Mansoura University
Faculty of Engineering
Mech. Power Eng. Dept.

Total 100 Marks
Fluid Mechanic(2)

2^{nd} Year Mech. Eng.
May 2012.
Time: 3 Hrs.

Answer all questions- Assume reasonable values for ungiven data:

1-a) the V-shaped tank in (Fig. 1-a) has width b normal to the paper. How long will it take the water surface to drop from $h = 1$ m to $h = 50$ cm? (12 Marks)

b) A lawn sprinkler is fed from a large reservoir. The water jets are inclined to the circumferential direction by the angle θ. The friction torque of the bearing is M_r.
Where:

$H = 7$ m,	$h = 1$ m,	$R = 0.15$ m,	$d = 7$ mm,
$A_1 = 1.5$ m^2	$\lvert M_r\rvert = 1.6$ N.m,	$p_{atm} = 10^5$ (N/m^2)	$\theta = 30^\circ$

Determine

(i) the number of revolutions,
(ii) the rate of volume flow,
(iii) the pressure p_1 ,
(iv) the maximum angular velocity, if the friction torque is assumed to be zero. (13 Marks)

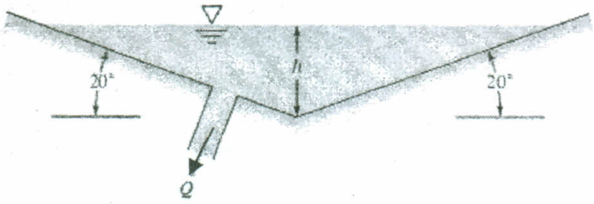


Fig. 1-a

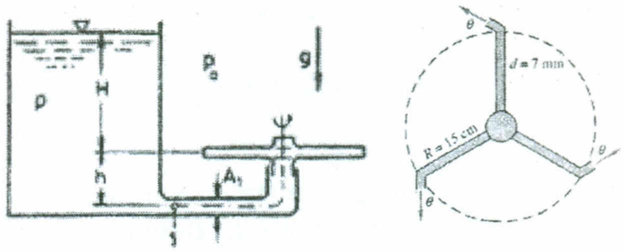


Fig. 1-b

2-a) An idealized velocity field is given by the formula

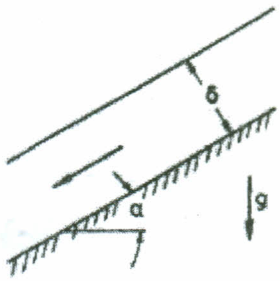
$$\mathbf{V} = 4tx\,\mathbf{i} - 2t^2 y\,\mathbf{j} + 4xz\,\mathbf{k}$$

Is this flow field steady or unsteady? Is it two- or three-dimensional? At the point (x, y, z) = (–1, +1, 0), compute the acceleration vector (5 Marks)

b) An oil film of constant thickness and width flows down on an inclined plate. Solve the Navier-Stokes equation for the velocity profile, then calculate the volume flow rate for the case:

$\delta = 3 \cdot 10^{-3}$ m	B (width) = 1 m	$\alpha = 30^\circ$
$\mu = 30 \cdot 10^{-3}$ Pa.s	$\rho = 800$ kg/m^3,	$g = 10$ m/s^2

(20 Marks)



3-a) The surface of a flat plate is parallel to the direction of a free stream of air.

$u_\infty = 45$ m/s, $\nu = 1.5 \cdot 10^{-5}$ m^2/s

Determine:

i) the transition point for $Re_{crit.} = 5 \cdot 10^5$,

ii) the velocity at the point $x = 0.1$ m, $y = 2 \,.\, 10^{-4}$ m with the aid of the Blasius solution! At what coordinate y does the velocity for $x = 0.15$ m attain the same value. (13 Marks)

b) Water approaches an infinitely long and thin flat plate with uniform velocity U.

i-Determine the velocity distribution $u(y)$ in the boundary layer given by:

$$u(y)/U = a\,y^2 + b\,y + c\,.$$

ii- Boundary layer displacement thickness.

iii- Boundary layer momentum thickness.

iv- What is the flux of mass (per unit length of plate) across the boundary layer?

v- Calculate the magnitude and the direction of the force needed to keep the plate in place.

(12 Marks)

4-a) a) Obtain the complex potential of a uniform flow at an angle α to the x-axis.

(5 Marks)

b) Examine, whether potential and stream function exist for the following velocity fields!

a) $u = x^2 y$ $\quad v = y^2 x$

b) $u = x$ $\quad v = y$

c) $u = y$ $\quad v = -x$

d) $u = y$ $\quad v = x$

Determine potential and stream-function for the possible flow from the above cases.

(10 Marks)

c) A source discharging 1 (m^3/s.m) is at (– 1, 0) and a sink taking in 1 (m^3/s.m) is at (+1, 0). If this is combined with uniform flow of u = 1.5 (m/s), left to right, calculate the length of the resolution of closed body contour.

(10 Marks)

==

GOOD LUCK ***Prof. Dr. M. Safwat***

The Blasius Velocity Profile.

$y[U/(\nu x)]^{1/2}$	u/U	$y[U/(\nu x)]^{1/2}$	u/U
0.0	0.0	2.8	0.81152
0.2	0.06641	3.0	0.84605
0.4	0.13277	3.2	0.87609
0.6	0.19894	3.4	0.90177
0.8	0.26471	3.6	0.92333
1.0	0.32979	3.8	0.94112
1.2	0.39378	4.0	0.95552
1.4	0.45627	4.2	0.96696
1.6	0.51676	4.4	0.97587
1.8	0.57477	4.6	0.98269
2.0	0.62977	4.8	0.98779
2.2	0.68132	5.0	0.99155
2.4	0.72899	∞	1.00000
2.6	0.77246		

Equations of motion

Continuity Equation:

$$\frac{\partial(\rho u)}{\partial x}+\frac{\partial(\rho v)}{\partial y}+\frac{\partial(\rho w)}{\partial z}=0$$

x-momentum:

$$\rho\left(\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}\right)=\rho g_x-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)$$

y-momentum:

$$\rho\left(\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}\right)=\rho g_y-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right)$$

z-momentum:

$$\rho\left(\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}\right)=\rho g_z-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)$$