(Time: 3 hours) **(Total Marks: 100)**

N.B : (1) All questions are compulsory.
(2) Figures to the right indicate maximum marks.
(3) Use of non-programmable calculators is permitted.
(4) Symbols used have their usual meaning

Q1. A) Select correct answer **(12)**

1 A spring stretches by 5cm when a mass of 2Kg is suspended at one end, The spring constant is:
a) 500N/m b) 234 N/m c) 392 N/m d) 400 N/m

2 At what rate must the fuel burn to give a 20kg rocket an acceleration of 1g having exhaust velocity 2500 m/sec.
a) 98gm/s b) 78.4 gm/s c) 10 kg/s d) 20 kg/s

3 The efficiency of a Carnot engine is 100%. The temperature of the sink is
a) 0 K b) 100 K c) 273 K d) None of these

4 The thermodynamic scale of temperature does not have
a) 0 K b) 10 K c) 100 K d) – 50 K

5 If $C_P = 6$ and $C_V = 4$ then the value of γ is
a) 1.4 b) 1.5 c) 24 d) 0.67

6 In Otto engine, the spark plug fires shortly before the following stroke
a) compression b) intake c) exhaust d) expansion

B) Answer in one sentence **(03)**

1 Define logarithmic decrement.
2 Give the Kelvin – Planck statement of the second law of thermodynamics.
3 Which substance is used in Diesel engine as a working substance?

C) Fill in the Blanks **(5)**

1 The projection of Uniform Circular motion on the diameter is _____
2 As damping increases the resonant frequency _____.
3 The entropy of the universe is _____.
4 A _____ process is necessarily quasistatic.
5 In case of substance that contracts on melting, $\frac{dP}{dT}$ is _____

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Q2. A) Attempt any one **(8)**

1 Set up the equation for damped harmonic oscillator. Solve it and show that the motion is oscillatory when damping is small.

2 Write the equation of motion for a rocket motion. From this get the expression for maximum velocity.

B) Attempt any one **(8)**

1 Derive the time period for a compound pendulum. Show that the point of suspension and point of oscillation are interchangeable.

2 Write the equation for forced damped oscillation. Solve this to get the expression for amplitude. Also get the expression for maximum amplitude.

C) Attempt any one **(4)**

1 A charged capacitor of 1.8mF discharges through an inductance of 0.5H. What should be the maximum value of the resistance so that the discharge is oscillatory.

2 Three particles of mass 2kg each has a position vectors given by $\boldsymbol{r_1}= 2t\boldsymbol{i}-3\boldsymbol{j}+t^2\boldsymbol{k}$, $\boldsymbol{r_2}= t^2\boldsymbol{i}+2t\boldsymbol{j}-\boldsymbol{k}$ and $\boldsymbol{r_3}= (t-1)\boldsymbol{i}+2t\boldsymbol{j}+2t\boldsymbol{k}$. Find the position of the center of mass and its velocity at t =1sec.

Q3. A) Attempt any one **(8)**

1 Draw the T – S diagram of the Carnot cycle and describe each stage.

2 State the Carnot's theorems and prove them.

B) Attempt any one **(8)**

1 Show that the ratio of any two temperatures on the thermodynamic scale of temperature is equal to the ratio of heat absorbed and heat rejected by a reversible engine operating between the same two temperatures.

2 Starting with the equation $TdS = C_vdT + pdV$ obtain the expressions for changes in the entropy of an ideal gas in various processes.

C) Attempt any one **(4)**

1 A Carnot engine whose sink temperature is 7^0 C has an efficiency of 40%. It is desired to increase the efficiency to 50%. Obtain the increase in temperature of the source.

2 Explain how the size of a degree is determined in the thermodynamic scale of temperature?

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Q4. A) Attempt any one **(8)**

1 What is Joule-Thomson effect? Show that Joule-Thomson expansion is an isenthalpic process.

2 Derive an expression for efficiency of an Otto cycle with neat labeled p-V diagram.

B) Attempt any one **(8)**

1 Write a note on properties and uses of liquid helium.

2 Explain the working Diesel engine with the help of its p-V diagram.

C) Attempt any one **(4)**

1 Calculate the depression in the melting point of ice produced by 2 atmosphere increase in pressure. Given : Latent heat of ice = 80 cal/g, Change in specific volume of transition from ice to water at 0°C=-0.091 cm^3.

2 Find the efficiency of a Diesel engine for which the adiabatic compression ratio is 16 and adiabatic expansion ratio is 4. Take γ=1.4.

Q5. Attempt any Four **(20)**

1 A mass m is suspended from a spring of force constant *k*. If the natural frequency is twice the damping frequency, show that the damping constant b is $\sqrt{3mk}$.

2 A U^{238} nucleus emits an alpha particle and is converted to Th^{234}. If the velocity of the alpha particle is $1.5X10^7$ m/s and the kinetic energy is 4.5MeV, calculate the recoil velocity and the kinetic energy of the Th^{234} nucleus.

3 Write a short note on reversible and irreversible processes.

4 Obtain an expression for energy that is not available for work in an irreversible process.

5 Considering entropy as a function of temperature and volume, prove that $C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P$ using Maxwell's thermodynamic relation.

6 Write a note on Unattainability of absolute zero.

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