Unit 17 · Lenses

HARDER PRACTICE QUESTIONS

Full marks 30

Write your answers on separate paper. Show your working. Use the "real is positive" sign convention: f and R positive for a convex lens or face, negative for a concave one. Take the least distance of distinct vision as 25 cm.

1 Spot the error [3]

Find the mistake in the working and correct it.

Aryan was asked for the focal length of two convex lenses of focal lengths 20 cm and 30 cm placed in contact. He wrote:
"Two lenses together are longer, so $F = f_1 + f_2 = 20 + 30 = \mathbf{50\ cm}$. The pair is weaker than either lens."

2 Two sharp images [4]

A candle and a screen are fixed 90 cm apart. A convex lens between them gives a sharp image on the screen in two positions, 30 cm apart.

i. Explain why there are two positions, and how u and v in one are related to those in the other.
ii. Find the object and image distances in each position, and the focal length.
iii. Find the magnification in each position and show that their product is 1.

3 What if? [4]

A thin glass lens ($\mu = 1.5$) has a focal length of 20 cm in air. Find its focal length when it is put in

i. a liquid of refractive index 1.25;
ii. a liquid of refractive index 1.65.
iii. Say what kind of lens it acts as in each liquid, and why.

4 Estimate it [3]

Taking the distance from the eye's nodal point to the retina as 17 mm, estimate the height of the image on the retina of

i. a door 2.0 m tall, 10 m away;
ii. a coin 2.0 cm across, held 25 cm from the eye.
iii. Which looks bigger, and why?

5 A real setting [3]

A watch repairer in Patan uses a magnifier (a loupe) of focal length 2.5 cm, holding it so that the image is at 25 cm from his eye.

i. Find its magnifying power.
ii. How far from the loupe must he hold the watch's gear?

6 Design it [3]

Opticians make most spectacle lenses as menisci. A lens of -2.0 D is to be made of glass of refractive index 1.5, with its convex face of radius 50 cm. What must the radius of the concave face be? Which face is curved more?

7 Which explanation fits the evidence? [3]

Swimmers can't see clearly under water, but they can with swimming goggles, which only keep a layer of air in front of the eyes. Two students explain the blur:
Nishma: “Water scatters light and makes it cloudy.”
Sudarshan: “The cornea bends light much less in water than in air, so the eye loses most of its power.”
Which explanation does the goggles' evidence support? Explain.

8 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

Anuska wrote: “A lens shaped like a convex lens always converges light. A lens of focal length 25 cm has a power of 25 D. If a lens's magnification is negative, its image is smaller than the object.”

9 Think [2]

A glass lens disappears completely when it is put in a liquid of exactly the same refractive index. Use the lens maker's formula to say what its focal length becomes, and explain why it can't be seen.

10 Make your own [2]

Choose two lenses, one convex and one concave, with powers you choose, that together make a diverging pair of focal length -50 cm. Show that your pair works.