[This question paper contains 4 printed pages.]

Sr. No. of Question Paper : 1792 **GC-3** **Your Roll No.....**

Unique Paper Code : 32221101

Name of the Paper : Mathematical Physics – I

Name of the Course : **B.Sc. (Hons.) Physics : Choice-based Credit System**

Semester : I

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.

1. (a) By calculating the Wronskian of the functions e^x, xe^x and e^{-x}, check whether the functions are linearly dependent or independent. (4)

   (b) Solve the inexact equation

   $$(y^4 + 2y)dx + (xy^3 + 2y^4 - 4x)dy = 0 \quad (5)$$

   (c) Solve the differential equation

   $$\frac{d^2y}{dx^2} - y = e^x \cos x \quad (6)$$

2. (a) Solve the differential equation

   $$\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = e^{2x} + \sin 3x \quad (8)$$

   (b) Solve the differential equation using method of undetermined coefficients

   $$\frac{d^2y}{dx^2} + \frac{dy}{dx} = x^2 + 2x + 4 \quad (7)$$

P.T.O.

3. (a) Solve the differential equation

$$\frac{d^2y}{dx^2}+3\frac{dy}{dx}=1-9x^2$$

given $y(0) = 0$ and $y'(0) = 1$. (8)

(b) Solve the differential equation using method of variation of parameters

$$\frac{d^2y}{dx^2}+a^2y = \text{cosec } ax$$ (7)

4. (a) Find

$$\frac{d}{dt}\left(\vec{V}.\frac{d\vec{V}}{dt}\times\frac{d^2\vec{V}}{dt^2}\right)$$

where $\vec{V}$ is a function of t.

(b) Find the Jacobian $J\left(\frac{x,y,z}{u,v,w}\right)$ of the transformation

$u = x^2 + y^2 + z^2$, $v = x^2 - y^2 - z^2$ and $w = x^2 + y^2 - z^2$.

(c) If $\vec{v} = \vec{w} \times \vec{r}$, find whether $\vec{v}$ is irrotational or not, where, $\vec{w}$ is a constant vector and $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$.

(d) Find $\vec{\nabla} \times \left(f(r)\vec{r}\right)$, where $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$.

(e) Find the directional derivative of a scalar function $\phi = 2xz - y^2$ at the point (1, 3, 2) in the direction of $xz\hat{i} + yz\hat{j} + xy\hat{k}$. (3×5=15)

5. (a) Prove that

$$\left(\vec{B}\times\vec{C}\right).\left(\vec{A}\times\vec{D}\right)+\left(\vec{C}\times\vec{A}\right).\left(\vec{B}\times\vec{D}\right)+\left(\vec{A}\times\vec{B}\right).\left(\vec{C}\times\vec{D}\right)=0 \qquad (5)$$

(b) Evaluate

$$\vec{\nabla}.\left[r\vec{\nabla}\left(\frac{1}{r^3}\right)\right]$$

where $r^2 = x^2 + y^2 + z^2$. (5)

(c) Evaluate

$$I = \oint_C \left(3x-8y^2\right)dx + (4y-6xy)dy$$

where C is the boundary of the region bounded by $x = 0$, $y = 0$ and $x + y = 1$. (5)

6. (a) Verify Stoke's theorem when

$$\vec{F} = \left(2xy - x^2\right)\hat{i} - \left(x^2 - y^2\right)\hat{j}$$

where C is the boundary of the region enclosed by $y^2 = x$ and $x^2 = y$. (10)

(b) Using Gauss Divergence theorem, prove that

$$\iiint_V \vec{\nabla}\times\vec{F}\,dV = \iint_S d\vec{S}\times\vec{F}$$

where V is the volume enclosed by surface S. (5)

7. (a) Derive an expression of curl of a vector field in orthogonal curvilinear coordinates. Express it in spherical coordinates. (6)

(b) Evaluate $\iiint_V (y^2 + z^2)\,dV$, where V is the volume bounded by the cylinder $x^2 + y^2 = a^2$ and the planes $z = 0$ and $z = h$. (6)

(c) Define the Dirac Delta function and establish

$$\int_{-\infty}^{+\infty} f(x)\delta'(x)\,dx = -f'(0)$$

(3)

[This question paper contains 4 printed pages.]

Sr. No. of Question Paper : 1793 **GC-3** **Your Roll No.....**

Unique Paper Code : 32221102

Name of the Paper : Mechanics

Name of the Course : **B.Sc. (Hons.) Physics : Choice Based Credit System**

Semester : I

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **Five** questions.
3. Question No. **1** is compulsory.
4. Use of Non-programmable scientific calculator is allowed.

1. Attempt **any five** of the following questions :

(i) A galaxy moves away from the earth at 0.2c. What is the natural wavelength of a spectral line whose wavelength measured in a laboratory is 600 nm ?

(ii) Calculate the minimum velocity with which a body may be projected so that it may become a satellite of the earth assuming it takes a circular orbit around earth.

(iii) A particle executing a S.H.M. has a maximum displacement of 4 cm and its acceleration at a distance of 1cm from its mean position is 3 cm/s^2. What will its velocity be when it is at a distance of 2 cm from its mean position ?

P.T.O.

(iv) Two objects, one initially at rest, undergo a one dimensional elastic collision. If half the kinetic energy of the initially moving object is transferred to the other object, what is the ratio of their masses ?

(v) Show that the force field $F = (y^2z^3 - 6xz^2)i + 2xyz^3j + (3xy^2z^2 - 6x^2z)\,k$ is a conservative force field. Hence, find the work done in moving a particle from the point A (–2, 1, 3) to (1, –2, –1) in the given force field.

(vi) Find the centre of mass of a homogeneous semi-circular plate of radius R.

(vii) Distinguish between inertial and gravitational mass of a body.

(viii) A hoop of radius 100cm and mass 19 Kg is rolling along a horizontal surface, so that its centre of mass has a velocity of 20 cms^{-1}. How much work will have to be done to stop it ?

(5×3)

2. (i) Setup the differential equation of motion of a damped harmonic oscillator subjected to a sinusoidal force, $F = F_0 Sin\omega t$. Discuss its steady state solution and obtain an expression for its maximum amplitude.

(ii) What is sharpness of resonance ? Explain the effect of damping on sharpness of resonance.

(12,3)

3. (i) What is reduced mass ? Reduce two body problem to one body problem and obtain equation of motion for equivalent one body problem for two masses.

(ii) A uniform sphere of mass M and radius R and a uniform cylinder of mass M and radius R are released simultaneously from rest at the top of an inclined plane. Which body reaches the bottom first if both roll without slipping ? Find the velocity of both at the bottom.

(9,6)

4. (i) What are Inertial and Non-Inertial frames ? Explain giving an example of each.

(ii) How does the rotation of Earth about its axis affect the acceleration due to gravity experienced by a body at rest at a point on the surface of earth ? Support your answe with a suitable derivation and diagram. (6,9)

5. (i) Deduce the mathematical expression for the law of addition of relativistic velocities. Hence, show that in no case the resultant velocity of a material particle can be greater than c and that the Lorentz velocity transformation equations reduce to Galilean ones for values of $v << e$.

(iii) A spaceship moving away from the earth with velocity 0.6c fires a rocket (whose velocity relative to the spaceship is 0.7c),

(a) away from the earth

(b) towards the earth.

What will be the velocity of the rocket, as observed from the earth in the two cases. (10,5)

6. (i) A projectile launched at an angle θ to the horizontal reaches a maximum height h. Show that its horizontal range is $4h/\tan\theta$.

(ii) Prove that in the Centre of mass frame of reference, magnitude of velocities of the two particles remain unaltered in an elastic collision between them.

(iii) A head-on elastic collision between two particles with equal initial speeds v leaves the more massive particle at rest. Find the ratio of the particle masses. (6,4,5)

7. (i) Obtain expressions for gravitational potential at a point inside and outside a thin uniform spherical shell of radius R and mass M. Also depict your results graphically.

(ii) (a) Find the moment of inertia of a solid cylinder of length L, radius R and mass M about an axis passing through its centre and perpendicular to its geometrical axis.

(b) Calculate the radius of gyration of the solid cylinder of min 34, length 24 cm and radius 8 cm about an axis through its centre and perpendicular to its geometrical axis. (7,6,2)

This question paper contains **4** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **842**

Unique Paper Code : **222103** **G**

Name of the Paper : **PHHT-102 Mechanics**

Name of the Course : **B.Sc. (Hons) Physics**

Semester : **I**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all including

Question No. **1** which is compulsory.

1. Attempt any *five* of the following :

   (*a*) Find the position of the center of mass of a semi-circular wire of mass M and radius R.

   (*b*) An object of mass *m* lies at a distance *r* from the center of the Sun. It is to be ejected perpendicular to the direction towards the Sun. What speed should it be ejected with so that it acquires a parabolic orbit ?

   (*c*) Find the ratio of the radii of gyration of a solid disk of mass M and radius R spinning about an axis through its center and perpendicular to its plane and a solid sphere of the same mass and radius spinning about its diameter.

   (*d*) Prove that under the influence of a central force, the motion of a particle is always confined to a plane.

   (*e*) Show that the theoretical limiting values of Poisson's ratio are – 1 and 0.5.

P.T.O.

(*f*) A cosmic ray proton has energy 10^{13} MeV and travels across our Galaxy of size 10^5 light years. How long does it take to cross the galaxy in its own rest-frame ? Assume the rest mass of the proton is 10^3 MeV.

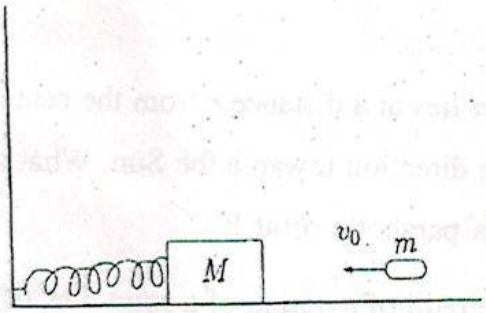
(*g*) Prove that the torque due to gravity on a rigid body about its center of mass is zero.

(*h*) Calculate the momentum of a photon of energy 1.5×10^{-18} Joules. 5×3=15

2. (*a*) Considering the flow of mass and momentum, carefully derive the equation of motion of a rocket, stating all assumptions and conventions. 5

(*b*) Solve this rocket equation for a constant gravitational field. Interpret this solution for how a rocket should burn its fuel in order to escape from Earth's gravity. Are this rocket equation and its solution applicable for a journey from Earth to Mars ? 3,1,1

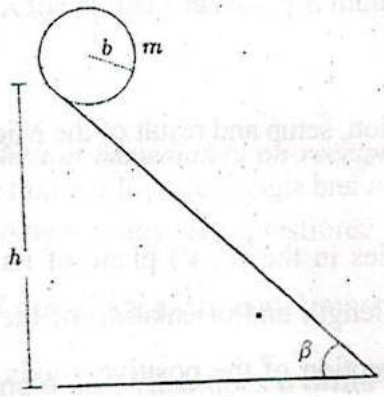
(*c*) A block of mass M is attached to a wall by a spring of spring constant k. A bullet of mass m is shot at the block with speed v_0. If the bullet gets embedded into the block, find the maximum compression in the spring. 5



3. (*a*) Derive an expression for the total angular momentum of an extended rigid body whose motion involves translation as well as rotation. Explain clearly why some terms survive and other terms vanish. For rotation about a fixed axis, obtain an expression for the component of angular momentum along the axis of rotation. Give the physical interpretation of each term in the final expression. 8

(*b*) Estimate the order of magnitude value of each term in the expression derived above for the Earth in motion around the Sun. (Assume $M_{Earth} = 6 \times 10^{24}$ kg, $R_{Earth} = 6400$ km, Sun-Earth distance = 150 million km). 2

(*c*) A uniform drum of radius *b* and mass *m* rolls without slipping on an inclined plane that makes an angle β with the horizontal. If the drum starts from rest, find the speed of its center of mass after it has descended a height *h*. 5



4. (*a*) Reduce the two-body problem for the motion of two masses interacting via a central force to a one-body problem. Obtain the one-body equation of motion in plane polar co-ordinates in terms of the reduced mass of the system. By considering the torque, prove that such motion must be confined to a plane. 7

(*b*) Give the expressions for the magnitude of angular momentum and the total energy (conserved quantities) in the above problem. By absorbing the tangential part of kinetic energy into U(*r*) potential energy, define an effective potential energy $U_{eff}(r)$. Sketch this effective potential energy in an energy diagram and qualitatively describe the different kinds of motion for different ranges of energy. 8

P.T.O.

5. (*a*) What are elastic constants of an elastic material ? Establish the relation between the elastic constants : Y (Young's Modulus), n (modulus of rigidity) and K (Bulk Modulus). 8

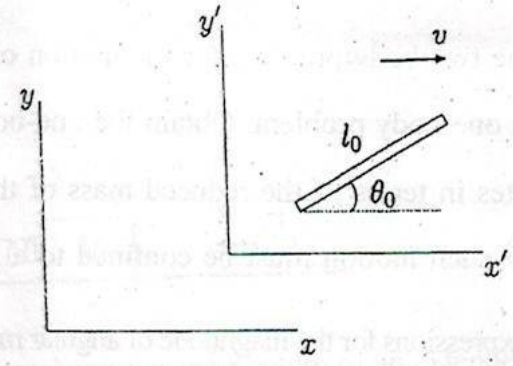
(*b*) Derive an expression for the rate of flow of a liquid through a capillary tube. 7

6. (*a*) What is an inertial frame of reference ? Derive the expression for Galilean Transformation equations for space-time coordinates. Show that acceleration is invariant under Galilean Transformation. 8

(*b*) Derive an expression for the time period of oscillation of the plane of a Foucalt pendulum when the pendulum is placed at a latitude of λ on Earth and the rotation angular frequency of Earth is Ω. 7

7. Describe the motivation, setup and result of the Michelson-Morley experiment and explain the physical interpretation and significance of the null result. 8

A rod of length l_0 lies in the (x', y') plane of its rest frame making an angle θ_0 with the x'-axis. What is the length and orientation of the rod in the lab frame (x, y) in which the rod moves in the direction of the positive x-axis with velocity v ? 7



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Roll No. | | | | | | | | | | | |

S. No. of Question Paper : 74

Unique Paper Code : 222363 G

Name of the Paper : **PHPT-303 : Physics-III Waves and Optics**

Name of the Course : **B.Sc. Physical Science/App. Physical Science Part-II**

Semester : **III**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any *five* questions.

All questions carry equal marks.

1. (*a*) What is a compound pendulum ? How does it differ from a simple pendulum and what are its advantages over a simple pendulum ?

   (*b*) Give the theory of compound pendulum. Show that there are four points on the pendulum having same time period. 5,10

2. (*a*) Obtain the equation of motion of a damped harmonic oscillator having one degree of freedom. Also derive its general solution.

   (*b*) Define logarithmic decrement, relaxation time and quality factor. Obtain a relation between them. 10,5

3. (*a*) Define degrees of freedom and normal co-ordinates.

   (*b*) Two identical simple pendulums of same mass '*m*' and length '*l*' are coupled by a linear spring of force constant '*k*'. Obtain normal co-ordinates and normal modes of their motion. 3,12

P.T.O.

4. (*a*) Derive the one-dimensional classical wave equation.

(*b*) What is the difference between division of wavefront and division of amplitude experiments in interference ? Explain by giving examples. 7,8

5. (*a*) What are Newton's rings and how are they formed ? Give the necessary theory. How would you use Newton's rings to measure wavelength of light ?

(*b*) In a Newton's rings experiment the diameter of the 15th dark ring is found to be 0.590 cm and that of the 5th ring is 0.336 cm. If the radius of the plano-covex lens is 100 cm, calculate the wavelength of light used. 10,5

6. (*a*) Deduce the expressions for intensity distribution in the diffraction pattern due to a plane transmission grating and hence obtain the grating equation.

(*b*) Calculate the minimum number of lines in a grating which will just resolve the two wavelengths 5890 Å and 5896 Å in its first order. 10,5

7. (*a*) Distinguish between Fresnel and Fraunhofer classes of diffraction.

(*b*) Explain Fresnel's division of a plane wavefront into half period zones. Show that the amplitude at a point due to the entire wavefront is approximately half of that due to the first zone alone. 5,10

8. (*a*) What are the conditions required to obtain a sustained interference pattern ?

(*b*) What is double refraction ? Define ordinary ray and extraordinary ray.

(*c*) What is Nicol prism and how is it used to produce polarised light ? 5,5,5

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **848**

Unique Paper Code : **222304** **G**

Name of the Paper : **Thermal Physics (PHHT-309)**

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **III**

Duration : **3 Hours** Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all,

including Question No. **1** which is compulsory.

All questions carry equal marks.

1. Attempt any *five* of the following : 5×3

(*a*) Show graphically the variation of Temperature with Entropy for a Carnot cycle.

(*b*) Find an expression for the work done in an adiabatic process.

(*c*) Obtain the relation :

$$F = U + T\left(\partial F/\partial T\right)_V.$$

(*d*) Define the principle of increase of entropy.

(*e*) Calculate the 'Lapse Rate' for dry air, taking M = 0.0029 kg/mole and $\gamma = 1.4$.

P.T.O.

(*f*) Calculate the coefficient of thermal conductivity of Helium at zero degree Celsius, taking

$M = 4$ kg/mole, $C_V = 12.5 \times 10^3$ Jkmole^{-1} K^{-1}, $\eta = 18.6 \times 10^{-6}$ Nsm^{-2}.

(*g*) Define third law of thermodynamics.

2. (*i*) Using first law of thermodynamics, derive the following relations : 3×3

(*a*) $dQ = C_V dT + \left[(\partial U/\partial V)_T + P\right]dV$

(*b*) $C_P = C_V + \left[(\partial U/\partial V)_T + P\right]V\alpha$

(*c*) $dQ = C_V dT + \left[(C_P - C_V)/V\alpha\right]dV$.

(*ii*) A cylinder contains 1 mole of oxygen gas at a temperature of 27°C and 1 atmospheric pressure. It is heated till its temperature becomes 127°C. Calculate : 3×2

(*a*) Work done by the gas

(*b*) Change in internal energy

(*c*) Heat transfer to the gas.

3. (*a*) Write Kelvin-Planck and Clausius statements of the second law of thermodynamics. 3

(*b*) Show that above statements are equivalent. 6

(*c*) State and prove Carnot's theorem. 6

4. (*a*) Calculate the entropy of 1 mole of perfect gas in terms of temperature and pressure. 5

(*b*) Using Carnot's theorem, prove the Clausius inequality. 4

(*c*) Calculate the increase in entropy when the temperature of 1 kg of ice is raised from $-10°C$ to $10°C$. Given that : 6

Specific heat of ice = 2.09×10^3 J/kg/K

Specific heat of water = 4.18×10^3 J/kg/K

Latent heat of ice = 3.35×10^5 J/kg.

5. (*a*) Define Thermodynamic potentials. 3

(*b*) Derive Maxwell's relations using thermodynamic potentials. 6

(*c*) Using Maxwell's relations, show that : 6

$$C_P - C_V = TV\alpha^2/K_T$$

where K_T is isothermal compressibility and α is volume expansivity.

6. (*a*) Using the Maxwell's law of distribution of molecular speed; derive expression for :

(*i*) Average speed

(*ii*) Most probable speed,

(*iii*) Root mean square speed. 6

(*b*) Derive an expression for coefficient of thermal conductivity of gases on the basis of kinetic theory. 5

(*c*) Prove : 4

$$V_{Average} \times (1/V_{Average}) = 4/\pi.$$

P.T.O.

7. (*a*) Describe experimentally the process of cooling due to adiabatic demagnetization. 4

(*b*) What are second order phase transitions ? Derive Ehrenfest's equations for second order phase transitions. 7

(*c*) Obtain van der Waals equations in terms of reduced parrameter P_r, V_r and T_r. 4

8. (*a*) Compare the p-v diagrams obtained from CO_2 in Andrews experiment with those obtained using van der Waals equations. 8

(*b*) What is Brownian motion ? Explain with example. 4

(*c*) Explain mathematically, the Joule-Thomson effect in terms of Deviation from Boyle's law and Joule's law. 3

This question paper contains 2 printed pages. *Your Roll No. .....*

Sl. No. of Ques. Paper : 947 **G**

Unique Paper Code : 251301

Name of Paper : **Digital Electronics (ELHT-301)**

Name of Course : **B.Sc. (Hons.) Electronics / Computer Science**

Semester : **III**

Duration : **3 hours**

Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Q. No. 1 is compulsory. Attempt five questions in all.
Use of scientific calculator is allowed.

1. (a) Given that $16_{10}=100_b$ find the value of b. 3

   (b) Implement a half adder using a 4×1 multiplexer. 3

   (c) Give the logic implementation of a 32×4 bit ROM using a decoder of suitable size. 3

   (d) Describe the Race around condition with reference to JK flip flop. 3

   (e) Define the terms:

   (i) Figure of Merit

   (ii) Noise Margin. 3

2. (a) Express the following functions as sum of Minterms and product of Maxterms:

   $F(A, B, C, D)= \overline{B}D+\overline{A}D+B\overline{D}$ 6

   (b) Given the 8-bit data word 01011011, generate the 12-bit composite word for the Hamming code that corrects and detects single errors. 5

   (c) Design a combinational circuit with three inputs x, y and z and three outputs A, B and C. When the binary input is 0, 1, 2 or 3, the binary output is two greater than the input. When the binary input is 4, 5, 6 or 7, the binary output is two less than the input. 4

3. (a) Design a 4 bit priority encoder with D_0 having lowest priority and D_3 having highest priority. 6

   (b) Using the Quine-McCluskey method, obtain the minimal expression for:

   $f=\sum m(6, 7, 8, 9)+d(10, 11, 12, 13, 14, 15)$. 5

   (c) Implement a half subtractor using a 2 to 4 line decoder. 4

P. T. O.

4. (a) A synchronous sequential machine has a single control input X, a clock and two outputs A and B. The clock triggers AB to change state from 00 to 01 to 10 to 11 and back to 00, if input X is 1 and the output remains in its present state if X is 0. Draw the state diagram, state table and implement using T flip-flops. 7

(b) Draw the circuit of a 4 bit parallel adder-subtractor using block diagram. 5

(c) Distinguish between combinational and sequential circuits. 3

5. (a) Design a type J-K counter that goes through states 0, 1, 2, 4, 0 ..... . Is the counter self-starting? Give the state diagram, state table and circuit diagram. 7

(b) Implement the logical expression for difference of a full subtractor using a 8×1 MUX. 4

(c) Convert an SR flip-flop to JK flip-flop using excitation table. 4

6. (a) Design a 4-bit BCD to gray code converter. 5

(b) Draw the block diagram of 4-bit Bidirectional shift register. 5

(c) Explain working of positive logic CMOS NAND gate. 5

7. (a) With the help of block diagram explain the working of successive approximation ADC. 6

(b) A 6-bit DAC has a step size of 50 mV. Determine the full scale output voltage and the percentage resolution. What would be the analog output if digital input is 100000? 5

(c) Distinguish between:

(i) SRAM and DRAM

(ii) PROM and EEPROM. 4

This question paper contains **4** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **1465**

Unique Paper Code : **2221301** **F-7**

Name of the Paper : **Mathematical Physics II (439)**

Name of the Course : **B.Sc. (H) Physics Admitted Previously under FYUP**

Semester : **III**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. **1** is compulsory.

1. Attempt any *five* questions : 3×5=15

(*a*) Show that an even function can have no sine terms in its Fourier expansion.

(*b*) Write Fourier sine series of function $f(t)$ having period 2T and find its Fourier coefficient.

(*c*) Write Legendre's Equation and show that :

$$P_n'(1) = \frac{1}{2} n\,(n+1).$$

(*d*) Show that :

$$J_{-\frac{1}{2}}(x) = \sqrt{\frac{2}{\pi x}} \cos x.$$

P.T.O.

(*e*) Reduce the following differential equations to Bessel equation :

$$x^2 \frac{d^2y}{dx^2} + x\frac{dy}{dx} + (kx^2 - n^2)y = 0.$$

(*f*) Evaluate :

$$\int_0^1 (x \ln x)^3 \, dx.$$

(*g*) Write three-dimensional Laplace's equation in spherical coordinates. Mention a physical problem involving such Laplace's equation.

2. An alternating current after passing through a rectifier has the form :

$$i(\theta) = \begin{cases} I\sin\theta & 0 < \theta < \pi \\ 0 & \pi < \theta < 2\pi \end{cases}$$

(*a*) Sketch its graph from -4π to 4π. 2

(*b*) State whether this function is odd, even or neither odd nor even. 1

(*c*) Find the Fourier series of the function. 12

3. (*a*) Obtain Parseval's Formula : 5

$$\int_{-l}^{l} [F(x)]^2 \, dx = l\left\{\frac{1}{2}a_0^2 + \sum_{n=1}^{\infty} \left(a_n^2 + b_n^2\right)\right\}$$

Assuming the Fourier series corresponding F(x) converges uniformly to F(x) in ($-l$, l) and the integral also exists.

(*b*) Obtain Fourier sine series for $f(x) = 1$ in $0 < x < \pi$ and deduce that : 10

$$\frac{\pi^2}{8} = 1 + \frac{1}{3^2} + \frac{1}{5^2} + \frac{1}{7^2} + \ldots\ldots$$

4. (*a*) Discuss the regular and irregular singular points of the following differential equation : 3

$$(1 + x^2)x^2 \frac{d^2y}{dx^2} + \frac{5dy}{dx} - y = 0.$$

(*b*) Using Frobenius method solve in series the Laguerre's differential equation : 12

$$x\frac{d^2y}{dx^2} + (1 - x)\frac{dy}{dx} + \lambda y = 0$$

Here λ is a constant.

5. (*a*) Prove that : 5

$$(n + 1)p_{n+1}(x) = (2n + 1)xP_n(x) - nP_{n-1}(x).$$

(*b*) Using (*a*) find $P_3(x)$, where $P_0(x) = 1$ and $P_1(x) = x$. 4

(*c*) Prove that : 6

$$\int_{-1}^{1} P_m(x)P_n(x)\,dx = 0 \quad \text{if } m \neq n.$$

6. (*a*) Verify that : 5

$$e^{\frac{x}{2}(t-\frac{1}{t})} = \sum_{n=-\infty}^{\infty} J_n(x)t^n.$$

(*b*) Using (*a*) show that : 2

$$J_n(0) = 0 \quad \text{for } n = 1, 2, 3, \ldots\ldots$$

P.T.O.

(*c*) Given : 3

$$\int_0^\infty \frac{x^{p-1}}{1+x}\,dx = \frac{\pi}{\sin p\pi} \qquad \text{where } 0 < p < 1.$$

Show that :

$$\Gamma(p)\Gamma(1-p) = \frac{\pi}{\sin p\pi}.$$

(*d*) Evaluate : 5

$$\int_0^\infty \frac{x\,dx}{1+x^6}.$$

7. A string is stretched and fastened to two points '*l*' apart. Motion is started by displacing the string in the form :

$$u = a\sin\frac{\pi x}{l}$$

from which it is released at time $t = 0$. Find the displacement $u(x, t)$ of any point at distance 'x' from one end and at any time 't'. 15

This question paper contains **4** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **1466**

Unique Paper Code : **2221302** **F-7**

Name of the Paper : **Digital System and Applications**

Name of the Course : **B.Sc. (Hons.) Physics/(II)/Admitted previously under FYUP**

Semester : **III**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all.

Question No. **1** is compulsory.

1. Answer any *five* of the following : 5×3

(*a*) Using Boolean Algebra prove that :

$$\bar{A}B + BC + AC = \bar{A}B + AC.$$

(*b*) What is an integrated chip ? Give *two* advantages and disadvantages of an IC.

(*c*) Add the decimal numbers 48 and 27 after converting each to its BCD code. Represent the answer in the BCD code.

(*d*) What is the function of the *Reset* and *Hold* signals in 8085 microprocessor.

(*e*) Implement 4 input NAND gates using 2-input NAND gates.

P.T.O.

(*f*) Realize F(ABC) = $\Sigma\, m(0, 1, 3, 4, 8)$ using an 8 to 1 multiplexer. Use only the block diagram of the multiplexer.

(*g*) A binary counter is being pulsed by a 256 KHz clock signal. The output frequency from the last flip-flop is 500 Hz. Determine the number of flip-flops used in the counter and the MOD number.

(*h*) Draw the truth-table of a full subtractor.

2. (*a*) Simplify the expression using Karnaugh-map and draw its logic circuit using NAND gates only :

$$f = \Sigma\, m(4, 6, 9, 10, 11, 14, 15) + \Sigma\, d(0, 1, 2, 3).$$ 6

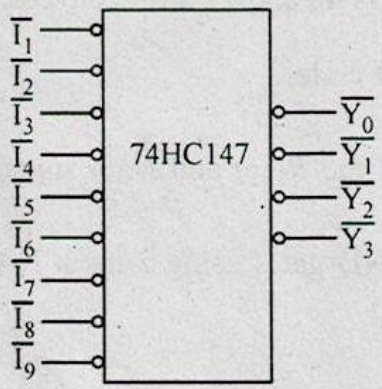
(*b*) What is PROM and E-PROM ? Describe the construction and working of a 8 × 4 diode ROM to write nibbles from 0000 to 0111. 6

(*c*) Subtract $(-35)_{10}$ from $(-15)_{10}$ using 2's complement method. 3

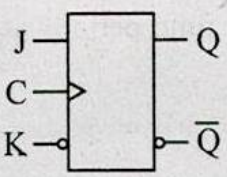
3. (*a*) Draw a circuit of parallel in-serial out shift register and explain its working. 8

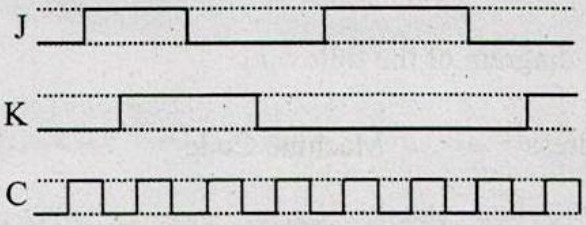
(*b*) Differentiate between demultiplexer and decoder. 4

(*c*) In the figure below, 74HC147 is a decimal to BCD encoder. What sort of input conditions would be required to generate the code for the number 7 and how that numerical quantity would be represented on the output (Y) lines ? 3



4. (*a*) Determine the Q output of the J-K flip-flop, if initially the flip-flop is reset. 4





(*b*) Draw the circuit diagram and explain the working of a 4-bit adder-subtractor. 6

(*c*) Give the truth-table and the circuit diagram of a JK flip-flop having preset and clear conditions. How is racing condition eliminated in JK flip-flop ? 5

5. (*a*) What are ring counters and where is it used ? 3

(*b*) Explain the working of a decade counter with the help of its circuit diagram. Draw its output waveforms and also write its truth-table. 8

(*c*) Explain glitches. How do we remove them from the output ? 4

6. (*a*) Explain the function of pins 2 and 4 of the IC 555. 3

(*b*) Draw the circuit diagram of 555 timer as a monostable multivibrator and explain its working. 6

P.T.O.

(*c*) Design a monostable multivibrator using 555 timer to get an output with a positive pulse of 10 ms. For this multivibrator, draw the output waveform a pin 3 when the input trigger has pulse width 2 ms and time periods are :

(*i*) 15 ms

(*ii*) 9 ms. 6

7. (*a*) Give the timing diagram of the following : 6

Memory Address	Machine Code	Mnemonics
2050H	41H	MOV B, C

(*b*) Describe with an example, each of 1 byte, 2 byte and 3 byte instruction in 8085 microprocessor instruction set. 6

(*c*) The memory requirement for an 8085A microprocessor based system is 24K-bytes RAM chips and 8K-bytes ROM chips. If memory chips of size 1K × 4 bits are available for both RAM and ROM, how many RAM and ROM chips are required ? 3

8. (*a*) Write an assembly language program to substract 5DH from FCH stored in memory locations 2006H and 2007H respectively using (*i*) direct and (*ii*) indirect addressing modes. The difference is to be stored in memory location 2008H and borrow in 2009H. 5

(*b*) Distinguish between memory-mapped I/O and peripheral-mapped I/O. 3

(*c*) What are flags ? If the accumulator contain 0BH and register C contain 05H, which flags are affected when CMP C is executed ? 4

(*d*) Define instruction cycle, machine cycle and T-states. 3

This question paper contains 2 printed pages. *Your Roll No. .....*

F-7

Sl. No. of Ques. Paper : **1467**
Unique Paper Code : **2221303**
Name of Paper : **Waves and Optics**
Name of Course : **B.Sc. (Hons.) Physics (Erstwhile FYUP)**
Semester : **III**
Duration : : **3 hours**
Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt five questions in all including Question No. 1 which is compulsory.
All questions carry equal marks.

1. Attempt any *five* of the following : 5x3=15

   (a) What are beats? Give necessary conditions for obtaining beats.
   (b) Obtain a relation between group velocity and phase velocity in a dispersive medium.
   (c) State and explain Huygens principle of secondary waves.
   (d) State the essential conditions for obtaining a sustained interference pattern.
   (e) When the movable mirror of Michelson's interferometer is shifted through 0.059 mm, a shift of 200 fringes is observed. Determine the wavelength of light used in Angstrom units.
   (f) Distinguish between Fraunhofer and Fresnel diffraction.
   (g) Calculate the minimum number of lines in a grating which will resolve the doublet of two sodium lines of wavelengths 5890 Å and 5896Å, in the first order.

2. (a) Explain the formation of standing waves on a stretched string by giving necessary theory. 10

   (b) Construct the Lissajous figure for the following if $\gamma = \pi/2$:
   $x = 2\cos(2\omega t+\gamma)$ and $y = 2\cos(\omega t)$. 5

3. (a) Describe briefly the Fresnel biprism experiment for producing interference fringes in a distant plane. 10

   (b) In a Newton's rings experiment the diameter of the 12^{th} ring changes from 1.50 cm to 1.35 cm when a liquid is introduced between the lens and the plate. Calculate the refractive index of the liquid. 5

4. (a) Describe briefly the construction and working of Michelson's interferometer. How it can be used to measure the refractive index of a thin transparent sheet. 12

   (b) Why interference fringes obtained in Fabry-Perot interferometer are

P. T. O.

sharper than that of Michelson's interferometer? 3

5. (a) Discuss Fraunhofer diffraction due to double slit. Draw and discuss the curve indicating distribution of intensity in the diffraction pattern. 12

(b) Calculate the aperture of the objective of a telescope which may be used to resolve stars separated by 4.88×10^{-6} radian for light of wavelength 6000 Å. 3

6. (a) Derive Fresnel's integrals. 10

(b) Discuss Fresnel diffraction pattern due to a narrow wire. 5

7. Write short notes on any *three* of the following:

(a) Linearity and Superposition Principle

(b) Haidinger and Fizeau fringes

(c) Cornu's Spiral

(d) Kirchoff's Integral Theorem (5×3=15)

[This question paper contains 2 printed pages.]

Sr. No. of Question Paper : 1907 **GC-3** **Your Roll No.....**

Unique Paper Code : 42224303

Name of the Paper : Thermal Physics and Statistical Mechanics

Name of the Course : **B.Sc. (Physical Sciences) CBCS : Physics – III**

Semester : III

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on the receipt of this question paper.
2. Attempt **Five** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.

1. Attempt any **five** of the following : (5×3=15)

   (a) State First law of thermodynamics & explain each of its terms.

   (b) Derive the expression for work done during an isothermal process.

   (c) Write the expression of Claussius-Clapeyron's First Latent heat equation. Using this, discuss the effect of pressure on boiling point of a liquid.

   (d) Explain the T-S diagram of a Carnot's Cycle.

   (e) Define mean free path of a gas molecule. How does it vary with temperature and pressure.

   (f) From Wein's displacement law, estimate the temperature of the Sun, given $\lambda_m = 4900 \times 10^{-7}$ cm and Wein's constant 0.292 cm K.

   (g) Define the terms "Microstate" and "Macrostate" of a thermodynamical system.

2. (a) State and prove Carnot's theorem.

   (b) A Carnot's engine whose low temperature reservoir is at 7°C has an efficiency of 50%. It is desired to increase the efficiency to 70%. By how many degrees should the temperature of high-temperature reservoir be increased. (10,5)

P.T.O.

3. (a) Give Kelvin Planck and Claussius' statements of second law of thermodynamics and prove their equivalence.

   (b) Prove that Entropy change during a reversible process is zero. (10,5)

4. (a) Using thermodynamic potentials, derive Maxwell's four relations.

   (b) Using appropriate Maxwell's relation deduce;

   (i) $C_p - C_v = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_p$

   (ii) $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$ (7,8)

5. Explain the porous – plug experiment in detail and derive the expression for temperature of inversion. (8,7)

6. (a) Derive Maxwell's velocity distribution law, stating the assumptions. Hence derive the probability of finding the number of molecules having energy between ε and $\varepsilon + d\varepsilon$.

   (b) Discuss experimental verification of Maxwell's velocity distribution law. (10,5)

7. (a) Give Planck's quantum postulates.

   (b) Drive Stefan's law and Wien's displacement law from Planck's law of black body radiation.

   (c) What is the wavelength of maximum intensity of radiation radiated from a source at temperature 3000°C ? Wien's constant = 2.898×10^{-3} mK. (3,9,3)

8. (a) Explain the term "Degeneracy". Differentiate between Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.

   (b) Derive Maxwell-Boltzman distribution law for a system of an ideal gas containing n molecules. (5,10)

[This question paper contains 2 printed pages.]

Sl. No.	:	2070	GC-3	**Your Roll No.....**
Unique Paper Code	:	32221301		
Name of Paper	:	Mathematical Physics-II		
Name of the Course	:	**B.Sc (Hons) Physics**		
Scheme of Examination	:	CBCS Part-III (Sem-III)		
Duration	:	3 hours		
Maximum Marks	:	75		

Instructions for Candidates

1. *Write your Roll No at the top of your Question Paper.*
2. *Question no 1 is compulsory. Attempt five questions in all.*
3. *In the question paper* $y \equiv y(x), y' \equiv \frac{dy}{dx}$ *and* $y'' \equiv \frac{d^2y}{dx^2}$.

1. Attempt any five questions

a) Find the indicial equation and its roots for the given differential equation

$$x^2y'' + 3xy' + 4xy = 0$$

b) Evaluate the value of $\frac{\Gamma(3)\Gamma(3/2)}{\Gamma(9/2)}$

c) Find the value of $P_n(-1)$.

d) State the Dirichlet's conditions.

e) Express $f(x)$ as a linear combination of Legendre Polynomials where

$$f(x) = 5x^3 + 2x^2 - 7x + 4$$

f) Given that $f(x)=f(x+2\pi)$ and if

$$f(x) = |x| if - \pi < x < \pi$$

Graphically represent the function in the interval $(-5\pi,5\pi)$

g) Evaluate $\int_0^2 x\sqrt[3]{8 - x^3}\,dx$ 5x3=15

2. A rectangular homogeneous membrane of length a and breadth b is fixed at the boundaries. The membrane is free to oscillate vertically with respect to its plane. Initially, the membrane was at rest and its initial position is given as $f(x,y)$. Find the displacement at any time 't' and at position (x,y). 15

P.T.O.

3. Find the Fourier series expansion of the function

$$f(x) = \begin{cases} -kif & -\pi < x < 0 \\ kif & 0 < x < \pi \end{cases} and f(x + 2\pi) = f(x)$$

Hence find the value of $\sum_{n=0}^{\infty} \frac{(-1)^n}{2n+1}$ 12+3=15

4. Prove that

$\int_{-1}^{1} P_m(x)P_n(x)dx = \frac{2}{2n+1}\delta_{mn}$ 12x7.5=15

Q5.a) Solve the given differential equation

$$y'' - 2xy' + 2\lambda y = 0$$

λ is a real constant. For λ=n=0,1,2,3.., show that one of the solution is a polynomial of order n. Name the polynomial.

b) Show that

$$J_{1/2}(x) = \sqrt{\frac{2}{\pi x}} Sin(x)$$ 12+3=15

6. a) For Legendre polynomial $P_n(x)$, prove that

$$nP_n = (2n-1)xP_{n-1} - (n-1)P_{n-2}$$

b) Show that $\Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$

c) Show that $\frac{d}{dx}\{x^n J_n(x)\} = x^n J_{n-1}(x)$ 3x5=15

7. Solve the differential equation 15

$$x^2y'' + xy' + (x^2 - 4)y = 0$$

[This question paper contains 2 printed pages.]

Sr. No. of Question Paper : 2071 **GC-3** **Your Roll No.....**

Unique Paper Code : 32221302

Name of the Paper : Thermal Physics

Name of the Course : **B.Sc. (Hons.) Physics CBCS**

Semester : III

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** questions in all including Question No. **1** which is compulsory.
3. All questions carry equal marks.

1. Answer any **five** of the following :
   (a) Using first law of thermodynamics, derive the relation C_P-C_V = R.
   (b) Show that enthalpy remains constant during Joule-Thomson experiment.
   (c) Calculate the average kinetic energy of thermal neutrons at temperature 27^0C
   (d) Formulate second law of thermodynamics in terms of entropy.
   (e) Give the kinetic interpretation of Temperature.
   (f) Define "Triple Point" and draw the phase diagram of water.
   (g) Derive the energy equation

$$\left(\frac{\partial U}{\partial V}\right)T = T\left(\frac{\partial P}{\partial T}\right)V - P \qquad (5\times3=15)$$

2. (a) What is Carnot's engine? Describe its operation with the help of a PV diagram and derive expression for its efficiency.
   (b) Establish the Clausius inequality theorem.
   (c) One gram mole of a perfect gas expands isothermally to four times its initial volume.

P.T.O.

Assuming complete conversion of heat into work, calculate the change in entropy. Given R = 8.314 J/mol-K. (7,5,3)

3. (a) What are transport phenomena? Deduce expression for thermal conductivity of a gas on the basis of kinetic theory.

   (b) What is meant by Lapse Rate? Obtain an expression for adiabatic lapse rate of earth's atmosphere.

   (c) Find the mean free path of a gas molecule whose diameter is 2 A^0 and number of molecules per cc is 3×10^{19}. (7,5,3)

4. (a) State and prove Carnot 's Theorem.

   (b) With the help of necessary diagram distinguish between first and second order phase transitions. Derive Clausius- Clapeyron equation of latent heat. (6,9)

5. (a) Define four thermodynamic potentials. Using these potentials derive the four Maxwell's thermodynamic relations.

   (b) Prove that

$$G = H + T\left(\frac{\partial G}{\partial T}\right)_P \quad \text{and} \quad F = U + T\left(\frac{\partial F}{\partial T}\right)_V \qquad (9,6)$$

6. (a) Write Maxwell-Boltzmann law of distribution of velocities for molecules of a gas. Hence obtain the relation between most probable velocity C_{mp}, average velocity C_{av} and root mean square velocity C_{rms} for molecules of the gas. Show that $C_{rms} > C_{av} > C_{mp}$.

   (b) Give Einstein's theory of translational Brownian motion in gases. (9,6)

7. (a) Discuss the results obtained by Andrews in his experiment on CO_2. Explain the term "Critical temperature" of a gas.

   (b) Calculate the critical constants of van der Waal's gas in terms of constants "a" and "b". Hence derive the reduced equation of state. (6,9)

8. (a) Discuss the cases when "μ" is negative, positive and zero. Obtain the expression for temperature of inversion of the gas. Explain why hydrogen and helium show heating effect at ordinary temperatures while other gases show cooling effect.

   (b) Derive the Ehrenfest's equations for second order phase transitions. (6,9)

(1500)

This question paper contains 2 printed pages. *Your Roll No. .....*

Sl. No. of Ques. Paper : 2072 **GC-3**

Unique Paper Code : 32221303

Name of Paper : **Digital Systems and Applications**

Name of Course : **B.Sc. (Hons.) Physics (CBCS)**

Semester : **III**

Duration : : **3 hours** *Maximum Marks* : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any five questions in all. Q. No. 1 is compulsory. All questions carry equal marks.

1. Attempt any five of the following: 5x3

a) Subtract decimal number 12 from decimal 9 using two's complement notation.

b) Describe with an example each of 1-Byte, 2-Byte and 3-Byte instructions in 8085 microprocessor.

c) The accumulator of 8085 microprocessor contains 5CH and carry is set. What will the accumulator contain and carry contain following each instruction given below
(i) XRA A (ii) RAL

d) What is meant by the term edge clocked/triggered and draw a digital symbol of a negative edge triggered JK flip flop.

e) Convert the hexadecimal number $8AD9_{16}$ to its octal equivalent.

f) What is the largest decimal value that can be represented in binary using?
(i) one byte and (ii) two byte

g) Explain rise time, fall time and duty cycle of a square wave.

h) Prove the following Boolean equations:
(i) $(A+B)(A+\bar{B})(\bar{A}+C) = AC$
(ii) $ABC + A\bar{B}C + AB\bar{C} = A(B+C)$

2. (a) Simplify the function using K-Map
Σ (3, 6, 7, 10, 11, 13,14, 15)
and give the logic circuit to realize this function. 7 ½

b) What is an encoder? Draw a circuit for a decimal to binary encoder and explain its functioning. 7 ½

3. (a) Draw a circuit for a 4 bit adder subtractor and explain its working. 7 ½

P. T. O.

b) What are shift registers? What type of shift register is the fastest? Realize a 4-bit SIPO shift register using block diagram of SR flip flop. 7 ½

4. (a) Explain working of a decade counter with the help of a circuit diagram. 7 ½

b) Draw the block diagram of a cathode ray oscilloscope and explain how it is used to calculate amplitude and frequency of a sinusoidal wave. 7 ½

5. (a) Draw the circuit of an Astable Multivibrator using IC 555 timer IC and explain its operation. Derive the expression for its frequency. 7 ½

(b) Explain the working of a MASTER-SLAVE JK flip flop using logic circuit diagram. How does it overcome racing problem. 7 ½

6. (a) Draw labelled pin out diagram of 8085 microprocessor. 5

b) Describe the various flags used in 8085 microprocessor and show their bit positions.

c) Write an assembly language program to multiply two eight bit number 04 H and 05H. Numbers are stored in memory location 2000H and 2001H. Store the result in 2002H. 5

7. (a) How Demultiplexing of address bus and data bus is done in 8085 microprocessor. Explain with the help of timing diagram. 10

(b) Write an assembly language program to add two sixteen bit numbers FDFF H and 0101 H. 5

This question paper contains **2** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **91**

Unique Paper Code : **222563** **G**

Name of the Paper : **Physics-V : Quantum Mechanics and Atomic Physics (PHPT-505)**

Name of the Course : **B.Sc. Physical Science / Applied Physical Science**

Semester : **V**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any *five* questions.

All questions carry equal marks.

1. (*a*) What is a wave packet ? Prove that the de-Broglie wave packet associated with a moving body travels with the same velocity as the body. 2,5

   (*b*) State Heisenberg uncertainty principle and derive it on the basis of wave packets. 2,6

2. (*a*) What is photoelectric effect ? Define threshold frequency and work function. Give an account of Einstein explanation of photoelectric effect on the basis of quantum theory. 3,3,5

   (*b*) Radiations of wavelength 5400 Å fall on a metal plate whose work function is 1.9 eV. Find the kinetic energy of the emitted photoelectrons. 4

3. (*a*) What are admissibe conditions for a wave function ? 3

   (*b*) How do you correlate the operator $\hat{H}$ to its corresponding phyiscal quantity ? 3

   (*c*) Starting with time dependent Schrodinger wave equation, derive an expression for time-independent wave function. 9

P.T.O.

4. Write short notes on any *two* of the following : 15

   (*a*) Inadequacies of classical mechanics

   (*b*) γ-ray microscope experiment

   (*c*) Compton effect

5. (*a*) What is Normal Zeeman effect ? Derive an expression for the frequency shift in Normal Zeeman effect. 3,7

   (*b*) Consider the normal Zeeman effect in the $3d \rightarrow 2p$ transition. Draw the energy-level diagram that shows the splitting of $3d$ and $2p$ levels in an external magnetic field. Also indicate all the possible transitions. 5

6. (*a*) What is Bohr Magneton ? Give its unit. 3

   (*b*) Discuss symmetric and anti-symmetric wave functions. 5

   (*c*) Explain space quantization of L and S with the help of an example. 7

7. (*a*) Discuss LS and *jj* coupling. 6

   (*b*) Find the possible values of total angular momentum quantum number J in LS coupling of two atomic electrons having orbital quantum numbers $l_1 = 2$ and $l_2 = 1$. 4

   (*c*) What is the physical significance of the magnetic orbital quantum number and magnetic spin quantum number ? 5

8. (*a*) State and explain the Pauli's exclusion principle. 4

   (*b*) Obtain an expression for the maximum number of electrons that can be accommodated in a shell. Give electronic configurations for the following elements : 4,2,2

   (*i*) Zn (Z = 30) and

   (*ii*) La (Z = 57)

   (*c*) Find the S, L and J values that correspond to each of the following states : 3

   $^2S_{1/2}$, $^3P_2$, $^2D_{3/2}$.

This question paper contains **4** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **852**

Unique Paper Code : **222501** **G**

Name of the Paper : **Mathematical Physics—V (PHHT-515)**

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **V**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Do *five* questions in all.

Question No. **1** is compulsory.

Do **2** questions from each Section.

1. Do any *five* questions :

(*a*) If F(k) is the Fourier transform of $f(x)$, find the Fourier transform of $f(ax)$.

(*b*) Find the Fourier transform of $e^{-|t|}$.

(*c*) If

$$L\{F(t)\} = f(s),$$

find $L\left\{F\left(\frac{t}{a}\right)\right\}$.

(*d*) Find the Laplace transform of the Dirac delta function $\delta(t-a)$, where a is positive real constant.

P.T.O.

(*e*) Show that :

$$\delta'(x) = -\frac{\delta(x)}{x}.$$

(*f*) Show that gradient of a scalar function is a tensor of order one.

(*g*) Find the second order anti-symmetric tensor associated with the vector :

$$2\hat{i} - 3\hat{j} + \hat{k}.$$

(*h*) Prove that product of tensors of rank one is a tensor of rank two. 5×3=15

Section A

2. (*a*) Find Fourier sine transform of e^{-x} and hence prove that : 4,4

$$\int_0^\infty \frac{t \sin tx}{1+x^2}\, dt = \frac{\pi}{2} e^{-x}.$$

(*b*) State and prove Convolution theorem for Fourier transforms. 2,5

3. (*a*) Find : 5

$$L^{-1}\left\{\frac{1}{s^2(s^2+a^2)}\right\}.$$

(*b*) Using Laplace transforms, solve the following coupled differential equations :

$$\frac{dX}{dt} + Y = 0, \qquad \frac{dY}{dt} - X = 0$$

under the condition X(0) = 1, Y(0) = 0. 10

4. (*a*) For the function :

$$G(t) = \begin{cases} e^{-xt}\phi(t) & ; t < 0 \\ 0 & ; t > 0 \end{cases}$$

Find the relation between Fourier transform of $G(t)$ and Laplace transform of $\phi(t)$. 6

(*b*) If $F(t)$ is a periodic function of period T, find its Laplace transform. 5

(*c*) Prove that :

$$\delta(ax) = \frac{\delta(x)}{|a|},$$

where $a > 0$. 4

Section B

5. (*a*) Derive an expression for the Moment of Inertia tensor. Prove that it is a symmetric tensor and it transforms like a second order tensor. 5,2,3

(*b*) Show that : 5

$$\in_{iks} \in_{mps} = \delta_{im}\,\delta_{kp} - \delta_{ip}\,\delta_{km}.$$

6. (*a*) Define Kronecker-Delta function. Show that it is : 1,2,2

(*i*) an isotropic tensor

(*ii*) a symmetric tensor of order 2.

(*b*) Using tensors, prove the following identities : 5,5

(*i*) $\vec{\nabla} \times \left(\phi \vec{A} \right) = \phi \left(\vec{\nabla} \times \vec{A} \right) + \left(\vec{\nabla} \phi \right) \times \vec{A}$

(*ii*) $\vec{\nabla} \times \left(\vec{\nabla} \times \vec{A} \right) = \vec{\nabla} \left(\vec{\nabla} . \vec{A} \right) - \nabla^2 \vec{A}$.

7. (*a*) If

$$ds^2 = 3(dx^1)^2 + 5(dx^2)^2 - 4dx^1 dx^2 ,$$

find the matrices :

(*i*) (g_{ij}),

(*ii*) (g^{ij}), and

(*iii*) the product of (g_{ij}) and (g^{ij}). 2,4,2

(*b*) Prove that : 7

$$\left\{ \begin{matrix} p \\ p\ q \end{matrix} \right\} = \frac{\partial}{\partial x^q} \ln \sqrt{g} .$$

This question paper contains **4** printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : **854**

Unique Paper Code : **222503** **G**

Name of the Paper : **Atomic and Molecular Physics (PHHT-517)**

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **V**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all.

Question No. **1** is compulsory.

1. Answer any *five* of the following : 5×3=15

   (*a*) Two non-relativistic electrons move in a circle under the influence of uniform magnetic field B. If the ratio of their orbital radii is 1/3, then calculate the ratio of their speeds.

   (*b*) Find the precessional frequency of an electron orbit when placed in a magnetic field of 6 T.

   (*c*) Explain the significance of Critical Potentials.

   (*d*) What is Paschen-Back effect ?

P.T.O.

(*e*) A substance shows a Raman line at 4567 Å when an exciting line of 4358 Å is used. Find the position of Stokes and anti-Stokes line for the same substance when an exciting line of 4047 Å is used.

(*f*) Estimate the value of the wavelength of K_α line of silver (Z = 47).

(*g*) What is meant by space quantization ?

2. (*a*) Derive the expression of radius and velocity of an electron in the *n*th Bohr orbit of Hydrogen atom.

(*b*) Calculate the ratio of the wavelengths of the de-Broglie waves in the second and third Bohr orbit of Hydrogen atom.

(*c*) What is the difference between the photons of continuous X-rays and characteristic X-rays ?

7,4,4

3. (*a*) Describe the principle, theory and significance of Stern-Gerlach experiment.

(*b*) In a Stern-Gerlach experiment, a beam of hydrogen atoms moves a distance of 20 cm in a homogeneous magnetic field of gradient 2×10^2 T/m. If the velocity of the Hydrogen atom is 2×10^5 m/s, calculate the maximum separation between the two traces on the collector plates.

10,5

4. (*a*) Explain the origin of spin-orbit coupling in atom. Compute the shift in the energy level due to spin-orbit coupling.

(*b*) Assuming jj coupling, find all possible values of J for two valence electrons having orbital quantum number $l_1 = 3$ and $l_2 = 1$.

10,5

5. (*a*) What is Normal Zeeman effect ? On the basis of quantum theory, explain the effect of magnetic field on the energy levels of the atom.

(*b*) Explain the splitting of spectral lines in Normal Zeeman effect for the $2p \rightarrow 1s$ transition.

(*c*) When hydrogen atoms with their electrons in $4d$ state are placed in strong magnetic field (Normal Zeeman effect), the degenerate level ($4d$) split into various levels. What is the maximum energy difference between the levels when atoms are placed in a magnetic field of 2.5 T. 6,6,3

6. (*a*) Evaluate the Lande's g factor for $^2D_{3/2}$ state.

(*b*) Find all possible orientations of total angular momentum vector J corresponding to $j = 3/2$ with respect to a magnetic field along the z-axis.

(*c*) Using Hund's rule find ground state quantum numbers for carbon (Z = 6). 5,5,5

7. (*a*) Distinguish between Raman scattering and Rayleigh scattering.

(*b*) Obtain the expression for the vibrational frequency of a diatomic molecule.

(*c*) The force constant for a vibrating HCl molecule is 470 N/m. Calculate the wavelength corresponding to the vibrating HCl molecule. In which region of the electromagnetic spectra do the vibrational spectra lie ? 5,5,5

8. (*a*) Explain the working of He-Ne Laser with the help of suitable energy level diagram.

(*b*) What is population inversion in a Laser ? How can we achieve a higher probability of stimulated emission as compared to that of spontaneous emission ?

(*c*) For a system in thermal equilibrium, calculate the temperature at which the spontaneous emission rate is equal to that of stimulated emission for a wavelength of 500 nm.

5,5,5

Given :

Planck's Constant : 6.63×10^{-34} J.sec

Electronic Charge : 1.6×10^{-19} C

Rydberg Constant : 1.097×10^{7} m^{-1}

Bohr magneton : 9.274×10^{-24} J/T

Mass of hydrogen atom : 1.674×10^{-27} kg

Mass of chlorine atom : 5.81×10^{-26} kg

Mass of electron : 9.1×10^{-31} kg.

This question paper contains **3** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **855**

Unique Paper Code : **222504** **G**

Name of the Paper : **Electronic Devices (PHHT 518)**

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **V**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Question No. **1** is compulsory.

Attempt *Five* questions in all.

1. Answer the following questions (any *five*) :

   (*a*) What is the position of the Fermi level in an intrinsic semiconductor ? How does its position change when :

   (*i*) donors and

   (*ii*) acceptors

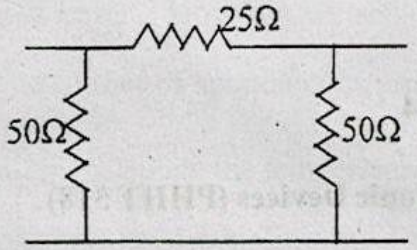
   are added to the semiconductor ? 3

   (*b*) Give *two* differences between BJT and FET. 3

   (*c*) A phase shift oscillator has three identical RC sections $R_L = R = 10\ k\Omega$ and $C = 0.01\ \mu F$. Determine the frequency of oscillation. 3

P.T.O.

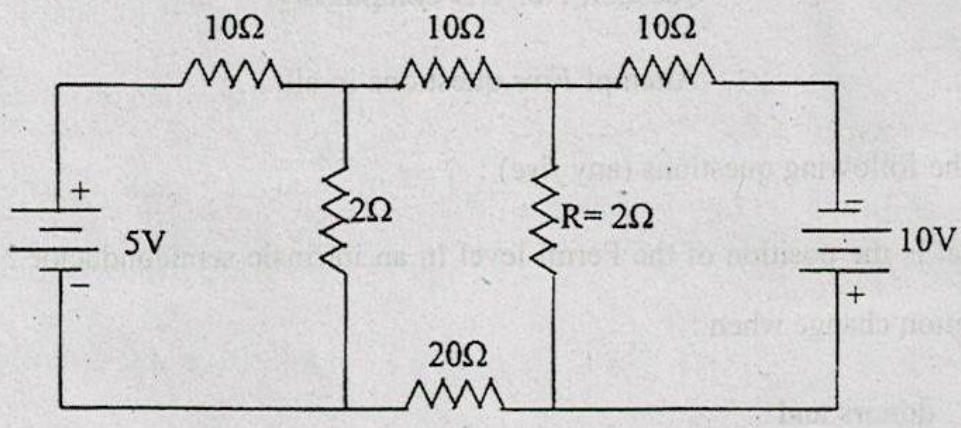
(*d*) Convert the following π to T network : 3



(*e*) Compare CE, CB and CC amplifiers in terms of current gain and voltage gain. 3

(*f*) For an abrupt *p-n* junction in Ge doped with donor and acceptor concentrations of $N_d = 10^{23}\ m^{-3}$ and $N_a = 10^{22}\ m^{-3}$. Calculate the height of the potential barrier. 3

2. (*a*) Find voltage across R using mesh analysis. 7



(*b*) For an unbiased *p-n* junction, sketch the variation of the space charge, electric field and electric potential as a function of distance across the junction giving the relevant equations. 8

3. (*a*) For a four terminal network derive its T equivalent circuit in terms of short circuit and open circuit impedances. 7

(*b*) Explain the formation of depletion layer in a *p-n* junction diode. Derive the expressions for potential barrier and width of depletion layer for a *p-n* step junction diode. 8

4. (*a*) With the help of energy band diagram, explain current *Vs.* voltage characteristics of Tunnel diode in forward and reverse biasing conditions. 8

(*b*) Give advantages of LED over a conventional light bulb. 4

(*c*) The wavelength of light emitted by a certain LED is 60 nm. Find the energy gap in eV. 3

5. (*a*) What is negative feedback ? How does it affect the input and output impedance of an amplifier (support your answer with derivation) ? 8

(*b*) A transistor used in CE configuration has the following set of *h*-parameters : h_{ie} = 1 kΩ, h_{fe} = 100, $h_{re} = 5 \times 10^{-4}$ and $h_{oe} = 2 \times 10^{-5}$ S with R_s = 2 kΩ and R_c = 5 kΩ, determine input impedance, voltage gain, output impedance and current gain. 7

6. Draw the circuit diagram of a RC coupled amplifier. Draw the a.c. equivalent circuit at mid, low and high frequency respectively. Calculate the voltage gain in mid and low frequency regions. 15

7. (*a*) Explain the basic concept of amplitude, frequency, and phase modulation. Define modulation index and derive power relations between carrier wave and side bands in an Amplitude Modulated wave. 10

(*b*) Draw the circuit diagram of a diode detector for demodulation of AM wave and explain its working. 5

[This question paper contains 2 printed pages.]

Sr. No. of Question Paper : 1380 **F-7** **Your Roll No.....**

Unique Paper Code : 2221501

Name of the Paper : Quantum Mechanics and its Applications I

Name of the Course : **B.Sc. (H) Physics (Erstwhile FYUP)**

Semester : V

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on the receipt of this question paper.
2. Attempt **five** questions in all.
3. Question No. **1** is compulsory.

1. Attempt any **five** questions of the following : (3×5=15)

(a) Prove the following commutation relations.

$[x, p_z] = 0$

$[x, y] = 0$

$[z, p_z] = i\hbar$

(b) Prove Heisenberg's uncertainty relation using the concept of wave packet.

(c) On the basis of energy bands differentiate among insulator, semi-conductor and conductor.

(d) Discuss the significance of the quantum numbers 1, m_l and m_s.

(e) Draw the wave function and corresponding probability density for the first three states of a simple harmonic oscillator.

(f) Prove $\sigma_x \sigma_y = 2i\, \sigma_z$, where the symbols have their usual memory.

(g) The wave function for hydrogen atom in 1s state is

P.T.O.

$$R_{1s}(r) = \frac{1}{\sqrt{\pi}}\left(\frac{1}{a_0}\right)^{3/2} e^{-r/a_0}$$

where a_0 = Bohr radius.

Calculate the expectation value of position of the electron in this state.

(h) Why is an inhomogeneous magnetic field required for Stern-Gerlach Experiment ?

2. (a) Derive time dependent Schrodinger equation. Using this equation obtain time independent Schrodinger equation. (10)

(b) Express the most general solution of the time dependent Schrodinger equation in terms of linear combination of stationary states. (5)

3. (a) Solve the Schrodinger equation for an electron moving in a one dimensional periodic potential and discuss how does it lead to the energy band formation in a solid. (10)

(b) Discuss the concept of effective mass of an electron in a metal. Give its physical significance. (5)

4. Solve the Schrodinger equation for a particle having energy $E < V_0$ for a square well potential of finite depth V_0. Discuss the graphical representation of the transcendental equations. (15)

5. (a) Using Schrodinger equation derive an expression of eigen energy for a particle moving in a simple harmonic potential. (10)

(b) What is zero point energy of a simple harmonic oscillator ? Give its physical significance. (5)

6. Starting from Schrodinger equation for hydrogen atom in spherical polar coordinates, split the equation into three parts. Obtain the solution for radial wave equation. (15)

7. (a) Describe and discuss the significance of Stern-Gerlach experiment. How does it lead to the space quantization due to spin ? (10)

(b) A beam of silver atoms with a velocity of 10^6 cm/s passes through a magnetic field of gradient 100 W/m /cm for a distance of 5 cm. What is the separation between the two components of the beam as it comes out of the magnetic field ? (5)

(100)

This question paper contains **3** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **1381**

Unique Paper Code : **2221502** **F-7**

Name of the Paper : **Electromagnetic Theory**

Name of the Course : **B.Sc. (Hons.) Physics (Erstwhile FYUP)**

Semester : **V**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

All questions carry equal marks.

Question No. **1** is compulsory.

1. Attempt any *five* of the following : 5×3=15

   (*a*) Discuss and compare Lorentz and Coulomb gauges.

   (*b*) If the earth receives 1400 Joules m^{-2} sec^{-1} solar energy, what are the amplitudes of the electric and magnetic fields of radiation.

   (*c*) Calculate the skin depth for radio waves of wavelength 4000 m for penetrating into sea water of conductivity σ = 4 mho/m.

   (*d*) Discuss the significance of plasma frequency in the transmission of radio waves through ionosphere.

P.T.O.

(*e*) An electromagnetic wave polarized parallel to plane of incidence is incident from air on to distilled water with $\mu_r = 1$ and $\varepsilon_r = 81$, find the brewsters angle.

(*f*) Show that good conductors are good reflectors.

(*g*) Show that E.B is relativestically invariant.

2. (*a*) Discuss how Maxwell's modified Ampere's law to make it consistent with the equation of continuity. Explain the significance of displacement current.

(*b*) The conduction current density in a dielectric is given by $J = 0.02 \sin (10^9 t)$ Amp/m^2. Find the displacement current density, if $\sigma = 10^3$ mho/m and $\varepsilon_r = 6.5$. 10,5

3. (*a*) Derive Fresnel's relation for reflection and transmission of electromagnetic waves having electric field component normal to the plane of incidence at the boundary of two dielectrics.

(*b*) Derive the boundary conditions satisfied by the electric and magnetic field vectors at the boundary of two dielectrics. 11,4

4. (*a*) Starting with the Maxwell's equations obtain the wave equation for the propagation of electromagnetic wave in a symmetric planar wave guide. Derive the appropriate eigen value equations.

(*b*) Show that there exists only one symmetric TE mode for $0 < V < \pi$. V being the dimensionless wave guide parameter. 12,3

5. (*a*) Explain how to produce and analyze plane and circularly polarized light from a beam of polarized light.

(*b*) What is the SOP of electromagnetic wave having electric field vector : 12,3

$$\overline{E} = 2\sin(\omega t - kz)\hat{i} + 3\sin(\omega t - kz - \frac{\pi}{2})\hat{j}.$$

6. (*a*) Deduce expressions for electric and magnetic fields of an oscillating electric dipole.

(*b*) Suppose that in one inertial system B = 0 but E ≠ 0 (at some point P). Is it possible to find another system in which the electric field is zero at P. Give reason. 12,3

7. (*a*) Derive the transformation laws for the electric and magnetic fields in the case of parallel plate capacitor.

(*b*) Show that $(E^2 - C^2B^2)$ is relativistically invariant. 12,3

This question paper contains **3** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **1382**

Unique Paper Code : **2221503** **F-7**

Name of the Paper : **Physics of Devices and Instruments**

Name of the Course : **Erstwhile FYUP**

Semester : **V**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. **1** is compulsory.

All questions carry equal marks.

Non-programmable calculators is allowed.

1. Attempt any *five* of the following : 5×3=15

   (*a*) Define the lock and capture ranges of a PLL.

   (*b*) Define ASK, PSK and FSK.

   (*c*) Explain briefly the working of a voltage controlled oscillator.

   (*d*) Give *three* differences between MOSFET and JFET.

   (*e*) Define modulation index for an AM wave. What happens when the modulation index is more than 100% ?

   (*f*) State the working principle of a thermistor.

   (*g*) What is the advantage of a shunt voltage regulator over a series voltage regulator ?

   (*h*) Explain the working principle of CCD.

P.T.O.

2. (*a*) Sketch the cross-section of an *n*-channel depletion MOSFET and explain its working.

(*b*) Distinguish between enhancement and depletion mode MOSFET.

(*c*) Obtain the expression for the time period of oscillations of a UJT relaxation oscillator. 6,3,6

3. (*a*) Derive an expression for the drain current of an *n*-channel JFET.

(*b*) An *n* channel JFET at 300K has a doping concentration of $N_a = 10^{18}$ per cm^3, $N_d = 10^{16}$ per cm^3. Assume a junction thickness of $a = 0.75$ μm. Find the pinch off voltage (Given : $\varepsilon_r = 12$ and $\varepsilon_0 = 8.854 \times 10^{-14}$ F/cm).

(*c*) Draw labeled energy band diagrams for Schottky and Ohmic contacts ? 8,3,4

4. (*a*) Explain the working of a monostable multivibrator using transistors. Give the necessary circuit diagrams.

(*b*) Discuss the working of an Exclusive-OR phase detector.

(*c*) Design a wide band pass Butterworth filter with $f_L = 500$ Hz, $f_H = 2$kHz and a passband gain of 4. Given C = 0.01 μF. Find its quality factor. 6,4,5

5. (*a*) Derive the expressions for the gain magnitude and phase angle of a first order low pass Butterworth filter. Plot the frequency response of the filter.

(*b*) Explain with help of a circuit diagram how short circuit protection is achieved to limit the load current in a series regulator circuit.

(*c*) A certain power supply has a 12V output when there is no load. At full load current of 10mA, the output voltage is 11.9V. Determine the percentage load regulation. 6,6,3

6. (*a*) What are transducers ? List *four* ideal characteristics of a transducer.

(*b*) Explain the working principle of a piezoelectric transducer.

(*c*) Derive an expression for gauge factor for a bonded resistance strain gauge.

(*d*) A platinum resistance thermometer has a resistance of 100 Ω at 25°C. At a certain temperature, the thermometer has a resistance of 200 Ω. Calculate the value of the temperature. Given $\alpha = 0.00392$ per °C. 3,3,6,3

7. (*a*) What is the basic difference between analog and digital modulation ? Define PAM, PWM, PPM.

(*b*) Draw the circuit of a CE amplitude modulator and derive the expression for its output.

(*c*) Peak to peak value of an AM wave has maximum value of 8V (E_{max}) and minimum value of 2V (E_{min}). Find the percentage modulation and amplitude of the unmodulated carrier wave. 4,7,4

This question paper contains **4** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **1383**

Unique Paper Code : **2221504** **F-7**

Name of the Paper : **Computer Programming and Numerical Analysis**

Name of the Course : **B.Sc. (Hons) Physics Erstwhile FYUP**

Semester : **V**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Non-programmable scientific calculators are allowed.

Question No. **1** is compulsory.

Attempt any *one* from Section A the and all *three* from Section B.

Attempt *five* questions in all.

1. Answer any *five* of the following : 5×3=15

(*a*) Find the relative error in $x = 0.003444$, if its value is truncated to three decimal places.

(*b*) Write the following expression in C/C++ :

$$3.5 \log_e x + \cos\theta - |x^2 + y^2| + \sqrt{2xy} + e^{-k}$$

(*c*) Show that the rate of convergence of Secant method is approximately 1.62.

(*d*) Explain the differene between if and if ..... else and switch statements in C/C++ with *one* examples of each.

(*e*) Find the largest Eigen value for the matrix using Iterative method (Power Method) :

$$\begin{bmatrix} 1 & 3 & -1 \\ 3 & 2 & 4 \\ -1 & 4 & 10 \end{bmatrix}$$

P.T.O.

(*f*) Find the minimum number to iterations required to attain an accuracy of 0.001 in the interval [1, 2] using bisection methods.

Section A

2. (*a*) What are the different types of data supported by C/C++ ?

(*b*) What is function prototype ?

(*c*) Write a C/C++ program to solve a Quadratic equation of the form $ax^2 + bx + c = 0$ for real, imaginary and equal roots. 5,2,8

3. (*a*) Bring out the difference between 'while' and 'do while' loops with the help of appropriate flow-charts.

(*b*) Write a C/C++ program to write the first 20 natural numbers along with their square-roots using :

(*i*) while/do-while loop and

(*ii*) for loop. 3,12

Section B

4. (*a*) Using Newton Backward difference formula, compute $f(x)$ and $f(4.5)$ from the following set of data :

x	y
1	14
2	27
3	40
4	55
5	68

(*b*) Derive the normal equations in corresponding to the least square fitting for a quadratic curve.

(*c*) Linearly fit the following data :

x	y
1	1.1
1.5	1.3
2	1.6
2.5	2.0
3.0	2.7
3.5	3.4
4.0	4.1

5,5,5

5. (*a*) Use Simpson's rule to compute the integral :

$$I = \int_5^{13} \frac{dx}{x} \text{ with } n = 4$$

(*b*) Solve $y^2 = 1 + y^2$, $h = (y \text{ at } x = 0.150)$ using modified Euler's method at $y = 1.5$ with $h = 0.5$.

(*c*) Find first and second derivative of $f(x)$ at $x = 1.5$ from the following tabulated values :

x	$f(x)$
1	3.23
1.5	3.19
2	3.0
2.5	2.91
3	2.81

5,5,5

Compute the result up to two places of decimal.

6. (*a*) Evaluate $\int_0^1 \frac{dx}{1+x}$ using Gauss Legendre's three point formula given below :

$$\int_{-1}^{1} f(x)dx = \frac{1}{9}\left[5f\left(-\sqrt{3}/5\right)+8f(0)+5f\left(\sqrt{3}/5\right)\right]$$

(*b*) Using Euler's method obtain the solution of the differential equation in the interval [0, 1] :

$$\frac{dy}{dx} = x + y + xy\,;\ y(0) = 1\ (h = 0.25).$$ 7,8

Sl. No. : 2605 GC -3

Unique Paper Code: 32225311

Name of the Paper: Quantum Mechanics

Name of the Course: CBCS - Generic Elective - Physics

Semester: V

Duration: 3 Hours

Maximum Marks: 75

Instructions for Candidates

Question ***No. 1*** is compulsory.

Attempt ***five*** questions in all.

1. Attempt any five of the following: 5×3=15

   (a) Express linear momentum, angular momentum & energy in their respective operator forms.

   (b) Explain the idea of Phase velocity and Group velocity.

   (c) Which of the following functions can be accepted as wave functions in one dimension: $sin(x)$, $exp(x)$ & $exp(-x^2)$.

   (d) List all the states belonging to $n=2$ for the hydrogen atom.

   (e) List all the states in an L-S coupling between two electrons described as $2p$ and $2d$.

   (f) Discuss the implications of *uncertainty relation* between momentum and position.

   (g) Give the values of n, l and j for the following states written in the spectral notation $2P_{3/2}$, $3D_{5/2}$, $3S_{1/2}$.

2. (a) Develop the time dependent Schrodinger equation and hence obtain the time independent Schrodinger equation.

   (b) Give the condition for the physical acceptability of the wave function solution to the time dependent Schrodinger equation.

   10,5

3. (a) Establish the Schrodinger equation for a particle in a one dimensional box of length 'a' and solve it to obtain the corresponding eigen-functions and eigenvalues.

(b) Find the expectation value of the position of the particle in the ground state of the above system.

10,5

4. (a) Solve the Schrodinger equation for one-dimensional Harmonic Oscillator to determine its energy levels.

(b) Discuss the significance of zero point energy of the Harmonic Oscillator.

12,3

5. (a) Setup the time independent Schrodinger equation for a hydrogen atom in the spherical polar coordinates. Using separation of variables obtain the equation for its radial 'r', spherical 'θ' and azimuthal 'φ' parts.

(b) Solve only the azimuthal 'φ' part of the equation and obtain the corresponding normalised wavefunction.

10,5

6. (a) Describe the Stern-Gerlach experiment and discuss the significance of the results of the Stern-Gerlach experiment.

(b) State and explain the Normal Zeeman effect.

10,5

7. (a) What is Pauli's exclusion principle? Show that since the electrons respect this principle, they cannot be described by symmetric wavefunctions.

(b) Discuss the significance of Spin-Orbit coupling.

10,5

[This question paper contains 2 printed pages.]

Sr. No. of Question Paper : 2145 **GC-3** **Your Roll No.....**

Unique Paper Code : 32223904 2016

Name of the Paper : Basic Instrumentation Skills

Name of the Course : **B.Sc. (Hons.) Physics (CBCS) Skill Enhancement Course**

Semester : III

Duration : 3 Hours Maximum Marks : 50

Instructions for Candidates

1. Write your Roll No. on the top immediately on the receipt of this question paper.
2. Attempt any **five** questions in all.

1. (a) Explain accuracy, precision and resolution of an instrument.

   (b) A set of independent voltage measurement taken by four observers was recorded as 117.02 V, 117.11 V, 117.08 V and 117.03 V. Calculate average voltage and average deviation. (5,5)

2. (a) How is an electronic voltmeter better than a conventional VOM ? Explain it in terms of input impedance and sensitivity.

   (b) Discuss the loading effect of a multimeter with the help of an example.

   (c) Calculate the value of multiple resistance on the 50 V range of a dc voltmeter that uses a 500 μA meter movement with an internal resistance of 1 kΩ. (4,4,2)

3. (a) Explain the principle of working of DSO.

   (b) How is the electrostatic focusing achieved in CRT ? Explain it with the help of a diagram. (5,5)

P.T.O.

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **2261**

Unique Paper Code : **32225103** **GC-3**

Name of the Paper : **Digital, Analog and Instrumentation**

Name of the Course : **Other than B.Sc. (Hons.) Physics : CBCS**

Generic Elective Paper-III

Semester : **I**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *four* questions in all, including

Q. No. **1** which is compulsory.

1. Attempt any *six* of the following : 6×5=30

   (*a*) Give the Boolean expression and truth table for the XOR gate. Highlight its specific properties.

   (*b*) Convert a decimal number 235_{10} to its binary equivalent and binary number 1101.101_2 to its decimal equivalent.

   (*c*) State and prove Demorgan's theorems.

   (*d*) Subtract $(1010)_2$ from $(1111)_2$ using 2's complement method.

   (*e*) Draw logic circuit diagram for the Boolean expression $Y = \bar{B}.\bar{C} + \bar{A}.\bar{C} + \bar{A}.\bar{B}$ using basic gates.

P.T.O.

(*f*) A transistor has β_{dc} of 108 and collector current I_C of 2.7 mA. Calculate the base current I_B.

(*g*) Determine the output voltage of the following circuit when $V_1 = 1V$:

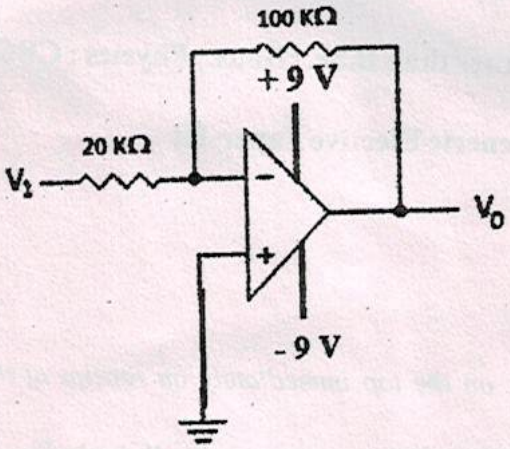


Fig. 1

(*h*) Write truth table for half subtractor and hence derive a Boolean expression for sum and carry using SOP method.

(*i*) Determine V_D, V_R and I_D for the following circuit :

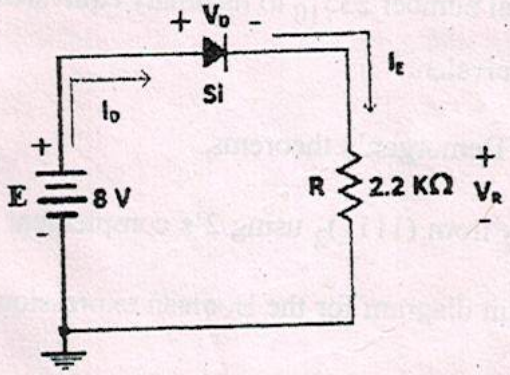


Fig. 2

(*j*) Draw Lissajous pattern when horizontal frequency is twice the vertical frequency and vice-versa.

2. (*a*) Draw a circuit diagram for a 4-bit binary adder/subtractor circuit and explain its working. 8

(*b*) Minimize the following logic function using Karnaugh map and hence design the corresponding logic circuit : 7

$$f(A, B, C, D) = \Sigma m(0, 1, 2, 5, 7, 8, 9, 10, 13, 15)$$

3. (*a*) Explain with the help of a circuit diagram how a Zener diode is used in voltage regulation under varying input voltage and varying load conditions. 8

(*b*) Determine V_L, V_R, I_Z and P_Z for the following circuit. Given $R_L = 3\ k\Omega$ and maximum power dissipation $P_{ZM} = 30$ mW. Symbols have their usual meaning. 7

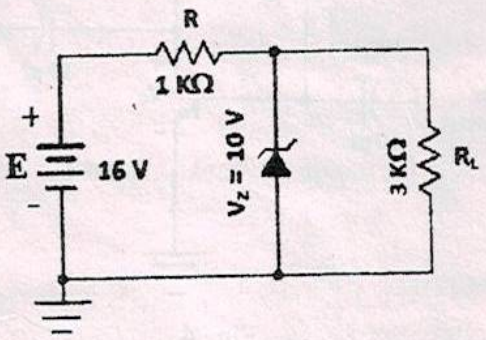


Fig. 3

4. (*a*) Draw a circuit diagram of a full wave bridge rectifier and explain its working. Show the input and output waveforms also. 8

(*b*) Draw a diagram for 555 timer IC in astable configuration and explain its working in brief. 7

P.T.O.

5. (*a*) Derive an expression for gain of an operational amplifier in both inverting and non-inverting modes. 7

(*b*) Describe how an op-amp can be used to perform the mathematical operation of an integrator. If input is given by $V_{in} = V_o \sin \omega t$, what is the expression for its output ? Also, draw the input and output waveforms. 8

6. (*a*) What is a transistor ? With the help of a circuit diagram explain the operation of a common emitter transistor. Draw input and output characteristics of the same. Explain the saturation, cut-off and active region of these characteristics. 10

(*b*) Determine I_B, I_C, V_{CE}, V_B, V_C and V_{BC} for the following fixed bias configuration. Given $\beta = 50$ and $V_{BE} = 0.7$ V. 5

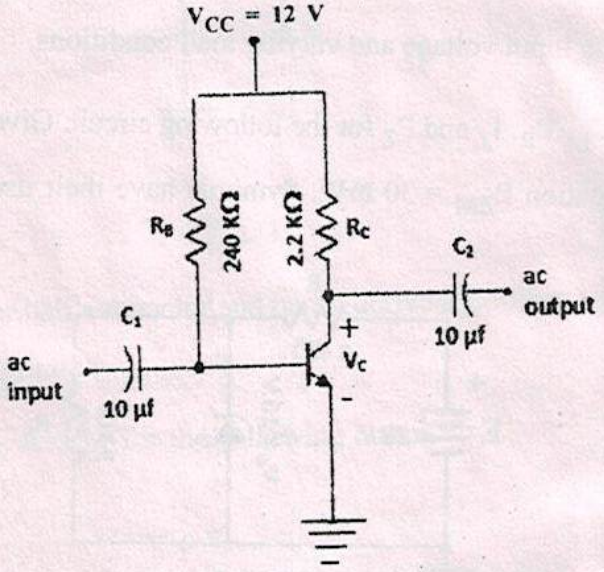


Fig. 4

7. (*a*) Draw the circuit diagram of RC phase shift oscillator, explain its working and find an expression for frequency. 8

(*b*) Give a brief description of : 7

(*i*) LED and

(*ii*) Solar cell.

(300)

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : 1415

Unique Paper Code : 2341504 F-7

Name of the Paper : Mathematical Physics—II

Name of the Course : B.Tech. (Computer Science) Allied Course

Semester : V

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Do *Five* questions in all.

Question No. 1 is compulsory.

1. Do any *five* questions : 5×3=15

(*a*) Classify (order, degree, linear/non-linear) the following differential equation :

$$5\left(\frac{d^3y}{dx^3}\right)^4 + 3x^2\left(\frac{d^2y}{dx^2}\right)^5 + 4x\left(\frac{dy}{dx}\right)^7 + y = x^3.$$

(*b*) Check whether the following functions are linearly dependent or independent :

$$e^x \sin x,\ e^x \cos x.$$

(*c*) Prove the following property of Poisson Bracket :

$$[a, bc] = b[a, c] + [a, b]c.$$

P.T.O.

(*d*) Find the extreme points of the function :

$$f(x, y) = 4xy - x^4 - y^4.$$

(*e*) Solve :

$$(x^2 + y^2)dx - 2xydy = 0.$$

(*f*) Define generalised momenta for *n*-particle system, and find its time derivative.

(*g*) Form the differential equation whose only solutions are :

$$a_1e^x,\ a_2e^{2x},\ a_3e^{3x}.$$

(*h*) Find the extremal of the integral :

$$\int_0^{\pi} \left(y'^2 - y^2\right)dx, \text{ here } y' = \frac{dy}{dx}.$$

2. Solve the following differential equations :

(*a*) $x^4\frac{dy}{dx} + x^3y = -\sec(xy)$ 6

(*b*) $\frac{dy}{dx} = \frac{y + x - 2}{y - x - 4}$. 9

3. Solve the following differential equations :

(*a*) $\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = e^{2x}\left(x^3 + \cos 3x\right)$ 6

(*b*) $x^2\frac{d^2y}{dx^2} - 3x\frac{dy}{dx} + 5y = x^2\sin(\ln x)$. 9

4. (*a*) Solve the following differential equation : 6

$$(x^3 + y^3)dx - 2xy^2dy = 0.$$

(*b*) Using the method of variation of parameters, solve : 9

$$(D^2 + 9)y = x \cos 3x;\ D \equiv \frac{d}{dx}.$$

5. (*a*) Using the method of undetermined coefficients, solve : 6

$$(D^2 + 1)y = 2e^x + \cos x;\ D \equiv \frac{d}{dx}.$$

(*b*) Solve the coupled differential equations : 9

$$\frac{dx}{dt} + \frac{dy}{dt} - x = 2t + 1$$

$$2\left(\frac{dx}{dt} + \frac{dy}{dt}\right) + x = t.$$

6. (*a*) Prove that the equation of the shortest path between two points on the surface of right circular cylinder of radius a is given by :

$$z = c_1\phi + c_2,$$

where c_1 and c_2 are constants. 6

(*b*) Using Lagrange's method of undetermined multiplier, find the area of the largest triangle inscribed in the circle of radius a. 9

7. (*a*) Find the Hamiltonian corresponding to the Lagrangian : 6

$$L = a\dot{x}^2 + b\dot{y}^2 - kxy.$$

(*b*) Starting from the expression :

$$H(q, p) = p\dot{q} - L(q, \dot{q})$$

Derive the Hamilton's equations of motion. 9

8. (*a*) Show that the time derivative of $u(q, p)$ is given by :

$$\frac{du}{dt} = [u, H]$$

here, H denotes Hamiltonian. 6

(*b*) Write the Lagrangian of the system of two masses m and $2m$, shown below in Fig. 1. In this figure, x_1 and x_2 are the displacements of two masses from their equilibrium positions. Hence obtain the equations of motion of these two masses. 9

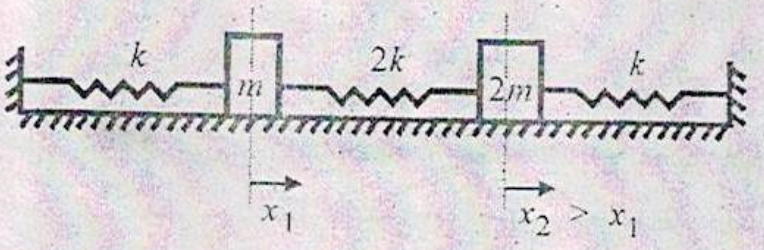


Fig. 1