PG Even Semester (CBCS) Exam., May—2017

PHYSICS

(4th Semester)

Course No. : PHYEC–404

Full Marks : 70
Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

Candidates are to answer *either* PHYEC–404 (A) *or* PHYEC–404 (B) *or* PHYEC–404 (D)

Course No. : PHYEC–404 (A)

(ASTROPHYSICS—II)

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

UNIT—I

1. It is generally observed that radiations received from AGNs are synchrotronic in nature, whereas radiations received from stars are Planckian in nature.

Explain why it is so, in terms of the physical processes ongoing in these two objects.

What are the different features by which these two radiations can be distinguished?

Hence derive the expression for power radiated by an accelerated charged particle. 14

2. Derive the expressions for Compton scattering and inverse Compton scattering. What are the important astrophysical processes in which these two types of scattering take place?

Hence discuss the case of bremsstrahlung radiations and their significance in gamma-ray astronomy. 14

UNIT—II

3. Describe in detail the structure of our galaxy with different parts. Explain why Milky Way bright patch is seen only during summer from northern hemisphere.

Discuss the rotation curves for Keplerian motion, rigid body rotation and that of our galaxy. Explain their differences and find an expression for 'missing mass' as a function of radius of our galaxy. 6+8=14

4. Explain Hubble's tuning fork diagram and the scheme for morphological classification of external galaxies.

What are the main differences between spiral and elliptical galaxies as can be recorded by an astronomer? List at least five such differences. How are AGNs distinguished from normal galaxies? Discuss about the differences between surface photometric feature of these two classes of objects.

Why are AGNs generally observed at large distances and normal galaxies observed at nearby distances? Provide some possible explanation. 4+4+4+2=14

UNIT—III

5. What is 'parallel transport'? Derive the covariant derivative of a tensor of rank 1. Hence show that $Dg_{ik} = 0$.

Also derive a relation between Christoffel symbol and metric tensor. 2+3+3+6=14

6. State and derive the equation of motion of a body moving through a gravitational field using covariant derivative.

Derive the Hamilton-Jacobi equation for the above body. Hence find the expression of gravitation redshift of electromagnetic radiation. 5+4+5=14

UNIT—IV

7. State and explain the significance of Hubble's law.

What is Birkhoff's law? Explain and derive the mathematical expressions, for our present matter density of the universe, which can decide the evolution of our universe. What is the critical density?

Hence derive the age of the universe in terms of Hubble's constant.

(You may adopt a semi-classical approach for the above calculations.) 3+7+4=14

8. Write down Einstein's field equation and explain the significance of each term in that equation.

From a symmetry point of view, obtain the expression for RLW model of the universe. From this model, derive the expression for $H(t)$. 4+10=14

UNIT—V

9. *(a)* How are type I-A supernovae formed? Why are they treated as standard candles? How do they provide evidence in favour of late time acceleration of the universe? 2+2+4=8

(b) What are gamma-ray bursts? How can their study help in understanding chemical evolution of the universe? 3+3=6

10. What are gravitation waves? Discuss the mechanism of generation of gravitational waves from three types of astronomical sources.

Discuss the properties of such waves. 2+6+6=14

Course No. : PHYEC–404 (B)

(CONDENSED MATTER PHYSICS—II)

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

UNIT—I

1. *(a)* What is Boltzmann distribution function? Obtain Boltzmann transport equation. 2+5=7

(b) Using Boltzmann transport equation, derive the expression for electrical conductivity of an electron gas. 7

2. *(a)* Derive the expression for Hall coefficient of a metal. How will you experimentally verify the type of a semiconductor? 7+2=9

(b) Write a short note on any *one* of the following : 5

(i) Magnetoresistance

(ii) Wiedemann-Franz law

UNIT—II

3. *(a)* What are energy bands in solid? Obtain the energy gap of electron in a fcc crystal. 2+8=10

(b) Explain exchange energy correlation. 4

4. *(a)* Prove Hohenberg-Kohn theorems. 7

(b) Write short notes on the following : 3½×2=7

(i) Kohn-Sham method

(ii) APW

UNIT—III

5. *(a)* Derive Clausius-Mosotti relation in dielectrics. 7

(b) Give the classical theory of electronic polarization. 7

6. *(a)* Give the dipole theory of ferroelectricity. 6

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

(i) Cole-Cole plot

(ii) Ionic polarization

UNIT—IV

7. *(a)* What are different kinds of magnetism? Classify them. 6

(b) Give Langevin's theory of paramagnetism. 8

8. *(a)* Discuss the origin of magnetic moments considering both orbital motion and spin. 6

(b) Give quantum theory of diamagnetism. 8

UNIT—V

9. *(a)* Describe classical model of optical conductivity. 7

(b) What are excitons? Classify them according to their strength of binding. 7

10. *(a)* What is a luminescence and its mechanism? What are different types of luminescence? Explain briefly. 2+2+4=8

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

(i) Color centre

(ii) Optical refractive index

(iii) Concentration dependance of luminescence efficiency

Course No. : PHYEC–404 (D)

(NON-LINEAR OPTICS AND LINEAR SPECTROSCOPY)

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

UNIT—I

1. Define *Q*-factor of an optical resonator. Explain in brief the technique of generation of *Q*-switched laser pulses. Derive the expressions for power and energy of a *Q*-switched pulse. 2+4+8=14

2. What are cavity modes? Derive the condition for which longitudinal modes are formed in a laser cavity. Also define FSR of a cavity. 2+10+2=14

UNIT—II

3. *(a)* What is non-linear absorption? Show that

$$\Delta N = \frac{\Delta NO}{1+S}$$

considering an open two-level system and hence discuss the variation of ΔN and S as function of incident laser frequency (symbols have their usual meanings). 3+5+4=12

(b) Why does saturation parameter (S) in closed and open system differ? 2

4. Explain how saturation of Doppler broadened in homogeneous line profile lead to creation of 'Bennet hole'. What is 'Lamb dip'? 8+6=14

UNIT—III

5. Give the basic principle of quantum beat spectroscopy. Describe an experimental set-up to observe quantum beats. 8+6=14

6. What is two-photon absorption? Derive the transition probability of two-photon absorption using the quantum mechanical perturbation theory. 4+10=14

UNIT—IV

7. *(a)* Distinguish between stimulated Raman scattering and hyper Raman scattering. 5

(b) Describe the use of CARS as a technique of non-linear Raman spectroscopy. 9

8. *(a)* What are the basic differences between stimulated and spontaneous Raman scattering? 4

(b) Derive the Stokes and anti-Stokes field amplitude equations in stimulated Raman scattering described by non-linear polarization. 10

UNIT—V

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

(a) Optical levitation

(b) Laser radiation force

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

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