KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF B.Ed (SCIENCE)

COURSE CODE: SPH 121

COURSE TITLE: GEOMETRIC OPTICS

DURATION: 2 HOURS

DATE: 16/05/2022 **TIME: 2:00PM-4:00PM**

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- The following constants might be used: Refractive index of water is 1.333; refractive index of air □1.00 and refractive index of glass □ 1.50

QUESTION ONE [30 Marks]

a) Define the following terms: [4 Marks]
   i. Index of refraction
   ii. Critical angle
   iii. Specular reflection
   iv. Wavelength of light

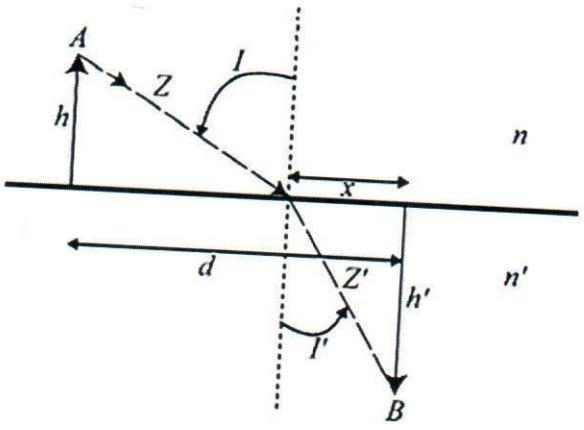
b) What is the physical basis for the difference between diffuse and specular reflection [3 marks]

c) Explain why a swimming pool is actually 2.5m deep appears to be only about 2m deep to an observer. [2 marks]

d) A beam of light originates at a point below the surface of a water tank. Assuming that refractive index of water n =1.333, calculate the angle the emerging beam makes with the vertical if the angle of incidence is

i. 30^0 [2 marks]
ii. 45^0 [2 marks]
iii. 75^0 [2 marks]

e) The figure below shows light path for propagation from point A in a medium with index n to point B in medium with index n^l. Use *Fermat's principle* to show that $n \sin I = n^l \sin I^l$. [4 marks]



f) A real object is 15.0 cm from a converging lens of focal length 25.0 cm. where is the image? [4 marks]

g) A woman 1.5m tall is located 3m from a convex mirror in a supermarket. The focal length of the mirror -0.25m. Find
   I. The position of her image, and [2 marks]
   II. The magnification [2 marks]

h) What is meant by paraxial rays? [1 mark]

QUESTION TWO [20 Marks]

a) i) State the laws of reflection. [2 mark]

ii) An object is placed 10 cm in front of a concave mirror of focal length 15 cm. Find the image position and magnification. Describe its nature. [5 Marks]

iii) What is the optical power of a glass surface in air, with radius of curvature =+10 cm, and refractive index = 1.5? [3 marks]

iv) Derive the mirror equation, $\frac{1}{p}+\frac{1}{q}=\frac{2}{R}$ where P is the object distance, q is the image distance and R is the radius of curvature. (use an appropriate diagram). [5 marks]

v) State two applications of convex mirrors [2 marks]

vi) Your eye is 50 cm in front of a convex mirror whose diameter is 4 cm and whose radius of curvature is 150 cm. What is the angular diameter of the field of view? [3 marks]

QUESTION THREE [20 Marks]

a) State the laws of refraction. [2 marks]

b) What is meant by *total internal* reflection and *critical angle*. [4 marks]

c) A small flat object lies at the bottom of tank containing water to a depth of 16 cm. Find the position of image when viewed above directly. [2 marks]

d) Show that the expression for the angle of deviation for a thin prism is given by $d = (n-1)A$ where the symbols have their usual meaning. [7 marks]

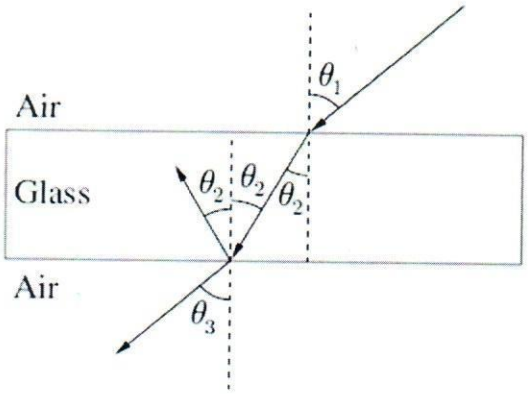
e) A ray of light in air strikes at an angle of incidence of 45^0 the planar surface of a piece of glass of index n = 1.5. Calculate the angle of refraction. [3 marks]

f) Draw a ray diagram to show why a pool of water appears to be only three-quarters of its depth when viewed vertically from above. [2 marks]

QUESTION FOUR [20 Marks]

a) Calculate the critical angle associated with interface between air and water of refractive index 1.33. [3 Marks]

b) Consider the reflection and refraction of monochromatic light on the interfaces between air and slab of glass as shown. The upper and the lower interfaces are parallel. The angle of incidence θ_1 is 50^0.



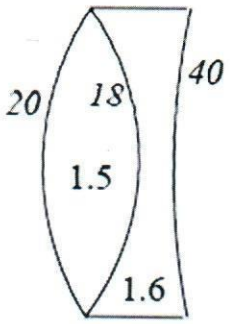
i) Define monochromatic light. [2 marks]

ii) find the angle of refraction θ_2 at the upper interface. [3 marks]

iii) find the angle of refraction θ_3 at lower interface [2 marks]

c) Using convergence, show that the power of a thin lens is given by $\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$ where the symbols have their usual meaning. [4 marks]

d) What is the focal length of this lens? The radii of curvature in cm and the refractive indices are marked. [4 marks]



e) A real object is 15 cm from a converging lens of focal length 25 cm. Where is the image? [2 marks]

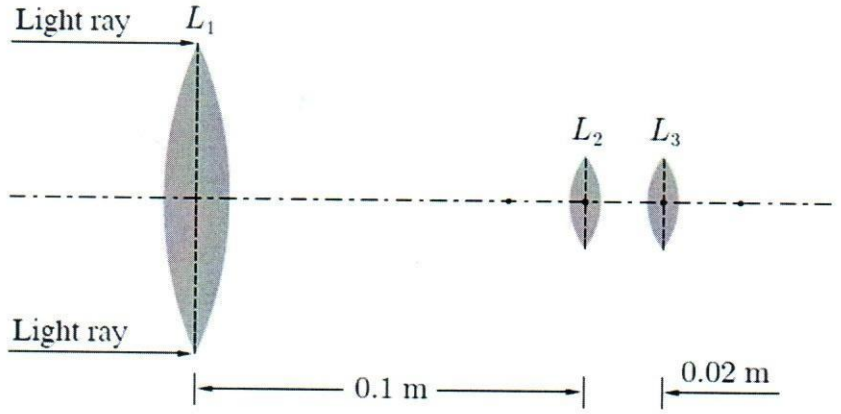
QUESTION FIVE [20 Marks]

a) For a concave mirror of focal length f, what is the object distance d_0 such that the image distance is equal to the object distance? [2 marks]

b) When an object is at a certain distance in front of a concave mirror, the magnification of the mirror is M_1. If the object is moved a distance of *l* from its original location, the magnification of the

image becomes M_2. What is the focal length of the concave mirror? [6 marks]

c) We consider a simple telescope consisting of three thin lens L_1, L_2, and L_3 as shown. L_1 functions as the aperture and the entrance pupil of the telescope. L_3 is the eye lens. The focal lengths and diameters of L_1, L_2 and L_3 are respectively f_1=0.100m, $f2=f_3$=0.020, D_1= 0.040m, and $D_2=D_3$=0.012m.



j) Trace a light ray entering the telescope in parallel to the optical axis through the telescope.
[2 marks]

ii) find the position of the exit pupil.
[3 Marks]

iii) A person of height h from the floor to the eye level stands in front of a plane mirror with the top at the eye level of the person. What is the minimum length of the mirror for the person to be able to see in the mirror the shoes the person is wearing as much as the person can possibly see?
[7 marks]

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