APL106
Minor 1

Time: 60+5 minutes
+ 10 minutes uploading

11-11-2020

Name

Entry No.

Please answer all the questions. All bold letters indicate vector quantities. Standard symbols have their usual meanings.
If required use the data as follows: a) ρ_{air} = 1.25 kg/m^3, b)) ρ_{water} = 1000 kg/m^3, c) g = 9.81 m/s^2.

Total 7 pages in Question paper including this page. 1 question on each page from page 2 to page 7.

Maximum Marks
Q1. 9 marks
Q2. 6 marks
Q3. 12 marks
Q4. 6 marks
Q5. 12 marks
Q6. 15 marks

Total 60 marks

All parts of the same question must be answered together.

Please sign the after writing the following statement:

I hereby declare that I have not taken any help from anyone in solving this examination.

_____
(Signature)

Q1. In a 2-D flow field the velocity field is given by

$\mathbf{V} = 4\,\mathbf{i}$ $0 \le t \le 4$ sec

$\mathbf{V} = 4\,\mathbf{i} + 4\,\mathbf{j}$ $4 \le t \le 8$ sec

$\mathbf{V} = 4\,\mathbf{j}$ $8 \le t \le 12$ sec

Qualitatively plot the following showing the origin (0,0) on each graph

a) Streamline passing through (0,0) at t = 2 sec

b) Pathline of a particle which was at (0,0) at t = 0 sec, observed at t = 2 sec.

c) Streakline of particles which are released from origin from time t = 0 onwards, observed at t = 2 sec.

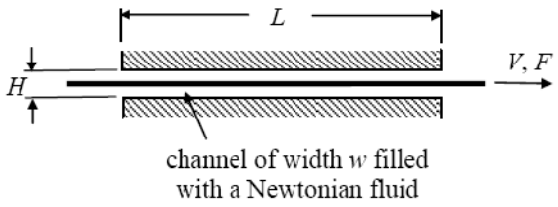
d) Streamline passing through (0,0) at t = 10 sec

e) Pathline of a particle which was at (0,0) at t = 0 sec, observed at t = 10 sec.

f) Streakline of particles which are released from origin from time t = 0 onwards, observed at t = 10 sec.

(1+1+1+1+2+3 marks)

Q2. During a coating process, a thin, flat tape of width *w* is pulled through a channel of length *L* containing a Newtonian fluid of density ρ and dynamic viscosity μ. The fluid is in contact with both sides of the tape. The tape has velocity *V* and the channel has height *H*. You may assume that the tape is much thinner than H and H << *L*.

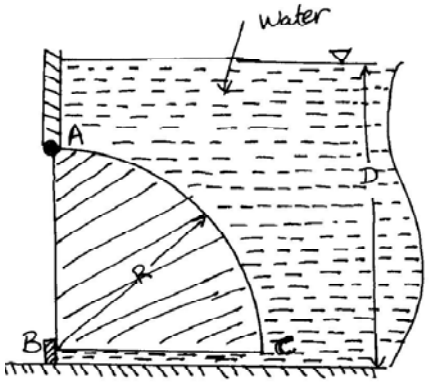


a) Estimate the force F required to pull the tape through the channel.

b) Estimate the power P required for this operation.

(5+1 marks)

Q3. A gate (ABC), in shape of a quarter circle, hinged at A and sealed at B, is 1 m wide. In the given figure the depth of water D = 2m and the radius R = 1m. Determine the force on the stop at B assuming that it acts only in the horizontal direction. Neglect the weight of the gate. Note the layer of water below the horizontal surface of the gate.

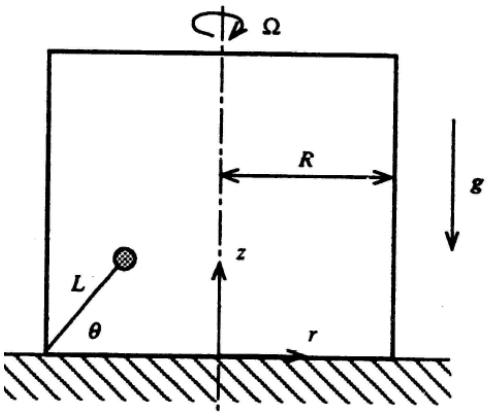


(12 marks)

Q4. A sealed container of radius R, filled with water of density ρ_w , is rotated about its vertical axis at a fixed angular speed of Ω. Avery small spherical cork of radius a << R and density $\rho_c < \rho_w$ is attached by a thread of length L < R to the outer bottom edge of the container as shown. The container, water and cork rotate like a rigid body.

a) Find an expression for ∇p, where p is the pressure inside the container.
b) Estimate the hydrostatic force on the cork.

(6 Marks)

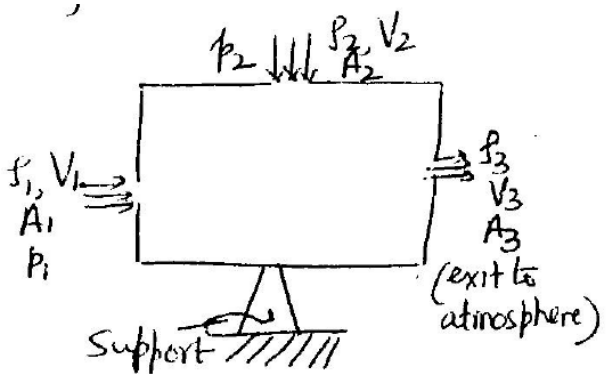


Q5. Consider the chamber shown. Fluid of constant density ρ_1 enters it through section 1 of area A_1 with velocity V_1 and fluid of constant density ρ_2 enters through section 2 of area A_2 with velocity V_2. Assume that the fluids mix thoroughly in the chamber so that the density in the chamber is ρ_3 at all points inside. At section 3 with exit area A_3, the flow exits to atmosphere as a jet with velocity V_3. The gauge pressures at section 1 and 2 are p_1 and p_2 respectively.

(i) Find V_3 and ρ_3 in terms of other variables. (4 marks)

(ii) If the volume of the chamber is V and its empty weight is W find the net force exerted on the support by the chamber. Assume that the pipes at inlet 1 and 2 are flexible so the flow does not exert any force at these sections. (6 marks)

(iii) Is applying Bernoulli's equation between sections 1 and 3 a reasonable approximation? Give reasons (2 marks)



Q6. A paddle wheel of an old saw mill is located in a water stream of width W = 2m. The water driving the mill is supplied by a reservoir whose water surface height is h_0 = 5m above the stream bed. The water is accelerated by passage under a sluice gate approaching the paddle wheel at a depth h_1 = 1m. The flow downstream of the paddle wheel has a depth h_2 = 2m. The flow may be assumed to be inviscid and 1-dimensional everywhere except in a region where the paddle wheel moves in the water where viscous interaction takes place along with mixing. The viscous shear force on the stream bed can be neglected everywhere.

Calculate:

a) the velocity V_1.
b) the velocity V_2.
c) the horizontal force F_x exerted by the flowing stream on the paddle wheel.

(15 marks)