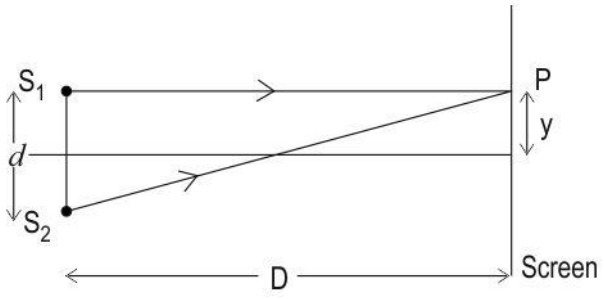
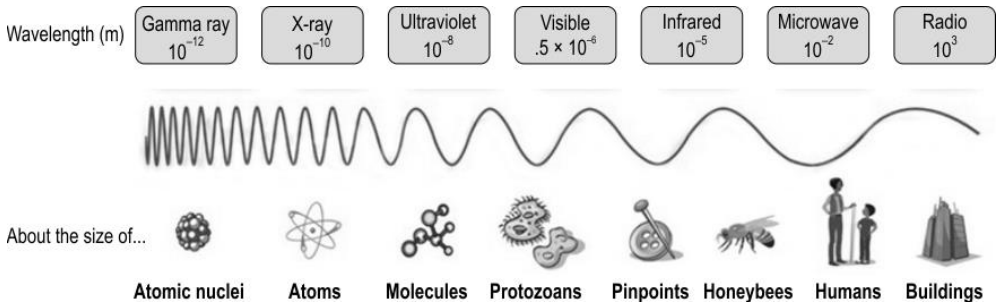
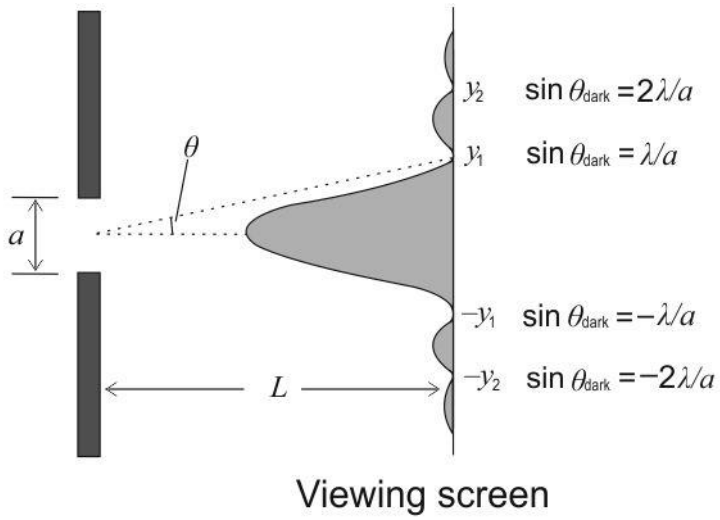
Wave Optics

Q.No	Question	Marks
	Multiple Choice Question	
Q.132	Two statements are given below. One is labelled Assertion (A) and the other is labelled Reason (R). Read the statements carefully and choose the option that correctly describes statements A and R. Assertion (A): When monochromatic light passes through a narrow opening, a pattern of alternate bright and dark fringes is produced. Reason (R): The edges of the opening become sources of secondary waves, which superpose to produce the pattern. A. Both assertion and reason are true and reason is the correct explanation for assertion. B. Both assertion and reason are true but reason is not the correct explanation for assertion. C. Assertion is true but the reason is false. D. Both assertion are reason are false.	1
	Free Response Questions/Subjective Questions	
Q.133	A white light is used to illuminate the two slits in a Young's double slit experiment. It results in the overlapping interference patterns on the screen as each wavelength corresponds to one interference pattern. [Refer to the diagram below for the various parameters of the experimental setup.]  At a point P, that is directly opposite to the slit S_1, find the series of wavelengths that will result in minima.	2
Q.134	In a Young's double slit experiment; the source of light consists of wavelengths in the range 3000 – 8000 Å. The distance of the screen from slits is 2 m and distance of separation between the two slits is 10^{-3} m.	2

	Determine the wavelengths in the visible range (400 nm -700 nm) present at a position that is 10^{-3} m from the central maxima.	
Q.135	A lamp sends out a plane wave through a slit of width 2 μm. The light from the lamp is composed of two spectral lines of wavelengths D_1 = 5896 Å and D_2 = 5900 Å. Determine the distance between the first secondary maxima of each of the spectral lines in the diffraction pattern formed on the screen that is 2 m away from the slits.	2
Q.136	Read the passage carefully and answer the questions given below. Diffraction of incoming beams by an obstacle or aperture is convincing proof of the wave nature of light. Diffraction takes place for all types of waves, mechanical or non-mechanical, transverse or longitudinal. However, its effects are perceptible only if the wavelength of radiation is comparable to the dimensions of the diffracting device. In the case of diffraction of light through apertures and obstacles instead of sharp shadow or uniform illumination, we get a fringe pattern called a diffraction pattern that depends on the nature of the diffracting device and the wavelength of the incoming light used. Given here is the representation of wavelengths of light waves in comparison to the sizes of various objects.  a. If the spacing of atoms in crystals is of the order of few Å, then can visible light waves be used to study the arrangement of atoms in a crystal? Give reason. b. Identify the waves that are most suitable for studying arrangements of atoms in a crystal. c. State true or false & give reason for your answer: Both a clap sound and a radio electromagnetic wave can be heard or received around the corner of a building. (Consider the wavelength of a clap to be about 0.1 m.) d. In the single slit diffraction arrangement, how would the image on the screen appear in case the wavelength λ of the incident light is much less than the aperture width d?	4

Q.137	Study the intensity distribution diagram for a diffraction pattern from a single slit of width 'a'. The positions of two minima on each side of the central maximum are labeled. (Drawing not to scale.)  Answer the following questions: a. Determine the ratio of width of the central bright maximum to the width of the second secondary maxima above it. b. What is sine of an angle at which the second secondary maxima is produced above the central maxima? c. If the slit width in Figure is made half as wide, what will be effect on the width of its central bright fringe? Explain your answer.	3

Answer key and Marking Scheme

Q.No	Answers	Marks
Q.132	C. Assertion is true but the reason is false.	1
Q.133	The distance y from center: y = (D/d) Δx , where Δx is the path difference between two light waves reaching point P. For the missing wavelengths (or minima points) at P, $\Delta x = (n + \frac{1}{2})\lambda$, with n = 0,1,2,3..... So $y = \frac{D}{d}\frac{(2n+1)}{2}\lambda$ [1 mark for the correct relation between for missing wavelength] As per the given diagram, $\frac{d}{2} = \frac{D}{d}\frac{(2n+1)}{2}\lambda$ $\lambda = \frac{d^2}{D\,(2n+1)}$ for n = 0,1,2,3... So all $\lambda = d^2/D$, $d^2/3D$, $d^2/5D$,... will form minima at point P. [1 mark for correct result of series of wavelengths]	2
Q.134	For a point that is at a distance y from central maxima, $y = \frac{D}{d}\Delta x = \frac{D}{d}n\lambda$ Here Δx is the path difference = nλ …. for the maxima at the position that is at a distance y from central maxima. λ = yd/nD where n = 1,2,3... [0.5 mark for the correct formula for wavelength in terms of y and other parameters] Substituting,	2

	$\lambda = \frac{10^{-3}\, x\, 10^{-3}}{n\,.\,2}$ = 0.5 x 10^{-6} /n = 5000/n Å with n = 1,2,3… So the following wavelengths are present at the given position: λ = 5000 Å, 2500 Å, 1666 Å,…. [1 mark for correct calculation of the range of wavelengths present at the given position] Out of these only the wavelength 5000 Å is in visible range. [0.5 mark for the correct identification of the wavelength in visible range present at the given position]	
Q.135	$sin\theta = (n + \frac{1}{2})\frac{\lambda}{d} = \frac{x}{D}$ here d = slit width, x is the distance of the maxima from the central line and D is the perpendicular distance of the screen from the slit. $x = (n + \frac{1}{2})\frac{\lambda D}{d}$ For the first secondary maxima $x = (1 + \frac{1}{2})\frac{\lambda D}{d}$ (1 mark) Distance between the two secondary maximas of the two spectral lines: $\Delta x = \frac{3D}{2d}(5900 - 5896)x10^{-10}$ $\Delta x = \frac{3\times2}{2\times2\times10^{-6}} \times 4x10^{-10}$ $\Delta x = 6 \times 10^{-4}m$ (1 mark)	2
Q.136	a. Wavelength of visible light waves ~4000 -7000Å is much higher than the spacing of atoms, which is few Å. Hence visible light cannot be used to study the arrangement of atoms in a crystal using the diffraction principle. [*0.5 marks for the correct answer and 0.5 marks for the reason.*] b. X rays [1 mark] c. True. In both cases the wavelengths of the clap sound and radio waves is comparable to the dimensions of the building.	4

	[1 mark] d. There will be a uniform illumination of the screen in the case of the wavelength of the light is much less than the slit width of the diffraction apparatus. [1 mark]	
Q.137	a. Width of the central maxima : $\frac{\lambda}{a} - \frac{-\lambda}{a} = \frac{2\lambda}{a}$ Each of the secondary maxima are of same width, that is , λ/a So the ratio = 2 : 1 [1 mark for the correct final result] b. Condition for the maxima : sinθ = (n + ½)λ/a , where n = +/- 1, +/- 2, …. For the second secondary maxima : n = +2 So sinθ = (2 + ½)λ/a = 5λ/2a [1 mark for the correct final result] c. As the angles on the either side of the central maxima: sinθ =+/- λ/a With the decrease in slit width a, the angle θ on the either side of the central maxima will increase, hence the width of the central maxima will increase. [0.5 mark for the correct change in width of central maxima & 0.5 mark for the correct reason]	3