2018/EVEN/08/21/
PHY–404 (A/B/C/D)/092

PG Even Semester (CBCS) Exam., May—2018

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* Option—A o*r* Option—B o*r* Option—C *or* Option—D

OPTION—A

Course No. : PHYCC–404 A

(ASTROPHYSICS)

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

UNIT—I

1. Describe synchrotron radiation. Show that the electric field created by an accelerated charged particle has two components—one corresponding to Coulomb field and other corresponding to radiation field. Hence show that the electromagnetic radiation caused due to such a field is 100 percent polarized and wavelength-independent. 4+5+5=14

2. What are Compton and inverse Compton scatterings? Derive the expression for the change in wavelength and energy loss for Compton scattering. Describe Bremsstrahlung radiation and discuss the astrophysical conditions under which one gets this radiation. 3+7+4=14

UNIT—II

3. With a diagram, describe the structure of Milky Way galaxy. Estimate the mass of Milky Way from its rotation curve and compare its value with total estimated baryonic mass of our galaxy. Explain if there are any differences between these two estimates. 5+5+4=14

4. Describe Hubble's scheme for morphological classification of normal galaxies. What is an active galactic nuclei (AGN)? Describe different types of AGN. How, from the image plate, can we distinguish a normal galaxy from galaxies containing AGN? 4+3+5+2=14

UNIT—III

5. Using locally inertial coordinate system, deduce Bianchi identities. From these identities in their covariant form, show that

$$R^{l}_{k;l} \quad \frac{1}{2} R_{,k}$$

10+4=14

6. *(a)* State and explain the principle of equivalence. 5

(b) Following Einstein, formulate the gravitational field equations. 9

UNIT—IV

7. Write notes on the following : 7+7=14

(a) Cosmological constant

(b) Standard cosmological model

8. *(a)* What can be considered possible candidates for relics of the big bang? Explain in brief. 5

(b) Explain why it is not possible to observe the past of the universe beyond redshift of $\sim 10^3$. 5

(c) If the spectrum of CMBR turns out to be marked by different from the Planckian form, what implication will it have in hot bing bang? 4

UNIT—V

9. *(a)* Discuss two observations which prove the existence of dark matter in the universe. 6

(b) Explain the remark, "Early universe is the poor man's high energy accelerator". 4

(c) Discuss the evidence for or against the presence of antimatter in the universe. 4

10. *(a)* Outline the observational difficulties that stand in the way of precise determination of Hubble's constant. 3

(b) Discuss in brief some new avenues that can be opened up in gravitational astronomy. Does a comparative study with astronomy use EM-waves? 5+6=11

OPTION—B

Course No. : PHYCC–404 B

(CONDENSED MATTER PHYSICS–II)

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

UNIT—I

1. *(a)* What is thermal conductivity? Using Boltzmann transport equation, deduce the expression for the thermal conductivity. 10

(b) Explain briefly Wiedmann-Franz law. 4

2. *(a)* Define magnetoresistance. Show that magnetoresistance increases to the order of B^2, when magnetic field B is applied perpendicular to the direction of current flow. 8

(b) Show that, the Hall voltage developed across an electrical conductor in a magnetic field perpendicular to the current flowing through it, is

$$V_H \quad \frac{BId}{ne}$$

symbols have their usual meanings and d is the thickness of the sample. 6

UNIT—II

3. What is tight binding method? Using the expression for energy in tight binding method, calculate the band gap for sc and bcc cubic crystal systems. 2+5+7=14

4. *(a)* Explain briefly the concept of density functional theory (DFT). What are the Hohenberg-Kohn theorems? Prove the Hohenberg-Kohn theorem–I. 2+6=8

(b) What is exchange correlation energy? What are LDA and GGA for exchange correlation energy calculation? 2+2+2=6

UNIT—III

5. *(a)* What is dielectric polarization? Discuss different types of dielectric polarization. 1+7=8

(b) Deduce the equation for cole-cole plot. What is the significance for cole-cole plot? 5+1=6

6. What are the ferroelectric materials? Discuss the properties of ferroelectric materials. Explain the phenomenon of polarization catastrophe in ferroelectric crystal. 2+4+8=14

UNIT—IV

7. *(a)* Find the susceptibility of a diamagnetic material by using Langevin's theory. 10

(b) What are the differences between diamagnetism and paramagnetism? 4

8. *(a)* Discuss quantum theory of paramagnetism. 10

(b) State briefly the phenomenon of paramagnetic cooling. 4

UNIT—V

9. *(a)* What is optical conductivity? Discuss briefly the optical properties of free electrons and deduce the expression for plasma frequency. 2+7=9

(b) Define exciton. What are the Frenkel and Wannier-Mott excitons? 1+4=5

10. *(a)* What is luminescence? Explain the mechanism of luminescence. 2+4=6

(b) Discuss in detail different kinds of luminescence. 8

OPTION—C

Course No. : PHYCC–404 C

(ADVANCED QUANTUM FIELD THEORY–II)

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

UNIT—I

1. Calculate the cross-section of scattering of electrons from a static Coulomb potential, illustrating the steps of calculation of QED. 14

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

(a) Crossing symmetry

(b) Mandelstam variables

UNIT—II

3. Calculate the unpolarized cross-section of the process $e\ e$ in the centre of mass frame. 14

4. Obtain the Klein-Nishina formula by performing QED calculations for Compton scattering. 14

UNIT—III

5. Discuss the electron vertex function with one loop QED correction. 14

6. Write a note on renormalization of electronic charge. 14

UNIT—IV

7. Starting with the kinematics of deep inelastic scattering, discuss Bjorken scaling of structure functions and the parton model. 14

8. Discuss scaling violation of structure function and QCD evolution equation. 14

UNIT—V

9. What is charge conjugation? Discuss charge conjugation in Dirac theory. 2+12=14

10. Discuss parity and time reversal as discrete spacetime symmetrics. What are the actions of the parity operator $\hat{P}$ and time-reversal operator $\hat{T}$ on bilinear covariants? 4+5+5=14

OPTION—D

Course No. : PHYCC–404 D

(NON-LINEAR OPTICS AND LASER SPECTROSCOPY–II)

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

UNIT—I

1. What is cavity dumping? Explain the mechanism of cavity dumping technique and derive an expression for amplitude of output wave extracted by this technique. What is its basic difference with Q-switching technique? 2+10+2=14

2. Explain the concept of cavity modes. Obtain the condition for formation of longitudinal modes in laser cavity. 4+10=14

UNIT—II

3. *(a)* Explain Doppler broadening of line width. 4

(b) Give a quantitative analysis of saturation broadening of homogeneous line profile. 10

4. *(a)* Explain the basic principle of polarization spectroscopy. Also derive an expression to represent the transmitted probe wave. 5+6=11

(b) Write the advantages of polarization spectroscopy. 3

UNIT—III

5. *(a)* Define two-photon absorption using appropriate energy-level diagram. 4

(b) Explain the technique of Doppler-free multiphoton absorption and an arrangement to observe multiphoton absorption experimentally. 5+5=10

6. *(a)* Explain the basic principle of quantum beat spectroscopy. 10

(b) What is photon echo? 4

UNIT—IV

7. Using non-linear polarization equation, show that stimulated Raman-Stokes emission is a gain process and anti-Stokes wave experiences attenuation. 14

8. *(a)* Explain the formations of equispaced anti-Stokes 'cones' and Stokes 'spot' in stimulated Raman scattering. 10

(b) Describe the mechanism of coherent anti-Stokes radiation (CARS) emission. How does it differ from hyperfine Raman frequency? 3+1=4

UNIT—V

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

(a) Optical levitation

(b) Optical cooling of atom

10. *(a)* What is optical trapping of atom? 4

(b) Describe an experimental arrangement for trapping of atoms. 10

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