Chapter # 10 (Optical Instrument)

Important Short Questions

1. What is least distance of distinct vision? Give its value. OR What is Near point?

Ans: Least distance of distinct vision:

The minimum distance from the eye at which an object appears to be distinct is called least distance of distinct vision or near point.

- It is denoted by 'd'
- Its value is 25 cm.

2. What is focusing at infinity, length of telescope?

Ans: Focusing at infinity:

When the image formed by the objective is at the focus of objective as well as eye piece. Then the telescope is in its normal adjustment or focused for infinity.

Length of Telescope:

In normal adjustment of telescope, the distance between eye piece and objective is called length of telescope.

$$L = f_o + f_e$$

3. Define spectrometer. Write its main path. Also write its uses.

Ans: Spectrometer:

The optical device which is used to study the spectrum of various sources of light is called spectrometer.

Main Parts:

- Collimator
- Turn Table
- Telescope

Uses of spectrometer:

It is used to:

i. Study the spectra of different light sources.
ii. Study the deviation of light by prism.
iii. Calculate the refractive index.
iv. Measure the wavelength of light prism.

4. Write function of collimator in spectrometer.

Ans: Function of collimator:

The function of collimator to make the rays coming from a nearby source parallel. At one end of the tube a convex lens is fixed and on the other hand an adjustable slit is provided. When slit is just at the focus of convex lens then light rays entering from slit become parallel after passing through the lens.

5. Define Total internal reflection. Write the conditions of total internal reflection.

Ans: Total Internal reflection:

When light enter from denser to rare medium in such a way that angle of incidence is greater than critical angle, then light totally reflected into the same denser medium. This phenomenon is called total internal reflection.

Conditions for total internal reflection:

- Light should enter from denser to rare medium.
- Angle of incidence should be greater than critical angle.

6. Define critical angle and refractive index.

Ans: Critical Angle:

The angle of incidence at which angle of refraction becomes 90^o is called critical angle.

Refractive Index:

The ratio of speed of light in vacuum (c) to the speed of light in medium (v) is called refractive index.

$$n = \frac{c}{v}$$

7. Define Snell's Law. Write its mathematical form.

Ans: Snell's Law:

The ratio of sine of angle of incidence to the sine of angle of refraction is equal to constant. This is called Snell's law.

$$n = \frac{\text{Sin}\theta}{\text{Sin}\theta}$$

8. What are the types of optical fibre? Explain.

Ans: There are three type of optical fibre.

i. Single mode index fibre
ii. Multimode step index fibre
iii. Multimode step index fibre

(i) Single Mode Step Index Fibre:

- It has very thin core about 5μm diameter.
- It has a relatively large cladding.
- Monochromatic light source is required to send light signals through it.
- It can carry more than 14 TV channels or 14000 phone calls.

(ii) Multimode Mode Step Index Fibre:

- It is the optical fibre in which central core has a large diameter such as 50μm and high refractive index.
- It is useful for short distance only.

(iii) Multimode Graded Index Fibre:

- It is an optical fibre in which central core has high refractive index, its density gradually decreases towards its outer surface.
- The diameter of the core ranges from 50μm to 1000μm.
- It is used for long range distances.

9. What are the three major components of fibre optic communication system?

Ans: The fibre optic communication system consists of three major components.

- Transmitter
- Optical Fibre
- Receiver

Exercise Short Questions

1. What do you understand by linear magnification and angular magnification? Explain how a convex lens is used as a magnifier?

Ans: Linear Magnification:

The ratio of size of image to the size of object is called linear magnification.

OR

The ratio of image distance to the object distance is called linear magnification

$$M = \frac{I}{O} = \frac{q}{p}$$

Angular Magnification:

The ratio of angle subtended by the image as seen through the optical device to that angle subtended by the object at the unaided eye is called angular magnification.

$$M = \frac{\beta}{\alpha}$$

Convex lens as a magnifier:

When an object is placed within the focal length of a double convex lens then a magnified, erect and virtual image is obtained.

2. Explain the difference between angular magnification and resolving power of an optical instrument. What limits the magnification of an optical instrument?

Ans:

Angular Magnification	Resolving Power
• The ratio of angle subtended by the image as seen through the optical device to that angle subtended by the object at the unaided eye is called angular magnification. $M = \frac{\beta}{\alpha}$	• The resolving power of an instrument is its ability to reveal the minor details of an object under examination. $R = \frac{D}{1.22\lambda}$
• Angular magnification increases the apparent size of image of the object.	• The resolving power of an instrument separates the images of two very close objects.

Limitation:

Chromatic and spherical aberration are two main defects which limited the magnification of optical instrument and details of the object cannot be seen clearly.

3. Why would it be advantage to use blue light with a compound microscope?

Ans: When we use blue light with a compound microscope it increases the resolving power. And more details of the object can be seen.

Reason:

As we know that resolving power, $R = \dfrac{1}{\alpha_{min}} = \dfrac{D}{1.22\lambda}$

Since the blue light is of shorter wavelength. It produces less diffraction. Hence, it increases the resolving power of compound microscope.

4. One can buy a cheap microscope for use by the children. The image seen in such a microscope have coloured edges, why is this so?

Ans: It is due to chromatic aberration.

Reason:

In chromatic aberration, the lens behaves as a prism. When light passes through lens then all wavelengths are not focused at one point. Due to chromatic aberration of the lens the image seen in cheap microscopes have coloured edges.

5. Describe with help of diagrams, how (a) a single biconvex lens can be used as a magnifying glass. (b) biconvex lenses can be arranged to form a microscope.

Ans: For Single Biconvex lens:

A biconvex lens is used as a magnifying glass. When object is placed within the focal length of the lens them an erect, virtual and magnified image is obtained.

For Biconvex lenses:

In compound microscope, when the image formed by the objective lens is within focal length of the eyepiece then a virtual, inverted and magnified image is obtained.

6. If a person were looking through a telescope at full moon, how would the appearance of the moon be changed by covering half of the objective lens.

Ans: The apparent size of image of moon does not change. It looks dim only.

Reason:

As intensity of light depends upon the diameter of objective lens. If the objective lens is half covered then there is no effect on the size of image but the brightness of image is reduced.

7. A magnifying glass gives a five-times enlarged image at a distance of 25 cm from the lens. Find, by ray diagram, the focal length of the lens.

Ans:

$M = 5, \quad d = 25cm$

$f = ?$

$$M = 1 + \frac{d}{f}$$

$$5 = 1 + \frac{25}{f}$$

$$5 - 1 = \frac{25}{f}$$

$$4 = \frac{25}{f}$$

$$f = \frac{25}{4} = 6.25 \text{ cm}$$

8. Identify the correct answer.

(i) The resolving power of a compound microscope depends upon:

(a) The refractive index of the medium in which the object is placed.
(b) The diameter of the objective lens.
(c) The angle subtended by the objective lens at the object.
(d) The position of an observer's eye with regard to the eye lens.

Ans: (b) The diameter of the objective lens.

(ii) The resolving power of a astronomical microscope depends upon:

(a) The focal length of objective lens.
(b) The least distance of distinct vision of the observer.
(c) The focal length of the eye piece.
(d) The diameter of the objective lens

Ans: (d) The diameter of the objective lens.

9. Draw sketches showing the different light paths through a single-mode and a multi-mode fibre. Why is the single-mode fibre preferred in telecommunications?

Ans: The different light paths through single mode and multi-mode fibre are shown below.

Preference of single – mode fibre:

Single mode is preferred in telecommunication because:

- A strong mono – chromatic source is used in single mode fibre.
- There is no dispersion of light and hence no signal is lost.

10. How the light signal is transmitted through the optical fibre?

Ans: The signals are transmitted through optical fibre by:

- Total internal reflection
- Continuous refraction

In multimode step index fibre, the signal is transmitted by mean of total internal reflection while in case of multimode graded index fibre, the signal is transmitted by total internal reflection and continuous refraction.

11. How the power is lost in optical fibre through dispersion? Explain.

Ans: Power is lost in optical fibre through dispersion due to:

- When light signal is not perfectly monochromatic, then light will disperse on passing through the core of the optical fibre into different wavelengths λ_1, λ_2 and λ_3.
- When light signals travel along fibres by multiple reflection, some light is absorbed due to impurities in the glass.
- Some of it is scattered by groups of atoms which are formed at places such as joints when fibres are joined together.

Carefully manufacturing can reduce the power losses by scattering and absorption.