PHYSICS 534

ANSWERS

EXERCISE-54 **Optical Power**

WALTON

Ernest Walton was awarded the 1951 prize for physics for his pioneer work on the transmutation of atomic nuclei.

The optical power of a lens is a measure of how much the lens bends light. The greater the optical power, the more the lens bends light. The optical power is the reciprocal of the focal length of the lens. The symbol for the optical power of a lens is P and the unit for the optical power is ***dioptres*** and is designated by the Greek symbol "δ":

$$\mathbf{P = \frac{1}{f}}$$

Study the examples below:

$f = 1$ cm	$P = 1/0.01$ m	$= 100\ \delta$
$f = 2$ cm	$P = 1/0.02$ m	$= 50\ \delta$
$f = 4$ cm	$P = 1/0.04$ m	$= 25\ \delta$
$f = 8$ cm	$P = 1/0.08$ m	$= 12.5\ \delta$
$f = 10$ cm	$P = 1/0.1$ m	$= 10\ \delta$
$f = 25$ cm	$P = 1/0.25$ m	$= 4\ \delta$
$f = 50$ cm	$P = 1/0.50$ m	$= 2\ \delta$
$f = 100$ cm	$P = 1/1$ m	$= 1\ \delta$

Note: The optical power of a converging lens is positive while the optical power of a diverging lens is negative

For a compound lens, the ***total*** optical power is given by the following formula:

$$\mathbf{P_T = P_1 + P_2 + P_3 + \cdots} \quad \text{or} \quad \mathbf{\frac{1}{f_T} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + \cdots}$$

1. Define the optical power of a lens:

The ability of a lens to bend (converge or diverge) light rays.

2. What type of a lens has positive optical power? ____ ***Converging lens*** _________

3. What type of a lens has a negative optical power? ___ ***Diverging lens*** _________

4. Listed below are the focal lengths of five lenses. Determine their optical powers.

a) f = 1 cm

Convert 1cm to 0.01m

$$\mathbf{P = \frac{1}{f} = \frac{1}{0.01\,m} = 100\,\delta\ (dioptres)}$$

b) f = 5 cm

Convert 5cm to 0.05m

$$\mathbf{P = \frac{1}{f} = \frac{1}{0.05\,m} = 20\,\delta}$$

c) f = 10 cm

Convert 10cm to 0.10m

$$\mathbf{P = \frac{1}{f} = \frac{1}{0.10\,m} = 10\,\delta}$$

d) f = -20 cm

Convert – 20cm to – 0.20m

$$\mathbf{P = \frac{1}{f} = \frac{1}{-0.20\,m} = -5\,\delta}$$

← [illegible]

e) f = 15 cm

Convert 15cm to 0.15m

$$\mathbf{P = \frac{1}{f} = \frac{1}{0.15\,m} = 6.7\,\delta}$$

5. Listed below are the optical powers of four lenses. Determine their focal lengths.

a) P = 20 δ

$$\mathbf{f = \frac{1}{P} = \frac{1}{20\,\delta} = 0.05\,m = 5\,cm}$$

b) P = 10 δ

$$\mathbf{f = \frac{1}{P} = \frac{1}{10\,\delta} = 0.10\,m = 10\,cm}$$

c) P = -25 δ

$$\mathbf{f = \frac{1}{P} = \frac{1}{-25\,\delta} = -0.04\,m = -4\,cm}$$

d) P = 8 δ

$$\mathbf{f = \frac{1}{P} = \frac{1}{8\,\delta} = 0.125\,m = 12.5\,cm}$$

6. A converging lens has a focal length of 25 cm. Determine its optical power.

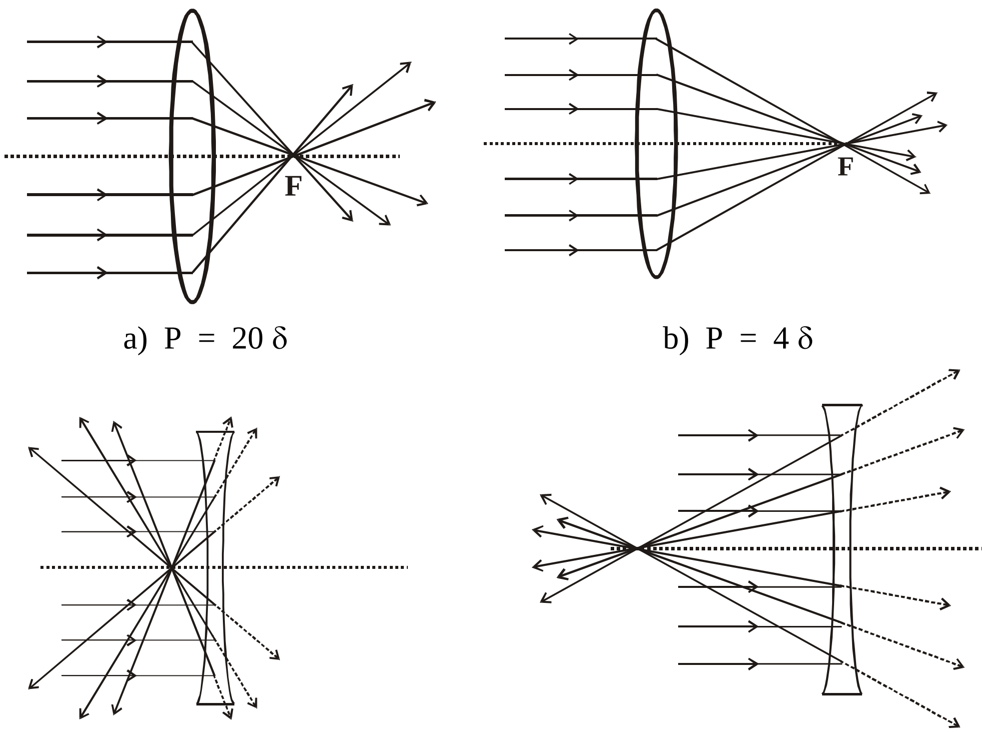
Convert 25 cm to 0.25 m

$$\mathbf{P = \frac{1}{f} = \frac{1}{0.25\,m} = 4\,\delta}$$

7. The optical power of a diverging lens is – 8.33 δ. Determine its focal length.

$$\mathbf{f = \frac{1}{P} = \frac{1}{-8.33\,\delta} = -0.12\,m = -12\,cm}$$

8. Draw the rays emerging from a lens having the following optical powers:



a) P = 20 δ   b) P = 4 δ

c) P = -20 δ   d) P = -4 δ

9. Two thin lenses are placed together to form an effective lens system. The lenses have powers of 20.0 δ and –12.0 δ respectively. Find the focal length of the system. [12.5 cm]

$$\mathbf{P_T = P_1 + P_2 = 20.0\,\delta + (-12.0\,\delta) = 8.0\,\delta}$$

$$\mathbf{Thus: \quad f_T = \frac{1}{P_T} = \frac{1}{8.0\,\delta} = 0.125\ m = 12.5\,cm}$$

10. A lens system consists of a converging lens and a diverging lens. The focal length of the converging lens is 60 cm. If the optical power of the system is to be 1.25 dioptres, what should be the focal length of the diverging lens? [-2.4 m]

$$\mathbf{P_T = P_1 + P_2 = \frac{1}{f_1} + P_2 \qquad or \qquad 1.25\,\delta = \frac{1}{0.6\,m} + P_2}$$

$$\mathbf{Thus: \quad P_2 = -0.41\,\delta}$$

$$\mathbf{But: \quad P_2 = \frac{1}{f_2} \qquad \therefore \quad f_2 = \frac{1}{P_2} = \frac{1}{-0.41} = -2.4\,m}$$