M.E. (Water Resources & Hydraulic Engineering) Examination, 2025

(1st Semester)

GEOPHYSICAL FLUID DYNAMICS

(Program Elective 3)

Time: Three Hours Full Marks: 100

Answer any ***four*** questions.

1.(a) Justify how rotation and stratification affect geophysical fluid dynamics.

(b) Prove the relation between length (L) & height (H) on a Planet rotating at a rate Ω

$$L \sim \frac{1}{\Omega}\sqrt{\frac{\Delta\rho}{\rho_0}gH}$$

(c) On Jupiter, a day lasts 9.9 earth hours and the equatorial circumference is 624, 48,600 km. Knowing that the measured gravitational acceleration of the equator is 26.4 m/s^2, what is the value of true gravitational acceleration?

8+8+7=25

2. (a) What is Coriolis force? Prove that the absolute velocity is equal to the relative velocity and entraining velocity due to the rotation of the reference framework in the Case of 2-D rotating frame.

(b) Prove that the Centrifugal acceleration is proportional to the square of angular rate & the co-ordinate in case of 2-D rotating frame.

15+10=25

3. (a) State the scale analysis of forward & backward difference of third order truncation error.
(b) Show that the fourth-order centered finite difference approximation of the first derivative is two centered differences, one across $2\Delta t$ and the other across $4\Delta t$.

10+15=25

4. (a) A Buoyant Jet is produced in the laboratory by discharging 40°C warm water @ 3 cm^3/s into a tank of water at 20°C. (i) Find the buoyancy of the discharge at the source (ii) Estimate the bouncy flux after the Jet is diluted 100 times by the entrainment of the ambient colder water into the jet. Assume sea water density at 40°C as 992.2204 kg/m^3; sea water density at 20°C as 998.2063 kg/m^3. Assume any data if needed.
(b) Differentiate between round Jet & plane Jet.
(c) Show that the velocity fluctuation & the Contaminant Concentration at any location are proportional to the center line velocity and initial concentration of plane jet at that location.

10+5+10=25

5. (a) What the different types of wave action formed particularly applicable in coastal engineering and describe them in brief with sketches?

(b) Deduce expressions for surface elevation, wave length, wave celerity, water particle velocity etc. as a function of wave height, period and water depth using the first principle for wave potential 'φ' with some assumptions

(c) Deduce an expression for the total pressure considering linear wave theory from the first principle of wave potential 'φ'.

5+15+5=25

6. (a) Briefly describe the term Rossby Number and its importance.

(b) What is geostrophic motion? Derive the equation for geostrophic motion considering steady flow with a pressure gradient.

6+19=25