2016

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) Find the real part of $\frac{1+z}{1-z}$.

(b) What is the argument of $-3i$?

(c) Define pole and residue.

(d) Find the principal value of i^i.

2. *(a)* 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

(b) Obtain the modulus of the complex number $\frac{1-i}{1+i}$. 2

3. *(a)* State De Moivre's theorem. 2

(b) Using De Moivre's formula, evaluate

$$(\cos 20^\circ + i \sin 20^\circ)^9$$ 2

4. *(a)* Define equivalent contour. 2

(b) Verify if the function $f(z) = z$ is analytic. 4

Or

(i) Determine if the function e^{iz} is analytic. 2

(ii) Prove that

$$\left(\frac{z_1}{z_2}\right) = \arg z_1 - \arg z_2$$ 2

5. *(a)* Check the analyticity and hence find the derivative of the function $f(z) = \sin z$. 5

Or

Find Taylor series expansion about the origin for $f(z) = \ln(1+z)$. 5

(b) Find Laurent expansion for the function $f(z) = \frac{\sin z}{z^4}$ about $z_0 = 0$ and hence classify the singularity and calculate the residue. 5

Or

State and prove Cauchy's integral theorem. 5

GROUP—B

(Classical Mech

(*Marks* : 3(

6. Answer the following ques

(a) State the principle of

(b) Define central force general expression fo

(c) Define Hamiltonian o

7. Answer any *three* of the foll

(a) Explain with exampl holonomic constraint

(b) Show that angular constant of central fo

(c) In a two-body system, the ratio 4 : 1. The m body is 10^{-28} g. Esti mass of the system.

(d) What are generalized generalized velocities

8. Answer any *four* of the follo

(a) Show that a two-b problem can be red problem.

(b) Find the equation of motion of a system with the given Lagrangian

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

where α and ω are constants.

(c) Obtain the general differential equation of a cental orbit.

(d) Show that if the Lagrangian function does not contain the time explicitly, the total energy of the conservative system is conserved.

(e) Construct the Lagrangian and hence equation of motion of a simple pendulum placed in a uniform gravitational field.

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

9. Establish Hamilton's canonical equations. 5

Or

Obtain Lagrange's equation of motion for a conservative system using D'Alembert's principle. 5

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2016

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 : 1×7=7

(a) The ratio of e/m of a proton to e/m of an electron is

(i) 1837

(ii) $\frac{1}{1837}$

(iii) $\frac{1}{1000}$

(iv) None of the above

(b) No two electrons in an atom will have the four quantum numbers identical. This statement is known as

(i) Heisenberg's uncertainty relation

(ii) Selection rule

(iii) Pauli's exclusion principle

(iv) None of the above

(c) The energy levels of a multi-electron atom depend on

(i) n

(ii) l

(iii) both n and l

(iv) None of the above

(d) The formation of electronic spectrum is due to

(i) change in electronic energy

(ii) change in vibrational energy

(iii) change in rotational energy

(iv) All of the above

(Continued)

(e) If a photon has a w the Compton wavele the photon is

(i) $E = \frac{1}{2} m_0 c^2$

(ii) $E = m_0 c^2$

(iii) $E = \frac{h}{m_0 c}$

(iv) None of the abo

(f) The rotational energy is

(i) equally spaced

(ii) unequally space

(iii) Both of the abo

(g) Matter waves

(i) are longitudinal

(ii) are electromagne

(iii) always travel wit

(iv) show diffraction

2. Answer any *four* of the fo

(a) Calculate the time tak to traverse the firs

hydrogen atom. Given,

Electronic charge

$e = 1 \cdot 6 \times 10^{-19}$ coulomb

Radius of the first orbit

$r_1 = 0 \cdot 526 \times 10^{-10}$ m

Velocity of electron in first orbit

$= 2 \cdot 19 \times 10^{6}$ m / sec

(b) Show that in a state of principal quantum number n, the maximum number of electron is $2n^2$.

(c) What is Lande g-factor? Use it to express the anomalous magnetic splitting of *D* lines of sodium.

(d) Show that it is not possible for a photon to transfer its entire energy to the recoil electron in Compton effect.

(e) What is the physical quantity expressed by the unit of electronvolt? Give the relation between electronvolt and joule.

(f) What is space quantization? Explain briefly.

(Continued)

3. Answer *(a)* and any *two* fr

(a) Differentiate betwee
Paschen-Back effect

(b) Describe the impr
Sommerfeld in Boh
How could it explai
of hydrogen spectra

(c) With the exciting l
Stokes-Raman line
observed at 2612
wavelength of antiSt

(d) Write a short note
following :

(i) excitation and io

(ii) Moseley law

(iii) L-S and J-J cou

4. Answer *(a)* and *(b)* and an
and *(e)* :

(a) Draw a neat and labe
apparatus used b

determination of q / M of positive rays. Show mathematically that positive ions with the same q / M value trace out a parabola. Explain how the mass of an isotope can be determined from the parabolic traces. 2+6+2=10

(b) Explain the emission of characteristic X-ray. Draw an energy-level diagram for K_α, K_β, L_α, L_β lines of characteristic X-ray spectrum. How does the frequency of characteristic X-ray depend upon the atomic number of element? 3+4+3=10

(c) What are the characteristics of the Raman effect? Discuss the theoretical explanation of Raman effect. Write the experimental method to obtain Raman spectrum. 3+5+2=10

(d) What is normal Zeeman effect? Give the theory of normal Zeeman effect and show how you can determine the value of specific charge (e / m) of electron with its help. 2+5+3=10

(Continued)

(e) What is Rayleigh sca
lamps in cars use
Mention two dif
Rayleigh scatterin
scattering. A phot
undergoes Compton
an electron by an an
energy of the scatte

$$\frac{h\nu}{1+\frac{h\nu}{m_0c^2}(}$$

where m_0 is the
electron and c is th
vacuum.

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2016

PHYSICS

(Major)

Paper : 5.3

(Quantum Mechanics and Astrophysics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

Write the answers to the two Groups in separate books

GROUP—A

(Quantum Mechanics)

(*Marks* : 40)

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

(a) Mention one experiment which demonstrates the wave nature of matter.

(b) Calculate the energy of a radiowave photon of wavelength $\lambda \approx 10$ m.

(c) Which one of the following is a true statement for photoelectric effect?

(i) Kinetic energy of ejected electrons depends on the intensity of incident light.

(ii) Kinetic energy of ejected electrons depends linearly on the frequency of an incident light.

(iii) Kinetic energy of ejected electrons is always zero.

(iv) It proves wave nature of light.

(Choose the correct option)

(d) Show that de Broglie wavelength of a relativistic particle of mass m moving with velocity v can be approximated as

$$\lambda \approx \frac{h}{mv} - \frac{hv}{2mc^2}$$

(e) The uncertainty of position of a particle of mass m inside a black hole of mass M is about $\Delta x \approx 2GM/c^2$. Here G is Newton's gravitational constant and c is the velocity of light. Calculate the approximate energy of the particle.

(Continued)

2. Answer any *two* questions

(a) Calculate the Compt electron. An X-ray ph $\lambda_0 = 1$ Å is incident which is initially at r scattered at angle $\theta \simeq$ direction. Also cal wavelength of the electron mass $m \simeq 9 \cdot$

(b) The photoelectric wo lithium is 2·3 eV. Fi frequency ν_t. If ul wavelength $\lambda = 3000$ lithium surface, calcu kinetic energy of the

(c) Energy of a particle of the gravitational fiel given by

$$E = \frac{p^2}{2m} - \frac{GM}{r}$$

Write down the Schrödinger equation The wave function of defined as $\psi(r) = f\frac{e^{ik}}{r}$

Obtain the probabili particle at r. Here complex number.

3. Answer any *four* questions : 5×4=20

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

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

Show that for long wavelength

$$\rho(\lambda, T) \rightarrow \frac{8\pi kT}{\lambda^4}$$

and for short wavelength

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

What is Planck's quantum hypothesis? Mention one experiment for determining Planck's constant, h. 1½+1½+1+1=5

(b) Show that the ratio of kinetic energy of an alpha particle of mass m_α to that of a proton of mass m_p having same de Broglie wavelength of 1 Å is

$$\frac{KE_\alpha}{KE_p} = \frac{m_p}{m_\alpha}$$

Thermal neutrons in
have kinetic energy of
the Boltzmann const
absolute temperatur
energy in eV and de B
of a thermal ne
temperature $T \simeq 300$ K

(c) What is the basic d
Davisson-Germer expe
Thomson's experime
diffraction? Show
wavelength of an elect
charge e, accelerated

$$\lambda = \frac{h}{\sqrt{2m}}$$

What is the signific
diffraction experiment
of a phenomenon wh
particle nature of ligh

(d) The energy of a par
moving in a gravitatio
M is given by

$$E = \frac{p^2}{2m} -$$

Suppose radius of the orbit satisfies the uncertainty principle $rp \simeq \hbar$. Show that energy of the particle becomes

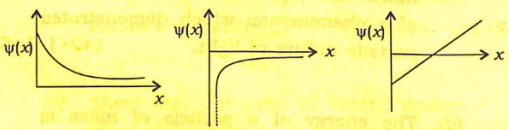
$$E = \frac{\hbar^2}{2mr^2} - \frac{GMm}{r}$$

Also, show that this energy has a minimum at $r = r_0 = (\hbar^2 / GMm^2)$. Obtain the minimum value of energy E_{min}. 1+2+2=5

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

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

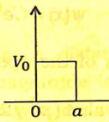
(a) Which one of the following graphs represents a well-behaved wave function in the range $x \in [0, \infty]$?



Find out the normalization constant A for the wave-function $\psi(x) = A \sin\left(\frac{n\pi x}{2a}\right)$ in the range $-a \le x \le a$. 1+4=5

(Continued)

(b) Consider a rectangula as shown in the figur



so that $V(x) = \begin{cases} 0, \\ V_0, \\ 0, \end{cases}$

The wave functions regions are given by

$$\psi(x) = \begin{cases} Ae^{ikx} + \\ Ce \end{cases}$$

(i) Identify incident wave and transm particle comes fr

(ii) Show that the p densities are

$$j = \begin{cases} \frac{\hbar k}{m}(|A|^2 - \\ \frac{\hbar k}{m} \end{cases}$$

(iii) Write down the reflection coeffici mission coefficien

(c) How do you represent dynamical variables in quantum mechanics? Show that $\psi(x) = Ce^{ipx/\hbar}$ is an eigenfunction of the operator $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$ having eigenvalue $(p^2/2m)$. What is the form of the wave function for a free particle? 1+3+1=5

GROUP—B

(Astrophysics)

(*Marks* : 20)

5. Answer any *three* from the following : 2×3=6

(a) What is the angle of inclination between the ecliptic and the celestial equators? A star has right ascension $\alpha = 6^h51^m$ and another star has $\alpha = 12^h52^m$. Which one of them rises earlier? 1+1=2

(b) Draw a neat diagram of the celestial sphere showing a star in northern hemisphere, the celestial equator, hour angle, observer's meridian and the right ascension of the star. 2

(c) The parallax angle of t
is 0″.285. Calculate it

(d) A star is at a distar
apparent magnitude is
absolute magnitude.

(e) Define local sidereal
ascension (α) and declir
are given as (18^h51^m1
which hemisphere shou
observing the star?

6. Answer any *two* of the follo

(a) What is the basis of H-I
stars? Display the ra
temperatures of *O*-, *B*- a
In the HR diagram, j
with 'extremely low t
large luminosity' ar
'extremely high tempe
luminosity' can exist.

(b) Out of pp-chain and CNO cycle, which one dominates the energy production in sun-like stars? What happens to the core of a star once hydrogen burning is exhausted? Discuss how a red giant forms. 1+1+2=4

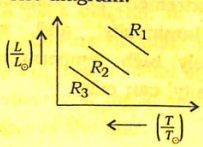
(c) Show that luminosity (L), radius (R) and surface temperature (T) of a star are related as

$$\left(\frac{L}{L_\odot}\right)=\left(\frac{R}{R_\odot}\right)^2\left(\frac{T}{T_\odot}\right)^4$$

where $L_\odot$, $R_\odot$ and $T_\odot$ are corresponding quantities for the sun.

The adjacent figure shows HR diagram with three straight lines across the main sequence, representing stars of radii R_1, R_2 and R_3. Which of the three lines represents the biggest stars?

Show the evolutionary track of a sun-like and a massive, luminous star in the HR diagram. 1+1+2=4



(Continued)

7. Write short notes on following :

(a) Spectral classificatio

(b) Celestial coordinates

(c) *PP*-chain and CNO c

(d) Trigonometric paralla

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2016

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 briefly : 1×7=7

(a) Why are semiconductor diodes called non-linear device?

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

(c) What should be the biasing of emitter-base and collector-base junctions of a transistor to operate it in active region?

(d) In class A transistor amplifier, what proportion of the input-cycle the transistor conducts?

(e) What should be the value of input resistance of an ideal operational amplifier?

(f) What is the cut-off frequency beyond which the ionosphere does not reflect electromagnetic waves?

(g) In AM transmission, what proportion of total power is carried away by the carrier wave for 100% depth of modulation with 600 watts of total power?

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

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

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

(c) What do you unders circuits? Give one ex

(d) What are the relativ disadvantages of neg transistor amplifiers?

3. Draw the circuit diagra emitter transistor amplif emitter-biasing configura advantages of self-biasir the relationship betwee current amplification facto base current amplificatior

4. Explain why half-wave r poor device for rectific expression for efficiency c

Or

Draw the symbolic re proper biasing for each electronic devices when i

(a) Zener diode

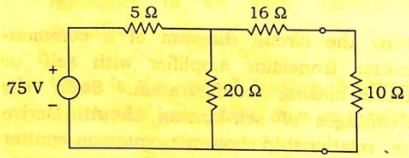
(b) Varactor diode

(c) LED

(d) Photodiode

How does LED differ f junction diode?

5. Transform the following circuit into Thevenin's equivalent circuit and hence find the value of *(a)* Thevenin's equivalent impedance, *(b)* Thevenin's equivalent voltage source, and *(c)* load current and power in 10 Ω resistance : 5



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

(a) Derive the *h*-parameters of transistor. Draw the *h*-parameter equivalent circuit of transistor CE amplifier.

(b) Draw the block diagram of a feedback amplifier and find an expression for overall gain of such amplifier. Define positive and negative feedback.

(c) What are the fundamental differences in operation of class A, class B and class C amplifiers explaining with the help of dynamic curves. Which one of them has maximum power conversion efficiency? Draw the circuit diagram of a push-pull amplifier. 3+1+1=5

(Continued)

(d) The open-loop gain amplifier is 200 and f $\beta = 0 \cdot 5$. Assuming ne determine—

(i) desensitivity factor

(ii) close-loop gain.

If the open-loop gain cl find the percentage (% close-loop gain and its

7. Answer any *two* ques following :

(a) What are the character operational amplifier? concept of virtual operational amplifier. integrator and different operational amplifier.

(b) Give the basic non-i of an operational ampl the expression for v such circuit. Find the non-inverting operati for $V_{in} = 5 \cdot 5$ mV, R $R_1 = 10$ kΩ.

(c) State why NAND and NOR gates are called universal gate. Give the truth table of NAND and NOR gates. Draw the diagram to show how OR, AND and NOT gates can be constructed using NAND gates only. 1+1+3=5

(d) Convert the decimal numbers 256·50 and 128·25 to its binary equivalent and find the difference using 2's complement method. Add the binary numbers 1011·10 and 111·01. Verify the result by converting them to decimal equivalent. 2+2+1=5

(e) Define FSK and PSK methods of digital transmission. Draw the block diagram of any one of them. 4+1=5

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

(a) Draw the block diagram of the analog communication system. State with the help of diagram any one method of generation of AM signal. Write the advantages of FM transmission over AM transmission. 1+2+2=5

(Continued)

(b) A 400 watts carrie modulated to a d Calculate the total p AM and SSB techniq power saving (in wa for SSB compared to

(c) (i) Draw the block d heterodyne AM re

(ii) The instantaneou AM wave is given

$V_{AM} = 20(1 + 0 \cdot 5\sin 2\pi \times 10^3$

Find the amplitud of two sidebands.

(d) Write short note on following :

(i) Norton's theorem

(ii) Multivibrator

(iii) *R-S* flip-flop

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