1. Physics I Paper (Phy. 311), 2066

(Mechanics Thermodynamics and Electricity)

Time : 3 hour   Full Marks : 100

Attempt ALL the questions.

1. Obtain expressions for the particle velocity and the particle acceleration for one dimensional equation of motion of a plane progressive wave.

   Hence establish the wave equation for such a motion.   [3+3+4]

OR

   Derive an expression for the gravitational potential at

   i) a point inside and ii) on the surface of a thin spherical shell. Sketch the variation of the surface of a thin spherical shell. Sketch the variation of the potential with distance within and outside the shell.   [4+4+2]

2. Combine first and second laws of thermodynamics to obtain $dF = -P\,dV - S\,dT$ and $dH = TdS + VdP$ where symbols carry their usual meanings.

   Hence establish Maxwell's thermodynamic relations

   $$\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial p}{\partial T}\right)_V \text{ and } \left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P \qquad [2+2+5]$$

OR

   Write down the physical basis on which Plank's radiation law is obtained. Hence derive a relation for energy density within the wavelength range λ and $\lambda + d\lambda$ in the spectrum of blackbody radiation. Also show that Rayleigh – Jean law is the special case of Plank's law.   [2+4+3]

3. Explain the physical meaning of divergence and curl of a vector and prove Stoke's theorem.   [3+6]

OR

   Derive Clausius Mossoti relation. What modifications were made by Debye ? Explain.   [4+4+1]

4. What are the parameters on which the coefficient of viscosity depend ? Derive a relation for the volume of liquid flowing out in a capillary tube.   [6]

OR

   State the theorems of parallel and perpendicular axes on moment of inertia of a body and derive expression for moment of inertia of an uniform rod about an axis through one end of the rod and perpendicular to its length.   [6]

5. Write down Van der Waal equation of gas and hence obtain expressions for critical temperature and critical pressure.   [6]

OR

   What are the conditions on which gaseous particles obey Bose – Einstein's statistics ? Hence derive Bose- Einstein distribution law.   [6]

6. Discuss the concept of electrical image in the case of an infinite plane conductor placed in front of charge and use it to find electric potential and field at any point.   [6]

OR

Draw a capacitive and an inductive a.c. circuits and show that the emf leads the current by $\frac{x}{2}$ in a purely inductive circuit. [6]

7. Answer ALL the questions: [6×3=18]
   a) What is a bending moment of a beam ? Explain.
   b) If the momentum and work done by a force are expressed respectively as mv and FS in linear motion write their corresponding analogous expressions in rotational motion.
   c) What are ensembles ? Write the types of ensemble you know.
   d) How is the mean path of a gas related with absolute temperature and pressure ? Explain.
   e) Explain with figure and difference between self and mutual inductance.
   f) Write Maxwell's relation equivalent to Ampere's and Faraday's laws.

8. Calculate the velocity with which a body should be projected upward so as to reach a height 3 R_e from the Earth surface, where R_e,
   The radius of the earth = 6.4×10^6m. [6]

9. A uniform metal disc rolls down a plane inclined at 30° to the horizontal. Calculate the distance traveled in 2 secs after starting from rest. [6]

10. A cantilever of length 50cm is depressed by 15mm at the loaded end. Calculate the depression at a distance 30cm from the fixed end. [6]

11. The frequency of the fourth harmonic in a stretched string of length 20cm is 600Hz. What is the velocity of the wave in the string ? [6]

12. 10 moles of an ideal gas undergo a reversible isothermal expansion from 0.1m³ to 0.2m³ at a temperature of 27°C. What is the change in entropy of the gas ? [6]

13. Calculate the inductance of a solenoid 0.5m long of cross-sectional area 20cm² with 500 turns. [6]

Physics I Paper (Phy.311), 2067
(Mech. Thermodynamics and Electricity)

Bachelor Level /Science & Tech. / I Year
Full Marks: 100
Time: 3 hrs.

Attempt ALL the questions.

1. Obtain differential equation for one dimensional progressive wave and apply it to obtain the velocity of transverse wave along a stretched string. [5+5]

OR

Define the centre of oscillation of a compound pendulum and obtain an expression for its time period. [5+5]

2. Obtain the expressions of Planck's radiation law and show Wien's displacement law and Rayleigh - Jean's are special case of it. [5+2+2]

OR

Show that Clausius - Clapeyron's equation can be obtained from Maxwell's thermodynamic relations. Mention physical significance of the Clausius - Clapeyron's equation. [5+4]

3. What is displacement current? Obtain Maxwell's electromagnetic equation and explain on which law they are based. [3+3+3]

OR

Define quality and power factor of an alternating current. How does the damping depend upon the quality factor? [2+2+5]

4. Obtain Poisenlle's law of fluid mechanics. Write the importance of Reynold's number. [4+2]

OR

Explain the Keplers law of planetary ,notion. [6]

5. What is entropy? State and prove the principle of increase of entropy? [6]

OR

State and prove Carnot theorem for reversible heat engine.

6. Discuss the concept of '"electrical image the case of an infinite plane conductor placed in front of a charge and use it to find electric potential and field at any point. [6]

OR

Explain the difference between self and mutual inductance of a coil. What is the physical laws of working of a search Coil? [6]

7. Answer ALL the questions: [6x3=18]

   a. Obtain the tangential velocity of a satellite revolving on the parking height of the earth.

   b. Obtain the moment of inertia of a disc about its axis perpendicular to the centre of the disc.

   c. Write difference between ideal gas and real gas.

   d. State and prove the law of equiportion of energy.

   e. Explain Stokes law in electricity.

   f. Explain ferromagnetic domain theory.

8. A thin uniform bar of length 100 cm is made to oscillate about an axis through its end. Find the period of oscillations and other two points about which it can oscillate with the same time period. [6]

9. A wave of frequency 512 Hz has a phase velocity of $330 mS^{-1}$ (a) How far apart are two points 60^0 out of phase (b) What is the phase difference between two displacement at a certain point at time 10^{-2} see apart? [6]

10. Calculate the mean free path of gas molecules in a cha"llber of 10^{-6} mm of H_g pressure assuming the 9 molecular diameter to be 2A.
    Take temperature of chamber to be 273K and one gram; mole of the gas occupies 22.4 liters at NTP.

11. Under what pressure ice would freeze at -1°C if the change in specific volume when 1gm of water frozen into ice is 0.091CC. [6]

12. Calculate the energy of a hollow charge metal sphere of radius 50em and the uniform charge on the sphere is 10-2C. [6]

13. A circuit contains a capacitor of 40 of and inductance L. What should the value of L so that the circuit resonates to 2000 Kilo Hertz. [6]

Physics I Paper (Phy.311), 2068

(Mech. Thermodynamics and Electricity)

Bachelor Level /Science &Tech. / 1 Year/

Full Marks: 100

Time: 3 hrs.

Attempt ALL the questions.

1. Explain Reynold's numbern and hence differentiate the stream-line and turbulent number flow. Derive the Poiseuille's formula for the rate of flow bf liquid through narrow tube.

    OR [10]

    What are the characteristics of a simple harmonic motion? Discuss the oscillation of two masses connected by a spring and hence obtain the time period of oscillation.

2. Explain the term entropy with reference to the second law of thermodynamics. Show that the entropy of a substance in a process can never decrease.

    OR [9]

    Discuss the Maxwell - Boltzmann statistics and derive the Maxwell - Boltzmann distribution law.

3. Explain how the magnetic fields of die, pare and ferromagnetic materials vary with magnetizing field. Why the magnetic hysteresis properties are shown only by ferromagnetic materials?

    OR [9]

    State Biot- Savart law and use it to calculate the magnetic field due to a solenoid. Explain the nature of the field lines.

4. Discuss stationary waves with emphasis on its energy transfer properties.

    OR [6]

    What is a forced oscillation? Under what condition the forced oscillation will have maximum amplitude?

5. Discuss the effects of pressure in the melting point of solids.

    OR [6]

    Justify the necessicity of Van der Waal's equation.

6. Explain the working of a transformer. What are the reasons for the efficiency of a transformer always less then 100%?

    OR [6]

    Why was it necessary for Maxwell to modify the Ampere's law? Explain.

7. Answer ALL the questions: [6x3=18]
    a. Explain elastic and inelastic collisions with examples.
    b. Moment of inertia -is the analogue in rotational dynamics of mass in linear dynamics. Explain.
    c. Calculate the force on an electron moving with a velocity of 10^6 m/s parallel to a magnetic field of 0.5T.
    d. Find the current carried by two straight parallel infinite wires which produce a force between them. of $2x 10^{-7} Nm^{-1}$ when placed 1 m apart.
    e. Write down Maxwell's thermodynamic relations.
    f. Discuss the significance of partition function in statistical physics.

8. What should be the size of earth if the escape velocity from it were to equal the speed of light in free space (mass of earth = 6×10^{24} kg)? [6]

9. Calculate the ratio of the maximum lengths of two rods having same cross section, that can be supported without breaking if their densities and breaking stress are of ratio $\frac{3}{4}$ and $\frac{3}{5}$, respectively. [6]

10. Calculate the Boyle's temperature and temperature of inversion for nitrogen gas whose critical temperature: is 126 K. [6]

11. Calculate the mean free path of oxygen molecule at STP (given: density = 1.40 kgm^{-3} and the coefficient of, viscosity = $1.92 \times 10^{-5} NSm^{-2}$). [6]

12. Find an expression for the electric field corresponding to a screened potential:
[6]

$$\Phi(r) = \frac{q}{r} e^{-\pi r}$$

13. Calculate the atomic polarizability of oxygen whose relative permittivity at STP is 1.00053. [6]

Physics (Phy.311), 2069
(Mech. Thermodynamics and Electricity)

Bachelor Level/Science & Tech./I Year   Full Marks : 100
For: Regular Examinee only   Time : 3hrs.
Attempt ALL the questions.

1. What are the advantages of a compound pendulum over a simple pendulum and define radius of gyration and obtain an expression for the time period of a compound pendulum. [2+2+6]

OR

State and prove the theorem of parallel axeses in moment of inertia. Derive an expression of moment of inertia of a circular disc about an axis touching circumference parallel to an axis passing through a centre of the disc normal to the area of the disc. [4+6]

2. Give an example of a Fermion starting from the postulate of Fermi-Dirac statistics derive the expression for the probability distribution of particles obeying F-D statistics. [7+2]

Or

Obtain the expression for Planck's law of radiation and show that Wien's displacement law and Rayleigh - Jean's law are special cases of it. [5+2+2]

3. What are polar and non-polar molecules? Obtain Clausius - Mossotti relation.

OR   [1+1+7]

What is divergence and curl of a vector and prove Stokes theorem. [2+2+5]

4. Obtain the differential equation of a transverse wave on a string fixed at both ends.

OR

Explain viscosity and obtain Poiseuille's formula in liquid and write the importance of Reynold's number.

5

5. What is entropy? Explain entropy related with second law of thermodynamics.

OR

What is Brownian motion? Deduce an expression for the coefficient of diffusion from random: molecular motion.

6. Show when a capacitor is discharged through an inductor of negligible resistance, the discharge is oscillatory and find its time period.

Or [6]

Explain displacement current and show

$$\vec{\nabla} \times \vec{H} = \vec{J} + \frac{a\vec{D}}{\partial t}$$

7. Answer ALL the questions: [6×3=18]

(a) Obtain tangential velocity of a satellite revolving in a parking orbit.

(b) State Kepler's law of planetary motion.

(c) What are ensembles? Write the types of ensembles.

(d) Explain the difference of self and mutual inductance.

(e) Find the divergence of a radial vector.

(f) How is the mean path of a gas related with absolute temperature and pressure ?

(g) Explain ferromagnetic domain theory.

8. Calculate the velocity with which a body be projected upwards so as to reach a height 4Re from the surface of Earth where Re is radius of earth = 6.4×10^6 m.

[6]

9. A wave of frequency 512 Hz has a phase velocity of 340 ms^{-1}. (a) How far apart are two points 45° out of phase (b) what is the phase difference between two points which is 10^{-2} sec apart? [6]

10. 10 gm of ice at −2°C is mixed with 20 gm of water at 10°C Calculate the change in entropy. [6]

11. The frequency of 3rd harmonics of a stretched string of length 30 cm is 400 Hz. What is the frequency of 2nd harmonics and the velocity of wave in string? [6]

12. An electron is projected at an angle 30° with the direction of magnetic field of 2 Tesla. Show the path of electron is helical and find the pitch of the path of electron. [6]

13. A hollow sphere of radius 20 cm is uniformly charged by 1μc. Calculate the energy on the sphere. [6]

Physics (Phy.101), 2070 (New course)

(Mechanics. Thermodynamics and Statistical Physics Electricity & Magnetism)
Four Year Bachelor Level/Science & Tech.   Full Marks: 100

Time: 3 hrs.

Attempt ALL the questions.

1. Define gravitational potential. Calculate the gravitational potential due to sphere at a point outside and inside the sphere. Show that the potential at the centre of the sphere is one and a half times that on its surface. [1+6+3]

Write down the equation of damped simple harmonic oscillator and derive the expression for its displacement. Discuss the case of critical damping.   [2+6+2]

2.   Write down Planck's hypothesis of quantum theory of radiation. Derive Planck's formula for the distribution of energy density in the spectrum of a black body. Show that Wein's law and Rayleigh Jean's law are its special cases.

<div align="center">OR   [2+5+3]</div>

What are transport phenomena? Derive an expression for the coefficient of viscosity of a gas on the basis of the kinetic theory of gases. How does it depend on pressure and temperature?   [3+5+2]

3.   What is electric dipole? Derive expression for the electric field and potential at a point due to the dipole. Write expression for the potential energy of the dipole when placed in an external electric field.   [1+6+3]

<div align="center">OR</div>

What do you mean by intensity of magnetisation and magnetic susceptibility? Derive the necessary expression to show that paramagnetic susceptibility of a gaseous substance is inversely proportional to the absolute temperature. What do you mean by hysteresis loss?   [2+5+3]

4.   Define a cantilever. Obtain an expression for the depression produced at its force end when the weight of the beam is negligible.   [2+6]

5.   Give the statistical definition of entropy and derive Boltzmann's canonical distribution law.   [2+6]

6.   Write down the Maxwell's equations for free space and hence obtain electromagnetic wave equations.   [2+6]

7.   Answer any TWO questions: [2×3=6]

   (a)   What do you mean by centre of mass frame of reference? Explain.

   (b)   Distinguish between Bose - Einstein and Fermi - Dirac statistics.

   (c)   Define coefficient of performance of a refrigerator. How is it related to the efficiency of a Carnot's engine operating between the same temperatures?

   (d)   What do you mean by irrotational vector? Explain with an example.

8.   Attempt ALL the questions: [4×2.5=10]

   (a)   Explain the meaning of power factor.

   (b)   State Ampere's circuital law. What is Lorentz force?

   (c)   Starting from Newton's 2nd law of motion, deduce the relation $v^2 = u^2 + 2aS$. Where symbols have their usual meaning.

   (d)   Show that, for an isobaric process, change in enthalpy is equal to the heat given to the system.

9.   The displacement equation for a transverse plane wave at any instant is

$$y(x, t) = 0.03 \sin(3\pi t - 0.03\pi x)$$

where x and t are in metres and seconds respectively. Calculate wavelength, frequency and velocity of the wave. Also calculate the phase difference between two particles 0.05 metre apart at any instant.   [5]

10. A thin uniform disc of radius 25cm and mass 1kg has a hole of radius 5cm in it. If the centre of the hole be at a distance of 10cm from the centre of the disc, calculate the moment of inertia about an axis perpendicular to its plane and passing through the centre of the hole. [5]

11. Calculate the change in temperature when helium gas suffers Joule - Thomson expansion at −173°C. the pressure difference on the two sides of the plug being 20 atmospheres. Does the gas show a heating effect or a cooling effect in this expansion at −173°C?

Given: R = 8.3 Joules/mole–K and for helium Vander Waal's constants

$a = 0.0341$ litre^2 atoms, mole^{-2} and $b = 0.0237$ litre mole^{-1}

12. A 50 Ω resistor carrying a constant current of 1A is kept at constant temperature of 27°C by a stream of cooling water. In a time interval of 1S.

(1) What is the change in entropy of the resistor?

(2) What is the change in entropy of the universe? [5]

13. The polarizability of NH_3 molecule is found experimentally by measurement of dielectric constant as 2.5×10^{-39} coulomb^2 m / Newton and 2×10^{-39} coulomb^2 m / Newton at 300°K and 400°K respectively- Calculate for each temperature the polarizability due to permanent dipole moment and due to deformation of the molecules. [5]

14. A 4μF condenser is connected to 240V D.C. source through a resistor of 0.25 MΩ. Calculate the charge on the condenser at 1 sec. after the application of the voltage. Also calculate the potential difference across the condenser and value of current in the circuit at this instant [5]

Physics (Phy.101), 2071

(Mechanics. Thermodynamics and Statistical Physics Electricity & Magnetism)
Bachelor Level (4 Yrs.) /I Year/Science & Tech. Full Marks: 100

Time: 3 hrs.

Attempt ALL the questions.

1. What do you mean by centre of mass? Show that, in the absence of external forces, the velocity of the centre of mass remains constant. Also show that the position of the centre of mass of a system of particles is quite independent of the frame of reference used. [2+4+4]

OR

Discuss the meaning of damping or dissipative force. What is its effect on a harmonic oscillator? Illustrate your answer by considering homely examples.

[2+6+2]

2. Explain the term 'entropy'. Calculate changes of entropy in reversible and irreversible processes. Also explain the 'principle of increase in entropy'.

[2+6+2]

OR

Explain the principle of regenerative cooling with the help of a diagram, describe a method of liquefying helium and explain how the principle of regenerative cooling has been utilized in this method. [4+4+2]

3. What is Biot-Savart law? Discuss it. Use it to find electric field at a point perpendicular to a long current carrying wire. [2+2+6]

OR

What do you mean by electric images of charge. Explain 'the method of images' in electrostatics. Explain with a suitable example. [2+6+2]

4. State and explain Bernoulli's theorem. Also mention its applications. [4+4]

5. Explain the meanings of 'macrostate' and 'microstate' of a system. Also explain the constraints and accessible states. [2+6]

6. What do you mean by field vectors? Discuss the Boundary conditions on field vectors, [2+6]

7. Solve any TWO questions: [2×3=6]
   (a) What do you mean by general equation of wave motion? Explain.
   (b) Explain inverse square law of force.
   (c) What are thermodynamic potentials? Write their meanings.
   (d) Write down the applications of a fluxmeteris.

8. Solve ALL the questions: [4×2.5=10]
   (a) Explain the meaning of displacement current.
   (b) How can you increase the sharpness of resonance?
   (c) Explain the meaning of spectral energy density'.
   (d) Write the expression for work done in twisting a rod. Explain the meanings of all the terms.

9. (a) Find out the magnitude of the angular momentum of a bicycle wheel (M = 2kg, R = 40cm) when rolling at 30 km/hr.
   (b) How much torque is needed to turn the handle bar through 1 radian in 0.1 sec? [2.5+2.5]

10. A particle of mass 4 gm lies in a potential field given by

$$V = (200 \ x^2 + 1500) \frac{erg}{gm}$$

Obtain frequency of vibration of the particle. [5]

11. Calculate the number of molecules per unit volume in a gas at 300K when the pressure is 10^{-3} Torr. [5]

12. Tc and Pc of CO_2 are 31.1°C and 73 atm respectively. Assuming that CO_2 gas obeys the Van der Waals equation, find (1) critical density and (2) diameter of CO_2 molecule. [5]

13. Calculate diamagnetic susceptibility of Neon at STP (0°C, 1 atm) on the assumption that only eight outer electrons in each atom contribute, and that their mean radius is R = 4.0×10^{-9}cm. [5]

14. Water is a polar molecule for which the Clausius - Mossotti equation is, strictly speaking not applicable. Assuming its validity determine the dipoie moment for the water molecule. [5]

Physics (Phy. 101), 2072

(Mechanics, Thermodynamics and Statistical Physics Electricity & Magnetism)

Bachelor Level (4 yrs. prog.) I Year/Scie. & Tech.　　　　Full Marks: 100

　　　　　　　　　　　　　　　　　　　　　　　　　　Time: 3 hrs.

Attempt ALL the questions.

1. Write down the equation of clamped simple harmonic oscillator. Find the expression for displacement and discuss when we get oscillatory damped simple harmonic motion. [2+6+2]

OR

What do you mean by plane progressive wave? Obtain an expression for energy density of a plane progressive wave. How is it related to energy current? [2+6+2]

2. State second law of thermodynamics and derive Clausius-Clapeyron latent heat equation. What is the importance of this equation? [2+6+2]

OR

What is difference between Ideal and Real gas? Obtain Vander Waals equation of state. What is the importance of critical temperature? [2+6+2]

3. What is meant by electrical image? Find the magnitude and location of image charge due to a point charge near a conducting sphere and also obtain an expression for the electric potential and field at any exterior point in this case. [2+4+4]

OR

What is displacement current? Obtain Maxwell's electromagnetic equation and explain on which law they are based. [2+5+3]

4. What are Kepler's laws of planetary motion? Show how the universal law of gravitation of Newton has been derived from these laws. [3+5]

5. State Planck's formula for black body radiation and derive it in terms of wavelength. [2+6]

6. Distinguish between polar and non-polar molecules. Derive the Langevin-Debye formula for polar molecules and write the importance of this formula. [2+5+1]

7. Answer any TWO questions: [2×3 = 6]

   (a) Define moment of inertia and radius of gyration of a rigid body, hence calculate the radius of gyration of a solid sphere rotating about its diameter if its radius is 0.05m.

   (b) Define Poisson's ratio of a material and show that its limiting values lie between -1 and 0.5.

   (c) What do you understand by phase space, micro and macro states of a system?

   (d) Define self inductance and mutual inductance and obtain a relation between them.

8. Do ALL the question: [4×2.5 = 10]

   (a) If a force $F = Ax + Bx^2$ acts parallel to x – axis on an object and moves it from $x = 1$ to $x = 2$, calculate the work done.

(b) What do you understand by Joule-Thomson expansion of a gas? Is the cooling effect ultimate result of Joule-Thomson expansion? Discuss.

(c) Define the terms emissive and absorptive power. State Kirchhoff's law of radiation and discuss its importance.

(d) Discuss the importance of the hysteresis curve. How would you use the hysteresis curve to select the material for the construction of a transformer?

9. A rocket of mass 20 kg has 180 kg fuel. The exhaust velocity of the fuel is 1.6 km/s. Calculate the minimum rate of consumption of fuel so that the rocket may rise from the ground. Also calculate the ultimate vertical speed gained by rocket when the rate of consumption of fuel is 20 kg/s. [5]

10. Calculate the rate of flow of glycerin of density 1.25×10^3 kg/m^3 through a conical section of a pipe if the radii of its ends are 0.1m and 0.04m and pressure-drop across its length is 10 N/m^2. [5]

11. For silver, the molar specific heat at constant pressure in the range 50 to 100K is give by

$$C_P = 0.076\, T - 0.00026\, T^2 - 0.15 \text{ cal/k}$$

Where T is the temperature in Kelvin. If 2 mole of silver is heated from 50 to 100K, calculate (i) heat required (ii) change in entropy. [5]

12. The molecular diameter of nitrogen is 3.5×10^{-10}m. Calculate the mean free path at temperature 27°C and pressure 1 atmosphere. [5]

13. A 60 Hz power transformer (turns ratio 2:1) has a primary inductance of 100 H and a d.c. resistance of 20Ω. The coupling coefficient between primary and secondary is close to unity if 1000V is applied across the primary, calculate the current in the primary winding (a) when the secondary is open-circuited. (b) when a load resistance of 20Ω is in the secondary circuit. [5]

14. In the Bohr model of the hydrogen atom the electron circulates around the nucleus in a path of radius 5.1×10^{-11}m at a frequency of 6.8×10^{15} rev/sec.

(i) What value of B is set up at the centre of orbit?

(ii) What is the equivalent magnetic dipole moment?

2. Chemistry (Chem.311), 2066

Time : 3 hrs.   Full Marks : 100

The Comprehensive Question of each group is compulsory.

Attempt EIGHT questions of Short Answer Questions of each group.

Group "A" (Inorganic)

1. **Comprehensive Question**

   Give the derivation of Schroedinger's wave equation (time independent) and define the terms involved in it. What is the significance of Ψ and Ψ^2 with reference to this equation ? [7+2]

   OR

   What is meant by "Diagonal Relationship" ?

   Explain with reasons the diagonal relationship between the following pairs: (i) B and Si (ii) Be and Al (iii) Li and Mg. [3+6]