Wave and Motion : Light Waves – Typical Questions

No of Questions:70 **Time Allotted: 7 Hours**

All questions are compulsory

[Note: a. Figures are conceptual only and not to the scale**]**

[b. Solutions may be taken up in Three parts as, Part I: 1 to 30 of Three Hours; Part II: 31 to 60 of Three Hours; Part III: 61 to 70 of One Hour]

[c. It is advised to attempt question under examination conditions**]**

Q-01	Light is (a) Wave phenomenon (b) particle phenomenon (c) both particle and wave phenomenon (d) none of the above
Q-02	The speed of light depends (a) On elasticity of the medium only (b) On inertia of the medium (c) On elasticity as well as inertia of the medium (d) Neither on elasticity nor on inertia
Q-03	The equation of a light wave is written as $y = A\sin(kx - \omega t)$. Here, y represents (a) Displacement of ether particles (b) Pressure of the medium (c) Density of medium (d) Electric field
Q-04	Which of the following properties show that light is a transverse wave? (a) Reflection (b) Interference (c) Diffraction (d) Polarization
Q-05	When light is refracted into a denser medium (a) Its wavelength and frequency both increase (b) Its wavelength increases but frequency remains unchanged (c) Its wavelength decreases but frequency remains unchanged (d) Its wavelength and frequency both decrease
Q-06	When light is refracted, which of the following does not change? (a) Wavelength (b) Frequency (c) Velocity (d) Amplitude
Q-07	The amplitude modulated (AM) radio wave bends appreciably round the corners of a 1 m × 1 m board but the frequency modulated (FM) wave only negligibly bends. If average wavelength of AM and FM waves are λ_a and λ_f, (a) $\lambda_a > \lambda_f$ (b) $\lambda_a = \lambda_f$ (c) $\lambda_a < \lambda_f$ (d) We don't have sufficient information to decide the relation of λ_a and λ_f
Q-08	Which of the following sources gives best monochromatic light? (a) A candle (b) A bulb (c) A mercury tube (d) Laser

Q-09	The wavelengths of a light wave travelling in vacuum are given by $x + y + z = c$. The angle made by the direction of propagation of light with the X-axis is (a) 0^0 (b) 45^0 (c) 90^0 (d) $\cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$
Q-10	The wavefronts of light coming from a distant source of unknown shape are nearly (a) Plane (b) Line source (c) Cylindrical (d) Spherical
Q-11	The inverse square law of intensity (i.e. the intensity $\propto \frac{1}{r^2}$) is valid for a (a) Point source (b) Line Source (c) Plane source (d) cylindrical source
Q-12	Two sources are called coherent if they produce waves (a) of equal wavelength (b) of equal speed (c) having same shape of wavefront (d) having a constant phase difference
Q-13	When a drop of oil is spread on a water surface, it displays beautiful colours in daylight because of (a) dispersion of light (b) reflection of light (c) polarization of light (d) interference of light
Q-14	Two coherent sources of different intensities send waves which interfere. The ratio of maximum intensity to the minimum intensity is 25. The intensities of the sources are in the ratio (a) 25:1 (b) 5:1 (c) 9:4 (d) 625:1
Q-15	The slits in a Young's double slit experiment have equal width and the source placed symmetrical with respect to the slits. The intensity at the central fringe is I_0. If one of the slits is closed, the intensity at the point will be (a) I_0 (b) $\frac{I_0}{4}$ (c) $\frac{I_0}{2}$ (d) $4I_0$
Q-16	A thin transparent sheet is placed in front of a Young's double slit. The fringe-width will (a) Increase (b) Decrease (c) Remain same (d) Become non-uniform
Q-17	If Young's double slit experiment is performed in water (a) The fringe width will decrease (b) The fringe width will increase (c) The fringe width will remain unchanged (d) There will be no fringe
Q-18	A light wave can travel (a) In vacuum (b) In vacuum only (c) In a material medium (d) In a material medium only
Q-19	Which of the following properties of light conclusively support theory of light (a) Light obeys law of reflection (b) Speed of light on water is smaller than the speed in vacuum (c) Light shows interference (d) Light shows photoelectric effect
Q-20	When light propagates in vacuum there is an electric field and magnetic fields. These fields are (a) Constant in time (b) Have zero average value (c) Are perpendicular to the direction of propagation of light (d) Are mutually perpendicular

Q-21	Huygens' principle of secondary wavelets may be used to – (a) Find the speed of light in vacuum (b) Explain the particle behavior of light (c) Find the new position of a wavefront (d) Explain Snelll's law
Q-22	Three observer's A, B and C measure the speed of light coming from a source to be v_a, v_b and v_c. The observer A moves towards the source and C moves away from he source at same speed. The observer B stays stationary. The surrounding space is vacuum everywhere. (a) $v_a > v_b > v_c$ (b) $v_a < v_b < v_c$ (c) $v_a = v_b = v_c$ (d) $v_b = \frac{1}{2}(v_b + v_c)$
Q-23	Three observer's A, B and C measure the speed of light coming from a source to be v_a, v_b and v_c. The observer A moves towards the source and C moves away from he source at same speed. The observer B stays stationary. The surrounding space is water everywhere. (a) $v_a > v_b > v_c$ (b) $v_a < v_b < v_c$ (c) $v_a = v_b = v_c$ (d) $v_b = \frac{1}{2}(v_b + v_c)$
Q-24	Light waves travel in vacuum along the X-axis. Which of the following may represent the wavefronts? (a) $x = c$ (b) $y = c$ (c) $z = c$ (d) $x + y + z = c$
Q-25	If the source of light used in a Young's double slit experiment is changed from red to violet, (a) The fringes will become brighter (b) Consecutive fringes will come closer (c) The fringe intensity of maxima will increase (d) The central bright fringe will become dark fringe
Q-26	A Young's double slit experiment is performed with white light (a) The central fringe will be white (b) There will not be a completely dark fringe (c) The fringe next to the central will be red (d) The fringe next to the central will be violet.
Q-27	Four light waves represented by (i) $y = a_1 \sin \omega t$ (ii) $y = a_2 \sin(\omega t + \varepsilon)$ (iii) $y = a_1 \sin 2\omega t$ (iv) $y = a_2 \sin 2(\omega t + \varepsilon)$ Interference fringes may be observed due to superposition of (a) (i) and (ii) (b) (i) and (iii) (c) (ii) and (iv) (d) (iii) and (iv)
Q-28	Find range of frequency of light that is visible to an average human being (400 nm < λ < 700 nm)
Q-29	The wavelength of sodium light in air is 589 nm. (a) Find the its frequency in air. (b) Find its wavelength in water (refractive index = 1.33) (c) Find its frequency in water (d) Find its speed in water
Q-30	The index of refraction of fused quartz is 1.472 for light of wavelength 400 nm and is 1.452 for light of wavelength 760 nm. Find the speed of light of these wavelengths in fused quartz.
Q-31	The speed of the yellow light in a certain liquid is 2.4×10^8 m/s. Find the refractive index the liquid.

Q-32	The narrow slits emitting light in phase are separated by a distance of 1.0 cm. The wavelength of the light is 5.0×10^{-7} m. The interference pattern is observed on a screen placed at a distance of 1.0 m. (a) Find the separation between the consecutive maxima. Can you expect to distinguish between these maxima? (b) Find the separation between the sources which will give a separation of 1.0 mm between the consecutive maxima.
Q-33	The separation between consecutive dark fringes in a Young's double slit experiment is 1.0 mm. The screen is placed at a distance of 2.5 m from the slits and the separation between the slits is 1.0 mm. Calculate the wavelength of light used for the experiment.
Q-34	In a double slit interference experiment, the separation between the slits is 1.0 mm, the wavelength of light used is 5.0×10^{-7}m and the distance of the screen from the slits is 1.0 m. (a) Find the distance of the center of the first minimum from the center of the central maxima (b) How many bright fringes are formed in one centimeter width on the screen?
Q-35	In a Young's double slit experiment, two narrow vertical slits placed 0.800 mm apart are illuminated by the same source of yellow light of wavelength 589 nm. How far are the adjacent bright bands in the interference pattern observed on a screen 2.00 m away?
Q-36	Find the angular separation between the consecutive bright fringes in a Young's double slit experiment with blue-green light of wavelength 500 nm. The separation between the slits is 2.0×10^{-3}m.
Q-37	A source emitting light of wavelength 480 nm and 600 nm is used in a double slit interference experiment. The separation between the slits is 0.25 mm and the interference is observed on a screen placed at 150 cm from the slits. Find the linear separation between the first maximum (next to the central maximum) corresponding to the two wavelengths.
Q-38	White light is used in a Young's double slit experiment. Find the minimum order of the violet fringe (λ=400 nm) which overlaps with a red fringe (λ=700 nm).
Q-39	Find the *t* thickness of a plate which will produce a change in optical path equal to half the wavelength λ of the light passing through it normally. The refractive index of the plate is μ.
Q-40	A plate of thickness *t* made of a material refractive index μ is placed in front of one of the slits in a double slit experiment. (a) Find the change in optical path due to introduction of the plate. (b) What should be the minimum thickness *t* which will make the intensity at the center of the fringe pattern zero? Wavelength of the light used is λ. Neglect any absorption of light in the plate.
Q-41	A transparent paper (refractive index = 1.45) of thickness 0.02 mm is pasted on one of the slits of a Young's double slit experiment which uses monochromatic light of wavelength 620 nm. How many fringes will cross through the center if the paper is removed?
Q-42	In Young's double slit experiment using monochromatic light, the fringe pattern shifts by a certain distance on the screen when a mica sheet of refractive index 1.6 and thickness 1.964 micron ($1 \text{ micron} = 10^{-6}$m) is introduced in the path of one of the interfering waves. The mica sheet is then removed and the distance between the screen and the slits is doubled. It is found that the distance between the successive maxima now is the same as the observed fringe-shift upon the introduction of the mica sheet. Calculate the wavelength of the monochromatic light used in the experiment.

Q-43 A mica strip and a polystyrene strip are fitted on the two slits of a double slit apparatus. The thickness of the strips is 0.50 mm and the separation between the slits is 0.12 cm. The refractive index of mica and polystyrene are 1.58 and 1.55 respectively for the light of wavelength 590 nm which is used in the experiment. The interference is observed on a screen at a distance one meter away.

(a) What would be the fringe-width?

(b) At what distance from the center will the first maximum be located?

Q-44 Two transparent slabs having equal thickness but different refractive indices μ_1 and μ_2 are pasted side by side to form a composite slab. This slab is placed just after the double slit in the Young's experiment so that the light from one slit goes through one material and light from other slit goes through the other material. What should be minimum thickness of the slab so that there is a minimum at the point P_0 which is equidistant from the slab?

Q-45 A thin paper of thickness 0.02 mm having a refractive index 1.45 is pasted across one of the slits in a Young's double slit experiment. The paper transmits 4/9 of the light energy falling on it.

(a) Find the ratio of the maximum light intensity to the minimum intensity in the fringe pattern.

(b) How many fringes will cross through the center if an identical paper piece is pasted on the other slit also?

Wavelength of the light used is 600 nm.

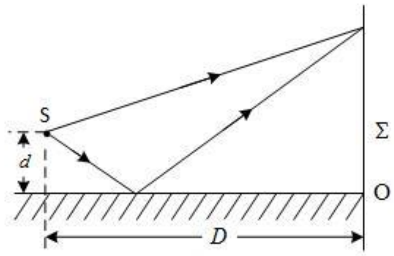
Q-46 A Young's double slit apparatus has slits separated by 0.28 mm and a screen 48 cm away from the slits. The whole apparatus is immersed in water and slits are illuminated by red light (λ = 700 nm in vacuum). Find the fringe width of the pattern formed on the screen.

Q-47 A parallel beam of monochromatic light is used in a Young's double slit experiment. The slits are separated by a distance d and the screen is placed parallel to the plane of the slits. Show that if the incident beam makes an angle $\theta = \sin^{-1}\left(\frac{\lambda}{2d}\right)$ with the normal to the plane of the slits, there will be a dark fringe at the center P_0 of the pattern.

Q-48 A narrow slit S transmitting light of wavelength λ is placed at a distance d above a large plane mirror as shown in figure. The light coming directly from the slit and that coming after reflection interfere at a screen Σ placed at a distance D from the slit.

(a) What will be the intensity at a point just above the mirror, i.e. above O?

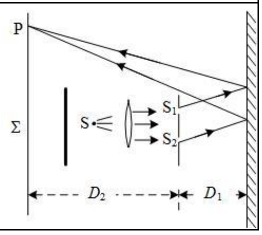
(b) At what distance from O does the first maximum occur?

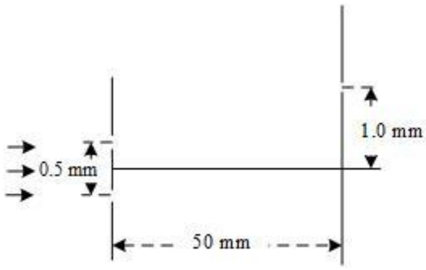
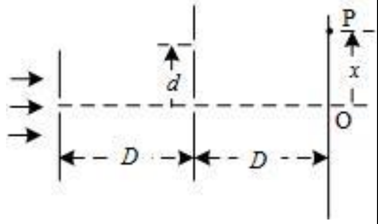
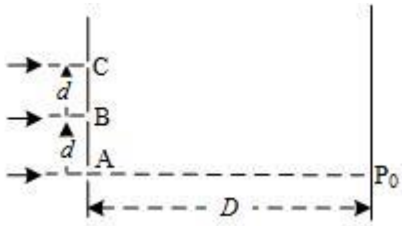


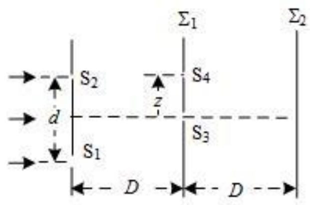
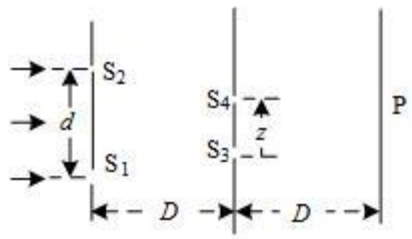
Q-49 A long narrow horizontal slit placed 1mm above a horizontal plane mirror. The interference between the light coming directly from the slit and that after reflection is seen on a screen 1.0 m away from the slit. Find the fringe-width if the light used has a wavelength of 700 nm.

Q-50 Consider the situation of a long narrow horizontal slit placed 1mm above a horizontal plane mirror. The interference between the light coming directly from the slit and that after reflection is seen on a screen 1.0 m away from the slit. If the mirror reflects only 64% of the light energy falling on it, what will be the ratio of the maximum to the minimum intensity in the interference pattern observed on the screen?

Q-51 A double slit S_1-S_2 is illuminated by a coherent light of wavelength λ. The slits are separated by a distance d. A plane mirror is placed in front of the double slit at a distance D_1 from it and screen Σ is placed behind the double slit at a distance D_2 from it as shown in the figure. The screen Σ receives only light reflected by the mirror. Find the fringe-width of the interference pattern on the screen.



Q-52	White coherent light (400nm - 700 nm) is sent through the slits of a Young's double slit experiment as shown in the figure. The separation between the slits is 0.5 mm and screen is 50 cm away from the slits. There is a hole in the screen at a point 1.0 mm away (along the width of the fringes) from the central line. (a) Which wavelength(s) will be absent in the light coming from the hole? (b) Which wavelength(s) will have a strong intensity? 
Q-53	Consider the arrangement shown in the figure. The distance D is large compared to the separation between the slits. (a) Find the minimum value of d so that there is a dark fringe at O. (b) Suppose d has the value determined at (a), find the distance x at which the next bright fringe is formed. (c) Find the fringe–width. 
Q-54	Two coherent point sources S_1 and S_2 vibrating in-phase emit light of wavelength λ. The separation between the sources is 2λ, Consider a line passing through S_2 and perpendicular to line joining S_1S_2. What is the smallest distance from S_2 where minimum intensity occurs?
Q-55	Figure shows three equidistant slits being illuminated by a monochromatic parallel beam of light. Let $BP_0 - AP_0 = \frac{\lambda}{3}$ and $D \gg \lambda$. (a) Show that in this case $d = \sqrt{\frac{2\lambda D}{3}}$ (b) Show that the intensity at P_0 is three times the intensity due to any of the three slits individually. 
Q-56	On a Young's double slit experiment, the separation between the slits id 2 mm, the wavelength of light is 600 nm and the distance of the screen from the slits is 2.0 m. If intensity at the center of the central maximum id 0.20 W/m^2. What will be the intensity at a point 0.5 cm away from the center along the width of the fringe?
Q-57	In a young's double slit interference experiment the fringe pattern is observed on a screen placed at a distance D from the slits. The slits are separated by a distance d and are illuminated by monochromatic light of wavelength λ. Find the distance from the central point where the intensity falls to (a) Half the maximum, (b) One fourth of the maximum
Q-58	In a young's double slit experiment λ = 500 nm, d = 1.0mm and D = 1.0. Find the minimum distance from the central maximum for which the intensity is half the maximum intensity.
Q-59	The linewidth of a bright fringe is sometimes defined as the separation between the points in the two sides of the central line where the intensity falls to half the maximum. Find line width if a fringe in a Young's double slit experiment in terms of λ, d and D where the symbols have their usual meanings.

Q-60	Consider the situation shown in the figure. The slits S_1 and S_2 placed symmetrically around the central line are illuminated by a monochromatic light of wavelength λ. The separation between the slits is d. The light transmitted by the slits falls on a screen Σ_1, placed at a distance D from the slits. The slit S_3 is at the central line and slit S_4 is at a distance z from S_3. Another screen Σ_2 is placed a further distance D away from Σ_1 . Find the ratio of the maximum to minimum intensity observed on Σ_2 if z is equal to (a) $z = \frac{\lambda D}{2d}$ (b) $z = \frac{\lambda D}{d}$ (c) $z = \frac{\lambda D}{4d}$ 
Q-61	Consider the arrangement shown in the figure. By some mechanism, the separation between the slits S_3 and S_4 can be changed. The intensity is measured at the point P which is at common perpendicular bisector of S_1S_2 and S_3S_4. When $z = \frac{\lambda D}{2d}$ the intensity measured at P is I. Find intensity when z is equal to (a) $\frac{\lambda D}{d}$ (b) $\frac{3\lambda D}{2d}$ (c) $\frac{2\lambda D}{d}$ 
Q-62	A soap film of thickness 0.0011 mm appears dark when seen by the reflected light of wavelength 580 nm. What is the index of refraction of the soap solution, if it is known to be between 1.2 and 1.5?
Q-63	A parallel beam of light of wavelength 560 nm falls on a thin film of oil (refractive index = 1.4). What should be the minimum thickness of the film so that it strongly reflects the light?
Q-64	A parallel beam of white light is incident normally on a water film 1.0×10^{-4} cm thick., Find the wavelength in visible range (400 nm – 700 nm) which are strongly transmitted by the film. Refractive index of water is 1.33.
Q-65	A glass surface is coated by an oil film of uniform thickness 1.00×10^{-4}cm. The index of refraction of the oil is 1.25 and that of the glass is 1.50. find the wavelength if the light in the visible region (400 nm – 750 nm) which are completely transmitted by the oil film under normal incidence.
Q-66	Plane microwave are incident on a long slit having width of 5.0 cm. calculate the wavelength of the microwave if the first diffraction minimum is formed at $\theta = 30^0$.
Q-67	Light of wavelength 560 nm goes through a pinhole of diameter 0.20 mm and falls on a wall at a distance of 2.00 m. What will be the radius of the central bright spot formed on the wall?
Q-68	A convex lens of diameter 8.0 cm is used to focus a parallel beam of light of wavelength 620 nm. If the light be focused at a distance of 20 cm from the lens, what would be the radius of the central bright spot formed?
Q-69	In Young's double slit experiment. The interference pattern is found to have an intensity ratio between bright and dark fringes as 9. This implies that – (a) The intensities at the screen due to the two slits are 5 units and 4 units respectively (b) The intensities at the screen due to the two slits are 4 units and 1 unit respectively (c) Amplitude ratio is 3 (d) Amplitude ratio is 2
Q-70	White light is used to illuminate the two slits in a Young's double slit experiment. The separation between slits is b and the screen is at a distance $d(\gg b)$ from the slits. At a point on the screen directly in-front of one of the slits, certain wavelength are missing. Some of the missing wavelengths are – (a) $\lambda = \frac{b^2}{d}$ (b) $\lambda = \frac{2b^2}{d}$ (c) $\lambda = \frac{b^2}{3d}$ (d) $\lambda = \frac{2b^2}{3d}$