Parvatibai Chowgule College of Arts and Science
Autonomous

BSc Semester End Examination, January/February 2022

Semester: I
Subject: Physics
Title: Mechanics – I (Core)
Duration: 2 hours Max. Marks: 45

Instructions: i) All questions are compulsory.
ii)Use of non-programmable calculators are allowed.
iii) Draw neat diagrams wherever necessary.

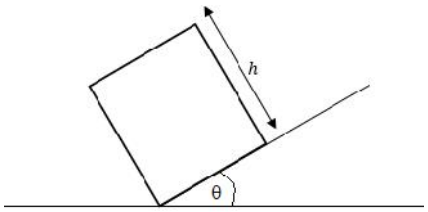
Q1. Answer **ANY THREE**of the following **[9]**

a) Obtain an expression for the force if the potential energy of a particle is given by

$$V = \frac{1}{2}kx^2$$

b) The velocity of a car, which is accelerating uniformly, changes from 60 ms^{-1} to 30 ms^{-1} in 65 m. How much further will it travel before coming to rest?

c) A uniform block of height h=70 cm with a square cross-sectional base of 60 cm x 60 cm is placed on a rough plane surface as shown in the diagram below. The inclination θ of the plane is gradually increased. Calculate the angle of inclination of the plane θ_{max} at which the block topples over.



d) A small block is pulled along a rough horizontal surface at a constant velocity of 4.0 m/s by a constant force. The force has magnitude 30 N and acts at an angle of 30° to the horizontal. Calculate the work done by this force in 15 s.

Q2. Answer **ANY TWO** of the following **[12]**

a) Show that the work done by the total external force in moving a particle from position 1 to 2 is given by

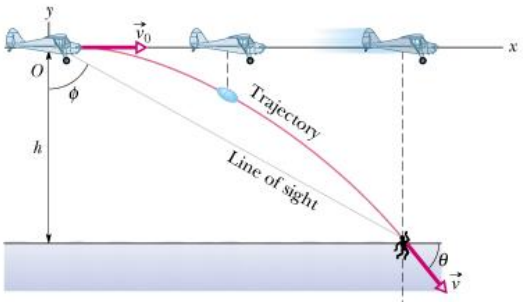
$$W = \int_1^2 \vec{F}.d\vec{r} = T_2 - T_1$$

where T_1 and T_2 are the kinetic energies of the particle in positions 1 and 2 respectively.

b) A light string is tied to two pegs P and R, with R above and to the right of P. A mass, m is attached to a point Q on the string such that the section PQ is horizontal and the

section QR makes an angle of $\theta=30^0$ to the horizontal. If the system is in equilibrium, what is the tension in the section of string PQ in terms of mg? Include a diagram in your solution.

c) A recue plane flies at 198 km/h (55 m/s) at constant height h=500 m toward a point directly over a victim, where a recue capsule is to land. What should be the angle of the pilot's line of sight to the victim when the capsule release is made?



Q3. Answer <u>ANY TWO</u> of the following **[12]**

a) Show that i) the total energy $\left(\frac{1}{2}mv^2 + qV\right)$ of a charged particle with charge q and mass m in a uniform electric field is constant. ii) Calculate the speed acquired by the particle in the direction of the field, if the particle initially at rest falls through a potential difference of V volts. (Given m = 9.11 x 10^{-31} kg, q = 1.60 x 10^{-19} C).

b) In an Atwood's Machine the two masses m_1 and m_2 are attached with a string having tension T over pulley. Obtain an expression for the acceleration of each block and tension in the string

c) Show that Newton's second law in plane polar co-ordinates is

$$\mathbf{F} = m\mathbf{a} \quad \Leftrightarrow \quad \begin{cases} F_r = m\left(\ddot{r} - r\dot{\theta}^2\right) \\ F_\theta = m\left(r\ddot{\theta} + 2\dot{r}\dot{\theta}\right) \end{cases}$$

Q4. Answer <u>ALL</u> of the following. **[12]**

a) Show that the trajectory of a body projected with velocity v_0 at an angle α with the horizontal is a parabola. Hence obtain an expression for the range of the projectile.

b) A man tosses a ball vertically up along y-axis with an initial speed of 12m/s. How long does the ball take to reach its maximum height? What is the balls maximum height above its release point?

c) Show that acceleration due to gravity varies with altitude and depth from the surface of earth. As we go away from the surface of the earth in the limit of R >> h show that

$$g_h = g\left(1 - \frac{2h}{R}\right)$$

OR

Q4. Answer <u>ALL</u> of the following. [12]

p) The first couple of minutes of the launch of a space shuttle can be described as follows: The initial mass is 2×10^6 kg, the final mass (after 2 minutes) is about 10^6 kg, the average exhaust speed V_{ex} is about 3000 m/s, and the initial velocity is zero. If all this were taking place in outer space, with negligible gravity, what would be the shuttle's speed at the end of this stage? What is the thrust during the same period?

q) Calculate the gravitational potential and field that would be experienced by a mass 'm' placed outside the uniform disc of mass M.

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