B. E. Instrumentation and Electronics Engineering First Year First Semester Examination (Old) - 2019

Subject: Physics 1A | Time: Three hours | Full Marks: 100

Answer **any five** questions

All questions carry equal marks

1. (a) On the basis of kinetic theory of gases, deduce an expression for the pressure of a gas in terms of kinetic energy.
(b) What do you mean by average velocity, rms velocity and most probable velocity.
(c) Calculate the mean translation kinetic energy per molecules of a gas at 727°C.
(d) Deduce the values of γ, the ratio of two specific heat C_P and C_V for (i) monoatomic gas and (ii) diatomic gases on the basis of the principle of equipartition of energy. [7+6+3+4]

2. (a) Using the Van-der Waal's equation of state, derive the theoretical values of critical constant in terms of the constant of the equation. What are the drawbacks of Van-der Waal's gas equation ?
(b) Derive the reduced equation of state from Van-der Waal's equation of state.
(c) Calculate the work done when 1 gram mole of a Vander waal's gas expands isothermally from volume of 10 litres to 20 liters at 0°C, given that the Vander Waal's constants $a = 1.4 \times 10^6$ atmosphere cm^6 and $b = 41$ cc. [8+6+6]

3. (a) State and explain the first law of thermodynamics. Distinguish between reversible and irreversible processes.
(b) What are the different operations involved in a Carnot cycle. Describe Carnot's reversible engine and find out its efficiency in terms of source and sink temperature.
(c) A reversible Carnot engine converts $\frac{1}{6}$th of the heat input into work. If the temperature of the sink is reduced by 62°C, its efficiency is doubled. Find the temperature of the source and sink. [7+8+5]

4. (a) State the second laws of thermodynamics. Discuss briefly the concept of entropy from this law.
(b) Derive a general expression for the change of entropy of a perfect gas.
(c) In N.T.P 8.4 litre of O_2 and 14 litre H_2 mixed together. Find the change

in entropy.
(d) Calculate the increase in entropy when 1g of ice at -10°C is converted into steam at 100°C. Given specific heat of ice = 0.5; latent heat of ice = 80 cal/g and latent heat of steam = 540 cal/g. [7+4+4+5]

5. (a) Given a vector $\vec{A} = 3\hat{i} + 4\hat{j} - 4\hat{k}$, find a unit vector $\hat{B}$ that lies in the XY plane and is perpendicular to $\vec{A}$. Find also a unit vector $\hat{C}$ that is perpendicular to both $\vec{A}$ and $\hat{B}$.
(b) A particle moving on the 2-dimensional plane has its dynamics suitably described in terms of the polar coordinates: (r, θ). Find the expressions for the *radial* and the *tangential* components of the acceleration of the particle (in plane polar coordinates).
(c) Define a *Central Force* and give a few examples. State some of its important properties, and in particular prove that for motion under a central force, the angular momentum is always conserved. [6+5+5+4] (d) Define *work* done by a force. What do you mean by a *conservative* force. A point mass moves under the action of an external force $\vec{F}$. Write down the expression for the total work done in moving the mass along an arbitrary closed loop, and hence establish that if $\vec{F}$ is conservative, this work done is zero.

6. A particle of mass m is moving in 3-dimensions and its coordinates satisfy (at any time t): $x = x_0 + at^2$, $y = bt$, $z = ct^3$. Find the force $\vec{F}$ acting on it and its angular momentum $\vec{L}$ at any time t. Define *torque* $\vec{\Gamma}$ due to a force and hence establish the relationship connecting the three vectors $\vec{\Gamma}, \vec{F}$ & $\vec{L}$. Please also check this explicitly by considering the above example. [6+5+4+5]

7. (a) Consider a solid sphere S of mass M and radius R is sitting at the origin. A small spherical hole S_H of radius $R/4$ (and centered at a point distance $R/2$ from the centre of the sphere S) is scooped out. Find the gravitational potential due to this combined system, at a point outside the sphere S. Does the value of this potential depend on the actual location of the hole ? Discuss.
(b) A point mass moves under the action of an external force $\vec{F}$, for example: $\vec{F}(x, y) = A_0 \left(x^2\vec{i} + xy^2\vec{j}\right)$ acting on the XY plane, with A_0 being a constant. Find the work done by this force on a body (of unit mass) which undergoes a displacement on the XY plane from the point $(0, 1)$ to the point $(2, 2)$. Also check whether the work done depends on the path along which the body moves.
[8 + 12]

8. Write Short Notes on (any TWO) : [10 X 2 = 20]
(a) The Parallel axis theorem (and its uses) concerning the Moment of Inertia of rigid bodies. (b) Streamlined flows and Bernoulli's Principle. (c) Non-inertial frames of reference and *pseudo-forces*. (d) The notion of a *rigid body*.