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

SCT 251-1 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. A uniform rod AB of mass M and l m long is suspended by two vertical springs X and Y attached to the rod at A and B respectively. The upper ends of the springs are attached to a horizontal beam. When the springs are unextended (not stretched) they have the same length. The tension Tx in X is given by Tx = kx and that in Y is given by Ty = 3ky, where k is a constant and x and y are the extensions of X and Y respectively. When a mass of 6M is attached z distance away from A, AB extends in such a way that the extension in Y is greater than that in X. Given the angle between AB and the horizontal is θ,

   a) find the extension of X
   b) the distance from A, i.e., z, a body of mass 6M to be attached.

   (25 marks)

2. State the Newton's second law of motion and derive the mathematical form of it.

   In a rescue operation, the pilot of a helicopter of mass 10^3 kg maintains it at a certain height above the ground imparting a downward velocity of 9.8 ms^{-1} to the air displaced by its rotating blades. Given the density of air = 1.3 kgm^{-3} calculate

   a) the area swept out by the rotating blades of the helicopter
   b) the height at which the helicopter is maintained above the ground
   c) the power needed to keep the helicopter in this way assuming that there is no lost of energy.

   (25 marks)

3. What do you mean by "drag force" and "terminal speed".

By considering a body falling down freely in air, obtain an expression for its terminal velocity, Vt, identifying each term in the expression you derive.

A rain drop with radius R falls from a cloud that is at height h above the ground. The drag coefficient, C, of the air for the rain drop is 0.60. Assuming that the drop is spherical throughout its fall, find the terminal speed, Vt, of the rain drop given the density of air is ρ and that of water is d. Take the mass of the water drop as m. What is the numerical value of Vt, if R = 1.5 mm, ρ = 1.2 kgm^{-3}, d = 1000 kgm^{-3} and h = 1.2 km.

(25 marks)

4. Show that a particle of mass m moving with a constant speed v in a circle with a radius r experiences a centripetal acceleration a equal to v^2/r.

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?

A spaceman in training is rotated in a seat at the end of a horizontal rotating arm of length 5 m. if he can withstand accelerations up to 9g, what is the maximum number of revolutions per second permissible?

(25 marks)

5. State the Newton's law of gravitation and derive the dimensions of the gravitational constant G in terms of mass M, length L, and time T.

Explorer 83, an astronomy research satellite of mass 3 x 10^5 g, circles the Earth in an orbit of average radius 5R/2 where R is the radius of the Earth. Assuming the gravitational pull on a mass of 1000 g at the Earth's surface to be 10 N, calculate the pull on the satellite.

An asteroid whose mass is 2.0 x 10^{-4} times the mass of Earth revolves in a circular orbit around the Sun at a distance that is twice Earth's distance from the Sun. (a) Calculate the period of revolution of the asteroid in years. (b) What is the ratio of the kinetic energy of the asteroid to the kinetic energy of Earth?

(25 marks)

6. State the principle of equivalence. Describe the circumstances under which a body can be said to be *weightless.*

Discuss with examples the idea of "*curvature of spacetime*" and present your thinking on the fact that the objects gravitate towards each other due to the *curvature of spacetime.* Explain briefly the phenomenon of gravitational lensing.

(25 marks)