TRACER STUDIES IN A PLUG FLOW REACTOR

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ABSTRACT

Chemical reactors are vessels that contain chemical reactions. Different types of chemical, biological and physical processes take place in reactors. Some examples of reactors include lakes, rivers, and sedimentation tanks. The degree of mixing and residence time in reactors affect the degree of completion of reactions within the reactor. A plug flow reactor (PFR) is a type of chemical reactor where the influent is pumped into the pipe. Chemical reactions occur through the length of the PFR and the reaction rate is not a constant. In this study, tracer experiments were carried out in a PFR built in-house. Triplicate set of tracer study experiments were conducted for a conductivity range of 0-2000 µS/cm and a light sensor range of 0-600 lux. Also, an additional Run 4 was carried out with a light sensor range of 0-6000 lux. Concentrated NaCl solution coupled with food coloring agent (dye) was injected at the inlet of the tube. The characteristic response curves of the conductivity probe and the light sensor at the exit of the tube were analyzed. From the response curves, it was evident that there was a lag between the food color and salt profiles. The triplicate response curves obtained were found to be in good correlation with each other. Hence, the detection ranges chosen for the conductivity and light probes are acceptable for the study of characteristic tracer curves. Similar response curves were obtained for a light sensor range of 0-600 lux and 0-6000 lux, for a constant conductivity range of 0-2000 µS/cm. Higher light sensor ranges (0-150,000 lux) failed to generate response curves for indoor illumination. The theoretical retention time (RT) of the reactor was found to be 149s, while the experimental retention time was 179s. From the triplicate runs, the calculated t_{10}/RT values were 0.44 (0-2000 µS/cm) and 0.36 (0-6000 lux) respectively, and from Run 4, the calculated t_{10}/RT values were 0.44 (0-2000 µS/cm) and 0.37 (0-2000 µS/cm) respectively. These results indicate that similar response curves yield comparable t_{10} values. Hence a light sensor range of 0-600 lux or 0-6000 lux work well for tracer studies carried out using indoor lighting.

INTRODUCTION

Reactors play an important role in many production facilities involving the chemical transformation of substances. Their performance determines the reliability and suitability of a process, it's environmental safety, the consumption of energy and the raw materials required. It is difficult to classify industrial chemical apparatus due to their diversity; however, a distinction is made between stirred tank reactors and plug flow reactors.

Stirred tank reactors are mainly characterized by the following features:

1) Perfect mixing allows the reaction to take place in the entire reactor volume and avoids the formation of stagnant zones.
2) Inlet concentration is not equal to the outlet concentration.
3) The particle residence time distribution is the arithmetic mean of the residence time of all particles.
4) The reactor can be operated under isothermal conditions at steady state. This condition allows the reactor to be easily controlled.
5) The process temperature can be varied in a cascade of stirred reactors from one reactor to another. The stable mode of operation can be achieved when each reactor in the cascade is under isothermal conditions.

The features of a plug flow continuous reactor are as follows:

1) Flow is laminar, the properties of the reaction medium (i.e. pressure, temperature, reactant and product concentrations) are the same throughout the entire cross section of flow.
2) All the elemental volumes of the reaction medium remain in the reactor for the same period of time, and the change in concentration, temperature, and pressure with time are identical for each elemental volume.
3) Additionally, there are temperature and reactant concentration gradients along the length of the reactor.
4) The rate of chemical reactions vary along the length of the reactor.

Plug-flow reactors usually operate in adiabatic or nonisothermal conditions (Minsker and et.al ,1999). Consequently, from the standpoint of the kinetic parameters of a chemical reaction under isothermal conditions, plug-flow reactors are more efficient than stirred tank reactors, especially when both volumes are equal. However, in practice, stirred tank reactors are convenient to use and more profitable as compared to plug flow reactors.

Plug Flow Reactor

It is generally an elongated rectangular basin that is assumed to be well mixed radially and axially. The only concern is the non-uniform mixing in the longitudinal direction(x).

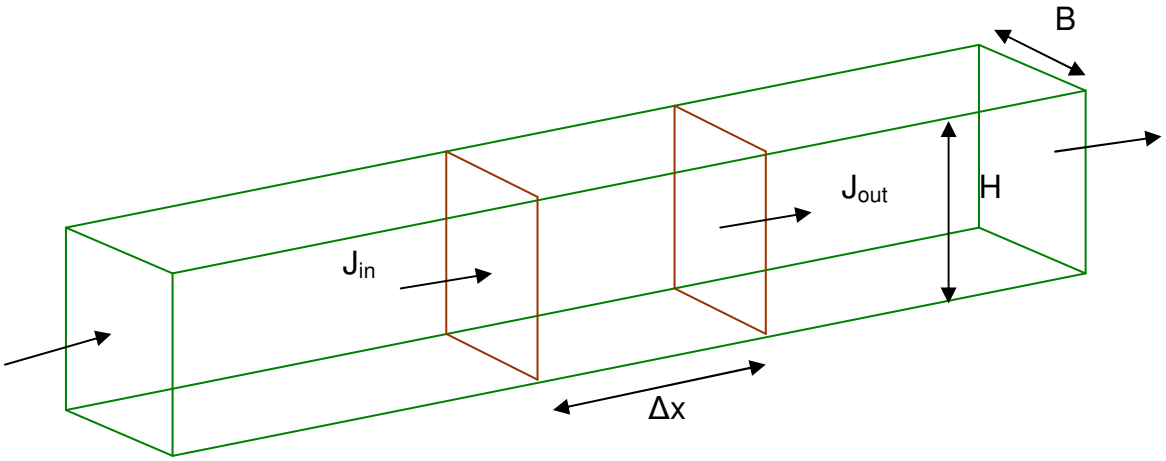

Figure1: An elongated rectangular reactor

Mass balance for a differential element of length Δx (Fig.1),

$$\Delta V \frac{\partial c}{\partial t} = J_{in} A_c - J_{out} A_c \pm reaction \qquad (1)$$

Where: ΔV= volume of the element =A_c Δx

A_c= crossectional area of the reactor= BH

B= Channel width

H= depth

J_{in} and J_{out} = flux of mass in and out of the elemnt due to transport

Reaction= gain or loss of mass within the element due to reaction

Advection dominates in a plug flow reactor. That means a plug of conservative dye introduced at one end will remain intact as it passes through the reactor (Fig. 2) or in other words, substances are discharged in the same sequence as they enter the reactor (Chapra,C.S, 1997).

The reactor flux into the element is defined as

$$J_{in} = Uc \tag{2}$$

Where: U= velocity =Q/A_c

The flux out is estimated by a first order Taylor series expansion.

$$J_{out} = U\left(c + \frac{\partial c}{\partial x}\Delta x\right) \tag{3}$$

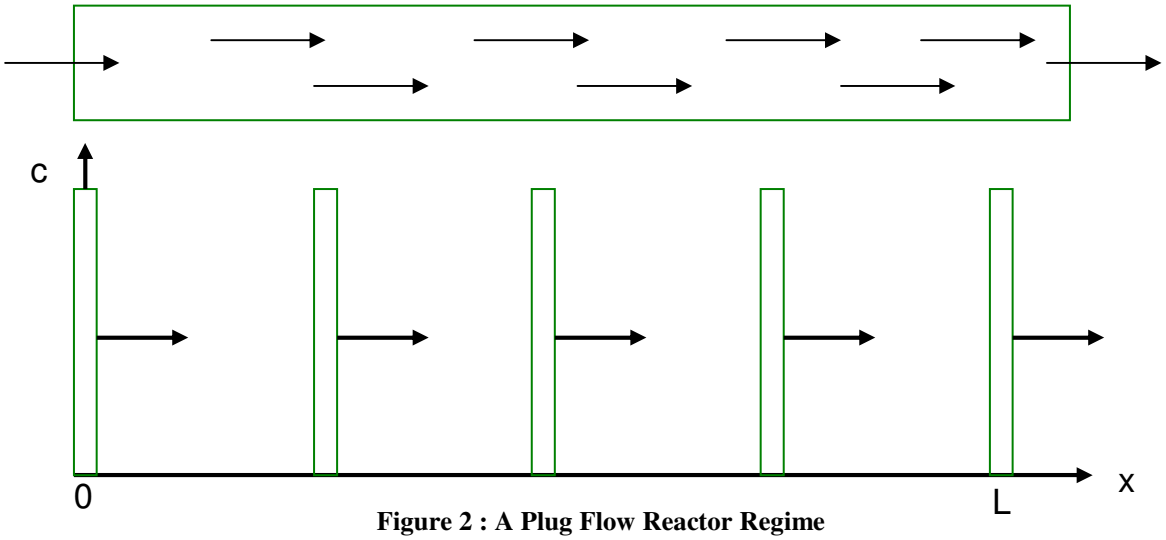

Figure 2 : A Plug Flow Reactor Regime

Finally assuming a first order decay reaction

$$\text{Reaction} = -k\Delta V\bar{c} \tag{4}$$

Where $\bar{c}$ denotes the average value for the element. Substituting the individual term into the equation (1)

$$\Delta V\frac{\partial c}{\partial t} = UA_c c - UA_c\left(c + \frac{\partial c}{\partial x}\Delta x\right) - k\Delta V\bar{c} \tag{5}$$

Combining terms

$$\Delta V \frac{\partial c}{\partial t} = -UA_c \frac{\partial c}{\partial x}\Delta x - k\Delta V\overline{c} \tag{6}$$

Dividing by $\Delta V = A_c \Delta x$ and taking the limit ($(\Delta x \to 0)$ yields

$$\frac{\partial c}{\partial t} = -U \frac{\partial c}{\partial x} - kc \tag{7}$$

At steady state this further modifies to

$$0 = -U \frac{dc}{dx} - kc \tag{8}$$

If $c=c_0$ at $x=0$ then , $$c = c_0 e^{-\frac{k}{U}x} \tag{9}$$

Equation (9) is an analytical relationship between sample concentration at any point in the reactor and the distance travelled by the sample in the reactor

OBJECTIVE

To build an experimental setup of a PFR, conduct tracer studies in the reactor and to generate characteristic tracer response curves using a Conductivity Probe and a Light Sensor

MATERIALS and METHODS

The plug flow reactor was designed using a 6 ft transparent PVC pipe purchased from Professional Plastics, Buffalo NY. The inner diameter of the pipe is 2 inches and the outer diameter is 2.25 inches. A 0.5 inch diameter hole was drilled towards the exit of the PVC pipe, to house the conductivity probe. The hole was sealed with a plastic fixture and two washers in order to avoid water leakage. One hole was drilled into each of the two rubber stoppers and sawed sections of a pipette were inserted through each hole. This offered flexibility while connecting the inlet and outlet tubes. The rubber stoppers were then inserted on either ends of the PVC pipe and were firmly fixed to the pipe using black duct tape. A three way valve was joined at the inlet of the PVC pipe. One end of the valve was joined to flexible tubing which in turn was connected to the tap. The other end of the valve, indicated by the green arrow in Fig. 3, was connected to a 5mL syringe. Figure 4 is a picture of the plug flow injection setup. The outlet was connected to flexible tubing which emptied into the sink. To allow uniform flow through the pipe, the pipe was set on a traditional laboratory stand placed at both ends (Fig. 4) and at the middle of the reactor.

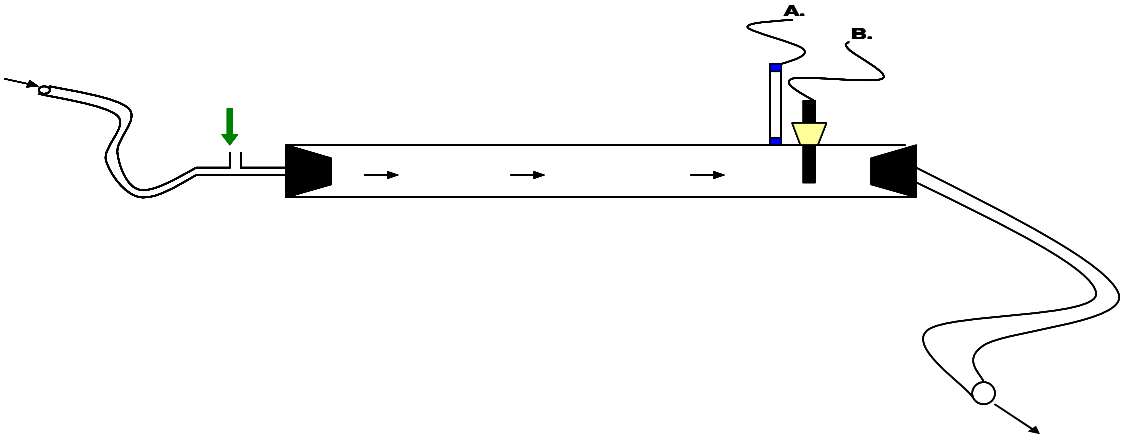

Figure 3 : Schematic of Plug Flow Reactor

A. Light Sensor Probe B. Conductivity Probe

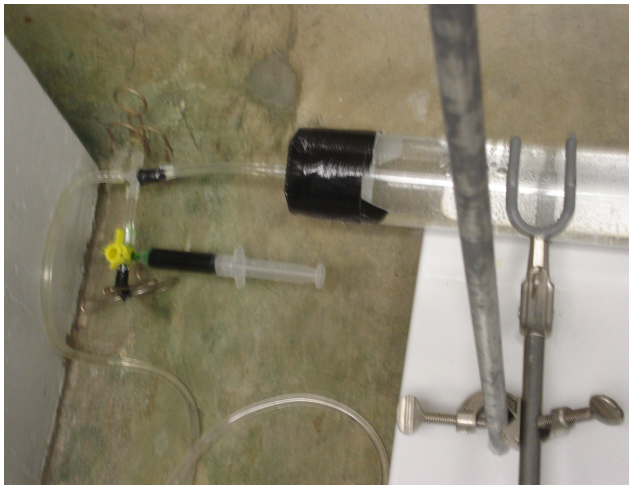

Figure 4 : Tracer Injection Setup

Figure 5 : Close up of a 3-way valve

A light sensor probe, a conductivity probe, LabPro software, and an interface for the probes, were purchased through Vernier, Beaverton OR. The conductivity probe was calibrated using a standard NaCl solution of 500mg/while the light sensor did not require any calibration. The conductivity probe has three settings which can be used to get the most sensitive and accurate readings. These settings are 0-200 µS/cm, 0-2000 µS/cm, and 0-20,000 µS/cm which correspond to 0-100 mg/L TDS as NaCl, 0-1000 mg/L TDS as NaCl, and 0-10000 mg/L TDS as NaCl respectively. For the experiments conducted, the chosen settings were 0-2000 µS/cm. Similarly the light sensor probe had three settings which included 0-600 lux (most sensitive range and useful at low levels of illumination), 0-6000 lux (good for general ranges of indoor light), and 0-150,000 lux (measurements in sunlight). For the triplicate set of experiments, the light sensor probe was set at 0-600 lux and 0-6000 lux. The conductivity probe was inserted into the drilled hole of the PVC pipe as described above. The light sensor was supported by a stand and positioned right above the PVC pipe. Also, the light probe was placed as close to the conductivity probe as possible in order to ensure comparable results. Indoor lighting was used for all the experiments.

The tracers used in this reactor were sodium chloride (NaCl) and dye (green color). A stock solution of sodium chloride was made at a concentration of 0.25 g/L and subsequently, 6 drops of food coloring agent (dye) were added to the solution. A tracer volume of 5mL was injected at the inlet of the reactor using a 5mL syringe. The flow rate of water used was 24.8mL/s and the volume of the reactor was 3.7L.

The LabPro interface was connected to the computer and data was analyzed through LabVIEW, National Instruments Corporation Austin TX. The operating diagram, Fig. 6, illustrates four channel plot areas and their corresponding median counters. The plots display amplitude (y-axis) versus time (x-axis). Two probes were used for the experiments, and hence only two channels were used.

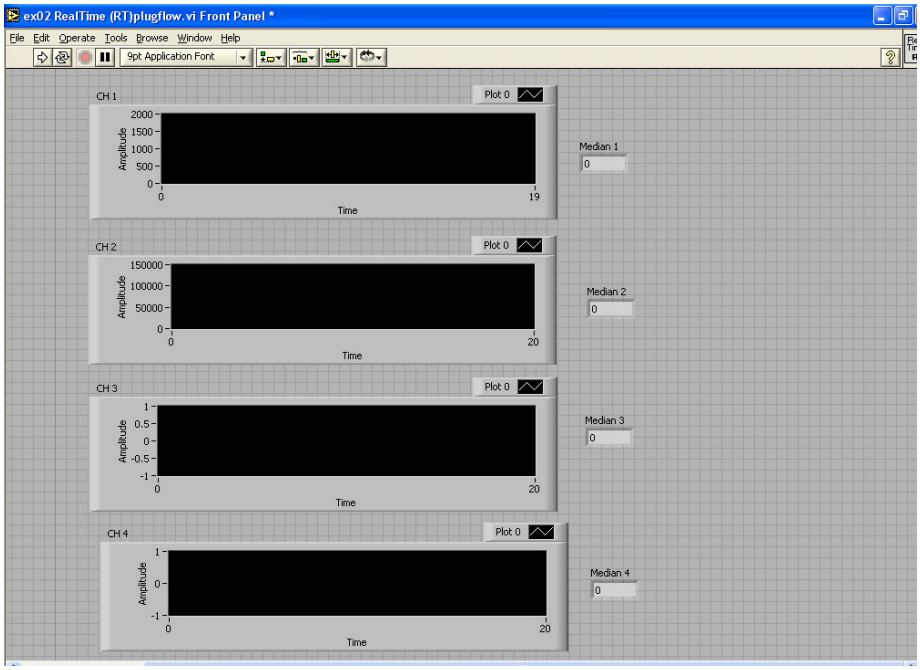

Figure 6 : LabView Operating Diagram

The block diagram for this experiment is illustrated in Fig. 7. Calibration of the conductivity probe was done by multiplying a factor of 0.982 to the Channel 1 output. This factor was obtained from the calibration experiments. The block diagram was created to export and save real-time data in Microsoft Excel. Additionally, a statistical analysis was added to compute the median output for each channel in real time.

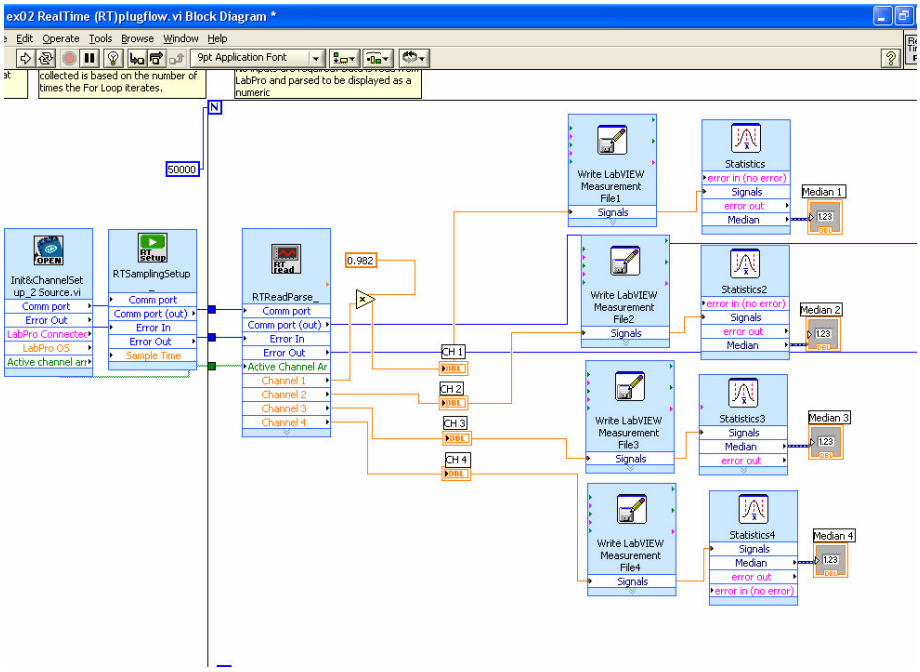

Figure 7 : LabView Block Diagram

RESULTS and DISCUSSION

The experiment involved the setup of an in-house PFR and included the application of a Conductivity Probe and a Light Sensor for tracer studies. The Conductivity Probe was set to a mid range of 2000 µS/cm for all the experiments. A triplicate set of runs were carried out using the Conductivity Probe and a Light Sensor. The Light Sensor was set to a range of 0-600 lux, which corresponds to low levels of light intensity. Triplicate runs were carried out to demonstrate reproducibility.

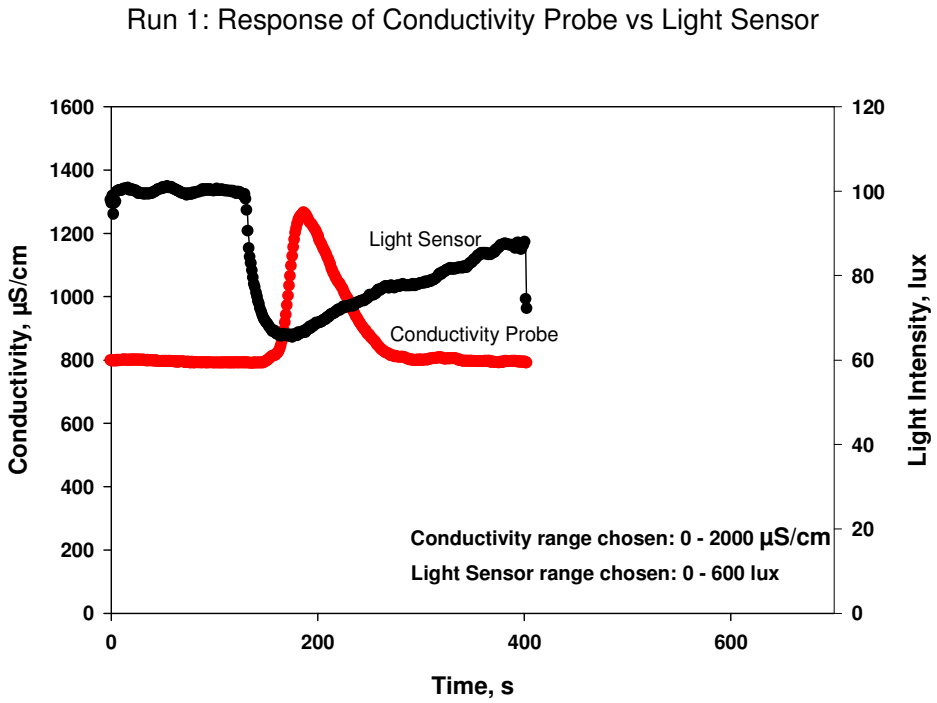

Figure 8 : Response of Conductivity Probe vs Light Sensor (Run 1)

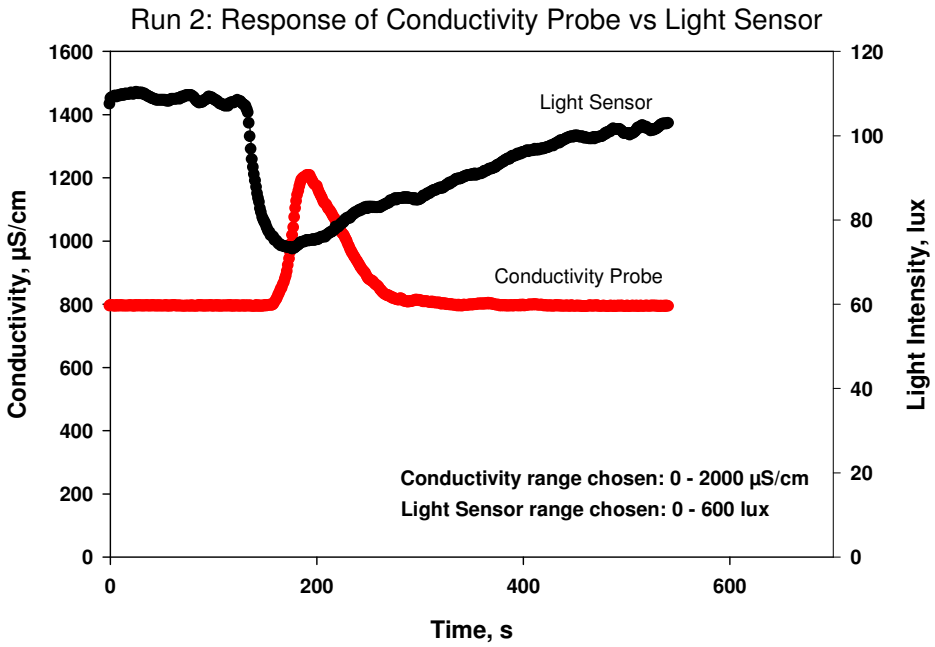

Figure 9 : Response of Conductivity Probe vs Light Sensor (Run 2)

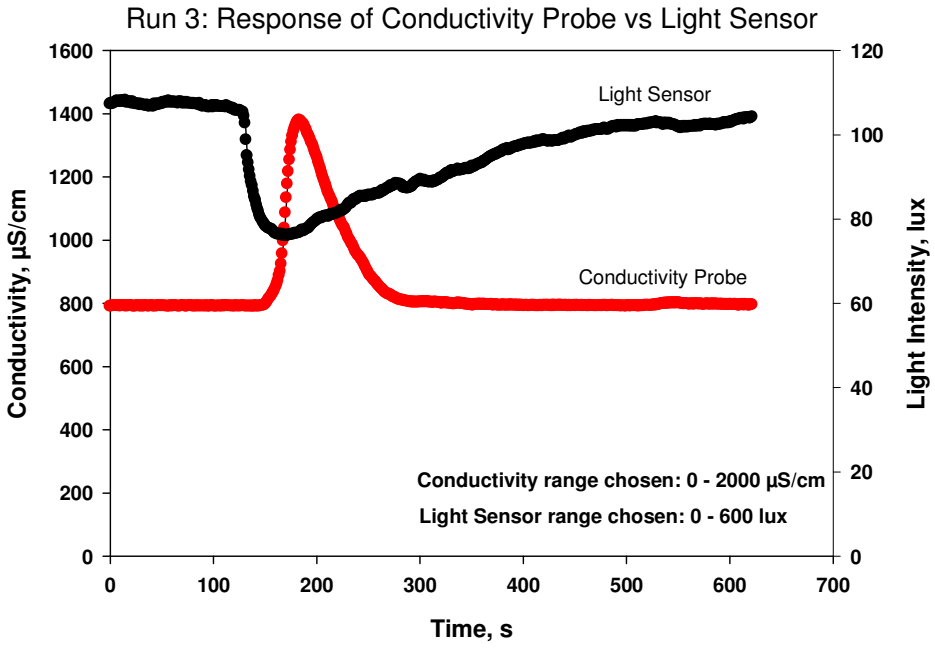

Figure 10 : Response of Conductivity Probe vs Light Sensor (Run 3)

In Run1, 2 and 3, an initial tracer concentration (NaCl + dye) of 0.25g/ml was injected as a slug input into a PFR having a constant flowrate of 24.8ml/s, and the corresponding response of the sensors with respect to conductivity and light intensity at the end of the

PFR were observed. Fig. 8, Fig. 9 and Fig. 10 clearly show that the salt arrives later at the exit of the PFR when compared to the dye. However, the response curve also shows that the salt exits quicker than the dye (as seen by the plateau towards the tail of the conductivity and light intensity curves). The maximum conductivity measured by each run was in the range of 1200-1400 µS/cm, while a maximum light intensity was in the range of 800-1000 lux.

In Fig. 11, the Light Senor setting was adjusted to 0 – 6000 lux. This range corresponds to indoor light intensity and was found to give a good response as well.

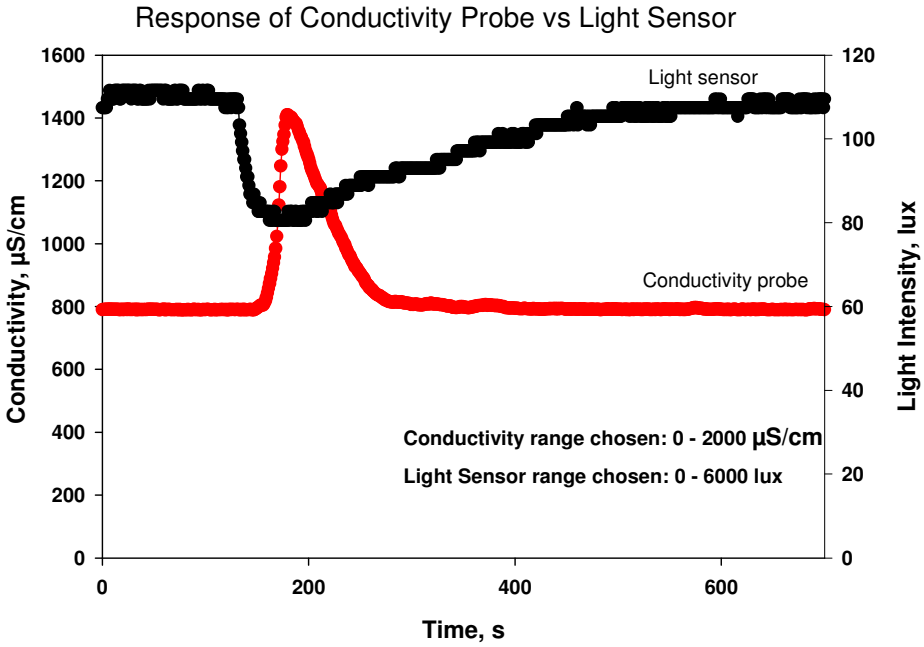

Figure 11 : Response of Conductivity Probe vs Light Sensor

The theoretical retention time (RT, the total time a sample remains in the PFR) of the PFR was found to be 149s, while the experimental retention time was approximately 179s as shown in Fig. 12. We also infer that the maximum dissociation of salt (~52%) for Run 4 in Fig. 12, directly corresponds to the experimental retention time.

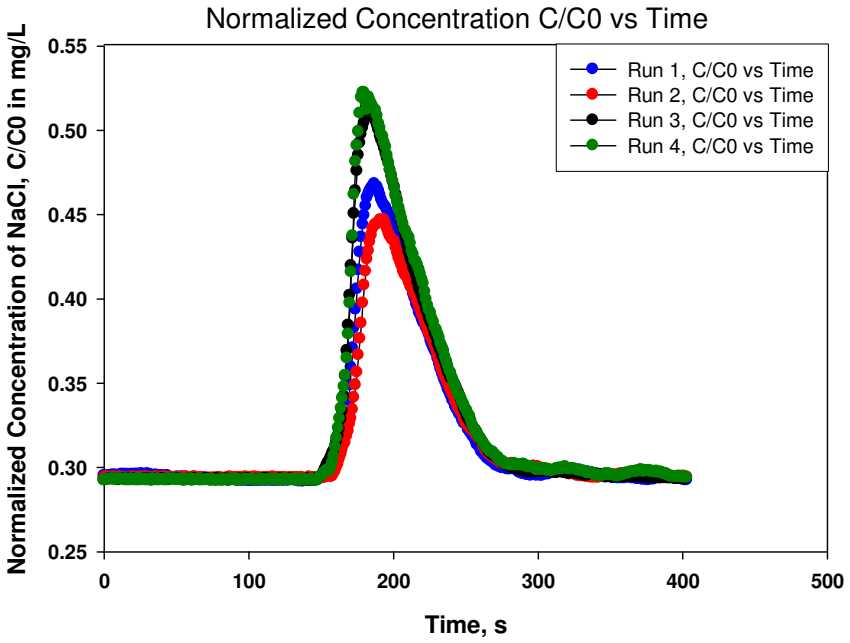

Figure 12 : Normalized Concentration C/C0 vs Time

t_{10} values (time taken for 10% of the tracer to exit the pipe), were obtained for a Conductivity range of 0-2000 µS/cm and a Light Intensity range of 0-600 lux and 0-6000 lux as shown in the Table 1 and Table 2.

Table 1 :Triplicate Run

Parameter / Time, s	Conductivity (0-2000 µS/cm)	Light Intensity (0-600 lux)
t_{10}	66	55
t_{10}/RT	0.442953	0.369128

Table 2 :Run 4

Parameter / Time, s	Conductivity 0-2000, µS/cm	Light Intensity 0-6000, lux
t_{10}	66	56
t_{10}/RT	0.442953	0.375839

The value t_{10}/RT is used as a measure plug flow. For ideal plug flow, the ratio of t_{10}/ RT should be equal to unity. As this value reduces, the performance of the plug flow reactor diminishes. The results from Table 1 and Table 2 indicate that t_{10} for the Light sensor is lower than the Conductivity Probe. Hence, it takes lesser time for the dye to exit the PFR as compared to the salt. A deviation from ideal flow could be due to the following reasons:

1) Poor selection of the injection point
2) Improper injection technique
3) Temperature variations along the pipe
4) Axial mixing
5) Incomplete mixing in the radial direction
6) Non uniform velocity profile along the cross section of the pipe

It was also observed that the Light Probe is very sensitive to small variations in intensity of light, and this can be demonstrated from Fig. 8 (towards the tail of the response curve) where a small change in light intensity could be picked up by the Light Probe, but not by the human eye. In summary, the Conductivity Probe and Light Sensor offered good responses indicating reasonable plug flow behavior within the pipe.

CONCLUSIONS

1. The tracer responses obtained from the triplicate runs (0-2000µS/cm, 0-600 lux) were in good correlation with each other.
2. A conductivity range of 0-2000 µS/cm and a Light Sensor range of 0-600 lux or 0-6000 lux work well for tracer studies that are carried out using indoor lighting.
3. The value of t10 for NaCl and dye are 66s and 56s respectively. Hence, there exists a lag between the response curves for Conductivity and Light Intensity

SCOPE for FUTURE WORK

1. To carry out triplicate runs for remaining ranges of Conductivity and Light Intensity.
2. To inject the tracer slug, perpendicular to flow and near the inlet of the reactor.
3. To study tracer response curves, where several reactor tubes are coupled together, to create a single PFR setup.

REFERENCES

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2. Minsker, K.S; Zakharov, V, P; Berlin, A.A. (1999). " Plug flow tubular turbulent Reactors: A new type of industrial apparatus".
3. Chapra,C.S, (1997). " Surface water quality modleing". WCB/McGraw-Hill.

APPENDIX-1

SAMPLE CALCULATION

Specification of the pipe:

Diameter= 2 inch

Length = 6 ft.

Measured flow rate, Q= 24.8 mL/s.

Area of the reactor= $\frac{\pi}{4}d^2 =$

$= \frac{\pi}{4}(2x2)^2 = 20.26cm^2$

Volume of the reactor = Area x Length= $20.26 \times 6 \times 12 \times 2.54 = 3705.14cm^3$

$Q = Area \times Velocity$

$\Rightarrow 24.8mL/s = 20.26cm^2 \times Velocity$

$\Rightarrow Velocity = 1.22cm/s$

$time = \frac{Volume}{Q} = \frac{3705.14}{24.8} = 149.4s$

So, the residence time of the reactor, RT= 149.4 s

Initial Concentration:

$C_0 = \frac{mass}{Volume} = \frac{mass}{Volume} = \frac{5gm}{3705.14} = 0.0013496gm/cm^3 = 1349.6mg/L$

Ratio of t_{10}/RT:

t_{10} = time taken for 10 % of the tracer mass to exit the reactor.

= 66 s for conductivity probe for a range of 0-2000 μS/cm

t_{10} = time taken for 10 % of the tracer mass to exit the reactor.

= 55 s for light probe for a range of 0-600 lux

t_{10}/RT= 66/149.4=0.44 for Conductivity probe with above mentioned range.

t_{10}/RT= 55/149.4=0.36 for Light probe with above mentioned range.

Appendix-II

Data from LabVIEW

Table 3: Run 1

Time(s)	Conductivity(µS/cm)	Light(lux)
0	796.39709	97.7778
1.001	795.38072	97.0256
1.993	795.38072	98.7179
2.994	796.39709	94.3932
3.996	795.38072	97.0256
4.997	795.38072	97.4017
5.999	797.412478	99.6581
7	795.38072	99.8462
8.001	797.412478	100.034
8.993	796.39709	100.034
9.994	796.39709	100.034
10.996	796.39709	100.034
11.997	798.428848	100.222
12.999	798.428848	100.41
14	798.428848	100.41
14.992	797.412478	100.41
15.993	798.428848	100.41
16.994	796.39709	100.598
17.996	797.412478	100.222
18.997	798.428848	100.034
19.999	797.412478	100.222
21	798.428848	100.222
21.992	798.428848	100.034
22.993	798.428848	99.8462
23.994	798.428848	100.034
24.996	797.412478	99.8462
25.997	799.444236	99.6581
26.999	798.428848	99.2821
28	797.412478	99.4701
28.992	797.412478	99.2821

Table 4: Run 2

Time(s)	Conductivity(µS/cm)	Light(lux)
0	792.333574	107.368
1.001	794.365332	108.684
2.003	794.365332	108.872
3.004	792.333574	108.872
4.006	792.333574	109.06
4.997	793.349944	109.248
5.998	791.318186	109.248
7	794.365332	109.06
8.001	793.349944	109.248
9.003	792.333574	109.436
10.004	792.333574	109.248
11.006	794.365332	109.436
11.997	792.333574	109.624
12.998	793.349944	109.436
14	792.333574	109.436
15.001	792.333574	109.624
16.003	792.333574	109.812
17.004	792.333574	109.624
17.996	792.333574	109.624
18.997	792.333574	109.624
19.999	794.365332	109.812
21	792.333574	110
22.001	792.333574	109.812
23.003	793.349944	109.624
24.004	791.318186	109.812
24.996	793.349944	110
25.997	794.365332	110.188
26.999	792.333574	110
28	792.333574	109.812
29.002	794.365332	110

29.993	799.444236	99.2821	30.003	792.333574	109.812
30.995	796.39709	99.2821	31.004	792.333574	110
31.996	798.428848	99.094	31.996	793.349944	109.812
32.997	796.39709	99.2821	32.997	793.349944	109.624
33.999	796.39709	99.094	33.999	792.333574	109.812
34.99	795.38072	99.2821	35	792.333574	109.436
35.992	797.412478	99.2821	36.002	794.365332	109.436
36.993	795.38072	99.094	37.003	792.333574	109.248
37.995	796.39709	99.2821	37.994	792.333574	109.06
38.996	796.39709	99.2821	38.996	793.349944	109.06
39.997	795.38072	99.2821	39.997	792.333574	108.872
40.989	796.39709	99.4701	40.999	793.349944	108.684
41.99	795.38072	99.6581	42	794.365332	108.684
42.992	794.365332	99.6581	43.002	793.349944	108.496
43.993	796.39709	99.8462	44.003	792.333574	108.496
44.995	794.365332	100.034	44.995	793.349944	108.308
45.996	793.349944	100.222	45.996	792.333574	108.308
46.998	793.349944	100.222	46.997	793.349944	108.308
47.999	793.349944	100.41	47.999	793.349944	108.308
48.99	793.349944	100.41	49	793.349944	108.308
49.992	793.349944	100.41	50.002	792.333574	108.308
50.993	794.365332	100.786	50.993	792.333574	108.308
51.995	793.349944	100.598	51.995	792.333574	108.308
52.996	793.349944	100.598	52.996	792.333574	108.308
53.998	794.365332	100.786	53.997	793.349944	108.308
54.989	792.333574	100.974	54.999	794.365332	108.12
55.99	793.349944	100.786	56	791.318186	108.12
56.992	794.365332	100.598	57.002	792.333574	108.12
57.993	793.349944	100.786	57.993	792.333574	108.12
58.995	793.349944	100.786	58.995	793.349944	108.308
59.996	792.333574	100.598	59.996	792.333574	108.496
60.998	793.349944	100.41	60.998	792.333574	108.496
61.989	793.349944	100.222	61.999	794.365332	108.496
62.991	791.318186	100.222	63	794.365332	108.496
63.992	793.349944	100.034	63.992	792.333574	108.496

64.993	791.318186	99.8462	64.993	792.333574	108.496
65.995	791.318186	99.8462	65.995	792.333574	108.684
66.996	792.333574	99.6581	66.996	793.349944	108.684
67.998	792.333574	99.4701	67.998	792.333574	108.496
68.989	792.333574	99.4701	68.999	792.333574	108.872
69.991	792.333574	99.2821	70	792.333574	109.06
70.992	792.333574	99.2821	71.002	791.318186	108.872
71.993	790.301816	99.2821	71.993	792.333574	109.06
72.995	790.301816	99.094	72.995	791.318186	109.248
73.996	791.318186	98.906	73.996	792.333574	109.248
74.988	791.318186	99.2821	74.998	792.333574	109.436
75.989	791.318186	99.2821	75.999	792.333574	109.248
76.991	789.286428	99.094	76.991	792.333574	109.436
77.992	789.286428	99.094	77.992	791.318186	109.436
78.994	791.318186	99.094	78.993	793.349944	109.436
79.995	789.286428	99.4701	79.995	793.349944	109.248
80.996	789.286428	99.2821	80.996	792.333574	109.06
81.988	789.286428	99.4701	81.998	791.318186	108.872
82.989	790.301816	99.4701	82.999	792.333574	108.496
83.991	790.301816	99.6581	84.001	791.318186	108.12
84.992	790.301816	99.6581	84.992	792.333574	108.12
85.994	788.270058	99.6581	85.993	793.349944	107.744
86.995	790.301816	99.8462	86.995	794.365332	107.556
87.986	789.286428	99.8462	87.996	793.349944	107.744
88.988	789.286428	100.222	88.998	793.349944	107.744
89.989	790.301816	99.8462	89.999	793.349944	107.744
90.991	790.301816	100.222	90.991	793.349944	107.932
91.992	788.270058	100.034	91.992	791.318186	108.308
92.994	789.286428	100.222	92.994	793.349944	108.308
93.995	789.286428	100.034	93.995	793.349944	108.496
94.987	790.301816	100.222	94.996	792.333574	108.684
95.988	788.270058	100.034	95.998	792.333574	109.06
96.989	790.301816	100.222	96.989	793.349944	109.06
97.991	790.301816	100.034	97.991	794.365332	108.684
98.992	788.270058	100.034	98.992	793.349944	108.872

99.994	788.270058	99.8462	99.994	791.318186	108.684
100.985	788.270058	100.034	100.995	793.349944	108.496
101.987	788.270058	100.034	101.996	792.333574	108.308
102.988	790.301816	100.41	102.998	792.333574	108.308
103.989	788.270058	100.034	103.989	794.365332	107.932
104.991	788.270058	100.034	104.991	791.318186	107.932
105.992	788.270058	100.034	105.992	793.349944	107.556
106.994	789.286428	100.034	106.994	793.349944	107.368
107.985	788.270058	100.222	107.995	791.318186	107.368
108.987	789.286428	100.034	108.997	792.333574	107.179
109.988	789.286428	100.034	109.998	792.333574	107.179
110.99	790.301816	99.8462	110.989	793.349944	106.991
111.991	788.270058	100.034	111.991	792.333574	106.803
112.992	789.286428	99.8462	112.992	792.333574	106.991
113.994	789.286428	99.8462	113.994	793.349944	107.179
114.985	788.270058	99.8462	114.995	793.349944	106.803
115.987	789.286428	99.8462	115.997	793.349944	107.368
116.988	788.270058	99.8462	116.988	794.365332	107.556
117.99	789.286428	99.6581	117.989	791.318186	107.556
118.991	788.270058	99.8462	118.991	793.349944	107.744
119.993	789.286428	99.6581	119.992	791.318186	107.556
120.994	789.286428	99.4701	120.994	793.349944	107.744
121.985	790.301816	99.2821	121.995	793.349944	107.932
122.987	789.286428	99.6581	122.997	792.333574	107.932
123.988	788.270058	99.6581	123.988	793.349944	108.308
124.99	789.286428	99.4701	124.99	793.349944	107.932
125.991	790.301816	99.4701	125.991	791.318186	107.932
126.993	788.270058	99.094	126.992	792.333574	107.932
127.984	789.286428	98.906	127.994	792.333574	107.556
128.985	790.301816	99.094	128.995	793.349944	107.368
129.987	789.286428	99.094	129.997	793.349944	107.179
130.988	789.286428	97.9658	130.988	791.318186	106.991
131.99	789.286428	95.3333	131.99	793.349944	106.803
132.991	790.301816	90.4445	132.991	792.333574	106.051
133.993	788.270058	86.3077	133.992	793.349944	105.299

134.984	787.25467	84.2393	134.994	792.333574	102.855
135.986	788.270058	82.735	135.995	792.333574	99.6581
136.987	787.25467	81.0427	136.987	793.349944	96.6496
137.988	787.25467	79.3504	137.988	791.318186	94.2051
138.99	789.286428	77.8462	138.99	791.318186	92.3248
139.991	789.286428	77.094	139.991	791.318186	90.6325
140.993	788.270058	75.7778	140.993	791.318186	89.1282
141.984	788.270058	74.8376	141.994	794.365332	87.6239
142.986	788.270058	73.7094	142.995	791.318186	86.1197
143.987	789.286428	73.1453	143.987	793.349944	84.9915
144.988	788.270058	72.0171	144.988	791.318186	84.0513
145.99	788.270058	71.265	145.99	793.349944	82.547
146.981	789.286428	70.5128	146.991	791.318186	81.6068
147.983	789.286428	69.9487	147.993	791.318186	80.4786
148.984	791.318186	69.3846	148.994	793.349944	79.9145
149.986	793.349944	69.0085	149.995	792.333574	79.3504
150.987	794.365332	68.6325	150.987	794.365332	78.9744
151.989	796.39709	68.4444	151.988	792.333574	78.2222
152.99	799.444236	68.0684	152.99	794.365332	77.6581
153.981	801.475994	67.6923	153.991	794.365332	77.094
154.983	805.53951	67.3162	154.993	795.38072	76.906
155.984	808.586656	66.9402	155.994	795.38072	76.1538
156.986	809.603026	66.5641	156.986	794.365332	76.1538
157.987	811.633802	66.7521	157.987	795.38072	75.9658
158.989	811.633802	66.7521	158.988	799.444236	75.7778
159.99	813.66556	66.188	159.99	803.507752	75.0256
160.981	817.729076	66	160.991	809.603026	75.0256
161.983	820.776222	66	161.993	814.68193	74.8376
162.984	826.871496	65.812	162.994	822.80798	74.4615
163.986	832.965788	65.6239	163.986	829.918642	74.0855
164.987	843.124578	65.4359	164.987	838.045674	74.0855
165.989	855.314144	65.812	165.988	846.171724	73.7094
166.98	873.598984	66	166.99	849.21887	73.7094
167.982	890.867454	65.6239	167.991	859.37766	73.7094
168.983	916.262956	65.812	168.993	867.50371	73.5214

169.984	940.642088	65.812	169.984	878.677888	73.5214
170.986	970.101106	65.6239	170.986	887.820308	73.5214
171.987	1000.57944	65.812	171.987	902.041632	73.3333
172.989	1032.06236	65.4359	172.989	921.34186	73.3333
173.98	1062.54364	65.4359	173.99	941.658458	73.3333
174.982	1095.04784	65.812	174.991	961.974074	73.3333
175.983	1125.5193	65.2479	175.993	989.40428	73.1453
176.984	1153.96784	65.812	176.984	1015.81026	72.9573
177.986	1178.34108	65.6239	177.986	1040.19332	73.3333
178.987	1198.65866	65.812	178.987	1072.69752	73.1453
179.989	1212.87802	66	179.989	1101.13624	73.3333
180.98	1228.11866	65.6239	180.99	1123.48656	73.5214
181.982	1241.32656	66.3761	181.991	1142.79268	73.7094
182.983	1247.41496	66	182.993	1155.99076	73.8974
183.985	1252.50172	66.3761	183.984	1170.21994	74.0855
184.986	1256.55738	66.188	184.986	1181.38528	74.4615
185.987	1259.6114	66.5641	185.987	1191.54898	74.4615
186.979	1263.66706	66.3761	186.989	1195.61446	74.6496
187.98	1260.62286	66.7521	187.99	1198.65866	74.6496
188.982	1258.59012	66.3761	188.992	1198.65866	74.6496
189.983	1252.50172	67.1282	189.983	1201.70286	74.8376
190.985	1245.38222	66.9402	190.984	1205.76834	75.0256
191.986	1238.27254	67.1282	191.986	1204.75688	75.0256
192.987	1232.18414	67.6923	192.987	1205.76834	74.8376
193.979	1229.13012	67.3162	193.989	1205.76834	75.0256
194.98	1226.08592	67.6923	194.99	1198.65866	75.0256
195.982	1221.00898	68.0684	195.992	1191.54898	75.0256
196.983	1214.91076	67.8803	196.983	1184.4393	75.2137
197.985	1210.84528	68.2564	197.984	1179.36236	75.0256
198.986	1204.75688	68.6325	198.986	1175.29688	75.0256
199.978	1197.6472	68.4444	199.987	1173.26414	75.2137
200.979	1189.51624	68.6325	200.989	1171.2314	75.4017
201.98	1179.36236	68.6325	201.99	1161.07752	75.2137
202.982	1171.2314	68.8205	202.992	1152.94656	75.4017
203.983	1166.15446	68.8205	203.983	1144.82542	75.5897

204.985	1158.0235	69.0085	204.985	1138.7272	75.7778
205.986	1151.9351	69.1966	205.986	1132.62898	75.7778
206.978	1144.82542	69.3846	206.987	1124.50784	75.7778
207.979	1137.70592	69.3846	207.989	1118.40962	75.9658
208.98	1131.61752	69.5726	208.99	1115.36542	75.7778
209.982	1122.4751	69.9487	209.992	1112.3114	76.1538
210.983	1115.36542	69.9487	210.983	1106.223	76.3419
211.985	1106.223	70.1367	211.985	1099.11332	76.5299
212.986	1099.11332	70.5128	212.986	1096.0593	76.7179
213.978	1086.91688	70.7009	213.988	1090.98236	76.906
214.979	1080.82848	70.7009	214.989	1085.90542	76.906
215.981	1071.68606	70.8889	215.99	1080.82848	77.094
216.982	1066.5993	70.8889	216.982	1074.73026	77.2821
217.983	1057.45688	71.265	217.983	1069.65332	77.4701
218.985	1053.40122	71.265	218.985	1062.54364	78.2222
219.976	1046.29154	71.641	219.986	1054.41268	78.0342
220.978	1041.20478	71.8291	220.988	1050.3472	78.0342
221.979	1039.17204	71.641	221.989	1044.2588	78.2222
222.981	1033.08364	71.8291	222.98	1038.16058	78.5983
223.982	1028.0067	72.0171	223.982	1030.02962	78.7863
224.983	1021.90848	72.3932	224.983	1023.94122	79.1624
225.985	1012.76606	72.3932	225.985	1019.87574	79.1624
226.986	1006.66784	72.2051	226.986	1015.81026	79.3504
227.978	1000.57944	72.3932	227.988	1009.72186	79.9145
228.979	996.51396	72.5812	228.989	1003.62364	79.9145
229.981	991.43702	72.3932	229.981	997.52542	80.2906
230.982	983.30606	72.5812	230.982	988.383	80.1026
231.984	975.18001	72.7692	231.983	981.275284	80.4786
232.985	967.05396	72.7692	232.985	973.148252	80.2906
233.976	959.942316	72.9573	233.986	966.03759	80.6667
234.978	952.831654	72.5812	234.988	959.942316	81.0427
235.979	947.75275	72.9573	235.989	954.863412	81.2308
236.981	941.658458	72.9573	236.981	948.76912	81.2308
237.982	934.547796	73.3333	237.982	944.705604	81.6068
238.984	929.46791	73.3333	238.983	937.594942	81.6068

239.985	924.389006	73.5214	239.985	933.531426	81.7949
240.976	917.278344	73.5214	240.986	927.437134	81.9829
241.978	914.231198	73.7094	241.988	923.373618	82.1709
242.979	907.120536	73.8974	242.989	916.262956	81.9829
243.981	903.05702	73.8974	243.981	912.19944	82.359
244.982	898.994486	73.8974	244.982	906.105148	82.359
245.974	893.9146	73.8974	245.984	903.05702	82.359
246.975	891.883824	74.2735	246.985	898.994486	82.735
247.977	884.77218	74.2735	247.986	895.946358	82.547
248.978	879.693276	74.4615	248.988	887.820308	82.9231
249.979	879.693276	74.6496	249.979	881.725034	82.547
250.981	876.64613	75.2137	250.981	877.6625	82.9231
251.982	869.535468	75.2137	251.982	875.630742	82.9231
252.984	866.488322	75.2137	252.984	873.598984	82.9231
253.975	863.440194	75.2137	253.985	870.550856	82.9231
254.977	859.37766	75.2137	254.986	870.550856	82.735
255.978	857.345902	75.5897	255.978	866.488322	82.9231
256.979	852.266998	75.5897	256.979	862.424806	82.735
257.981	846.171724	75.9658	257.981	859.37766	82.735
258.982	844.139966	76.3419	258.982	857.345902	82.735
259.974	841.09282	76.5299	259.984	854.298756	82.735
260.975	834.997546	76.3419	260.985	851.250628	82.9231
261.977	832.965788	76.5299	261.987	844.139966	82.735
262.978	828.903254	76.7179	262.988	842.108208	82.9231
263.98	827.886884	76.906	263.979	837.029304	83.1111
264.981	823.82435	76.906	264.981	834.997546	83.2991
265.982	822.80798	77.2821	265.982	830.935012	83.2991
266.974	820.776222	77.2821	266.984	828.903254	83.4872
267.975	818.744464	77.2821	267.985	826.871496	83.6752
268.977	817.729076	76.906	268.987	825.855126	83.6752
269.978	816.713688	76.906	269.978	825.855126	83.8633
270.98	812.650172	77.094	270.979	823.82435	83.8633
271.981	813.66556	77.4701	271.981	820.776222	84.4274
272.972	810.618414	77.094	272.982	820.776222	84.4274
273.974	811.633802	77.094	273.984	816.713688	84.4274

274.975	808.586656	76.906	274.985	817.729076	84.6154
275.977	809.603026	77.2821	275.987	814.68193	84.8034
276.978	808.586656	77.2821	276.978	814.68193	84.9915
277.98	807.571268	77.4701	277.98	812.650172	84.6154
278.981	806.554898	77.2821	278.981	812.650172	84.8034
279.973	806.554898	77.2821	279.982	810.618414	84.9915
280.974	806.554898	77.4701	280.984	814.68193	84.9915
281.975	807.571268	77.4701	281.985	815.697318	84.9915
282.977	806.554898	77.8462	282.977	814.68193	84.9915
283.978	806.554898	77.6581	283.978	811.633802	84.9915
284.98	805.53951	77.4701	284.98	807.571268	85.1795
285.981	804.52314	77.4701	285.981	807.571268	84.9915
286.973	801.475994	77.4701	286.982	806.554898	85.1795
287.974	801.475994	77.4701	287.984	805.53951	84.9915
288.975	799.444236	77.4701	288.975	804.52314	85.1795
289.977	799.444236	77.4701	289.977	806.554898	84.9915
290.978	798.428848	77.6581	290.978	805.53951	84.9915
291.98	798.428848	77.4701	291.98	806.554898	84.9915
292.981	797.412478	77.8462	292.981	806.554898	84.9915
293.973	797.412478	77.6581	293.983	808.586656	84.9915
294.974	796.39709	77.4701	294.984	808.586656	84.6154
295.976	797.412478	77.6581	295.975	809.603026	84.9915
296.977	797.412478	77.6581	296.977	811.633802	84.6154
297.978	798.428848	77.8462	297.978	810.618414	84.6154
298.98	796.39709	77.8462	298.98	810.618414	84.6154
299.971	798.428848	78.0342	299.981	810.618414	84.8034
300.973	798.428848	78.0342	300.983	808.586656	84.8034
301.974	796.39709	78.0342	301.984	808.586656	84.9915
302.976	796.39709	78.2222	302.975	807.571268	85.1795
303.977	799.444236	78.0342	303.977	805.53951	85.5556
304.979	799.444236	78.4103	304.978	806.554898	85.5556
305.98	798.428848	78.2222	305.98	805.53951	85.5556
306.971	798.428848	78.2222	306.981	806.554898	85.7436
307.973	799.444236	78.4103	307.983	805.53951	86.1197
308.974	801.475994	78.5983	308.974	804.52314	86.1197

309.976	800.460606	78.4103	309.976	803.507752	86.1197
310.977	802.491382	78.7863	310.977	803.507752	86.4957
311.979	801.475994	78.7863	311.978	805.53951	86.4957
312.98	803.507752	78.7863	312.98	802.491382	86.6838
313.971	802.491382	78.9744	313.981	804.52314	86.8718
314.973	803.507752	79.1624	314.983	802.491382	86.8718
315.974	804.52314	79.3504	315.974	801.475994	86.8718
316.976	805.53951	79.7265	316.976	802.491382	87.0598
317.977	804.52314	80.1026	317.977	801.475994	87.2479
318.969	805.53951	80.2906	318.978	802.491382	87.2479
319.97	805.53951	80.1026	319.98	801.475994	87.4359
320.971	804.52314	80.2906	320.981	799.444236	87.4359
321.973	803.507752	80.6667	321.973	798.428848	87.4359
322.974	800.460606	80.6667	322.974	800.460606	87.4359
323.976	800.460606	80.8547	323.976	799.444236	87.6239
324.977	800.460606	81.0427	324.977	798.428848	87.812
325.979	802.491382	81.2308	325.979	799.444236	88
326.97	802.491382	81.2308	326.98	796.39709	88.188
327.972	800.460606	81.4188	327.981	796.39709	88.188
328.973	802.491382	81.6068	328.973	797.412478	88.5641
329.974	802.491382	81.4188	329.974	795.38072	88.3761
330.976	801.475994	81.4188	330.976	797.412478	88.7521
331.977	802.491382	81.4188	331.977	795.38072	88.7521
332.969	801.475994	81.4188	332.979	795.38072	88.9402
333.97	802.491382	81.4188	333.98	794.365332	89.1282
334.972	801.475994	81.6068	334.981	795.38072	89.3162
335.973	800.460606	81.6068	335.973	794.365332	89.5043
336.975	797.412478	81.7949	336.974	793.349944	89.5043
337.976	798.428848	81.6068	337.976	795.38072	89.6923
338.967	797.412478	81.7949	338.977	793.349944	89.5043
339.969	795.38072	81.7949	339.979	794.365332	89.6923
340.97	795.38072	81.6068	340.98	793.349944	89.6923
341.972	794.365332	81.9829	341.972	793.349944	89.8803
342.973	795.38072	81.9829	342.973	795.38072	90.0684
343.975	794.365332	81.7949	343.974	795.38072	90.0684

344.976	795.38072	81.7949	344.976	794.365332	90.2564
345.967	794.365332	82.1709	345.977	794.365332	90.2564
346.969	793.349944	82.359	346.979	795.38072	90.4445
347.97	794.365332	82.735	347.98	794.365332	90.4445
348.972	795.38072	82.9231	348.972	796.39709	90.4445
349.973	794.365332	82.9231	349.973	796.39709	90.4445
350.975	793.349944	83.2991	350.974	795.38072	90.6325
351.976	793.349944	83.6752	351.976	795.38072	90.4445
352.968	793.349944	83.6752	352.977	797.412478	90.6325
353.969	793.349944	84.0513	353.979	796.39709	90.8205
354.97	792.333574	84.2393	354.97	796.39709	90.4445
355.972	792.333574	84.6154	355.972	798.428848	90.6325
356.973	793.349944	84.6154	356.973	798.428848	90.6325
357.975	792.333574	84.8034	357.975	799.444236	90.8205
358.966	793.349944	85.1795	358.976	798.428848	90.8205
359.968	792.333574	84.9915	359.977	799.444236	90.8205
360.969	793.349944	85.1795	360.979	799.444236	91.0086
361.97	794.365332	85.1795	361.98	798.428848	91.0086
362.972	793.349944	84.9915	362.972	799.444236	91.3846
363.973	794.365332	85.1795	363.973	799.444236	91.3846
364.975	792.333574	84.9915	364.975	800.460606	91.3846
365.966	794.365332	84.8034	365.976	799.444236	91.5727
366.968	794.365332	84.9915	366.977	801.475994	91.7607
367.969	791.318186	84.8034	367.979	799.444236	91.9487
368.971	791.318186	84.9915	368.97	800.460606	91.9487
369.972	792.333574	85.1795	369.972	798.428848	91.9487
370.973	791.318186	85.3675	370.973	799.444236	92.1368
371.965	790.301816	85.3675	371.975	797.412478	92.1368
372.966	790.301816	85.9316	372.976	796.39709	92.3248
373.968	790.301816	85.9316	373.978	795.38072	92.3248
374.969	790.301816	86.3077	374.979	795.38072	92.7009
375.971	789.286428	86.4957	375.97	795.38072	92.8889
376.972	790.301816	86.6838	376.972	795.38072	92.8889
377.973	790.301816	87.0598	377.973	793.349944	93.0769
378.975	792.333574	87.0598	378.975	794.365332	93.265

379.966	790.301816	87.2479	379.976	793.349944	93.453
380.968	792.333574	87.2479	380.978	794.365332	93.641
381.969	792.333574	87.4359	381.969	792.333574	93.641
382.971	794.365332	87.2479	382.97	794.365332	94.0171
383.972	793.349944	87.2479	383.972	792.333574	94.0171
384.974	792.333574	87.2479	384.973	793.349944	94.2051
385.965	793.349944	87.0598	385.975	793.349944	94.3932
386.966	793.349944	87.0598	386.976	792.333574	94.2051
387.968	793.349944	87.0598	387.978	792.333574	94.3932
388.969	794.365332	87.0598	388.969	794.365332	94.7692
389.971	793.349944	87.0598	389.971	792.333574	94.9573
390.972	793.349944	87.0598	390.972	792.333574	94.9573
391.964	794.365332	86.3077	391.973	793.349944	94.9573
392.965	792.333574	87.2479	392.975	794.365332	95.1453
393.966	793.349944	87.6239	393.976	794.365332	95.1453
394.968	791.318186	87.6239	394.968	792.333574	95.5214
395.969	793.349944	86.3077	395.969	794.365332	95.3333
396.971	791.318186	86.1197	396.971	793.349944	95.5214
397.972	791.318186	86.1197	397.972	795.38072	95.7094
398.964	792.333574	86.8718	398.974	793.349944	95.5214
399.965	790.301816	87.0598	399.975	795.38072	95.8974
400.967	792.333574	87.812	400.976	795.38072	95.8974
401.968	789.286428	74.2735	401.968	793.349944	95.8974
402.969	789.286428	72.0171	402.969	794.365332	96.0855

Table 5: Run 3

Time(s)	Conductivity(µS/cm)	Light(lux)
0	394.643214	107.179
1.002	394.643214	107.368
2.003	395.150908	107.179
3.005	395.150908	107.368
4.006	395.659093	107.368
5.008	395.659093	107.556
6.009	395.659093	107.744
7.01	395.150908	107.932
8.002	395.659093	107.744
9.003	395.150908	107.744

Table 6: Run 4

Time(s)	Conductivity(µS/cm)	Light(lux)
0	789.286428	107.429
1.001	790.301816	107.429
2.002	790.301816	107.429
3.004	790.301816	107.429
3.995	790.301816	107.429
4.997	791.318186	109.495
5.998	790.301816	109.495
7	791.318186	111.56
8.001	791.318186	109.495
9.002	790.301816	109.495

10.005	394.643214	107.932	10.004	790.301816	109.495
11.006	395.659093	107.744	10.995	791.318186	109.495
12.008	395.659093	107.932	11.997	790.301816	111.56
13.009	395.659093	107.932	12.998	790.301816	111.56
14.001	395.659093	107.744	14	790.301816	111.56
15.002	394.643214	108.12	15.001	791.318186	111.56
16.003	395.659093	107.556	16.003	789.286428	111.56
17.005	394.643214	107.556	17.004	789.286428	109.495
18.006	395.150908	107.744	17.995	789.286428	109.495
19.008	395.659093	107.556	18.997	791.318186	111.56
20.009	395.659093	107.744	19.998	789.286428	111.56
21.001	395.659093	107.368	21	789.286428	111.56
22.002	394.643214	107.744	22.001	790.301816	111.56
23.003	394.643214	107.368	23.003	791.318186	111.56
24.005	394.643214	107.368	24.004	789.286428	111.56
25.006	394.643214	107.179	24.995	791.318186	111.56
26.008	395.659093	107.179	25.997	791.318186	111.56
27.009	395.150908	107.179	26.998	789.286428	111.56
28.001	395.659093	107.179	28	790.301816	109.495
29.002	394.643214	106.991	29.001	789.286428	111.56
30.004	394.643214	107.179	30.003	790.301816	111.56
31.005	395.659093	106.991	30.994	790.301816	111.56
32.006	394.643214	106.991	31.996	790.301816	111.56
33.008	394.643214	106.991	32.997	788.270058	111.56
33.999	395.659093	106.803	33.998	791.318186	109.495
35.001	395.659093	106.803	35	789.286428	109.495
36.002	395.150908	106.991	36.001	789.286428	111.56
37.004	394.643214	106.803	37.003	790.301816	111.56
38.005	394.643214	106.615	37.994	789.286428	109.495
39.006	395.150908	106.803	38.996	789.286428	109.495
40.008	395.659093	106.803	39.997	790.301816	109.495
40.999	395.659093	106.803	40.998	789.286428	109.495
42.001	394.643214	106.615	42	790.301816	109.495
43.002	394.643214	107.179	43.001	789.286428	109.495
44.004	395.150908	106.803	44.003	790.301816	109.495
45.005	394.643214	107.179	44.994	791.318186	111.56
46.007	395.150908	107.179	45.996	790.301816	109.495
46.998	395.659093	106.991	46.997	790.301816	111.56
47.999	395.659093	107.179	47.999	791.318186	111.56
49.001	395.150908	107.179	49	790.301816	111.56
50.002	395.150908	107.179	50.001	790.301816	111.56
51.004	395.659093	107.556	50.993	790.301816	111.56
52.005	395.150908	107.368	51.994	790.301816	111.56

52.997	395.150908	107.556	52.996	790.301816	111.56
53.998	395.150908	107.744	53.997	790.301816	111.56
54.999	394.643214	107.556	54.999	788.270058	111.56
56.001	394.643214	107.556	56	789.286428	111.56
57.002	394.643214	107.932	57.002	789.286428	111.56
58.004	394.643214	107.556	57.993	790.301816	111.56
59.005	395.659093	107.744	58.994	790.301816	109.495
60.007	395.150908	107.556	59.996	791.318186	111.56
60.998	394.643214	107.556	60.997	788.270058	111.56
62	395.659093	107.744	61.999	790.301816	111.56
63.001	395.659093	107.556	63	789.286428	109.495
64.002	395.150908	107.556	63.992	790.301816	109.495
65.004	395.150908	107.556	64.993	790.301816	109.495
66.005	394.643214	107.368	65.994	789.286428	109.495
66.997	394.643214	107.744	66.996	789.286428	109.495
67.998	394.643214	107.556	67.997	789.286428	109.495
69	395.150908	107.744	68.999	789.286428	109.495
70.001	395.659093	107.368	70	789.286428	111.56
71.002	395.659093	107.556	70.992	789.286428	111.56
72.004	395.659093	107.368	71.993	790.301816	109.495
73.005	394.643214	107.556	72.995	789.286428	109.495
73.997	394.643214	107.368	73.996	788.270058	111.56
74.998	394.643214	107.556	74.997	790.301816	111.56
76	395.150908	107.368	75.999	789.286428	111.56
77.001	395.659093	107.368	77	788.270058	111.56
78.003	395.659093	107.368	77.992	788.270058	111.56
79.004	395.659093	107.368	78.993	789.286428	109.495
80.005	394.643214	107.179	79.995	789.286428	109.495
80.997	395.150908	107.368	80.996	789.286428	109.495
81.998	394.643214	107.179	81.997	788.270058	109.495
83	394.643214	107.179	82.989	790.301816	109.495
84.001	395.659093	107.179	83.99	789.286428	109.495
85.003	394.643214	107.179	84.992	789.286428	109.495
86.004	395.150908	106.991	85.993	788.270058	109.495
86.995	395.150908	107.368	86.995	789.286428	109.495
87.997	394.643214	106.803	87.996	789.286428	109.495
88.998	395.150908	106.991	88.998	791.318186	109.495
90	395.150908	106.615	89.999	789.286428	109.495
91.001	394.643214	106.803	90.99	789.286428	109.495
92.003	395.150908	106.803	91.992	789.286428	109.495
92.994	394.643214	106.803	92.993	790.301816	111.56
93.996	395.659093	106.615	93.995	788.270058	111.56
94.997	394.643214	106.427	94.996	789.286428	109.495

95.998	394.643214	106.615	95.998	788.270058	109.495
97	394.643214	106.427	96.989	789.286428	111.56
98.001	395.659093	106.615	97.99	790.301816	111.56
99.003	395.150908	106.803	98.992	789.286428	109.495
100.004	395.659093	106.427	99.993	789.286428	109.495
100.996	394.643214	106.803	100.995	790.301816	111.56
101.997	394.643214	106.803	101.996	790.301816	111.56
102.998	394.643214	106.615	102.988	790.301816	111.56
104	394.643214	106.803	103.989	789.286428	109.495
105.001	395.150908	106.615	104.991	788.270058	109.495
105.993	395.150908	106.615	105.992	789.286428	109.495
106.994	394.643214	106.615	106.993	789.286428	109.495
107.996	394.643214	106.615	107.995	789.286428	109.495
108.997	395.150908	106.615	108.996	790.301816	109.495
109.999	395.659093	106.615	109.998	788.270058	109.495
111	394.643214	106.615	110.989	789.286428	109.495
112.001	395.659093	106.427	111.991	789.286428	109.495
112.993	395.659093	106.803	112.992	789.286428	109.495
113.994	395.150908	106.615	113.993	789.286428	109.495
114.996	395.150908	106.427	114.995	790.301816	109.495
115.997	395.150908	106.427	115.996	789.286428	109.495
116.999	395.150908	106.239	116.988	790.301816	109.495
118	394.643214	106.051	117.989	789.286428	109.495
119.002	395.150908	106.239	118.991	789.286428	107.429
119.993	394.643214	106.051	119.992	790.301816	109.495
120.994	394.643214	105.675	120.994	788.270058	107.429
121.996	395.659093	105.675	121.995	788.270058	107.429
122.997	395.150908	105.675	122.986	790.301816	109.495
123.999	394.643214	105.675	123.988	790.301816	109.495
125	395.150908	105.675	124.989	789.286428	107.429
125.992	394.643214	105.675	125.991	790.301816	109.495
126.993	395.150908	105.487	126.992	790.301816	109.495
127.994	395.150908	105.299	127.994	789.286428	109.495
128.996	395.659093	105.299	128.995	789.286428	109.495
129.997	395.150908	104.359	129.986	790.301816	107.429
130.999	394.643214	102.667	130.988	790.301816	109.495
132	395.150908	98.7179	131.989	790.301816	107.429
132.992	394.643214	94.9573	132.991	788.270058	103.297
133.993	394.643214	93.265	133.992	789.286428	101.231
134.995	395.150908	91.5727	134.994	790.301816	99.1648
135.996	394.643214	90.0684	135.995	788.270058	97.0989
136.997	394.643214	88.7521	136.987	790.301816	95.033
137.999	395.150908	87.812	137.988	790.301816	95.033

139	394.135029	86.4957	138.989	788.270058	92.967
139.992	395.150908	85.1795	139.991	789.286428	90.9011
140.993	395.659093	84.4274	140.992	789.286428	90.9011
141.995	394.643214	83.2991	141.994	789.286428	88.8352
142.996	394.643214	82.359	142.995	790.301816	86.7692
143.997	395.150908	81.7949	143.987	790.301816	86.7692
144.999	394.643214	80.8547	144.988	788.270058	86.7692
145.99	395.150908	80.2906	145.989	789.286428	84.7033
146.992	395.659093	79.9145	146.991	788.270058	86.7692
147.993	396.166787	79.3504	147.992	790.301816	84.7033
148.995	396.166787	78.9744	148.994	792.333574	84.7033
149.996	397.182666	78.5983	149.985	795.38072	84.7033
150.998	398.706239	78.2222	150.987	796.39709	82.6374
151.999	400.737997	78.0342	151.988	799.444236	82.6374
153	403.277449	77.8462	152.99	802.491382	84.7033
153.992	406.325086	77.6581	153.991	804.52314	82.6374
154.993	408.356844	77.6581	154.992	803.507752	82.6374
155.995	410.388111	77.4701	155.994	803.507752	82.6374
156.996	412.927563	77.4701	156.985	808.586656	82.6374
157.998	415.9752	77.094	157.987	816.713688	82.6374
158.999	418.006958	76.906	158.988	827.886884	82.6374
159.99	421.562289	76.5299	159.99	842.108208	82.6374
160.992	425.625314	76.5299	160.991	856.329532	82.6374
161.993	430.196524	76.3419	161.992	872.582614	80.5714
162.995	435.275428	76.3419	162.984	887.820308	82.6374
163.996	443.401969	76.3419	163.985	904.07339	80.5714
164.998	450.004937	76.3419	164.987	920.326472	80.5714
165.989	461.686809	76.3419	165.988	938.61033	82.6374
166.991	477.939891	76.3419	166.99	956.89517	82.6374
167.992	498.25698	75.9658	167.991	984.31752	80.5714
168.993	518.57456	76.1538	168.993	1022.91994	80.5714
169.995	542.44207	75.9658	169.984	1072.69752	80.5714
170.996	566.31449	75.9658	170.985	1122.4751	80.5714
171.998	588.15417	75.9658	171.987	1180.37382	80.5714
172.989	607.96602	76.1538	172.988	1246.4035	80.5714
173.991	626.25086	76.1538	173.99	1299.22528	80.5714
174.992	641.99232	76.1538	174.991	1324.6198	80.5714
175.993	654.68958	76.3419	175.983	1346.97012	80.5714
176.995	664.34264	76.3419	176.984	1376.43012	80.5714
177.996	671.45232	76.3419	177.985	1401.82464	80.5714
178.988	676.52926	76.5299	178.987	1409.94578	80.5714
179.989	680.59474	76.5299	179.988	1409.94578	82.6374
180.991	684.14958	76.5299	180.99	1393.69368	80.5714

181.992	687.19869	76.5299	181.991	1392.68222	82.6374
182.994	689.22652	76.7179	182.993	1402.8361	82.6374
183.995	688.72079	76.7179	183.984	1397.75916	82.6374
184.996	688.21506	76.906	184.986	1391.66094	80.5714
185.988	685.67168	77.2821	185.987	1387.59546	80.5714
186.989	684.14958	77.2821	186.988	1382.51852	82.6374
187.991	682.11684	77.094	187.99	1381.50706	82.6374
188.992	678.562	77.2821	188.991	1372.36464	80.5714
189.994	675.00716	77.4701	189.983	1360.1682	80.5714
190.995	669.93022	77.6581	190.984	1353.05852	80.5714
191.996	666.88111	77.6581	191.986	1342.90464	80.5714
192.988	663.832	77.8462	192.987	1338.83916	82.6374
193.989	660.27716	78.2222	193.988	1329.69674	80.5714
194.991	655.70595	78.4103	194.99	1322.58706	82.6374
195.992	652.15111	78.7863	195.981	1309.37916	82.6374
196.994	648.09054	78.9744	196.983	1297.19254	80.5714
197.995	643.00869	79.1624	197.984	1286.01738	82.6374
198.987	637.93175	79.3504	198.986	1277.89624	82.6374
199.988	633.36054	79.5385	199.987	1267.73254	82.6374
200.989	629.29506	79.9145	200.989	1256.55738	82.6374
201.991	623.20175	79.9145	201.99	1243.3593	82.6374
202.992	618.63054	80.1026	202.981	1234.21688	84.7033
203.994	612.53723	80.2906	203.983	1225.07446	82.6374
204.995	606.94965	80.1026	204.984	1216.9435	84.7033
205.987	601.36207	80.2906	205.986	1207.80108	84.7033
206.988	596.79086	80.4786	206.987	1199.67012	84.7033
207.989	592.72538	80.4786	207.989	1190.5277	82.6374
208.991	587.64844	80.6667	208.99	1187.4835	82.6374
209.992	582.06086	80.6667	209.981	1181.38528	84.7033
210.994	576.98392	80.6667	210.983	1177.32962	84.7033
211.995	572.91844	80.4786	211.984	1168.1872	84.7033
212.987	569.3636	80.8547	212.986	1155.99076	82.6374
213.988	564.79239	81.0427	213.987	1149.90236	84.7033
214.99	562.25392	80.8547	214.989	1140.75994	84.7033
215.991	558.18844	81.0427	215.98	1138.7272	84.7033
216.992	553.1115	81.0427	216.982	1133.65026	84.7033
217.994	548.54029	81.2308	217.983	1126.54058	84.7033
218.985	545.99691	81.2308	218.984	1119.42108	84.7033
219.987	542.44207	81.2308	219.986	1110.27866	84.7033
220.988	538.3815	81.4188	220.987	1104.19026	86.7692
221.99	535.84303	81.6068	221.989	1090.98236	84.7033
222.991	530.76118	81.6068	222.98	1078.79574	84.7033
223.992	528.22271	81.9829	223.982	1068.63204	84.7033

224.994	524.15723	81.7949	224.983	1060.5109	84.7033
225.985	521.11303	81.9829	225.984	1057.45688	86.7692
226.987	519.58602	82.1709	226.986	1048.31446	86.7692
227.988	516.03118	82.359	227.987	1042.22606	84.7033
228.99	511.45997	82.547	228.989	1033.08364	86.7692
229.991	508.9215	82.9231	229.98	1030.02962	86.7692
230.993	503.33392	83.2991	230.982	1022.91994	86.7692
231.994	500.79545	83.6752	231.983	1016.83154	86.7692
232.985	498.25698	83.4872	232.985	1007.68912	86.7692
233.987	494.1915	83.6752	233.986	1001.5909	86.7692
234.988	492.15876	84.0513	234.987	996.51396	86.7692
235.99	489.113578	84.4274	235.979	986.35026	88.8352
236.991	485.050553	84.6154	236.98	979.243526	86.7692
237.993	481.495222	84.4274	237.982	972.132864	86.7692
238.984	478.95577	84.6154	238.983	964.005832	88.8352
239.985	475.908133	84.9915	239.985	960.958686	88.8352
240.987	474.892254	84.9915	240.986	952.831654	88.8352
241.988	473.368681	85.1795	241.988	945.720992	88.8352
242.99	470.829229	85.3675	242.979	940.642088	88.8352
243.991	468.289777	85.1795	243.98	934.547796	88.8352
244.993	465.24214	85.1795	244.982	926.420764	88.8352
245.984	462.702688	85.3675	245.983	924.389006	88.8352
246.986	459.147357	85.3675	246.985	920.326472	88.8352
247.987	456.09972	85.1795	247.986	913.21581	88.8352
248.988	452.036695	85.3675	248.978	910.167682	88.8352
249.99	449.497243	85.5556	249.979	904.07339	90.9011
250.991	445.941912	85.5556	250.98	901.025262	88.8352
251.983	443.401969	85.5556	251.982	894.93097	90.9011
252.984	441.878396	85.5556	252.983	891.883824	90.9011
253.986	439.846638	85.5556	253.985	884.77218	90.9011
254.987	437.815371	85.5556	254.986	876.64613	90.9011
255.988	435.783613	85.7436	255.978	872.582614	90.9011
256.99	434.767734	85.9316	256.979	868.52008	90.9011
257.991	432.735976	85.9316	257.981	865.471952	88.8352
258.983	429.68883	85.9316	258.982	859.37766	90.9011
259.984	428.672951	86.1197	259.983	856.329532	90.9011
260.986	426.133499	85.9316	260.985	854.298756	90.9011
261.987	424.609435	86.1197	261.986	850.23524	90.9011
262.989	422.578168	86.3077	262.978	846.171724	90.9011
263.99	421.562289	86.6838	263.979	843.124578	90.9011
264.991	420.038225	86.4957	264.981	840.07645	90.9011
265.983	417.498773	86.6838	265.982	838.045674	90.9011
266.984	416.482894	86.8718	266.983	834.997546	90.9011

267.986	414.959321	87.0598	267.985	834.997546	90.9011
268.987	414.451627	87.2479	268.976	833.982158	90.9011
269.989	413.435748	87.2479	269.978	829.918642	90.9011
270.99	413.943442	87.4359	270.979	828.903254	90.9011
271.981	411.912175	87.812	271.981	824.839738	90.9011
272.983	411.912175	87.6239	272.982	824.839738	90.9011
273.984	409.880417	87.812	273.984	819.760834	90.9011
274.986	409.372232	87.812	274.985	819.760834	90.9011
275.987	408.864538	88.188	275.976	818.744464	90.9011
276.989	407.340965	88.3761	276.978	815.697318	90.9011
277.99	407.340965	88.188	277.979	814.68193	90.9011
278.982	405.816901	88.188	278.981	814.68193	90.9011
279.983	405.309207	88.188	279.982	813.66556	90.9011
280.984	405.309207	88.188	280.984	812.650172	90.9011
281.986	404.293328	88	281.985	813.66556	90.9011
282.987	404.293328	88	282.976	812.650172	90.9011
283.989	404.293328	87.4359	283.978	815.697318	92.967
284.99	403.277449	87.4359	284.979	813.66556	92.967
285.982	402.769755	87.4359	285.981	812.650172	92.967
286.983	403.277449	87.2479	286.982	813.66556	90.9011
287.984	402.26157	87.2479	287.984	813.66556	90.9011
288.986	402.26157	87.2479	288.975	812.650172	92.967
289.987	402.26157	87.4359	289.977	814.68193	92.967
290.989	401.245691	87.4359	290.978	811.633802	92.967
291.98	401.753876	87.6239	291.979	812.650172	92.967
292.982	400.737997	87.6239	292.981	809.603026	92.967
293.983	401.753876	88.188	293.982	810.618414	92.967
294.985	400.737997	88.188	294.984	810.618414	92.967
295.986	401.245691	88.5641	295.975	809.603026	92.967
296.987	401.245691	88.7521	296.977	809.603026	92.967
297.989	400.737997	88.7521	297.978	808.586656	92.967
298.98	401.245691	88.9402	298.979	805.53951	92.967
299.982	401.753876	89.1282	299.981	806.554898	92.967
300.983	401.245691	89.3162	300.982	805.53951	92.967
301.985	401.245691	88.9402	301.974	805.53951	92.967
302.986	402.26157	89.1282	302.975	807.571268	92.967
303.988	401.245691	88.9402	303.977	806.554898	92.967
304.989	402.26157	89.1282	304.978	807.571268	92.967
305.98	401.245691	88.7521	305.98	804.52314	92.967
306.982	402.26157	88.7521	306.981	804.52314	92.967
307.983	402.26157	88.7521	307.982	805.53951	92.967
308.985	400.737997	88.5641	308.974	803.507752	92.967
309.986	401.245691	88.7521	309.975	804.52314	92.967

310.988	401.245691	88.7521	310.977	804.52314	92.967
311.979	400.737997	88.5641	311.978	805.53951	92.967
312.98	400.230303	88.5641	312.98	807.571268	92.967
313.982	401.245691	88.9402	313.981	806.554898	92.967
314.983	401.245691	88.7521	314.982	808.586656	92.967
315.985	401.245691	88.9402	315.974	807.571268	92.967
316.986	400.737997	89.1282	316.975	806.554898	92.967
317.988	400.737997	89.1282	317.977	809.603026	92.967
318.979	400.230303	89.3162	318.978	810.618414	92.967
319.981	400.230303	89.6923	319.98	807.571268	92.967
320.982	399.722118	89.6923	320.981	807.571268	92.967
321.983	399.722118	89.6923	321.973	806.554898	92.967
322.985	400.230303	89.8803	322.974	807.571268	92.967
323.986	400.230303	90.2564	323.975	807.571268	95.033
324.978	400.230303	90.2564	324.977	806.554898	92.967
325.979	399.722118	90.6325	325.978	806.554898	95.033
326.981	400.230303	90.8205	326.98	805.53951	92.967
327.982	399.214424	90.8205	327.981	804.52314	95.033
328.983	399.214424	90.6325	328.973	805.53951	95.033
329.985	399.214424	91.1966	329.974	804.52314	95.033
330.986	398.706239	91.3846	330.975	803.507752	95.033
331.978	398.198545	91.0086	331.977	803.507752	95.033
332.979	398.198545	91.1966	332.978	802.491382	95.033
333.981	398.198545	91.3846	333.98	800.460606	95.033
334.982	398.706239	91.3846	334.971	800.460606	95.033
335.984	399.214424	91.3846	335.973	801.475994	95.033
336.985	400.230303	91.7607	336.974	801.475994	95.033
337.986	399.214424	91.5727	337.976	800.460606	95.033
338.978	399.214424	91.3846	338.977	797.412478	95.033
339.979	399.722118	91.5727	339.978	796.39709	95.033
340.981	398.706239	91.5727	340.97	796.39709	95.033
341.982	398.706239	91.5727	341.971	796.39709	95.033
342.984	399.214424	91.7607	342.973	795.38072	95.033
343.985	397.69036	91.7607	343.974	796.39709	97.0989
344.976	397.69036	91.9487	344.976	796.39709	97.0989
345.978	398.198545	91.7607	345.977	797.412478	97.0989
346.979	397.182666	91.7607	346.978	799.444236	97.0989
347.981	397.182666	91.7607	347.98	797.412478	97.0989
348.982	397.69036	92.1368	348.971	799.444236	97.0989
349.984	397.182666	91.9487	349.973	797.412478	97.0989
350.975	396.674972	92.5128	350.974	797.412478	97.0989
351.977	396.674972	92.3248	351.976	797.412478	97.0989
352.978	397.69036	92.3248	352.977	796.39709	97.0989

353.979	397.182666	92.5128	353.979	795.38072	97.0989
354.981	397.69036	92.7009	354.98	795.38072	97.0989
355.982	397.182666	92.8889	355.971	795.38072	97.0989
356.984	398.198545	92.8889	356.973	797.412478	97.0989
357.985	397.182666	93.0769	357.974	797.412478	97.0989
358.977	398.198545	93.0769	358.976	797.412478	97.0989
359.978	397.182666	93.265	359.977	798.428848	97.0989
360.979	397.182666	93.265	360.969	800.460606	99.1648
361.981	398.198545	93.641	361.97	799.444236	97.0989
362.982	397.69036	93.641	362.971	801.475994	99.1648
363.974	397.182666	93.8291	363.973	801.475994	99.1648
364.975	397.182666	94.0171	364.974	802.491382	99.1648
365.977	397.182666	94.2051	365.976	802.491382	97.0989
366.978	397.182666	94.3932	366.977	802.491382	99.1648
367.98	397.182666	94.5812	367.969	803.507752	99.1648
368.981	397.69036	94.7692	368.97	802.491382	99.1648
369.982	397.69036	94.7692	369.972	804.52314	99.1648
370.974	396.674972	94.9573	370.973	805.53951	99.1648
371.975	396.674972	95.1453	371.974	805.53951	99.1648
372.977	397.182666	95.1453	372.976	802.491382	99.1648
373.978	397.182666	95.3333	373.977	804.52314	99.1648
374.98	396.674972	95.3333	374.979	803.507752	99.1648
375.981	396.674972	95.5214	375.97	804.52314	99.1648
376.982	396.166787	95.7094	376.972	804.52314	99.1648
377.974	396.166787	95.7094	377.973	802.491382	99.1648
378.975	396.166787	95.8974	378.974	803.507752	99.1648
379.977	396.674972	95.8974	379.976	802.491382	99.1648
380.978	397.182666	96.2735	380.967	801.475994	99.1648
381.98	396.166787	96.2735	381.969	803.507752	99.1648
382.981	396.674972	96.4615	382.97	801.475994	99.1648
383.973	396.166787	96.4615	383.972	802.491382	101.231
384.974	396.166787	96.6496	384.973	800.460606	99.1648
385.975	396.674972	96.2735	385.975	801.475994	99.1648
386.977	396.674972	96.4615	386.976	799.444236	99.1648
387.978	396.674972	96.4615	387.967	798.428848	101.231
388.98	397.182666	96.6496	388.969	799.444236	99.1648
389.981	396.166787	96.8376	389.97	797.412478	99.1648
390.973	396.166787	96.8376	390.972	795.38072	99.1648
391.974	396.166787	97.0256	391.973	795.38072	99.1648
392.975	396.674972	97.0256	392.975	795.38072	99.1648
393.977	396.674972	97.0256	393.976	794.365332	99.1648
394.978	395.659093	97.2137	394.967	794.365332	99.1648
395.98	396.166787	97.2137	395.969	794.365332	99.1648

396.981	396.674972	97.4017	396.97	795.38072	101.231
397.973	395.659093	97.4017	397.972	794.365332	99.1648
398.974	396.166787	97.4017	398.973	794.365332	101.231
399.976	396.166787	97.5897	399.975	794.365332	99.1648
400.977	395.150908	97.5897	400.966	793.349944	99.1648
401.978	395.659093	97.7778	401.968	794.365332	99.1648
402.98	396.166787	97.7778	402.969	793.349944	99.1648