KATHMANDU UNIVERSITY
End Semester Examination [C]
December, 2024

Marks Scored:

Level : B.E.
Year : III

Course : MEEG 303
Semester : I

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date : 18 DEC 2024

SECTION "A"
[20 Q. × 1 = 20 marks]

Choose the most appropriate answer and ***mark [X]****.*

1. Stagnation point is the point in fluid mechanics where the velocity of the fluid at that point is _____
   [ ] Infinite [ ] Constant [ ] Maximum [ ] Zero

2. Which of the following is a formula for the friction factor of circular pipes?
   [ ] Re/64 [ ] 16/Re [ ] 64/Re [ ] Re/16

3. If the mechanical efficiency of a centrifugal pump is 68% and the manometric efficiency is 74%, what is the overall efficiency of the pump?
   [ ] 0.5032% [ ] 50.32% [ ] 83.2% [ ] 0.832%

4. The imaginary line drawn in the fluid in such a way that the tangent to any point gives the direction of motion at that point, is known as
   [ ] Path line [ ] Stream line [ ] Streak line [ ] Potential line

5. The pitot tube is used to measure
   [ ] Velocity at stagnation point [ ] Stagnation pressure
   [ ] Static pressure [ ] Dynamic pressure

6. An open tank contains 1 m deep water with 50 cm depth of oil of specific gravity 0.8 above it. The pressure at the bottom of the tank will be
   [ ] 4 kN/m^2 [ ] 10 kN/m^2 [ ] 12 kN/m^2 [ ] 14 kN/m^2

7. A fluid particle is rotating at a speed of 12 rad/s. What is the vorticity of this particle?
   [ ] 12 rad/s [ ] 24 rad/s [ ] 48 rad/s [ ] 6 rad/s

8. Which of the following parameter has the unit of force per unit length
   [ ] Dynamic viscosity [ ] Kinematic viscosity
   [ ] Surface tension [ ] Wall stress

9. The major loss of energy in long pipes is due to
   [ ] Sudden enlargement [ ] Sudden contraction
   [ ] 90 degree bend [ ] Friction

10. An open tank contains 1 m deep water with 50 cm depth of oil of specific gravity 0.8 above it. The pressure at the bottom of the tank will be
    [ ] 4 kN/m^2 [ ] 10 kN/m^2 [ ] 12 kN/m^2 [ ] 14 kN/m^2

11. Stream lines and path lines always coincide in case of
[ ] Steady flow [ ] Laminar flow [ ] Uniform flow [ ] Turbulent flow

12. Equation of continuity is based on the principal of conservation of
[ ] Mass [ ] Energy [ ] Momentum [ ] None of the above

13. In series-pipe problems
[ ] the head loss is same through each pipe
[ ] the discharge is same through each pipe
[ ] the discharge through each pipe is added to obtain total discharge
[ ] none of the above

14. In the case of an external parallel flow over a flat plat, which of the following drag can be neglected?
[ ] Pressure drag [ ] Friction drag
[ ] Total drag [ ] Both drags are significant

15. The gage pressure in a pipe is measured by a manometer containing mercury ($\rho = 13{,}600$ kg/m^3). The top of the mercury is open to the atmosphere and the atmospheric pressure is 100 kPa. If the mercury column height is 24 cm, the gage pressure in the pipe is:
[ ] 32 kPa [ ] 24 kPa [ ] 76 kPa [ ] 68 kPa

16. For laminar flow in a pipe of circular cross section, the Darcy's friction factor f is
[ ] directly proportional to Reynolds number and independent of pipe wall roughness
[ ] directly proportional to pipe wall roughness and independent of Reynolds number
[ ] inversely proportional to Reynolds number and independent of pipe wall roughness
[ ] inversely proportional to pipe wall roughness and independent of Reynolds number

17. Irrotational flow is characterized by one in which
[ ] fluid flows along a straight line
[ ] fluid does not rotate as it moves along
[ ] net rotation of fluid particles about their mass centers remains zero
[ ] streamlines of flow are curved and closely spaced

18. In a hydropower plant, the difference between the free surfaces in the headrace and tailrace is 100 m. However, 15 m of head is lost due to the friction in the piping. If the water supplied to the turbine is at the rate of 160 kg/s, and the efficiency of the turbine is 82%, determine the shaft power output from the turbine.
[ ] 109 kW [ ] 113 kW [ ] 118 kW [ ] 126 kW

19. In a Francis turbine, the guide vanes are used to:
[ ] Control the flow rate
[ ] Increase the pressure of the water
[ ] Reduce the pressure of the water
[ ] Convert hydraulic energy into mechanical energy

20. Property of a fluid by which molecules of different kinds of fluid are attracted to each other is called
[ ] adhesion [ ] cohesion [ ] surface tension [ ] viscosity

KATHMANDU UNIVERSITY
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Level : B.E. | Course : MEEG 303
Year : III | Semester : I
Time : 2 hrs. 30mins. | 18 DEC 2024 | F. M. : 55

SECTION "B"
[5 Q. × 11 = 55 marks]

Attempt ALL questions. Assume suitable data if any is missing (Required data sheets are included)

1.

a. Define Lagrangian and Eulerian description of the flow. Explain how Reynold's Transpart Theorem is useful for relating these two descriptions. [5]

b. A 0.6 mm diameter glass tube is inserted into water at 20°C in a cup. Determine the capillary rise of water in the tube by equating the vertical component of the surface tension force to the weight of the liquid column. The surface tension of water is 0.073 N/m and the contact angle of water with glass is approximately 0°. [3]

c. Consider the flow of a fluid with viscosity μ through a circular pipe. The velocity profile in the pipe is given as

$$u(r) = u_{max}\left(1 - \frac{r^n}{R^n}\right)$$

Where u_{max} is the maximum flow velocity, which occurs at the centerline; r is the radial distance from the centerline; and $u(r)$ is the flow velocity at any position r. Develop a relation for the drag force exerted on the pipe wall by the fluid in the flow direction per unit length of the pipe. [3]

2.

a. The resultant of the pressure and wall shear forces acting on a body is measured to be 580 N, making 35^0 with the direction of the flow. Determine the drag and the lift forces acting on the body. [3]

b. Explain velocity triangles with figures and mathematical relation between different velocity components. [3]

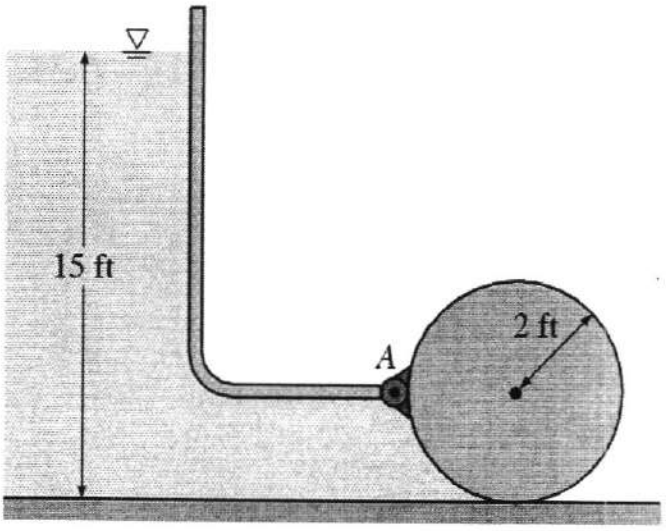
c. Draw a sectional view of Francis turbines and indicate the following components: [5]
   i. Spiral casing
   ii. Guide vane
   iii. Stay vane
   iv. Runner
   v. Draft tube

3.

a. List the different pressure measurement devices for fluid and discuss the principle of any three of them briefly. [5]

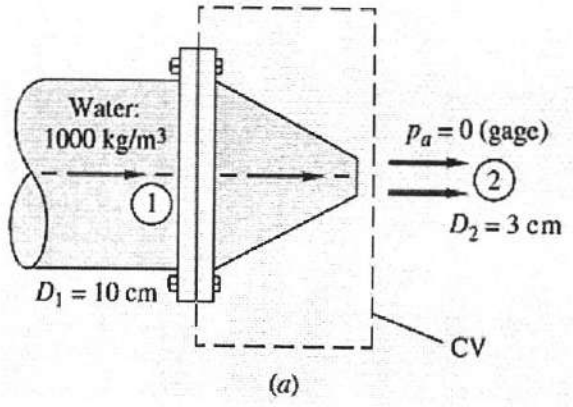
P.T.O.

b. A long, solid cylinder of radius 2 ft hinged at point A is used as an automatic gate, as shown in Figure. When the water level reaches 15 ft, the cylindrical gate opens by turbine about the hinge at point A. Determine a) the hydrostatic force acting on the cylinder and its line of action when the gate opens and b) the weight of the cylinder per ft length of the cylinder. [6]

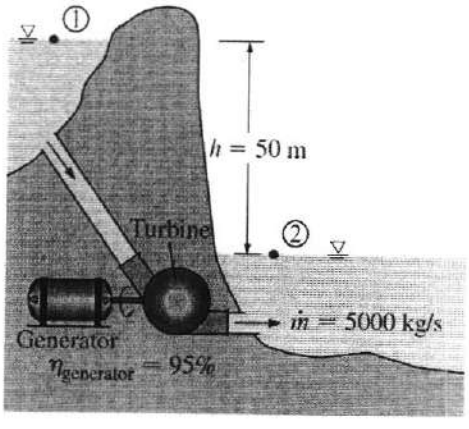


4.

a. A 10 cm fire hose with a 3 cm nozzle discharges 1.5 m^3/min to the atmosphere. Assuming frictionless flow, find the force F_B exerted by the flange bolts to hold the nozzle on the hose. [6]



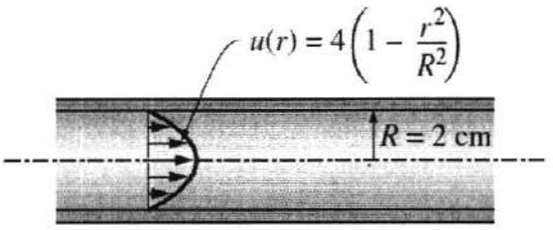
i. The water in a large lake is to be used to generate electricity by the installation of a hydraulic turbine–generator. The elevation difference between the free surfaces upstream and downstream of the dam is 50 m. Water is to be supplied at a rate of 5000 kg/s. If the electric power generated is measured to be 1862 kW and the generator efficiency is 95 percent, determine
   a. the overall efficiency of the turbine–generator,
   b. the mechanical efficiency of the turbine, and
   c. the shaft power supplied by the turbine to the generator. [5]



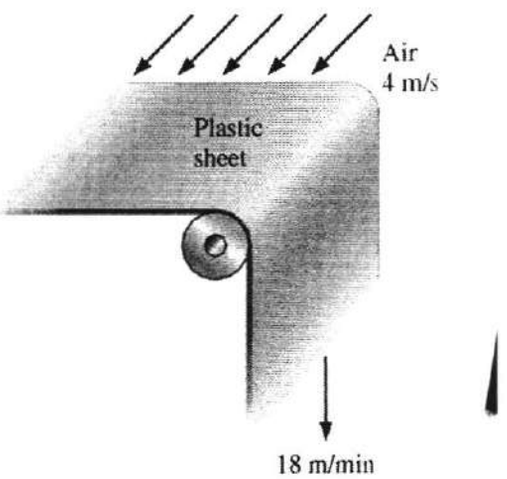
5.

a. Write a short note on tip vortex and a way to reduce the induced drag because of these vortices. [3]

b. The velocity profile in fully developed laminar flow in a circular pipe of inner radius R = 2 cm, in m/s, is given by u(r) = 4 (1 - r^2/R^2). Determine the average and maximum velocities in the pipe and the volume flow rate. [3]



c. The forming section of a plastics plant puts out a continuous sheet of plastic that is 1.2 m wide and 2 mm thick at a rate of 18 m/min. The sheet is subjected to airflow at a velocity of 4 m/s on both top and bottom surfaces normal to the direction of motion of the sheet. The width of the air cooling section is such that a fixed point on the plastic sheet passes through that section in 2 s. Using properties of air at 1 atm and 60°C, determine the drag force the air exerts on the plastic sheet in the direction of airflow. [5]



Relevant equations and charts:

External Flow

Laminar: $\delta = \frac{4.91x}{\mathrm{Re}_x^{1/2}}$ and $C_{f,x} = \frac{0.664}{\mathrm{Re}_x^{1/2}}$, $\mathrm{Re}_x \lesssim 5 \times 10^5$

Turbulent: $\delta = \frac{0.38x}{\mathrm{Re}_x^{1/5}}$ and $C_{f,x} = \frac{0.059}{\mathrm{Re}_x^{1/5}}$, $5 \times 10^5 \lesssim \mathrm{Re}_x \lesssim 10^7$

Laminar: $C_f = \frac{1.33}{\mathrm{Re}_L^{1/2}}$ $\mathrm{Re}_L \lesssim 5 \times 10^5$

Turbulent: $C_f = \frac{0.074}{\mathrm{Re}_L^{1/5}}$ $5 \times 10^5 \lesssim \mathrm{Re}_L \lesssim 10^7$

$$C_f = \frac{0.074}{\mathrm{Re}_L^{1/5}} - \frac{1742}{\mathrm{Re}_L} \qquad 5 \times 10^5 \lesssim \mathrm{Re}_L \lesssim 10^7$$

Fully rough turbulent regime: $C_f = \left(1.89 - 1.62 \log \frac{\varepsilon}{L}\right)^{-2.5}$

TABLE A–9

Properties of air at 1 atm pressure

Temp. T, °C	Density ρ, kg/m³	Specific Heat c_p J/kg·K	Thermal Conductivity k, W/m·K	Thermal Diffusivity α, m²/s	Dynamic Viscosity μ, kg/m·s	Kinematic Viscosity ν, m²/s	Prandtl Number Pr
−150	2.866	983	0.01171	4.158×10^{-6}	8.636×10^{-6}	3.013×10^{-6}	0.7246
−100	2.038	966	0.01582	8.036×10^{-6}	1.189×10^{-6}	5.837×10^{-6}	0.7263
−50	1.582	999	0.01979	1.252×10^{-5}	1.474×10^{-5}	9.319×10^{-6}	0.7440
−40	1.514	1002	0.02057	1.356×10^{-5}	1.527×10^{-5}	1.008×10^{-5}	0.7436
−30	1.451	1004	0.02134	1.465×10^{-5}	1.579×10^{-5}	1.087×10^{-5}	0.7425
−20	1.394	1005	0.02211	1.578×10^{-5}	1.630×10^{-5}	1.169×10^{-5}	0.7408
−10	1.341	1006	0.02288	1.696×10^{-5}	1.680×10^{-5}	1.252×10^{-5}	0.7387
0	1.292	1006	0.02364	$1.81\beta \times 10^{-5}$	1.729×10^{-5}	1.338×10^{-5}	0.7362
5	1.269	1006	0.02401	1.880×10^{-5}	1.754×10^{-5}	1.382×10^{-5}	0.7350
10	1.246	1006	0.02439	1.944×10^{-5}	1.778×10^{-5}	1.426×10^{-5}	0.7336
15	1.225	1007	0.02476	2.009×10^{-5}	1.802×10^{-5}	1.470×10^{-5}	0.7323
20	1.204	1007	0.02514	2.074×10^{-5}	1.825×10^{-5}	1.516×10^{-5}	0.7309
25	1.184	1007	0.02551	2.141×10^{-5}	1.849×10^{-5}	1.562×10^{-5}	0.7296
30	1.164	1007	0.02588	2.208×10^{-5}	1.872×10^{-5}	1.608×10^{-5}	0.7282
35	1.145	1007	0.02625	2.277×10^{-5}	1.895×10^{-5}	1.655×10^{-5}	0.7268
40	1.127	1007	0.02662	2.346×10^{-5}	1.918×10^{-5}	1.702×10^{-5}	0.7255
45	1.109	1007	0.02699	2.416×10^{-5}	1.941×10^{-5}	1.750×10^{-5}	0.7241
50	1.092	1007	0.02735	2.487×10^{-5}	1.963×10^{-5}	1.798×10^{-5}	0.7228
60	1.059	1007	0.02808	2.632×10^{-5}	2.008×10^{-5}	1.896×10^{-5}	0.7202
70	1.028	1007	0.02881	2.780×10^{-5}	2.052×10^{-5}	1.995×10^{-5}	0.7177
80	0.9994	1008	0.02953	2.931×10^{-5}	2.096×10^{-5}	2.097×10^{-5}	0.7154
90	0.9718	1008	0.03024	3.086×10^{-5}	2.139×10^{-5}	2.201×10^{-5}	0.7132
100	0.9458	1009	0.03095	3.243×10^{-5}	2.181×10^{-5}	2.306×10^{-5}	0.7111
120	0.8977	1011	0.03235	3.565×10^{-5}	2.264×10^{-5}	2.522×10^{-5}	0.7073
140	0.8542	1013	0.03374	3.898×10^{-5}	2.345×10^{-5}	2.745×10^{-5}	0.7041
160	0.8148	1016	0.03511	4.241×10^{-5}	2.420×10^{-5}	2.975×10^{-5}	0.7014
180	0.7788	1019	0.03646	4.593×10^{-5}	2.504×10^{-5}	3.212×10^{-5}	0.6992
200	0.7459	1023	0.03779	4.954×10^{-5}	2.577×10^{-5}	3.455×10^{-5}	0.6974
250	0.6746	1033	0.04104	5.890×10^{-5}	2.760×10^{-5}	4.091×10^{-5}	0.6946
300	0.6158	1044	0.04418	6.871×10^{-5}	2.934×10^{-5}	4.765×10^{-5}	0.6935
350	0.5664	1056	0.04721	7.892×10^{-5}	3.101×10^{-5}	5.475×10^{-5}	0.6937
400	0.5243	1069	0.05015	8.951×10^{-5}	3.261×10^{-5}	6.219×10^{-5}	0.6948
450	0.4880	1081	0.05298	1.004×10^{-4}	3.415×10^{-5}	6.997×10^{-5}	0.6965
500	0.4565	1093	0.05572	1.117×10^{-4}	3.563×10^{-5}	7.806×10^{-5}	0.6986
600	0.4042	1115	0.06093	1.352×10^{-4}	3.846×10^{-5}	9.515×10^{-5}	0.7037
700	0.3627	1135	0.06581	1.598×10^{-4}	4.111×10^{-5}	1.133×10^{-4}	0.7092
800	0.3289	1153	0.07037	1.855×10^{-4}	4.362×10^{-5}	1.326×10^{-4}	0.7149
900	0.3008	1169	0.07465	2.122×10^{-4}	4.600×10^{-5}	1.529×10^{-4}	0.7206
1000	0.2772	1184	0.07868	2.398×10^{-4}	4.826×10^{-5}	1.741×10^{-4}	0.7260
1500	0.1990	1234	0.09599	3.908×10^{-4}	5.817×10^{-5}	2.922×10^{-4}	0.7478
2000	0.1553	1264	0.11113	5.664×10^{-4}	6.630×10^{-5}	4.270×10^{-4}	0.7539