ME, MCE

Reg. No. : | | | | | | | | | | | |

H 2101

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2009.

Third Semester

Mechanical Engineering

CE 253 — FLUID MECHANICS AND MACHINERY

(Common to Mechatronics Engineering)

Time : Three hours — Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Distinguish between 'mass density' and 'weight density'.
2. Define compressibility of a fluid.
3. State atleast two assumptions in Bernoulli's equation.
4. Differentiate between 'hydraulic gradient line' and 'energy gradient line'.
5. Define :
   (a) Euler number
   (b) Mach number.
6. Define 'specific speed' as applied to pumps.
7. What is an 'indicator diagram"?
8. Distinguish between 'major' and 'minor' losses with reference to flow through pipes.
9. State the 'momentum equation'. When can it be applied?
10. State the advantages of fitting air vessels in a reciprocating pump.

PART B — ($5 \times 16 = 80$ marks)

11. (a) (i) The space between two parallel plates 5 mm apart, is filled with crude oil of specific gravity 0.9. A force of 2 N is required to drag the upper plate at a constant velocity of 0.8 m/s. The lower plate is stationary. The area of the upper plate is 0.09 m^2. Determine. (1) The dynamic viscosity in prise and (2) Kinematic viscosity of the oil in stokes. (10)

(ii) Determine the bulk modulus of elasticity of a liquid, if, the pressure of the liquid is increased from 7 MN/m^2 to 13 MN/m^2, the volume of liquid decreases by 0.15%. (6)

Or

(b) (i) The velocity components in a three dimensional fluid flow are :

$u = x^2 + y^2 z^3 ; v = -(xy + yz + zx)$.

Determine the missing component of velocity such that the continuity equation is satisfied. (6)

(ii) Derive from first principles, the Euler's equation of motion for a steady flow along a stream line. Hence derive Bernoulli's equation. State the various assumptions involved in the above derivation. (10)

12. (a) (i) A uniform circular tube of bore radius R_1 has a fixed co-axial cylindrical solid core of radius R_2. An incompressible viscous fluid flows through the annular passage under a pressure gradient $\left(\frac{-\partial p}{\partial x}\right)$. Determine the radius at which shear stress in the stream is zero, given that the flow is laminar and under steady state condition. (6)

(ii) An existing 300 mm diameter pipeline of 3200 m length connects two reservoirs having 13 m difference in their water levels. Calculate the discharge Q_1. If a parallel pipe 300 mm in diameter is attached to the last 1600 m length of the above existing pipeline, find the new discharge Q_2. What is the change in discharge? Express it as a percentage of Q_1. Assume friction factor $(f) = 0.04$ in Dancy - Weisbach formula. (10)

Or

(b) (i) Define the term 'boundary layer'. (4)

(ii) Define 'miner losses'. How they are different from 'major losses'? (4)

(iii) The discharge of water through a horizontal pipe is 0.25 m³/s. The diameter of above pipe which is 200 mm, suddenly enlarges to 400 mm at a point. If the pressure of water in the smaller diameter of pipe is 120 kN/m², determine : loss of head due to sudden enlargement; pressure of water in the larger pipe and the power lost due to sudden enlargement. (8)

13. (a) (i) State Buckingham-π theorem. Mention the important principle for selecting the repeating variables. (6)

(ii) The resistance R, to the motion of a completely submerged body depends upon the length of the body (L), velocity of flow (V), mass density of fluid (ρ), Kinematic viscosity of fluid (γ). Prove by dimensional analysis that

$$R = \rho V^2 L^2 \phi\left(\frac{VL}{\gamma}\right).$$ (10)

Or

(b) (i) What is meant by geometric, kinematic and dynamic similarities? Are these similarities truly attainable? If not, why? (8)

(ii) In order to predict the pressure drop in a large air duct a model is constructed with linear dimension $\left(\frac{1}{10}\right)^{th}$ that of the prototype and that water was used as the testing fluid. If water is 1000 times denser than that of air and has 100 times the viscosity of air, determine the pressure drop in the prototype, for the conditions corresponding to a pressure drop of 70 kPa, in the model. (8)

14. (a) (i) Enumerate the losses that occur during the operation of a centrifugal pump. (6)

(ii) A centrifugal pump with 1.2 m diameter, runs at 200 rpm and discharges 1880 litres/s, against an average lift of 6 m. The angle which the vanes make at exit with the tangent to the impeller is 26° and the radial velocity of flow is 2.5 m/s. Find the manometric efficiency and the least speed to start the pump against the head of 6 m. Assume the inner diameter of the impeller as 0.6 m. (10)

Or

(b) (i) How is a 'specific speed' of a turbine, defined? (4)

(ii) A Francis turbine with an overall efficiency of 75% is required to produce 149.26 kN. It is working against a head of 7.62 m. The peripheral velocity is $0.26\sqrt{2gH}$ and the radial velocity of flow at inlet is $0.96\sqrt{2gH}$. The wheel runs at 150 rpm and the hydraulic losses in the turbine account for 22% of the available energy. Assume radial discharge, determine : the guide blade angle, the wheel vane angle at inlet, diameter of the wheel at inlet and width of the wheel at inlet. (12)

15. (a) (i) Define : slop, percentage slip and negative slop with respect to a reciprocating pump. (6)

(ii) The diameter and length of stroke of a single acting reciprocating pump are 100 mm and 200 mm respectively. The pump is used to deliver water to a tank 14 m above the pump through a pipe 30 mm in diameter and 18 m long by taking its supply from a sump 4 m below the pump, through a pipe 40 mm in diameter and 6 m long. If separation occurs at 78.48 kN/m^2, below the atmospheric pressure find the maximum speed at which the pump can be operated without separation. Assume 1 atm pressure = 10.3 m of water column and the plunger undergoes simple harmonic motion. (10)

Or

(b) (i) Prove that work done by the pump is proportional to the area of indicator diagram. (6)

(ii) The plunger diameter and stroke length of a single-acting reciprocating pump are 300 mm and 500 mm, respectively. The speed of the pump is 60 rpm. The diameter and length of delivery pipe are 150 mm and 60 m respectively. If the pump is equipped with an air vessel on the delivery side at the centre lone of the pump, find the power saved in overcoming friction in the delivery pipe. Assume Darcy's friction factor as 0.04, and the plunger undergoes a simple harmonic motion. (10)
