Unique Paper Code	:	32221201_OC	**Set B**
Name of the Paper	:	Electricity and Magnetism	
Name of the Course	:	B. Sc. (H) Physics – CBCS – (OC)	
Semester	:	II	
Duration	:	3 hours	
Maximum Marks	:	75	

Instructions for Candidates

Attempt any **four** questions.

All questions carry equal marks.

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1. (a) A solid sphere of radius *R* carries volume charge density given by $\rho(r) = \rho_0 \left(1 - \frac{r}{R}\right)$ for $r \leq R$ and $\rho(r) = 0$ for $r>R$. Find the electric field inside and outside the sphere using Gauss's law. Can Gauss's law be used to find field if the charge distribution is not spherically symmetric? Identify the specific step(s) in the above derivation which cannot be carried out if the charge distribution is not spherically symmetric.
(b) If the earth were treated as an isolated insulated conductor situated in vacuum, what would be its capacitance? Take the radius of the earth as 6300 km.

(c) Using the case of a parallel plate capacitor derive an expression for the electrostatic energy density associated with an electric field. (8.75,5,5)

2. (a) Use Laplace's equation to prove that a point charge located in an electric field cannot exist in a state of stable equilibrium under the action of the electric field alone.
(b) Electric field in a given region of space is given by $\vec{E} = 5x\hat{\imath} + 6\frac{y}{z}\hat{\jmath} + 5z\hat{k}$, find the volume charge density and describe it physically.
(c) A point charge $+q$ is placed ad distance *d* in front of an infinite conducting plane connected to earth. Determine by the method of images the force of attraction between the charge and the plane. (6,6,6.75)

3. (a) Show that in electrostatics while the electric field is necessarily irrotational, this not the case with electric displacement.

(b) A point charge Q is placed at the centre of a dielectric sphere of radius R and dielectric constant K. Find bound surface and volume charge densities. What is the total bound charge on the surface of the sphere?

(c) A surface separates two dielectrics with dielectric constant ϵ_1 and ϵ_2. Electric field lines bend across the boundary due to bound polarisation charges (assume there are no free charges). Take the boundary normal **n** from medium 2 to medium 1. Field $\mathbf{E}_1$ in medium 1 makes angle θ_1 with the normal, $\mathbf{E}_2$ in medium 2 makes angel θ_2 with it. Show that (i) the planes defined by $\mathbf{E}_2$ and **n** and $\mathbf{E}_1$ and **n** are same (i.e. planes of 'incidence' and 'refraction' are same) , and (ii) $\frac{tan\theta_1}{tan\theta_2} = \epsilon_1/\epsilon_2$. (3,8,7.75)

4. (a) Write down the differential equation which shows that magnetic field lines do not have any sources and sinks. Draw field lines of an electric dipole and a magnet, including inside the magnet. Are the field lines of an electric dipole and magnet similar in shape in far field region? Are they similar in shape and direction inside the magnet and close to the dipole?

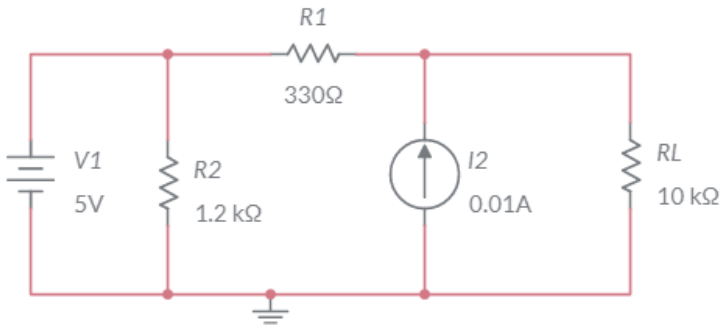
   (b) Derive the relation $\oint_C \boldsymbol{A}.\boldsymbol{dl} = \Phi$, where $\boldsymbol{A}$ is vector potential and Φ is the magnetic flux crossing the surface bounded by C. Use it to find vector potential of a long solenoid carrying current I, and having radius R and n turns per unit length. In a diagram show directions of the vector potential both inside and outside the solenoid. Show that $\boldsymbol{\nabla}.\boldsymbol{A} = 0$ for the solution derived. (7, 11.75)

5. (a) Define self-inductance of a current carrying loop. Show that the work done in establishing current I in a loop with self-inductance L is $W = \frac{1}{2}LI^2$.

   (b) Two solenoids have same axis and length have radii R_a and R_b , with $R_a > R_b$. The inner solenoid has current I flowing counter-clockwise through it, and the outer solenoid has no current. The outer solenoid has resistance R. The inner solenoid wire is cut by scissors, so that in a fairly small duration current in it drops to zero. What is the direction of induced current in the outer solenoid? How much total charge passes a point in the outer solenoid during the period this current flows? (8, 10.75)

6. (a) A series LCR circuit with L = 25nH, C = 70μF has a lagging phase angle of 20° at ω = 2 kHz. At what frequency will the phase angle be leading by 30°?

   (b) Use the superposition theorem to find current through R_L for the given network.



(c) State Reciprocity theorem and explain using a suitable circuit diagram. (5,6 ,7.75)

Useful Constants

$\epsilon_0 = 8.85 \times 10^{-12} \mathrm{C^2 N^{-1} m^{-2}}$

$\mu_0 = 4\pi \times 10^{-7} \mathrm{N A^{-2}}$

Roll No. ……

Name of the Department	:	Department of Physics and Astrophysics
Name of Course	:	B.Sc. Hons. - CBCS
Semester	:	IV - Semester
Name of the Paper:	:	Analog Systems and Applications
Unique Paper Code	:	32221403_OC
Question paper Set number	:	Set 2
Duration	:	3 hours
Max. Marks	:	75 marks

Attempt <u>FOUR</u> questions in all. All questions carry equal marks

(Given : $\varepsilon_o = 8.85 \times 10^{-12}\ F/m$; $k = 1.38 \times 10^{-23}\ J/K$; $q = 1.6 \times 10^{-19}$C)

Q1

(a) Sketch the variation of the space charge, depletion region, electric field and electrostatic potential barrier as a function of distance across the junction, for an unbiased *p-n* Junction. Obtain an expression for the width of depletion region for an unbiased *p-n* junction diode. (15)

(b) Determine the forward bias voltage applied to a silicon diode to cause a forward current of $10mA$ and reverse saturation current of 2.5 μA at room temperature. (3.75)

Q2

(a) In a full-wave rectifier, the voltage applied to each diode is $240sin377t$, the load resistance is 2000Ω and each diode has a forward resistance of 400Ω. Determine the (i) Peak, average and *rms* value of current (ii) efficiency of the rectifier and (iii) ripple factor. (7)

(b) Determine the maximum allowable Zener current for a Zener diode (20 V, 1200 mW) working as a voltage regulator. Also determine the range of input voltage to keep Zener diode under regulation if the values of limiting resistance and the fixed load resistance are $1k\Omega$ and $20k\Omega$ respectively. Support your answer with the voltage regulator circuit diagram. (8)

(c) Give two advantages and two limitations of using a LED. What is the wavelength of emitted electromagnetic radiation if the band gap value of a semiconductor is 1.43 *eV*. (3.75)

Q3

(a) Describe the construction of a transistor including emitter, base and collector. Explain how current flows due to charge carriers in *npn* transistor. (3.75)

(b) Define current gain in CB configuration (α) and current gain in CE configuration (β). Derive the relation between them. (3)

(c) Find the following for the circuit below, (12)
(i) I_C.
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(v) V_B.
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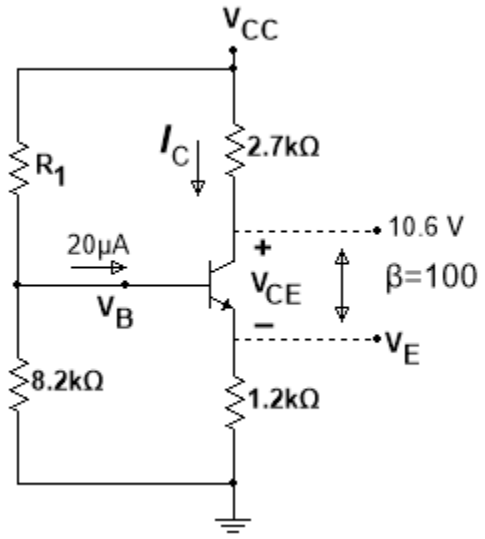


Q4

(a) Draw the circuit diagram of an RC coupled amplifier. Give the AC equivalent circuit in low, mid and high frequency range and state the associated assumptions for each frequency range . Derive an expression for voltage gain in low frequency region. (8.75)

(b) Define stability factor. Explain how addition of emitter resistance enhances the stability of the fixed bias circuit. (6)

(c) For an *npn* transistor $\alpha = 0.98$, $I_E = 10\ mA$ and the leakage current I_{CBO}=0.4μA. Calculate the values of I_C , I_B , β and I_{CEO}. (4)

Q5

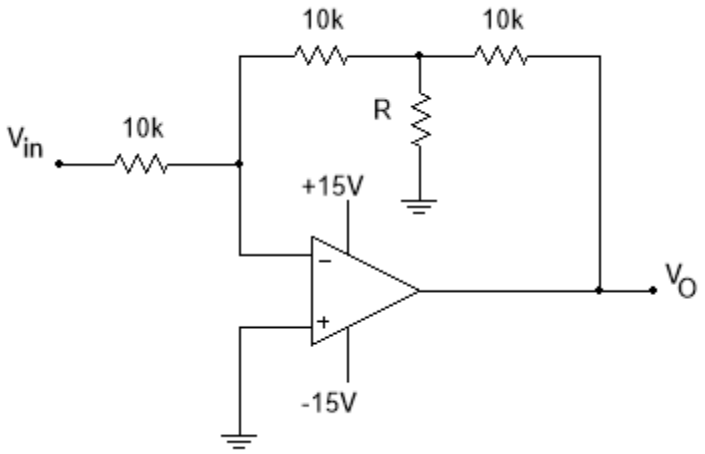
(a) An amplifier has a mid-band gain of 100 and a bandwidth of 250 kHz. If 4% negative feedback is introduced, find the new bandwidth and gain. (4)

(b) Derive the expression for frequency of oscillation and the condition for sustained oscillations for a RC phase shift oscillator. (9)

(c) A Colpitts oscillator is designed with capacitor $C_1 = 100pF$ and $C_2 = 7500pF$ and a variable inductor. Determine the range of inductance, if the frequency of oscillations is to vary between 950 kHz to 2050 kHz. (5.75)

Q6

(a) Determine the value of the resistance R the given circuit if the gain of the circuit is 10. (5)



(b) Derive an expression for frequency of oscillations and the condition for sustained oscillations for a Wien bridge oscillator using op-amp. In which frequency range it can be used. (8.75)

(c) Derive an expression for output of an ideal integrator. What are the limitations of ideal op-amp integrator? Give the circuit of practical integrator and explain how these limitations can be overcome. (5)

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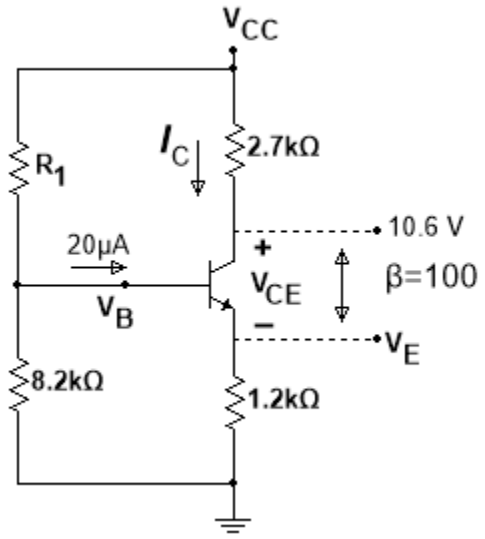

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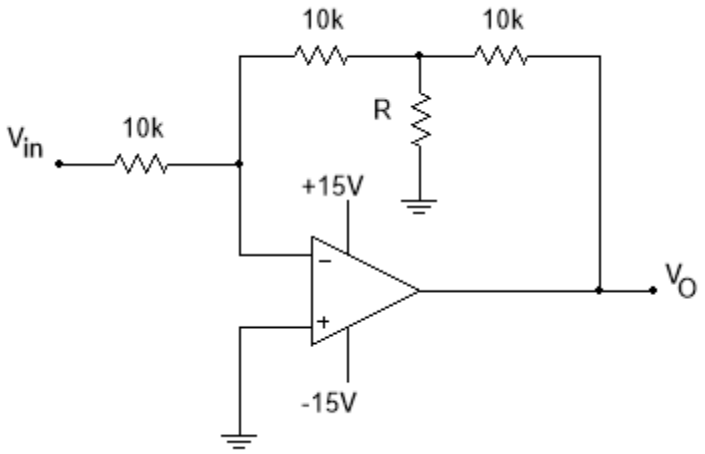

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Unique Paper Code	**3221401 OC**
Name of Paper	Mathematical Physics III
Name of Course	**B.Sc.(Hons.)Physics-CBCS**
Semester	I**V**

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

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

Use of Scientific calculator is allowed

1. Prove that $\cos^{-1} z = \frac{1}{i}\ln(z + \sqrt{z^2 - 1})$ for the principal branch and then find all the values of $\cos^{-1} i$.

   Locate and name the singularities of the following functions

   $f(z) = cosec(\frac{1}{z^2})$

   $f(z) = \sqrt{\frac{z}{(1-z)}}$

2. Expand $f(z) = \frac{z}{(z-1)(2-z)}$ in a Laurent's series valid for

   $1 < |z| < 2$

   $|z - 1| > 2$

   Find the residue of $f(z) = \exp\left(\frac{3}{z}\right) at\ z = 0$

3. Using the method of contour integration prove the following

   $\int_0^\infty \frac{\sin x}{x}\, dx = \frac{\pi}{2}$

   $\int_0^\infty \frac{dx}{x^4+1} = \frac{\pi}{2\sqrt{2}}$

4. Determine the Fourier transform of xe^{-x^2}

   If $F(\omega)$ is the Fourier transform of $f(x)$, determine the Fourier transform of $f(x)sin\ px$

   Where $p > 0$

5. Solve the following simultaneous differential equations using Laplace Transforms

   $2x(t) - y(t) - y'(t) = 4(1 - e^{-t})$

   $2x'(t) + y(t) = 2(1 + 3e^{-2t})$

   subject to the conditions $x(0) = y(0) = 0$

   $y'(t) = \frac{dy}{dt};\ \ x'(t) = \frac{dx}{dt}$

Determine the inverse Laplace transform of the following function

$F(s) = \frac{1}{s(s^2+1)}$

6. Evaluate the Laplace transform of $f(t) = \left\{\frac{1-e^{-t}}{t}\right\}$

Given$f(x) = 1 - x^2$ for $|x| < 1$
$f(x) = 0$ for $|x| > 1$
Determine the Fourier transform of $f(x)$

Evaluate the following integral $\int_0^3 \delta(x+1)(3x-5)dx$

18.75

Set B

Name of the Department: Department of Physics and Astrophysics
Name of Course: B.Sc. Hons. Physics – CBCS (Core)
Name of the Paper: Statistical Mechanics
Semester - VI
Unique Paper Code: 32221602
Question paper Set number: Set B

Maximum Marks: 75

Attempt any four questions. All questions carry equal marks.

Q1. Explain the concept of microstate, macrostate and the most probable macrostate on the basis of the results obtained when throwing two identical 6-sided dice, each with the numbers 1-6 written on their faces. Identify the macrostates having zero entropy.

An isolated system consists of 10 particles distributed among three two-fold degenerate energy levels labelled 1, 2, 3, such that the energies of the levels are ϵ_1= 2 eV, ϵ_2= 3 eV, ϵ_3= 4 eV, and their occupation numbers are N_1 = 4, N_2 = 3, N_3 = 3. (a) If the occupation number of level 1 decreases by 2, find the new occupation numbers of levels 2 and 3. (b) Find the thermodynamic probabilities and entropies of the new macrostate, if the particles are (i) distinguishable, (ii) indistinguishable.

Q2. Define partition function. Discuss its significance.

Consider a system consisting of two particles, each of which can be in any one of four single particle states of respective energies 0, ϵ, 2ϵ and 3ϵ. The system is in contact with a heat reservoir at temperature $T = (k\beta)^{-1}$. Determine the partition function Z if the particles obey (a) MB statistics, (b) BE statistics, (c) FD statistics.

A system of N particles exists in a phase space of two cells, with degeneracies $g_1 = g_2 = 1$. If $\varepsilon_1 = 0$ and $\varepsilon_2 = \varepsilon$, find the number of particles in each cell and the total energy of the system in equilibrium. Find the values of the total energy when $T = 0$ and $T = \infty$.

Q3. A system consisting of N diatomic molecules each of mass m and moment of inertia I is confined in a volume V and at temperature T. The partition function of the system is given by

$$Z = V\left(\frac{2\pi mkT}{h^2}\right)^{3/2}\left(\frac{2\pi}{h}\right)^2 2IkT$$

Find the (a) Helmholtz function F, (b) Pressure P, (c) Internal energy U, (d) Entropy S, (e) Enthalpy H, and (f) Gibb's function G, of the system.

Q4. Obtain Planck's law for blackbody radiation treating it as a collection of oscillators. Use Planck's radiation formula to obtain Wien's constant and Stefan's constant.
A body at 1000 K emits maximum energy at a wavelength 30,000 Å. If a star emits maximum energy at wavelength 5000 Å, what would be the temperature of the star?

Q5. Consider a system of N indistinguishable spinless bosons, each of mass m, confined in a cubical box of volume $V = L^3$ at temperature $T > 0$.

Obtain expressions for (i) density of states in the neighbourhood of energy ϵ, (ii) number of bosons $n(\epsilon)$ having energy between ϵ and $\epsilon+d\epsilon$, in terms of mass m, volume V, energy ϵ, temperature T, chemical potential μ.

Show that in the limit of the Bose-Einstein distribution becoming equal to the classical (Boltzmann) distribution with $e^{-\mu/kT} >> 1$, the average distance d between the particles becomes very large compared to the de Broglie wavelength λ associated with their thermal motion.

Evaluate the first order difference in internal energy between the system of N indistinguishable spinless bosons when $d >> \lambda$ and the system of N distinguishable spinless classical particles, both systems having the same volume $V = L^3$ and particle mass m.

Q6. Show that the electron gas in a white dwarf star of mass $M = 10^{30}$ kg and density $\rho = 10^{10}$ kg m^{-3} is highly degenerate and relativistic. The temperature of the star is of the order of 10^7 K.

Obtain an expression for the mass-radius relationship for a white dwarf star. What is the physical significance of Chandrasekhar mass limit?

Calculate the temperature at which a state with energy 0.4 eV above the Fermi energy has 2% probability of being occupied by an electron.

Name of the Department	:	Physics
Name of the Course	:	B.Sc. (Hons.) Physics-CBCS_Core
Name of the Paper	:	Electromagnetic Theory
Semester	:	VI
Unique Paper Code	:	32221601
Question paper set number	:	B

Duration: 3 Hours Maximum Marks: 75

Instructions for Candidates

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

1) **(a)** In a free space $\mathbf{E} = 0.5 \cos(\omega t - \beta x)\ \hat{y}$ V/m. Find the total power passing through a circular plate of area 50 sq cm on the plane $x + y = 5$

(b) Show that Ampere's law fails for non-steady current.

(c) Two plates of area 0.8 sq cm are separated by a distance of 0.3 mm to form a capacitor. The region between the plates is filled with a dielectric having $\varepsilon_r = 5$ and conductivity 0.15 S/m. A signal of amplitude 8V and frequency 20 MHz is applied between the capacitor plates. Find the value of total current flowing between the capacitor terminals.

(d) What is displacement current? List three differences between conduction current and displacement current

(e) Starting from the Maxwell's equations, establish the Coulomb's law of electrostatics.

(3+4+3+5.75+3)

2) **(a)** What is the phase difference between electric and magnetic field vectors in a dielectric medium? Justify your answer.

(b) What is the physical significance of intrinsic impedance? Starting from Maxwell's equations for a dielectric medium, obtain the expression for intrinsic impedance. And compare it with corresponding expression in free space.

(c) The magnetic field of a plane electromagnetic wave in a dielectric medium of $\mu_r = 1$ is given by the following expression.

$$\mathbf{H} = 30 \cos(2\pi \times 10^{-6}\, t + 9x)\ \hat{y}\ \text{mA/m}$$

Find the value of,

(i) ε_r
(ii) Wavelength of the wave
(iii) Polarization of the wave
(iv) Electric field
(v) Sketch the wave at $t = 0$ and $t = t_1$ when the wave has advanced $\lambda/4$

(3+5.75+10)

3) **(a)** An electromagnetic wave is propagating along the z-axis. It gets totally reflected when it is incident from air on a surface having non-zero permeability and permittivity. Show that the superposition of incident and reflected wave results in a standing wave. Determine the time averaged Poynting vector.

(b) Can a medium behave as a conductor at one frequency and dielectric at another frequency? Explain with an example.

(c) Consider a plane electromagnetic wave propagating in a material having conductivity

10 S/m and dielectric constant 8. If the electric field of the wave has amplitude 25 V/m and a frequency of 50 MHz, then,

(i) Calculate phase shift constant, attenuation constant and intrinsic impedance.

(ii) Write the time domain expression of electric and magnetic field if the wave is polarized in y- direction and is propagating in negative z- direction.

(8.75+4+6)

4) **(a)** A plane electromagnetic wave having power density 5 W/m^2 is incident at an air-dielectric plane interface with perpendicular polarization. If the parameters of the dielectric are $\varepsilon_r = 4$ and $\mu_r = 1$ and angle of incidence is 60°, find the power density of the reflected and transmitted waves.

(b) Explain the phenomenon of double refraction.

(c) The electric field of a polarized light is given by the following expression.

$$\mathbf{E} = 20 \cos(\omega t - kz)\ \hat{x} + 35 \sin(\omega t - kz)\ \hat{y}\ \text{V/m}.$$

Determine the state of polarization of this wave. If this wave passes through a quarter wave plate what will be the state of polarization of the emergent wave?

(d) The equation of continuity valid for an open surface or closed surface? Is it dependent on the geometrical shape of the surface? Justify your answer.

(4+6.75+4+4)

5) **(a)** Use the Maxwell's equations to derive the wave equation for the propagation of TE modes of EM wave in a symmetric planar waveguide whose refractive index profile is given by,

$n(x) = n_1$ for $|x| < d/2$ and

n_2 for $|x| > d/2$ where d is the thickness of the film

(b) Obtain the eigen-value equations for symmetric modes and anti-symmetric modes; and thus show that there exists only two TE modes, one symmetric and one anti-symmetric modes, for $\pi < V < 2\pi$.

(c) If a symmetric planar waveguide of thickness 6.8 μm is used to support only a single pair of TE and TM modes at wavelength $\lambda = 1.36$ μm, determine the maximum possible value of n_1 if $n_2 = 1.436$.

(7.75+8+3)

6) **(a)** Show that propagation of electromagnetic waves is possible in ionized medium only if the refractive index is real.

(b) Show that ionosphere behaves like a medium having a refractive index given by,

$$\{1 - (81 n_0/f^2)\}^{0.5}$$

Here, n_0 is the electron number density in m^3 and f is the frequency

(c) Show that the electromagnetic potentials (**A**, ϕ), in a uniform electric and magnetic field can be expressed as, $\mathbf{A} = 1/2\ (\mathbf{B} \times \mathbf{r})$ and $\phi = -\mathbf{E} \cdot \mathbf{r}$

(7.75+5+6)

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(4+6.75+4+4)

5) **(a)** Use the Maxwell's equations to derive the wave equation for the propagation of TE modes of EM wave in a symmetric planar waveguide whose refractive index profile is given by,

$n(x) = n_1$ for $|x| < d/2$ and

n_2 for $|x| > d/2$ where d is the thickness of the film

(b) Obtain the eigen-value equations for symmetric modes and anti-symmetric modes; and thus show that there exists only two TE modes, one symmetric and one anti-symmetric modes, for $\pi < V < 2\pi$.

(c) If a symmetric planar waveguide of thickness 6.8 μm is used to support only a single pair of TE and TM modes at wavelength $\lambda = 1.36$ μm, determine the maximum possible value of n_1 if $n_2 = 1.436$.

(7.75+8+3)

6) **(a)** Show that propagation of electromagnetic waves is possible in ionized medium only if the refractive index is real.

(b) Show that ionosphere behaves like a medium having a refractive index given by,

$$\{1 - (81 n_0/f^2)\}^{0.5}$$

Here, n_0 is the electron number density in m^3 and f is the frequency

(c) Show that the electromagnetic potentials (**A**, ϕ), in a uniform electric and magnetic field can be expressed as, $\mathbf{A} = 1/2\ (\mathbf{B} \times \mathbf{r})$ and $\phi = -\mathbf{E} \cdot \mathbf{r}$

(7.75+5+6)

Examination Roll No……..

S.No of Question Paper : ……

Name of the Department : **Physics**

Question paper Set number : **B**

Unique Paper Code : **32227626**

Name of Paper : **Classical Dynamics**

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

Semester : **VI**

Duration :3 Hours Maximum Marks : 75

Instructions for Candidates

All questions carry equal marks.

Attempt four questions in all.

Q 1. Define D'Alembert principle. Find Lagrangian, Hamiltonian and Hamilton equation of motion for compound pendulum also find its time period.

Q 2. Obtain the expression of Lagrangian for two masses m_1 and m_2 moving under a central potential V(r). Reduce it into a one body problem and show that angular momentum remains conserved. According to Yukawa's theory of nuclear forces, the attractive force between two nucleons inside a nucleus is given by the potential

$$V(r) = k [e^{-ar} / r], \text{ a= constant.}$$

If the particle moves in a circle of radius r_0 , determine (I) total energy, E (ii) angular momentum J and (iii) period of circular motion.

Q3. Discuss the principle of conservation of four momentum. Show that when an energetic proton collides with a proton at rest, a proton-antiproton will be produced only when the least kinetic energy of incident proton is 6 Mc^2, where M is the mass of the proton.

Q4 Discuss the normal mode frequencies of oscillations of a linear triatomic molecule. Explain its various modes with the help of the diagram.

Q5. Show that $E^2 - p^2c^2$ is Lorentz invariant quantity. The photon energy in the frame S is equal to E. Derive the expression for energy E' in frame S', moving with a velocity v relative to the frame S in the photon's motion direction. At what value of v is the energy of the photon is equal to E' =E/2.

Q 6. Derive the Euler's equation of fluid dynamics and from it deduce Bernoulli's equation. A pipe is of length 'l' and has slowly tapering cross section. It is inclined at an angle 'α 'to the horizontal. Water flows steadily through it from upper end to the lower end. The section at the upper end has twice the radius of the lower, where water is delivered at atmospheric pressure. If the pressure at upper end is twice atmospheric pressure, find the velocity of delivery.

Course Name	:	B.Sc. (Prog.) Physical Sciences
Semester	:	II
Paper Name	:	Electricity, Magnetism and Electromagnetic Theory
Unique Paper Code	:	42221201_OC (Old Course)
Paper	:	Set – B

Maximum Marks: 75

Instructions for Candidates

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

1. **(a)** Given two vectors $\vec{A} = 2\hat{i} + 3\hat{j} - 4\hat{k}$ and $\vec{B} = -6\hat{i} - 4\hat{j} + \hat{k}$. Find the component of $\vec{A} \times \vec{B}$ along the direction of $\hat{i} - \hat{j} + \hat{k}$

(b) Prove that $\nabla \times \nabla T = 0$, where T is a scalar function.

(c) State the Stokes' theorem of vectors.

(10 + 5 + 3.75)

2. **(a)** Define the electric potential. Show that electric potential can be expressed as a line integral of the electric field. Why can the potential be determined only up to an arbitrary constant? What is the physical significance of this result?

(b) The potential function at any point is given by $V = x(3y^2 - x^2 + z)$. Find the components of the electrostatic field for this potential.

(c) Derive expressions for electrostatic potential inside and outside of a uniformly charged spherical conductor shell.

(7.75 + 4 + 7)

3. **(a)** Derive an expression for Gauss's law in the presence of dielectric. What is polarization vector? What is the significance of polarization of dielectrics? Explain electric displacement vector.

(b) A thin dielectric rod of cross-section A extends along the z-axis from $z = 0$ to $z = h$. The polarization of the rod along z-axis is given by $P_z = 3z^2 + 2$. Find the bound volume charge density, the bound surface charge density and the total charge density.

(9.75 + 9)

4. **(a)** Calculate the magnetic field at the center of a current carrying circular loop of radius 'r' and at a distance 'z' above the center.

(b) A circular coil carrying a current of 0.5A of radius 8 cm has 100 turns. Find the magnitude of magnetic field at the center of the coil and at a distance of 18 cm from the center of the coil.

(9.75 + 9)

5. **(a)** Derive an expression for the energy stored in a magnetic field of a solenoid

(b) Consider two solenoids S_1 and S_2 of same length 'l' such that their axes are aligned and S_2 surrounds S_1 completely. If 'n_1' and 'n_2' are the number of turns per unit length of solenoids S_1 and S_2 respectively, derive an expression for the mutual inductance between two solenoids.

(c) Calculate the self-inductance of an air-core toroid of mean radius $20\ \text{cm}$ and circular cross-section of area $5\ \text{cm}^2$. It is given that the total number of turns on the toroid is 3000.

(7 + 7 + 4.75)

6. (a) Write the four Maxwell's equations in their integral and differential forms. Explain the physical significance of every equation.

(b) Derive the wave equation for the propagation of electromagnetic waves through an isotropic dielectric medium and show that electromagnetic waves are transverse in nature.

(c) The displacement current density for a material having $\sigma = 0, \epsilon = 3\epsilon_0, \mu = 4\mu_0$ is given by the following expression. Determine $\vec{D}$ and $\vec{E}$.

$$2\cos(\omega t - 6z)\,\hat{a_x}\ \ \mu\text{Am}^{-2}$$

(8 + 7.75 + 3)

Name of the Department: PHYSICS

Name of the Course: B.Sc. Prog.–CBCS_Electronics (Old course)

Name of the Paper: Microprocessor and Microcontroller

Semester: IV

Unique Paper Code: 42514413_OC

Question paper Set number: SET-2

Q1. Write an assembly language program for the addition of two 16-bit hexadecimal numbers. Save the result and borrow (if any) to different memory locations. Also specify the contents of carry, parity and zero flag at the end of every instruction assuming that initially they all are reset.

Q2. Two machine codes 0000 1110 (MVI C) and 0011 0011 are stored in memory locations 3055H and 2056H, respectively. Illustrate the steps and the timing of data flow (labelled Timing diagram) as these machine codes are executed. Also evaluate the time required for the execution of these 2 machine codes, if the clock frequency is 3 MHz.

Q3. Distinguish between the following instructions in 8085 microprocessor

(i) MOV A, M and LDAX D

(iii) LDA 2012H and LHLD 2012H

(iii) ADI 89H and ACI 89H

(iv) XRI 56H and ORI 56H

Q4. Draw pin out diagram of 8051 microcontroller. Explain the function of each pin in detail.

Q5. What are the different types of conditional and unconditional jump instructions used in 8051 microcontroller? Explain them in detail.

Q6. Explain the four timing modes in 8051 microcontroller. Write an assemble language program to generate a square wave of any frequency using any timer mode.

SET B

Name of Course	:	**B.Sc. (Hons.)_CBCS_GE (Old Course)**
Semester	:	**II**
Name of the Paper	:	**Mechanics**
Unique Paper Code	:	**32225201_OC**
Duration	:	**3 Hours** Maximum Marks: **75**

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

1. (a) Prove that $\vec{\nabla}.\left(\vec{\nabla}\ X\ \vec{A}\ \right) = 0$.

   (b) Show that $(3x^2 + y\cos x)dx + (\sin x - 4y^3)dy = 0$ is an exact differential equation and find its general solution. **(8, 10.75)**

2. (a) Obtain the expression for the velocity of a rocket in term of its exhaust velocity and initial mass, including the effect of the gravitational pull of the Earth.

   (b) State and prove the work-energy theorem. **(10, 8.75)**

3. (a) Define the centre of mass of a system of particles? Show that in the absence of external forces the velocity of centre of mass remains constant.

   (b) Find the center of mass of a hemispherical shell of radius *R*. **(10, 8.75)**

4. (a) Define the kinetic energy of rotation. Develop an expression for kinetic energy involving both translation and rotational motion. A solid cylinder of mass M and radius R rolls down a ramp which makes and θ with the horizontal. Derive an expression for the speed of the center of mass as a function of distance travelled.

   (b) A torque of $1\ Nm$ is applied to a wheel of mass $10\ kg$ and radius of gyration $50\ cm$. What is the resulting translation acceleration? **(12, 6.75)**

5. (a) Write down the equation of motion of a mass m attached to a spring of spring constant k. Find a general solution involving amplitude and phase of oscillation? What is the solution if at instant $t = 0$, the mass crosses equilibrium position with velocity v_o towards the direction of positive displacement?

(b) What is Hooke's law? Describe the behavior of a wire under an increasing load till its break point. The spring constant of a spring depends upon which elastic constant? Give reason for your answer.

(10, 8.75)

6. (a) State postulates of Special Theory of Relativity. Derive Lorentz transformations and use these to find formula for time dilation.

(b) Find the mass and speed of an electron whose total energy is 5 MeV. **(12, 6.75)**

SET-VI

Unique Paper Code : 32223904_OC

Name of the Paper : Basic Instrumentation Skills

Name of the Course : B. Sc (Hons) and B. Sc. (Prog)-CBCS_SEC

Semester : IV-Semester

Medium : English

Duration : 3 hours **Maximum Marks : 50**

Instructions for Candidates

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

Q1. What are the different types of errors present in the measurement system?
A 0-150 V voltmeter has a guaranteed accuracy of 1 per cent full-scale reading. The voltage measured by this instrument is 43 V. Calculate the limiting error in per cent. How does this value change when the voltmeter reads 115 V? (8, 4.5)

Q2. Draw a neat labelled block diagram of Cathode Ray Tube (CRT). Explain why the screen of CRT is coated with phosphor? What is aquadag? What is its function. Explain how phase difference two sinusoidal waves of same frequency is measured using CRO. (3, 2, 1,2,4.5)

Q3. Explain the operation of a Q meter with help of its block diagram. Mention its applications.
A 1000 Hz bridge has the following constants
Arm AB: R=1 KΩ in parallel with C=0.05 μF.
Arm BC: R=1.5 KΩ in series with C=0.25μF.
Arm CD: L=50 mH in series with R=200Ω
Find the constants of arm DA to balance the bridge. (5, 2.5, 5)

Q4. Compare digital voltmeter with the analog voltmeter. What is the basic working principle of digital voltmeter ? Explain briefly the following characteristics of digital meters:

(i) Resolution (ii) Sensitivity (iii) Accuracy. (4, 4, 4.5)

Q5. Draw the block diagram and explain the working of multimeter. What are the advantages of electronic voltmeter over conventional voltmeter. (7.5, 5)

Q6. Draw the block diagram of an audio frequency signal generator and explain its components. What is the difference between signal generator and function generator? What is harmonic distortion factor? (7.5, 3, 2)

Name of Course	: **CBCS B.Sc. Mathematical Sciences**
Unique Paper Code	: **42353604**
Name of Paper	: **SEC-4: Transportation and Network Flow Problems**
Semester	: **VI**
Duration	: **3 hours**
Maximum Marks	: **55 Marks**

Attempt any four questions. All questions carry equal marks. All Symbols have usual meaning.

1. Consider the transportation model is given in the table. Use Vogel Approximation Method (VAM) to find the starting basic feasible solution. Hence find optimal solution by the method of multipliers.

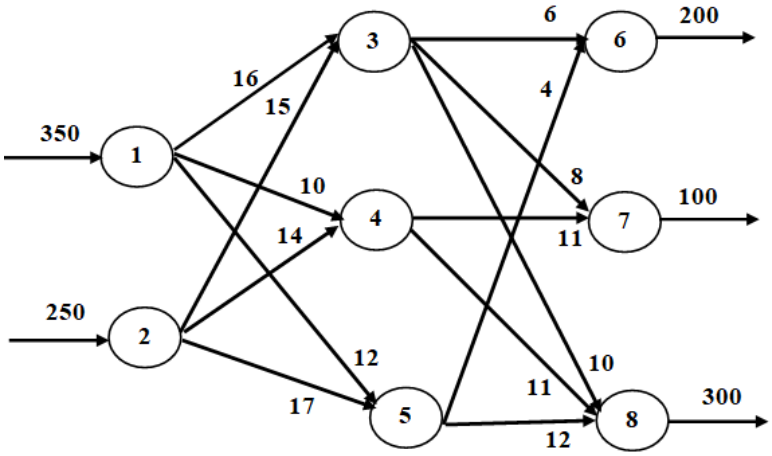
		Destinations						
		D_1	D_2	D_3	D_4	D_5	D_6	Availability
Sources	S_1	5	3	7	3	8	5	3
	S_2	5	6	12	5	7	11	4
	S_3	2	8	3	4	8	2	2
	S_4	9	6	10	5	10	9	8
Requirement		3	3	6	2	1	2	

2. Consider the following cost matrix of assigning five jobs to four persons:

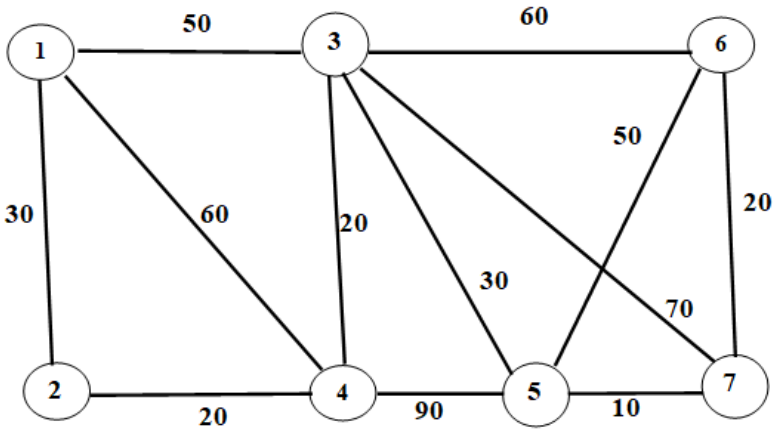
		Jobs				
		J_1	J_2	J_3	J_4	J_5
Persons	P_1	8	9	12	11	8
	P_2	4	3	6	7	5
	P_3	13	20	17	18	12
	P_4	23	26	25	33	20

   Use Hungarian method to find an optimal assignment of the above problem.

3. Develop the transshipment model for the following network. Also identify pure supply nodes, pure demand nodes, transshipment nodes and the buffer amount.

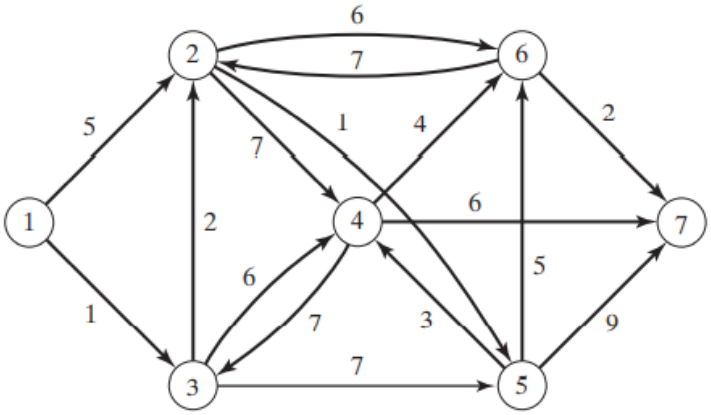


4. Consider the following network:

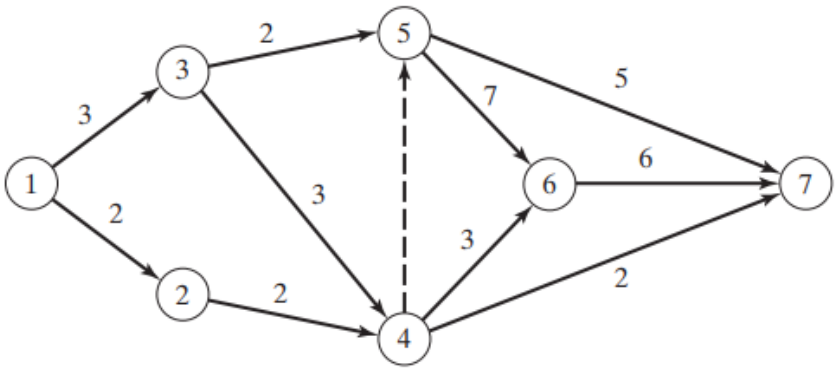


In the above network, Find 2 paths, 2 tree, a spanning tree and the minimal spanning tree.

5. Find the shortest route between node 1 to node 7 using Dijkstra's algorithm.



6. Determine the critical path for the project network:



Name of the Department: **Department of Physics**

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

Name of the Paper: **Communication Systems**

Semester: **VI**

Unique Paper Code: **32227613**

Question paper Set number: **Set C**

Duration: **3 Hours**

Maximum Marks: **75**

Attempt any four questions. All questions carry equal marks.

Q1 a)Explain Amplitude Modulation (AM) in detail and also write frequency spectrum of AM.

b) Explain the generation of Single-Side-Band (SSB) variant of AM.

c) Deduce the formula for the power required for the transmission of SSB variant in term of power required to transmit carrier signal only.

d) A 400 W carrier is modulated to a depth of 50%. Calculate the total power required in case of SSB technique. How much power saving is achieved in case of SSB compared to Double-Side-Band-Full-Carrier (DSBFC) and Double-Side-Band-Suppressed-Carrier (DSBSC) techniques. (5+5+3.75+5)

Q2 a) What is Frequency Modulation (FM) in analog communication? Write the formula for instantaneous voltage and modulation index in FM. Explain the generation of FM using Voltage-Controlled-oscillator (VCO). (2+2+5)

b) Explain the working of super-heterodyne receiver in detail. If the frequency of incoming radio signal is 540 kHz and intermediate frequency is 455 kHz in super-heterodyne receiver, then calculate the frequency of local oscillator (LO) to get the desired intermediate frequency. Also calculate the image frequency of 540 kHz radio frequency signal. (5.75+4)

Q3 (a) What is channel capacity? Write Shannon-Hartley formula for channel capacity and also explain channel capacity for infinite bandwidth of signal if some noise present is present in system.

(b) What is sampling theorem? Explain in detail.

(c) What is Pulse-Amplitude-Modulation (PAM)? Explain the generation and detection of PAM. (6+6+6.75)

Q4 a) What is digital communication and its need?

b) Explain in detail Pulse Code Modulation (PCM).

c) Explain how a digital message signal modulates amplitude, frequency and phase of high frequency analog carrier signal? (4+8+6.75)

Q5 a) What is the need of satellite communication? What is geosynchronous satellite? What are the advantages of geostationary satellite?

b) What is transponder in communication satellite? What are the uplink and downlink frequencies in C-band transponder? Why is uplink frequency kept higher than downlink frequency?

c) Considering unit antenna gain, calculate path loss in dB if the signal of 500 MHz is transmitted upto 1000 km.

(8+6+4.75)

Q6 a) Why is mobile phone known as a cell phone? What are the different types of cells?

b) What is frequency reuse, cell sectoring and cell splitting in mobile communication?

c) What is data encryption and why is it needed?

d) Give qualitative ideas about 2G, 3G and 4G in mobile communication. (5+6+4.75+3)

Set 1

Name of the course : B.Sc (Prog) Physics DSE-3B
Semester : VI Semester
Name of the Paper : Solid State Physics
Unique Paper code : 42227637
Duration : 3 hours Max. marks : 75

Instruction for students:
Attempt any **FOUR** questions in all.
All questions carry equal marks.

Q.1: a) The primitive translation vectors of the hexagonal space lattice may be taken as following:

$$\boldsymbol{a}' = \left[\frac{\sqrt{3}}{2} a\,\hat{\boldsymbol{x}} + \frac{1}{2} a\,\hat{\boldsymbol{y}}\right]; \quad \boldsymbol{b}' = \left[-\frac{\sqrt{3}}{2} a\,\hat{\boldsymbol{x}} + \frac{1}{2} a\,\hat{\boldsymbol{y}}\right]; \quad \boldsymbol{c}' = \mathrm{c}\,\hat{\boldsymbol{z}}$$

Determine the primitive translation vectors of the corresponding reciprocal lattice. Show that the lattice is its own reciprocal but inverted. (4+4)

b) Obtain the Bragg's law of diffraction and state its limitations. What is the optimal order of X-Ray wavelength to be chosen so as to observe the diffraction effects? What happens if the wavelength deviates too much from this value? (5+2+2+1.75)

Q2. a) Show that a one dimensional lattice of identical atoms can be considered as a low pass filter which transmits frequencies only between zero and $\omega_{max} = 2\sqrt{\frac{K}{M}}$. (12)

b) The Debye temperature for silver is 25 K. Calculate the highest possible frequency for lattice vibrations in silver and its molar heat capacity at 25 K. (6.75)

Q.3. State Bloch theorem and write Bloch function. (5.5)
Discuss the Kronig Penney model. How does it explain the formation of energy bands? (13.25)

Q.4. What do you understand by polarization in a dielectric material? Discuss briefly different types of polarization mechanism. Derive expression for dipolar polarizability and discuss its variation with temperature. (2+11.25)

The dielectric constant of helium, measured at 0°C and 1 atmospheric pressure, is 1.000684. Under these conditions, the gas contains 2.7×10^{25} atoms/m^3. Calculate the radius of electron cloud. (5.5)

Q.5 Distinguish between diamagnetic, paramagnetic and ferromagnetic substances on the basis of magnetic susceptibility and permeability. (6)

Discuss Weiss theory of ferromagnetism and explain how magnetic susceptibility varies with temperature for ferromagnetic materials. (12.75)

Q.6. Explain the three kinds of energy zone schemes on the basis of E-K curves. (8)

What is Superconductivity? Give its two applications? What does Meissner effect signify about super conductors, explain with suitable diagram? (2+2+6.75)