

Exercise Solutions

Question 1: In an experiment to measure the speed of light by Fizeau's apparatus, following data are used:

Distance between the mirrors = 12.0 km,

Number of teeth in the wheel = 180.

Find the minimum angular speed of the wheel for which the image is not seen.

Solution:

In the Fizeau's apparatus,

Distance between the mirrors, $D = 12.0 \text{ km} = 12 \times 10^3 \text{ m}$

Number of teeth in the wheel, $n = 180$

Speed of light = $3 \times 10^8 \text{ ms}^{-1}$

we know,

Speed of light, $c = (2Dn\omega)/\pi$

$\Rightarrow \omega = c\pi/(2Dn) \text{ rad/sec} = c\pi/(2Dn) \times 180/\pi \text{ degree/sec}$

$\Rightarrow \omega = [3 \times 10^8]/[24 \times 10^3] = 1.25 \times 10^4 \text{ degree/sec}$

Question 2: In experiment with Foucault's apparatus, the various distances used are as follows:

Distance between the rotating and the fixed mirror = 16 m

Distance between the lens and the rotating mirror = 6 m,

Distance between the source and the lens = 2 m.

Solution:

Distance between fixed and rotating mirror = $R = 16 \text{ m}$

Distance between lens and rotating mirror = $b = 6 \text{ m}$

Distance between source and lens = $a = 2 \text{ m}$

Angular speed = $\omega = 356 \text{ rev/s} = 356 \times 2\pi \text{ rad/sec}$

Shift in image = $s = 0.7 \text{ cm} = 0.7 \times 10^{-3} \text{ m/s}$

Now,

Speed of light = $c = (4R^2\omega a)/s(R+b)$

$$= [4 \times 16^2 \times 356 \times 2\pi \times 2] / [0.7 \times 10^{-3} (16+6)]$$

$$= 2.975 \times 10^8 \text{ m/s}$$

Question 3: In a Michelson experiment for measuring speed of light, the distance travelled by light between two reflections from the rotating mirror is 4.8 km. The rotating mirror has a shape of a regular octagon. At what minimum angular speed of the mirror (other than zero) the image is formed at the position where a nonrotating mirror forms it?

Solution:

Distance travelled by the light wave between two reflections from the rotating mirror =

$$D = 4.8 \text{ km} = 4.8 \times 10^3$$

Number of faces of the mirror = $N = 8$

In the Michelson experiment, the speed of light = $c = (D\omega N)/2\pi$

Where, ω is angular speed of the mirror.

$$\text{Or } \omega = (2\pi c)/DN \text{ rad/s} = c/(DN) \text{ rev/sec}$$

$$= [3 \times 10^8] / [4.8 \times 10^3 \times 8]$$

$$= 7.8 \times 10^3 \text{ rev/sec}$$