TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Applied & Health Sciences

DEPARTMENT OF MATHEMATICS & PHYSICS

UNIVERSITY EXAMINATION FOR DEGREE OF:

BACHELOR OF TECHNOLOGY IN RENEWABLE ENERGY (BTRE 14S)
BACHELOR OF TECHNOLOGY IN APPLIED PHYSICS (BTAP 14S)

APS 4107: GEOMETRICAL OPTICS

END OF SEMESTER EXAMINATION
SERIES: DECEMBER 2014
TIME ALLOWED: 2 HOURS

Instructions to Candidates:
You should have the following for this examination
- *Mathematical tables*
- *Scientific Calculator*

This paper consist of **FIVE** questions
Answer question **ONE (COMPULSORY)** and any other **TWO** questions
Maximum marks for each part of a question are as shown
This paper consists of **TWO** printed pages

Question One (Compulsory)

a) (i) Define the term optical path length as used in Geometrical optics. **(3 marks)**
(ii) State Format's principle **(1 mark)**
(iii) Derive Snell's Law of refraction at the plane plate interface between TWO materials of refractive index n and n' (Hint: Use a diagram for illustration) **(6 marks)**

b) (i) Use the concept of optical path to briefly describe why a mirage occurs **(5 marks)**
(ii) Early in the morning, on a sunny day, the heat of the sun produces a thin layer of warm air above the surface of along straight road. Consider a possible light ray path such as that illustrated below.

The ray path connects an eye-level point on the tree with an observer of height h = 2m. If the layer of hot air has refractive index n = 1.00020, while the cold air has refractive index n1 = 1.0030.
(i) Show that the optical path length from the tree to the eye level is approximately:

$$n_2 x + n_1\sqrt{(d - x^2) + 4n^2}$$

(4 marks)

(ii) By using Fermat's principle, determine the actual distance that the ray travels in the layer of hot air when d = 500m **(6 marks)**

c) A concave spherical mirror of small a perture has a radius of curvature of 30cm.Where must an object be placed relative to mirror, in order to produce an image that is 3 times the size of the object? Solve the problem and draw the ray diagram. **(5 marks)**

Question Two

a) A piece of chocolate candy is placed 10cm from a converging tens of focal length 15cm. If the chocolate is 4.3cm high. Describe fully the image formed. use a diagram to help you with the problem **(10 marks)**

b) Where must an object 20cm high be placed if a diverging lens of focal length 22cm is to form a virtual image 18cm from the tens on the same side as the object:

(i) Find the object distance and

(ii) Draw a diagram to illustrate this arrangement. **(10 marks)**

Question Three

a) Write down the lens maker's formula relating the focal length of alens to the objet and image distances. Explain the sign convention used for the distances involved. **(6 marks)**

b) Show that as two lenses are brought into constant, the focal length of the combined system, f, can be expressed as:

$$1/f = 1/f_1 + 1/f_2$$

where f_1 and f_2 are the focal lengths of the two separate lenses. (Hint: Illustrate using a diagram) **(9 marks)**

c) A spherical concave shaving mirror has a radius of curvature of 12cm. What is the magnification when the face is 4cm from the vertex of the mirror? Include a ray diagram of the image formation. **(5 marks)**

Question Four

Derive expressions for the refraction matrix and translation matrix for a single lens (Hints Use a diagram for illustration and derivation) **(20 marks)**

Question Five

a) Obtain the matrix equations for a pair of surface of radii r1 and r2 and refractive index n separated by distance d and placed in air. (Hint: Use diagram for illustration) **(15 marks)**

b) Using the results in part (a) show that for a thin lens. **(5 marks)**

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$