# CHAPTER EIGHT

8.1 a) $Q = (2/3)\ CL\ \sqrt{2g}\ H^{3/2}$

$[Q] = L^3/T = L(L/T^2)^{1/2}L^{3/2}$

$L^3/T = L^3/T$ homogeneous

b) $V = (1.49/n)R^{2/3}S^{1/2}$

$[V] = L/T = L^{-1/6}L^{2/3}$ not homogeneous

c) $h_f = f(L/D)V^2/2g$

$[h_f] = L = (L/L)(L/T)^2/(L/T^2)$ homogeneous

d) $D = 0.074\ R^{-0.2}Bx\rho V^2/2$

$[D] = F = L \times L \times (FT^2/L^4)(L/T)^2$ homogeneous

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8.2 a) $[T] = FL;\quad [T] = (ML/T^2) \times L = ML^2/T^2$

b) $[\rho V^2/2] = (FT^2/L^4)(L/T)^2 = F/L^2; [\rho V^2/2] = (M/L^3)(L^2/T^2) = M/LT^2$

c) $[\sqrt{T/\rho}\ ] = \sqrt{(F/L^2)/(FT^2/L^4)} = L/T$

d) $[Q/ND^3] = (L^3/T)/(T^{-1}L^3) = 1 \rightarrow$ Dimensionless

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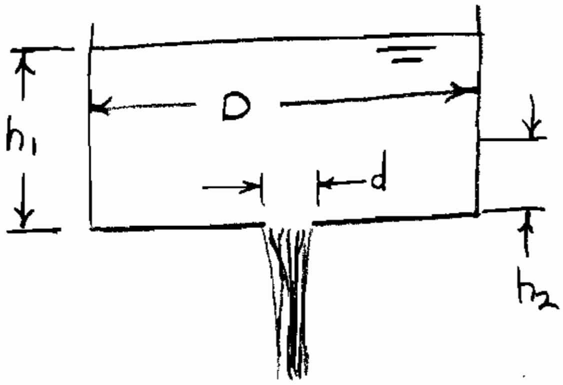
8.3

GIVEN: TANK DRAINING SO THAT LIQUID LEVEL GOES FROM $h_1$ TO $h_2$ IN TIME $\tau$.




FIND: DIMENSIONLESS GROUPS IN THIS FORM: $\frac{\Delta h}{d} = f_1(\pi_1, \pi_2, \pi_3)$

SOLUTION:

1. IDENTIFY SIGNIFICANT VARIABLES

$h_1$, $h_2$, $D$, $d$, AND $\tau$ ARE IN THE PROBLEM STATEMENT. NOTE THAT $\tau$ IS THE <u>ONLY</u> VARIABLE THAT CONTAINS DIMENSIONS OF TIME, NEED TO IDENTIFY ANOTHER VARIABLE THAT HAS TIME IN IT. I PICK <u>GRAVITATIONAL ACCELERATION</u>, $g$.

NOTE THAT TANK WILL DRAIN IN A DIFFERENT AMOUNT OF TIME IF $g$ CHANGES.

$h_1$, $h_2$, $D$, $d$, $\tau$, AND $g$

2. $[h_1] = L$

$[h_2] = L$

$[D] = L$

$[d] = L$

$[\tau] = t$

$[g] = \frac{L}{t^2}$

3. $n - m = ?$

$6 - 2 = 4$

THERE WILL BE A TOTAL OF 4 DIMENSIONLESS GROUPS

4. ELIMINATE $t$: $[\tau^2 g] = L$

ELIMINATE $L$: $\frac{h_1 - h_2}{d}, \frac{D}{d}, \frac{\tau^2 g}{d}, \frac{h_1}{d}$

$$\frac{h_1 - h_2}{d} = f\left(\frac{D}{d}, \frac{h_1}{d}, \frac{\tau^2 g}{d}\right)$$

THIS SET OF DIMENSIONLESS GROUPS IN NOT UNIQUE. THERE ARE OTHER COMBINATIONS THAT WILL WORK, BUT THERE MUST BE 4 GROUPS AND EACH OF THE VARIABLES MUST BE USED AT LEAST ONCE.