MACHAKOS UNIVERSITY COLLEGE

(A Constituent College of Kenyatta University)
University Examinations 2015/2016

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING AND CIVIL ENGINEERING

SECOND SEMESTER EXAMINATION FOR DEGREE IN BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECV 207: FLUID MECHANICS

Date: 18/4/2016 **Time: 8:30 – 10:30am**

INSTRUCTIONS

- *This paper comprises five questions*
- *Answer question number one and any other two questions*
- *All the optional questions carry equal marks*
- *Candidates to have relevant design manuals*

QUESTION ONE (30 MARKS)

a) Parametric equation for the position of a particle in a flow field are given as

$$x_p = c_1 e^{at} \quad \text{and} \quad y_p = c_2 e^{-bt}.$$

i) Find the equation of the path line for allocation at (x,y)=(1,2) at t=0. (2marks)
ii) Compare with a streamline through the same point. (1mark)

b) A source with strength 0.2m^3/(sm) and a vortex with strength 1m^2/s are located at the origin.
i) Determine the equations for velocity potential and stream function. (1mark)
ii) Calculate the velocity components at x=1m, y= 0.5m (2 marks)

c) Water flows through a 2cm diameter pipe at 1.6m/s.

Calculate:

i) The Reynolds number (2 marks)

ii) The velocity required to give the same Reynolds number when the pipe is transporting air. (2 marks)

(Kinematic viscosity of water is $1.31 \times 10^{-6} m^2/s$, density is $1000 kg/m^3$. And kinematic viscosity of air is $15.1 \times 10^{-6} m^2/s$, density is $1.19 kg/m^3$).

d) Water flows steadily up the vertical *0.1 m* diameter pipe and out the nozzle, which is *0.05 m* in diameter, discharging to atmospheric pressure, as shown in figure 1. The stream velocity at the nozzle exit must be *20 m/s*. Calculate the minimum gauge pressure required at section ①. (4 marks)

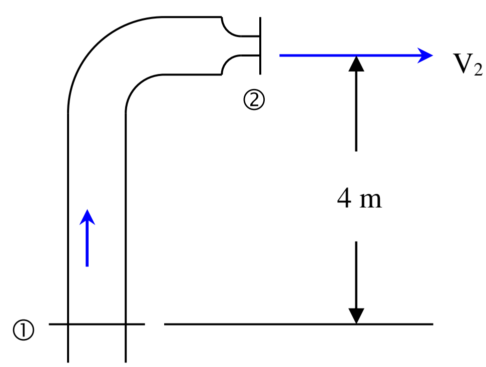

Fig. 1

e) In figure 2, A pump draws water through a 20-cm suction pipe and discharges it through a 10-cm pipe in which the velocity is 3m/s. The 10-cm pipe discharges horizontally into air at point *C*. Calculate height above the water surface at *A* that the water can be raised if 35kW is delivered to the pump. Assume that the pump operates at 60% efficiency and that the head loss in the pipe between *A* and *C* is equal to $2V^2/2g$.Assume α = 1.0 at all locations. (4 marks)

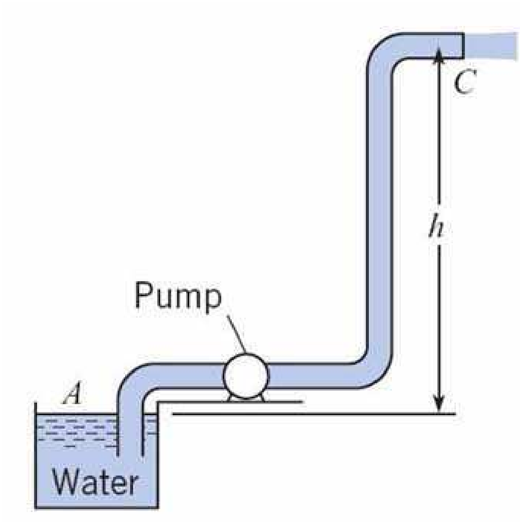

Fig. 2

f) An incompressible fluid flows over a flat with zero pressure gradient. The boundary layer thickness is 1mm at a location where the Reynolds number is 1000. If the velocity of the fluid alone is increased by a factor 4, show that the boundary layer thickness at the same location, is 0.5 mm (4 marks)

g) In figure 3, a reservoir is circular in plan and the sides slope at an angle of $\tan^{-1}(1/5)$ to the horizontal. When the reservoir is full the diameter of the water surface is 50m. Discharge from the reservoir takes place through a pipe of diameter 0.65m, the outlet being 4m below top water level. Determine the time for the water level to fall 2m assuming the discharge to be $0.75a\sqrt{2gH}$ cumecs where *a* is the cross sectional area of the pipe in m^2 and *H* is the head of water above the outlet in meters (4 marks)

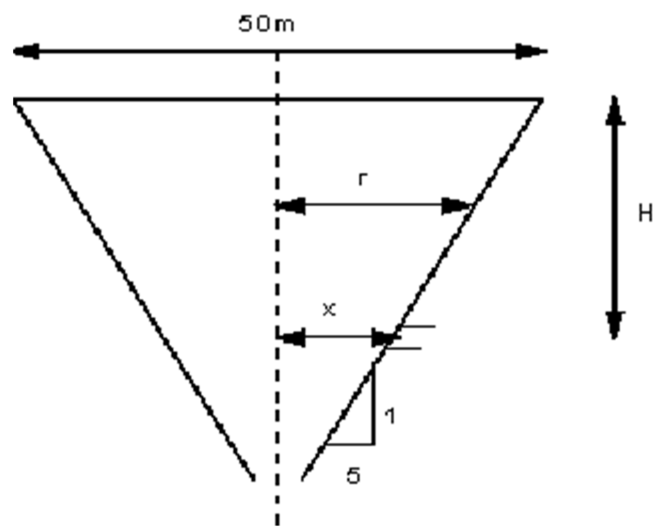

Fig. 3

h) A pump draws water through a 20-cm suction pipe and discharges it through a 10-cm pipe in which the velocity is $3 m/s^2$. The 10-cm pipe discharges horizontally into air at point *C* as shown in figure 4. Calculate height *h* above the water surface at *A* that the water can be raised if 35kW is delivered to the pump. Assume that the pump operates at 60% efficiency and that the head loss in the pipe between *A* and *C* is equal to $2V^2/2g$. Assume $\alpha = 1.0$ at all locations. (4 marks)

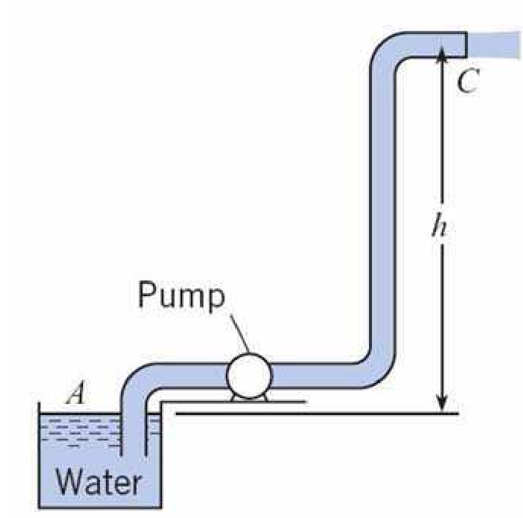

Fig.4

QUESTION TWO (20 MARKS)

An air speed indicator consisting of a converging-diverging duct is shown in Figure 5. The diameter of the duct at 2 is three-quarters of the entrance diameter t 1. The differential pressure gauge records a pressure of 4000Pa, and the density of the air is 1kg/m^3.
(The air flow is steady, incompressible, in viscid and irrotational).
Determine the airspeed U.

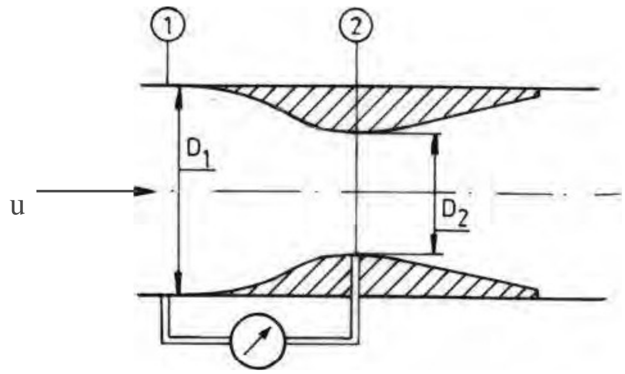

Fig. 5

QUESTION THREE (20 MARKS)

In figure 6, a smooth flat plate with a sharp leading edge is placed along a gas stream flowing at U=10 m/s. The thickness of the boundary layer at section r-s=10 mm, the breadth of the plate is 1m (onto the paper) and the density of the gas $\rho = 1.0\ kg/m^3$. Assume that the boundary layer is thin, two dimensional, and follows a linear velocity distribution, $u = U(y/\delta)$, at the section r-s, where y is the height from plate.

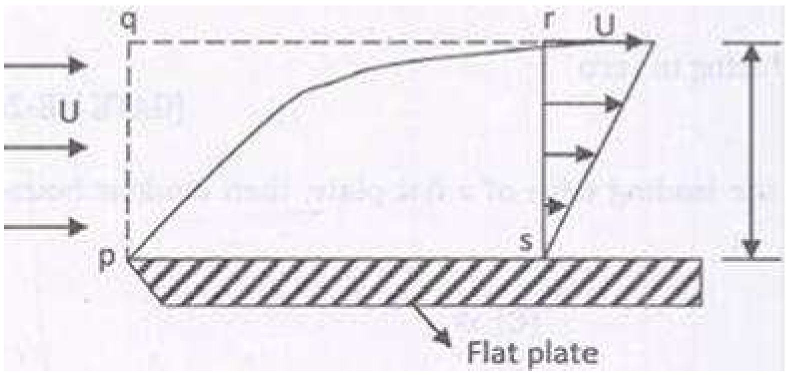

Fig. 6

Show:

i) That the mass flow rate (in kg/s) across the section q-r is 0.05 kg/s (10 marks)

ii) The integrated drag force (in N) on the plate, between p-s, is 0.17 N (10 marks)

QUESTION FOUR (20 MARKS)

In figure 7, d=25cm, D=40cm, and the head loss from the venture meter to the end of the pipe is given by h_L=0.9V^2/2g, where V is the velocity in the pipe. Neglecting all other head losses, determine what head H will first initiate cavitation if the atmospheric pressure is 100k Pa absolute. Calculate the discharge eat incipient cavitation. Assume α=1.0 at all locations.

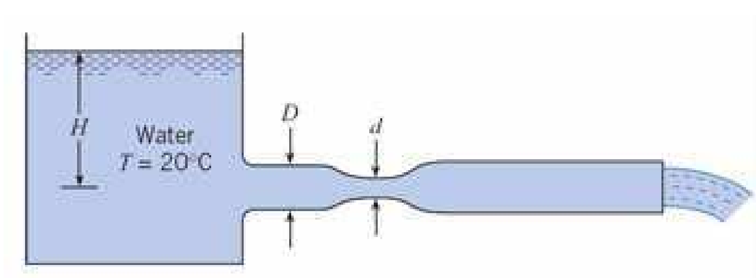

Fig 7

QUESTION FIVE (20 MARKS)

In figure 8, a rectangular swimming pool is 1m deep at one end and increases uniformly in depth to 2.6m at the other end. The pool is 8m wide and 32m long and is emptied through an orifice of area $0.224m^2$, at the lowest point in the side of the deep end. Taking C_d for the orifice as 0.6, find, from first principles,

a) the time for the depth to fall by 1m (10 marks)

b) the time to empty the pool completely. (10 marks)

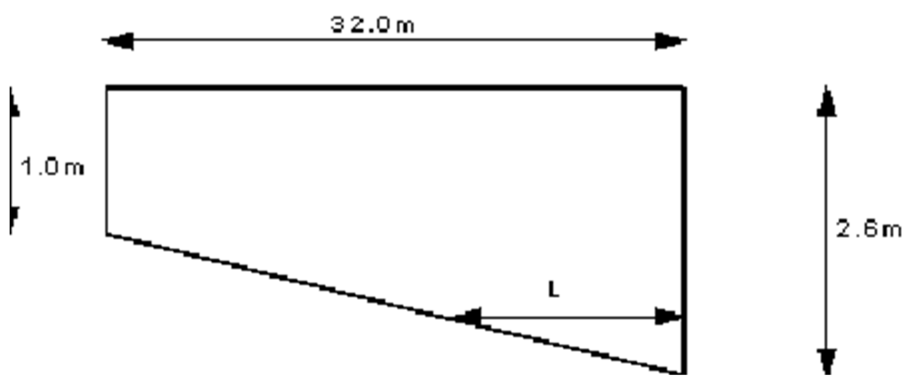

Fig. 8