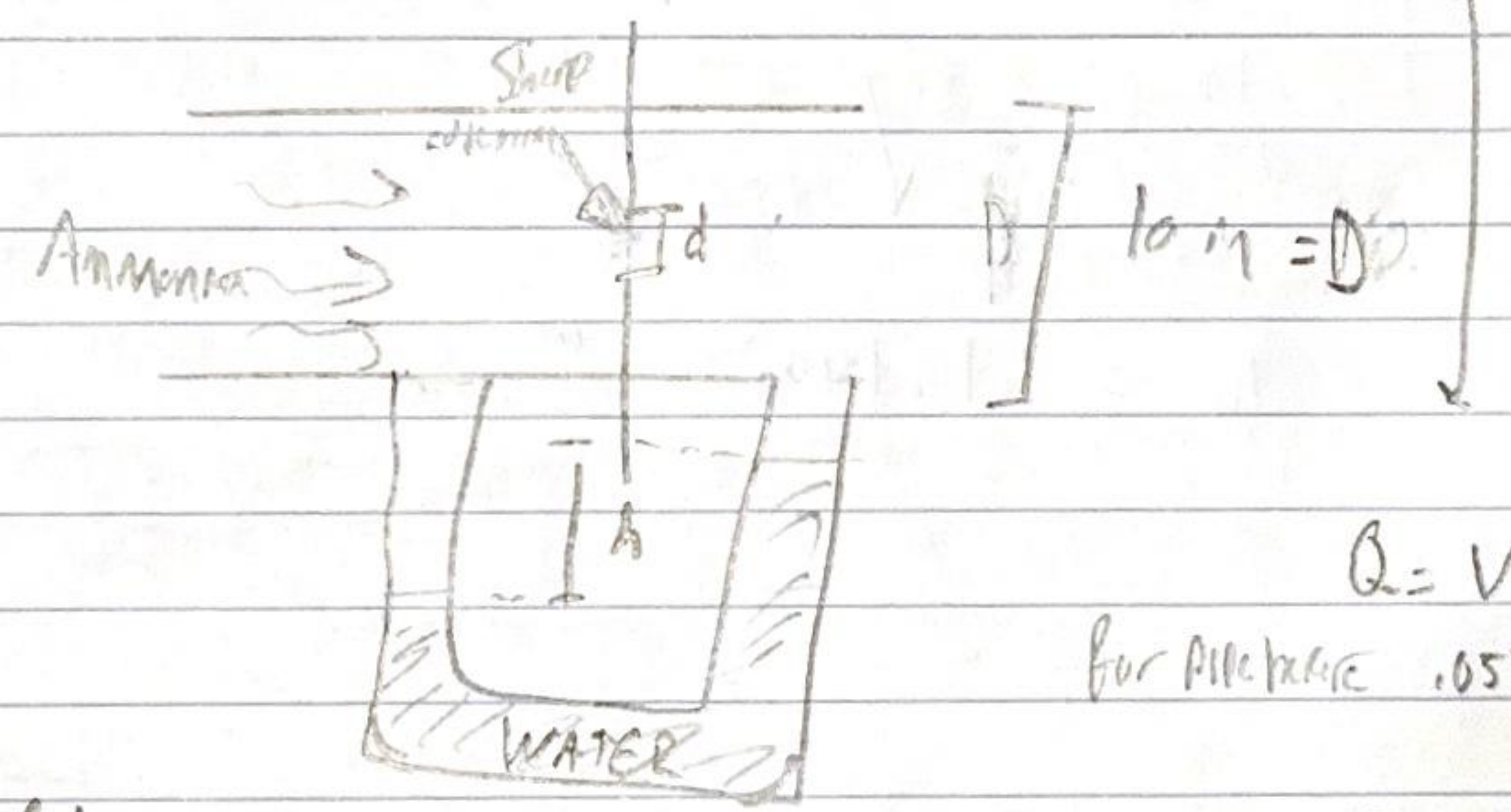
Ch 15 : 4, 9, 15

Callaway money
10/23/2024
MET 330

HW 24

15-4 / a sharp-edged orifice placed in a 10 in diameter pipe carrying Ammonia. Volume flow rate is 25 gal/min. Find deflection of water manometer if
a.) orifice diameter = 1.0 in
b.) orifice diameter = 7.0 in
Also given Ammonia sg = .83
dynamic viscosity = 2.5×10^{-6} lb·s / ft²

$Q = 25 \text{ gal/min} \cdot (1 \text{ ft}^3/\text{s}) / (449 \text{ gal/min}) = .0557 \text{ ft}^3/\text{s}$



$Q = VA$

for pipe rate $.0557 \text{ ft}^3/\text{s} = V(\pi((\tfrac{10}{12}A)^2))$

$V = .102 \text{ ft/s}$

$$N_R = \frac{VD\rho}{\eta}$$

$$= \frac{(.102 \text{ ft/s})(\tfrac{10}{12}\text{ ft})(.83 \cdot 1.94 \text{ slugs/ft}^3)}{2.5 \times 10^{-6} \text{ lbs/ft}^2}$$

$= 54746.8 \approx 55 \text{ k ish}$

Useful
Eq 15.6

$$V_1 = C \cdot \sqrt{\frac{2gh\,[(\gamma_m/\gamma_f) - 1]}{(A_1/A_2)^2 - 1}}$$

and using sharp-edge orifice chart!
for a) $d/D = 1 \text{in}/10 \text{in} = .1$ $C = .595$
b.) $d/D = 7 \text{in}/10 \text{in} = .7$ $C = .618$
using $N_R \approx 65000$

Cont

2/6

15.4 Given

a. 1 in diameter

$$V_1 = C\sqrt{\frac{2g(P_1-P_2)/\gamma}{(A_1/A)^2-1}}$$

a. 1 in diameter is 27.97 ft deflection

$$= C\sqrt{\frac{2gh(\gamma_m/\gamma_w)-1}{(A_1/A_2)^2-1}}$$

$$.102 \text{ ft/s} = (.595)\cdot\sqrt{\frac{(2)\cdot(32.2 \text{ ft/s}^2)(h)\left[\left(1/.866\right)-1\right]}{\left[\pi(5/12)^2 / \pi(1/24)^2\right]^2-1}}$$

$$\frac{.102 \text{ ft/s}}{.595} = \sqrt{\frac{10.5 (h)}{9999}}$$

$$h = (.1714)^2 \cdot \frac{9999}{10.5} = 27.97 \text{ ft}$$

Unit check, all good

b. 7 in diameter

$$.102 \text{ ft/s} = .618 \cdot \sqrt{\frac{(2)\cdot(32.2 \text{ ft/s})\cdot h \cdot (1/.866-1)}{\left[(\pi(5/12)^2)/(\pi(7/24)^2\right]^2-1}}$$

$$\frac{.102 \text{ ft/s}}{.618} = \sqrt{\frac{(10.5)(h)}{3.165 \text{ ft}^2}}$$

$$h = (.165)^2 \cdot \frac{3.165}{10.5} = .008 \text{ ft?}$$

Solns

a.) 27.97 ft deflection at 1 in diameter orifice

b.) .008 ft deflection of 7 in diameter orifice

this seems suspect

15-9 Flow nozzle to be installed in a 5-in Type K Copper tube Carrying linseed oil @ 77°F,

Mercury Manometer measured Δp across nozzle, with flowrate between 700- 1000 gal/min. Mercury manometer between 0 - 8.0 in.
... Size of Nozzle? (Diameter)

First app: App H

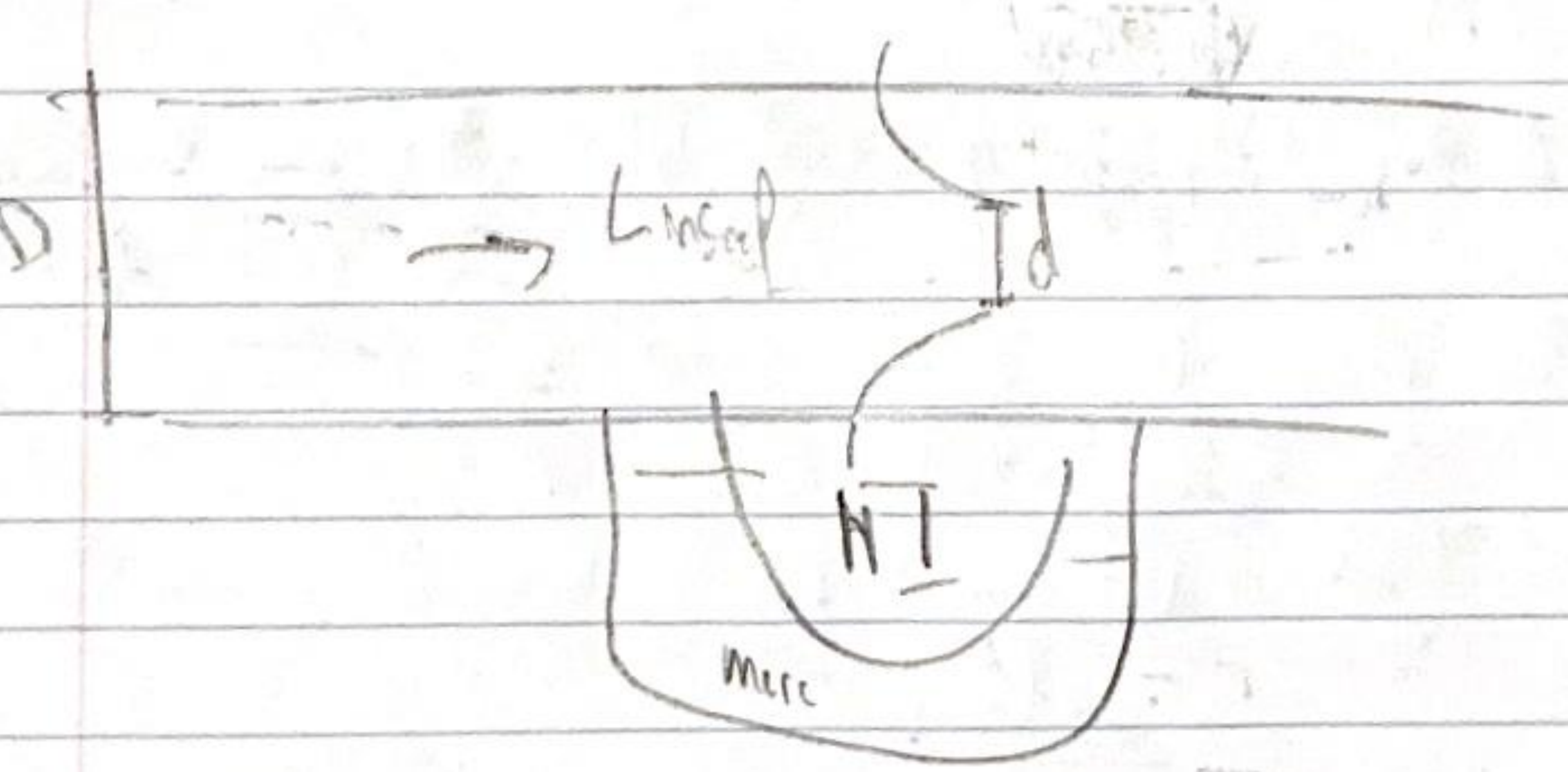
5 in Type K Copper tube $ID = .4004\ ft$
$A_1 = .1259\ ft^2$

App B → Merc $Sg = 13.54$

Linseed oil @ 77°F: $Sg = .930$
$\rho = 1.8\ slugs/ft^3$
$\eta = 6.91 \times 10^{-4}\ lb\text{-}s/ft^2$

$Q = 700 - 1000\ gal/min$ H must be lower than $8.0\ in = 2/3\ ft$
a $1\ ft^3/s = 449\ gal/min$
$Q = 1.56 - 2.23\ ft^3/s$

We will



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15-9 | Cont

using (15-6)

$$V_1 = C\sqrt{\frac{2gh[(\gamma_m/\gamma_L)-1]}{[(A_1/A_2)^2-1]}}$$

$Q = VA$

$V = Q/A$ low

$Q = 1.56$ ft^3/s → $A_1 = .1259\ ft^2$ → low $V_1 = 12.4\ ft/s$

$Q = 2.23$ ft^3/s → max $V_1 = 17.7\ ft/s$

A_2 refers to the cross-sectional area of the nozzle, which is how we find diameter

Also

$\gamma_m/\gamma_L = sg_m/sg_L$
$= 13.54/.93$
$= 14.56$

$$A_2 = \frac{A_1}{\sqrt{\frac{2gh\left(\frac{\gamma_m}{\gamma_L}-1\right)}{(V_1/C)^2}+1}}$$

all variables available except $\underline{C}$ and $\underline{A_2}$

how to find last unknown C:

Using largest flow rate $2.23\ ft^3/s$

Guess $C = .95$, check work

$A_2 = .077\ ft^2$

If $A = .077\ ft^2 = \pi(d/2)^2 \Rightarrow d = .313\ ft$ Maybe .3? Check

Now checking r

$$N_R = \frac{VD\rho}{\eta} = \frac{(17.73\ ft/s)(.657\ ft)(1.8\ slugs/ft^3)}{6.91\times10^{-4}\ lb\cdot s/ft^2}$$

$= 30738$ and using Fig 15.5

$C = .93$,

Rerun with $C = .93$

$C = .93$

$$A_2 = A_1 \Big/ \sqrt{\frac{2gh[(\gamma_m/\gamma_L) - 1]}{(V_1/C)^2 - 1} + 1}$$

$$\left.\begin{array}{l} A_1 = .1259\ ft^2 \\ g = 32.2\ ft/s^2 \\ h = 9/12\ ft \\ V_1 = 17.7\ ft/s \\ C = .93 \\ \gamma_m/\gamma_L = 13.57/.93 \end{array}\right\} \quad A_2 = .078\ ft^2$$

$$d = \sqrt{\left(\frac{.078\ ft^2}{\pi}\right)} \cdot 2$$

$$\underline{d = .315\ ft}$$

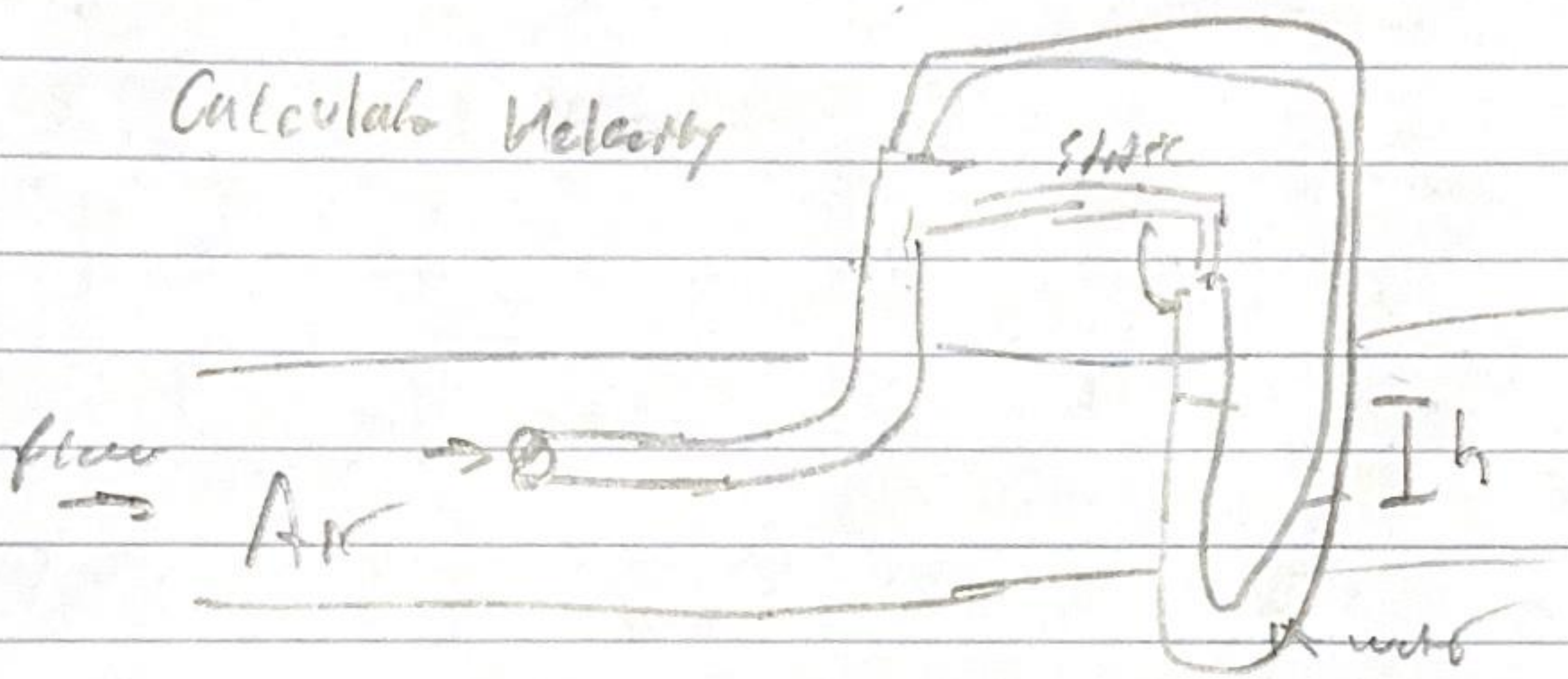
Conclusion. appropriate nozzle diameter would be $\underline{.315\ ft}$

15-151 a Pitot-static tube is inserted into a duct carrying air at std atm and a temp of ?
120 °F

Let's say 120 °F, close to 50 °C from last question (15-14)

A manometer reads 0.24 inch of water

Calculate Velocity



$$V_1 = \sqrt{2gh(\gamma_g - \gamma)/\gamma}$$

$\sqrt{2gh}$

where $h = .24 \text{ in} = .02 \text{ ft}$ air air

$g = 32.2 \text{ ft/s}$

$\gamma_g = 61.7 \text{ lb/ft}^3$ for water at 120 °F at std atm [APP A] A.2

$\gamma = .0685 \text{ lb/ft}^3$ for air at 120 °F at std atm [APP E] E.2

lb/ft³

$$V_1 = \sqrt{2(32.2 \text{ ft/s}^2)(.02 \text{ ft})\left[(61.7 - .0685)/.0685\right]}$$

Conclusion

$= 34 \text{ ft/s}$ Seems like a realistic answer

34 ft/s is how fast the air is moving (Velocity of flow)