Govt. Polytechnic, TPG, D.CE III Semester Hydraulics formula Sheet

I. Fluid Properties

1. Specific Weight (w) **w = ρ x g**

2. Specific Gravity $s = \frac{\text{Specific weight or density of that liquid}}{\text{Specific weight or density of pure water at } 4^0 c}$

3. Mass density of water (ρ) = 1000 Kg/m3
   Specific weight of water (w) = 9810 N/m3
   Specific gravity of water (s) = 1
   Specific gravity of mercury varies from 13.5 to 13.6

4. Bulk Modulus (k) (kN/m^2) $K = \frac{dp}{\left(\frac{dv}{v}\right)}$

5. Surface Tension (σ) units – N/m
   Surface Tension on Liquid Droplet $p = \frac{4\sigma}{d}$

7. Surface Tension in Hollow bubble (Soap bubble) $p = \frac{8\sigma}{d}$

8. Capillary Rise $h = \frac{4\sigma \cos\theta}{\omega d}$

9. Dynamic viscosity or viscosity (μ) $\tau = \mu \frac{du}{dy}$
   Units - N.Sec / m^2

10. Kinematic Viscosity (ν) $\nu = \frac{\mu}{\rho}$
    Units - m^2/sec

III. Flow of Fluids

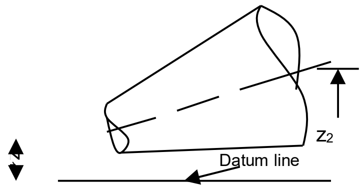
1. Discharge Q = AV. Units: mm3 / sec, (or) cm3/ sec, (or) m3 / sec
   1m3/sec = 1000 lit /sec; lit / sec = 1000 cm3/sec; m^3/sec = 106 cm^3/sec; 1 m^3/sec = 1 cumec

2. Continuity Equation. $a_1 v_1 = a_2 v_2$

3. *Total Energy*, $E = z + \frac{p}{w} + \frac{v^2}{2g}$ *Total* Head, $H = z + \frac{p}{w} + \frac{v^2}{2g}$

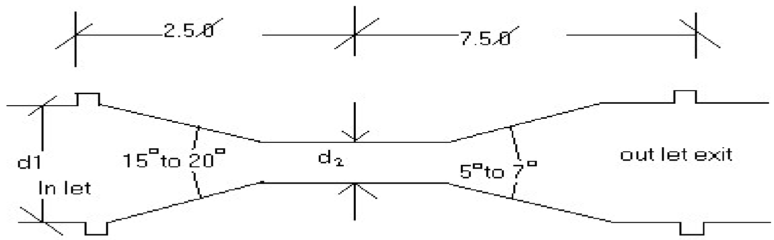
4. Bernoulli's Theorem $\frac{p}{w} + \frac{v^2}{2g} + z = const$

5. If the Bernoulli's equation is applied between two section (1) & (2) then



$$\frac{p_1}{w}+\frac{v_1^2}{2g}+z_1=\frac{p_2}{w}+\frac{v_2^2}{2g}+z_2$$

6. Verturimeter. it consists of three parts,
    1. Convergent cone
    2. Throat and
    3. Divergent cone

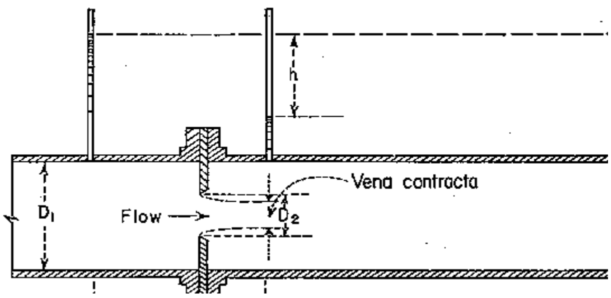


7. Discharge of Venturimeter $Q = Cd\,\frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a^2{}_1 - a_2{}^2}}$

8. Case 1: Let the differential manometer contains a liquid which is heavier than the flowing of liquid.
   Where S_h= specific gravity of the heavier liquid.
   S_f = specific gravity of the flowing liquid.
   x= difference of the heavier liquid column in the manometer Then $h = x\left[\frac{S_h}{S_f} - 1\right]$

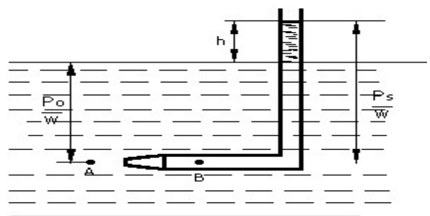
9. Case 2: If the differential manometer contains a liquid which is lighter than the liquid flowing through the pipe the value of h is given by
   where S_l = specific gravity of the lighter liquid $h = x\left[1 - \frac{S_l}{S_f}\right]$
   S_f= specific gravity of the flowing liquid.
   x = difference of the lighter liquid columns in the U- tube.

10. Orifice Meter discharge is given by



$$Q = Cd\,\frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a^2{}_1 - a_2{}^2}}$$

11. Pitot Tube is used to measure the velocity of flow V=



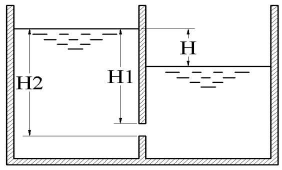
IV. Orifice & Mouth Pieces

1. Small Orifice (h>5d); Large Orifice (h<5d)
2. Equation for Discharge through small orifice

Discharge = Area orifice X velocity $Q = AXv$ where v = √ (2gh)
h = head causing flow (measured from the centre of orifice)
Units of Q = m3/sec

3. Hydraulic Co – efficient & their relationship
$C_d = Q_{act}/Q_{the}$; $C_v = v_{act}/v_{the}$; $C_c = a_{act}/a_{the}$; $C_d = C_c \times C_v$
4. Vena Contracta
It is a section along the jet of water where the cross sectional area of jet is minimum.
5. Average value of Cc = 0.64 Average value of Cv = 0.97 Average value of Cd = 0.62
Cr =Loss of head in the orifice / Head of water
6. Experimental Method for the Determination of Hydraulic Co- efficient
Co – efficient of velocity Cv = √(x2/4hy).
Co- efficient of Discharge Cd = (AH/t) / (a √ (2gh))
Co- efficient of Contraction Cc = a_{act}/a_{the}
7. Discharge thro. Large rectangular orifice $Qa = \frac{2}{3} cd.b\sqrt{2g}\,(H_2^{\frac{3}{2}} - H_1^{\frac{3}{2}})$
8. Discharge through Wholly Drowned Orifice

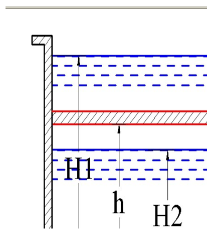
Q = Cd b[H2 – H1] √2gH



9. Discharge through Partially Drowned Orifice
The discharge through partially drowned orifice is obtained by treating the lower portion as a drowned orifice (Q1), and The upper portion as a free orifice (Q2).
Q = Q1 + Q2. Where Q1 = Cd b[H2 – H] √2gH
Q2 = (2/3) Cd b√2g [H3/2 – H13/2]

10. Time of emptying a tank through an orifice at its bottom

$$T = \frac{2A\,[H_1^{1/2} - H_2^{1/2}]}{C_d\, a\, \sqrt{2g}}$$



`

11. Discharge through an
External Mouth Piece Q = Cd a √2gh; Cd = 0.855
Convergent Mouth Piece Q = Cd a √2gh; Cd = 1.0
Convergent Divergent Mouth Piece Q = Cd a √2gh; Cd = 1.0
Internal Mouth Piece (Re – entrant or Borda's Mouth Piece)
a. Mouth Piece Running Full Q = Cd a √2gh; Cd = 0.5
b. Mouth Piece Running Free Q = Cd a √2gh; Cd = 0.707

V. Notches & weirs

1. Cippolletti weir: A trapezoidal weir having side slopes of 1horizontal to 4 vertical

Disharge $Q = \frac{2}{3} C_d L \sqrt{2g} H^{\frac{3}{2}}$

Considering the velocity of approach then $Q = \frac{2}{3} C_d\, L\sqrt{2g}\,[\ ((H + ha)^{\frac{3}{2}} - ha^{\frac{3}{2}}\ ]$

2. Discharge over rectangular notch or weirs with 'n' end contractions
   $Q = 2/3\ Cd\ L\ (L- 0.1nH)\sqrt{2g}H^{3/2}$
   If vel. Approach is consider $Q = 2/3\ Cd\ L\ (L-0.1nH)\ \sqrt{2g}(H1^{3/2}-Ha^{3/2})$

3. Francis formula for discharge over rectangular weir

   $Q = 1.84\ (L-0.1nH)(H_1^{3/2}-Ha^{3/2})$

   Where $H_1 = H + ha$
   $= H + Va^2 /2g$

4. Suppressed weir
   When there are no end contraction & velocity of approach is considered $n = 0$
   $Q = 1.84\ L\ H^{3/2}$
   $Q = 1.84\ L\ (H^{3/2} - ha^{3/2})$

5. Discharge formula for a narrow crested weir Q = $\frac{2}{3}C_d L\sqrt{2g}H^{\frac{3}{2}}$

6. Discharge formula for a Broad crested weir $Q\max = C_d.L.\frac{2}{3\sqrt{3}}\sqrt{2g}H^{\frac{3}{2}}$

7. Discharge over a sharp crested rectangular weir Q = $\frac{2}{3}C_d L\sqrt{2gH}^{\frac{3}{2}}$

   If velocity of approach is taken into consideration the discharge over a rectangular weir

   $$Q = \frac{2}{3}C_d L\sqrt{2g}((H+h_a)^{\frac{3}{2}} - h_a^{\frac{3}{2}})$$

8. Discharge over trapezoidal notch is given by: $Q=\frac{2}{3}C_{d_1}\sqrt{2g}LH^{\frac{3}{2}}+\frac{8}{15}C_{d_2}\sqrt{2g}\mathrm{Tan}\frac{\theta}{2}H^{\frac{5}{2}}$

9. Discharge formula for a rectangular notch

VI Flow thro. Pipes

1. Darcy-Weisbach formula: $h_f = \frac{4\ f\ l\ v^2}{2\ g\ d}$

2. Chezy's Formula $V = C\sqrt{mi}$

   A = cross sectional area
   P = wetted perimeter $i = hf / l$

3. Loss of the head at entrance of pipe (hi) $h_i = 0.5\frac{v^2}{2g}$

   Loss of head at exit of pipe $h_0 = \frac{v^2}{2g}$

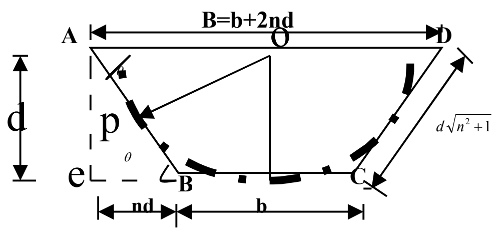
   Loss of head due to sudden Enlargement (he) $h_e = \frac{(v_1 - v_2)^2}{2g}$

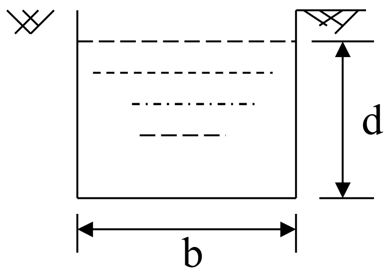
   Loss of head due to sudden Contraction $h_c = 0.5\frac{v_2^2}{2g}$

4. Reynolds's Number $= \frac{\rho v d}{\mu}$ $\quad \mathrm{Re} = {}^{v_d}\!/_{\upsilon}$ $\quad$ since $\upsilon = {}^{\mu}\!/_{\rho}$

- It is Dimension less
- It gives the Information about flow
- $\mathrm{Re} \leq 2000$ Laminar flow
- $\mathrm{Re} \geq 40000$ Turbulent flow
- $4000 \geq \mathrm{Re} \leq 2000$ Critical flow

VII. Open Channel Flow





1. Rectangular channel section
   Area of flow, A = b*d
   Wetted perimeter, p=b+2d
   Hydraulic mean depth, m=A/P m=b*d/(b+2d)

2. Trapezoidal section
   Top width B= b+2 (nd); Sloping side $= d\sqrt{n^2+1}$
   Area = [(b+2nd)+b]/2* d = (b+ nd) d; Wetted perimeter p $= b+2d\sqrt{n^2+1}$

   Hydraulic radius m $= \frac{A}{P} = \frac{(b+nd)d}{b+2d\sqrt{n^2+1}}$ Hydraulic Depth D $= \frac{\text{A}}{\text{TOPWIDTH}} = \frac{(\text{b + nd})\ \text{d}}{(\text{b + 2 nd})}$

3. CHEZY'S FORMULA for Discharge through open Channel $Q = A \times C\sqrt{mi}$

   Chezy's Constant $C = \sqrt{W/f}$ Velocity $V = C\sqrt{mi}$

   Bazin's Formula $C = \frac{157.6}{1.81 + K/\sqrt{m}}$ Kutter's Formula $c = \frac{23 + \frac{0.00155}{i} + \frac{1}{N}}{1 + \frac{N}{\sqrt{m}}\left(23 + \frac{0.00155}{i}\right)}$

   Manning's Formula $V = \frac{1}{N} m^{2/3} i^{1/2}$ $\quad C = \frac{1}{N} m^{1/6}$

4. Most economical rectangular section
   For maximum discharge d = b / 2; m = d / 2

5. Most Economical Trapezoidal section
   $(Top\ width)/2 = length\ of\ sloping\ side$ $\quad \frac{(b+2nd)}{2} = d\sqrt{n^2+1}$
   Hydraulic mean depth = Half the depth of flow m = d / 2

"DO UR BEST, THEN GOD WILL SEE THE REST"