Name: BITS ID:

BITS Pilani, Pilani campus

Mid-semester examination, First semester 2022-2023

MF F218 Transport Phenomena in Manufacturing

Total marks: 30, Weightage: 30%, and Date & Time: 01/11/2022&2:00pm to 3:30 pm.

Instructions

(i) It's an open book examination but the textbook by Welty et al. as per the course handout, class slides, and hand written notes are only permitted.

(ii) Assume any missing data and state the assumptions if any.

Questions

1. The region between two coaxial glass tubes of diameter 5 mm and 6 mm forms a cylindrical annulus. Note that the top and bottom sides of this cylindrical annulus are kept open. Further, the cylindrical annulus is immersed vertically in water kept in an open beaker at 20^oC. Estimate the capillary rise through the cylindrical annulus. Assume the surface tension of water on glass is 72.8 mN/m and contact angle between them is 0^o. [2 marks]

2. Consider the composite wall of constant width 1 m (into the plane of paper) and the lengths and thermal conductivities of individual blocks are as shown in Fig. 1. Assume that the composite wall is of constant height of 10 cm and the concrete and brick blocks are of equal height. Draw the thermal circuit for the wall and identify all four thermal resistances. Determine T_1, T_2in $^oC$and the rate of heat transfer across the composite wall (from left to right), Q in W. [4 marks]

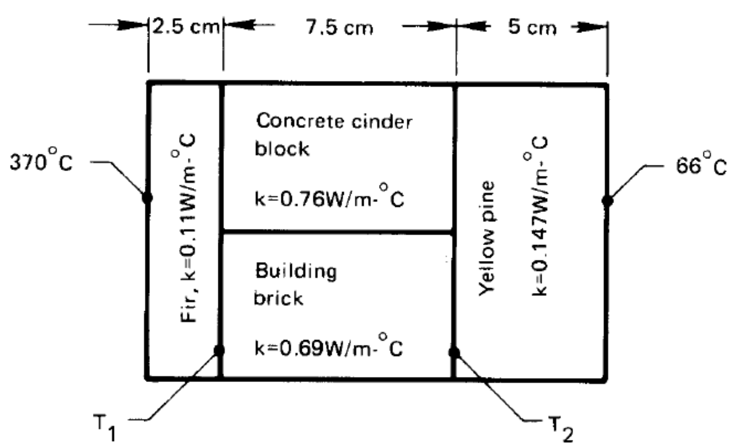

Fig. 1. Problem description for Q2

3. A cone of wood floats in a fluid of specific gravity 0.9 with its apex downwards. If the specific gravity of the wood is 0.6 and the cone weighs 300 N, find the weight of steel ball of specific gravity 7.8 which should be suspended with the help of a string tied to the apex of the cone so as to just submerge it. [5 marks]

4. Consider the two-dimensional flow field defined by the following velocity components: u= x/(1+t), v =y/(1+t). For this flow field, find the equation of (a) The streamline through the point (1, 1) at t = 0, (b) The pathline for a particle released at the point (1, 1) at t = 0, (c) The streakline at t=0 that passes through the point (1, 1). [6 marks].

5. Consider the differential control volume over a steady, isothermal, and 1-D fluid flow as shown in Fig. 2 in gray shades. Reduce the general form of conservation of mass and the momentum equations for the given control volume with adequate explanations. Further, show that: $dp + \rho v dv + \rho \vec{g} dy = 0$. Take constant density and neglect viscous effects. [6 marks]

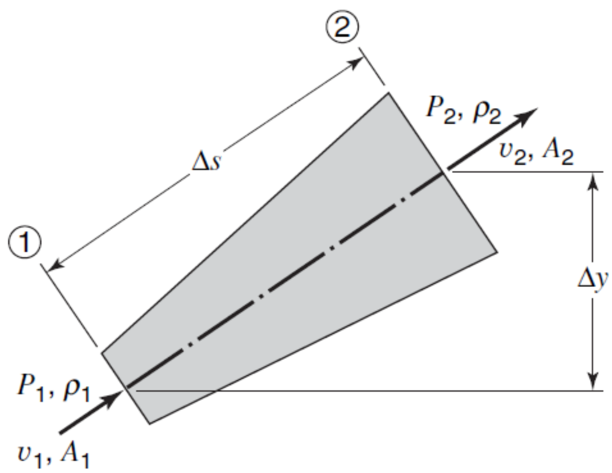

Fig. 2. Problem description for Q5

6. A typical example for planar Couette flow is a flow generated in a fluid confined between two parallel plates of gap H by moving the upper plate at a constant velocity U. In a typical planar Poiseuille flow, the fluid is driven through a long, straight, and rigid channel formed by two parallel plates of gap H, by imposing a pressure difference Δp between the two ends of the channel. Now, consider a combined Poiseuille and Couette flow by applying a pressure difference Δp over a section of length L in the x direction for a planar Couette flow. Draw a neat schematic diagram to describe the flow under consideration. Assuming a steady, incompressible, laminar, and fully developed flow of Newtonian fluid, deduce expressions for the velocity field, the volume flow rate, and wall shear stress from the general forms of governing equations with the help of suitable boundary conditions. [7 marks].