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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER I
SESSION 2016/2017**

COURSE NAME : BIOMEDICAL OPTICS
COURSE CODE : BEU 41303
PROGRAMME : BEJ
EXAMINATION DATE : DECEMBER 2016/JANUARY 2017
DURATION : 3 HOURS
INSTRUCTION : ANSWER ALL QUESTIONS

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THIS QUESTION PAPER CONSISTS OF SIX (6) PAGES

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- Q1** (a) Discuss the differences between the formation of interference from Young slits experiment and diffraction phenomenon. (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 . (6 marks)
- (iii) Based on your answer in **Q1(b)(ii)**, assess if Snell's law has been achieved? Explain your reason why. (3 marks)
- (c) Total internal reflection (TIR) is a condition occurred when the refraction angle of an incident light is greater than 90° , this results in the rays to reflect back into the first medium. An example of optical device that adopted the concept of TIR is light pipe shown in **Figure Q1(c)**. Referring to **Figure Q1(c)**,
- (i) Calculate the critical angle, θ_c , of this optical system. (5 marks)
- (ii) Predict what would happen if the refractive index n_2 in medium 2 is reduced to 1. (5 marks)
- Q2** (a) Compare between real image and virtual image formed by a positive lens. (8 marks)
- (b) The simplest positive lens is symmetric bi-convex with the same front and back focal length. Given that an object of height, $h_o = 10$ 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)

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- (ii) Using the ray tracing technique, determine the size and location of the image.
(8 marks)
- (c) **Figure Q2(c)** shows an optical system consisted of 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 $h_o = 3$ cm is located at 9 cm away from the achromatic lens.
- (i) Determine the effective focal length of the achromatic lens, f_e .
(4 marks)
- (ii) Evaluate the final location of the image.
(8 marks)
- (iii) Calculate the total magnification of the entire system.
(5 marks)
- (iv) Determine the size of the image formed by L_2 .
(4 marks)
- Q3** (a) Mention the working principle of Avalanche Photodetector (APD).
(8 marks)
- (b) Signal to noise ratio (SNR) is a parameter commonly used to characterize the quality of a measurement and determine the ultimate performance of a system. Given that an incoming ray with incident photon flux, P , given by 200×10^3 photons/pixel/second is detected by a photodetector with quantum efficiency, $Q_e = 40\%$. The system read noise, n_r , is given by 300 electrons rms/pixel, whereas dark noise, $D = 1,000$ electrons/pixel/second.
- (i) Determine the SNR value if the integration time, t , of the detector is given by 10 milliseconds.
(8 marks)
- (ii) Evaluate the system dark noise, D value that is required to produce SNR value of 70 dB with integration time of 50 milliseconds.
(5 marks)

Q4 (a) 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. Evaluate the wavelength of light emitted by this laser.

(4 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 event and briefly discuss its working principle.

(6 marks)

- END OF QUESTIONS -

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FINAL EXAMINATION

SEMESTER/SESSION: SEM I/2016/2017

PROGRAMME : 4 BEJ

COURSE NAME : BIOMEDICAL OPTICS

COURSE CODE: BEU 41303

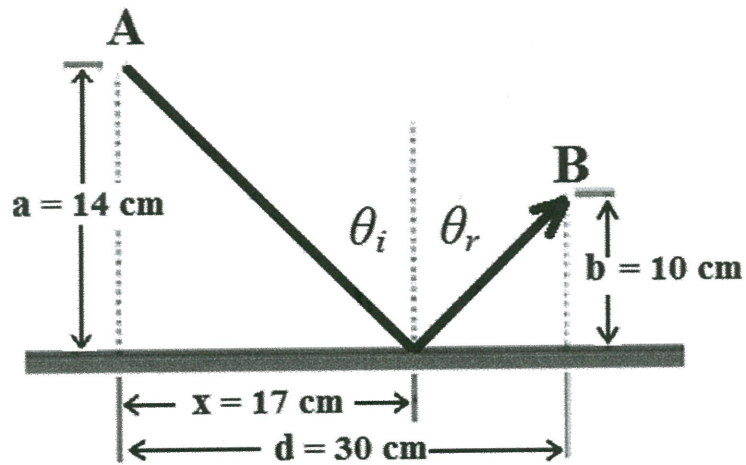


Figure Q1(b)

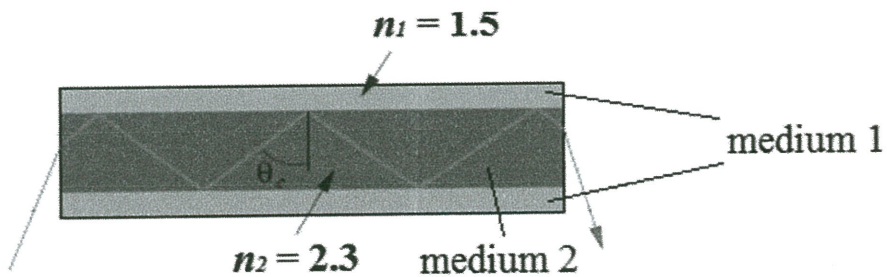


Figure Q1(c)

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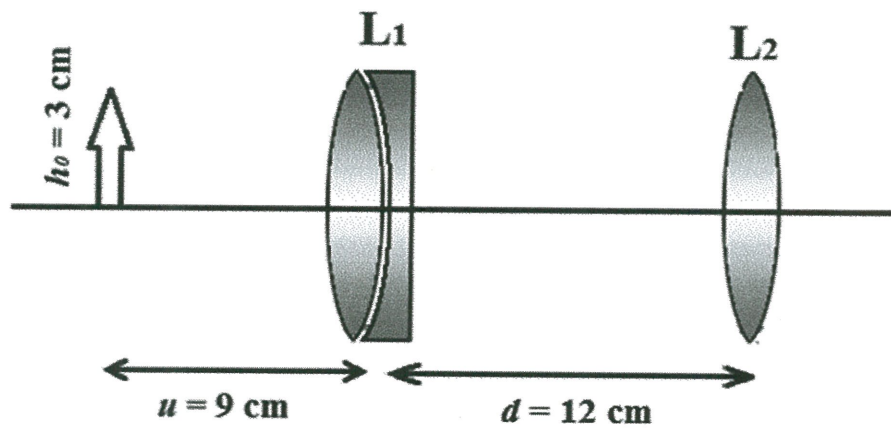


Figure Q2(c)

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