JORDAN UNIVERSITY
FACULTY OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF MECHANICAL ENGINEERING
ENGINEERING MEASUREMENTS (0904423)
First Test, SUMMER SEMESTER 2008-2009

Dr. Jehad A. A. Yamin **Date:** 22nd October, 2008

Time: 15 minutes.

Q1) The discharge coefficient Cd for an obstruction flow measurement device can be found by collecting the water flowing over certain period of time under constant head "h". The relation prescribing the discharge coefficient is:

(25 Points)

$$C_d = \frac{m}{t * \rho * A\sqrt{2 * g * h}}$$

Where, $m = 400 \pm 0.25$kg
$t = 600 \pm 2$ sec;
$\rho = 1000 \pm 0.1\%$ kg/m^3.
$d = 1.25 \pm 0.0025$ cm $(A = 0.25*\pi*d^2)$
$g = 9.807 \pm 0.1\%$ m/s^2.
$h = 3.65 \pm 0.003$ m.

1) Calculate the nominal value for the coefficient of discharge and its limiting and relative limiting error.

$$C_D = \frac{400}{600 * 1000 \frac{\pi}{4}\left(\frac{1.25}{100}\right)^2 * \sqrt{2 * 9.81 * 3.65}} = \underline{0.642}$$

$$\frac{\delta C_D}{C_D} = \pm\left[\frac{\delta m}{m} + \frac{\delta t}{t} + \frac{\delta \rho}{\rho} + 2\frac{\delta d}{d} + \frac{1}{2}\frac{\delta g}{g} + \frac{1}{2}\frac{\delta h}{h}\right] =$$

$$= \pm\left[\frac{0.25}{400} + \frac{2}{600} + \frac{0.1}{100} + 2\frac{0.0025}{1.25} + \frac{1}{2}\frac{0.1}{100} + \frac{1}{2}\frac{0.003}{3.65}\right]$$

$$= \pm 0.00987 \Rightarrow \delta C_D = \pm 0.00633$$

2) If the ~~above values were for the uncertainty, how much~~ will be the value of the uncertainty and relative uncertainty in the discharge coefficient.

$$W_{C_D} = \pm\sqrt{\left(\frac{\partial C_D}{\partial m}W_m\right)^2 + \left(\frac{\partial C_D}{\partial t}W_t\right)^2 + \left(\frac{\partial C_D}{\partial \rho}W_\rho\right)^2 + \left(\frac{\partial C_D}{\partial d}W_d\right)^2 + \left(\frac{\partial C_D}{\partial g}W_g\right)^2 + \left(\frac{\partial C_D}{\partial h}W_h\right)^2}$$

~~Wish You the Best~~

$$\therefore \frac{W_{C_D}}{C_D} = \pm\sqrt{\left(\frac{W_m}{m}\right)^2 + \left(\frac{W_t}{t}\right)^2 + \left(\frac{W_\rho}{\rho}\right)^2 + \left(\frac{W_d}{d}\right)^2 + \left(\frac{W_g}{g}\right)^2 + \left(\frac{W_\rho}{\rho}\right)^2}$$

$$= \pm 0.00537 \Rightarrow W_{C_D} = \pm 3.45224 \times 10^{-3}$$

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Q1) The density of air is to be determined using the ideal gas equation of state i.e.: **(25 Points)**

$$P = \rho * R * T$$

0.4874577

Where, P = is the pressure = 55 ± 0.5 kPa
R = is the gas constant for air = 287.1 J/kg.K; and;
T = is the temperature of gas = 125 ± 0.4 °C.

0.0090909+
0.01032

1) Calculate the nominal value for the density in kg/m³ and its uncertainties.

$$\rho = \frac{P}{RT} = \frac{55*10^3 (N/m^2)}{287.1\left(\frac{J}{kg.K}\right) * (125+273)(K)} = \underline{0.48115 \frac{kg}{m^3}}$$

$$\frac{\partial \rho}{\partial P} = \frac{1}{RT} = \rho/P,$$
$$= 0.0000088$$

$$\frac{\partial \rho}{\partial T} = -\frac{P}{RT^2} = -\rho/T = -0.0012403$$

$$\therefore \frac{w_\rho}{\rho} = \pm\sqrt{\left(\frac{w_P}{P}\right)^2 + \cancel{\left(\frac{w_R}{R}\right)^2} + \left(\frac{w_T}{T}\right)^2} = \pm 9.63266*10^{-3}$$

$$w_\rho = \pm 0.004637 \text{ kg/m}^3$$

2) If the above values were for the limiting errors, how much will be the value of the limiting and relative limiting error in density.

$$\frac{\delta \rho}{\rho} = \pm\left[\frac{\delta P}{P} + \cancel{\frac{\delta R}{R}} + \frac{\delta T}{T}\right] = \underline{\pm 0.0122909}$$

$$\therefore \delta \rho = \pm 0.0059137 \text{ kg/m}^3$$

$$\frac{N/m^2}{\frac{N\text{-}m}{kg}}$$

Wish You the Best

$(0.0004961)^2 + (0.0000841)^2$

kg/m³

0.000002

$\frac{1}{\frac{kJ}{kg.K}.K}$ $\frac{kg}{kg}$