RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

FIRST YEAR [2019-22]

B.A./B.Sc. FIRST SEMESTER (July – December) 2019

Mid-Semester Examination, September 2019

Date : 16/09/2019 | **PHYSICS (Honours)**

Time : 1 pm – 2 pm | **Paper : II[CC 2]** | Full Marks : 25

(Answer any five questions taking at least two from each group)

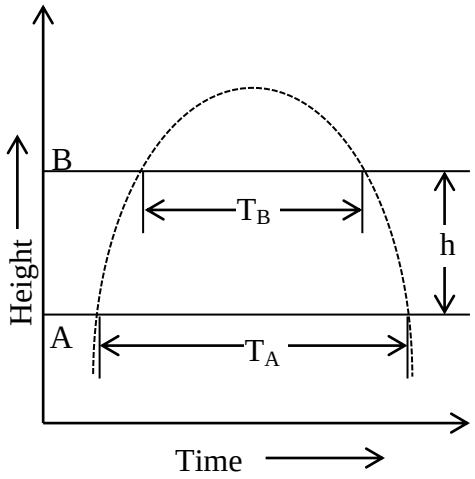
Group A

[5×5]

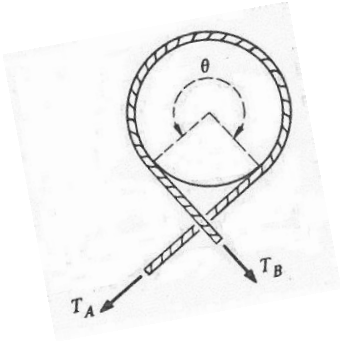
1. a) Let $\vec{A}$ be an arbitrary vector and let $\hat{n}$ be a unit vector in some fixed direction. Show that
$\vec{A} = \left(\vec{A}.\hat{n}\right)\hat{n} + \left(\hat{n} \times \vec{A}\right) \times \hat{n}$ [2+3]

b) Show that if the time the body takes to pass a horizontal line A in both directions is T_A, and the time to go by a second line B in both direction is T_B, then assuming the acceleration (g) is constant,

the magnitude of $g = \dfrac{8h}{T_A^2 - T_B^2}$

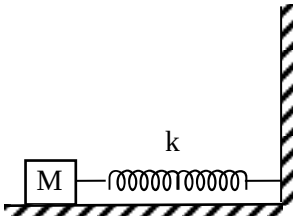


2. The rope is wrapped around a fixed drum. The load on the rope pulls it with a force T_A, and the end is held at much smaller force T_B. Show that $T_B = T_A e^{-\mu\theta}$, where 'μ' is the coefficient of friction and 'θ' is the total angle subtended by the rope on the drum. [5]



3. A rocket ascends from rest in a uniform gravitational field by ejecting exhaust with constant speed 'μ'. Assume that the rate of which mass is expelled is given by $\dfrac{dm}{dt} = \gamma m,$ where 'm' is the instantaneous mass of the rocket and γ is the constant, and that the rocket is retarded by air resistance with a force 'mbν', where 'b' is a constant. Find the speed of rocket as a function of time. [5]

4. The block shown in the drawing is acted by a spring with spring constant 'K' and a weak friction force of constant magnitude 'f '. The block is pulled a distance 'x_0' from equilibrium and released. It oscillates many times and eventually comes to rest. Show that number of cycles 'n', the mass oscillates before coming to rest is given by $n = \frac{1}{4}\left[\left(kx_0 / f\right) - 1\right]$



Group B

5. a) A massless cantilever of length *l* and geometric moment of inertia I_B is clamped at one end and loaded at the other end by a weight W. Show that the maximum depression of the cantilever is $\frac{Wl^3}{3YI_B}$. [3]

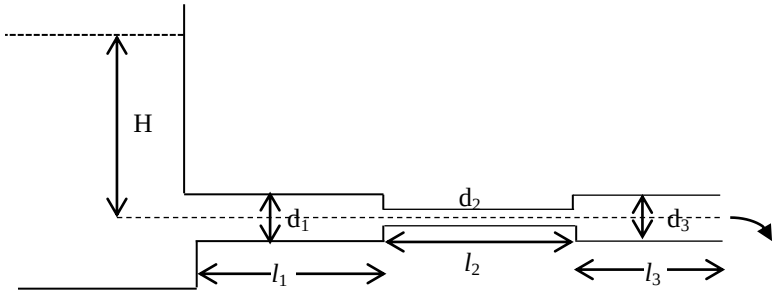
   b) Show that the square cross-sectional cantilever is stiffer than circular of the same cross-sectional area. [2]

6. a) Deduce Bernoulli's equation for incompressible fluid. Hint : Euler's equation is given by

$$\frac{\partial \vec{v}}{\partial t} + \left(\vec{v}.\vec{\nabla}\right)\vec{v} = \vec{F} - \frac{1}{\rho}\vec{\nabla}P$$

   where $\vec{v}$ is velocity, $\vec{F}$ is body force, P is pressure and ρ is density. [3]

   b) A horizontal pipeline is attached to the wall of reservoir as shown in figure. The water level in the upper reservoir is at the height H = 1.5 m above the pipe line axis. Diameters and lengths of the pipelines are respectively $d_1 = 0.24m$, $l_1 = 3m$, $d_2 = 0.1m$, $l_2 = 1m$, $d_3 = 0.12m$ and $l_3 = 2m$. If water flows out to the open space from the other end of this pipelines then calculate the velocities of water in different pipes (consider the liquid to be ideal). [2]



7. a) Find the gravitational field at a distance r along the axis of a thin ring of mass M and radius *a*. [2.5]

   b) Find the force necessary to make a particle describe the lemniscates $r^2 = a^2 \cos 2\theta$ [2.5]

8. a) What do you mean by geosynchronous satellite? What should be the length of semi major axis of a geosynchronous orbit? [2]

   b) A satellite is to be placed in synchronous circular orbit around the planet Jupiter to study the famous "red spot" in Jupiter's lower atmosphere. How high above the surface of Jupiter will the satellite be? The rotational period of Jupiter is 9.9 hour, its mass M_J is about 320 times of Earth mass and its radius R_J is about 11 times that of the Earth. [3]

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