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PHYSICS - Optional

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Waves & Optics 2015 - 2019

UPSC – PHYSICS Optional – 2015 Questions

1. A convex lens of focal length 20 cm is placed after a slit of width 0.5 mm. If a plane wave of wavelength 5000 A^o falls normally on the slit, calculate the separation between the second minima on either side of the central maximum. **[10M]**

2. What is the role of an optical resonator in a laser? Why does one prefer curved mirrors instead of plane mirrors in designing an optical resonator? **[10M]**

3. Find out the phase and group velocities of a radio wave of frequency $\omega = \sqrt{2}\,\omega_p$ in the ionosphere (as a dielectric medium) of refractive index $n = \sqrt{1 - \frac{\omega_p^2}{\omega^2}}$. Here, ω_p is the ionospheric plasma frequency. **[15M]**

4. Using matric method, find out the equivalent focal length for a combination of two thin lenses of focal lengths f_1 and f_2 separated by a distance a. **[10M]**

5. What are the characteristic features of Rayleigh scattering? A very thin monochromatic beam of light is incident on a particle. Suggest a simple experimental method to ascertain whether the scattering by the particle is of Rayleigh type. **[20M]**

UPSC – PHYSICS Optional – 2016 Questions

1. The refractive indices of core and cladding in a step index optical fiber are 1.52 and 1.48 respectively. The diameter of the core is $30\mu m$. If the operating wavelength is $1.3\mu m$, calculate the V parameter and the maximum number of modes supported by the fiber. **[10M]**

2. Can D_1 and D_2 lines of sodium light $\left(\lambda_{D_1} = 5890\ A^o \text{ and } \lambda_{D_2} = 5896\ A^o\right)$ be resolved in second-order spectrum if the number of lines in the given grating is 450? Explain. **[10M]**

3. The equation of a progressive wave moving on a string is $y = 5\sin\pi(0.01x - 2t)$. In this equation, y and x are in centimetres and t is in seconds. Calculate amplitude, frequency and velocity of the wave. If two particles at any instant are situated 200 cm apart, what will be the phase difference between these particles? **[10M]**

4. Explain the principle of (i) induced absorption, (ii) spontaneous emission and (iii) stimulated emission. Show that the ratio of Einstein's coefficients is given by $\frac{A}{B} = \frac{8\pi h\nu^3}{c^3}$ **[20M]**

5. In Michelson interferometer, 100 fringes cross the field of view when the movable mirror is displaced through 0.029 mm. Calculate the wavelength of the light source used. **[05M]**

6. Obtain an expression for the resolving power of a grating explaining the Rayleigh's criterion of resolution. **[15M]**

7. Explain the principle of producing polarized light by the method of reflection, refraction and double refraction with the help of neat diagrams. **[15M]**

8. Obtain the conditions for constructive interference and destructive interference in a thin film due to reflected light. **[10M]**

UPSC – PHYSICS Optional – 2017 Questions

1. Describe Michelson-Morley experiment and show how the negative results obtained from this experiment were interpreted. **[10M]**

2. Sunlight is reflected from a clam lake. The reflected light is 100% polarized at a certain instant. What is the angle between the sun and horizon? **[10M]**

3. Explain with proper example the interferences due to 'division of wavefront' and 'division of amplitude'. **[10M]**

4. Find the velocity of sound in a gas in which two waves of wavelengths 1.00 m and 1.01 m produce 10 beats in 3 seconds. **[10M]**

5. Define moment of inertia and explain its physical significance. Calculate the moment of inertia of an annular ring about an axis passing through its centre and perpendicular to its plane. **[20M]**

6. A diatomic molecule can be considered to be made up of two masses m_1 and m_2 separated by a fixed distance r. derive a formula for the distance of centre of mass C, from mass m_1. Also show that the moment of inertial about an axis through C and perpendicular to r is μr^2, where $\mu = \frac{m_1 m_2}{m_1 + m_2}$ **[15M]**

7. State and explain Stokes' law. A drop of water of radius 0.01 m is falling through a medium whose density is 1.21 kg/m^3 and $\eta = 1.8 \times 10^{-5}$N-s/$m^2$. Find the terminal velocity of the drop of water. **[15M]**

8. What is multiple-beam interference? Discuss the advantages of multiple-beam interferometry over two beam interferometry. Explain the fringes formed by Fabry-Perot interferometer. **[15M]**

9. Show that the areas of all the half-period zones are nearly the same. Find the radius of 1st half-period zone in a zone plane whose folcal length is 50 cm and the wavelength of the incident light is 500 nm. **[15M]**

10. A plane – polarized light passes through a doubler – refracting crystal of thickness 40 μm and emerges out as circularly polarized. If the birefringence of the crystal is 0.00004, then find the wavelength of the incident light. **[10M]**

11. Obtain the system matrix for a thin lens placed in air and made of material of refractive index 1.5 having radius of curvature 50 cm each. Also find its focal length. **[10M]**

12. How is laser light different from ordinary light? Discuss the working principle of ruby laser. What role do chromium ions play in this process? **[15M]**

13. Explain the principle of operation of optical fibre. What are different losses that take place in optical fibre? **[10M]**

14. Write down Stefan-Boltzmann law of radiation and derive it form Planck's law of radiation **[07M]**

UPSC – PHYSICS Optional – 2018 Questions

1. When the two waves of nearly equal frequencies interfere, then show that the number of beats produced per second is equal to the difference of their frequencies. **[10M]**

2. A plane transmission grating has 3000 lines in all, having width of 3 mm. What would be the angular separation in the first order spectrum of the two sodium lines of wavelengths 5890 A^o and 5896 A^o? Can they be seen distinctly? **[10M]**

3. Explain the principle and working of He-Ne laner. What is the role of he gas? Why is it necessary to use narrow tube? How many longitudinal modes can be excited for an He-Ne laser in cavity of length 30 cm and having half width of gain profile of laser material $2 \times 10^{-3}\ nm$? The emission wavelengths is $6328A^o$ **[15M]**

4. Distinguish between positive and negative crystals in terms of double refraction. How are these crystals used to make quarter wave plates? Explain how the quarter wave plate is used in producing elliptically and circularly polarized light. **[15M]**

5. Describe how Michelson Interferometer can be used to determine refractive index of a gas. In a Michelson Interference experiment, a tube of length 25 cm containing a gas of refractive index μ is introduced between the upper mirror and the beam splitter. 150 fringes cross the centre of the field of view when the wavelength of light used is 5890 A^o. Find the value of μ. **[20M]**

6. Discuss the intensity distribution in Fraunhofer diffraction pattern due to a single slit. Obtain conditions for maxima and minima of the intensity distribution. Show that the intensity of the first maxima is about 4.95% of that of the principal maxima. **[20M]**

7. What do you mean by spherical aberration of a lens? Show that if two plano-convex lenses are kept at a distance equal to the difference of their focal lengths, the spherical aberration would be minimum. **[15M]**

8. A star is receding with a speed of 3000 km/s and emitting spectral line of hydrogen, H_α of wavelength $656.1\ nm$. What would be the wavelength observed by an observer on the Earth? **[10M]**

UPSC – PHYSICS Optional – 2019 Questions

1. **(i)** How does Reynolds number help in the study of fluid motion?

(ii) In a horizontal pipeline of uniform area of cross-section, the pressure falls by $5\ \text{Nm}^{-2}$ between two points separated by a distance of 1 km. Calculate the change in kinetic energy per kg of oil flowing at these points. Density of oil $= 800\ \text{kg m}^{-3}$. **[10M]**

2. What is axial chromatic aberration? A convex lens has a focal length of 15.5×10^{-2} m for red colour and 14.45×10^{-2} m for violet colour. If an object is kept at a distance of 40 cm from the lens, calculate the longitudinal chromatic aberration of the lens. **[10M]**

3. **(i)** What are the fringes of equal thickness and fringes of equal inclination?

(ii) In a Newton's ring arrangement with a source emitting two wavelengths $\lambda_1 = 6 \times 10^{-7}$m and $\lambda_2 = 5.9 \times 10^{-7}$m, it is found that the m^{th} dark ring due to one wavelength coincides with the $(m+1)^{th}$ dark ring due to the other. Find the diameter of the m^{th} dark ring, if the radius of curvature of the lens is 90 cm. **[10M]**

4. Prove that when light goes from one point to another via a plane mirror, the path followed by light is the one for which the time of flight is the least. **[10M]**

5. (i) How can one convert a left-handed circularly polarised light into a right-handed one (and vice versa)?

(ii) Calculate the thickness of a quarter-wave plate when the wavelength of light is 589 nm. Given : $\mu_o = 1.544$ and $\mu_E = 1.553$ **[20M]**

6. Discuss how population inversion is achieved in Ruby laser. What is 'laser spiking'? why does it occur? **[15M]**

7. Two β- particles A and B emitted by a radioactive source R travel in opposite directions, each with a velocity of 0.9 c with respect to the source. Find the velocity of B with respect to A (Here c is the velocity of light). **[15M]**

8. In what way is holography different from conventional photography? Discuss the salient features of a hologram. What are the requirements for the formation and reading of a hologram? **[20M]**