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

(Evening), 2018

(First Year-2nd Semester)

GEOPHYSICAL FLUID DYNAMICS

Time : Three Hours Full Marks : 100

Answer any ***four*** questions.

1. (a) Define Geophysical Fluid Dynamics. Explain how you justify "Importance of Rotation" and "Importance of Stratification" which effects in Geophysical Fluid Dynamics.
   (b) On Jupiter, a day lasts 9.9 earth hours and the equatorial circumference is 448,600 km. Knowing that the measured gravitational acceleration of the equator is 28.4 m/s^2, deduce the true gravitational acceleration and the centrifugal acceleration.
   3+14+8 =25

2. (a) What is Integral Transform (IT)? Classify different types of IT. Differentiate between Laplace Transform & Fourier Transform.
   (b) Solve Inverse Transform

$$\frac{S^2 - 3S + 4}{S^3} \qquad \frac{S + 2}{S^2 - 4S + 13}$$

   (c) State the difference between ODE & PDE.
   (d) The bullet train zips from one station to another (both at approx 35^0N) at a speed of 195 km/hr. In the design of the train and tracks, do you think that engineers had to worry about earth's rotation? 7+8+3+7=25

3. (a) State the scale analysis of forward and backward difference of second 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 $4\Delta t$.

   (c) Using scaling, compare the dynamic pressure induced by a stream (speed=1 m/s) width 40 km and depth 500 m with the main hydrostatic pressure due to the weight of the water depth. Also convert dynamic pressure scale to its equivalent height of hydrostatic pressure head. What can you infer about the possibility of measuring oceanic dynamic pressure by pressure gauge?
   7+9+3+6=25

4. (a) What is Coriolis Force?
   (b) Prove that the absolute velocity is proportional to the relative velocity and entraining velocity due to the rotation of the reference framework in case of 2-D rotating frame.

(c) Prove that the Coriolis acceleration is proportional to angular rate and relative velocity in case of 2-D rotating frame.

(d) A laboratory tank consists of a cylindrical container 30 cm in diameter, filled while at rest with 20 cm of fresh water and then spun at 30 rpm. After a state of solid-body rotation is achieved, what is the difference in water level between the rim & the centre? How this difference does compares with the minimum depth at the centre?

5+8+5+7=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) 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 plane jet at that location.
(c) A buoyant jet is produced in the laboratory by discharging 40^0C warm water @ 3.5 cm^3/s into a tank of water at 20^0C. (i) find the buoyancy of the discharge at the source (ii) 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 40^0C-992.2 kg/m^3; seawater density at 20^0C- 998.2 kg/m^3. Assume any data if needed.

7+9+9=25