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THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

A. M. E. C. E. A

MAIN EXAMINATION

JANUARY – APRIL 2018 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

REGULAR PROGRAMME

PHY 104: GEOMETRICAL OPTICS

| Date: APRIL 2018	Duration: 2 Hours
INSTRUCTIONS: Answer Question ONE and any other Two Questions	

Use the following values where necessary:

Index of refraction for water is 1.33.

Index of refraction for flint glass is 1.63.

Q1.   a)   Explain what total internal reflection is and state why it is very common in telecommunications.   **(3 Marks)**

b)   State Snell's law   **(2 Marks)**

c)   Complete the ray diagram below to show the path of light.

(2 Marks)
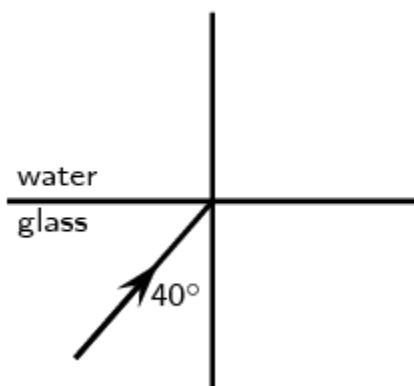
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d) Use the aid of a diagram to state the laws of reflection **(3 Marks)**

e) Light travels from glass (n=1.5) to acetone (n=1.36). The angle of incidence is 25°.

   i) Describe the path of light as it moves into the acetone. **(1 Mark)**

   ii) Calculate the angle of refraction. **(3 Marks)**

   iii) State what happens to the speed of the light as it moves from the glass to the acetone. **(1 Mark)**

   iv) Mention what happens to the wavelength of the light as it moves into the acetone. **(1 Mark)**

f) Use the Wavefront diagram below to answer the questions below it
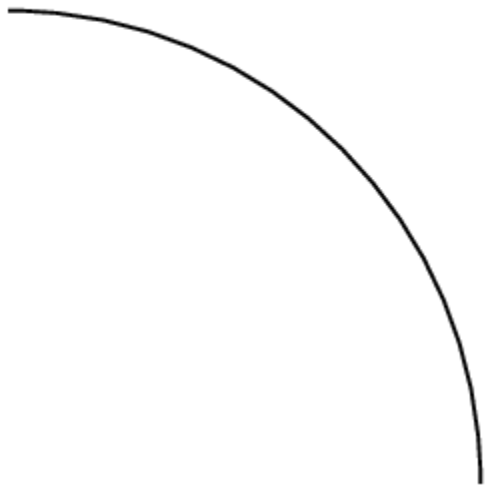
i) Define a Wavefront **(1 Mark)**

ii) Use the Huygens Principle to determine the wavefront at a later time. **(4 Marks)**

g) The diagram below shows a wave incident at an opening and whose wavelength is greater than the width of the opening.
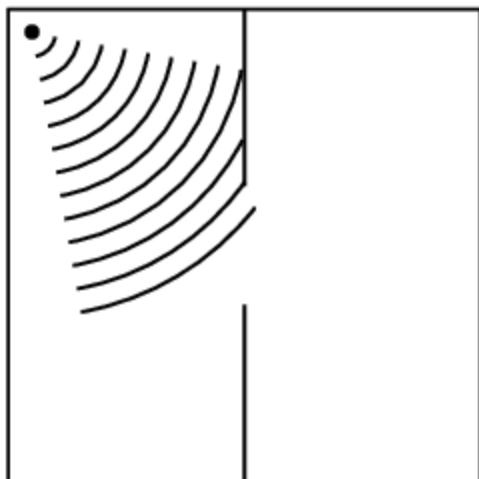
    i)   Define Diffraction   **(2 Marks)**

    ii)   Draw how the wavefronts will propagate after diffraction in the given diagram.   **(2 Marks)**

h) A real object is 15 cm from a converging lens of focal length 25 cm. Find the position of the image and describe it.   **(5 Marks)**

Q2.   a)   In a handheld optical instrument used under water, light is incident from water onto the plane surface of flint glass at an angle of incidence of 45°.

      i)   Find the angle of reflection of light off the flint glass.   **(2 Marks)**
      ii)   Describe the appearance of the refracted ray   **(2 Marks)**
     iii)   Calculate the angle of refraction in the flint glass   **(4 Marks)**

   b)   A glass of unknown index of refraction is shaped in the form of an isosceles prism with an apexangle of 25°. In the laboratory, with the help of a laser beam and a prism table, the *minimum* angleof deviation for this prism is measured carefully to be 15.8°. Determine the refractive index of this glass material.   **(4 Marks)**

   c) Using the law of reflection, describe how to complete the ray-trace diagram for the four rays (a, b, c, d) incident onthe curved surface shown below, given the center of the curved surface is at point C.

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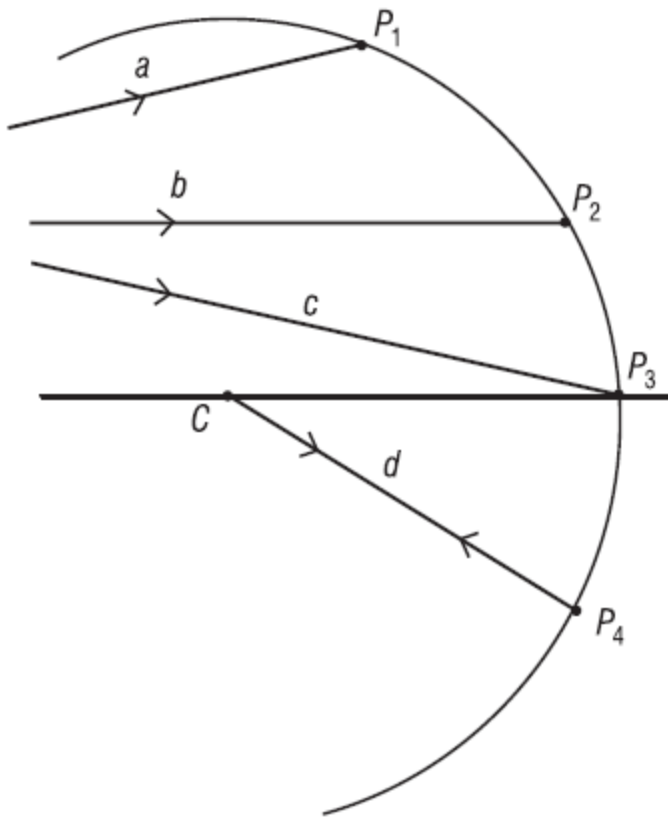
(8 Marks)

Q3. a) Give the names of five geometrical aberrations studied in optics.

(5 Marks)

b) With the aid of a diagram, show that when small angles are involved when looking down into a pool, the ratio of real to apparent depth is approximately equal to the refractive index n of the water. **(5 Marks)**

c) Show the expression for the ratio of real to apparent depth if the angles involved are not small. **(5 Marks)**

d) Draw the image of the letter L positioned above a plane mirror as shown in the figure below:

(5 Marks)
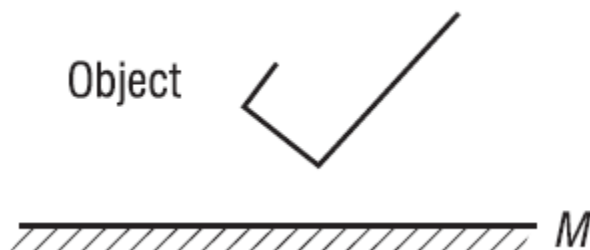
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Q4. a) A meterstick lies along the optical axis of a convex mirror of focal length 40 cm, with its near end 60 cm from the mirror surface. Five-centimeter toy figures stand erect on both the near and far ends of the meterstick.

   i)   Sketch the appearance of the toys along the optical axis of the convex mirror   **(2 Marks)**

   ii) Use the mirror formula to find the length of the virtual image of the meterstick.   **(4 Marks)**

   iii) Using the mirror formula, find how tall the toy figures are in the image, and state if they are erect or inverted.   **(3 Marks)**

   b) Draw a well labelled diagram that uses three key rays to locate the image IP' of an object OP as viewed from a convex side mirror of an automobile.
                                                                                                                                                        (5 Marks)

   c) The figure below shows a step-index fiber, 0.0025 inch in diameter and which has a core index of 1.53 and a cladding index of 1.39.
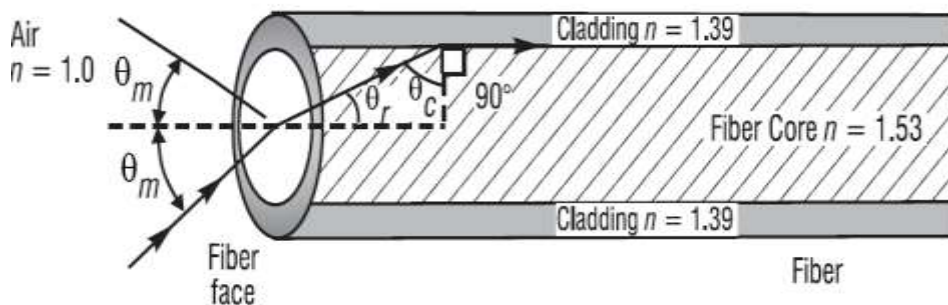
Find the maximum acceptance angle θm for a cone of light rays incident on the fiber face suchthat the refracted ray in the core of the fiber is incident on the cladding at the critical angle.   **(6 Marks)**

Q5. Two converging lenses, with the focal length f_1 = 10 cm and f_2 = 15 cm are placed 40 cm apart, and an object is placed 60 cm in front of the first lens as show in the figure below.

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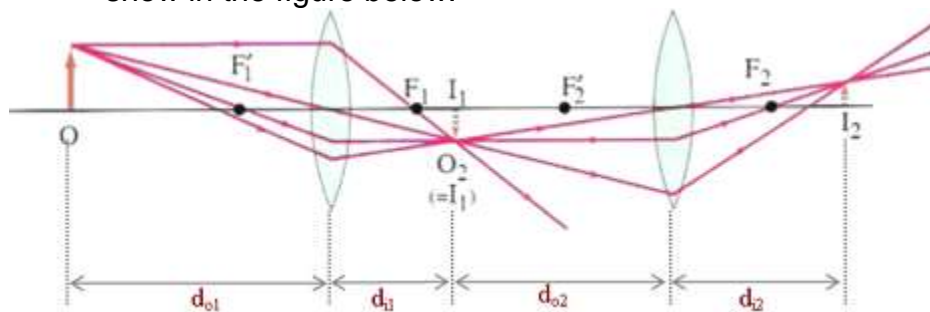
i) Explain the meaning of any eight labels used apart from F_1 and F_2
(4 Marks)

ii) Find using lens equation, the position of the final image formed by the combination of the two lenses **(8 Marks)**

iii) Find magnification of the final image formed by the combination of the two lenses. **(8 Marks)**

END

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