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RAJARATA UNIVERSITY OF SRI LANKA

FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
First Year - Semester I Examination - September/October 2014

PHY 1201 –GENERAL AND THERMAL PHYSICS

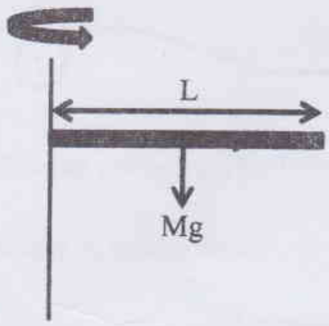
Answer **all five** questions Time allowed: **2 hours**

Gravitational field intensity $g = 9.8 \text{ m s}^{-2}$.

Universal gas constant $R = 8.314 \text{ J K}^{-1}\text{mol}^{-1}$

1. The moment of inertia of a solid uniform rod hanging from its center is equal to $\frac{ML^2}{12}$, where M is the mass of the rod and L is the length of the rod.

   I. Find the moment of inertia of the system if the above rod is hanging from its end as shown in the following diagram.



A constant torque of 20 N m turns the above rod about its end. If the mass and the length of the rod are 0.5 kg and 3 m respectively, find

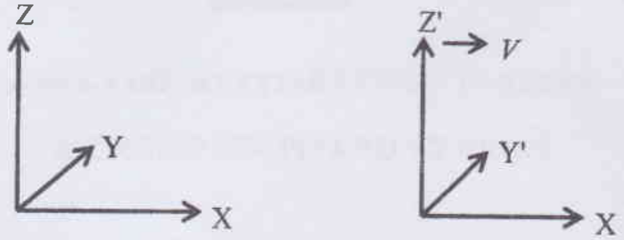
   II. the moment of inertia of the rod around its end.

   III. the angular velocity gained in 4 s.

   IV. the kinetic energy gained after 20 revs.

(20 marks)

2. Consider two reference frames S and S' shown in the figure. The reference frame S' moving at a velocity V with respect to the reference frame S. If both frames coincide at $t = t' = 0$,



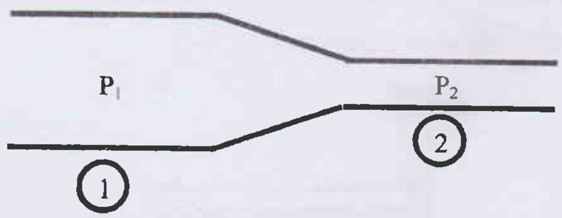
I. Write down the relationship between coordinate systems after time t.

II. Show that the velocity $U'_x = U_x - V$ and the acceleration $a'_x = a_x$.

III. A ball is thrown at 15.0 **m/s** speed inside a car moving along the highway at 50.0 **m/s.** Using Galilean transformations find the speed of the ball relative to the ground if the ball is thrown forward.

(20 marks)

3. The horizontal constricted pipe known as a *venture tube* can be used to measure the flow speed of an incompressible fluid.



I. If the pressure difference P_2-P_1 is known, show that the velocity at point 2 is given by $V_2 = A_1\sqrt{\frac{2(P_2-P_1)}{\rho(A_1^2-A_2^2)}}$, where A_1 and A_2 represent the area inside the tube at point 1 and point 2 respectively.

II. Water runs through a water main of cross sectional are 0.4 m^2 with a velocity of 6 m/s. Assuming water behave as an ideal fluid, find the velocity of the water when the pipe tapers down to a cross sectional area of 0.3 m^2.

(20 marks)

4. A 4.00 kg particle moves along the x axis. Its position varies with time according to $x = t + 2.0\,t^3$, where x is in meters and t is in seconds. Find
   I. the kinetic energy at any time t,
   II. the acceleration of the particle and the force acting on it at time t,
   III. the power being delivered to the particle at time t, and
   IV. the work done on the particle in the interval $t = 0$ to $t = 2.00$ s.

(*20 marks*)

5. Consider an ideal gas consisting of N molecules in a container of volume V. Container is a cube with edges of length d.
   I. If the average force exerted on the walls of the cube by gas molecules is given by $F = \frac{Nm}{3}\frac{\bar{v}^2}{d}$, show that the pressure inside the container $P = \frac{2}{3}\left(\frac{N}{V}\right)\left(\frac{1}{2}m\bar{v}^2\right)$.
   Where, m is the mass of a gas molecule and $\bar{v}^2$ is the mean square velocity of a gas molecule.
   II. Using the relationship in *part (i)* and the ideal gas law ($PV = Nk_BT$), show that the average kinetic energy of the gas $E = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}k_BT$.
   (*k_B – Boltzmann constant*)
   III. Show that the total translational kinetic energy of N molecules of gas is given by, $E_{Trans} = \frac{3}{2}nRT$.

A tank used for filling helium balloon has a volume of 0.300 m^3 and contain 2.00 moles of helium gas at 20.0 ^{0}C. Assume helium behaves as an ideal gas

   IV. Calculate the total translational kinetic energy of the gas.
   V. What is the average kinetic energy per mole?

(*20 marks*)

$$v = \frac{dx}{dt} \qquad \int x\,dx = \frac{x^2}{2}$$

$$a = \frac{d^2x}{dt^2} \qquad \int x^3\,dx = \frac{x^4}{4}$$