Name of the Department	:	Physics
Name of the Course	:	B. Sc. (H) Physics – CBCS – NC - Core
Semester	:	I
Name of the Paper	:	Mathematical Physics I
Unique Paper Code	:	32221101
Question Paper Set Number	:	A
Maximum Marks	:	75

Instruction for Candidates

1. Attempt **FOUR** questions in all.
2. All questions carry equal marks.

1. Solve the following first order differential equations

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

b. $(x-2)\frac{dy}{dx}=y+2(x-2)^3$

c. $(x^2+y^2)dy-xy\,dx=0$

d. A machine produces 1% defective components. If the random variable X is the number of defective components in production of 50 components, then find the probabilities that X takes the value 2.

2. Solve the following second order differential equations

a. $(D^2-5D+6)y=e^x$

b. $(D^2-3D+2)y=\sin 2x$

c. $(D^2+16)y=\sin x$ (Use the method of variation of parameters)

3. Find the constants a and b so that the surface $ax^2-byz=(a+2)x$ will be orthogonal to the surface $4x^2y+z^3=4$ at the point $(1,-1,2)$.

Show that $\vec{E}=\frac{\vec{r}}{r^2}$ is irrotational. Find ϕ such that $\vec{E}=-\nabla\phi$ and such that $\phi(a)=0$ where a>0.

4. Is there a differentiable vector function $\vec{V}$ such that,

$$\nabla\times\vec{V}=\vec{r}$$

$$\nabla\times\vec{V}=2\hat{\imath}+\hat{\jmath}+3\hat{k}$$

If yes, then find $\vec{V}$.

Find the value of $\nabla^2\ln r$

5. Verify Green's theorem in the plane for $\oint(y-\sin x)\,dx+\cos x\,dy$, where C is the triangle formed by points (0, 0), ($\frac{\pi}{2}$, 0) and ($\frac{\pi}{2}$, 1).

$$\iiint_V \frac{dV}{r^2}=\iint_S \frac{\vec{r}\circ\hat{n}}{r^2}dS$$

6. Derive an expression for $\nabla\times\vec{A}$ in orthogonal curvilinear coordinates.

Evaluate $\iint\vec{A}.\hat{n}\;dS$, where $\vec{A}=z\hat{\imath}+x\hat{\jmath}-3y^2z\hat{k}$ and S is the surface of the cylinder $x^2+y^2=16$ included in the first octant between $z=0$ to $z=5$.

Sl. No. of Ques. Paper	:	Set B
Unique Paper Code	:	32221102
Name of the Paper	:	Mechanics
Name of the Course	:	B.Sc. Hons. – CBCS_Core
Semester	:	I
Duration	:	3 hours
Maximum Marks	:	75

*Attempt any **four** questions.*

1. (a) Deduce the equation of motion for a rocket as : (10.75)

$$\vec{F} = M\frac{d\vec{V}}{dt} - \vec{v}\frac{dM}{dt}$$

where M and $\vec{V}$ are the instantaneous mass and velocity of the rocket and $\vec{v}$ is the velocity of the gas with respect to the rocket. Hence, find the expression for the final velocity of a rocket launched from the surface of earth.

(b) A proton makes a head-on collision with an unknown particle at rest. The proton rebounds straight back with 4/9 of its kinetic energy. Find the ratio of the mass of the unknown particle to the mass of proton, assuming that the collision is elastic. (8)

2. (a) Calculate the moment of inertia of a solid sphere (mass M, radius R) about its diameter and tangent. (8.75)

(b) A particle of mass 10 g has position and velocity vectors

$\vec{r} = 10\hat{i} + 6\hat{j}$ meter, $\vec{v} = 5\hat{i}$ m/sec.

Find the angular momentum of this particle about the origin. (5)

(c) Find the centre of mass of thin rod of length ℓ whose density ρ varies with distance x from one end as: $\rho = \frac{\rho_0 x}{\ell}$, where ρ_0 is a constant. (5)

3. (a) Show that the areal velocity remains constant, when the particle moves under the influence of a central force. (6)

(b) A planet revolves around a star in an elliptical orbit. The ratio of the farthest distance to the closest one of the planet from the star is 4. Find the ratio of the kinetic energies of the planet at the farthest to the closest positions. (6)

(c) A satellite of mass m is fired from the surface of a stationary planet of mass M and radius R, with speed u at 30^o with the vertical direction. The satellite reaches a maximum distance of $5R/2$ from the centre of the planet. Show that

$$u = \sqrt{5GM/4R}$$ (6.75)

4. (a) Write down the equation of motion of a damped harmonic oscillator and solve it for lightly damped case. Also, calculate the rate of energy dissipated in the system. (11.75)

(b) A particle executing SHM has speeds v_1 and v_2 corresponding to the displacements x_1 and x_2, respectively. Show that the period of SHM is given by

$$T = 2\pi\sqrt{\frac{x_2^2 - x_1^2}{v_1^2 - v_2^2}} \qquad (7)$$

5. (a) Prove that acceleration of any particle in frame S' rotating with uniform angular speed ω with respect to another frame S given by

$$\vec{a}_{S'} = \vec{a}_S - 2\,\vec{\omega}\times\vec{v}_{S'} - \vec{\omega}\times\left(\vec{\omega}\times\vec{R}\right), \qquad (8.75)$$

where the symbols have their usual meanings.

(b) Cartesian coordinate system xyz is rotating with angular velocity $\vec{\omega}$ w. r. t. fixed cartesian coordinate system XYZ. If origins of both the systems coincide, prove that angular acceleration is same in both the systems. (4)

(c) A spaceship is receding from earth at a speed of $0.21c$. A light from the spaceship appears as yellow (λ = 589.3 nm) to an observer on earth. What would be its color as seen by the passenger of the spaceship? (6)

6. (a) On the basis of Lorentz transformation equations, derive the expression for time dilation. (6.75)

(b) Frame S' is moving w. r. t. frame S along common x-x' axis with speed 0.8c. If a rod of length 2 m is at rest in frame S, making an angle 45° with the x-axis, find the length and orientation (w. r. t. x'-axis) of rod in frame S'. (6)

(c) A particle at rest decays into two particles of rest mass m_o and $2m_o$. If the lighter particle moves with a speed of 0.8c, find the speed of other particle in lab frame and hence find the rest mass of the original particle. (6)

Name of the Department	**:**	**Physics**
Name of the Course	**:**	**B.Sc. (Hons.) Physics (CBCS)**
Name of the Paper	**:**	**Mathematical Physics-II**
Semester	**:**	**III**
Unique Paper Code	**:**	**32221301**
Question Paper	**:**	**Set-C**

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

Attempt any **four** questions. All questions carry equal marks.

Q1. Using method of separation of variables, solve 2-D equation $\frac{\partial^2 u}{\partial t^2} = c^2(\frac{\partial^2 u}{\partial r^2} + \frac{1}{r}\frac{\partial u}{\partial r} + \frac{1}{r^2}\frac{\partial^2 u}{\partial \theta^2})$ subjected to the conditions

$u(a, \theta, t) = 0,$

$u(r, \theta, 0) = 0$ and

$(\frac{\partial u}{\partial t})_{t=0} = g(r, \theta)$ (18.75)

Q2. (a) Using one dimensional heat equation $\frac{\partial V}{\partial t} = h^2 \frac{\partial^2 V}{\partial x^2}$, find the temperature V (x, t) in a bar of length which is perfectly insulated and whose ends are kept at temperature zero and the initial temperature is

$f(x) = x$ when $0 < x < \frac{L}{2}$

$= L - x$ when $\frac{L}{2} < x < L$ (10.75)

(b) Show that $\int_0^a x^{m-1}(a-x)^{n-1}\, dx = a^{m+n-1}\beta(m, n)$ (4)

(c) Show that the relation between beta and gamma function is

$\beta(m, n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$ (4)

Q3. Given, f(x) = x for $0 < x < 2$

(a) Find the Fourier cosine series of the function in half range. (10.75)

(b) Sketch the function. (3)

(c) Using Parseval's identity deduce that $\frac{\pi^4}{96} = \sum_1^\infty \frac{1}{n^4}$ (5)

Q4. (a) Find the complex form of the Fourier series of f(x) = exp(-x) for $-1 \le x \le 1$ (10.75)

(b) Show that

(i) $(x^2 - 1)\, P'_n(x) = n\,(x\, P_n(x) - P_{n-1}(x))$

(ii) $x\, J'_n(x) = -\, n\, J_n(x) + x\, J_{n-1}(x)$ (4, 4)

Q5. (a) Discuss the nature of singularity at x=1 of the differential equation

$(x^2-1)\, y'' + x\, y' - y = 0$ (5)

(b) Solve the differential equation $(x - x^2)\frac{d^2y}{dx^2} + (1 - 5x)\frac{dy}{dx} - 4y = 0$ using Frobenius method about x=0. (13.75)

Q6. (a) Solve the differential equation in power series, $y'' + x\, y' + y = 0$. (10.75)

(b) Show that $\int_{-1}^{+1} [Pn(x)\ Pm(x)]\, dx = \frac{2}{2n+1}\delta_{mn}$ (8)

Name of the Department: Physics

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

Name of the Paper: Thermal Physics

Semester: III

Unique Paper Code: 32221302

Question paper Set number: A

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

Instructions for Candidates

Answer any **four** questions.
All Questions carry equal marks.

Q1. (a) Explain the concepts of temperature and thermal Equilibrium on the basis of Zeroth Law. (4)

(b) Show that the heat transferred during an infinitesimal quasistatic process of an ideal gas can be written as

$$\delta Q = \frac{C_v}{nR} VdP + \frac{C_p}{nR} PdV$$

where n denotes the number of moles and R is the Gas Constant. Apply the above equation to an adiabatic process to show that $PV^{\gamma} = constant.$ (8.75)

(c) The temperature of an ideal gas at initial pressure P_1 and volume V_1 is increased isochorically until the pressure is doubled. The gas is then expanded isothermally until the pressure drops to original value. Then it is compressed isobarically until volume returns to initial value. Sketch this process in the P-V and P-T plane. Calculate the total work done if n = 2 kilomoles, $P_1 = 10^5$ Pascal, $V_1 = 2m^3$. (6)

Q2. (a) Describe construction and working of Carnot's heat engine. Derive expression for its efficiency in terms of temperatures of its heat reservoirs. (6)

(b) The efficiency of a Carnot's engine is 40% when the temperature of the sink is 27 °C. What is the temperature of the source? In order to raise its efficiency to 50%, what do you think, out of the following two, is more effective way:

(i) Decreasing the temperature of the sink (while the temperature of the source remains the same)

(ii) Increasing the temperature of the source (while the temperature of the sink remains the same)?

Justify your answer. (6.75)

(c) A heat engine employing Carnot's cycle with an efficiency η=20% is used as a refrigerating machine, the thermal reservoirs being the same. Find the coefficient of performance of the machine. (6)

Q3. (a) Establish the concept of entropy and explain the second law of thermodynamics on the basis of the entropy. (5)

(b) Consider that an ideal gas initially confined in a volume at any given temperature is allowed to expand and the whole arrangement is thermally insulated. Is it possible not to have any thermodynamic work even though there is expansion in its volume? Justify your answer and give an example. Find the entropy change of an ideal gas undergoing such a process. (8.75)

(c) Calculate the entropy change when 3 g of ice is converted into steam and is then heated to 140 °C under constant pressure. Given that specific heat of water = 4180 J kg^{-1} K^{-1}

Latent heat of ice = 3.35 x 10^5 J kg^{-1}

Latent heat of steam = 2.26 x 10^6 J kg^{-1}

Specific heat of steam = 2 x 10^3 J $kg^{-1}K^{-1}$ (5)

Q4. (a) Describe how the process of Adiabatic demagnetisation leads to cooling in paramagnetic salt. (5)

(b) From the equation of state of paramagnetic material M = k B/T show that the partial derivatives $\left(\frac{\partial M}{\partial B}\right)_T, \left(\frac{\partial B}{\partial T}\right)_M, \left(\frac{\partial T}{\partial M}\right)_B$ satisfy the cyclic relation. (7.75)

(c) Show that

$$(i)\ dH = C_P dT + V\,(1 - \alpha T)dP$$

$$(ii)\ dF = -(P\alpha V + S)dT + P\beta V dP$$

α denotes volume expansivity and β denotes compressibility. (6)

Q5. (a) Describe how the distribution of molecular velocities would be like for an ideal gas confined in a volume at a constant temperature and pressure. Consequently, derive the law which explains the molecular velocities on the basis of the kinetic theory of gases. (7.75)

(b) Given that the molar mass of a gas is 44 g mol^{-1}, calculate the temperature at which most molecules in a given volume attain velocity equal to 355 m s^{-1}. (4)

(c) Discuss what possible phenomena occurs when molecules of a gas at any temperature, are moving with a range of velocities in a given volume under non equilibrium conditions. Discuss briefly about Brownian motion and its significance. (7)

Q6. (a) Define critical temperature (T_C), critical pressure (P_C) and critical volume (V_C). Using van der Waal's equation of state, find their expressions in terms of van der Waal's constants 'a' and 'b'. Hence prove that for real gases, $\frac{RT_C}{P_C V_C} = \frac{8}{3}$; where R is universal gas constant. (8.75)

(b) The volume occupied by a gas at 300 K is 1.0 lit/mole. Compare the corresponding pressures considering the gas to be

i) An ideal gas

ii) A van der Waal's gas (given $a = 1.32\ atm\ lit^2 mole^{-2}$ and $b = 0.312\ lit/mole$) (6)

(c) Express van der Waal's equation of state for 1 mole of a real gas in Virial form. Hence obtain the expressions for the second Virial coefficient and Boyle's temperature of the gas. (4)

Name of the Department: PHYSICS DEPARTMENT

Name of Course: B.Sc. Hons.–CBCS_Core (NC)

Semester: V- Semester

Name of the Paper: Quantum Mechanics and Applications

Unique Paper Code: 32221501

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

Attempt four questions out of six. Each question carries equal marks.

1.

i. A particle is represented at (t=0) by the wave function:

$$\psi(x,0) = \begin{cases} A(a^2 - x^2) & -a \le x \le a \\ 0 & otherwise \end{cases}$$

Find A and expectation value of $x, x^2, p\ and\ p^2$. Find uncertainties in position and momentum.

ii. Show that Divergence of J (probability current density) is zero for stationary states.

iii. Find the Fourier transform of the wave function e^{-ax^2}.

(14.75+2+2)

2.

i. State Heisenberg's Uncertainty principle. What is the origin of concept of uncertainty in position and momentum? Derive $\Delta x \Delta p \ge \hbar/2$.

ii. Verify whether the following operators are linear:

a. $\widehat{f(x)} = \frac{d}{dx} f(x)$

b. $\widehat{f(x)} = \sqrt{f(x)}$

iii. What is uncertainty in the location of a photon of wavelength 5000 Angstrom which is known to an accuracy of one part in 10^7?

(12.75+3+3)

3.

i. Solve Schrodinger's equation for the potential energy $V = (1/2)kx^2$ and show that the energy eigenvalue are $E_n = (n + \frac{1}{2})\hbar\omega$.

ii. Which of the following wave functions

$$\text{(i) } e^{-ax^2} \text{ (ii) } \sin(kx)$$

are eigenvalues of operator (a) p and (b) p^2.

iii. Find the locations of classical turning points for a One Dimensional Harmonic Oscillator in its ground state.

(12.75+4+2)

4.

i. Describe the Stern-Gerlach Experiment and its theory. Discuss the significance of the experiment. Why is an inhomogeneous magnetic field required?

ii. A beam of silver atoms moving with a velocity of $10^5 cm/s$ passes through a magnetic field of gradient 0.50Wb/m^2/cm for a distance of 10cm. Determine acceleration of Ag atoms, time spent by atoms in the field and displacement of Ag atoms along z-direction as it comes out of the magnetic field (along z-axis).

iii. Show that $\frac{d}{dt}\int_{-\infty}^{\infty} \psi_1^* \psi_2 dx = 0$ for any two (normalizable) solutions to Schrodinger's equation, ψ_1 and ψ_2.

(12.75+3+3)

5.

i. Derive an expression for energy difference ΔE between doublets due to Spin-Orbit coupling. How does ΔE depend on quantum numbers n and l?

ii. Show that the angle between angular momentum (**L**) and z-axis is given by $\theta_{m_l} = cos^{-1}(\frac{m_l}{\sqrt{l(l+1)}})$. Find the values of angle θ_{m_l} for l=2.

iii. Calculate the probability of finding the electron in the region $\frac{a_0}{2} < r < 2a_0$ in a hydrogen atom in ground state given that wave function for the ground state of Hydrogen atom is $\psi(r) = \frac{1}{\sqrt{\pi a_0^3}} e^{\frac{-r}{a_0}}$, where $a_0 = \frac{4\pi\epsilon_0\hbar^2}{me^2}$.

(12.75+3+3)

6.

i. Solve 1-D time independent Schrodinger's equation for a particle having energy E for a square well of finite depth V_0 ($E<V_0$). Show graphically existence of bound states.
ii. An electron moves in 1-D potential well of width 8 Angstrom and depth 12eV. Find the number of bound states?
iii. Assuming LS coupling scheme, list the possible total angular momentum and spectral terms for three electron having configuration 2p 3p 4d.

(12.75+3+3)

Physical Constants:

Mass of Ag atom = 107.87amu,

Charge of electron = 1.6 x 10^{-19}C,

h=6.626 x 10^{-34}Js

Mass of electron = 9.1 x 10^{-31}Kg.

Roll Number: …………….

Unique Paper code : **32221502**

Name of the Paper : **Solid State Physics**

Name of the course : **B.Sc. Hons.–CBCS_Core**

Semester : **V**

Duration: 3 Hours Maximum Marks: 75

Answer any four questions. All the questions carry equal marks.

Q.1: How the Brillouin Zone associated to reciprocal vectors of any structure? Assuming hexagonal translation lattice vectors are $a_1 = \frac{\sqrt{3}}{2}\hat{\imath} + \frac{a}{2}\hat{\jmath}$, $a_2 = -\frac{\sqrt{3}}{2}\hat{\imath} + \frac{a}{2}\hat{\jmath}$, $a_3 = a\hat{k}$. Calculate the dimensions first Brillouin Zone for the Hexagonal lattice. (8.75+10)

Q.2: How phonons can be generated? Why is diamond a good of heat conductor like metals but a bad conductor of electricity unlike metals? Does the observed shift in photonic frequency agree with theoretical value? What are the fundamental assumptions in Debye's theory of lattice specific heat of solids?

(2+4+6+6.75)

Q.3: The energy wave vector dispersion relation for one dimensional crystal of lattice constant a is given by $E(k)=E_o-\alpha-2\beta\cos ka$, where E_o, α, β are the constants. Obtain the effective mass of the electron at the bottom and at the top of the band. What is the concept of effective mass of electron and hole (give your separate comments)? (10+4.25+4.5)

Q.4: Explain the formation of ferromagnetic domains. The magnetic susceptibility of silicon is -0.4×10^{-5}. Calculate the flux density and magnetic moment per unit volume when magnetic field of intensity 5×10^5 *A/m* is applied. ($\mu_o=4\pi \times 10^{-7}$). Explain that why Wiess molecular constant /Wiess factor have different values for ferro-magnetics? (6+8+4.75)

Q.5: Derive expression for polarizability assuming that 1D diatomic ionic solid (NaCl) subjected to an alternating electric field $E=E_L\, e^{-i\omega t}$. The dielectric constant of Si is 12. The length of the edge of its unit cell is 54.3 nm. Find the polarizability of Si atom. ($\varepsilon_o=8.854X10^{-12}$ F/m^3).

(10+8.75)

Q.6: What are the London equations? Prove that susceptibility of superconductor is -1 and relative permeability is zero**.** Drive London equation for the absence of resistance. Find the critical current which can pass through a long thin superconducting wire of aluminum of diameter 2 mm, the critical magnetic field for aluminum is 7.9×10^3 A m^{-1}. (2+8+4+2.75)

Unique Paper Code **: 32225310**

Name of the Paper **: Waves and Optics**

Name of Course **: B.Sc. Hons.-CBCS_GE**

Semester **: III - Semester**

Duration **: 3 Hours**

Maximum Marks **: 75**

Attempt any four questions in all. All questions carry equal marks.

Q1. (a) A particle is subjected simultaneously to two simple harmonic motions of the same period but of different amplitudes and phases in perpendicular directions. Derive the expression for the resultant motion. For what conditions the path may be a straight line, ellipse or circle? Discuss the different important cases. **(12)**

(b) A particle is subjected to two perpendicular simple harmonic motions simultaneously.

$x = A_1 Cos\ (2\omega t + \alpha) \qquad y = A_2 Cos(\omega t)$

Obtain lissajous figures analytically and graphically if $\alpha = \pi/2\ and\ \pi$ **(6.75)**

Q2. (a) Discuss the phenomenon of interference due to parallel thin films and find the conditions of maxima and minima. **(10.75)**

(b)Show that the conditions of Maxima and minima in reflected and transmitted monochromatic light are complementary. **(4)**

(c) Show that a film of infinitesimally small thickness appears dark in reflected light. **(4)**

Q3.(a) In Fresnel Diffraction, show that the intensity due to entire wavefront is given by $R_1{}^2/4$ where R_1 is the amplitude for first Fresnel half period zone. **(10)**

(b) Discuss the theory of zone plate and show that it acts as convex lens. **(8.75)**

Q4 (a) Giving the necessary theory, discuss the formation of Newton's rings by reflected light and explain how it can be used for determination of wavelength of monochromatic source of light. Why Newton's rings are circular? **(14)**

(b) In a Newton's ring experiment, the diameter of the 15th ring was found to be 0.590 cm and that of the 5th ring was 0.336 cm. If the radius of the plano-convex lens is 100 cm, calculate the wavelength of light used. **(4.75)**

Q5. (a) Distinguish between Fresnel and Fraunhofer class of diffraction. **(3)**

(b) Derive an expression for intensity distribution for Fraunhofer diffraction due a single slit. What happens when the width of the slit is gradually increased? **(15.75)**

Q6. (a). Explain briefly, the different ways of producing plane polarized light? What is Nicol prism and how is it used to produce polarized light? **(12.75)**

(b)What are sound waves? How can they be produced? Write four properties of sound waves. **(6)**

[This question paper contains 2 printed pages] Roll No. _______

S. No. of Question Paper:
Unique Paper Code: 32223912
Name of the Department: Physics
Name of the paper: Numerical Analysis
Name of the Course: B.Sc. (Hons)+ B.Sc. (Prog)- CBCS_SEC
Semester: III
Question paper Set number: Set A
Duration: 3 Hours Maximum Marks**: 50**

Instructions for Candidates
Attempt **four** questions in all. All questions carry equal marks.

1. Explain the geometrical significance of Secant Method. Use the secant method to determine the root of the equation $\cos(x) - xe^{x} = 0$ with initial approximations as 0 and 1 up to four decimal places. (Compute atleast 5 iterations)
Consider Kepler's equation regarding planetary orbits M = E - ϵ sin(E) where M is the mean anomaly, E is the eccentric anomaly and ϵ measures ecocentrism. Use Newton Raphson's Method to solve for E where M =π/3 and ϵ = 0.25, rounded to three decimals. (Perform only three iterations)

2. Using the function $f(x) = -0.1\ x^4 - 0.15\ x^3 - 0.5\ x^2 - 0.25\ x + 1.2$, calculate the first derivative of the function at x=0.5 (a) analytically (b) using the forward difference approximation with a step size of h= 0.25 (c) absolute, relative and percentage errors.
Find the sum, $S_n = 1^2 + 2^2 + 3^2 + \ldots\ldots\ldots\ldots + n^2$ using Newton's forward Interpolation Formula

3. The population, P of a small community on the outskirts of a city grows rapidly over a 20-year period.

t (years)	0	5	10	15	20
P	100	200	450	950	2000

Employ the exponential model using linear regression to forecast the population 5 years into the future in order to anticipate the demand for power.
Compute $\sqrt{x} - \sqrt{y}$ and $\frac{x-y}{\sqrt{x}+\sqrt{y}}$ using 4 significant digits where x=497.0 and y=496.0. Compare the two results.

4. Faraday's law characterizes the voltage drop across an inductor L as: $V_L = L\frac{dI}{dt}$, where V_L = Voltage drops (V), L= inductance (Henrys), I= current (A) and t= time (s). Determine the voltage drop at t= 0.1 sec from the given data for L = 4 H.

t (sec)	0	0.1	0.2	0.3	0.4	0.5
I (A)	0	0.16	0.32	0.56	0.84	2.0

From the table given below, determine the value of X at minimum value of Y. Also find this value of Y.

X	3	4	5	6	7	8
Y	0.205	0.240	0.259	0.262	0.250	0.224

5. The data for the force F(x) and the angle θ(x) as a function of the position x is given below:

x (m)	0	5	10	15	20	25	30
F (N)	0.0	9.0	13.0	14.0	10.5	12.0	5.0
θ(rad)	0.5	1.40	0.75	0.90	1.30	1.48	1.50

Calculate the work done, W given by the formula: W = $\int_a^b F(x)\cos(\theta(x))\,dx$ using *Weddle's Rule.*

A 11-m beam is subjected to a load, and the shear force follows the equation: $V(x) = 5 + 0.25\,x^2$ where V is the shear force and x is length in distance along the beam. The bending moment, M is given by M= $\int_0^x V\,dx$ + M_o. Using $M_o = 0$, calculate M using 3 points Gauss- Legendre Integration formula with abscissa and weights given below:

n	u_i	W_i
3	0	0.88889
	± 0.7746	0.55556

6. The radioactive decay equation is given $\frac{dN}{dt} = -\lambda N$ with N (0) = N_o, where N(t)= number of radioactive nuclei in a sample at time t, λ = probability per unit time for a nucleus to decay, N_o = number of nuclei at time t =0. Calculate the number of nuclei between the time range [0,5] with step size = 1 sec, where the initial number of nuclei are 1200 and λ= 0.2 using Euler's Method.

Explain the geometrical significance of Modified Euler's Method and how it is overcomes the limitation of Euler's Method.

Roll No.......................

Unique Paper Code : 32227502

Name of Paper : Advanced Mathematical Physics

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

Semester : **V-Semester**

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

All questions carry equal marks.

Attempt four questions in all.

Use of Scientific calculator is allowed.

1 (a) If V is the vector space spanned by the vectors α_1, α_2 and α_3, then show that the vectors $\beta_1 = \alpha_1, \beta_2 = \alpha_1 + \alpha_2$ and $\beta_3 = \alpha_1 + \alpha_2 + \alpha_3$ also spans V.

(b) A transformation $T: R^2 \rightarrow R^2$ is defined by

$$T[x, y] = \left[\frac{x}{\sqrt{2}} - \frac{y}{\sqrt{2}}, \frac{x}{\sqrt{2}} + \frac{y}{\sqrt{2}}\right]$$

Show that T is linear and give the geometrical interpretation of T.

(c) Find the dimension of, and a basis for, the solution space of the system of equations

$$x + 2y - 2z + 2s - t = 0$$
$$x + 2y - z + 3s - 2t = 0$$
$$2x + 4y - 7z + s + t = 0$$

(4.75+7+7)

2(a) Verify Cayley-Hamilton theorem for the given matrix B.

$$B = \begin{bmatrix} 1 & 2 & 0 \\ 2 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$

(b) Find the inverse of matrix B.

(b) What constant should be multiplied to make the given matrix Unitary?

(6+6 + 6.75)

3. (a) Solve the given system of differential equations using matrix method:

$$y_1' = y_1 + y_2$$
$$y_1' = 4y_1 + y_2$$

subject to the initial conditions$y_1(0) = y_2(0) = 1$.

(b) If A is square matrix prove that e^A is nonsingular.

(15+3.75)

4. Explain and prove the Quotient Law. If $A_{ij}B^i = C_j$ are component of covariant vector for all choice of contravariant vector, B^i then A_{ij} is a covariant tensor.

(18.75)

5. (a) Prove that

$$\nabla(\nabla . A) = \nabla \times (\nabla \times A) + \nabla^2 A \text{using tensors.}$$

(b) Explain the physical significance of diagonal and off-diagonal terms of strain tensor. Also prove that it is symmetric tensor of rank two.

(8.75, 10)

6. (a) Show that one time contraction reduces the order of tensor by 2.
(b) Show that $T_k^{ij}\delta_l^i$ is not a tensor, where T_k^{ij} and δ_l^h are tensor.

(8.75, 10)

Your Roll No……………………

Unique Paper Code : 32227504

Name of Paper : Nuclear and Particle Physics

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

Semester : **V**

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

All questions carry equal marks.

Attempt four questions in all.

Use of Scientific calculator is allowed.

1. (a) Calculate the mass defect in amu for a deuteron nucleus given that its mass is 2.014103 u, mass of a neutron is 1.008665 u and mass of a proton is 1.007825 u. (4)
(b) Neutron has a non-zero magnetic moment, though the net charge on neutron is 0. Discuss. (2)
(c) Estimate the energy of a neutron to be a part of the nucleus using uncertainty principle. (4.75)
(d) Determine the ratio of the nuclear radius of U^{238} and He^{4}. (3)
(e) Represent graphically, the N-Z curve where N is the number of neutrons and Z is the number of protons for known stable nuclei. What conclusions can be drawn from this curve? (5)

2. (a) How did the shell model explain the nuclear magic numbers. (4)
(b) State four properties of nuclei that were successfully explained by the semi empirical mass formula. (6.75)
(c) Find the value of total angular momentum j and parity of the ground state of $_{13}Al^{27}$ according to the single particle nuclear shell model. (4)
(d) State the assumptions for the Fermi gas model for the nucleus. (4)

3. (a) State two differences between electron capture and positron emission with examples. (4.75)
(b) Determine if the nucleus $_{1}^{3}H$ can undergo a β^{-} decay and produce the daughter nucleus $_{2}^{3}He$ nucleus. (5)
(c) Represent graphically (explaining every term but NO derivation), the relationship between the energy of the alpha particle emitted by a nucleus and its decay constant. (5)
(d) Determine the wavelength of the gamma rays emitted when electron and positron annihilate. (4)

4. (a) What is meant by cross section of a nuclear reaction ? Write its units. Distinguish between microscopic cross section and macroscopic cross section of nuclear reactions. (5)

(b) Give an example each of direct nuclear reaction and compound nucleus formation reaction. (2.75)

(c) What are exoergic and endoergic reactions. Explain with examples. (4)

(d) Using a non-relativistic approach, calculate the threshold energy for the reaction $^{16}_{8}O(p,d)^{15}_{8}O$ both in the centre of mass frame and the lab frame.
Given mass of $^{16}_{8}O$ = 15.994915 u ; mass of $^{1}_{1}H$ = 1.007825 u ; mass of $^{2}_{1}d$ = 2.014102 u; mass of $^{15}_{8}O$ = 15.003070 u (7)

5. (a) Enumerate three differences between internal conversion and gamma decay. (3)

(b) In Compton effect show that the change in wavelength of a photon is independent of the incident wavelength. Calculate the ratio of Compton wavelength of proton to the Compton wavelength of electron. (6)

(c) In a scintillation counter the Cs^{137} (662 KeV) peak is observed at a pulse height voltage of 60 volts. The spread in its peak profile is 100 KeV. Calculate the percent resolution of the spectrometer. (3)

(d) In scintillation detectors, what is the role of the photomultiplier tube? (6.75)

6. (a) Tabulate the composition of Ω^- and K^+ according to Quark model including the quark content, Baryon number and strangeness. (4)

(b) List two features of strange particles with examples. (2)

(c) Explain which of the following reactions are allowed or forbidden under the conservation of strangeness, conservation of baryon number, conservation of charge, conservation of isospin, conservation of z component of Isospin, conservation of Lepton number. Also state the kind of interaction followed. Else state the conservation laws violated.

i) $p \rightarrow e^+ + \pi^0$

ii) $\Xi^- \rightarrow \Lambda^0 + \pi^-$ (3+3)

(d) Explain the principle and working of a linear accelerator. (6.75)

SET-1

Sr. No. of Question Paper: Student's Roll No. : ……………

Unique Paper Code : 42221101

Name of Paper : Mechanics

Name of the Course : B. Sc. (Prog.)_CBCS_New Course

Semester : I

Duration : **03:00 Hours** Max. Marks: **75**

Instructions for Students

Write your Roll Number on the top immediately on the receipt of this question paper.

All questions carry equal marks. Attempt any **four** questions in all.

Q.1 (a) What are physical and non-physical quantities? How physical quantities are classified? (***03 Marks***)

(b) Find out a unit vector lying in XY-plane and perpendicular to the vector $\vec{A} = 3\hat{\imath} + 4\hat{\jmath} + \hat{k}$. (***03 Marks***)

(c) Show that the gradient of a scalar function $\phi(x, y, z)$ is normal to the surface $\phi(x, y, z) = c$, where 'c' is a constant. Also, find a unit vector normal to the surface $x^2 + y^2 + z^2 = 3$ at the point (1, 1, 1). (***05 Marks***)

(d) Determine the constant a, b and c so that the following vector is irrotational:

$$\vec{V} = (x + 2y + cz)\hat{\imath} + (ax - 3y - z)\hat{\jmath} + (4x + by + 2z)\hat{k}$$ (***03 Marks***)

(e) Solve the following differential Equation: $\frac{d^2y}{dx^2} + 5\frac{dy}{dx} + 4y = 3 - 2x$ (***4.75 marks***)

Q.2 (a) Define centre of mass of a system of particle. The centre of mass of a system consisting of four particles of masses 2, 3, 4 and 5 kg is at (1, 1, 1). The centre of mass shifts to (2, 2, 2) on removing the particle of mass 5 kg. Find the position of the particle of mass 5kg. (***2+4 = 06 Marks***)

(b) What are conservative and non-conservative forces? Give the examples of each forces. Write down the properties of conservative forces? Show that the work done by a conservative force around a closed path is always zero. (***2+2+2+3 = 09 Marks***)

(c) Differentiate between elastic and inelastic collisions? Prove that in elastic head-on collision, the relative velocity with which two particles approach each other before collision is equal to the relative velocity with which they recede from each other after collision. (***1+ 2.75 = 3.75 Marks***)

Q. 3 (a) Define angular momentum. Prove that the relation between angular momentum ($\vec{J}$) about a reference point and angular momentum ($\vec{J}_{cm}$) about center of mass of a system of particles is given by $\vec{J} = \vec{J}_{cm} + \vec{R} \times \vec{P}$ in which $\vec{R}$ and $\vec{P}$ are respectively the position vector and linear momentum of the center of mass of the system about the reference point.

(***0.75+ 8 = 8.75 Marks***)

(b) Define moment of inertia. Write down the statement of the theorems of parallel and perpendicular axes. Find out the moment of inertia of a rod having length L and mass M about an axis perpendicular to its length and passing through (i) its center of mass and (ii) its one end. (***2+4+4=10 Marks***)

Q.4 (a) Write down the most general form of central force. Prove that when a particle moves under the action of a central force, its angular momentum remains conserved and motion takes place in a fixed plane. (***0.75+3.5+3.5 = 7.75 Marks***)

(b) What are geostationary orbit and geostationary satellite? Find out the radius of the geostationary orbit and velocity of the geostationary satellite. (***3+4+4 = 11 Marks***)

Q.5 (a) Define damping. Is damping force conservative or non-conservative in nature? (***03 Marks***)

(b) Derive the differential equation of damped harmonic oscillator and find out its solution. Consider the underdamped case and show that the effect of damping is to increase the periodic time. Define logarithmic decrement. (***5+5+5+0.75= 15.75 marks***)

Q.6 (a) Differentiate between inertial and non-inertial frames of reference? Prove that the interval $S^2 = x^2 + y^2 + z^2 - c^2t^2$ is invariant under Lorentz Transformations. (***3+5 = 08 Marks***)

(b) In Michelson-Morley experiment, the length of the arm of interferometer was 11.5 meters, the wavelength of the light 5000A and earth's velocity is 30 Km/s, calculate the fringe shift.

(***04 Marks***)

(c) Find the speed of a particle at which its mass will become 8 times of its rest mass. (***04 Marks***)

(d) What do you mean by time dilation? Why do we not observe the effect of time-dilation in everyday life? (***2.75 Marks***)

Name of the Department : Physics and Astrophysics

Name of the Course : B.Sc. Prog.–CBCS_Core

Name of the Paper : Thermal Physics and Statistical Mechanics

Semester : III

Unique Paper Code : 42224303

Question paper Set Number: A

Duration:3 hours **Max Marks: 75**

Attempt any FOUR questions of this question paper. Each question is of 18.75 marks.

1. (a) Define extensive and intensive variables with the help of examples. Explain how first leads to the concept of internal energy law of thermodynamics. (8)

(b) Draw P-V diagrams representing isothermal and adiabatic process of an ideal gas. Why is P-V curve for adiabatic process steeper than that for isothermal process (5)

(c) Deduce the latent heat equation of Clausis $C_2 – C_1 = (dL/dT)- (L/T)$ where C_1 and C_2 represent the specific heat of a liquid and its saturated vapour and L is the latent heat of the vapour. (5.75)

2. (a) State Carnot's theorem and show that it is necessary consequence of second law of thermodynamics. Using Carnot theorem, prove Clausis inequality. (12)

(b) There are two Carnot engines A and B operating in two different temperature regions. For Engine A the temperatures of the two reservoirs are 200°C and 150°C. For engine B the temperatures of the reservoirs are 300°C and 250°C. Which engine has lesser efficiency? (6.75)

3.(a) Define the principle of increase of entropy. Explain the second law of thermodynamics in terms of entropy? (6.75)

(b) 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 (12)

4. (a) Using Maxwell's thermodynamic relations, show that the ratio of adiabatic and isothermal elasticity is equal to ratio of molar specific heat at constant pressure and volume.

(12)

(b) Find the change in entropy when 1 gram of water at 0ºC is converted into steam at 100 ºC. The specific heat of water is 1cal/gm ºC and latent heat of steam at 100 ºC is 540 cal/gm.

(6.75)

5 (a) Derive Wein's displacement law and Stefan's law from Planck's radiation law. (10.75)

(b) Explain the ultraviolet catastrophe according to Rayleigh-Jeans distribution law. (5)

(c) A body at 1500 K emits maximum energy of wavelength 2000 nm. If the sun emits maximum energy of wavelength 550 nm, what would be the temperature of the sun? (3)

6. (a) Define and explain the terms Macrostate and Microstate with the help of an

example. (6)

(b)What is meant by the term thermodynamic probability of macrostate? How it is related to probability of occurrence of that state. How does it differ from mathematical probability?

(8.75)

(c) 4 molecules are to be distributed in 2 cells. Find possible no. of macrostates and corresponding no. of microstates. (4)

Unique Paper Code	:	32177901
Name of the Paper	:	DSE: Novel Inorganic Solids
Name of the Course	:	B.Sc. Prog.
Semester	:	V
Duration	:	3 hours
Maximum Marks	:	75

Instructions for Candidate

Attempt FOUR QUESTIONS in all.
QUESTION NO.1 is compulsory.
All Questions carry equal marks

1. **(a)** Fill in the blanks:

(i) Ag_2HgI_4 is a good solid ionic conductor due to the mobility of ……….ions.

(ii) ……………….. materials are fluid, but with positional order in at least one dimension.

(iii) …………….is an example of p-type semiconductors.

(iv) …………….is an example of black pigment.

(v) …………….is the most suitable source reagent of SiO_2 in Sol-gel method of synthesis of solids.

(vi) ……………..is a visible radiation source in the visible spectrophotometer.

(6×1=6)

(b) Answer the following as True or False:

(i) Graphene is a carbon atom monolayer. It is possible to roll it, but not to wrap it.

(ii) Porcelain is an example of ceramic material.

(iii) Scanning Probe microscopy is used to characterize a conductive surface of nanomaterials.

(iv) Tamman's rule suggests that a temperature of about two-thirds of the melting point (K) of the lower melting reactant is required for the reaction to occur in a reasonable time.

(v) Due to interactions between molecules, single-molecule magnets stay magnetized even when the magnetic field is turned off.

(vi) Prussian blue pigment imparts color due to d-d transition.

(6×1=6)

(c) Answer the following very short type questions:

(i) Carbon nanotubes and DNA are 1D nanomaterials because these can be elongated in one direction only.

(ii) Why does increased pressure reduce the conductivity of K^+ in β-alumina more than that of Na^+ in β -alumina?

(iii) Why do Quantum dots of the same material may exhibit different colors?

(iv) An intercalation reaction is an example of a Topochemical reaction. Explain.

(v) How does Pt-Pt bond distance is affected in $K_2Pt(CN)_4$ complex on oxidation?

(vi) Does λ_{max} of sample change within the same solvent but with the difference in molarity? If so, why?

(1.25+1.25+1.25+1.25+1.25+1.75=6.75)

2. (a) What is Peierls distortion? Give its significance in one-dimensional metals.
(b) What are Single Molecular Magnets? Explain giving examples.
(c) What are condensates? What role do they play in *in-vitro* DNA synthesis control?

(6.25×3=18.75)

3. (a) Discuss the working of Solid Oxide Fuel Cells (SOFCs). What are its advantages and disadvantages?
(b) What are topotactic reactions? Discuss nucleation of $MgAl_2O_4$ Spinel on the surface of: (i) MgO & (ii) Al_2O_3.
(c) Discuss different types of Solid Electrolytes with examples. Why are cationic electrolytes more common than solid anionic electrolytes?

(6.25×3=18.75)

4. (a) What are the differences between SEM and TEM techniques used for characterizing nanoparticles. Which one is more suitable for measuring the size and shape of nanoparticles, and why?
(b) Discuss the conduction mechanism of conducting polymer polypyrrole. Also, give its applications.
(c) What are nematic liquid crystals? Describe the various applications of inorganic liquid crystals.

(6.25×3=18.75)

5. (a) What is the Reinforcement or Reinforcing phase? Give its significance. Discuss different types of Reinforcements used in Composites.
(b) Explain the hydrothermal process of synthesis of solids. Also, give its limitations.
(c) Explain biomimetics with respect to artificial fossilization. Discuss the shell of Red Abalone, a natural composite

(6.25×3=18.75)

6. Write short notes on *any three* of the following:
(a) Refractories
(b) Self-assembly of nanostructures
(c) Ion-exchange resins
(d) Quantum confinement

(6.25×3=18.75)

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Name of the Department: **Department of Physics and Astrophysics**
Name of Course: **B.Sc. Prog. _CBCS_DSE**

Semester: **V- Semester**

Name of the Paper: **Elements of Modern Physics**

Unique Paper Code: **42227529/ (New Course)**

Question Paper Set Number: **5**

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

All questions carry equal marks. Attempt any four of the following questions.

Q1.(a) Explain de-Broglie hypothesis. Give an experiment in its support and show how does it verify the de-Broglie hypothesis. (3,5,3.5)

(b) The work function of a metal A is twice the work function of the metal B. How will be their threshold frequency be related? (4)

(c) Calculate the fractional change in the wavelength of an X-ray of wavelength $0.400\ \text{Å}$, which undergoes a 90^o Compton scattering from an electron. (3.25)

Q2. (a) Distinguish between:

(i) Emission spectrum and absorption spectrum.

(ii) line spectra and continuous spectra (4)

(b) "All electron can circle the nucleus only if its orbit contains the integral number of de Broglie wavelength". Prove mathematically how this statement combines particle and wave character of electron in a stationary orbit. (8)

(c) The ionization energy of H-like atom is 4 Rydberg. What is the wavelength of radiation emitted when the electron jumps from the first excited state to ground state ? (6.75)

Q3. (a) Deduce the Uncertainty relation between energy and time by considering the motion of wave packet. Explain its physical significance. (7)

(b) The average period that elapses between the excitation of an atom and the time it emits radiation is 10^{-8} sec. Find the uncertainty in energy emitted and the uncertainty in frequency of light emitted. (5.75)

(c) Prove that for rotational motion of a particle the uncertainty principle can be given as

$\Delta L.\Delta\varphi \geq h/2\Pi$ where, ΔL is uncertainty in angular momentum of the particle and $\Delta\varphi$ is uncertainty in its angular position. (6)

Q4. (a) What are the Postulates of quantum Mechanics? Illustrate their use by an example. (8)

(b) Explain with diagram 2-Slit interference Pattern with electron and photon. (3,3)

(c) An electron has a speed of 600 m/s with an accuracy of 0.05%. Calculate the minimum uncertainty in the location of the electron. (4.75)

Q5. (a) Define one dimensional potential box. Also explain zero-point energy for the particle in one dimensional box. (6)

(b) Calculate the three lowest energy levels (in eV) for an electron inside a one-dimensional infinite potential well of width 2Å. Also determine the corresponding normalized eigenfunctions and eigenvalues. (12.75)

Q6. (a) What do you mean by continuous β-spectrum? What is discrete β-spectrum and end point energy? The half-life of $_{11}^{24}Na$ is 14 hours. How long does it take for 93.75 % of a sample of this isotope to decay? (12.75)

(b) What do you understand by mass deficit? Calculate the energy of γ-rays in the β-decay of ^{28}Al. (Given: E_{max}=2.86 MeV.) (6)

Name of Course : **CBCS B.Sc. (Math Sci)- II / B.Sc. (Phy Sci)-II / B.Sc. (Life Sci)-II / Applied Sciences-II**

Unique Paper Code : **42357502_OC**

Name of Paper : **DSE- Mechanics and Discrete Mathematics**

Semester : **V**

Duration : **3 hours**

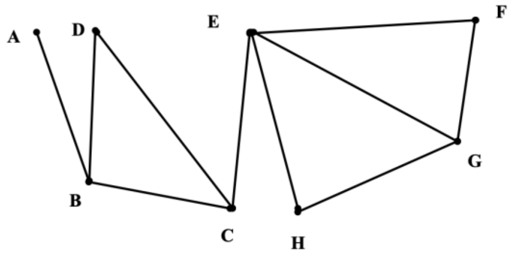
Maximum Marks : **75 Marks**

Attempt any four questions. All questions carry equal marks.

1 If R is the horizontal range of a projectile and H is its greatest height. Prove that its initial velocity is

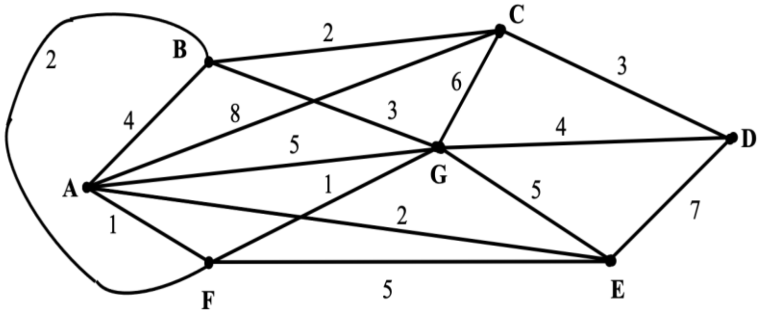
$$u = \sqrt{\left[2g\left(H + \frac{R^2}{16H}\right)\right]}$$

Find the cut vertices and cut edges of the following graph. Justify your answer using graphs.



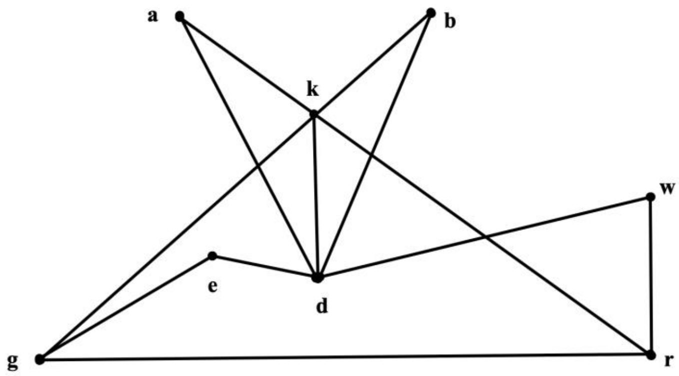
2 A particle describes a curve (for which S and ψ vanishes simultaneously) with uniform velocities v. If the acceleration at any point is $\left(\frac{v^2c}{S^2+c^2}\right)$. Find the intrinsic equation of the curve.

Apply the Dijkstra's Algorithm to find the shortest path from A to Z in the graph shown below. Explain the steps.



3 Find the center of gravity of a triangle coincides with that of there particles of same weight placed at its corners.

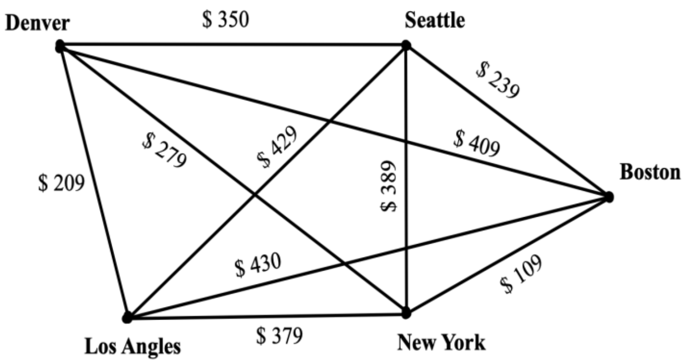
In the graph given below describe an Eulerian circuit or explain why no Eulerian circuit exists. If Euler circuit does not exist describe an Eulerian path, if it exits. Describe a Hamiltonian path of the given graph.



4 A uniform elastic string has length a_1 when the tension is T_1 and a length a_2 when the tension is T_2. Show that its natural length is $\frac{(a_2T_1-a_1T_2)}{(T_1-T_2)}$ and the amount of work done in stretching it from the natural length to length a_1+a_2 is

$$\frac{(a_1T_1-a_2T_2)^2}{2\,(a_1-a_2)(T_1-T_2)}.$$

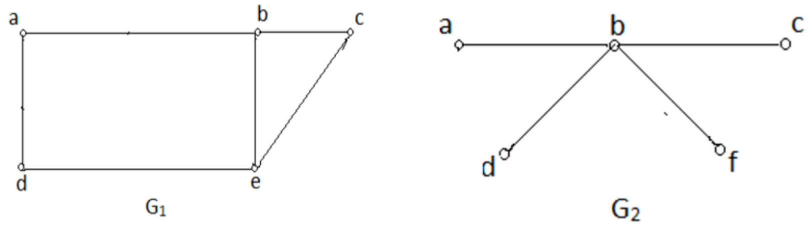
Find a route with the least total airfare that visits each of the cities in the graph exactly once and returns back to starting city. In the given graph the weight on an edge is the least fare available for a flight between the two cities.



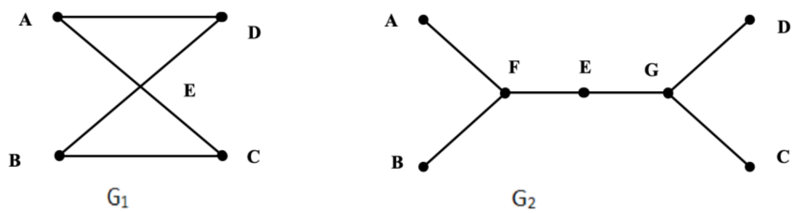
5 *ABCDEF* is regular hexagon and *O* is its center. Forces of magnitude is *3,5,2,6,7,9* act in the Lines *BA, CB, CD, ED. EF, AF* in the senses indicated by the order of the letters. Reduced the system of force at *O* and a couple.

Find the union of the graphs G_1 and G_2 ; explain your answer:

(i)



(ii)



6 A uniform beam of Length *2a*, rest in equilibrium against a smooth vertical wall and upon a peg at a distance "*b*" from the wall. Show that the inclination of the beam with the vertical is $sin^{-1}\left(\frac{b}{a}\right)^{1/3}$.

Determine whether the given graph is bipartite. Also verify whether it is complete bipartite or not. Justify your answer.