**B.Tech Odd Semester (CBCS) Exam., December—2017**

AGRICULTURAL ENGINEERING

**( 3rd Semester )**

Course No. : AE–301 (C)

**( Fluid Mechanics )**

*Full Marks* : 75
*Pass Marks* : 30

*Time* : 3 hours

*Note* : 1. Answer **one** question from each Unit.
2. Begin each answer in a new page.
3. Answer parts of a question at a place.
4. Assume reasonable data wherever required.
5. The figures in the margin indicate full marks for the questions.

UNIT—1

**1.** *(a)* What is surface tension? What is it caused by? Why is the surface tension also called surface energy? 5





*(b)* A 50 cm×30 cm×20 cm block weighing 150 N is to be moved at a constant velocity of 0·8 m/s on an inclined surface with a friction coefficient of 0·27 as shown in Fig. 1 : 5+5

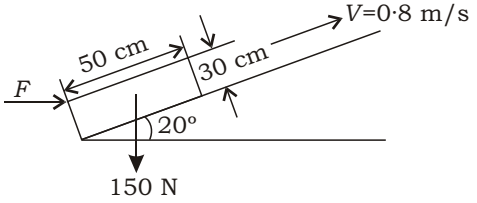


Fig. 1

*(i)* Determine the force $F$ that needs to be applied in the horizontal direction.

*(ii)* If a 0·4 mm thick oil film with a dynamic viscosity of 0·012 Pa-s is applied between the block and inclined surface, determine the percent reduction in the required force.

**2.** *(a)* Derive the only possible dimensionless group which combines velocity $V$, body size $L$, fluid density and surface tension coefficient . 5

*(b)* Derive a relation for the capillary rise of a liquid between two large parallel plates a distance $t$ apart inserted into the liquid vertically. Take the contact angel to be . 10

UNIT—2

**3.** *(a)* What is the difference between gauge pressure and absolute pressure? 5

*(b)* Two chambers with the same fluid at their base are separated by a piston whose weight is 25 N, as shown in Fig. 2. Calculate the gauge pressures in chambers *A* and *B*. 10

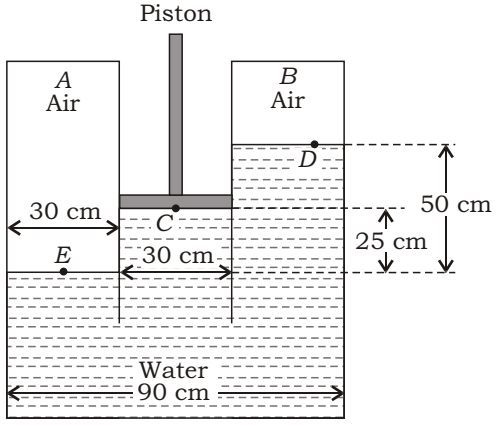


Fig. 2

**4.** *(a)* Derive the expression for resultant hydrostatic force acting on a submerged flat surface, and the center of pressure with the help of a sketch. 7





*(b)* The basic barometer can be used to measure the height of a building. If the barometric readings at the top and at the bottom of a building are 730 mm Hg and 755 mm Hg, respectively, determine the height of the building. Assume an average air density of 1·18 kg/m$^3$. 8

UNIT—3

**5.** *(a)* The water in a 25 m deep reservoir is kept inside by a 150 m wide wall whose cross-section is an equilateral triangle, as shown in Fig. 3. Determine *(i)* the total force (hydrostatic + atmospheric) acting on the inner surface of the wall and its line of action and *(ii)* the magnitude of the horizontal component of this force. Take $P_{atm}$ 100 kPa : 7

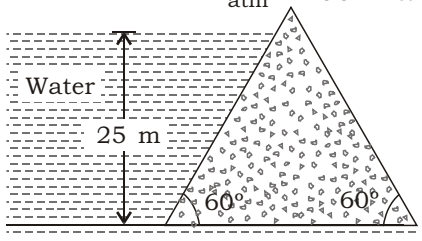


Fig. 3

*(b)* The hull of a boat has a volume of 150 m$^3$, and the total mass of the boat when empty is 8560 kg. Determine how much load this boat can carry without sinking *(i)* in a lake and *(ii)* in seawater with a specific gravity of 1·03. 4+4

**6.** *(a)* What are the Lagrangian and Eulerian descriptions of fluid motion? 5

*(b)* A steady, incompressible, two-dimensional velocity field is given by the following components in the $xy$-plane :

$u$ 1·1 2·8$x$ 0·65$y$, $v$ 0·98 2·1$x$ 2·8$y$

Calculate the acceleration field (find expressions for acceleration components $a_x$ and $a_y$), and calculate the acceleration at the point $(x, y)$ ( 2, 3). 6+4

UNIT—4

**7.** *(a)* Define path line and streak line. What do they indicate? 4+3

*(b)* A cylindrical tank of water rotates in solid-body rotation, counterclockwise about its vertical axis at angular speed $\dot{n}$ 360 rpm as shown in Fig. 4. Calculate the vorticity of fluid particles in the tank : 8

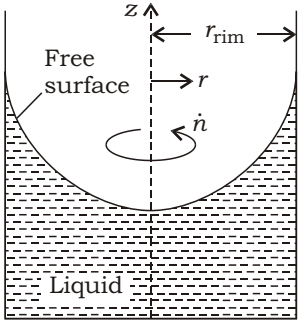


Fig. 4





**8.** *(a)* What is a boundary layer? What causes a boundary layer to develop? 5

*(b)* Consider fully developed two-dimensional Poiseuille flow—flow between two infinite parallel plates separated by distance $h$, with both the top plate and bottom plate stationary, and a forced pressure gradient $dP/dx$ driving the flow as illustrated in Fig 5. ($dP/dx$ is constant and negative). The flow is steady, incompressible and two-dimensional in the $xy$-plane. The velocity components are given by

$$u \quad \frac{1}{2}\frac{dP}{dx}(y^2 \quad hy), \; v \quad 0$$

where is the fluid's viscosity. Is this flow rotational or irrotational? If it is rotational, calculate the vorticity component in the $z$-direction. Do fluid particles in this flow rotate clockwise or counterclockwise? 10

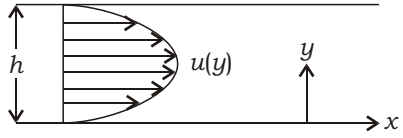


Fig. 5

UNIT—5

**9.** *(a)* Define mass and volume flow rates. How are they related to each other? Does the amount of mass entering a control volume have to be equal to the amount of mass leaving during an unsteady-flow process? 5

*(b)* A desktop computer is to be cooled by a fan whose flow rate is $0{\cdot}34\ m^3/min$. Determine the mass flow rate of air through the fan at an elevation of 3400 m where the air density is $0{\cdot}7\ kg/m^3$. Also, if the average velocity of air is not to exceed 110 m/min, determine the diameter of the casing of the fan. 10

**10.** *(a)* Express the Bernoulli equation in three different ways using *(i)* energies, *(ii)* pressures and *(iii)* heads. 6

*(b)* Water is pumped from a lake to a storage tank 20 m above at a rate of 70 L/s while consuming 20·4 kW of electric power as shown in Fig. 6. Disregarding any frictional losses in the pipes and any changes in kinetic





energy, determine *(i)* the overall efficiency of the pump-motor unit and *(ii)* the pressure difference between the inlet and the exit of the pump : 5+4

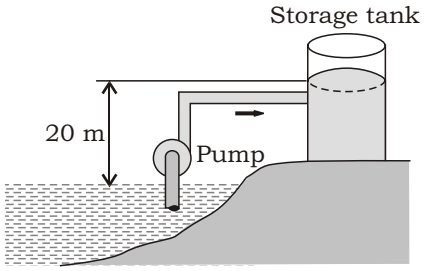


Fig. 6

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