

M.E. (Water Resources & Hydraulic Engineering) Examination, 2019
(Evening) (1st Year-2nd Semester)

GEOPHYSICAL FLUID DYNAMICS

Paper-II

Time : Three Hours

Full Marks : 100

Answer any *four* questions.

1. (a) Explain how you justify "Importance of Rotation" which effects in Geophysical Fluid Dynamics.
 (b) Prove the relationship between length (L) and height (H) on a planet rotating at rate Ω .

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

- (c) On Jupiter, a day lasts 10.8 earth hours and the equatorial circumference is 642,500 km. Knowing that the measured gravitational acceleration of the equator is 30.1 m/s^2 , what is the value of true gravitational acceleration.

8+8+7=25

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

10+15=25

3. (a) Prove that the absolute velocity is equal to the relative velocity and entraining velocity due to the rotation of the reference framework in case of 2-D rotating frame.
 (b) Prove that the centrifugal acceleration is proportional to the square of angular rate and the coordinates in case of 2-D rotating frame.
 (c) Define temporal Rossby number, Rossby number and Ekman Number. What is Coriolis Force?

10+8+7=25

4. (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

5+20=25

5. (a) What are the different types of diffusers used for discharging in coastal water bodies? Differentiate between round plume and plane plume.

(b) Show that the velocity fluctuations and the contaminant concentration at any location are proportional to the centre line velocity and initial concentration of the round jet at that location.

(c) A buoyant jet is produced in the laboratory by discharging 40°C warm water @ $3\text{ cm}^3/\text{s}$ into a tank of water at 20°C (i) find the buoyancy of the discharge at the source (ii) Estimate the buoyancy flux after the jet is diluted 100 times by entrainment of the ambient colder water into the jet. Assume seawater density at 40°C - 992.2204 kg/m^3 ; seawater density at 20°C - 998.2063 kg/m^3 . Assume any data if needed.

6+10+9=25

6. (a) What is Integral Transform (IT)? Classify different types of IT. Differentiate between Laplace Transform & Fourier Transform.

(b) Solve Inverse Transforms of

$$\sin 2t \sin 3t \quad ; \quad \sin^3 2t$$

(c) State the difference between ordinary differential equation & partial differential equation.

(d) The bullet train zips from one station to another (both at approx 36°N) at a speed of 180 km/hr . In the design of the train and tracks, what is the value of the coriolis acceleration and the tilt of the net acceleration? Assume rotation rate = $7.229 \times 10^{-5}\text{ /s}$

7+8+3+7=25