



# MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

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## UNIVERSITY EXAMINATIONS 2023/2024

FIRST YEAR, FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN PHYSICS, BACHELOR OF SCIENCE IN MATHEMATICS AND PHYSICS AND BACHELOR OF EDUCATION SCIENCE

### SPH 3101: GEOMETRICAL OPTICS

DATE: DECEMBER 2023

TIME: 2 HOURS

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

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#### QUESTION ONE (30 MARKS)

- In what two positions will a converging lens of focal length +9cm form images of a luminous object on a screen located 40cm from the object? (4 Marks)
  - State the laws of refraction. (3 Marks)
  - State the Fermat principle. (2 Marks)
  - Using a ray sketch diagram, explain the dispersion of light. (4 Marks)
  - Using a ray sketch diagram, differentiate between real and apparent depth. (3 Marks)
  - using a ray sketch diagram, differentiate between a myopic and hyperopic eye. (4 Marks)
  - List six aberrations of lenses (3 Marks)
  - List six optical instruments (3 Marks)
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MUST is ISO 9001:2015 and



ISO/IEC 27001:2013 CERTIFIED

- i) State the Huygens principle. (2 Marks)
- j) Explain the variation of the frequency and wavelength of the electromagnetic spectrum. (2 Marks)

### QUESTION TWO (20 MARKS)

- a) A narrow beam of light is incident from air onto a glass surface with index of refraction 1.56. Find the angle of incidence for which the corresponding angle of refraction is one-half the angle of incidence. [*Hint*: You might want to use the trigonometric identity  $\sin 2\theta = 2 \sin \theta \cos \theta$ .] (6 Marks)
- b) For a lens with focal length  $f$  find the smallest distance possible between the object and its real image. (4 Marks)
- c) A concave spherical mirror with a radius of curvature of 15.0 cm produces a virtual image one-third the size of the real object. Where is the object? Use geometrical construction and the mirror equations separately, then compare the answers. (10 Marks)

### QUESTION THREE (20 MARKS)

- a) An object of height 4cm is placed 20cm in front of a thin convex lens of focal length +12cm. Determine the location and characteristics of the image by (i) geometrical construction and (ii) computation. (8 Marks)
- b) Differentiate between a myopic and a hyperopic eye using a ray diagram. (4 Marks)
- c) Write the lens' makers equation. (2 Marks)
- d) Explain total internal reflection using a sketch ray diagram? Hence draw the structure of a fiber optic cable and list three of its applications. (6 Marks)



**QUESTION FOUR (20 MARKS)**

- a) Use the Fermats' principle to derive the laws of refraction. (10 Marks)
- b) Show by geometric construction that when light reflects from two mirrors that meet each other at a right angle, the outgoing ray is parallel to the incoming ray, as illustrated in figure I below.

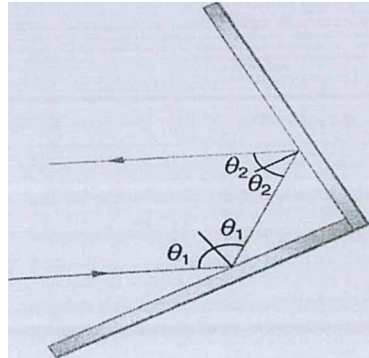


Figure I A corner reflector sends the reflected ray back in a direction parallel to the incident ray, independent of incoming direction (10 Marks)