2019/EVEN/08/21/PHY–404 (A/B/C/D)/068

PG Even Semester (CBCS) Exam., May—2019

PHYSICS

(4th Semester)

Course No. : PHYCC–404

Full Marks : 70
Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

Candidates have to answer *either* from Group—A *or* Group—B *or* Group—C *or* Group—D

GROUP—A

Course No. : PHYCC–404 (A)

(ASTROPHYSICS—II)

Answer **five** questions, taking **one** from each Unit

UNIT—I

1. *(a)* Derive the expression for Lienard-Wiechert potentials at a distance for distribution of charges. 7

(b) Derive the expression for Poynting vector for the radiation emitted by an arbitrarily moving single charge. 7

2. *(a)* Derive the expression for wavelength shift for Compton scattering. 10

(b) What are inverse Compton scatter and bremsstrahlung scattering? Describe. 2+2=4

UNIT—II

3. *(a)* Describe the structure of our galaxy and its different parts. 6

(b) Describe the rotation curve of our galaxy and make an estimate for the missing mass. 4+4=8

4. *(a)* Describe Hubble's tuning fork diagram explaining the different morphological classes of galaxies. 7

(b) What are AGNs? In what way they are different from normal galaxies? Describe the different types of AGN and wherever possible connect them with corresponding normal galaxies. 3+4=7

UNIT—III

5. Discuss the clock paradox and its resolution in the light of equivalence principle. 14

6. Show that in weak-field limit Newtonian theory can be derived from Einstein's theory. 14

UNIT—IV

7. *(a)* What is cosmological redshift? How is it observationally detected? 4

(b) Show how cosmological redshift indicates an expanding universe. 10

8. *(a)* Formulate Friedmann equation from simple non-relativistic argument. 7

(b) Show that the expansion/contraction of the universe is such that the total entropy of matter and radiation remains constant. 7

UNIT—V

9. What are the different possible constituents of dark matter and their observational status? 14

10. What are GRBs? What may be the possible sources and reasons behind their generation? Discuss the possible impacts of a nearby GRB on earth. 2+4+8=14

GROUP—B

Course No. : PHYCC–404 (B)

(CONDENSED MATTER PHYSICS—II)

Answer **five** questions, taking **one** from each Unit

UNIT—I

1. *(a)* What is Boltzmann transport equation? Deduce Boltzmann transport equation when the collisions are absent. 1+6=7

(b) Derive the expression for thermal conductivity in metals using Boltzmann transport equation. 7

2. *(a)* Deduce the expression for viscosity using Boltzmann transport equation. 6

(b) Write short notes on the following (any *two*) : 4×2=8

(i) Hall effect

(ii) Magnetoresistance

(iii) Thermoelectric effect

UNIT—II

3. *(a)* What are energy bands in solid? Obtain the expression for energy gap in case of a simple cubic crystal. 2+7=9

(b) What are the various points considered in free-electron approximation and tight-binding approximation? 5

4. *(a)* State and prove the Hohenberg-Kohn theorems. 8

(b) Write short notes on the following (any *two*) : 3×2=6

(i) Exchange correlation

(ii) APW

(iii) LDA

UNIT—III

5. *(a)* Deduce Clausius-Mosotti equation in dielectrics. Give its significance. 6+1=7

(b) Derive the expression for Cole-Cole plot. Explain its significance. 6+1=7

6. *(a)* Describe the phenomenon of polarization catastrophe in ferroelectric crystalline material. 6

(b) Write short notes on the following (any *two*) : 4×2=8

(i) Dielectric polarization

(ii) Ionic polarization

(iii) Ferroelectricity

UNIT—IV

7. *(a)* Give Langevin's theory of para-magnetism to obtain the expression for susceptibility. 7

(b) Explain how Weiss theory could overcome the shortcomings of the Langevin's theory. 7

8. *(a)* Give the quantum theory of diamagnetism. 10

(b) Write a short note on the following (any *one*) : 4

(i) Magnetic moment

(ii) Paramagnetic cooling

UNIT—V

9. *(a)* Give the classical model of photo-conductivity. 7

(b) What are traps? What are the different types of traps? Describe the fundamental processes involved in recombination through traps. 2+2+3=7

10. *(a)* What are the different kinds of luminescence processes? How does phosphorescence differ from fluorescence? Give one example each of phosphorescence and fluorescence. 3+2+1=6

(b) Write short notes on the following (any *two*) : 4×2=8

(i) Exciton

(ii) Color centres

(iii) Excitation and emission

GROUP—C

Course No. : PHYCC–404 (C)

(ADVANCED QUANTUM FIELD THEORY—II)

Answer **five** questions, taking **one** from each Unit

UNIT—I

1. Compute the Feynman diagram for Moller scattering $e\ e \quad e\ e$ and obtain the differential cross-section. 14

2. Explain crossing symmetry. Calculate the amplitudes of the process $e\ e$ and $e \quad e$ and show that they are related by crossing symmetry. 4+10=14

UNIT—II

3. Perform QED calculations to compute the differential cross-section for electron-positron annihilation. 14

4. Obtain the differential cross-section of the process $e \quad e$ in the laboratory frame. 14

UNIT—III

5. Discuss self-energy of the electron arising due to one loop QED diagrams. 14

6. Write short notes on the following : 7×2=14

(a) Vacuum polarization

(b) Lamb shift

UNIT—IV

7. Discuss electron-proton elastic scattering and interpret the electromagnetic form factors that appear in the hadronic tensor. 8+6=14

8. Discuss QCD improved parton model which leads to scaling violation. 14

UNIT—V

9. Define parity, charge conjugation and time-reversal transformations. How do the Dirac bilinear covariants transform under parity and charge conjugation? 6+4+4=14

10. Describe CP transformation and discuss its action on left-handed current in weak interactions. 4+10=14

GROUP—D

Course No. : PHYCC–404 (D)

(NON-LINEAR OPTICS AND LASER SPECTROSCOPY—II)

Answer **five** questions, taking **one** from each Unit

UNIT—I

1. What is mode locking? Derive the expression for total amplitude of phase-locked modes in active mode locking. 4+10=14

2. *(a)* Distinguish between 'cavity dumping' and 'Q-switching' techniques. Explain the technique of generation of Q-switched laser pulses. 4+6=10

(b) What is Q-factor of an optical resonator? 4

UNIT—II

3. *(a)* Define non-linear absorption and write the expression for power absorbed in the process. 4

(b) Show that the saturation population difference in a two-level open system is given by

$$N \quad \frac{N^{\circ}}{1 \quad S}$$

(Symbols have their usual meaning)

Also discuss the variation of N and S with the intensity of incident laser. 5+5=10

4. *(a)* Explain the formation of 'Lamb dip' in a Doppler broadened profile. 5

(b) What is saturation spectroscopy? Give a brief account of its experimental realization (experimental setup). 4+5=9

UNIT—III

5. *(a)* Define two-photon absorption. Explain how it is possible to select upper state in two-photon absorption by proper choice of polarization characteristic of incident light. 4+5=9

(b) Briefly explain the principle of Doppler-free multiphoton absorption. 5

6. *(a)* Derive the expression for transition probability of two-photon absorption using the quantum mechanical perturbation theory. 12

(b) What are quantum beats? 2

UNIT—IV

7. *(a)* Distinguish between spontaneous and stimulated Raman scattering. 4

(b) Derive the expressions for Raman susceptibilities from non-linear polarization equation. 10

8. *(a)* Write the difference between coherent anti-Stokes Raman scattering (CARS) and hyper Raman effect. 4

(b) Describe the use of CARS as a technique of non-linear Raman spectroscopy. 10

UNIT—V

9. Describe briefly *(i)* optical trapping of atom and *(ii)* laser radiation force. 7+7=14

10. What is photon recoil? Give an account of optical cooling by photon recoil. 4+10=14

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