KISII UNIVERSITY
UNIVERSITY EXAMINATIONS

FIRST YEAR EXAMINATION FOR THE AWARD OF
THE DEGREE OF BACHELOR OF SCIENCE IN EDUCATION (PHYSICS)
SECOND SEMESTER 2015/2016
(MAY - AUGUST 2016)

PHYS 121: GEOMETRICAL OPTICS

STREAM: Y1S2 **TIME:** 2 HOURS

DAY: THURSDAY, 12.00 – 2.00 PM **DATE:** 28/07/2016

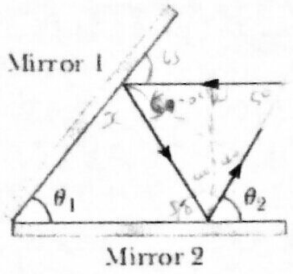
INSTRUCTIONS

1. *Do not write anything on this Question paper.*
2. *Answer Question ONE and any other TWO Questions.*

Q1: COMPULSORY (30 MARKS)

a) Distinguish between geometric and physical optics. (2 mk)

b) Two plane mirrors are at an angle of $\theta_1 = 65.0°$ with each other as in the side view shown in Figure below.



If a horizontal ray is incident on mirror 1, at what angle θ_2 does the outgoing reflected ray make with the surface of mirror 2? (3 mks)

c) Explain the advantages of optical fibers to electric cables in communication industry. (6 mks)

d) The light emitted by a helium–neon laser has a wavelength of 589 nm in air. The light travels from air into zircon of refractive index n = 1.923, find its (i) speed, (ii) wavelength, and (iii) frequency, all in the zircon. (5 mks)

e) A beam of light is incident from air on the surface of a liquid. If the angle of incidence is 40.0° and the angle of refraction is 28.0°, find the critical angle for the liquid when surrounded by air. (4 mks)

f) A spherical mirror is to be used to form an image, five times as tall as an object, on a screen positioned 5.0 m from the mirror. (i) Describe the type of mirror required. (ii) Where should the mirror be positioned relative to the object? (5 mks)

g) An object is placed 50.0 cm from a screen. (i) Where should a converging lens of focal length 10.0 cm be placed to form an image on the screen? (ii) Find the magnification of the lens. (5 mks)

Q2: (20 MARKS)

a) A cubical block of ice 50.0 cm on an edge is placed on a level floor over a speck of dust. Locate the image of the speck, when viewed from directly above, if the index of refraction of ice is 1.309. (5 mks)

b) A contact lens is made of plastic with an index of refraction of 1.50. The lens has an outer radius of curvature of +2.00 cm and an inn radius of curvature of +2.50 cm. What is the focal length of the lens? (4 mks)

c) A diverging lens has a focal length of magnitude 20.0 cm. (I) Locate the images for object distances of (i) 40.0 cm, (ii) 20.0 cm, and (iii) 10.0 cm. For each case, state whether the image is (II) real or virtual and (II) upright or inverted. (IV) For each case, find the magnification. (6 mks)

d) A spherical mirror is to be used to form, on a screen located 5.00 m from the object, an image five times the size of the object. (a) Describe the type of mirror required. (b) Where should the mirror be positioned relative to the object? (5 mks)

Q3: (20 MARKS)

a) A virtual image is formed 20.0 cm from a concave mirror having a radius of curvature of 40.0 cm.

(i) Find the position of the object. (3 mks)

(ii) What is the magnification of the mirror? (3 mks)

b) A dentist uses a mirror to examine a tooth that is 1.00 cm in front of the mirror. The image of the tooth is formed 10.0 cm behind the mirror. Determine

(i) the mirror's radius of curvature. (4 mks)

(ii) the magnification of the image. (2 mk)

c) At an intersection of hospital hallways, a convex spherical mirror is mounted high on a wall to help people avoid collisions. The magnitude of the mirror's radius of curvature is 0.550 m.

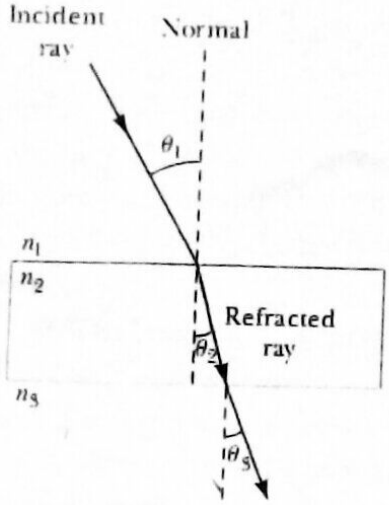
(i) Locate the image of a patient located 10.0 m from the mirror. (4 mks)

(ii) Indicate whether the image is upright or inverted. (1 mk)

(iii) Determine the magnification of the image. (3 mks)

Q4: (20 MARKS)

a) A light ray of wavelength 589 nm (produced by a sodium lamp) traveling through air is incident on a smooth, flat slab of crown glass of index of refraction 1.52 at an angle θ_1 of 30.0° to the normal, as sketched in Figure below.



(i) Find the angle of refraction, θ_2. (3 mks)

(ii) At what angle θ_3 does the ray leave the glass as it re-enters the air? (2 mks)

(iii) How does the answer for θ_3 change if the ray enters water of index of refraction 1.33 below the slab instead of the air? (2 mks)

b) A paperweight is made of a solid glass hemisphere with index of refraction 1.50. The radius of the circular cross section is 4.0 cm. The hemisphere is placed on its flat surface, with the center directly over a 2.5-mm-long line drawn on a sheet of paper. What length of line is seen by someone looking vertically down on the hemisphere? (6 mks)

c) A jellyfish is floating in a water-filled aquarium 1.00 m behind a flat pane of glass 6.00 cm thick and having an index of refraction of 1.50.

(i) Where is the image of the jellyfish located? (3 mks)

(ii) Repeat the problem when the glass is so thin that its thickness can be neglected. (2 mks)

(iii) How does the thickness of the glass affect the answer to part (i)? (1 mk)

Q5: (20 MARKS)

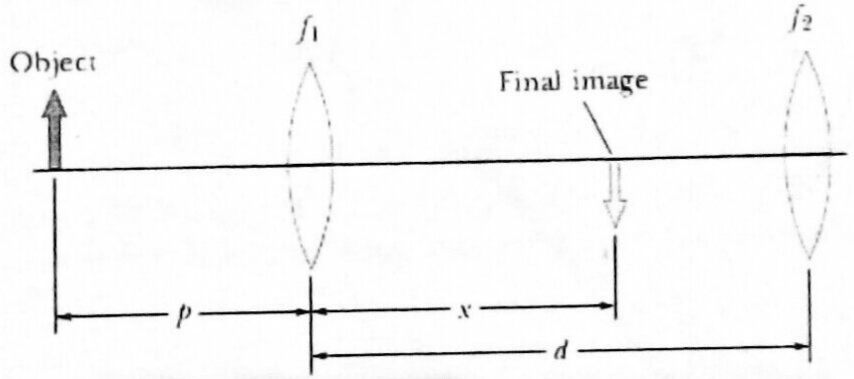
a) Use the Fermat's Principle to derive Snell's law of refraction. (6 mks)

b) A 1.00-cm-high object is placed 4.00 cm to the left of a converging lens of focal length 8.00 cm. A diverging lens of focal length 216.00 cm is 6.00 cm to the right of the converging lens.

(i) Find the position and height of the final image. (3 mks)

(ii) Is the image inverted or upright? Real or virtual? (2 mks)

c) Two converging lenses having focal lengths of $f_1 = 10.0$ cm and $f_2 = 20.0$ cm are placed d = 50.0 cm apart, as shown in Figure below.



The final image is to be located between the lenses, at the position x = 31.0 cm indicated.

(i) How far to the left of the first lens should the object be positioned? (3 mks)

(ii) What is the overall magnification of the system? (2 mks)

(iii) Is the final image upright or inverted? (1 mk)

d) A flint glass plate (n = 1.66) rests on the bottom of an aquarium tank. The plate is 8.00 cm thick (vertical dimension) and covered with water (n = 1.33) to a depth of 12.0 cm. Calculate the apparent thickness of the plate as viewed from above the water. (Assume nearly normal incidence of light rays.) (3 mks)