Name____Date_February 2, 2016_ Tutorial _01__

Student ID:____________________________

ENGG 201 – WINTER 2016 - QUIZ (/60) [60 min.]

- Closed book, closed notes, Schulich Calculator Only.
- Show all work, and box final answer.
- Use the back of pages if needed and indicate with an arrow if you do so

1. The Froude number is used to determine the nature of flow in open channels (e.g., flow of water in a river):

$$Fr = \frac{V}{\sqrt{gy}}$$

The flow depth y at any distance x is determined from the following dimensionally homogeneous equation

$$\frac{dy}{dx} = \frac{S}{1 - Fr^2}$$

where, Fr = Froude number
V = flow velocity
g = gravitational acceleration
y = flow depth (height of the liquid)
x = distance
S = difference between the bottom slope and friction slope of the channel

(i) Use the dimensions of V, g, and y, to show that the Froude number is dimensionless (/5)

$$Fr = \frac{V}{\sqrt{gy}}$$

$$[Fr] = \frac{[V]}{[\sqrt{gy}]} = \frac{[\frac{L}{t}]}{[\sqrt{\frac{L}{t^2} \cdot L}]} = \frac{[\frac{L}{t}]}{[\frac{L}{t}]} = 1$$

$\Rightarrow$ Fr is dimensionless.

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(ii) Show that the quantity S in the second equation is also dimensionless. (/5)

$$\frac{dy}{dx} = \frac{S}{1 - Fr^2}$$

$$\Rightarrow S = \frac{dy}{dx}(1 - Fr^2)$$

Fr is dimensionless. Then,

$$[S] = \left[\frac{dy}{dx}\right] \times 1 = \frac{[L]}{[L]} \times 1 = 1$$

So, S is dimensionless.

(iii) Find the unit of the constant c appearing in the following dimensionally homogeneous equation:

$$Q = cby^{\frac{5}{3}}\sqrt{S}$$

where, Q is the volumetric flow rate (m^3/s) in the channel, b is the breadth (m) of the channel, and y is the height of liquid (m). (/5)

$$c = \frac{Q}{by^{5/3}\sqrt{S}}$$

We showed that S is dimensionless.

Then, units of c

$$= \frac{\frac{m^3}{s}}{m \cdot m^{5/3}} = \frac{m^3/s}{m^{8/3}}$$

$$= \frac{m^3}{s} \cdot m^{-8/3} = \frac{m^{3-8/3}}{s} = \boxed{\frac{m^{1/3}}{s}}.$$ Ans

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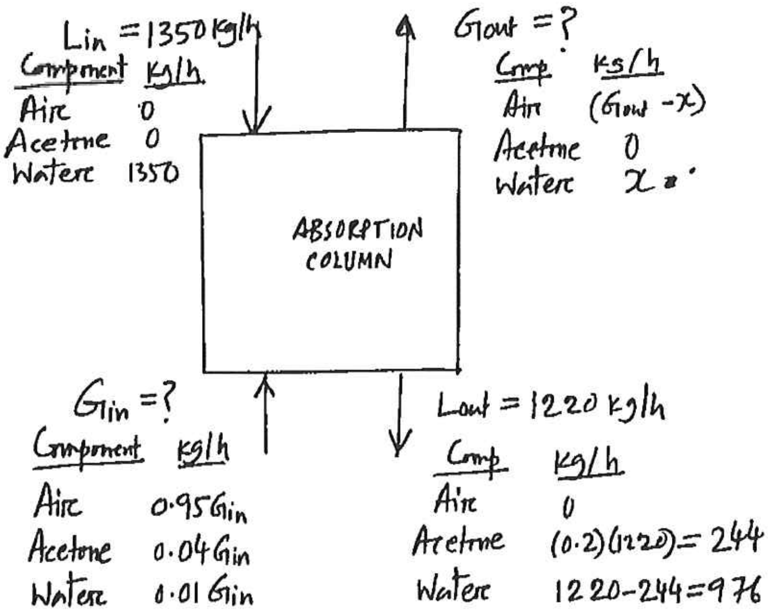
2. A stream of pure water (flow rate = 1350 kg/h) and a stream of a gas mixture enter into an absorption column. The entering gas stream ('G_{in}') has the following composition: 95 mass percent air, 4 mass percent acetone, and 1 mass percent water vapor. These two streams mix inside the column. A liquid stream and a gas stream leave the column. The leaving liquid stream (flow rate = 1220 kg/h) contains no air and has the following composition: 20 mass percent acetone and 80 mass percent water. The leaving gas stream ('G_{out}') has no acetone, and contains only air and moisture (water vapor). Assume the absorption column operates at steady-state and air is a single component.

   a. Calculate the flow rate (kg/h) of gas mixture entering the column. (/5)
   b. Calculate the flow rate (kg/h) of gas mixture exiting the column. (/5)
   c. Calculate percent mass of water in the gas stream leaving the column. (/5)



Let, x = amount (kg/h) of watere in Gout.

3 unknowns: G_{in}, G_{out} & x. 3 equations may be required.

A. No reactions, steady-state (IN=OUT) operation.

Acetone appears in fewer places. So, write an acetone balance first.

Acetone Balance: IN=OUT

$\Rightarrow 0.04\,G_{in} = 244 \Rightarrow G_{in} = \boxed{6100 \text{ kg/h}}$ ← (part 'a')

Overall mass balance: $1350 + G_{in} = G_{out} + 1220$

$\Rightarrow 1350 + 6100 = G_{out} + 1220 \Rightarrow G_{out} = \boxed{6230 \text{ kg/h}}$

Part 'b'

Water balance: $1350 + 0.01\,G_{in} = x + 976$

$\Rightarrow 1350 + 0.01 \times 6100 = x + 976 \Rightarrow x = 435$ kg/h

Then, % mass of water in $G_{out} = \frac{x}{G_{out}} \times 100\% = \frac{435}{6230} \times 100\%$

$= \boxed{6.98\%}$ ← part 'c'