KRISHNA ENGINEERING COLLEGE

Model Question Bank

Engineering Physics-NAS-101

2014 – 2015

CONTENTS

Ist Unit - Relativistic mechanics.

Short Answer Type Questions.

1. Is earth an inertial or non – inertial frame of reference? Explain.
2. What is the difference between inertial or non inertial frame of reference?
3. What do you understand by the terms variants and invariants under Galilean transformation?
4. What was the main object of Michelson – Morley experiment?
5. Write down the postulates of special theory of relativity.
6. What are Lorentz transformation equations?
7. At very low velocities, how Lorentz equations reduce to the classical Galilean equations.
8. What is the concept of simultaneity?
9. What are massless particles?
10. Show that massless particles can exist only if they move with the speed of light and their energy E and momentum p must have the relation E = pc.

Long Answer Type Questions.

1. What was the objective of conducting the Michelson – Morley experiment? Describe the experiment. How is the negative result of the experiment interpreted?
2. State the fundamental postulates of special theory of relativity. Derive the inverse Lorentz transformation equations.
3. Show that the apparent length of a rigid body in the direction of its motion with uniform velocity v is reduced by the factor $\sqrt{1-\frac{v^2}{c^2}}$.
4. Deduce an expression for time dilation on the basis of Lorentz transformation equations. Give an example to show that time dilation is real effect.
5. Deduce the relativistic velocity addition theorem. Show that it is consistent with Einstein's second postulate of special theory of relativity.
6. Show that the space time interval between two events remains invariant under Lorentz transformation. **'OR'** Show that $x^2 + y^2 + z^2 - c^2t^2$ Is invariant under Lorentz transformation equations.
7. Show from Lorentz transformation that two events simultaneous $(t_1 = t_2)$ at different positions $(x_1 \neq x_2)$ in a reference frame S are not in general simultaneous in another reference frame.
8. Show that the relativistic form of Newton's second law, when '**F**' is parallel to '**v**' is $F = m_0 \frac{dv}{dt}\left(1-\frac{v^2}{c^2}\right)^{-3/2}$

9. Show that the momentum of a particle of rest mass m_0 and kinetic energy 'K' is given by the expression. $p = \sqrt{\frac{K^2}{c^2} + 2m_0 K}$
10. Derive Einstein's mass energy relation.

Numerical Problems.

1. How fast would a rocket have to go relative to an observer for its length to contracted to 99% of its length at rest.
   (Ans.:- 0.1416 c.)
2. A clock keeps correct time. With what speed should it be moved relative to an observer so that it may be appear to lose 4 minutes in 24 hours.
   (Ans.:- $2.32 \times 10^7 \, m/s.$ **)**
3. A particle of mass 'm' moves with speed 'v'. Calculate the mass, momentum, total energy and kinetic energy of the particle.
   $\left(Ans: -\sqrt{2}m_0, m_0 c, \sqrt{2}\, m_0 c^2, 0.41 m_0\right.$
4. Calculate the work done to increase the speed of electron of rest energy 0.5 MeV from 0.8 c to 0.9 c. **(Ans:-** $5.02 \times 10^{-14} J$ **)**
5. The mass of a moving electron is 11 times its rest mass. Calculate its kinetic energy and momentum. **(Ans:-** $8.2 \times 10^{-13} J, 2.99 \times 10^{-21} kgm/\sec.$ **)**
6. Show that the circle $x^2 + y^2 = a^2$ in frame S appears to be an ellipse in frame S' which is moving with velocity 'v' relative to S.
7. Calculate the percentage contraction of a rod moving with a velocity of 0.8c in a direction inclined at 60^0 to its own length. **(Ans;- 8.4%)**
8. A particle has a velocity, u' = 3i + 4j + 12k m/sec. in a co – ordinate system moving with velocity 0.8c relative to laboratory along +ve direction of x – axis. Find u in laboratory frame. (Ans:- $2.4 \times 10^8 i + 2.4 j + 7.2k$ m/sec.)

Ist Unit. (Wave Mechanics)

1. What are matter waves? Show that the wavelength λ associated with a particle of mass m and kinetic energy E is given by $\lambda = \frac{h}{\sqrt{2mE}}$.
2. What are De-Broglie wave? How do they help in the interaction of Bohr's quantization rule?
3. Describe Davisson and Germer experiment to prove that electrons possess wave nature.
4. Distinguish between phase velocity and group velocity of a wave packet. Prove that, $V_p . V_g = c^2$.
5. Derive a general relation between phase velocity and group velocity and prove that in the absence of dispersion in the medium the two velocities are equal.
6. State Heisenberg uncertainty principle. Use this (i) show that electron cannot exist in the nucleus, (ii) Find the radius of Bohr's first orbit, (iii) Prove that the minimum energy of a harmonic oscillator is $\frac{1}{2}$ ħω.

7. Derive Schrödinger's time independent and time dependent equations of matter waves. Give the physical interpretation of the wave function, ψ.
8. A particle is in motion along a line between x = 0 and x = a with zero potential energy. At points for which x < 0 and x > a, the potential energy is infinite. Solving Schrödinger's equation, obtain energy eigen values and normalized wave function for the particle.
9. Show that the de-Broglie wavelength for a material particle of rest mass m_0 and charge q accelerated from rest through a potential difference of V volts relativistic ally is given by $$\lambda = \frac{h}{\sqrt{2m_0 qV\left(1+ {qV}/{2m_0c^2}\right)}}.$$
10. A particle of rest mass m_0 has a kinetic energy K. Show that its de – Broglie wavelength is given by, $\lambda = \frac{hc}{\sqrt{K\left(K+2m_0c^2\right)}}$. what will be the value of λ if $K << m\,c^2$?
11. Show that the phase velocity of de – Broglie waves associated with a moving particle having a rest mass m_0 is given by, $v_p = c\left[1+\left(\frac{m_0 c\lambda}{h}\right)^2\right]^{1/2}$.

Numerical Problems with Solution

1. A particle of charge q and mass m is accelerated from rest through a potential difference V, calculate its de-Broglie wavelength, if particle is an electron and potential difference V = 50 volts. **Solution: -**

$$\lambda = \frac{12.28}{\sqrt{V}} = \frac{12.28}{\sqrt{50}} = 1.74\ \overset{0}{\text{A}}.$$

2. Calculate the velocity and kinetic energy of a neutron having de-Broglie wavelength 1 Å.

Solution:- $\because \lambda = \frac{h}{mv}$, $\therefore v = \frac{h}{m\lambda} = \frac{6.62\times10^{-34}}{1.67\times10^{-27}\times1\times10^{-10}} = 3.96\times10^{3}\, m/\text{sec.}$

and the kinetic energy of the neutron is,

$$E = \frac{1}{2}mv^2 = \frac{1}{2}\times1.67\times10^{-27}\times\left(3.96\times10^{3}\right)^2 = 1.31\times10^{-20}\ joule.$$

3. Calculate the de-Broglie wavelength associated with a proton moving with a velocity equal to (1/20)th velocity of light. **Solution:-**

$$\because \lambda = \frac{h}{mv} = \frac{6.62\times10^{-34}\times20}{1.67\times10^{-27}\times3\times10^{8}} = 2.64\times10^{-14}\, m.$$

4. Can a photon and an electron of the same momentum have the same wavelength? Compare their wavelength if the two have the same energy.
5. An electron has de – Broglie wavelength 2.0×10^{-12} m. Find its kinetic energy, also find the phase and group velocities of its de – Broglie waves. **Solution:-**

$\because E^2 = p^2c^2 + m_0^2c^4$ and $p = \frac{h}{\lambda}$

$$\therefore E^2 = \frac{h^2c^2}{\lambda^2} + m_0^2c^4 \text{.......... ....}(1)$$

and, $K = E - m_0c^2$.......... ....(2) from (1) & (2) $\boxed{K = 4.68\times10^{-14}\,J = 293.64keV}$ For group velocity. $\because m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} \Rightarrow \sqrt{1-\frac{v^2}{c}} = \frac{m_0}{m} = \frac{m_0c^2}{mc^2} = \frac{E_0}{E}$ Hence group velocity, $\boxed{v = v_g = c\sqrt{1-\frac{E_0^2}{E^2}} = 0.7724c}$ For phase velocity

$$\boxed{\because v_p \times v_g = c^2 \Rightarrow v_p = \frac{c}{v_g} = 1.29c}$$

6. An electron has speed 600m/s with an accuracy of 0.005%. Calculate the certainty with which we can locate the position of the electron. **Solution:-** According to Heisenberg uncertainty principle, $\boxed{\Delta x.\Delta p \geq \hbar}$

$$\boxed{\Rightarrow \Delta x.m\Delta v \geq \hbar \Rightarrow \Delta x = \frac{\hbar}{m\Delta v} = \frac{1.05\times10^{-34}\times100}{9\times10^{-31}\times600\times0.005} = 0.39m.}$$

7. A hydrogen atom is 0.53Å in radius. Use uncertainty principle to estimate the minimum energy, an electron can have in this atom. **Solution:-**

$\because \Delta x \times \Delta p \geq \hbar$..(1) and,

$K.E. = \frac{\Delta p^2}{2m}$.......... ....(2) from (1) & (2)

$$\boxed{K.E. = 21.6\times10^{-19}\,J = 13.5eV}$$

8. If an excited state of hydrogen atom has a life time of $2.5\times10^{-14}\,\mu s$, what is the minimum error with which the energy of this state can be measured? Solution:-

$$\boxed{\because \Delta E.\Delta t \geq \hbar \Rightarrow \Delta E = \frac{\hbar}{\Delta t} \Rightarrow \Delta E = 4.22\times10^{-15}\,J = 26.37KeV}$$

9. Find the minimum energy of an electron moving in one dimension in an infinitely high potential box of width 1Å. Solution:-

$\because E = \frac{n^2h^2}{8mL^2}$,

For minimum energy taking n=1, $\boxed{\therefore E = \frac{h^2}{8mL^2} = 6.03\times10^{-18}\,J = 37.69eV}$

10. A particle confined to move along X – axis has the wave function $\Psi = ax$ between $x = 0$ and $x = 1.0$ and $\Psi = 0$ elsewhere. Find the probability that particle can be found between $x = 0.35$ to $x = 0.45$. **Solution:-** From normalization condition,

$\int_0^1 |\Psi|^2 dx = 1 \Rightarrow \int_0^1 a^2x^2dx = 1 \Rightarrow a = \sqrt{3}$ =1.732, Now,

$$\boxed{P = \int_{0.35}^{0.45} a^2x^2dx = 0.048 = 4.8\%}$$

11. Find the probabilities of finding a particle trapped in a box of length L in the region from 0.45 L to 0.55 L for the ground state and the first excited state. Solution:- Using $\Psi_n(x) = \sqrt{\frac{2}{L}}$. Sin $\frac{n\pi x}{L}$, and taking n = 1 for ground state, and n = 2 for first excited state, Then P = 19.8% for n = 1, and 0.65% for n = 2.

12. A particle is moving in an one dimensional potential box of infinite height. What is the probability of finding the particle in a small interval Δx, at the centre of the box when it is in the energy state, next to least energy state? **Solution:-** The wave function for the particle in n^{th} state is given by, $\Psi_n(x) = \sqrt{\frac{2}{L}}$. Sin $\frac{n\pi x}{L}$

The state next to the least energy state is second energy state. Therefore, n = 2, Hence,

$\Psi_2(x) = \sqrt{\frac{2}{L}}$. Sin $\frac{2\pi x}{L}$. At the centre of the box, x = L/2, Therefore, $\Psi_2(x) = \sqrt{\frac{2}{L}}$. Sin $\frac{2\pi(L/2)}{L} = 0$, Hence, $\boxed{P = \Psi_2^2 \Delta x = 0}$

13. Calculate the energy difference between the ground state and the first excited state for an electron in a one dimensional rigid box of length $10^{-8\ cm}$

Solution:- $E_n = n^2 h^{2/} 8mL^2$ ▼ $E_2 - E_1 = 114$ev

IIIrd Unit- INTERFERENCE OF LIGHT

SHORT ANSWER QUESTIONS.

1. An excessively thin film appears black in reflected system, explain.
2. Explain the formation of Newton's Ring.
3. How will you obtain Newton's Ring with bright centre due to reflected light?
4. Discuss the effect of increasing the distance between lens and plate or lifting up the lens from the flat surface.
5. Discuss the effect of placing the lens on silver glass plate or mirror.
6. Why two independent sources cannot be coherent?
7. Why do you need coherent sources for observing interference pattern??
8. Explain the formation of Newton's rings.
9. Explain spatial and temporal coherence.
10. What will happen if a little water is introduced between the lens and the glass plate of Newton's Ring experiment?

LONG ANSWER TYPE QUESTIONS.

1. Discuss the phenomenon of interference formation of interference fringes due to thin films and find the condition of maxima and minima. Show that the interference patterns of reflected and transmitted monochromatic light are complementary.
2. What are Newton's rings? Describe and explain the formation of Newton's rings in reflected monochromatic light. Why Newton's rings are circular? Prove that in reflected light: (i) diameters of bright rings are proportional to the square root of odd natural numbers. (ii) Diameters of dark rings are proportional to the square root of natural numbers.
3. Describe Newton's Ring method for measuring the wavelength of monochromatic light.

NUMERICAL PROBLEMS:-

1. Determine the coherence length and coherence time for white light.

(Given that $\nu_{violet} = 7.7 \times 10^{14}\, Hz, and\, \nu_{red} = 3.85 \times 10^{14}\, Hz.$)

Solution:- $\because \Delta\nu = \nu_{violet} - \nu_{red} = (7.7 - 3.85) \times 10^{14} = 3.85 \times 10^{14}\, Hz$

$$\therefore \text{Coherence time } \tau_c = \frac{1}{\Delta\nu} = 2.6 \times 10^{-15} \sec,$$

and Coherence length $L_c = c \times \tau_c = 7.8 \times 10^{-7}\, m.$

2. A man whose eyes are 150cm above the oil film on water surface observe the greenish colour at a distance of 100 cm from his feet. Calculate the probable thickness of the film.

(Given that, $\lambda_{green} = 5000\ \overset{0}{A}, \mu_{oil} = 1.4, \mu_{water} = 1.33$)

(Ans:- $9.725 \times 10^{-6}(2n-1)$ cm, where, n = 1, 2, 3…………….)

3. A soap film of refractive index 1.43 is illuminated by white light incident at an angle of 30^0. The refracted light is examined by a spectroscope in which dark band corresponding to the wavelength 6000 Angstrom is observed. Calculate the thickness of the film.

(Ans: - $2.28 \times 10^{-7}\, m.$)

4. A film of refractive index μ is illuminated by white light at an angle of incidence i. In reflected light two consecutive bright fringes of wavelength $\lambda_1 and \lambda_2$ is founding overlapping. Obtaining an expression for the thickness of the film.

5. Newton's rings are observed by keeping a spherical surface of 100 cm radius on a plane glass plate. If the diameter of the 15^{th} bright ring is 0.590 cm and the diameter of the 5^{th} ring is 0.336 cm, what is the wavelength of light used. (Ans: - 5880 Angstrom.)

6. A non reflecting film is to be deposited. What would be the necessary thickness for zero reflection at 5500 Angstrom? The refractive index of layer is 1.334.

(Ans:- $1.0307 \times 10^{-5}\, cm.$**)**

DIFFRACTION OF LIGHT.

SHORT TYPE QUESTIONS

1. Write the conditions of maxima and minima in diffraction due to single slit.

2. What do you mean by missing order in plane diffraction grating?

3. Distinction between Fresnel and fraunhofer diffraction.

4. Show that grating element determines the maximum number of possible orders in diffraction grating.

5. Define Rayleigh criterion of resolution.

6. What do you mean by dispersive power of a plane diffraction grating?

7. What are the characteristic of grating spectra?

8. What is the main difference between the dispersive power and resolving power of a grating?

LONG ANSWER TYPE QUESTIONS.

1. Discuss the phenomenon of Fraunhofer diffraction at a single slit, and show that relative intensities of successive maxima are nearly.
   $$1 : \frac{4}{9\pi^2} : \frac{4}{25\pi^2} : \frac{4}{49\pi^2} : \ldots\ldots\ldots\ldots\ldots\ldots\ldots .$$

2. Give the construction and theory of plane transmission grating and explain the formation of spectra by it.
3. What do you mean by missing order spectrum? What particular spectra will be absent if the width of the transparencies and opacities of the grating are equal, and also show that, only first order is possible if the width of the grating element is less than twice the wavelength of light.
4. What do you mean by the resolving power of grating? Derive the necessary expression.
5. Explain Rayleigh criteria for limit of resolution. Obtain an expression for resolving power of grating

NUMERICAL PROBLEMS.

1. A single slit is illuminated by light composed of two wavelengths $\lambda_1 and \lambda_2$. One observe that due to Fraunhofer diffraction, the first minima obtained for λ_1 coincides with the second diffraction minima of λ_2. What is the relation between $\lambda_1 and \lambda_2$?
2. A diffraction grating used at normal incidence gives a green line (5400 Angstrom) in a certain order n superimposed on the violet line (4050 Angstrom) of the next higher order. If the angle of diffraction is 30^0. Calculate the value of n .Also find how many lines per cm are there in grating. (Ans:- 3, 3086)
3. How many orders will be visible if the wavelength of incident radiation is 5000 Angstrom and the number of lines on the grating is 2620 to an inch? (Ans:- 19)
4. Find the minimum number of lines in a plane diffraction grating required to just resolve the sodium doublet (5890 & 5896 Angstrom) in the first order and second order. (Ans:- 982 & 491)

IVth Unit- POLARISATION OF LIGHT

SHORT TYPE QUESTION

1. How will you produce plane polarized light by reflection?

2. Define optic axis and principal section of the crystal.

3. What are ordinary and extraordinary rays?

4. How will you use Nicol Prism as polarizer and analyzer?

5. How will you convert elliptically polarized light into circularly polarized light?

6. What do you mean by phase retardation ?

7. Define Brewster's law?

LONG ANSWER TYPE QUESTION.

1. Explain the phenomenon of double refraction in a calcite crystal. Describe the construction and working and use of Nicol prism.
2. How will you produce and detect plane, elliptically, and circularly polarized light?
3. What are retardation plates? Obtain expression for the minimum thickness of half wave & quarter wave plate.

NUMERICAL PROBLEMS.

1. The values of μ_e & μ_o for quartz are 1.5508 and 1.5418 respectively. Calculate the phase retardation for $\lambda = 5000 \overset{0}{A}$, when the plate thickness is 0.032mm. (Ans:- 3.617 rad.)
2. Plane polarized light is incident on a plate of quartz cut with faces parallel to optic axis . calculate the thickness for which the phase difference between the two rays is 60^0 where μ_e & μ_o is 1.5583 and 1.5442 $\lambda = 5000 \overset{0}{A}$,

LASER.

SHORT TYPE QUESTIONS.

1. Differentiate spontaneous and stimulated emission radiation.

2. What is optical pumping?

3. What is population inversion and how it can be achieved?

4. What are the main component of LASER ?

LONG ANSWER TYPE QUESTION

1. What are Einstein's coefficients? Derive the relation between them.
2. Explain the principle of a laser and describe working of a Ruby laser.
3. Explain the 'helium – neon' laser. How is it superior to Ruby laser?
4. Show that a two level laser system has no practical significance for lasing?
5. What are the requirements for producing laser action? How they are achieved? Explain the principle of laser by schematic diagram.

NUMERICAL PROBLEM.

1. Calculate the population ratio of two states in He – Ne laser that produce light of wavelength 6000 Angstrom at 300K. (Ans: - e^{-80})

2. The coherence length for sodium D_2 line is 2.5cm. deduce (i) coherence time (ii) the spectral width of the line –**Hint τ_c x c= l_c,**

3. In a ruby laser, total number of Cr ions is 2.8x 10^{19} . if the laser emits radiation of wavelength 7000A^o. Calculate the energy of the laser pulse.

Vth Unit- FIBER OPTICS.

SHORT TYPE QUESTIONS.

1. Describe the basic principal of an optical fiber?

2. How will you compare single mode index and multimode index fiber?

3. Why modal dispersion is negligible in single mode fiber?

4. What are advantages and disadvantages of optical fiber?

5. What do you mean by attenuation ?

LONG ANSWER TYPE QUESTIONS.

1. Define acceptance angle. Derive an expression for it in terms of n_1 and n_2. Where n_1 is the refractive index of the core and n_2 is the refractive index of cladding.
2. What is fractional refractive index change? Define numerical aperture. Derive an expression for numerical aperture in terms of fractional refractive index change.
3. What are the basic principle of optical fiber ? Explain the difference between the step index and graded index fibres
4. What are the single mode and multimode fiber? what are the advantage of optical fibre over copper wire.

NUMERICAL PROBLEMS.

1. An optical fiber has the following data: refractive index of core = 1.55, refractive index of cladding = 1.50 and core diameter = 50µm, Calculate the numerical aperture and acceptance angle. How many reflections per meter are suffered by the guided ray at steepest angle to the fiber axis? (Ans ;- 0.3905, 23^0, 5209)
2. An optical fiber made of silica glass has a relative refractive index difference of 0.45% and acceptance angle for the fiber in the air is 0.115 radian. Find the speed of light in the fiber core. (Ans:- $2.48\times10^8 m/s.$)
3. The optical power, after propagating through a fiber is 500m long is reduced to 25% of its original value. Calculate the fiber loss in dB/km. (Ans:- 12.042dB/km.)

HOLOGRAPHY.

1. Describe the process of construction and reconstruction of image on hologram/also describe the application of holography
2. What are the main characteristic and application of holography.