University of Technology
Engineering Department of Building and Construction
Final Exam-First attempt 2012-2013

Subject: Fluid Mechanics
Division: All Divisions
Examiners: Fluid mechanics committee

Year: Second
Time: 180 min.
Date :8/6/2013

Answer FIVE Questions Only

Q1: A) – For flow in a circular pipe the max.shear stress at the wall equal to $\tau_o = \gamma R_h S_e$ where (γ)weight density,(R_h)hydraulic radius and (S_e)slope of energy line. Show that the head due to friction in pipe is calculate from Darcy's equation $h_f = \frac{fLV^2}{D.2g}$. *(10 Mark)*

B) – Calculate the capillary effect in millimeters in a clean glass tube of 4mm diameter, when immersed in :- 1)Water (surface tension 0.0735 N/m). 2) Mercury (surface tension 0.051 N/m). Take (specific weight of water to 9790N/m^3 and S=13.5 for mercury). *(10 Mark)*

Q2: A) – Fill in the blanks: - (*Answer eight only*) *(10 Mark)*

1-The branch of engineering science, which deals with water at rest or in motion, is called ——.
2-The side of the dam to which the water from the river or the stream approaches is known ——.
3-If measured the pressure relative to atmospheric pressure or to surrounding pressure, it is called ——.
4-Liquid moves in a circle path with a constant velocity, therefore the normal acceleration equal to —— and tangential acceleration equal to ——.
5- Continuity equation is based on the principle of ——.
6- The flow is laminar when the viscosity is —— and velocity is ——.
7- The wave celerity is equal to——.
8- The depth of flow in an open channel where the specific energy minimum is called ——.
9- For a Laminar flow over a plate, the thickness of this layer equal to——.

B) – Why the phenomena (or events) occur of the following: - (*Answer three only*) *(10 Mark)*

1) Hydraulic jump in open channels. 2) Laminar and turbulent flow. 3) Cavitations in siphon pipe.
4) In sometimes, the flow in a conduit pipe considers flow in open channel.

Q3: A) – The velocity distribution in a pipe of 1m diameter represented by $V = 2\left(1 - \frac{r^2}{R^2}\right)$ where R is the radius in(m)and V(m/s) is the velocity in a distance(r) from the center, find the discharge and the average velocity. *(10 Mark)*

B) – 1) What are the factors effecting on the variation of coefficient of friction for a circular pipe? *(5 Mark)*
2) What are the factors affecting on instability of flow (dimensionless parameters (χ))? *(5 Mark)*

Q4: A) – Select the **true** statements **only** for the following: - *(10 Mark)*

1- Viscosity of liquid increased with increasing degree of temperature.
2- The vertical component of the hydrostatic force on a submerge curve surface is the weight of the liquid vertically above it.
3- The shear stress between two fixed parallel plates with a laminar flow between them varies parabolically as the distance from the mid-plane.
4- For two pipes connected in series, the total discharge is equal to summation of discharge in each pipe.
5- Energy line and hydraulic gradient line can intersect each other.
6- The cross section of an open channel is said to be "the best" if the roughness coefficient is the least.

B) A pipe system carries water (viscosity =0.0113×10^{-4} m^2/s, density=999kg/m^3) from a reservoir and discharges it as a free jet, as shown in Fig.(1).How much flow is to be expected through a 200mm steel pipe (e=0.000046m)with the fittings shown? *(10 Mark)*

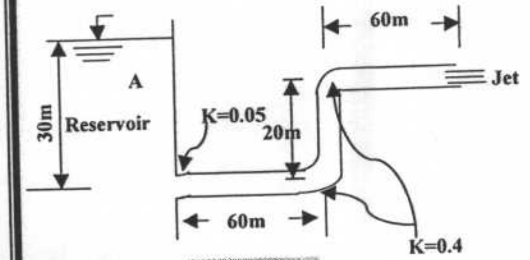


Figure (1).

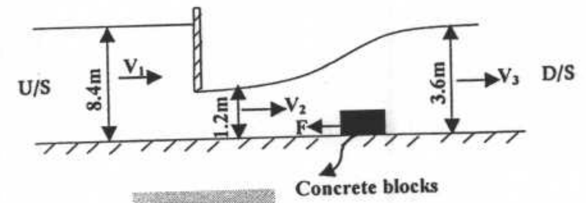


Figure (2).

Values of (n) in Manning's formula

Natural of surface	n
Concrete Precast	0.013
Cement mortar surface	0.015
Common – clay drainage tile	0.017
Concrete monolithic	0.016
Smooth concrete	0.012
Brick with cement mortar	0.017
In rock cuts smooth	0.035
Rough beds and weeds on sides	0.04

الحلول النموذجية للدور الاول
٢٠١٢ - ٢٠١٣
ميكانيك الموائع

Q.1 A) $\tau_o = \gamma R_h S_e$ & $\tau_o = \gamma \frac{D}{4}\left(\frac{h_f}{L}\right)$

$\therefore h_f = \left.\frac{4\tau_o}{\gamma}\frac{L}{D}\right]$ divided by $V^2/2g$

$$\frac{h_f}{V^2/2g} = \frac{4\tau_o L/D}{V^2/2g} \quad \text{—— (1)}$$

$$\& \; f = \frac{4\tau_o/\gamma}{V^2/2g} \quad \text{—— (2)}$$

from eq. (1) & (2) and sub. the value of (f), we get

$$\frac{h_f}{V^2/2g} = f \cdot \frac{L}{D} \Rightarrow \boxed{h_f = \frac{f \cdot L V^2}{D \cdot 2g}}$$

B) a) for water $h = \frac{4 * 0.0735 * \cos 0}{9790 * 0.004} = \boxed{7.51 * 10^{-3} m = 7.51m \text{ rise}}$

b) for mercury $h = \frac{4 * 0.051 * \cos 130}{(13.6 * 9790) * 0.004} = -2.46 * 10^{-3} m$

$\boxed{= -2.46mm \text{ depression}}$

Q.2 A) 1. Hydraulics. 2. upstream. 3. gage pressure.
4. $\frac{V^2}{r}$, Zero. 5. Conservation of mass law. 6. very high, very low.
7. $\sqrt{g y_h}$. 8. critical depth. 9. $\frac{5.2 * X}{\sqrt{Re}}$.

B) (1) Hydraulic Jump occur due to changing in velocity & flow between two section or due to change the type of flow from supercritical to subcritical.

(2) laminar flow & turbulent flow occur due to exiting a viscosity (fluid having a viscosity).

(3) If the absolut pressure at the summit reaches the vapour pressure.

Q.3

A))

$$dA = 2\pi r\,dr$$

$$Q = \int_0^A v\,dA = \int_0^R 2\left(1-\frac{r^2}{R^2}\right)2\pi r\,dr$$

$$= 4\pi\int_0^R\left(1-\frac{r^2}{R^2}\right)r\,dr = 4\pi\left[\int_0^R r\,dr - \int_0^R \frac{r^3}{R^2}\,dr\right]$$

$$= 4\pi\left[\left[\frac{r^2}{2}\right]_0^R - \left[\frac{r^4}{4R^2}\right]_0^R\right] = \frac{4\pi R^2}{2} - \frac{4\pi R^2}{4}$$

$$Q = 2\pi R^2 - \pi R^2 = \pi R^2 = \pi\left(\tfrac{1}{2}\right)^2 = \frac{\pi}{4} = \boxed{0.785\ m^3/s}$$

$$A = \pi R^2 = \pi\left(\tfrac{1}{2}\right)^2 = \frac{\pi}{4}\ m^2$$

$$V = \frac{Q}{A} = \frac{\pi/4}{\pi/4} = \boxed{1.0\ m/s}$$

B) ① friction factor as a function of the following varibles

$$f = f[(V, \mu, \rho, D, e)]$$

and

$f = \phi[Re, \frac{e}{D}]$, In General

$f = \phi[Re]$. laminar or turbulent in smooth pip

$f = \phi[\frac{e}{D}]$. Turbulent rough pipe

$f = \phi[Re, \frac{e}{D}]$ turbulent & smooth to transi to rough pipe.

②

$$x = \frac{\rho y^2 \frac{dv}{dy}}{\mu}$$

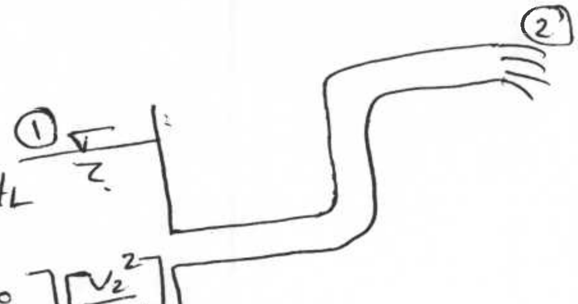
ρ = mass Density, y = distance from the wall to the center

$\frac{dv}{dy}$ = velocity gradient & μ = viscosity

$$x = \left\{\rho, y^2, \frac{dv}{dy}, \mu\right\}$$

Q.4 A)) The true statment is No. two (2)

2. The vertical component of hydrostatic force on a submerge curve surface is the weight of liquid vertically above it.



B)) $(H_L = h_f + h_m)$

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + H_L$$

$$h_f = \frac{f \cdot L V^2}{D \cdot 2g} = f\left[(60+20+60)/\frac{200}{1000}\right]\left[\frac{V_2^2}{19.62}\right]$$

$$= 35.69\, f V_2^2$$

$$h_m = K(V^2/2g) = [0.05 + 2(0.4)][V_2^2/19.62]$$

$$= 0.04334\, V_2^2$$

$$0 + 0 + 30 = 0 + \frac{V_2^2}{2g} + 20 + (35.69\, f V_2^2 + 0.0433\, V_2^2)$$

$$V_2 = \sqrt{10/(35.69f + 0.09432}$$

Try $f = 0.014 \Rightarrow V_2 = 4.103\ m/s \rightarrow Re = 7.26 \times 10^5$

from Mody Digram with $\frac{e}{D} = 0.00023$ & $Re = 7.26 \times 10^5$

$f = 0.0152$ & $V_2 = 3.963\ m/s \rightarrow Re = 7.01 \times 10^5$

∴ $f = 0.0152$ o.k

$$Q = AV = \frac{\pi}{4}\left(\frac{200}{1000}\right)^2 * 3.963 = 0.125\ m^3/s$$

Q.5 A)) ①

(n) from table equal to $n = 0.012$

$Q = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} A \Rightarrow 2.832 = \frac{1.11}{0.012} (0.2934)^{\frac{2}{3}} S_o^{\frac{1}{2}}$

$A = 3.05 * 0.366 = 1.11 m^2$

$P = 2 * 0.366 + 3.05 = 3.782$

$\frac{A}{P} = 0.2934$

$q = \frac{Q}{B} = \frac{2.832}{3.05} =$

$S_o = 0.0048$

② $y_c = (q^2/g)^{\frac{1}{3}} = \left(\frac{(0.928)^2}{9.81}\right)^{\frac{1}{3}}$

$= 0.444 m$

$q = \frac{y_c}{n} (y_c)^{2/3} S_c^{\frac{1}{2}}$

$0.928 = \frac{0.444}{n} (0.444)^{\frac{2}{3}} (0.0048)^{\frac{1}{2}}$

$n = 0.0193$

③ for Best Hydraulic section $B = 2y$ ∴ $A = 2y^2$, $P = 4y$, $R_h = \frac{y}{2}$

$Q = \frac{A}{n} R_h^{\frac{2}{3}} S^{\frac{1}{2}}$

$2.832 = \frac{2y^2}{0.0193} \left(\frac{y}{2}\right)^{2/3} (0.0048)^{\frac{1}{2}}$

$y = 0.839 m$ & **$B = 1.678 m$**

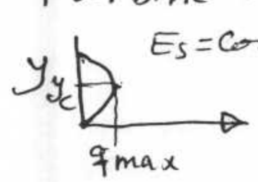
Q /

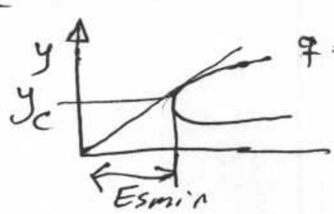
B)) ① Types of H.J are:-
① Undular Jump.
② weak Jump.
③ oscillating Jump.
④ Strong Jump.

② $h_f = \frac{f \cdot L V^2}{D \cdot 2g}$ all factors in Darcy equation.

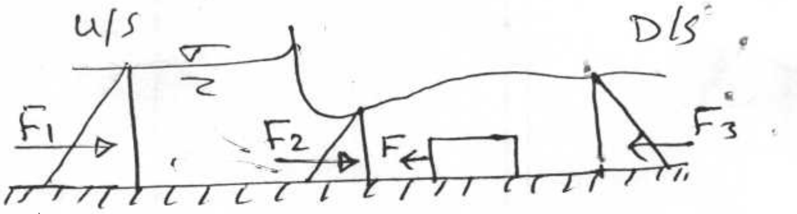
③ The viscosity of water at 20° is high viscosity of water at 40°

④ pump if increase in head by (E_P).
Turbine if decrase in head by (E_T).

⑤ 

④ 

Q.6



A Applying Bernoulli's eq.

$$\frac{v_1^2}{2g} + y_1 = \frac{v_2^2}{2g} + y_2 \Rightarrow \frac{v_1^2}{2g} + 8.4 = \frac{v_2^2}{2g} + 1.2$$

$$v_1 = v_2 \frac{y_2}{y_1} = v_2 * \frac{1.2}{8.4} = 0.1428 v_2$$

$$\frac{(0.142 v_2)^2}{2g} + 8.4 = \frac{v_2^2}{2g} + 1.2 \Rightarrow v_2 = 12 \ m/s$$

$$\& \ v_1 = 0.1428 * 12 = 1.7136$$

Q.3

$$Q = v_2 A_2 = v_1 A_1 = 12(7.2 * 1.2) = 1.7136 * 7.2 * 8.4$$

$$= 103.6 \ m^3/s$$

$$v_3 = \frac{Q}{A} = \frac{103.6}{7.2 * 3.6} = 3.998 \ m/s$$

$$\Sigma F = \rho Q (V_{out\,3} - V_{in\,2})$$

$$F_2 - F - F_3 = 1 * 103.6 (3.998 - 12)$$

$$\frac{\gamma y_2^2}{2} * B - F_{block} - \frac{\gamma y_3^2}{2} * B = -829$$

$$\therefore F_{block} = 422.58 \ KN$$

B Total supply/day $= 3000 * 0.18 = 540 \ m^3$

$$\therefore Q = \frac{540}{16 * 3600} = 0.0093 \ m^3/s$$

$$h_f = \frac{f L}{12.1 D^5} Q^2$$

$$18 = \frac{0.028 * 4000}{12.1 (D^5)} (0.0093)^2$$

$$D = \sqrt[5]{0.00045196}$$

$$D = 0.135 m$$

5