2018

PHYSICS

(Major)

Paper : 5.1

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

GROUP—A

(Mathematical Methods)

(*Marks* : 30)

1. Answer the following questions : 1×4=4

(a) What is analytic function?

(b) Define a complex variable.

(c) State De Moivre's theorem.

(d) Find out $(i)^{1/2}$.

2. *(a)* Verify whether the function $f(z) = 3z^2 + 2$ is an analytical function or not. 2

(b) Demonstrate a graphical representation of complex variable through Argand diagram. 2

3. Find the complex conjugate of the functions

$$(x+iy)\cdot(a+ib) \text{ and } \frac{x-iy}{a+ib}$$

where x, y, a and b are real. 4

Or

Obtain the residues of the function

$$f(z) = \frac{1}{z^2 + a^2} \quad a > 0$$

4. Give the Laurent series expansion for $f(z)$. Obtain the Laurent expansion for the function

$$f(z) = \frac{1}{z(z-1)} \text{ about } z_0 = 0 \quad 2+3=5$$

(Continued

5. *(a)* *(i)* Define isolated singular point and non-isolated singularity. 2

(ii) Using residue theorem, evaluate

$$\int_0^{2\pi} \frac{d\theta}{5+4\cos\theta}$$ 5

Or

State and prove Taylor's theorem.

2+5=7

(b) State and prove Cauchy-Riemann conditions for analytical functions.

2+4=6

Or

Show that $\int_{-\infty}^{\infty} \frac{1}{(1+x^2)^2}\,dx = \frac{\pi}{2}$. 6

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(Turn Over)

GROUP—B

(Classical Mechanics)

(*Marks* : 30)

6. Answer the following questions/Choose the correct option : 1×4=4

(a) What is reversed effective force?

(b) What do you mean by holonomic constraint?

(c) For a conservative system, the potential energy does not depend upon

(i) force

(ii) generalised velocity

(iii) generalised coordinate

(iv) None of the above

(d) If a coordinate does not appear in Lagrangian, then it is called

(i) cyclic

(ii) non-cyclic

(iii) free

(iv) holonomic

(Continued)

7. Answer any *two* of the following questions : 2×2=4

(a) Define virtual displacement and discuss its significance.

(b) State and explain Hamilton's principle.

(c) Show that in a central force field the angular momentum of a particle is conserved.

(d) Mention two properties of Poisson bracket with proof.

8. Answer any *two* of the following questions : 3×2=6

(a) Show that the motion of a particle under central force always takes place in a plane.

(b) Find an expression for centripetal acceleration for a bead sliding on a uniformly rotating wire.

(Turn Over)

(c) Show that Hamiltonian H is a constant of motion if the Lagrangian L is not an explicit function of time.

9. (a) Set up the Lagrangian for a simple pendulum and hence obtain equation describing its motion.

Or

Find the equation of motion of a system with the following Lagrangian :

$$L = \frac{1}{2} e^{\alpha t} (\dot{x}^2 - \omega^2 x^2)$$

where α and ω are constants.

(b) Establish the differential equation for the orbit of a particle under central force.

Or

Set up Lagrangian equation for an Atwood machine and find an expression for its acceleration.

10. What is d'Alembert's principle? Obtain Lagrange's equation of motion for a conservative system using d'Alembert's principle. 2+6=8

Or

Define Hamiltonian of a system and establish Hamilton's canonical equations. 2+6=8

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2018

PHYSICS

(Major)

Paper : 5.2

(Atomic Physics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option of any *seven* of the following : 1×7=7

   (a) An electron revolves about a proton in second excited state. The angular momentum of the electron is

   (i) $\frac{h}{2\pi}$

   (ii) $\frac{h}{\pi}$

   (iii) $\frac{3h}{2\pi}$

   (iv) 0

(b) Lines of Balmer series are obtained from the hydrogen atom, when electron jumps from some higher orbit to

(i) fourth orbit

(ii) third orbit

(iii) second orbit

(iv) None of the above

(c) The formation of electronic spectrum is due to

(i) change in electronic energy

(ii) change in vibrational energy

(iii) change in rotational energy

(iv) change in all (i), (ii) and (iii)

(d) The minimum wavelength of X-rays produced by electrons accelerated by a potential difference of V volts is

(i) $\frac{eV}{\upsilon c}$ (ii) $\frac{eV}{hc}$

(iii) $\frac{hc}{eV}$ (iv) $\frac{h}{\upsilon}$

(e) The minimum number of electrons in a sub-shell with orbital angular momentum quantum number l is

(i) $2(2l+1)$ (ii) $(2l-1)$

(iii) $2(2l-1)$ (iv) $(2l+1)$

(Continued)

(f) Stern-Gerlach experiment confirms

(i) electron spin and associated magnetic moment

(ii) orbital motion of the electron and associated moment

(iii) specific charge (e / m) of the electron

(iv) spin-orbit interaction of the electron

(g) If ν_{K_α} and ν_{L_α} be the frequencies of K_α and L_α characteristic X-ray lines, then

(i) $\nu_{K_\alpha} = \nu_{L_\alpha}$ (ii) $\nu_{K_\alpha} < \nu_{L_\alpha}$

(iii) $\nu_{K_\alpha} > \nu_{L_\alpha}$ (iv) $\nu_{K_\alpha} = \frac{1}{\nu_{L_\alpha}}$

(h) The shape of the electron orbit is determined by the quantum number

(i) n (ii) l

(iii) j (iv) mj

(i) The splitting of spectral lines with components in strong electric field is known as

(i) normal Zeeman effect

(ii) anomalous Zeeman effect

(iii) Paschen-Back effect

(iv) Stark effect

(Turn Over)

2. Answer any *four* of the following : 2×4=8

(a) A charged oil drop is suspended in an uniform electric field of 3×10^{4} V/m so that it neither rises nor falls. If the mass of the drop is $9\cdot75\times10^{-15}$ kg, find the charge on the drop.

(b) Find the precessional frequency of an electron orbit when placed in a magnetic field of 6 tesla. ($e=1\cdot6\times10^{-19}$ C, $m=9\cdot1\times10^{-28}$ kg)

(c) Electron moves at right angles to magnetic field of 150×10^{-14} tesla with a velocity of 6×10^{6} m/s. Find the radius of circular path. ($e/m=1\cdot7\times10^{11}$ C/kg)

(d) What is Lande *g*-factor? What is the value of *g*-factor of an atom with a single electron in $d_{3/2}$ state.

(e) If the PD between the anode and the cathode is 25 kV, what is the cut-off wavelength and the cut-off frequency of the emitted X-rays? ($c=3\times10^{8}$ m/s, $h=6\cdot6\times10^{-34}$ J-s)

(f) Using vector atom model, determine the possible values of the total angular momentum of an *f*-electron ($l=3$).

(Continued

3. Answer the questions *(a)* and any *two* from *(b)*, *(c)* and *(d)* : 5×3=15

(a) Mention the important feature of Rutherford's scattering of α-particles by gold foil which supported the nuclear model of the atom against Thomson model.

(b) A 2 keV electron enters a magnetic field of 5×10^{-4} Wb/m^{2}. If the radius of the electron path is 0·303 m, find the (e/m) of the electron.

(c) A beam of X-rays of wavelength 0·842 Å is incident on a crystal at a glancing angle of 8·6°, when the first-order Bragg's reflection occur. Calculate the glancing angle of the third-order reflection.

(d) Write any *one* explanatory note on the following :

(i) Pauli's exclusion principle

(ii) Alkali spectra

(iii) Vector atom model

(Turn Over)

4. Answer the questions *(a)* and *(b)* and any *one* from *(c)* and *(d)* : 10×3=30

(a) If the positive charge of the gold atom is supposed to be spreaded uniformly over a spherical surface of diameter 1 Å, show that the α-particle of energy greater than a certain value E will not be reflected back. Calculate the value of E. $\left(\frac{1}{4\pi\varepsilon_0} = 9\times10^9\right)$ 5+5=10

Or

What is Compton effect? Derive an expression for the change in wavelength of a photon when it is scattered by an electron. Justify the importance of its theory. 2+5+3=10

(b) *(i)* Describe and explain *L-S* coupling. Under what condition does it hold?

(ii) Under what condition *L-S* coupling breaks down and what kind of new coupling takes place?

(iii) Describe *J-J* coupling. Illustrate *L-S* and *J-J* coupling with the help of vector diagram. 3+3+4=10

(Continued)

Or

Using the physical constants given below, calculate the following for hydrogen atom : 2+3+3+2=10

(i) Velocity of an electron in the ground state

(ii) Radius of Bohr orbit in the ground state

(iii) Time taken by the electron to transverse first orbit

(iv) Rydberg constant

$C = 1\cdot6\times10^{-19}$ C, $m = 9\cdot1\times10^{-31}$ kg

$h = 6\cdot6\times10^{-34}$ J-s, $c = 3\times10^8$ m/s

$\varepsilon_0 = 8\cdot86\times10^{-12}$ $C^2/N-m^2$

(c) *(i)* Enumerate briefly the theory of Raman effect.

(ii) Why are the Stokes lines brighter than the anti-Stokes lines?

(iii) Compare Raman spectra with infrared spectra. 4+3+3=10

(d) What is Zeeman effect? Draw a neat diagram to illustrate the Zeeman splitting of D_1 and D_2 lines of sodium. What is the difference between normal and anomalous Zeeman effect? Write the Zeeman shift in terms of wavelength and e/m in terms of Zeeman shift. 2+3+3+2=10

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2018

PHYSICS

(Major)

Paper : 5.3

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

GROUP—A

(Quantum Mechanics)

(*Marks* : 40)

1. Answer any *four* questions as directed : 1×4=4

(a) Select the correct answer :

All the radiation laws can be shown to be special care of

(i) Wien's law

(ii) Rayleigh-Jeans law

(iii) Planck's law

(iv) Stefan-Boltzmann law

(b) Which statement is correct?

(i) Phase velocity (v_p) of light wave is independent of λ in vacuum.

(ii) Phase velocity of matter depends on λ in vacuum.

(iii) Phase velocity of matter wave is independent on λ in vacuum.

(iv) Phase velocity of light wave is dependent on λ in vacuum.

(c) What is the ground-state energy of a linear harmonic oscillator?

(d) Show that

$$\left[x, \frac{\delta^2}{\delta x^2}\right] = -2\frac{\delta}{\delta x}$$

(e) What is the total number of energy level (or degeneracy) for nth state of hydrogen atom?

2. Answer any *three* questions : 2×3

(a) A radio station operates at frequency of 103·7 Hz with a power output of 200 kW. Determine the rate of emission of quanta from the station.

(b) What is the physical significance of the wave function $\psi(x, t)$?

(c) Assume the uncertainty in the location of a particle is equal to its de Broglie wavelength. Show that the uncertainty in the velocity is equal to its velocity.

(d) What is quantum mechanical tunnelling? Under what condition, the transmission coefficient $T = 1$?

(e) Draw the wave function of a particle in a box of infinite depth.

3. Answer any *four* questions : $5\times4=20$

(a) The energy distribution of blackbody radiation is given by Planck's law :

$$\rho(\lambda T) = 8\pi hc/\lambda^5 \frac{1}{\exp\left(\frac{hc}{\lambda kT}\right)-1}$$

Show that for long wavelength

$$\rho(\lambda, T) \to 8\pi kT/\lambda^4$$

and for short wavelength

$$\rho(\lambda T) \to 8\pi hc/\lambda^5 \exp\left(\frac{-hc}{\lambda kT}\right)$$

What is Planck's quantum hypothesis? Mention one experiment for determining Planck's constant h. $3+1+1=5$

(b) An α-particle is accelerated through a potential difference of 2000 volts. What is the wavelength of the associated de Broglie wave?

Given, mass of the proton = $1 \cdot 67 \times 10^{-27}$ gms

Planck's constant $h = 6 \cdot 62 \times 10^{-27}$ erg sec

(c) (i) State and explain Heisenberg uncertainty principle.

(ii) Give an account of the γ ray microscope experiment. 2+3=

(d) Explain the need for differential wave equation. Starting from the wave equation and introducing energy and momentum of the particle, obtain three-dimensional Schrödinger equation in time-dependent form. 2+3=

(e) (i) What is one-dimensional potential step?

(ii) A particle of mass m is moving in one-dimensional potential given by

$$V = \begin{cases} 0 & \text{for } x < 0 \\ v_0 & \text{for } x > 0 \end{cases}$$

If energy E of the incident particle is greater than v_0, then calculate the coefficients of refraction and transmission. 2+2

(Continue

4. Answer any *two* questions : 5×2=10

(a) (i) What is an observable corresponding to a quantum mechanical system?

(ii) Establish the relation

$$[L_x, L_y] = i\hbar L_z;\ [L^2 L_z] = 0$$

where the notations have their usual meanings. What conclusion about the eigenfunction of the operators involved can be shown from those relation? 1+4=5

(b) Discuss the wave mechanics of the electron in a hydrogen atom in a spherically symmetric potential and derive the energy state and energy function. 2+3=5

(c) Briefly discuss G. P. Thomson's experiment of electron diffraction, and its significance for quantum theory. 5

(Turn Over)

GROUP—B

(Astrophysics)

(*Marks* : 20)

5. Answer any *three* from the following : 2×3=

(a) Draw a neat diagram of the celestial sphere showing a star in northern hemisphere, the celestial equator hour angle and the right ascension of the star.

(b) If one P-P chain transform $4{\cdot}8\times10^{-29}$ kg, then how many reaction cycles must produce the total transformed mass per second?

(c) What is universal time? Express 2165 sidereal days in terms of mean solar days.

(d) What do you mean by color index? What is the declination (δ) at celestial pole and celestial equator? 1+1

(e) Calculate the temperature of Sun from the following data :

$$\lambda_m T = 0{\cdot}287,\ \lambda_m = 4753\ \text{Å}$$

(Continue

6. Answer any *two* of the following : 4×2=8

(a) How are the spectra classified? What are the various spectral classes? Show that the colour of a star defines a spectral class. 1+1+2=4

(b) What is the main process that creates energy in solar system? Discuss P-P cycle. What is the end product of CNO cycle reaction under equilibrium condition? 1+2+1=4

(c) A star has a proper motion of 10 arc second per year. It is about 2 per sec away. The star radial velocity is measured to be 100 km/sec, i.e. it is moving towards the earth. Calculate star's space velocity. 4

7. Write short notes on any *two* of the following : 3×2=6

(a) Sidereal time

(b) Pulsars

(c) H-R diagram

(d) Black hole

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2018

PHYSICS

(Major)

Paper : 5.4

(Electronics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Answer the following questions very briefly : 1×7=7

(a) What is meant by race-around condition in flip-flop?

(b) What is surface leakage current in a junction diode?

(c) The basic principle of a power amplifier does not violate the law of conservation of energy. Explain.

(d) What is current gain of a transistor?

(e) In an amplitude modulation, the value of modulation index m_a is equal to 1. What is the physical meaning of it?

(f) What is the condition that must be satisfied in order to receive the maximum power by a two-terminal network from another network?

(g) There are two basic conditions for oscillation in a feedback amplifier. What are these basic conditions?

2. Answer the following questions : 2×4=8

(a) Distinguish between Zener breakdown and Avalanche breakdown in semi-conductor diodes.

(b) Determine the current I_D and the voltage v_0 in the circuit of Fig. 1, if the voltage drop across the diode is 0·7 volt.

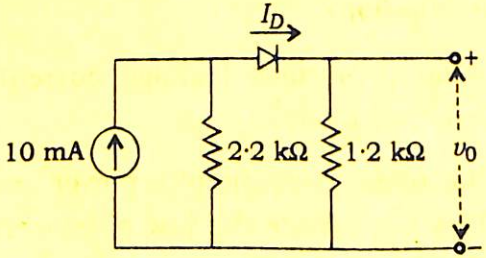

Fig. 1

(c) What could be the possible reasons for reduction in voltage gain of transistor *R-C* coupled amplifier at high frequency?

(Continue

(d) Mention one advantage and one disadvantage of single sideband transmission.

3. What do you mean by a clamping circuit? Draw the circuit diagram of a d.c. restorer. How does the circuit function? 1+2+2=5

Or

Explain why half-wave rectifier is called a poor device for rectification. Derive an expression for efficiency of such rectifier. 2+3=5

4. What is the basic principle of power amplifier? Draw the circuit diagram of a class *B* push-pull power amplifier using power transistor and derive an expression for the efficiency. What is the percentage of maximum efficiency? 1+3+1=5

Or

How can a transistor be considered as a two-port of four-terminal device? What are the variables related to input and output ports in case of a transistor? Establish the relations of *h* parameters with these variables for small input a.c. signal and hence draw the *h* parameter a.c. equivalent circuit. 1+2+2=5

(Turn Over)

5. Transform the circuit in Fig. 2 into Thevenin's equivalent circuit, where R_L is load resistance. Calculate the Thevenin's equivalent impedance and voltage. Draw the Norton's equivalent circuit. 2+2+1=5

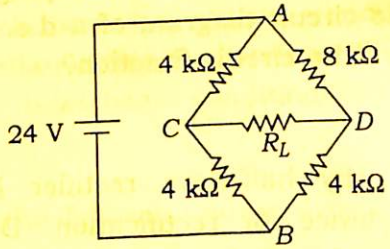

Fig. 2

6. Answer any *two* questions from the following : 5×2=10

(a) Convert the decimal numbers $128 \cdot 25_{10}$ and $100 \cdot 75_{10}$ to its binary equivalent and find the difference using 2's complement method. Add binary numbers $1100 \cdot 11_2$ and $1011 \cdot 01_2$. Verify the result by converting them to decimal numbers. 3+1+1=

(b) Define the critical frequency of an ionospheric layer. Show that the critical frequency f_c is related to the peak electron concentration N_p of the reflecting layer by $f_c = 9\sqrt{N_p}$ (in SI unit). 2+3

(Continue

(c) Fig. 3 shows an OP-AMP circuit with capacitor C in between inverting input and output. Express v_0 in terms of v_1 and v_2. 5

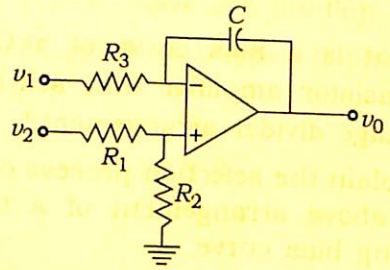

Fig. 3

(d) If an amplifier is to be unstable and oscillate it must satisfy the Nyquist criterion. What is Nyquist criterion? Explain its significance. 5

7. Answer any *two* questions from the following : 5×2=10

(a) Define ASK, FSK and PSK methods of digital communication. Draw the diagrams of any two of them in response to a modulating signal. 3+2=5

(b) What are the different types of CRO? Lissajous figures can be employed to measure the phase difference between two signals. Briefly explain how this is measured. 2+3=5

(Turn Over)

(c) What is amplitude modulation? Show that in amplitude modulation two sidebands are equispaced with respect to carrier frequency. 1+4=5

(d) What is a bias curve of a CE mode transistor amplifier with self-bias and voltage divider arrangement?

Explain the selection process of Q point in above arrangement of a transistor using bias curve.

8. Answer any *two* questions from the following : 5×2=10

(a) What is discriminator? What are the processes for FM wave detection? Give a sketch of frequency response curve of the Foster-Seely detector. 1+3+1

(b) Show that NOR gate is equivalent to bubbled AND gate. IC 7400 is a Quad 2-input NAND gate. It is possible to obtain AND, OR, NOT gates from this IC. How? 2+3

(c) What is an integrated circuit? Describe the photolithographic etching process used in IC fabrication. 1+4

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

(i) Microprocessor

(ii) Master slave J-K flip-flop

(iii) Function of L-type LC filter

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