Speed of Light

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 km = 12×10^3 m
Number of teeth in the wheel, n = 180
Speed of light = 3×10^8 ms^{-1}

we know,

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

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

$\Rightarrow \omega = [3x10^8]/[24x10^3] = 1.25 \times 10^4$ 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 = 16m
Distance between lens and rotating mirror = b = 6m
Distance between source and lens = a = 2m
Angular speed = $\omega = 356$ rev/s = $356 \times 2\pi$ rad/sec
Shift in image = s = 0.7 cm = 0.7×10^{-3} m/s
Now,
Speed of light = $c = (4R^2\omega a)/s(R+b)$

$= [4x16^2x\ 356x2\pi\ x\ 2]/[0.7x10^{-3}(16+6)]$

$= 2.975\ x\ 10^8$ 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 = $D = 4.8$ 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.

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

$= [3x10^8]/[4.8x10^3x8]$

$= 7.8\ x\ 10^3$ rev/sec