CS/B.Tech/ECE/EE/AEIE/PWE/EEE/BME/ICE/ Even/2nd Sem/PH-201/2014

2014

Physics - I

Time Alloted : 3 Hours *Full Marks : 70*

The figure in the margin indicate full marks. Candidates are required to give their answers in their own words as far as practicable

GROUP - A
(Multiple Choice Type Questions)

1. **Choose the correct alternative for any ten of the following :** 10x1=10

i) In a single slit Fraunhofer diffraction, if the slit width is increased, the width of central maximum will

a) increases b) remains same
c) decreases d) uncertain

ii) For a point source of light the nature of wavefront is

a) cylindrical b) spherical
c) straight line, d) plane wave

iii) In Ruby laser is, the host crystal is

a) Al_2O_3 b) MnO_2
c) $CaCO_3$ d) NaCl.

iv) The emissive power of a black body kept at an absolute temperature T is proportional to

a) T^4 b) T^3
c) T^5 d) T^2

v) The resolving power of a grating, having N number of total rulings in nth order is

a) $\frac{n}{N}$ b) nN

c) $\frac{N}{n}$ d) $(nN)^{-1}$

vi) In Fraunhofer diffraction the incident wavefront is

a) Plane b) spherical
c) cylindrical d) ellipsoidal

vii) In a Nicol prism the O-ray is totally internally reflected and the E-ray is transmitted. The statement is

a) True b) False
c) Partly true d) Partly false

viii) The [111] and [222] planes in a lattice are

a) parallel to each other
b) perpendicular to each other
c) inclined at an angle 60° to each other
d) inclined at an angle 45° to each other

ix) Compton wavelength is given by

a) $\lambda = \frac{h}{m_0 c^2}$ b) $\lambda = \frac{h}{m_0}$

c) $\lambda = \frac{h}{m_0 c}$ d) $\lambda = \frac{m_0}{hc}$

x) For a dispersive medium, the relation between phase velocity v_p and group velocity v_g is

a) $v_p > v_g$ b) $v_p \leq v_g$
c) $v_p = v_g$ d) $v_p < v_g$

xi) Heisenberg position momentum uncertainty principle is

a) $\Delta x \Delta p_x = h$ b) $\Delta x \Delta p_x \geq h/2$
c) $\Delta x \Delta p_x \leq h/2$ d) $\Delta x \Delta p_x = 1$

xii) The relaxation time is the time in which the amplitude of the damped oscillator

a) grows to e times the initial value
b) decays to 1/e times the initial value
c) grows to e^2 times the initial value
d) decays to $1/e^2$ times the initial value

xiii) If λ_L and λ_K are the wave length of L and K x-rays respectively, then

a) $\lambda_L > \lambda_K$ b) $\lambda_L < \lambda_K$
c) $\lambda_L = \lambda_K$ d) $\lambda_K = 4\lambda_L$

xiv) The relativistic energy momentum relation is

a) $p^2=E^2+m_0^2c^2$ b) $E^2=p^2c^2+m_0^2c^4$
c) $E^2=p^2+m_0^2c^4$ d) $p^2=E^2c^2+m_0^2c^4$

xv) In holography, the 3D images are formed obeying the principle of

a) Interference b) Diffraction
c) Polarization d) Dispersion

GROUP - B
(Short Answer Type Questions)

Answer any *three* of the following 3x5=15

2. a) A solid cylinder of mass *M* is attached to a massless horizontal spring of constant *k* and it executes SHM, when rolls without slipping. Show that, its period of oscillation is $T = 2\pi\sqrt{\frac{3M}{2k}}$

b) Calculate the displacement to amplitude ratio for SHM when the kinetic energy is 90% of the total energy. 3+2

3. a) A quarter wave plate is fabricated with smallest possible thickness for wavelength of 589.3nm. What phase retardation will be obtained with this plate with light having wavelength of 435.8nm? You may neglect the variation of refractive indices with wavelength for this problem.

b) Why optical resonator is necessary to produce laser? 3+2

4. a) Deduce an expression for calculating very small thickness of a mica sheet with the help of Young's double-slit experiment.

b) A piece of glass of refractive index 1.5 is introduced in one of the interferring beams in Young's experiment. The central bright fringe is observed to shift to the position previously occupied by the 4^{th} bright fringe at a distance $2mm$ from the central maximum. If the fringe width and wave length of light used are $1.1mm$ and $5890A^{\circ}$ respectively, find the thickness of the plate. 3+2

5. a) Show that the Atomic packing factor of FCC is 74%.

b) A cubic crystal has lattice constant $4.3A^{\circ}$ and density $963kg/m^3$. If its atomic weight is 63, then what type of cubic cell does it form? 2+3

6. a) State the reason of modified and unmodified lines in Compton effect.

b) Write down Planck's law of frequency distribution of Black body radiation. Convert the expression into the wavelength distribution and find out the limiting form of this distribution at very small wavelengths? 2+3

GROUP - C
(Long Answer Questions)

Answer any *three* of the following 3x15=45

7. a) Two slits in Young's double slit experiment are 1.3 mm apart from each other and the screen is placed 1.6 m away from the slites. Calculate the distance of the fifth bright fringe. The wavelength of light used is 6000 $\mathring{A}$.

b) In what ways the interference in Young's experiment and interference in Newton's rings experiment differ?

c) A microscope is used to resolve two point sources separated by a distance 4×10^{-5} *cm*. If the wavelength of light be 5461 $\mathring{A}$, calculate the numerical aperture of the objective.

d) Critical angle for refraction for glass to air is 40°. Calculate the polarizing angle for glass.

e) Write down an expression for the intensity due to Fraunhoffer diffraction in a single slit. How this expression will be modified in case Fraunhoffer diffraction in double slit? Explain. Find the condition for interference maxima for Fraunhoffer diffraction in double slit.

3+2+3+2+(1+2+2)

8. a) Show that the frequency of oscillation of a body of mass *M* suspended from a uniform spring of force constant *k* and mass is given by $\frac{1}{2\pi}\sqrt{\frac{k}{M+m/3}}$ It is given that the velocity of any element of the spring is proportional to its distance from the fixed end of the spring.

b) The equation for displacement of a point of damped oscillator is given by $X = 5e^{-0.5t}\sin(\pi/2)t$ m. Find the velocity of oscillating point at $t = T/5$ and T, where T is the time period of oscillation.

c) Difference between velocity resonance and amplitude resonance.

d) A particle of mass 0.1kg is placed in a field of potential energy $U = 2x^2 + 4x + 4$ Jkg^{-1}. Find the frequency, force constant and equilibrium positions.

5+4+3+3

9. a) A photon of frequency v is scattered through an angle of 90° in Compton scattering. Show that the scattered frequency is

$$v' = \frac{m_0c^2}{hv + m_0c^2}v$$

b) Show that the expression for de-Brogile wavelength of a particle with rest mass energy E_0, and kinetic energy K both in eV can also be written as $\lambda = \frac{hc}{\sqrt{K\left(2m_0c^2 + K\right)}}$

c) What do you mean by group velocity and phase velocity.

d) Deduce Wien's displacement law from Planck's law of black body radiation.

e) Show that electron can not exists in the nucleus of an atom.

3+3+3+3+3

10. a) State Heisenberg's uncertainty principle. Show that $v_p v_g = c^2$.

b) Find an expression for the fractional change in natural frequency of a damped harmonic oscillator in terms of the quality factor Q.

c) Why is laser needed for holography?

d) Two polarizers are placed at cross position (angle between the polarizing plane is 90°). A third polarizer with angle θ with the first one is placed between them. An unpolarized light of intensity I is incident on the first one and passes through all three polarizers. Find the intensity of light that comes out from second polarizers.

e) Show that for a system of forced vibration, the ratio two energy as follows $\frac{\text{average potential energy}}{\text{average kinetic energy}} = \frac{\omega^2}{\omega'^2}$

(2+3)+3+2+2+3

11. a) Explain the term 'absorption', 'spontaneous emission' and 'stimulated emission' by diagram hence derive the relation for Einstein's A, B coefficient.

b) Explain the working principle of He-Ne laser with energy level diagram.

c) A relative population (Boltzmann ratio) of $\frac{1}{e}$ is representative

of the ratio of populations in two energy states at room temperature (T=27°C). Determine the wavelength of the radiation emitted at the temperature.

d) If the wavelength of radiation of ruby laser is 6943 , $\mathring{A}$ what is the energy of a photon emitted?

6+4+3+2

12. a) *X*-ray diffraction can not be seen in plane transmission grating. Explain it.

b) A beam of *X*-rays of wavelength of 0.9 $\mathring{A}$ is incident on a crystal at a glancing angle of 8°6' when first order Bragg's reflection occurs. Find the consecutive distance between two planes if the reflection occur from the planes having Miller indices (2 2 1) Calculate the angle for 3rd order reflection.

c) Aluminium is an FCC crystal with lattice constant $a = 0.405nm$. Calculate the number of unit cell present in an aluminium foil of $0.005cm$ thickness and two sides of 25 cm length.

d) What is the origin of characteristics X-ray? If a beam of electron is diffracted from a crystal of interplanar separation *d*, at an angle θ then show that the acceleration voltage *V* for the beam of electron is given by $V = \frac{1}{2me}\left(\frac{h}{2d\sin\theta}\right)^2$. Symbols have their usual significance?

e) What is Moseley's law?

2+(3+1)+3+(1+3)+2