Uva Wellassa University, Sri Lanka
B.Tech. Degree Programme
End Semester Examination- Semester 1
January - 2009

SCT 151-1 MECHANICS

Answer four (4) questions only **Time: One (01) Hour**

$g = 9.81\ ms^{-2}$
$G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$

1. State the Newton's laws of motion and derive the mathematical form of the second law.

A 15 kg block of mass is held stationery by a cord with negligible mass on a frictionless plane inclined at an angle of 27^0 to the horizontal.

a) Draw a free-body diagram for the block showing all the forces acting on it.
b) What are the magnitudes of the forces on the block from the cord and the plane?
c) Does the block accelerate as it slides down the inclined plane if we now cut the cord? If so what is its acceleration?

(25 marks)

2. (a) An electron with a speed of $1.2 \times 10^7\ ms^{-1}$ moves horizontally into a region where a constant vertical force of 4.5×10^{-16} N acts on it. The mass of the electron is 9.11×10^{-31} kg. Determine the vertical distance the electron is deflected during the time it has moved 30 mm horizontally.

(b) A ship initially at rest accelerates steadily on a perfectly smooth sea. How would you attempt to estimate the value of the acceleration from within the ship? You are not allowed to see outside but provided with the apparatus normally you find in a first year physics laboratory (you may assume that the acceleration is not less than $1\ ms^{-1}$).

(25 marks)

3. Explain why a body moving with uniform speed in a circle must experience a force towards the centre of the circle. Write an expression for its magnitude.

What force is necessary to keep a mass of 0.8 kg revolving in a horizontal circle of radius 0.7 m with a period of 0.5 s? What is the direction of this force?

An airplane is flying in a horizontal circle at a speed of 480 km/h. It wings are tilted at angle $\theta = 40^0$ to the horizontal. If the force required to fly in this way is provided entirely by "an aerodynamic lift" that is perpendicular to the wing surface, what is the radius of the circle in which the plane is flying?

(25 marks)

4. Show that the total kinetic energy (KE) of a rolling object is a combination of KEs associated with rotational and translational motions of the object.

A round body of mass M and radius R rolls smoothly down a ramp which is at angle θ to the horizontal. Given the moment of inertia of an axis going through the centre of the body is I_{com} and the acceleration due to gravity is g, obtain an expression for the linear acceleration a_{com} of the center of the rolling body. Show clearly the forces acting on the object.

Given $\theta = 30^0$ and the round body descends a vertical height of 1.20 m to reach the bottom of the ramp, calculate the linear speed of the body at the bottom $\left(I_{com} = {}^5/_2 MR^2\right)$.

(25 marks)

5. State the Kepler's law of planetary motion and obtain an expression for the third law.

Comet Halley orbits the Sun with a period of 76 years and, in 1986, had a distance of closest approach to the Sun which is known as *perihelion distance* $R_p = 8.9 \times 10^{10}$ m. Given the mass of the Sun is equal to 1.99×10^{30} kg, what is the comet's farthest distance from the Sun, which is called *aphelion distance* R_a? (Note $R_p + R_a = a$ where a is the semimajor axis of the comet's orbit)

What is the eccentricity e of the orbit of comet Halley given $ea = a - R_p$?

(25 marks)