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**ST. JOSEPH'S COLLEGE (AUTONOMOUS), BANGALORE-27**
**B.Sc. PHYSICS – I SEMESTER**
**SEMESTER EXAMINATION: OCTOBER 2019**
**PH118: MECHANICS, HEAT & THERMODYNAMICS**

**Time:** $2\frac{1}{2}$ **hours** **Maximum marks: 70**

*This question paper has 2 printed pages and 3 parts*

## PART A

Answer any **FOUR** of the following questions. Each question carries 10 marks. $[4 \times 10 = 40]$

1. (a) Describe the working principle of a rocket. Why do we need multi-stage rocket? [3]
   (b) Obtain an expression for the instantaneous velocity of a rocket far from the Earth. [7]

2. (a) With the help of a neat diagram, obtain the Galelian transformation equations when one frame is moving relative to the other with a uniform velocity along the positive x-axis. [3]
   (b) Considering a uniformly rotating frame of reference, obtain an expression for Coriolis acceleration. How can you explain the behaviour of cyclones using the above idea? [7]

3. (a) Show that the acceleration of a body rolling down an inclined plane is

$$a = \frac{g \sin\theta}{1 + \frac{k^2}{r^2}}$$

   where $\theta$,$k$,$r$ are the angle of inclination, the radius of gyration and the radius of the rolling body respectively. [8]
   (b) Can we use perpendicular axes theorem to determine the moment of inertia of a solid cylinder about an axis passing through its centre and perpendicular to it's axis of symmetry? Explain. [2]

4. (a) Stating the assumptions of kinetic theory of gases, obtain an expression for the pressure of an ideal gas. [8]
   (b) Deduce Boyle's law and Charle's law from the kinetic theory of gases. [2]

5. (a) With the help of a neat P-V diagram, derive the Clausius-Clayperon equation. [7]
   (b) Explain the principle of increase of entropy. [3]

6. (a) Write a note on Andrew's isothermal curves for real gases. [7]
   (b) Differentiate between Joule-Thomson expansion and Adiabatic expansion. [3]

## PART B

Solve any **FOUR** of the following problems. Each problem carries 5 marks. $[4 \times 5 = 20]$

7. Find the unit vector perpendicular to the plane containing the vectors $\vec{A} = -\hat{i} + 2\hat{j}$ and $\vec{B} = -\hat{i} + 3\hat{k}$.

8. Two masses of 90kg and 60kg are seperated by a distance of 20 m. If the mid point is taken as the origin, find the position of the centre of mass. If the mass 90 kg is moved 6 m towards the origin, what should be the position of the 60 kg mass so that the centre of mass remains the same?

9. A uniform rod of length 10 m and mass 10 kg, hinged at one end, is capable of rotating in the vertical plane under the action of gravity. The rod is held horizontally and then released. i) What will be the initial torque acting on the rod? ii) What will be the initial angular acceleration of the rod? iii) What will be the linear acceleration of the tip of the free end of the rod? Given: Acceleration due to gravity is 10 $ms^{-2}$.

10. The rms velocity of oxygen is 459.6 $ms^{-1}$ and its density is 1.43$kgm^{-3}$. If coefficient of viscosity of oxygen is $1.95 \times 10^{-5}$ $Nsm^{-2}$, calculate i) the mean free path and ii) the molecular diameter of the oxygen gas. Assume that the number density of oxygen gas at STP is $2.5 \times 10^{25}$.

11. Two Carnot engines A and B are working in series. Carnot engine A receives heat at 1000K and rejects heat to a heat reservoir kept at T K. Carnot engine B receives heat from the heat reservoir at T K and rejects heat to a reservoir kept at 400 K. Calculate the temperature T of the reservoir when a) same work is done by both the Carnot engines b) when the efficiencies of both Carnot engines are the same.

12. Calculate at what pressure water will boil at $120°$C if the change in specific volume is $1500 \times 10^{-6}$ $m^{-3}$. Given:- The heat absorbed when $10^{-3}$ kg is converted into steam is $2.268 \times 10^3$ Joules. 1 atmospheric pressure $= 10^5$ Pa.

## PART C

Answer any **FIVE** of the following questions. Each question carries 2 marks. $[5 \times 2 = 10]$

13. (a) If $\vec{A} \times \vec{B} = 0$, what can you tell about these vectors?
    (b) How do you know that $\frac{d\hat{r}}{d\theta} = \hat{\theta}$?
    (c) If the tail rotor of a helicopter stops functioning the body of the helicopter will start spinning in opposite direction to the main rotor. Why?
    (d) Internal energy is a state function. Explain.
    (e) In a reversible isothermal process the work done is equal to the decrease in Helmholtz free energy. Explain.
    (f) In a chemical reaction taking place in an open test tube at constant temperature, which of the thermodynamic potentials should be a constant? Why?