

Topic 1: Models in Optics

Aim

This lecture reviews the various models used in optics and the basic assumptions and approximations used in each. The range of applicability of each model will be reviewed, and scope of the course will be defined.

References

- Hecht, Chapter 1 & 5.
- Physics 3 Optics notes

1 Revision and General Optics

All questions here are general background optics which will be assumed in this course. Problem 3 requires technical details of the microscope which most of you will require to look up in a standard textbook.

1.1 Simple Lens

Use geometric optics and Snell's law to show that for a thin lens of focal length f the object and image plane distances are related by

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

If the lens is made of glass with refractive index n show that

$$\frac{1}{f} = (n - 1) \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$$

where R_1 and R_2 are the radii of curvature of the lens surfaces.

1.2 Binocular, and Telescopes

You are asked by a horse racing punter to supply them with a pair of binoculars that will allow them to read the starting prices from the far side of Musselburgh race course, which is approximately 400 m across. The starting prices are written in chalk in approximately 10 cm high letters. Specify a suitable magnification, and sketch a possible optical system for the binoculars.

Hint: Most people can easily obtain the minimum standard of vision required to drive a car (read a numberplate at 25 yards). The optical system in a binocular is similar to a telescope, but it is folded with a prism(s) that also re-inverts the image.



1.3 Microscopes

A microscope objective is marked $\times 20$, 0.35NA. Explain what these terms mean. What is the focal length of this objective. Sketch an optical system to give a $\times 300$ visual magnification, and calculate the required focal length of the eye piece.

Hint: Assume a “tube length” of 160 mm and a visual near point of 254 mm. You will need to look-up these terms in a standard optics book. The easiest explanation is in Hecht’s *Optics* page 190(ish).

1.4 Lens Power

Somebody who is myopic (short sighted), tells you that their prescription is -3.75D in the right eye and -4.50D in the left. What are the focal lengths of the their lenses?

Suggest a simple scheme to check that these focal lengths are right. (You may assume that you have a single positive lens of focal length 100 mm that you may wish to use).



1.5 A Tricky Puzzle

A metal plate with a hole of unknown diameter is placed at one end of an optical bench and a screen at the other. The metal plate is illuminated from behind with a ordinary lightbulb and a lens is used to form a sharp image on the screen. The diameter of the image is 4.5 cm. The lens is then moved towards the screen until a second sharp image is formed, this time of 2.0 cm in diameter. What is the size of the hole in the metal plate.

Hint: Draw out the two conditions for a sharp image and remember that object and image are interchangeable. Yes there *is* enough information to solve this.