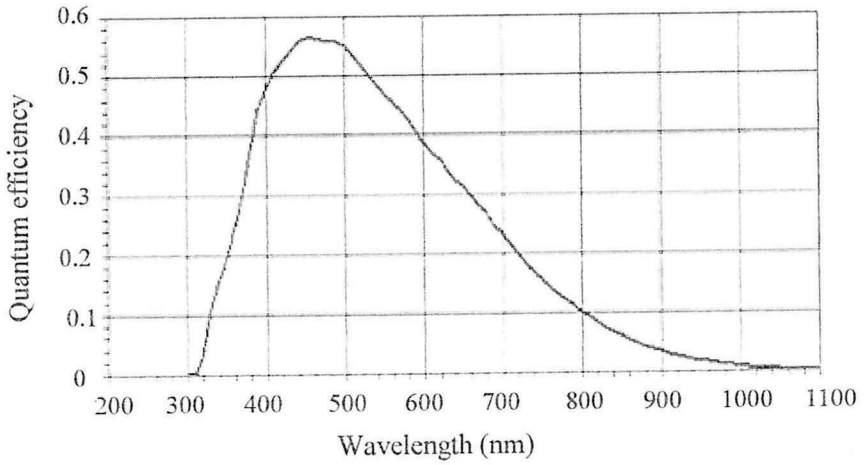

Figure Q3(c)

(i) Determine its responsivity at light wavelength, λ= 0.6 μm.

(3 marks)

(ii) Evaluate the optical power that is required to produce photocurrent of 10 nA at λ= 400 nm.

(5 marks)

(d) The noise equivalent power of a photodetector with a bandwidth of 10 Hz and an area 1 cm^2 is measured to be 8×10^{-9} $W/\sqrt{Hz}$. Determine the ratio of noise to the signal voltage if the incident power is 300 W/mm^2.

(5 marks)

Q4 (a) Name **TWO (2)** differences between spontaneous and stimulated emission.

(4 marks)

(b) List down **ONE (1)** application of laser in medicine and briefly explain its function.
(4 marks)

(c) One of the keys to the operation of a laser is stimulated emission process in an active medium. Given that in the stimulated emission for a certain helium/neon laser, the energy difference is 1.54 eV. Determine the wavelength of light emitted by this laser.
(5 marks)

(d) Describe the differences between Class 2 and Class 4 lasers.

(3 marks)

- **END OF QUESTION –**