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B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017

Third/Fourth Semester

Mechanical Engineering

CE 6451 – FLUID MECHANICS AND MACHINERY

(Regulations 2013)

(Common to Aeronautical Engineering/Automobile Engineering/Industrial Engineering/Industrial Engineering and Management/Manufacturing Engineering/ Mechanical and Automation Engineering/Mechatronics Engineering/Production Engineering)

Time : Three Hours Maximum : 100 Marks

Any missing data can be suitably assumed.

Answer ALL questions.

PART – A (10×2=20 Marks)

1. Brief on the consequences of Pascal's Law.
2. Differentiate between steady and unsteady flow.
3. State significance of Navier-Stokes equation.
4. What is meant by roughness Reynolds number ?
5. A piping system involves two pipes of different diameters (but of identical length, material and roughness) connected in parallel. How would you compare the flow rates and pressure drops in these two pipes ?
6. The excess pressure Δp inside a bubble is known to be a function of the surface tension and the radius. By dimensional reasoning determine how the excess pressure will vary if we double the surface tension and the radius.
7. Define Net Positive Suction Head.
8. Draw the outlet velocity triangle for a forward curved centrifugal pump.
9. What is the need for draft tube ?
10. Discuss the importance of Muschel curves.

PART – B (5×13=65 Marks)

11. a) A 'U' tube manometer is used to measure water in a pipeline which is in excess of atmosphere pressure. The right limb of the manometer contains mercury and is open to atmosphere. The contact between water and mercury is in the left limb. Calculate the pressure of water in the mainline if the difference in level of mercury in the limbs is 10.5 cm and the free surface of mercury is in level with centre of pipe. If the pressure of water in the pipeline is reduced by (i) 10000 N/m^2 and (ii) 12000 N/m^2 find the new difference if level of mercury.

(OR)

b) In a vertical pipe carrying water, pressure gauges are inserted at points X and Y where the pipe diameters are 0.2 m and 0.1 m respectively. The point Y is 2.25 m below X and when the flow rate down the pipe is 0.025 m^3/s, the pressure at Y is 15686 N/m^2 greater than that at X. Assuming the losses in the pipe between X and Y can be expressed as $k\frac{v^2}{2g}$ where v is the velocity at X, find the value of k.

If the gauges at X and Y are replaced by tubes filled with water and connected to a U-tube containing mercury of relative density 13.6, calculate difference in the levels in the two limbs of the U-tube.

12. a) Water at 10° C ($\rho = 999.7\ kg/m^3$ and $\mu = 1.307\times 10^{-3}\ kg/m.s$) is flowing steadily in a 0.20 cm-diameter, 15 m long pipe at an average velocity of 1.2 m/s. Determine the pressure drop, the head loss and the pumping power requirement to overcome this pressure drop. If the velocity is increased by two times find the above parameters.

(OR)

b) Water flowing through an 10 cm diameter pipe enters a porous section of same diameter which allows a uniform radial velocity v_w through the wall surfaces for a distance of 2 m. (i) If the entrance average velocity V_1 is 12 m/s, find the exit velocity V_2 if v_w = 15 cm/s out of the pipe walls; v_w = 10 cm/s into the pipe. What value of v_w will make V_2 = 9 m/s ? (ii) If the entrance average velocity V_1 is 18 m/s, find the exit velocity V_2 if v_w = 18 cm/s out of the pipe walls; v_w = 12 cm/s into the pipe. What value of v_w will make V_2 = 12 m/s ?

13. a) Consider flow over a very small object in a viscous fluid. Analysis of the equations of motion shows that the inertial terms are much smaller than the viscous and pressure terms. It turns out, then that fluid density drops out of the equations of motion. The only important parameters in the problem are the velocity of motion U, the viscosity of the fluid μ and the length scale of the body. Using the Buckingham pi theorem, generate an expression for the two-dimensional drag $D_{2\text{-}D}$ as a function of the other parameters in the problem. Use cylinder diameter d as the appropriate length scale. Repeat the dimensional analysis with ρ included as a parameter. Find the non dimensional relationship between the parameters in this problem.

(OR)

b) Vortex shedding at the rear of a structure of a given section can create harmful periodic vibration. To predict the shedding frequency, a smaller model is to be tested in a water tunnel. The air speed is expected to be about 90 kmph. If the geometric scale is 1:6.8 and the water temperature is 28° C determine the speed to be used in the tunnel. Consider air temperature as 40° C. If the shedding frequency of the model was 60 Hz, determine the shedding frequency of the prototype. The dimensions of the structure are diameter 0.2 m and height 0.4 m.

14. a) The dimensionless specific speed of a centrifugal pump is 0.06. Static head is 30 m. Flow rate is 50 lit/s. The suction and delivery pipes are each of 15 cm diameter. The friction factor is 0.02. Total length is 55 m and other losses equal 4 times the velocity head in the pipe. The vanes are forward curved at 120°. The width is one tenth of the diameter. There is a 6% reduction in flow area due to the blade thickness. The manometric efficiency is 80%. Determine the impeller diameter if inlet is radial.

(OR)

b) A centrifugal pump delivers 50 lit/s when running at 1500 rpm. The inner and outer diameters are 0.15 m and 0.25 m respectively. The blades are curved at 30° to the tangent at the outlet. The flow velocity is 2.5 m/s and is constant. The suction and delivery pipe diameters are 15 cm and 10 cm, respectively. The pressure head at suction is 4 m below atmosphere. The pressure at the delivery is 18 m above atmosphere. The power required was 18 kW. Determine the vane angle at inlet for zero whirl at inlet. Also find the manometric efficiency and overall efficiency.

15. a) A Francis turbine works under a head of 100 m, the flow rate being 6 m^3/s. The flow velocity remains constant at 18 m/s. The blade inlet is at 90°. The width of the runner at inlet is 0.16 times the diameter and the inner diameter is 0.6 times the outer diameter. Determine the runner diameter and hydraulic efficiency. Also calculate the guide blade and runner outlet angles. Assume zero whirl at exit. Assume that blade thickness reduces the flow area by 10%. If the flow rate is 12 m^3/s, estimate the above parameters.

(OR)

b) A Kaplan turbine runner hub and tip diameters are 2.5 m and 5 m respectively. When running at 150 rpm under a head of 30 m, it develops 30 MW. The overall efficiency is 85% and hydraulic efficiency is 90%. Determine the runner blade angles at inlet and outlet both at the tip and the hub. Assume zero whirl at exit and the product of whirl and tip speed is constant at all diameters.

PART – C (1×15=15 Marks)

16. a) A centrifugal pump delivers water at 0.075m^3/s with a head of 20 m while operating at 880 rpm. The hub-to-shroud radius ratio at the inlet is 0.35 and the relative velocity makes an angle of –52° at the inlet, (i) Find the reversible work done by the pump, (ii) What is the work done by the impeller ? (iii) Find the impeller radius and the inlet radius of the shroud, (iv) Determine the blade width at the exit of the impeller, (v) Assume a reasonable number of blades, and calculate the blade angle at the exit. Use the Pfleiderer equation to determine more accurately the number of blades and recalculate the blade angle at the exit if needed, (vi) What is the power required to drive the pump ?

(OR)

b) Water is to be supplied to the Pelton wheel of a hydroelectric power plant by a pipe of uniform diameter, 400 m long, from a reservoir whose surface is 200 m vertically above the nozzles. The required volume flow of water to the Pelton wheel is 30 m^3/s. If the pipe skin friction loss is not to exceed 10% of the available head and f = 0:0075, determine the minimum pipe diameter. You are required to select a suitable pipe diameter from the available range of stock sizes to satisfy the criteria given. The range of diameters (m) available are : 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8. For the diameter you have selected, determine : (i) the friction head loss in the pipe; (ii) the nozzle exit velocity assuming no friction losses occur in the nozzle and the water leaves the nozzle at atmospheric pressure; (iii) the total power developed by the turbine assuming that its efficiency is 75% based upon the energy available at turbine inlet.
