Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	BIOMEDICAL OPTICS
COURSE CODE	:	BEJ 45503
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER ALL QUESTIONS
		2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**
		3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK
		4. RETURN THIS QUESTION PAPER WITH YOUR ANSWER BOOK

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) Sketch a diagram showing the differences in the intensity distribution pattern formed from the Young double slits experiment and the single slit diffraction phenomenon. Explain how does single slit cause interference pattern.

(6 marks)

(b) Fermat principle mentioned that light follows the path of least time and when the speed is constant, the minimum time path is simply the minimum distance path. Using the Fermat principle and given that light travels from point **A** to **B** is as shown in **Figure Q1(b)**,

(i) Calculate the total light pathlength from point **A** to **B**.

(3 marks)

(ii) Determine the incident angle, θ_i, and reflectance angle, θ_r.

(4 marks)

(iii) Based on your answer in **Q1(b)(ii)**, assess if Snell's law has been achieved? Justify your answer.

(3 marks)

(c) Predict and draw the output wavefront for the incoming waves shown in **Table Q1(c)**. Write your conclusion of the results.

(8 marks)

Q2 (a) Compare between real image and virtual image formed by a positive lens.

(4 marks)

(b) The simplest positive lens is a symmetric bi-convex with the same front and back focal length. Given that an object of height, h_0 = 10 mm, is placed at a distance of 3.5 cm in-front of a symmetric bi-convex lens with focal length, f_L= 20 mm.

(i) Sketch this optical arrangement according to the actual scale.

(4 marks)

(ii) Using the ray tracing technique, determine the size and location of the image.

(8 marks)

(c) **Figure Q2(c)** shows an optical system consisting of an achromatic doublet, L_1, and a bi-convex lens, L_2. The distance between L_1 and L_2, d, is given by

12 cm. The achromatic doublet, L_1, is made of a thin bi-convex and bi-concave lens in contact and their focal length are given by f_L = +3 cm and f_L = -1 cm, respectively. Meanwhile the focal length of L_2 is given as f_L = +5 cm. An object of height h_0 = 3 cm is located at 9 cm away from the achromatic lens.

(i) Calculate the effective focal length of the achromatic lens, f_e.

(2 marks)

(ii) Find the image location of the achromatic doublet.

(4 marks)

(iii) Determine the final image location of the bi-convex lens.

(4 marks)

(iv) Evaluate the total magnification of the entire system.

(3 marks)

(v) Estimate the size of the final image formed by L_2.

(2 marks)

Q3 (a) State the working principle of Avalanche Photodetector (APD).

(6 marks)

(b) A Charge Coupled Detector (CCD) of model FL2G-50S5M has technical specification shown in **Table Q3(b)**.

(i) Define full well capacity.

(2 marks)

(ii) Explain the relationship between full well capacity of a sensor and signal to noise ratio (*SNR*).

(5 marks)

(iii) Determine the *SNR* value when the incident photon flux is 800 photons per second and the integration time, t, of the detector is given by 200 milliseconds.

(8 marks)

Q4 (a) One of the keys to the operation of a laser is the stimulated emission process in an active medium. In the stimulated emission for a certain helium/neon laser, the energy difference is 1.54 eV. Evaluate the wavelength of light emitted by this laser.

(4 marks)

(b) A laser is used in eye surgery to weld a torn retina back into place. The laser wavelength, λ, is 514 nm and its pulse power, P, is 1.5 W in each laser pulse. During the surgery the laser is pulsed for a time duration, t, of 50 ms.

(i) Find the frequency of the produced light wave.

(3 marks)

(ii) Determine the energy of each photon.

(3 marks)

(iii) Calculate total energy of light produced for $t = 50$ ms.

(4 marks)

(iv) Based on your solution for **Q4(b)(iii)** calculate the number of photons produced.

(3 marks)

Q5 (a) Draw a diagram showing the basic optical system of a microscope and label all the parts in the diagram.

(3 marks)

(b) Absorption is the primary event that allows a laser or other light source to cause a potentially therapeutic (or damaging) effect on a tissue and has been widely adopted in dermatology. Name **ONE (1)** dermatology therapy which is based on tissues absorption events and briefly discuss its working principle.

(4 marks)

- END OF QUESTIONS -

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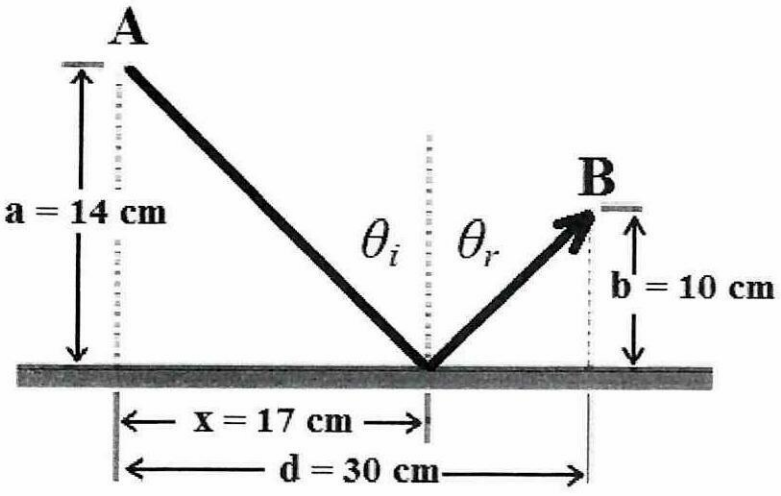
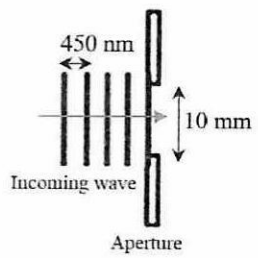
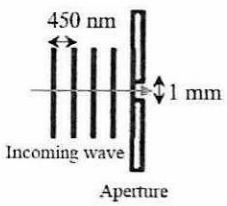
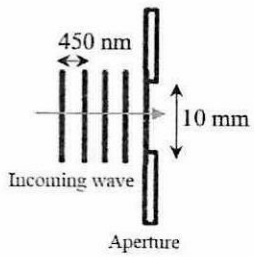
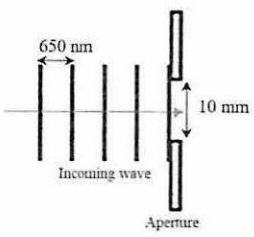


Figure Q1(b)

Table Q1(c)

Compare and draw the output wavefront		Conclusion
		
		

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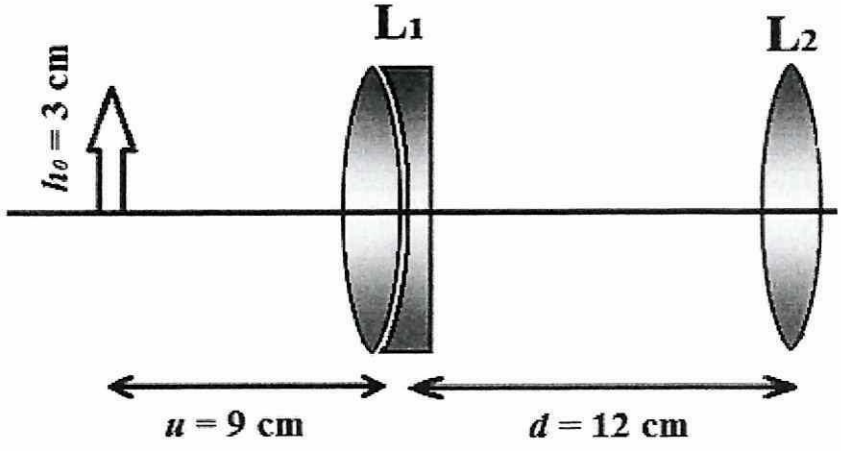

Figure Q2(c)

Table Q3(b)

Camera	Quantum efficiency (e-/photon)	Pixel Clock Frequency (MHz)	Dynamic Range (dB)	Full well capacity (e-)	Dark Current (e-/second)
FL2G-50S5M	0.6	49.15	53	6000	28