मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज – 211004 [भारत]

Motilal Nehru National Institute of Technology Allahabad
Prayagraj - 211004, [India]

End Semester Examination Odd Semester (Session 2019-20)

Programme Name: B.Tech.
Course Code: PH11101
Branch: All Branches
Duration: 3 Hours

Semester:I
Course Name: Physics-I
Student Reg. No.: 20198042
Max. Marks: 60

Instructions:

- This paper consists of 6 (six) questions in all and has 4 (four) printed pages.
- Answer all the sub-parts of a question at one place only.
- Figures to the right indicate maximum marks.

Question 1:

(a) If u and u' are the velocities of a particle in frames S and S' respectively, where frame S' is moving with velocity v along the x-direction with respect to frame S, then prove that

$$\sqrt{1-\frac{u'^2}{c^2}} = \frac{\sqrt{1-\frac{u^2}{c^2}}\sqrt{1-\frac{v^2}{c^2}}}{1-\frac{vu_x}{c^2}},$$

where u_x represents the x-component of u.

5 Marks

(b) Define momentum and force relativistically. The velocity of a particle is $5\hat{i} + 5\hat{j} + 20\hat{k}\ m/s$ in a frame of reference moving with uniform velocity $0.5c$ with respect to the laboratory along +ve x-direction. Find out the velocity of the particle in the laboratory.

3 Marks

(c) What is the concept of simultaneity? Show that the relation, $E^2 - p^2c^2 = m_0^2c^4$ is invariant under Lorentz transformations, where p and c represent the momentum and the velocity of the light respectively.

OR

Evaluate the speed of electron whose kinetic energy is equal to its rest energy.

2 Marks

Question 2:

(a) What is the effect of the temperature and the pressure on the mean free path for a gas in thermal equilibrium?

2 Marks

(b) Calculate the viscosity and thermal conductivity for the oxygen gas at $16°C$. Given that molecular weight of oxygen = 32 *amu*, diameter of molecules = $4\times10^{-10}\ m$, Specific heat for oxygen = $0.92\ J/g\,K$, Avogadro number = 6.023×10^{23}/mole and Boltzmann Constant = $1.38 \times 10^{-23}\ J/K$.

5 Marks

(c) Derive an expression for **any one** of the following:
a) Viscosity of gasses, b) Thermal conductivity of gasses

OR

A gas follows Maxwell-Boltzmann distribution for the components of velocity of its molecules, *i.e.*, the probability density is given by,

$$P(v_j) = \sqrt{\frac{m}{2\pi KT}} \exp\left(-\frac{mv_j^2}{2KT}\right)$$

where $v_j = v_x, v_y$ and v_z for x, y and z-component of the velocity respectively. The mass of molecules, Boltzmann constant and temperature of gas is denoted by m, K and T respectively. Evaluate the following:
a) Average velocity of all particles, b) Average velocity of particles having $v_x \geq 0$.

3 Marks

Question 3:

(a) Derive an expression for the intensity in the Fraunhofer diffraction due to single-slit. Also, discuss the conditions of its minima.

5 Marks

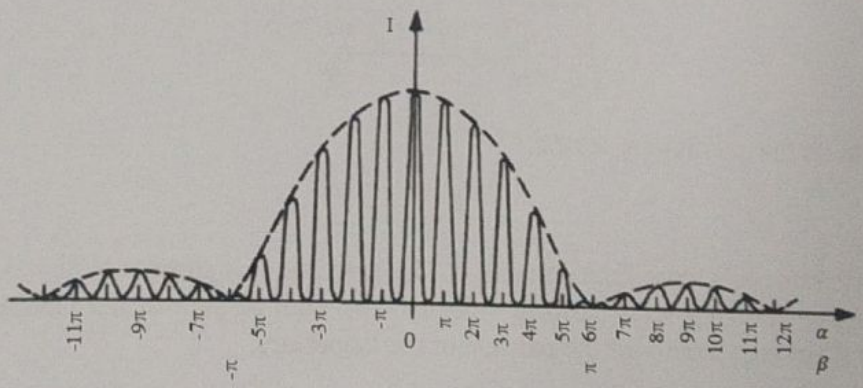

Figure for Problem No. 3b

(b) Figure above shows intensity distribution due to double-slit Fraunhofer diffraction, where $\alpha = \sqrt{\frac{\pi}{\lambda}} d \sin\theta, \beta = \sqrt{\frac{\pi}{\lambda}} b \sin\theta$. Here d represents the distance between the center of two consecutive slits *i.e.*, slit separation, b represents slit width, θ represents diffraction angle, and λ represents wavelength of incident light. Evaluate the relation between slit separation (d) and slit width (b).

3 Marks

(c) Write down the condition of 2^{nd} (second) interference minima after 4^{th} (fourth) interference principle maxima in a Fraunhofer diffraction due to N-slits.

OR

Make a rough sketch for the intensity distribution in the N-slits Fraunhofer diffraction for $N = 5$.

2 Marks

Question 4:

(a) Using the properties of cardinal points, draw representative ray diagrams in lens combinations acting as convergent and divergent systems respectively.

3 Marks

(b) A thin converging lens and a thin diverging lens are placed coaxially at a distance of 5 *cm*. If the focal length of each lens is 10 *cm*, find for the combination (a) the focal length (b) the power and (c) the positions of the principal points.

3 Marks

(c) The focal length of more convergent lens of a Huygen's eye piece is 0.5 *cm*. Calculate the focal length of the eye piece and locate on the **diagram** the positions of its focal points.

4 Marks

Question 5:

(a) A plane light wave with wavelength $\lambda = 0.7\ \mu m$ falls normally on the base of a biprism made of glass ($n = 1.52$) with refracting angle $\theta = 5°$. Behind the biprism, there is a plane-parallel plate, with the space between them filled with benzene ($n' = 1.5$) as shown in figure below. Find the width of a fringe on the screen placed slightly behind the system.

4 Marks

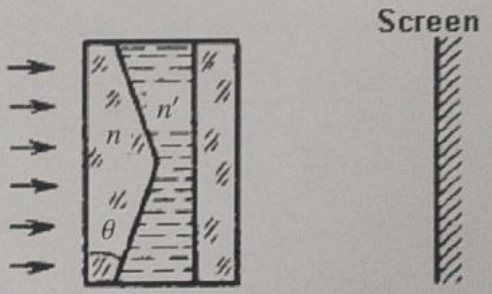

Figure for Problem No. 5a

(b) Explain the reason why the Newton's rings are circular, while the fringes due to air-wedge are straight.

2 Marks

(c) Show that for a normal optical source with temperature about $10^3 K$ and wavelength 6000 Å, the emission is predominately due to spontaneous transitions.

4 Marks

Question 6:

(a) Differentiate between the ordinary and extraordinary rays (o- and e-rays). A plane polarized light incident perpendicularly on a quartz plate cut with faces parallel to optic axis. Find the thickness of quartz plate, which produces phase difference of 60° between e- and o-rays. Given $\mu_e = 1.553$ and $\mu_o = 1.544$.

3 Marks

(b) A 200 *mm* long tube containing 48 cm^3 of sugar solution produces an optical rotation of 11° when placed in a saccharimeter. If the specific rotation of sugar solution is 66°, calculate the quantity of sugar contained in the tube in the form of a solution.

OR

Solution A with a path of 20 *cm* shows 70° clockwise rotation and solution B with a path of 10 *cm* shows 60° anticlockwise rotation. What amount of rotation will be produced by 10 *cm* path of mixture *A* and *B* in the ratio 1 : 2?

3 Marks

(c) Write the assumptions of the Fresnel theory of optical rotation. Derive an expression for the angle of rotation of plane polarized light using this theory.

4 Marks

PAPER ENDS HERE

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मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद - 211004 (भारत)
Department of Physics
Motilal Nehru National Institute of Technology Allahabad - 211004 (INDIA)

End Semester Examination, Academic Session 2013-14 (Odd Semester)

Physics - I (PH-1101) [New Course] / Physics – I (PH101) [Old Course]

Time: 3 hours Max Marks: 60

Note: Attempt all the sub-parts of a question at one place only.

1. (a) To an observer at rest on the ground, a body thrown vertically upwards in a uniformly moving frame S', appears to describe a parabolic path. What is the path of the body as it would appear to an observer in a frame S'' moving parallel to S' with velocity: (i) same as the velocity of frame S' (ii) a velocity equal and opposite to S' (iii) a velocity twice of S'? 3

   (b) A man on the moon sees two spacecraft A and B, coming toward him from opposite directions at the respective speed of 0.8c and 0.9c. (i) What does a man on spacecraft A measure for speed with which he is approaching the moon? (ii) For the speed with which he is approaching the spacecraft B? (iii) What does a man on spacecraft B measure for the speed with which he is approaching the moon? (iv) For the speed with which he is approaching the spacecraft A? 4

   (c) State the fundamental postulates of special theory of relativity. Using Lorentz transformations show that two events simultaneous ($t_1 = t_2$) at different position ($x_1 \neq x_2$) in a frame of reference S are not simultaneous in another reference frame S' moving with a uniform velocity with respect to S. Also find out $t_1 - t_2$. 3

2. (a) Derive expressions for the thermal conductivity and viscosity of the gas. Hence obtain the relation between the two. 4

   (b) Calculate thermal conductivity of air using the following data where notations have their usual meanings: ρ=1.29 Kg-m^{-3}, $v_{avg.}$ = 460 ms^{-1}, λ = 6.4 x 10^{-8} m, M = 29, γ= 1.4 R=8.31 kJkmol^{-1}K^{-1} 3

   (c) Obtain relation between transition probabilities for spontaneous and stimulated emission of radiation. 3

3. (a) Discuss Fraunhofer diffraction of monochromatic light from a single slit and show that the intensity of the first subsidiary maximum is roughly 4.5% of that of the principal maximum. 4

   (b) Fraunhofer diffraction of double slit is observed in the focal plane of a lens of focal length 50 cm with monochromatic light of wavelength 600 nm. The distance between two minima adjacent to the central maxima is found to be 0.5 cm and 4th order maxima is missing. Compute the width of the slit and distance between their centres. 3

   (c) Two spectral lines have wavelength λ and $\lambda + d\lambda$, respectively where $d\lambda << \lambda$. Show that their angular separation $d\theta$ in a grating spectrometer is given by $d\theta = d\lambda / [\{(e+d) / n\}^2 - \lambda^2]^{1/2}$ where (e+d) is the grating element and n the order at which lines are observed. 3

4. (a) What is Brewster's angle? Prove that when the angle of incidence corresponds to the Brewster angle, the reflected and refracted rays are at right angles. Light travelling in water of index of refraction 1.33 is incident on a plate of glass of index of refraction 1.53. At what angle of incidence is the reflected light completely linearly polarized? 4

(b) How to convert left handed elliptically polarized light into right handed elliptically polarized Light? A left handed circularly polarized light (λ=5893Å) is incident normally on a calcite crystal (with its optic axis parallel to the surface) of thickness 0.005141 nm. What will be the state of polarization of the emergent beam? 4

(c) What does the word "Half" in Lorentz half shade polarimeter signify? 2

5. (a) Explain the following:
(i) An extremely thin film when seen in white light appears to be completely dark in the reflected part. 1
(ii) A thick film illuminated with white light shows no colours in the reflected part. 2
(iii) Why Newton's rings are circular, while the fringes due to air-wedge are straight? 2

(b) A wedge-shaped film of refractive index μ is seen in the reflected light when light is normaly incident on it. Deduce the expression for the fringe-width. 2½

(c) Differentiate between the spontaneous emission and stimulated emission. A ruby laser emits 1.0 J pulse of light of wavelength 6940 Å. Calculate the minimum number of Cr^{3+} ions in the ruby laser. 2½

6. (a) What are relative merits and demerits of Ramsden's and Huygen's eyepieces? Ramsden's eyepiece consists of two plano-convex lenses of focal length 3 cm each. Deduce the cardinal points and show them with a diagram. 3

(b) The radii of curvature of a convex meniscus lens are 15 cm and 10 cm and its thickness is 2 cm. Calculate its focal length and positions of cardinal points. If an object is placed at a distance of 100 cm from this lens, calculate the position and magnification of the image. 4

(c) Show that for a co-axial lens system, $XX' = ff'$, where X and X' are the respective distances of the object and the image from the first and second focal points and f and f' are the two focal lengths. What form does the expression take when the media on the two sides of the system are the same? 3

----Paper Ends---

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Department of Physics
Motilal Nehru National Institute of Technology Allahabad – 211004 (INDIA)

Reg no. 2015203

End Semester Examination, Academic Session 2015-16 (Odd Semester)

Physics - I (PH-1101) / Physics – I (PH101) [Old Course]

Time: 3 hours

Max Marks: 60

Note: Attempt all the sub-parts of a question at one place only.

1. (a) A particle moves with velocity represented by a vector $u' = 3\hat{i} + 4\hat{j} + 12\hat{k}$ m/s in frame S'. Find the velocity of the particle in frame S if S' moves with velocity 0.8 c relative to S along positive x - direction. 4

   (b) Find the velocity that an electron must be given so that its momentum is 10 times its rest mass times the speed of light. What is the energy at this speed? 4

   (c) Derive mass-energy equivalence relation. 2

2. (a) On the basis of Maxwell's law of distribution of velocities, deduce expression for root-mean – square velocity, average velocity and most frequent velocity of gas molecules and find the relation between them. 4

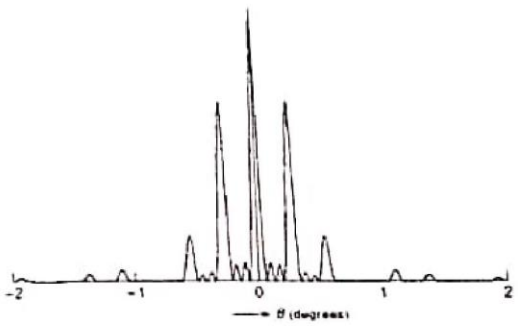
   (b) Hydrogen and Nitrogen are maintained under identical conditions of temperature and pressure. Calculate the ratio of their coefficient of viscosity if diameters of these molecules are 2.5 Å and 3.5 Å. Given Molecular weight of Hydrogen=2, Molecular weight of Nitrogen=28 and Gas Constant=8.31 $kJkmol^{-1}K^{-1}$. 2

   (c) Explain spontaneous and stimulated emission of radiation. What are the Einstein's coefficients? Derive Einstein's relation. 4

3. (a) Establish conditions for the positions of Maxima and Minima in Two-Slit Frauhnhofer diffraction pattern. 4

   (b) Validate the statement "Only a finite number of principal Maxima are observed in N-Slit Frauhnhofer diffraction pattern". 3

   (c) The adjacent figure shows Intensity distribution corresponding to the Four-Slit Frauhnhofer diffraction pattern corresponding to slit-width (b)=0.0044cm, slit-separation (d)=0.0132 and wavelength of incident light (λ)=6.328×10^{-5} cm. Which order of principle maxima is absent in this pattern and why? 3



4. (a) Determine the state of polarisation of the following light waves: 3

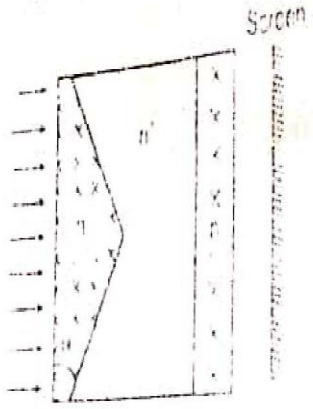
   (i) $\vec{E} = 4\ \mathrm{Sin}\,(kx - wt + \frac{\pi}{4})\,\hat{j} + 5\ \mathrm{Sin}\,(kx - wt + \frac{3\pi}{4})\,\hat{k}$

   (ii) $\vec{E} = \mathrm{Cos}\,(kx - wt)\,\hat{j} + 2\ \mathrm{Cos}\,(kx - wt + \frac{\pi}{4})\,\hat{k}$

   (b) How will you convert elliptically polarised light into circularly polarised light? A Sugar solution in a tube of length 20 cm produces optical rotation of 13^0. The solution is then diluted to one-third of its previous concentration. Find the optical rotation produced by 30 cm long tube containing the diluted solution. 3

(c) State the Fresnel's theory of optical rotation. Elliptically polarised light falls normally on a quarter wave plate. Explain the nature of emergent light if the axis of the ellipse makes the angle 0^0, 30^0 and 90^0, respectively with the principal plane of the quarter wave plate. 4

5. (a) A plane light wave with wavelength $\lambda = 0.7$ μm falls normally on the base of a biprism made of glass ($n = 1.52$) with refracting angle $\theta = 5^0$. Behind the biprism, there is a plane-parallel plate, with the space between them filled with benzene ($n' = 1.5$). Find the width of a fringe on the screen placed slightly behind the system. Also, draw the ray diagram for producing coherent sources. 3



(b) A glass plate of refractive index 1.5 is coated with a thin layer of thickness t and refractive index 1.8. Light of wavelength λ travelling in air is incident normally on the layer. It is partially reflected at the upper and the lower surface of the layer and the two reflected rays interfere. Write the condition for their constructive interference. If $\lambda = 648$ nm, obtain the least value of t for which the rays interfere constructively. 2

(c) Why does an extremely thin film when seen in white light appear to be completely dark in the reflected part, while a thick film illuminated with white light shows no colour in the reflected part? 2

(d) Explain the reason why are Newton's rings are circular, while the fringes due to air-wedge are straight? 2

6. (a) Explain specifically as to why plano convex lenses are used in eyepieces. 1

(b) What are the uses of an eyepiece? Describe briefly and locate the cardinal points for (i) Huygen's Eyepiece and (ii) Ramsden's eyepieces. Explain image formation in these eyepieces. 4

(c) Two convex lenses each of focal lengths 20 cm are placed 5cm apart. A tower of height 100 meters and 200 meters distant is viewed through them. Find the position and the size of the image (i) Numerically and (ii) Graphically? 5

---Paper Ends---

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भौतिकी विभाग

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY, ALLAHABAD

Department of Physics

End-Semester Examination, Academic Session 2017-18 (Odd Semester)

Physics-I [PH11101/PH1101]

Time: 3 hours **Max. Marks: 60**

(a) What is the concept of simultaneity? An observer S_1 who lives on the x-axis sees a flash of red light at x = 1210 m, then after 4.96 μs, a flash of blue at x = 480 m. Calculate the followings:

(i) What is the velocity relative to S_1 of an observer S_2 who records the events as occurring at the same place?

(ii) Which event occurs first according to S_2 and what is the measured time interval between these flashes?

.....*4 marks*

(b) Show that the rest mass of a photon is zero. A circular ring of radius 'a' is at rest in the x'y' plane of an inertial reference frame S' moving at constant speed v along x-direction with respect to another inertial reference frame S:

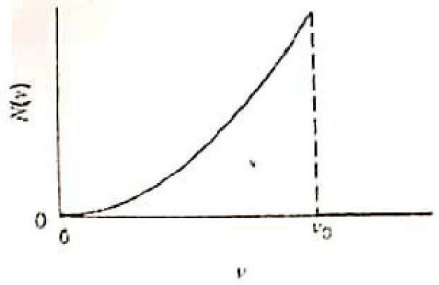
(i) Show that the measurement made in frame S will indicate the ring elliptical in shape.

(ii) Compute the eccentricity of this ellipse in frame S. .....*3 marks*

(c) Show that no particle can attain a velocity larger than the velocity of light. Calculate the fringe shift in Michelson-Morley experiment. Given L (length) = 11 m, v (velocity) = 30 km/sec and λ (wavelength) = 6 X 10^{-5} cm. .....*3 marks*

2. (a) Calculate the fraction of gas molecules having translational kinetic energies lying between 0.01 kT and 0.03kT, where the symbols have their usual significance. .....*3 marks*

(b) Figure shows a hypothetical speed distribution of N gas molecules with $N(v) = Cv^2$ for $0 < v < v_0$, and $N(v) = 0$ for $v > v_0$. Find (i) an expression for C in terms of N and v_0, (ii) the average speed of the gas molecules, and (iii) the rms speed of the gas molecules. .....*4 marks*



(c) Show that for a normal optical source with temperature about 10^3 K and wavelength 6000 Å, the emission is predominantly due to spontaneous transitions. .....*3 marks*

3. (a) Two convex lenses of focal length 50 cm and 20 cm are placed coaxially in air and are separated by a distance of 30 cm. Determine the position of cardinal points. Find the position of the image and its magnification of an object placed 25 cm in front of the first lens. .....*3 marks*

(b) Derive an expression of focal length for a thick lens. Discuss how the converging and diverging properties of such lenses vary with thickness. .....*4 marks*

(c) Explain the construction and working of a Huygens eyepiece. Why cannot a cross-wire be used with it? .....*3 marks*

4. (a) Describe Fresnel's biprism. Explain how the wavelength of light can be determined with its help.
.....3 marks

(b) A thin equiconvex lens of focal length 4 m and refractive index 1.50 rests on an optical flat surface and using light of wavelength 5460 A , Newton's rings are viewed normally by reflection. What is the diameter of the 5^{th} bright ring?
.....3 marks

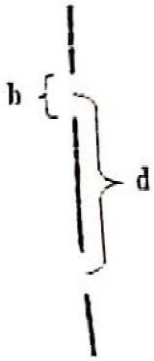
(c) Explain spontaneous and stimulated emissions of radiation? Discuss four level scheme for laser action.
.....4 marks

5. (a) What is double refraction? Explain the construction and working of Nichol prism.
.....3 marks

(b) What do you mean by optical rotation? Explain the Fresnel's theory of optical rotation. Show that the rotation of plane of vibration is given by $\frac{\pi d}{\lambda}(\mu_A \sim \mu_C)$, where μ_A and μ_C are refractive indices of the crystal in the direction of the optic axis for anti-clockwise and clockwise circularly polarized light respectively and d is the thickness of the crystal plate.
.....4 marks

(c) The values of μ_E and μ_o for a crystal are 1.55 and 1.54 respectively. Calculate the phase retardation for wavelength of 4500 Å when the plate thickness is 0.005 cm.
.....3 marks

6. (a) Show that the intensity (I) distribution in Fraunhofer diffraction produced by two parallel slits [See adjacent figure] (each of width b) separated by a distance d (*i.e.* the distance from the centre of one slit to the centre of other slit) is given by following expression.



$$I = 4I_o \frac{\sin^2\beta}{\beta^2}\cos^2\alpha$$

where, $\beta = \frac{\pi}{\lambda} b \sin\theta$ & $\alpha = \frac{\pi}{\lambda} d \sin\theta$, I_o = *Intensity at* $\theta = 0$.
.....4 marks

(b) Consider the case of two parallel slits as given in part (a) of this question, where slit width = 8.8×10^{-3} cm, slit separation 7.0×10^{-2} and wavelength of light $\lambda = 6.328 \times 10^{-5}$ cm. How many interference minima will occur between the two diffraction minima on either side of the central maximum?
.....2 marks

(c) (i) Draw a rough sketch of the intensity distribution in N-slit Fraunhofer diffraction for an array of 6 parallel slits (*i.e.* N = 6) separated by a distance (*d = the distance between the centres of two consecutive slits*) equal to 4 times the individual slit width (b).
.....3 marks

ii) Will there be missing order in this case? Justify your answer.
.....1 mark

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Physics - I (PH-11101 / PHY101)

Time: 3 hours

Max Marks: 80

Note: Attempt all questions. Write the sub-parts of a question at one place only. Symbols have their usual meaning. Use suitable data, in case missing.

1. (a) Calculate the mass and speed of 2 MeV electron. 4

(b) An electron has an initial speed of 1.5×10^{8} m/s. How much additional energy must be imported to it for its speed to double? 4

(c) What was the objective of Michelson-Morley experiment? Describe the experiment. How negative result of the experiment is interpreted? 5

2. (a) On the basis of kinetic theory of gases, drive the expression for coefficient of viscosity and thermal conductivity of a gas. Hence, obtain the relation between the two. 4

(b) On the basis of Maxwell's law of distribution of velocities deduce expression for root-mean-square velocity, average velocity and most frequent velocity of gas molecules and find the relation between them 4

(c) Explain spontaneous and stimulated emission of radiation? What are Einstein's coefficients? Derive Einstein's relation. 5

3. (a) Derive intensity expression for single slit Fraunhofer diffraction. Also, discuss positions of its maxima and minima. 8

OR

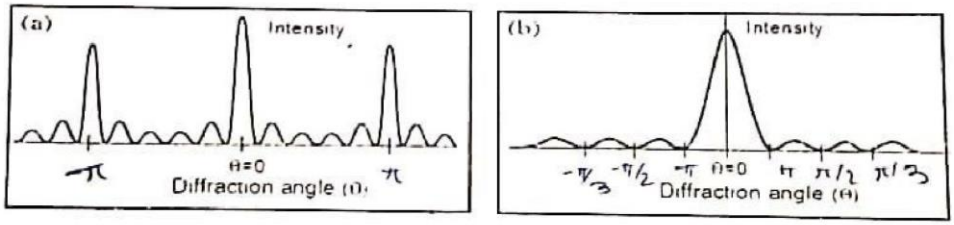
Derive intensity expression for double slit Fraunhofer diffraction. Also, discuss positions of its maxima and minima.

(b) What is missing order in double slit Fraunhofer diffraction? 3

OR

What is missing order in N-slit slit Fraunhofer diffraction?

(c) From the figures (a) & (b) as shown below, identify which intensity pattern is for single slit Fraunhofer diffraction and which one is for N-slit Fraunhofer diffraction? Justify your answer. 3



4. (a) Why does an extremely thin film when seen in white light appears to be completely dark in the reflected part, while a thick film illuminated with white light shows no colour in the reflected part? 4

(b) Show that when a liquid of refractive index μ is introduced between the glass plate and the plano-convex lens, the Newton's rings get contracted. 4

(c) A wedge-shaped film of refractive index μ is seen in the reflected light when light is incident normally on it. Deduce an expression for the fringe-width. 5

5. (a) Explain Fresnel's theory of optical rotation. What will be the state of polarization of the resultant wave formed by the superposition of two plane waves. $X = 4 \sin(\omega t + \pi/4)$ and $Y = 5 \sin(\omega t + 3\pi/4)$? 8

(b) Define double refraction. Write the characteristics of E- ray and O-ray. 3

(c) How would you produce and detect the following with the help of a Nicol prism and quarter wave plate (i) plane polarized (ii) circularly polarized (iii) elliptically polarized light? 5

6. (a) Mention the cardinal points of a co-axial optical system of thin lenses. Find the distance between the nodal points and the respective principal points and prove that they coincide when the medium is same on both sides. 7

(b) Two convex lenses of focal length 10 cm and 15 cm are placed coaxially 5 cm apart in air. Locate the cardinal points of the combination. Also find the position and the size of the image of an object 2 cm long placed 20 cm in front of the first lens. 6

The End

मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान, इलाहाबाद

भौतिकी विभाग

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY, ALLAHABAD

Department of Physics

Supplementary Examinations 2019

Programme: B.Tech. | Subject: Physics-I [PH1101/PH11101]

Time: 3 hours | Max. Marks: 80

All questions are compulsory. Answer all the sub-parts of a question at one place only.

1. (a) The position vector of a point in frame S is $\vec{r} = 4\hat{i} - 6\hat{j} + 2\hat{k}$. If another frame S' is moving with the velocity $\vec{v} = 0.8\,c\hat{i}$ relative to S then what will be the new position vector of this point in frame S at time $t = \frac{2}{c}$ sec.

5 marks

(b) A wrist watch gives correct time on the surface of earth. A pilot wears this watch and leaves the earth in a spaceship which moves at a speed of $\sqrt{5} \times 10^8$ m/s. How many seconds will the watch loose per day with respect to observer on earth?

5 marks

(c) Prove that $x^2 + y^2 + z^2 - c^2t^2$ is invariant under Lorentz transformations. Further, show that the momentum of a particle of rest mass m_0 and K.E. (K) is given by

$$P = \sqrt{\frac{K^2}{C^2} + 2m_0K}$$

3 marks

2. (a) Show that the number of gas molecules having kinetic energy between E and $(E + dE)$ is given by

$$dn = 2n\left(\frac{E}{\pi}\right)^{1/2}(kT)^{-3/2}e^{-E/kT}\,dE$$

where the symbols used have their usual significance.

6 marks

(b) What do you understand by the mean free path of gas molecules? Derive an expression for it.

(3 + 4) marks

3. (a) What are cardinal points for a coaxial optical system? State their properties and illustrate the use of these points in the formation of an image by a lens system.

6 marks

(b) Mention the uses of an eyepiece. Explain image formation in Huygen's as well as Ramsden's eyepieces. With the help of simple diagrams locate the positions of cardinal points for the above two eyepieces.

6 marks

(c) A Ramsden's eyepiece has to work with an effective focal length of 3 cm. Calculate the focal lengths of the lens components and their distance of separation.

2 marks

4. (a) Give the theory of interference due to coherent sources and deduce the expression for fringe width. How the wavelength of monochromatic source of light can be measured using Fresnel's biprism.

6 Marks

(b) Two plano-convex lenses, each of radius of curvature 100cm, are placed with their curved surfaces in contact with each other. Newton's rings are formed by using a light of wavelength 6×10^{-5} cm. Find the distance between 10^{th} and 20^{th} ring.

3 Marks

B. Tech I Semester End Semester-Examination 20010-11
Physics I (PH-101)

Time: 2½ hour Max Marks: 40

Note: Attempt all the **six** questions.

1.(a) Describe the theory of Michelson-Morley experiment and discuss its negative result. 2

(b) If a photon traverses a path in frame S' in such a way that it moves in x'-y' plane and makes an angle φ with the x-axis, then prove that in the reference frame S, $u_x^2 + u_y^2 = c^2$, the frame S' is moving with velocity v relative to frame S along x-direction. 2

(c) If u and u' are the velocities of a particle in frames S and S' respectively, where frame S' is moving with velocity v along the x-direction with respect to frame S, then prove that

$$\sqrt{1-\frac{u'^2}{c^2}} = \frac{\sqrt{1-\frac{u^2}{c^2}}\sqrt{1-\frac{v^2}{c^2}}}{1-\frac{vu_x}{c^2}},$$

where u_x and u_y are the x- and y-components of u respectively. 2

2.(a) In the laboratory frame, the life-time of a particle moving with speed 2.8×10^8 m/s is found to be 2×10^{-7} s. Calculate the proper life-time of the particle. 1½

(b) For a particle in motion with relativistic speed, derive the expression for variation of its mass with velocity and show that no material particle can have velocity equal to or greater than the velocity of light, c. 2½

(c) A particle of rest mass m_o is traveling so that its total energy is just twice its rest mass energy. It collides with a stationary particle of rest mass m_o to form a new particle. What is the rest mass of the new particle? 2

3.(a) Show that the fraction of molecules moving with energy between E and (E+dE) is given by $\frac{dn}{n} = \frac{2}{\sqrt{\pi}}(kT)^{-3/2} E^{1/2} e^{-E/kT} dE$, where the symbols used have their usual significance. 2

(b) The velocity (viscosity) of O_2 molecules at 273 K is 19.2 μNs/m^2. Estimate the hard sphere radius of O_2 molecules. 2

(c) What are Einstein's A and B coefficients? Show that the probabilities of stimulated absorption and stimulated emission are equal. 3

4.(a) Deduce the formula for fringe width in bi-prism experiment. 2

(b) In a bi-prism experiment, the readings on the optical bench for the uprights of eye-piece and the two positions of the convergent lens are 100, 67 and 34 cm respectively. The distances d_1 and d_2 are 0.3 and 1.2 mm respectively and the width of 10 fringes is 9.720 mm. Assuming no index error in any case, calculate (i) the distance D between the focal plane of the eye-piece and the plane of interfering sources and (ii) the wavelength of the light used. 2½

(c) An air-wedge of length 18 cm is formed between two plane glass plates by separating them at one end by a wire of diameter 0.036 mm and in contact at the other end. If monochromatic light of wavelength 589 nm falls normally on it, find the width between any two consecutive bright fringes observed in reflected light. 2½

5.(a) A converging lens has radii of curvature 10.0 cm and -6.0 cm and thickness 5.0 cm. The refractive index of the material is 1.60. Calculate its focal length. For what value of thickness this lens will behave like a diverging lens? 2

(b) The intensity distribution due to single slit is given by $I_\theta = I_0 \frac{\sin^2 \alpha}{\alpha^2}; where\ \alpha = \frac{\pi a \sin\theta}{\lambda}$. Plot a graph showing I_θ / I_0 against $\sin\theta$ for the case a = 2.5λ. Compare the intensity of the first maximum on either side to the intensity of central maxima. 3

(c) Show that the angular width of the principle maxima in a plane diffraction grating is inversely proportional to the total number of lines on the grating. 2

6.(a) Prove that when the angle of incidence corresponds to the Brewster angle, the reflected and refracted rays are at right angles to each other. 1½

(b) The electric field components of a plane electromagnetic waves are
$E_x = 2E_o \sin(\omega t - kz + \Phi)$; $E_y = E_o \sin(\omega t - kz)$
What would be the state of polarization (i.e. circular, plane, elliptical) when (i) $\Phi = 0$, (ii) $\Phi = \pi/2$, and (iii) $\Phi = 3\pi/2$ 1½

(c) A left handed circularly polarized light of wavelength 5893 A is incident normally on a calcite crystal plate cut with faces parallel to its optic axis and of thickness 0.005141 mm. Find out the state of polarization of the emergent beam? Given $\mu_O = 1.65836$ and $\mu_E = 1.48641$. 2½

(d) What is optical activity? Among pure water and sugar solution which one is optically active and why? 1½

B. Tech I Semester End-Semester Examination 2009-10
(Common to all branches)
Physics I (PH-101)

Time: 2½ hour Max Marks: 40

Note: Attempt all questions.

1(a) Why was the concept of ether introduced? What is the significance of the null result of Michelson-Morley experiment? 2

(b) A rigid rod of length L makes an angle θ with the X-axis of the system in which it is at rest in the X-Y plane. Show that for an observer moving with respect to the rod with speed v along the positive X-direction; the apparent Length L' and the angle θ' are given by

$$L' = L\left[\left(\frac{Cos\theta}{\Gamma}\right)^2 + sin^2\theta\right]^{1/2}$$

$$tan\theta' = \Gamma\, tan\theta$$

where; $\Gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2}$ 3

(c) Show that the relativistic form of Newton's second law, when $\vec{F}$ is parallel to $\vec{v}$, is

$$\vec{F} = m_o \frac{d\vec{v}}{dt}\left(1 - \frac{v^2}{c^2}\right)^{-3/2}$$ 2

2(a) Derive the expression for coefficient of viscosity of a gas in terms of mean free path of its molecules. Show that it is independent of pressure but depends upon the temperature of the gas. Discuss the effect of pressure and temperature on the coefficient of viscosity. 3

(b) The mean free path of the molecules of a certain gas at pressure P and temperature T is 2×10^{-5} cm. Deduce the mean free path under the following conditions:

(iii) pressure P× 10^{-6}, temperature T, 3

(iv) pressure P/2, temperature 2T.

3(a) A lens combination consists of a convergent lens of focal length 12 cm and a divergent lens of focal length 15 cm and separated by a distance of 6 cm. locate the cardinal points of the system and indicate them on a diagram. Using Newton's formula, find the position of the image when an object is situated at a distance of 108 cm in front of the convergent lens. 3

(b) Calculate the positions of principal and focal points of a transparent sphere (μ = 1.5) of radius 5 cm and show them on a neat diagram. 2

4(a) Deduce an expression for the half-angular width of n^{th} order principal maximum of the diffraction pattern of a grating having N slits. 2

(b) Explain the effect of closeness' of rulings and the width of ruled space on the grating spectrum. 2

(c) What are the advantages of increasing the number of rulings in a grating? 1

(d) Explain and obtain the condition of absent spectra in a plane transmission grating. If the width 'b' of the opaque space is equal to thrice the width of the transparent space, which orders will be absent? Draw the diffraction pattern also. 3

5(a) How Michelson Interferometer is used to determine the difference between two wavelengths very close to each other? 2½

(b) A soap film 5×10^{-5} cm thick (μ = 1.33) is viewed at an angle of 35° to the normal. Find the wavelength of light in the visible spectrum which will be absent in the reflected light. 2½

(c) Describe briefly, the construction and working of a ruby laser. 2

6(a) Show that the plane polarized and circularly polarized lights are special cases of elliptically polarized light. 2

(b) How would you distinguish between circularly polarized and unpolarized light? 1½

(c) The refractive indices of quartz for right handed and left handed circularly polarized light of wavelength 7620 A are 1.53914 and 1.53920 respectively. Calculate the angle of rotation produced by its plate of thickness 0.5 mm. 1½

(d) 80 gm of impure sugar dissolved in one litre of water gives optical rotation of 9.9° when placed in a tube of length 2 dm. If specific rotation of sugar is 66°$dm^{-1}gm^{-1}$ cm^3, find the percentage purity of the sugar sample. 2

B.Tech. I[st] Semester, End-Semester Examination (Odd Semester) Exam. 2018-19

Physics-I (PH11101)/PH(1101) [New & Old Curriculum]

Time: 3 hours | Max Marks: 60

Note: Attempt all the sub-parts of a question at one place only. All questions are compulsory. Assume suitable data, if considered necessary, and indicate the same clearly. Unless and otherwise indicated, symbols and notations carry their usual standard meanings.

Q.1 (a) Two photons approach to each other, what would be their relative velocity? If u and u' are the velocities of a particle in frames S and S' respectively, where frame S' is moving with velocity v along the x-direction with respect to frame S, then prove that, $\sqrt{1-\frac{u'^2}{c^2}} = \frac{\sqrt{1-\frac{u^2}{c^2}}\sqrt{1-\frac{v^2}{c^2}}}{1-\frac{vu}{c^2}}$ [4 Marks]

(b) Two events occurring at different positions are simultaneous in a rest frame (S). How these events are being observed by an observer moving relativistically with a velocity, v relative to frame S? Calculate the velocity of the mass if its kinetic energy is equal to twice the rest mass energy. [4Marks]

(c) What was the objective and outcome of the Michelson-Morley experiment? Show that the relation, $E^2 - p^2c^2 = m_0c^4$ is invariant under Lorentz transformation. [2Marks]

Q.2 (a) What are your objectives while performing Nodal Slide Experiment? By drawing neat and clean diagrams, explain the principle of Nodal Slide Experiment. [3 Marks]

(b) A telephoto lens consists of a convergent lens of focal length 12 cm. facing the object and a divergent lens of focal length 5 cm. placed 8 cm. behind the former. Locate the positions of the cardinal points the telephoto lens. Also find the position where the plate be placed to photograph a distant object. [4Marks]

(c) Distinguish between positive and negative eye-pieces. What will happen to the main optical defects in Huygens' eye-piece? [3 Marks]

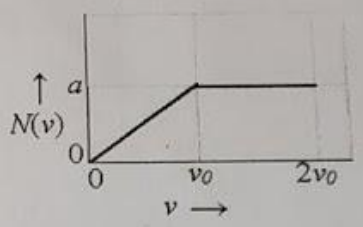
Q.3 (a) Write down expression (derivation not required) for Intensity distribution due to single-slit Fraunhofer diffraction and discuss positions of their maxima and minima. [4 Marks]

(b) Consider the case when slit width (b) = 8.8×10^{-3} cm, slit separation *i.e.* the distance between the centre of two slits (d) = 7.0×10^{-2} cm and wavelength of incident light (λ) = 6.328×10^{-5} cm in double-slit Fraunhofer diffraction. How many interference minima will occur between the two diffraction minima of either side of the central maximum? [3 Marks]

(c) What would be the condition for obtaining second interference minima after 3[rd] (n=3) principle interference maxima on right side of N-slit Fraunhofer diffraction intensity pattern? [3 Marks]

Q.4 (a) Find the fraction of molecules in a gas having translational kinetic energies within a range $0.02kT$ centered on the most probable energy. [4Marks]

(b) A gas of N molecules has the hypothetical speed distribution shown in Fig. [Note that $N(v) = 0$ for $v > 2v_0$].



(i) Express a in terms of N and v_0. [1 Marks]

(ii) What fraction of the molecules has a speed between $1.5v_0$ and $2.0v_0$? [1 Marks]

(iii) Express the average speed of the molecules in terms of v_0. [2 Marks]

(iv) Find v_{rms}. [2 Marks]

Q.5 (a) Explain with necessary theory the Newton's rings method of measuring the wavelength of light. How can the refractive index of a liquid be determined using these fringes? What is the difference between these fringes and those produced by a biprism. [4 Marks]

(b) Interference fringes are observed with a biprism of refracting angle 1° and refractive index 1.5 on a screen 80 cm away from it. If the distance between the source and the biprism is 20 cm , calculate the fringe width when the wavelength of light used is 6900Å. [3 Marks]

(c) Explain spontaneous and stimulated emission of radiation? Obtain Einstein's relations for spontaneous and stimulated emission of radiation. [3 Marks]

Q.6 (a) What is meant by optical rotation? Give Fresnel's theory of optical rotation. Hence derive a relation for the angle of rotation of plane of polarization. [4 Marks]

(b) Calculate the thickness of half-wave plate for sodium light, if $\mu_0 = 1.54$ and the ratio of velocity of ordinary and extraordinary wave is 1.007. Is the crystal is positive or negative? [3 Marks]

(c) If the refractive indices of Calcite and Canada Balsam are 1.676 and 1.540 for ordinary component of light, evaluate the maximum angle allowable for incident ray with the axis of symmetry of the Nicol prism so that ordinary component is still quenched. [3 Marks]

----------Paper Ends----------