Bago University
Department of Physics
Second Semester Examination, September 2019

Second Year (BSc)
(Physics Specialization)

Phys 2106
Analytical Mechanics
Time Allowed: (3) Hours

Answer any Six questions.

1 (a) Define 'the center of mass of a system' and 'the center of mass of solid bodies' in mathematical form. Write down the equations to find the center of mass of two particles having masses m_1 and m_2 where they are joining on the x-axis.

(b) A uniform steel meter bar rests on two scales at its ends. The bar weighs 4.0 lb. Find the readings on the scales.

2 (a) How do you understand translational equilibrium, rotational equilibrium and coefficient of friction? What are the conditions for equilibrium of a rigid body acted upon by a system of coplanar forces?

(b) Calculate the center of mass of a uniform semi-circular wire of radius 'a'.

3 (a) (i) Define gravitational field strength and gravitational potential.

(ii) State the Law of Gravitation in words and in symbols.

(b) Find the work done in moving a particle from the point (1,-1, 2) to (2, 3, -1) in a force field with potential $V = x^3 - y^3 + 2xy - y^2 + 4x$.

4 (a) Show that $F_x = -\frac{\partial V}{\partial x}$, $F_y = -\frac{\partial V}{\partial y}$, $F_z = -\frac{\partial V}{\partial z}$ and then, $\vec{F} = -\vec{\nabla}V$.

(b) Find the work done in moving a particle around a circle 'C' in the XY-plane, if the circle has center at the origin and radius 4 and if the force field is given by
$\vec{F} = (2x - y + z)\hat{i} + (x + y - z^2)\hat{j} + (3x - 2y + 4z)\hat{k}$.

5 (a) A particle moving in a central force field located at $r = 0$ describe $r = e^{-\theta}$. Prove that the magnitude of the force is inversely proportional to r^3.

(b) Explain the linear momentum and the angular momentum of the particle. In the central force field, show that the radius vector drawn from the sun to a planet describes equal areas in equal times.

6 (a) Compute the kinetic energy of a particle motion in a central force field.

(b) Show that the squares of the periods of the different planets are proportional to the cubes of semi-major axes of their respective path.

7 (a) Deduce the equation of motion for a compound pendulum.

(b) A ball of mass 'm' and a ball of unknown mass, approach each other from opposite directions and have the same speed v_0. The ball of unknown mass is brought to rest by the impact, while the other ball is not. What is the mass of the unknown? And what is the speed of the ball of mass 'm' after impact?

8 (a) What are the expressions for kinetic energy, potential energy and total energy of a simple harmonic oscillator? What is meant by resonance frequency?

(b) (i) Prove that the force $\vec{F} = -kx\,\hat{i}$ acting on a simple harmonic oscillator is conservative.
(ii) Obtain the potential energy of a simple harmonic oscillator.