Ex/PG/DB/SWRE/03/2024

M.E. WATER RESOURCES AND HYDRAULIC ENGG.(EVENING) FIRST YEAR SECOND SEMESTER - 2024
GEOPHYSICAL FLUID DYNAMICS

Time : Three Hours | Full Marks : 100

Answer any ***four*** questions.

1. (a) Define ambient rotation, rate, ambient rotation, rotation also stratification scale which effects in Geophysical Fluid Dynamics.
   (b) On Jupiter, a day lasts 9.7 earth hours and the equatorial circumference is 450,600 km. Knowing that the measured gravitational acceleration of the equator is 27.6 m/s^2, deduce the true gravitational acceleration and the centrifugal acceleration.
   (c) Prove the relationship between length (L) and height (H) on a planet rotating at rate Ω with density as an importance in Geophysical Fluid Dynamics.

   8+10+7 =25

2. (a) Derive the Nyquist frequency and Cut-off frequency considering two velocities (u and v) for lower and higher frequency with a phase angle (φ) and time interval (Δt) during collection of sampling for two signals.
   (b) Establish the equation of second-order finite difference approximation of the first derivative is to be $2\Delta t$ plus the second order truncation error.
   (c) The bullet train zips from one station to another (both at approx 36^0N) at a speed of 160 km/hr. In the design of the train and tracks, what is the value of the tilt of the net acceleration? Assume rotation rate = 7.2×10^{-5} /s

   10+10+5=25

3. (a) Derive the relationship between Coriolis acceleration, Centrifugal acceleration and absolute acceleration for a 3-Dimensional rotating Planet.
   (b) A laboratory experiment is conducted in a cylindrical tank 30 cm diameter filled with homogenous mixture of water with a maximum velocity of 2 cm^2/s for rotating frame of 40 rpm having 20 cm deep at the centre at a steady state condition by a source-sink device. Find out the temporal Rossby Number, Rossby Number and Ekman Number. Assume viscosity of water at 20^0C. 15+10=25

4. (a) Prove that the expressions for wave length (L) and wave celerity (C) as a function of wave period (T) and water depth (h) using the first principle for wave potential 'φ' with some assumptions for intermediate waves

$$C - \sqrt{\frac{gL}{2\pi}\tanh\left(\frac{2\pi}{L}.h\right)}$$

$$L = \frac{gT^2}{2\pi}\tanh\left(\frac{2\pi}{L}.h\right)$$

[Turn over

(b) Find out the total pressure (in Pa) considering linear wave theory from the first principle of wave potential 'φ' having wave length (200 km) and wave height (50 m) as a function of wave period (1 hr) and water depth (4 km) with horizontal distance 350 m and vertical distance 500 m. Assume atmospheric pressure 101 kPa and density of sea water 1100 kg/m^3.

18+7=25

5. (a) Write two different equation of maximum center line velocity and maximum contaminant concentration for both 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^{0}C warm water @ 1 cm^2/s for 2 m length into a tank of water at 20^{0}C. Estimate the buoyancy flux after the jet is diluted 120 times by entrainment of the ambient colder water into the jet. Assume seawater density at 40^{0}C-992 kg/m^3; seawater density at 20^{0}C- 998 kg/m^3. Assume any data if needed.

5+10+10=25

6. (a) Briefly describe the different applications of GFD.

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

6+19=25