Bago University
Department of Physics
Second Semester Examination, September 2019

Fourth Year (BSc) **Phys 4110**
(Physics Specialization) **Theoretical Physics**
Time Allowed: (3) Hours

Answer any Six questions.

1 (a) A rigid body symmetric about an x-axis has one point fixed on this axis. Discuss the rotational motion of the body when there is no other force acting except the reaction force at the fixed point.

(b) Evaluate the acceleration of a circular wheel rolling with constant speed along a straight level track.

2 (a) Write down theorem of a rigid body in the general case and prove that the first part of this theorem.

(b) Deduce the velocity $\vec{v}$ of any point on the straight line between two points in a rigid body.

3 (a) Prove that the stress at a point of a perfect fluid is the same across every plane.

(b) If C is the circulation around any closed curve moving with the fluid, prove that $\frac{dC}{dt} = \int p\, d\left(\frac{1}{\rho}\right)$ where the field is conservative and pressure p depends only on the density ρ.

4 (a) Determine the different types of motion involved with the velocity field $\vec{q} = (Ax + 2By + u_0)\hat{\imath} + (Ay + v_0)\hat{\jmath} + (-2Az + w_0)\hat{k}$ where A, B, u_0, v_0 and w_0 are constants.

(b) Consider any arbitrary closed surface drawn in the region occupied by the fluid and moving with the fluid so that it contains the same fluid particles at every time. Obtain the equation of motion for a perfect fluid due to Euler.

5 (a) A body of liquid with constant density rotates with constant angular velocity about a vertical axis under the action of gravity only. Show that the free surface is a paraboloid of revolution with axis vertical and that the vorticity at any point of the fluid is equal to angular velocity.

(b) Derive the equation of continuity of an incompressible fluid for irrotational motion in terms of the scalar velocity potential.

6 (a) State the basis of two suppositions and transform the Euler's equation of motion on it.

(b) A sphere of constant radius is moving in a fluid with constant velocity $\vec{u}$; show that at any point $\vec{r}$ of the sphere at time t, the velocity $\vec{q}$ of the fluid satisfies the condition $(\vec{q} - \vec{u}).(\vec{r} - \vec{u}t) = 0$, the centre of the sphere being at the origin at time t = 0.

7 (a) Deduce the equation of continuity in cylindrical coordinates.

(b) If the lines of motion are curves on the surfaces of cones having their vertices at the origin and Z- axis as the common axis, show that the equation of continuity is $\frac{\partial\rho}{\partial t} + \frac{\partial(\rho u)}{\partial r} + \frac{\operatorname{cosec}\theta}{r}\frac{\partial(\rho v)}{\partial \rho} + \frac{2(\rho u)}{r} = 0$, where u, v are the components of velocity in the direction of $\vec{r}$ increasing and ϕ increasing respectively.

8 (a) State Bernouilli's theorem for steady motion and prove that it is valid in two cases of motion.

(b) In the steady motion of an incompressible homogeneous fluid under no force, the velocity at any point is $ax\hat{\imath} + ay\hat{\jmath} - 2az\hat{k}$. Find the surfaces of equal pressure.
