CONTROLLED OXYGEN LEVELS DURING KIDNEY MACHINE PERFUSION

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ABSTRACT

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The surgical research laboratory at the University Medical Center Groningen (UMCG) aims to improve their system that pumps blood (or substitute) through kidneys, while outside of a body, for research applications. This process is called machine perfusion. Literature suggests that during machine perfusion high levels of oxygen in the blood should be avoided when pumping at normal temperatures (37°C). Additionally the concept of adjusting for different needs of kidneys is explored as well. Therefore the goal of this project was to build a solution for an automated system that can dynamically control the oxygen level in a kidney perfusion machine for research applications. A conceptual model was created that makes use of dynamically combining gases to the artificial lung in order to influence the oxygen level in the blood. It was implemented such that the oxygen level in the outgoing blood was kept at a stable level. This with the hypothesis that a kidney that consumes less also requires less oxygen. The resulting prototype was able to keep a stable (± 0.79) 45 hPa oxygen level in the outgoing blood, tested on one kidney.

Warning: this document includes images of real porcine organs and blood.

DECLARATION

I hereby certify that this report constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions or writings of another.

I declare that the report describes original work that has not previously been presented for the award of any other degree of any institution.

Signed,

EWOUT BERGSMA

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1 Rationale

At new year's eve 2018 in the Netherlands there were 1,195 patients waiting for organ donation, 741 of which were waiting for a kidney. Since 2015 these numbers have been increasing every year. In 2017 83% of the patients waiting for just a kidney had to wait for at least a year and 15% had to wait five years or longer [1–3]. There is a dramatic shortage. This shortage has led to extending the donor criterias, such as an increased use of donors of older age and donors that have experienced a loss of blood flow. Unfortunately, this does not come without consequences, as these donor organs are more susceptible to ischemia-reperfusion injury (IRI). IRI is damage caused by a lack of oxygenation, either caused by a lack of blood flow or an insufficient amount of oxygen before (artificially) restoring the blood and oxygen supply. This has negative results on the health and survival of the organ. This has led to a growing interest in research aimed at oxygenation during machine perfusion (MP) [4, 5]. MP is a technique that revolves around artificially supplying the organ with oxygenated blood or blood substitute, in order to supply the organ with oxygen in an attempt to reduce IRI. Ultimately with the goal of keeping the organ as healthy as possible during the transplantation process, including the transportation of the organ from the donor to the recipient.

Traditionally organ preservation was done by cooling and submerging the organ in a cold preservation solution and transporting it on melting ice, a method called cold storage (CS) [6]. Since then a method involving cold MP (4°C), called hypothermic machine perfusion (HMP), has been established in clinical practice [7]. This shift in technique adds three years to the survival of the kidney after transplantation due to the added oxygenation [8]. However, research suggests that MP during normal temperatures (37°C), a method called normothermic machine perfusion (NMP), may enhance the condition of the kidney when comparing it to the currently used HMP technique [9–11]. However, one of the current challenges during NMP is the excessive supply of oxygen. Currently, oxygenation during NMP typically happens at levels higher than normally found in nature. New insights suggest that non-excessive oxygen delivery might be of utmost benefit during NMP [12, 13]. Additionally, it appears to be the case that there is no default oxygen supply requirement by organs. Instead it should be tailored for the specific needs of an individual organ, which may change over time [12].

Therefore the goal of this project is to create an automated system that can dynamically control the oxygen level in the blood or blood substitute. Preferably one that can adjust for the specific needs of the kidney.

Although the clear and important clinical relevance of oxygenation during MP, this project will aim towards the research field. Naturally, as this is where innovation is supposed to start, but also as MP has its purpose in the research field. It allows an organ to be examined in an isolated environment, as it excludes other organs, opening the doors for a whole new type of research. A type in which the excluded organs do not influence the results of the organ of interest. Furthermore it can solve ethical challenges, as organs that have been discarded for transplantation may be used, reducing the need of living subjects. A solution which may also help to reduce the amount of tests on animals, as some research may be shifted away from animal testing to MP research. Noteworthy not only for its ethical reasons, but also noteworthy as reduction of animal testing has been a subject the Dutch government has been pushing [14].

Important to note is that the project will focus on kidney MP. Mainly due to the fact that this is the specialization of the environment this project has taken place in, but also because excluding other organs helps with the feasibility of the project's time scope. Additionally, this document will use the term perfusion solution, as a term to include both blood and blood substitutes in the MP context.

1.1 Research question

"How can one build a solution for an automated system that can dynamically control the oxygen level in a kidney perfusion machine for research applications?"

- What type of oxygen sensor is the best fit for the system?
- How should the oxygen level be influenced by the system?
- How can the system adjust for the different oxygen requirements of the kidney?

2 Situational & theoretical analysis

2.1 Slaughterhouse model

The surgical research laboratory of the UMCG, the area this project has taken place in, has a model that supplies them with the kidneys required for their research. This subsection is dedicated to explaining the procedure the laboratory follows, in order to get a better understanding of the current situation. The source of information in this subsection originates from proprietary documentation and verbal communication with the laboratory managers and researchers, unless stated otherwise.

The laboratory uses porcine organs for most of their research, due to being similar to human organs [15]. Porcine kidneys are obtained from a nearby slaughterhouse. The employees there have been carefully instructed on how to retrieve the kidneys, such that they are not damaged and remain suitable for research. Once the kidneys are retrieved they are handed over to the researcher, including the corresponding blood would the researcher have requested this. Whether the researcher requires blood depends on their specific research. The researcher will then prepare the kidney, by removing excessive fat and preparing the artery such that it can be cannulated. A cannula, as seen in figure 1, is a special piece of tubing which will be partially inserted into the aorta such that the kidney can be attached to the perfusion machine and such that the oxygenated perfusion solution can enter the kidney later. Afterwards the kidney will be flushed with a cold solution using a syringe, in order to remove the remaining blood but also to start the cooling of the kidney.

The cold storage (CS) and hypothermic machine perfusion (HMP) preservation methods mentioned in the rationale are the two available options for transportation. Both of these methods happen at low temperatures in order to lower the metabolic rate, in order to enhance the preservation. HMP has an advantage in terms of preservation over CS, but practically CS is a simpler method as it excludes all of the extra hardware required by the added oxygenation which the HMP method provides [16].

Once the kidney arrives at the laboratory the kidney is taken out of CS or HMP and is attached to the perfusion machine, assuming the intend of the research is to perform normothermic machine perfusion (NMP).

Figure 1: Image of the cannula used during the project. The left side connects to the perfusion machine, the right side inserts into the artery.

Figure 2: Kidney prepared at slaughterhouse.

2.2 Perfusion machine

The concept of the existing perfusion machine that is used in the current situation is displayed in figure 3. The product of this project has to extend or modify this setup in order to achieve its goals. The source of information of this subsection originates from proprietary documentation and verbal communication with the laboratory managers and researchers, unless stated otherwise.

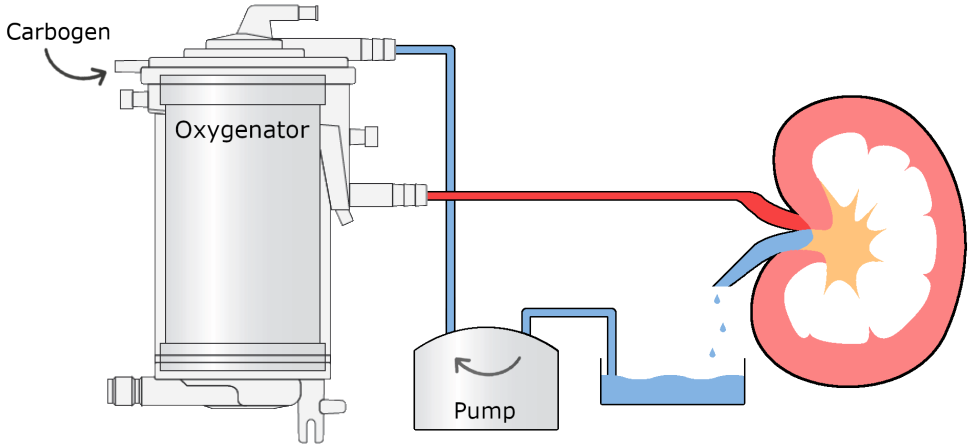

Figure 3: Schematic representation of the current perfusion machine. Carbogen is a gas mixture consisting of 95% oxygen and 5% carbon dioxide. The oxygenated perfusion solution depicted in red, perfusion solution with lower oxygen levels depicted in blue.

The above figure merely shows the system without any sensors that might be added by the user. In this typical setup the oxygenator is supplied with carbogen, a gas consisting of 95% oxygen and 5% carbon dioxide. This gas is used by the oxygenator to oxygenate and to extract the carbon dioxide from the perfusion solution. Inside the oxygenator a membrane allows gas to move between the supplied gaseous mixture and the perfusion solution [17]. Which results in oxygenation of the perfusion solution and potentially extracting carbon dioxide produced by the kidney from said solution. The oxygenated perfusion solution then travels into the artery of the kidney, such that the kidney is supplied with oxygen. The perfusion solution then flows through the kidney, for it to eventually leave the kidney through the venous. From the venous the perfusion solution leaks into a bath which then ultimately gets pumped into the oxygenator, completing the full loop of the perfusion solution.

However, this does not create the 37°C required during NMP. The process of achieving this temperature has three elements. Firstly, a chamber meant for isolation is used. The equipment displayed in figure 3 is placed inside this transparent chamber, such that the only the inside of the chamber has to have its temperature increased. Secondly, a heater is placed inside the chamber. Its goal is to increase the temperature of the air inside the chamber to the desired temperature. Lastly a specialized water bath, at the desired temperature, pumps its warm water through the dedicated heat exchanging in and outlet of the oxygenator. This process increases the temperature of the perfusion solution inside the oxygenator.

Additionally adding sodium bicarbonate to the perfusion solution can be used during MP experiments. It is used for its pH buffer properties, in order to achieve physiological pH levels.

2.3 Oxygen dissociation curve

In order to gain a better understanding of the underlying principles that are associated with oxygenation this subsection will cover the forms of oxygen and their relationships that will be encountered. This understanding will become essential during the decision making of the type of oxygen sensor later in this document, but is also important for the entirety of this project. For the scope of this project oxygen can come in three different forms:

- Gaseous oxygen
- Dissolved in the perfusion solution
- Bound to an oxygen carrier

As can be seen in figure 3, oxygen enters the oxygenator in a gaseous form. Inside the oxygenator it dissolves into the perfusion solution. A process explained by Henry's law, which states that the amount of dissolved gas in a solvent is proportional to the partial pressure of the gas in contact with the solvent. E.g. given a beaker with water without a lid, the amount of dissolved oxygen in the water is directly proportional to the partial pressure of the oxygen in the air. This law is expressed as follows:

$$C = k * P_{gas}$$

In which C stands for the dissolved concentration, k for Henry's law constant and P for the partial pressure of the gas [18]. However in MP it is not only the dissolved oxygen that is important. Perfusion solutions can hold oxygen carriers, such as hemoglobin. These carriers can bind oxygen, extracting the oxygen from the solvent. During oxygen uptake this creates a situation in which oxygen dissolves into the solvent, after which it binds to the oxygen carrier. Consequently allowing new gaseous oxygen molecules to dissolve into the solvent. A reverse of this principle holds true during oxygen delivery [19].

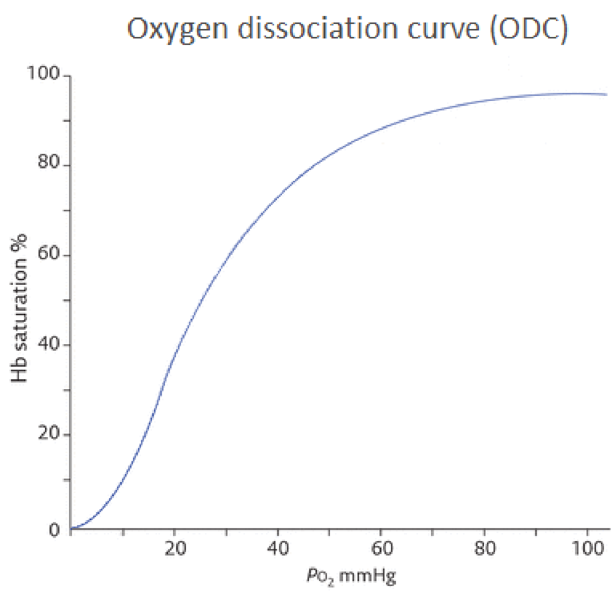

Figure 4: ODC in a theoretical healthy human [19]. Vertical axis: Hemoglobin (Hb) saturation, horizontal axis: PO_2, partial pressure of oxygen.

Figure 4 shows a graphical representation of the relationship between the hemoglobin saturation and the partial pressure of oxygen, a relation with the name oxygen dissociation curve (ODC). The affinity of an individual hemoglobin molecule for oxygen increases as the amount of oxygen bound to the hemoglobin increases. This explains the initial increase in slope. Consequently the chances of oxygen molecules binding to hemoglobin decreases as the hemoglobin saturation increases, completing the sigmoid shape of the curve. Additionally there are multiple factors that decrease the initial slope of the curve, opposites (e.g. increasing instead of decreasing a factor) increases the initial slope of the curve. Often referred to as shifting the ODC left or right [19, 20]:

- Decrease in pH
- Increase in temperature
- Increase in partial pressure of carbon dioxide

The influence of carbon dioxide factor on the ODC is explained by a phenomenon called the Bohr effect [21]. This effect is partially explained by the following underlying biochemical reaction:

$$CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$$

As can be seen in the formula, an increase of carbon dioxide (CO_2) results in an increase of H^+ and thus decreases the pH. The change in pH influences the slope of the ODC, as mentioned above [22]. However, the change in pH is not the only way carbon dioxide influences the slope of the ODC. The partial pressure of carbon dioxide itself increases the slope of the ODC, independent of the change in pH [19, 23]. Although, the independent influence of carbon dioxide on the ODC appears to be small. As under conditions normally found in humans (37°C, 7.3 pH and 118.7 hPa oxygen) an artificial carbon dioxide change of 53.3 hPa to 106.7 hPa influences the hemoglobin saturation by less than 1% [20].

2.4 Cellular respiration

For metabolism in mammals and for the scope of this project cellular respiration plays a key factor. Cellular respiration is a process in which larger molecules are broken down into smaller molecules, ultimately netting energy. The combination of steps can be summarized as follows [24]:

$$Glucose + Oxygen \rightarrow Carbon\ dioxide + Water + Energy$$

In isolation this information would suggest that monitoring the amount of one of the components would allow to comprehend all of the formula. E.g. knowing the amount of oxygen consumed in a kidney gives direct insight on the amount of energy that has been extracted. However, this is not the case, which can be explained with a property called the respiratory quotient (RQ). RQ is the volumetric ratio between the total consumed oxygen and the carbon dioxide evolved from oxygen in an organism. Research has shown that RQs ranging from less than 0.7 to up to 0.8 can be found in humans [25]. Therefore expressing the flaw in just monitoring oxygen when requiring information regarding the cellular respiration.

A possible oxygen consuming process is the creation of reactive oxygen species, which in excessive amounts results in oxidative stress. This stress results into cell and kidney damage [26]. At oxygen levels higher than normally found in nature called supraphysiological oxygen levels, mitochondria respond with creating a burst of ROS [27, 28]. Therefore demonstrating the importance of monitoring oxygen levels and avoiding supraphysiological oxygen levels.

2.5 Oxygenator

The equipment used to supply the perfusion solution with oxygen is called the oxygenator. In mammals this task is normally performed by the lungs. An UMCG specific study regarding an alternative to the currently used oxygenator has not led to a different oxygenator for kidney MP research at the UMCG [29]. Additionally, a system is in place that enables oxygenators to be reused for research purposes. These oxygenators, called the Medos Hilite 1000, have been previously used in the clinic. For these reasons and as a manner to keep the financial stress at a minimum the Medos Hilite 1000 will be considered exclusively. Figure 5 shows an image of this oxygenator.

Relevant specifications of the Medos Hilite 1000 [17]:

- Maximum gas flow rate: 2.0 l/min
- Blood flow rate range: 0.15 - 1.0 l/min

2.6 Rotameter

As has become apparent, this project will involve gases. Typically, the laboratory uses rotameters for volumetric flow rate measurements. Parts of the research design of this project will make use of these available rotameters. A rotameter consists of a tube with a float inside, as can be seen in figure 6. In this figure the float has the shape of a sphere, however different types of floats are available. The gas of which the flow rate is to be measured travels through the tube. The drag created by the travelling gas pushes the float upwards, while gravity pulls the float downwards, assuming the rotameter is in an upright position such that gravity pulls in parallel direction to the rotameter. This relation allows to measure the flow rate of the gas travelling through the tube [30]. Rotameters typically come with a knob that can be tightened to decrease the total flow going through it.

Rotameters are calibrated for a medium with a set density, thus being incorrect for all mediums with different densities [30, 31]. However, for conversion between one gaseous medium to another the following formula can be used [31]:

$$K = \sqrt{\frac{D_{calibrated}}{D_{measured}}}$$

Where K is the conversion factor, $D_{calibrated}$ and $D_{measured}$ are the densities of the original calibrated gas and the actual measured gas. See table 1 for a list of gas densities:

	O_2	N_2	N_2O	CO_2	Carbogen
Density (g/L)	1.429	1.251	1.834	1.977	1.456

Table 1: List of gas densities at standard conditions for temperature and pressure [18]. Carbogen defined as a mixture of 95% oxygen and 5% nitrogen.

Figure 5: Image of a Medos Hilite 1000.

Figure 6: Image of a Louchen rotameter.

2.7 Perfusion solution

Perfusion solutions used in MP can be divided into two groups. One group with and the other without oxygen carriers. As previously discussed in section 1, literature appears to agree on the necessity of avoiding non-physiological oxygen levels during NMP [4, 5]. Furthermore, during near-physiological thermal conditions oxygen carriers are important to meet the oxygen demand of the kidney [32]. In order to enable the system to meet the oxygen demand of the kidney during NMP the use of oxygen carriers appears to be unavoidable.

The current slaughterhouse model, which the surgical research laboratory operates on, enables the supply of porcine organs. This includes the corresponding blood. Due to this model the laboratory has a time and cost effective supply of organs for research purposes. For this reason, and due to the significantly higher cost of other perfusion solutions with oxygen carriers, this project will exclusively use blood when deemed necessary. This however does not mean that other types of perfusion solutions should be neglected during considerations of design choices.

2.8 Requirements

One of the main challenges is to set the initial requirements of the system. The unprecedented intents of this project disallow comparing or getting inspiration from an existing system. Moreover, without extensive research the exact requirements of the ideal solution remain unknown. Possibly the outcome of this project may contribute to such research. Before then the best efforts within the scope of this project are to make educated estimations. Whenever necessary small-scale experiments will be conducted.

The answer to finding the range in which the oxygen sensor has to perform might come from physiology. However using physiological values in a MP context requires upmost care. In the context of this project the only organ within the system is the kidney. Logically, as excluding all other organs, tissue and other parts that make up a body means that all of their functions are lost simultaneously. Therefore MP conditions will deviate from physiology. Though research suggests that during NMP supraphysiological oxygen levels should be avoided [12, 13]. Therefore the best estimation to the range in which the oxygen sensor has to perform is to at least cover the physiological range, which is from 45 hPa to 133.3 hPa [33].

A complex requirement to determine is the maximum expected change in oxygen level. The sensor should be able to measure correct values even if there is a sudden change in oxygen level. However no data in literature was found regarding the partial pressure of oxygen during extreme changes in oxygen level. Nor can we extract valuable information from physiology, as MP researchers expose kidneys to changing conditions not found in physiology. E.g. when transferring a kidney from CS to NMP, this change in temperature will increase the metabolic rate and thus increase the oxygen consumption [12]. However from all the data regarding oxygen levels created by the surgical research laboratory of the UMCG one experiment emerges. The yet unpublished work by Hanno Maassen researches the possibilities regarding a hydrogen sulphide induced hypometabolic state. During this research a substantial sudden decrease in metabolic rate was observed through the use of hydrogen sulphide. From this data a maximum change of 325.8 hPa/min had been observed. For the scope of this project this observed change will be considered the maximum change of oxygen partial pressure that the sensor has to be able to measure.

In order to influence the oxygen levels in the perfusion solution one could attempt to achieve this by changing the carbogen flow. However this also influences the rate at which carbon dioxide can leave the oxygenator. E.g. during a situation in which the kidney suddenly requires lower amounts of oxygen restricting the carbogen flow may answer the change in oxygen demand, but will also restrict the amount of carbon dioxide that can leave the perfusion solution. In order to avoid this, rather than restricting the carbogen flow this project will investigate the viability of controlling the carbogen concentration. This will be done by adding nitrogen to a dynamic amount of carbogen supplied to the gas inlet of the oxygenator. Nitrogen was chosen as typical air consists of more than 70% nitrogen. This means that the content of actual lungs typically contains nitrogen, thus partially supplying the artificial lung with nitrogen appears to be a natural solution.

Additional quantification of the requirements will become apparent in the remainder of this section and the results section 5. A summary of the requirements can be found in section 3.

2.9 Oxygen sensors

As explained in section 2.3, oxygen is present in three different forms within the scope of this project. All three forms have available sensors, all of which will be considered.

2.9.1 Gaseous oxygen

Theoretically it is possible to monitor the oxygen level in the perfusion solution by sensing the gaseous oxygen levels. Knowing the amount of oxygen supplied into the gas inlet of the oxygenator and the amount of gaseous oxygen that exits the oxygenator gives insight on the total oxygen consumption. However multiple considerations have to be evaluated when choosing for this approach.

Firstly, by examining the commercially available gaseous oxygen sensors can be concluded that typical oxygen sensors sense the concentration of oxygen. In order to gain information regarding the oxygen content the sensor has to closely collaborate with a gas flow sensor. Potentially both at the inlet and outlet, as gas both dissolves and condenses inside the oxygenator.

Secondly, adding sensors to the outlet of the oxygenator could add to the resistance the gas experiences. As a consequence the total pressure of the gas has to increase in order to keep the gas flow identical. Hypothetically this could have negative results on the membrane that divides the gas and the perfusion solution inside the oxygenator. These consequences could include reduced lifespan of the oxygenator and accumulation of gas in the perfusion solution. The latter due to a mismatch of pressures from both sides of the membrane, resulting in an excess of gas moving through it.

Thirdly, changes in the ODC results in a difference of oxygen entering and leaving the perfusion solution. Therefore changes in ODC will change the difference between in and out going gaseous oxygen content, thus influencing the measured values on top of influencing the oxygen consumption [24].

Lastly, it is not necessarily the case that all of the oxygen in the perfusion solution is directly consumed by the kidney. This means that some oxygen remains in the perfusion solution. Therefore, the system has no insight on the potential accumulation of oxygen that remains in the perfusion solution by exclusively monitoring the gaseous oxygen.

2.9.2 Oximetry

Oximeters are used to measure the ratio of hemoglobin bound to oxygen molecules to the total amount of hemoglobin or an approximation thereof. Which results in a measurement of oxyhemoblobin saturation. The core principle on which oximeters and pulse oximeters operate are identical. Typically, two different lights each at a different wavelength are emitted in series. Each of the wavelengths are absorbed differently, one by hemoglobin bound to oxygen and the other by hemoglobin not bound to oxygen [19, 34, 35]. Important to note is that oximetry ignores dissolved oxygen and only performs a measurement on oxygen bound to hemoglobin.

One of the limitations during the use of oximetry is its response to anemia, a clinically used term for the deficiency of hemoglobin [35]. Informing that measurements done during oximetry are influenced by the hemoglobin concentration.

2.9.3 Dissolved oxygen

Dissolved oxygen sensors can be divided into two groups, namely amperometric and optical. However the amperometric sensors consume oxygen, require more maintenance and calibration [36, 37]. All of which are undesirable for this project, the former as it should be the organ that consumes the oxygen and the latter two for a pure practical standpoint. Therefore the remainder of this subsection will exclusively consider optical dissolved oxygen sensors.

Optical dissolved oxygen sensors operate on the principle of emission of light by a substance caused by previously absorbed light, called fluorescence. This substance, the luminophore, is located at the end of the sensor and is in contact with the liquid. The sensor emits a light after which the luminophore responds with emitting a light at a different wavelength. The lifespan of the light emitted by the luminophore is influenced by the presence of oxygen. Therefore, by measuring the lifespan a conclusion can be made regarding the concentration of oxygen [36]. A visual representation can be found in figure 7:

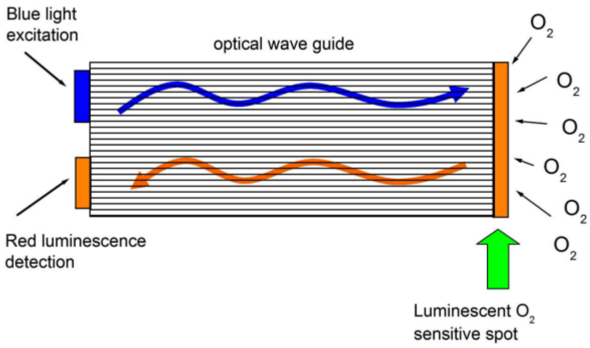

Figure 7: Optical oxygen sensor principle [36].

It is important to note that dissolved oxygen sensors do not sense oxygen bound to an oxygen carrier, but exclusively measure the dissolved oxygen. Therefore, in order to supply a constant oxygen content while controlling on partial pressure the ODC should not shift. This requires a constant pH, temperature and concentration of hemoglobin. Which, judging by the research protocols of MP researches, is typically already a goal for prolonged periods during the MP researches for pH and temperature. The excluded constant hemoglobin concentration can be disturbed by subsequently added chemicals, however if deemed necessary then combining these chemicals with hemoglobin could keep the concentration constant. Furthermore, changes in these factors could theoretically be compensated for mathematically, but this will remain outside of the scope for this project [20]. In table 2 a selection of potential online dissolved oxygen sensors can be found:

Producer	**Products**	**Range** (hPa)	**Accuracy** (hPa)	**Response time** (s)	**Cost** (€ ex. VAT)
Ocean Optics [38]	NEOFOX-KIT-PROBE	0-230	±0.55 at 11.5 ±5.49 at 229.9	Unknown	3,660
PreSens [39]	EOM-O2-FOM, FTC-PSt3	0-1330	±0.55 at 2.19 ±4.39 at 229.29	<40	3,125
Pyro Science [40]	FSO2-1, TOFTC2	0-680	±0.30 at 11.0 ±3.0 at 164.6	<9	3,580

Table 2: List of potential online dissolved optical oxygen sensors. Range and accuracy converted to hPa at 37° C and 1160 hPa pressure, physiological values [24]. Ocean Optics products require a custom part to enable online capability, excluded from price. Response time defined as 90% of a signal measured during a transition from an air saturated to an oxygen deprived solution [39, 40].

2.10 Control

In order to control the carbogen flow the system requires a proportional flow. A selection of low flow proportional valves can be found in table 3. Variable carbogen pressure of 0-4 bar differential pressure can be achieved at the surgical research lab. The incoming pressure of the gas from the perspective of the valve influences the maximum achievable flow.

Producer	**Product**	**Flow rate** (l/min)	**Differential pressure** (bar)	**Hysteresis** (%)	**Cost** (€ ex. VAT)
Aircom [41]	PVK-092	3	3.5	<10	109
Aircom [42]	PV202-004	5	10	<5	110
Baccara [43]	GEM-PR	1.1	12	Unknown	120 (+28.7)
Bürkert [44]	274910	1.2 per bar	10	5	185
Parker [45]	P910000200003	4.2 (2)	0.69 (0.18)	7	108.34 (+10)

Table 3: List of potential proportional valves. Shipping prices in brackets.

2.11 Gas flow sensors

From the datasheets of the proportional valves mentioned in table 3, it can be understood that the relationship between control and flow is not linear [41–45]. Additionally, this relationship is influenced by the pressure at the intake and the hysteresis of the valve. A gas flow sensor could counteract these challenges by creating a feedback loop. Furthermore, with information regarding the gas flow the representation of the results become more meaningful, as a non-linear "control" axis can be replaced with a linear flow axis. Lastly the gas flow sensor could be used to signal the end user for any malfunctioning that might appear during typical usage, e.g. a gas leakage before the flow sensor preventing the system to reach the desired gas flow. A selection of gas flow sensors can be found in table 4:

Producer	**Product**	**Flow rate** (l/min)	**Accuracy** (%)	**Cost** (€ ex. VAT)
Honeywell [46]	AWM3300V	0-1	±1	114
Omron [47]	D6F-P0010A1	0-1	±5	60
Omron [48]	D6F-01A1-110	0-1	±3	109
Omron [48]	D6F-02A1-110	0-2	±3	115

Table 4: List of potential gas flow sensors.

3 Conceptual model

Thus far requirements and other quantifiable parameters have been scattered throughout the document. Table 5 collects these, including the section in which it was discussed and the original source.

Name	Value	Comment	Section	Reference
Max. total gas flow	2.0 l/min	Oxygenator specific parameter	2.5	[17]
Blood flow range	0.15 - 1.0 l/min	Oxygenator specific parameter	2.5	[17]
Physiological PO_2 range	45 - 133.3 hPa	Total range found in blood	2.8	[33]
Max. change oxygen partial pressure	325.8 hPa/min	Unpublished PhD research	2.8	Unpublished
Max. carbogen pressure available	0 - 4 bar	Laboratory specific	2.10	NA
Max. nitrogen pressure available	0 - 4 bar	Laboratory specific	2.10	NA
Gas ratio for 133.3 hPa oxygen	500:175 (ml/min) nitrogen:oxygen	Results following experiment	5.2	NA

Table 5: Collection of requirements and other quantifiable parameters. Max. = maximum, PO_2 oxygen partial pressure, NA = not applicable.

A diagram of the conceptual model of this project can be found in figure 8. Rather than just carbogen entering the gas inlet of the oxygenator a dynamic mixture of carbogen and nitrogen will be supplied. Nitrogen will be kept at a constant flow, as the goal of the system is to achieve a range that is at the bottom of the full possible range of oxygen in the perfusion solution. By dynamically controlling the carbogen and thus the oxygen supply the system should be able reach the entire desired range.

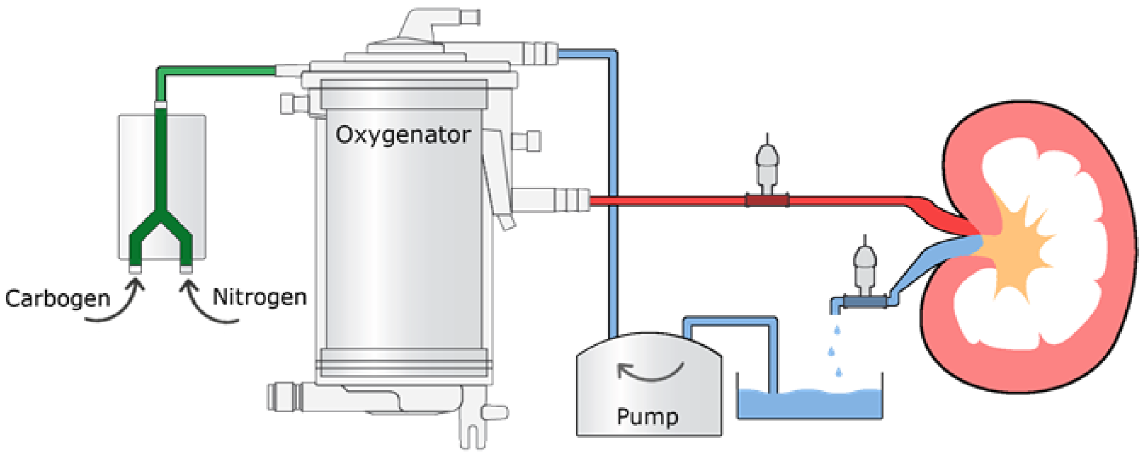

Figure 8: Schematic representation of the conceptual model.

Adding a sensor on the arterial side or the venous side (or both) should allow the system to create a feedback loop using one of the two sensors. However, the prototype will make use of a venous oxygen sensor. This with the hypothesis that a kidney that consumes less also requires less oxygen. Therefore when the kidney changes its consumption, but the system keeps the venous level at a constant level, the arterial oxygen supply has to be adjusted. With this approach the aim is to adjust for the specific needs of the kidney.

3.1 Oxygen sensor

Although gaseous oxygen sensors appear to be a theoretical viable option the practicality presents multiple challenges, as discussed in section 2.9.1. Due to time constraints combined with the practical challenges and due to the fact that another group of engineers and researchers is currently researching this option a decision against gaseous oxygen sensors was taken for the scope of this project. Additionally a decision against oximetry was taken. Choosing for oximetry would disable any option to use the system without hemoglobin, e.g. during hypothermic machine perfusion (HMP) or when using perfusion solutions with a different oxygen carrier. Furthermore, this avoids anemic based misreadings, giving the user liberty over the hemoglobin concentration.

This leaves dissolved oxygen sensors as the last option. However, choosing dissolved oxygen sensing requires to keep the ODC in mind. An unstable ODC would change the total oxygen delivery when keeping just the dissolved oxygen stable. Fortunately, keeping the temperature and pH constant already appears to be a goal during a typical MP setup, as discussed in section 2.2. From the list of potential sensors, found in table 2, the sensor made by Pyro Science appears to beat the competition. It has a better accuracy than both of its competitors and the response time is more than four times faster than the PreSens sensor. Nevertheless, this project will be using the PreSens sensor option, considering the substantial prices and the availability of the PreSens sensor at the laboratory. Unfortunately this presents a challenge in obtaining the data, as this project uses the product in a way it was not designed to. The technical details including the solution to this challenge can be found in appendix A.

3.2 Control

Deciding which low flow proportional valve to choose from the selection found in table 3 brings a challenge. It is known that the oxygenator has a 2.0 l/min limit, but it is unknown how much of the total supply should be nitrogen or carbogen. In order to find a better understanding an experiment had to be set up. The results following this experiment show a 175 ml/min carbogen flow against a 500 ml/min of nitrogen flow, for a 133.3 hPa oxygen level in the perfusion solution (see section 5.2). Furthermore, if possible a low incoming pressure to the valve could improve the user experience. Simply as lower pressures could prevent the tubing installed by the user to come loose.

From the list of potential proportional valves, seen in table 3, can be observed that the documentation of the first three products ignore any information regarding the behaviour when supplied with lower incoming pressures. For this reason a decision against these valves. The process of ordering and testing these products would be too resource intensive for the scope of this project. Additionally there does not appear to be a standard conversion available, judging by the different responses that are documented for other low flow proportional valves [44, 45, 49]. Ultimately a decision for the Bürkert 274910 valve was taken, as the other remaining valve made by Parker was unable to be shipped within the desired time frame. Additionally, the 274910 appears to be the most flexible with a 1.2 l/min/bar flow. This allows any range of flow between 0-2 l/min with incoming pressures lower than 1.7 bar, including a 0.5 l/min at 0.7 bar.

3.3 Gas flow sensor

As with the previous subsection, the results in section 5.2 found a 175 ml/min carbogen flow. Therefore, all ranges of the sensors found in table 4 suffice. When comparing cost and accuracy there seem to be two competitors. The D6F-P0010A1 appears to be the low cost low accuracy winner. The AWM3300V is three times as accurate as the remaining sensors while being of similar cost. The budget allows the extra cost of the AWM3300V, therefore a choice for the extra accuracy has been made.

3.4 Feedback loop design

Only connecting all the different components of the system together does not yield a full prototype. The system needs software that allows the input, the oxygen measurement, to be translated into a corresponding change in output, the openness of the carbogen valve. Therefore a feedback loop design is required. The design of the feedback loop of this project consists of two proportional–integral–derivative (PID) controllers. PID controllers are error based feedback loops. The error is the difference between the setpoint the system aims to achieve and the calibrated value the sensor measures. A combination of the three elements (proportional, integral and derivative) determine how much the control adjusts for a given error.

A diagram of the double feedback loop design can be seen in figure 9. The inner (green) PID controller takes care of the carbogen flow. This allows the proportional valve to get adjusted to the feedback gained from the gas flow sensor that monitors the carbogen flow. Using the oxygen sensor, the outer (orange) feedback loop determines the setpoint of the inner (green) loop. Ultimately this means that the system can achieve the goal of adjusting the proportional valve such that a desired oxygen level in the perfusion solution is met.

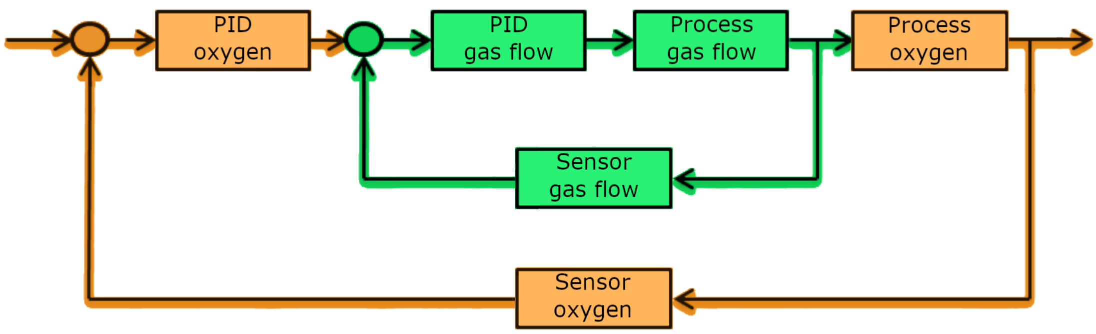

Figure 9: Diagram of the PID control, the gas flow PID (green) nested inside of the oxygen PID (orange).

The decision of using two loops instead of one larger feedback loop was made for multiple reasons. Firstly, it allows for the development to be done in smaller consecutive steps. Separating a task into smaller and thus less complex steps may prevent mistakes. Secondly, it enhances the ease of debugging, during the development but also after production. Enabling the ability to check whether smaller steps of an overall system are done successfully allows for more efficient trouble shooting. Lastly, it increases the flexibility of the system, as one could take out the inner (green) loop and use it in a different setup without much modifications.

3.5 realization

Figure 10 displays an image of the realizations of the conceptual model. Note that the rotameter inlcuded in the figure is used to achieve a stable 500 ml/min nitrogen flow.

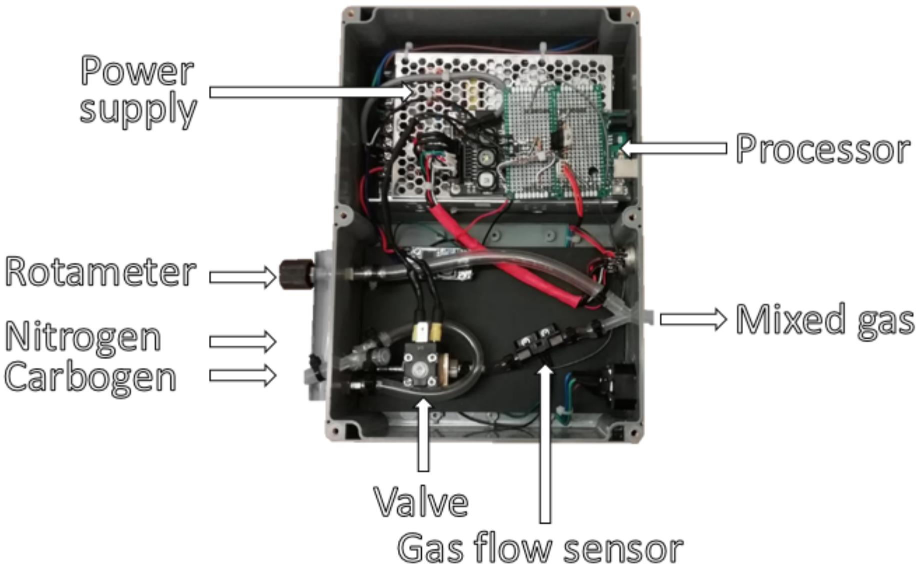

Figure 10: Picture of the realization of the conceptual model in the form of a prototype. Figure excludes (external) oxygen sensors and laptop. Nitrogen and carbogen enter the system through separate tubing and leave the system in a mixed form.

4 Research design

4.1 Response time of the oxygen sensor

Two experiments have been performed in order to investigate whether the response time of the oxygen sensor fits within the requirements. The combination of these experiments will assist in the decision making concerning the oxygen sensor.

4.1.1 Effect of flow rate

One could hypothesise that the flow of the perfusion solution may influence the time in which the sensor responds to a change in oxygen level. In order to find out whether this variable actually influences the response time an experiment was set up. A diagram of the setup can be seen in figure 11:

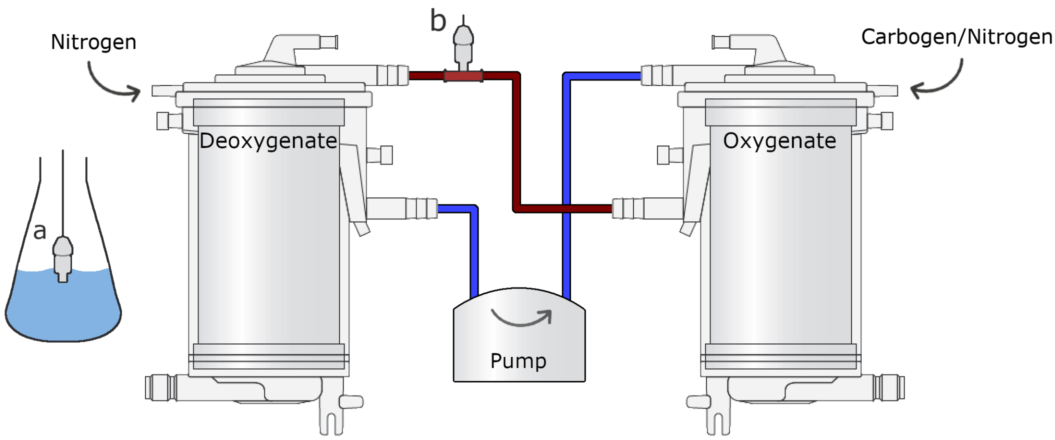

Figure 11: Schematic representation of the response time experiment setup.

By supplying the left oxygenator with nitrogen its purpose is to remove the oxygen from the water. By adjusting the mixture of carbogen and nitrogen supplied to the right oxygenator different oxygen levels in the water at point b can be achieved. Water was chosen as it was not expected to behave differently than other possible perfusion solutions. This choice brings obvious financial and ethical advantages. Once a desired stable oxygen level at point b was achieved, the sensor would move to point a. After a stable reading is achieved at point a, the sensor would be moved back to point b. The time the sensors takes to read the original reading at point b again will be considered the response time, within the margin of the documented accuracy. Important to note is that the gaseous supplies during this experiment are achieved by the use of the available rotameters.

To test whether the flow of the water has an influence two different groups have been created. One with a low flow, another with a high flow. If these groups have a statistically significant difference then the flow variable will have to be taken into account in the following response time experiment.

4.1.2 Response time to different deltas

One of the characteristics of dissolved oxygen sensors is their relatively high response time. The response time of the sensor used during this project, the FTC-PSt3, is <40 seconds, defined as 90% of the signal measured during a transition from an air saturated to an oxygen deprived solution [39]. However, this does not provide information regarding response times to different changes than the documented one. Therefore this experiment has been created to find whether the maximum change of 325.8 hPa/min can be achieved by the sensor (see section 2.8 for more information).

Following the results found in section 5.1.1, it can be concluded that the flow has an influence on the response time. The lower the flow, the lower the response time. Therefore this experiment will use the minimum flow specified in the documentation of the oxygenator, 150 ml/min [39].

The overall setup was identical to the one in section 4.1.1. However, during this experiment the groups were subjected to different oxygen deltas between point a and b. The flow of the water was kept at a constant for all the groups in this experiment.

4.2 Desired ratio of gas mixture

To aid the decision making regarding the purchasing of the proportional valve and gas flow sensor an experiment was performed. This experiment aims to investigate the desired ratio in which the nitrogen and carbogen have to be presented to the oxygenator in order to achieve desired oxygen levels in the perfusion solution. In figure 12 a diagram of the setup can be found:

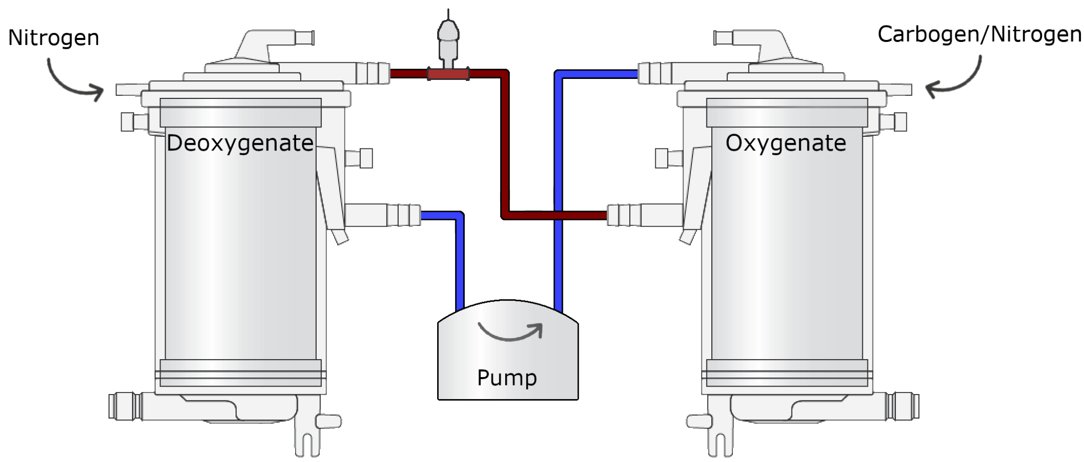

Figure 12: Schematic representation of the desired steady state setup.

As can be seen, the setup is similar to the previous experiments. The nitrogen removing the oxygen and the dynamic carbogen and nitrogen supply principles remain. However, a porcine blood based perfusion solution has replaced the water. Different carbogen and nitrogen ratios will be supplied to the right oxygenator and will be adjusted until an oxygen pressure of 133.3 hPa is measured.

The carbogen flow was measured using an oxygen calibrated rotameter, the nitrogen flow was measured using a nitrous oxide rotameter. Using the method explained in section 2.6 the following two rotameter conversions have been used:

Oxygen to carbogen:

$$K = \sqrt{\frac{1.429}{1.456}} = 0.991$$

Nitrous oxide to nitrogen:

$$K = \sqrt{\frac{1.834}{1.251}} = 1.211$$

4.3 Gas flow subsystem

The double feedback loop design discussed in the conceptual model (see section 3) includes the gas flow subsystem. This section includes two experiments that have been performed in order to complete this subsystem, such that it can later be incorporated into the full system.

4.3.1 Gas flow sensor calibration

The gas flow sensor required calibration, as the manual only includes calibration for air [50]. Using a rotameter, that has been calibrated for pure oxygen, the actual carbogen flow was found using the method explained previously (see section 2.6). The corresponding sensor readout was saved. The result of this allows to convert the sensor readout to a measurement in ml/min.

The rotameter conversion calculation:

$$K = \sqrt{\frac{1.429}{1.456}} = 0.991$$

4.3.2 Inner loop PID tuning

The gas flow feedback loop requires to know how much it should adjust the proportional valve given an error. This error is the difference between the measured and the desired carbogen gas flow. To achieve this a set of step inputs will be administered to the system. These step inputs create a sudden change in how open the valve is. During this time the resulting flow will be measured.

Using this data the software called TuneWizard will be used to create a corresponding mathematical model [51]. This model is then used to derive the proportional, integral and derivative gain. Using these gains the system is informed how much it should change the openness of the valve given an error in gas flow. Figure 13 shows the corresponding feedback loop diagram:

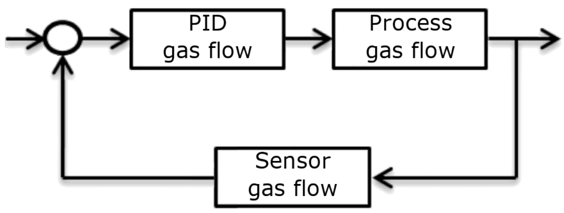

Figure 13: Diagram of the PID control which will be tuned in this experiment. Diagram identical to the inner (green) loop seen in figure 9.

4.3.3 Inner loop PID validation

Before nesting the inner loop into the whole system it is important to know whether the inner loop works as intended. Therefore this experiment was performed. After the implementation of the PID control that makes up the inner loop the system was tasked to create a multitude of set flows. Once the set flow had been reached it was tasked to hold it for a period of time. From here the difference between the measured and the set flow can be calculated. Additionally, the time it takes the system to go from one set point to the next can be investigated as well.

The system is expected to hold the flow at a stable level without large deviations, once the set flow is reached. Also, preferably the system should not take too much time moving between different set points.

4.4 Complete system

4.4.1 Outer loop PID tuning

This experiment is the first experiment in which the full setup explained in section 3 was deployed, thus including a porcine kidney. The only exclusion was the automation part of the outer feedback loop seen in figure 14, as the proportional, integral and derivative gains for this PID loop were unknown before this experiment.

Rather than directly dictating the openness of the valve the gas flow subsystem is dictated to create step inputs by changing its carbogen flow setpoint. Ultimately, this creates different oxygen levels in the perfusion solution that enters the kidney. As different oxygen levels entered the kidney, the oxygen levels leaving the kidney were also expected to differ. These resulting venous oxygen levels were saved, such that the required gains can now be calculated in similar fashion as explained in section 4.3.2.

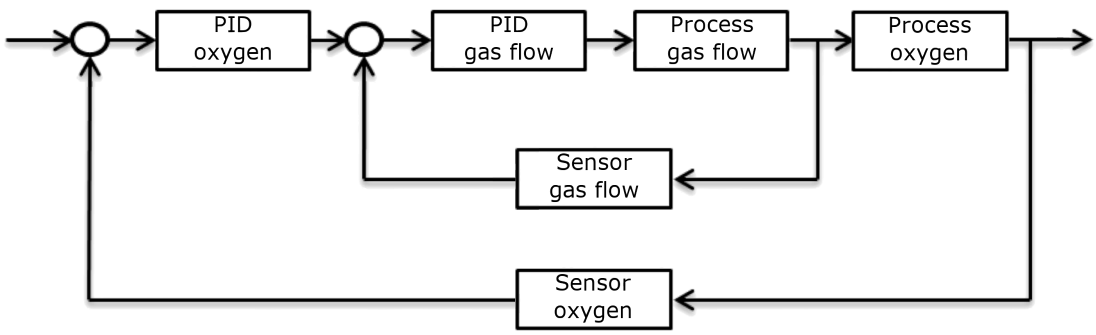

Figure 14: Diagram of the PID control. The outer loop has been tuned in this experiment. Diagram identical to the loop seen in figure 9, excluding the colors.

4.4.2 Outer loop validation

After the entire system was tuned it was ready to undergo a validation procedure. The system was tasked to keep a set venous oxygen level. Once it has done this for a period of time the system will be subjected to a temperature change. With a change in temperature a change in metabolic rate is expected, for which the system would have to adjust. As less or more oxygen would have to be delivered to the kidney when its consumption changes, in order to keep the venous oxygen level at a constant.

In order to change the temperature ice will be added to the waterbath that warms the perfusion solution, the chamber will be opened and the heater will be turned off (see section 2.2).

During the period in which no change in temperature is experienced the system is expected to keep its actual oxygen level close the set oxygen level. Once the temperature change and thus the metabolic change happens the system is expected to follow the metabolic change as closely as possible, by keeping the venous oxygen level at a stable level.

5 Results

When applicable, all raw data of the results can be found in the appendix. Titles of the appendix are labelled with the corresponding number of the subsections found in this section. Note that the research design subsections follow the same order as the corresponding results subsections (e.g. the research design in section 4.1.1 corresponds to results in section 5.1.1).

5.1 Response time of the oxygen sensor

5.1.1 Effect of flow rate

During the experiment that investigated the effect of the flow rate on the response time of the dissolved oxygen sensor the following results were created, see table 6:

Run	**Group 150 ml/min response time** (s)	**Group 575 ml/min response time** (s)
1	49	29
2	58	29
3	48	27
4	51	30
5	54	30
Mean	52	29

Table 6: Results of the effect of flow rate on the response time of the dissolved oxygen sensor. First group experienced a flow rate of 150 ml/min, the second group 575 ml/min.

From this table a histogram including the statistical significance has been created, see figure 15:

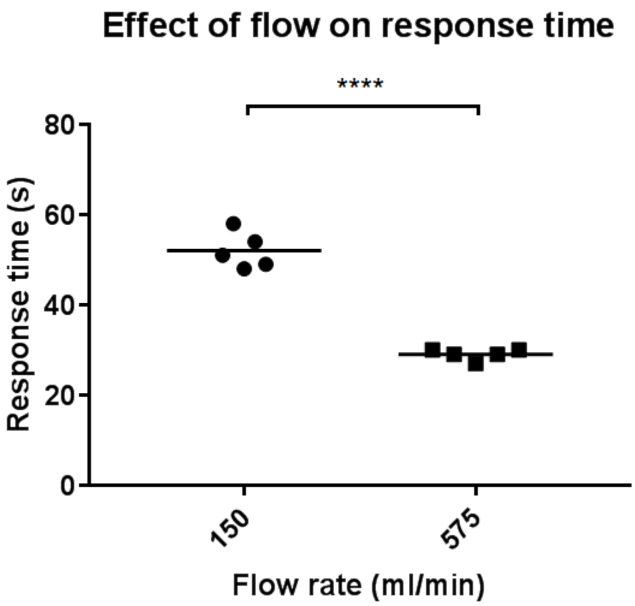

*Figure 15: Histogram of the results of the effect of flow rate on the response time of the dissolved oxygen sensor. First group experienced a flow rate of 150 ml/min, the second group 575 ml/min. A statistical significant difference between the two groups was observed. **** significance indicates $P \leq 0.0001$.*

From the statistical significance between the two groups can be concluded that the flow rate does have an influence on the response time. A lower flow rate results in a lower response time. This information was used in the following experiment.

5.1.2 Response time to different deltas

In this followup experiment the response times to different oxygen deltas were researched. The flow was kept at a stable 150 ml/min. The results can be found in table 7:

Run	**Δ300 hPa response time** (s)	**Δ350 hPa response time** (s)	**Δ400 hPa response time** (s)	**Δ610 hPa response time** (s)
1	46	48	49	62
2	50	45	58	60
3	49	47	48	61
4	48	50	51	57
5	48	49	54	55
Mean	48.2	47.8	52	59

Table 7: Results of the response times to different changes in oxygen level. The group with a 610 ΔhPa was added to investigate statistical difference.

From the above table the following histogram was created, see figure 16:

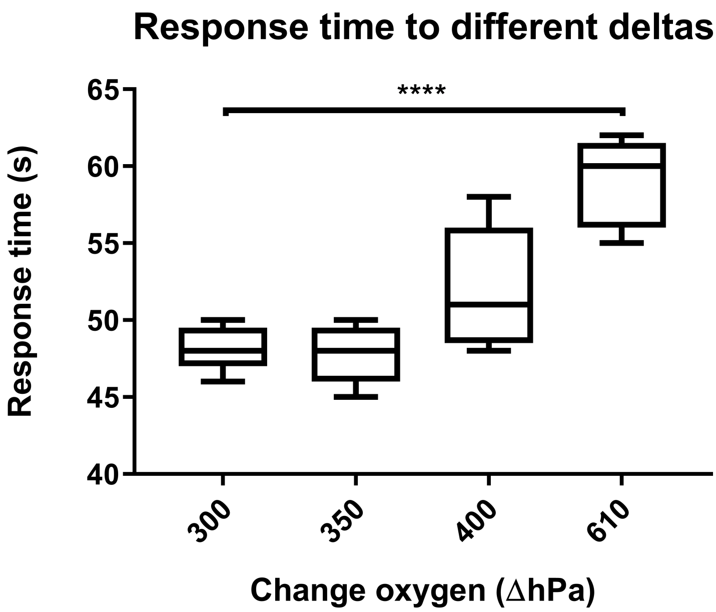

*Figure 16: Histogram of the results of the response time of the dissolved oxygen sensor to different oxygen deltas.**** significance indicates P ≤ 0.0001, between the 300ΔhPa and 610 ΔhPa groups.*

All of the measurements of the 300, 350 and 400 ΔhPa groups stayed within the 60 seconds response time. Therefore a 400 hPa/min change can be observed by the dissolved oxygen sensor. A change greater than the 325.8 hPa/min requirement, meaning the requirement is met.

The 610 ΔhPa group was added to the experiment in order to investigate the statistical significance. The group had two measurements outside of the 60 seconds response time. Therefore a change of 610 hPa/min can not be reliably measured.

5.2 Desired ratio of gas mixture

During the experiment that researched the ratio between nitrogen and carbogen supplied to the oxygenator, in order to achieve an oxygen level of 133.3 hPa, the following results were measured. Note that the measured flows by the rotameters used in this experiment have to be converted. In table 8 both the original measured flows and the adjusted flows can be observed:

Measured carbogen flow (l/min)	**Converted carbogen flow** (ml/min)	**Measured N2 flow** (l/min)	**Converted N2 flow** (ml/min)	**Oxygen** (hPa)
0.17	168.4	0.5	525	134
0.25	247.7	0.65	682.5	132.5
0.48	475.5	1	1050	133.3
0.09	89.2	0.25	262.5	132.3
0.81	802.5	1.5	1575	133.6
0.34	336.8	0.75	787.5	132.5
0.66	653.9	1.25	1312.5	132.7

Table 8: Results of the experiment that researched the ratio between nitrogen and carbogen supplied to the oxygenator in order to find a 133.3 hPa dissolved oxygen level.

The seemingly linear relation between the nitrogen and carbogen have been plotted in figure 17, alongside a linear fit:

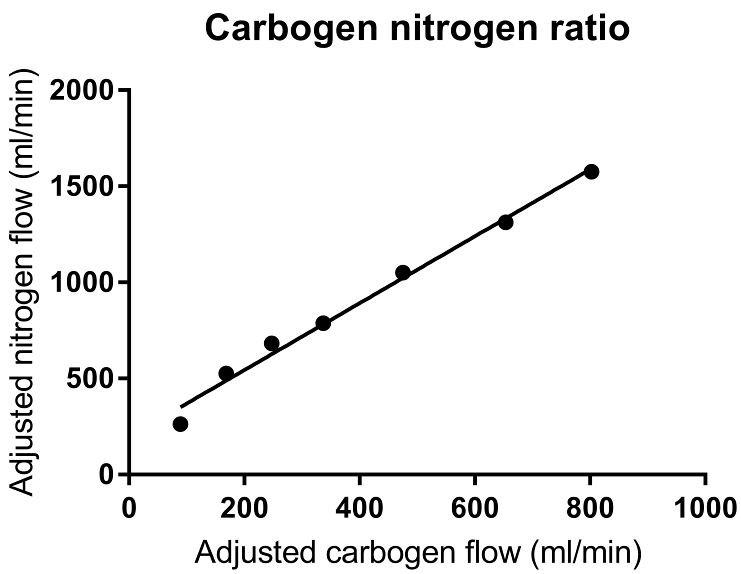

Figure 17: Graph of the ratio between nitrogen and carbogen in order to achieve an oxygen level of 133.3 hPa, alongside a linear fit with an R^2 of 0.9891.

The formula of the linear fit results in:

$$Flow_{nitrogen} = 1.7402 * Flow_{carbogen} + 195.4$$

Which results in a 175 ml/min carbogen flow for a 500 ml/min nitrogen flow. These results guided the decision making regarding the proportional valve and the gas flow sensor, found in section 3.

5.3 Gas flow subsystem

5.3.1 Gas flow sensor calibration

The results of the gas flow sensor calibration can be found in table 9. Both the original and the rotameter converted data are included:

Signal 1 (0-1023)	**Signal 2** (0-1023)	**Signal 3** (0-1023)	**Average** (0-1023)	**Measured flow** (ml/min)	**Converted flow** (ml/min)
202	204	206	204	0	0
395	393	394	394	100	99.1
539	546	541	542	200	198.2
661	658	661	660	300	297.2
751	748	751	750	400	396.3
806	816	814	812	500	495.3
860	854	863	859	600	594.4
921	930	921	924	700	693.5
953	944	950	949	800	792.5
989	994	990	991	900	891.6
1020	1012	1022	1018	1000	990.7

Table 9: Results of the calibration of the gas flow sensor.

Plotting this data shows a graph that does not appear to be linear, see figure 18:

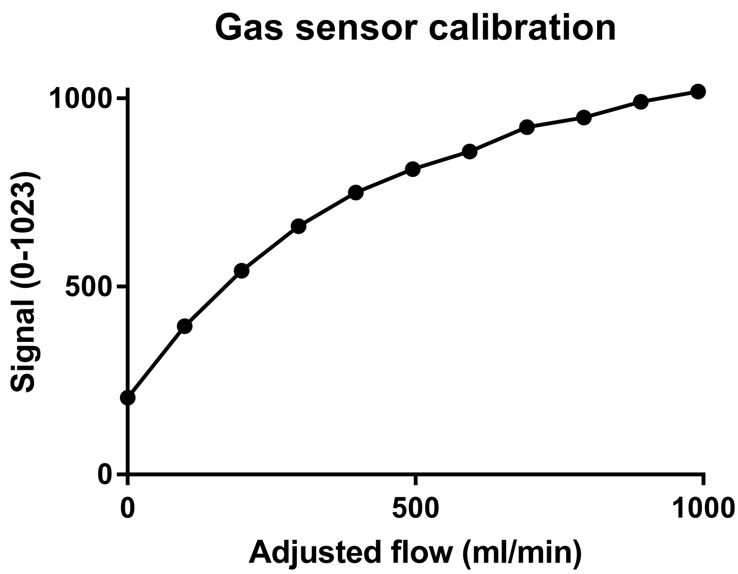

Figure 18: Graph of the calibration results of the gas flow sensor. Error bars not shown, due to being graphically too small.

Fitting the above data to the following equation scores an R^2 of 0.9996:

$$y = 1369.664 + \frac{203.5855 - 1369.664}{1 + (\frac{x}{454.166})^{1.068381}}$$

However, implementing the above equation on the available embedded system yielded inaccurate mathematical results. The type of computing power required for the fit was unavailable. Therefore the following consecutively ordered linear equations are used, expressed in C++ code:

```
// C++ implementation of the gas flow calibration

double CalibrationFunction(double analog) {
  if (analog < 205) return 0;
  else if (analog < 395) return 0.521413 * analog - 106.3682;
  else if (analog < 543) return 0.6693815 * analog - 164.6679;
  else if (analog < 661) return 0.8395632 * analog - 256.9064;
  else if (analog < 752) return 1.088664 * analog - 421.3131;
  else if (analog < 813) return 1.624073 * analog - 823.4051;
  else if (analog < 858) return 2.10784 * analog - 1216.223;
  else if (analog < 925) return 1.52413 * analog - 714.8171;
  else if (analog < 950) return 3.962739 * analog - 2968.091;
  else if (analog < 992) return 2.358773 * analog - 1445.928;
  else if (analog < 1024) return 3.669202 * analog - 2744.563;
}
```

5.3.2 Inner loop PID tuning

The inner loop PID tuning data regards the gas flow subsystem. In figure 19 two graphs can be seen, the input (green) and the output (blue). The input is the variable that is being controlled and it regards the openness of the valve that proportionally allows or restricts the carbogen to flow. The output is the resulting flow, measured by the gas flow sensor. In figure 19 can be seen that the output follows the input, ultimately showing that a more open valve results in a higher measured flow:

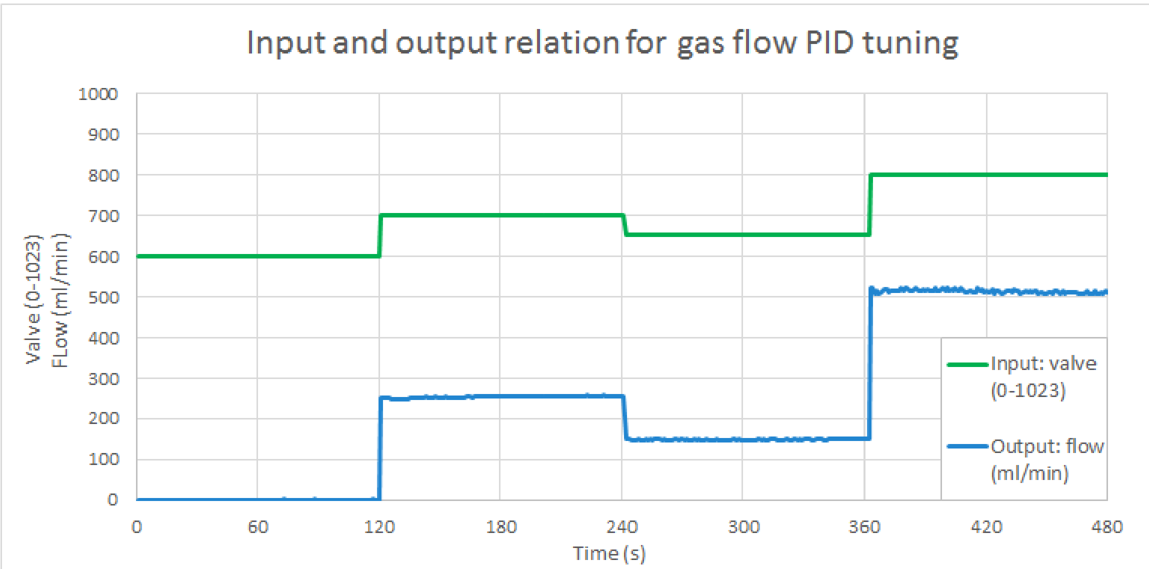

Figure 19: Plots of the input and resulting output of the gas flow subsystem during a series of step inputs.

However, the reason of the above graph was not to see if the output follows the input. The actual purpose of this data was to create a mathematical model of the relation between the input and output. This was done by feeding the above data into the TuneWizard software in order to make this model [51].

Using the above mentioned mathematical model the plot in figure 20 was made. This plot includes two graphs, one for the mathematical model (orange) the other for the actual response (blue). The actual response is the same the previous output seen in figure 19. The mathematical model was simulated to respond to the same input as the actual model. The goal of the mathematical model is to approximate the actual response.

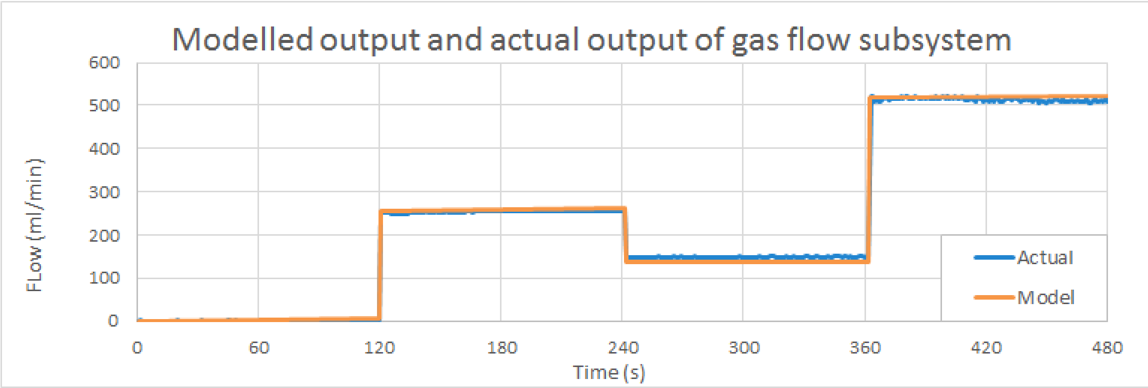

Figure 20: Plots of the response of the mathematical model and the actual response given the same input, for the gas flow subsystem.

Note that the purpose of the model should not be confused. The model will not be used to calculate the desired openness of the valve for a given flow. Instead the model is used to calculate the three gains of the PID system. The above process was repeated in order to find a total of 3 sets of gains, which can be found in table 10:

	Proportional gain	**Integral gain**	**Derivative gain**
Run 1	0.13	0.19	0
Run 2	0.14	0.19	0
Run 3	0.13	0.19	0
Mean	0.13	0.19	0

Table 10: Table of proportional, integral and derivative gains for the gas flow subsystem.

The above mean gain will be used to tune the inner feedback loop.

5.3.3 Inner loop PID validation

After the tuning of the inner loop an experiment was performed to see how well this implementation performs. Figure 21 holds a plot including two graphs. The desired (blue) graph was the flow the system was aiming to achieve at a given moment. Additionally the measured flow (orange) can be observed as well.

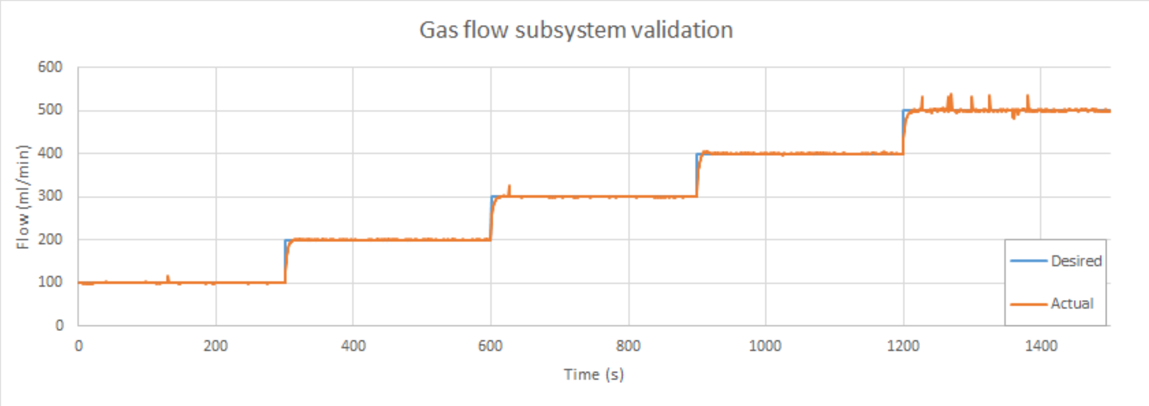

Figure 21: Graph of the desired and actual flows of the gas flow subsystem, during the validation experiment.

With the combination of data points after a reading had become stable a standard deviation was calculated, for each of the different set flows. The time to stable was found by finding the first measurement that came within the standard deviation of the corresponding set flow. The time it takes to come back, within the standard deviation margin, after an overshoot was added to the time. See table 11:

Flow (ml/min)	100	200	300	400	500
SD	1.13	0.60	1.87	1.21	5.28
Time to stable (s)	-	14	14	21*	12

*Table 11: Standard deviation and time to stable for different gas flow set points, during the validation experiment. * indicates an overshoot causing the time to stable to be increased.*

From the above graph and table we can see that the system was effective in maintaining a set gas flow once the set point had been reached. All groups achieved standard deviations of $\leq 1.13\%$ of the corresponding set point. Interesting to note however are the observed sudden changes, which can be seen in figure 21 as sharp spikes in the graph. The origin of these sudden changes remain unknown, they may be caused by the proportional valve, they may be false reading of the sensor or caused by an external variable. Even more impressive standard deviations would have been observed were these sudden changes be absent. Expressing the error in standard deviation was chosen as the observed spikes would influence the total $\pm$ error drastically.

The time it takes the system to reach a set point appears to be less impressive. However, whether such sudden changes in gas flow are required in the complete system is unknown. Also the potential consequences of this are unknown. All we can use this data for is highlight a potential area of improvement, would complementary research request such.

5.4 Complete system

5.4.1 Outer loop PID tuning

In similar fashion as in the previous experiment, the outer oxygen feedback loop was submitted to a series of step inputs. In figure 22 the input (green) and the resulting output (blue) can be found:

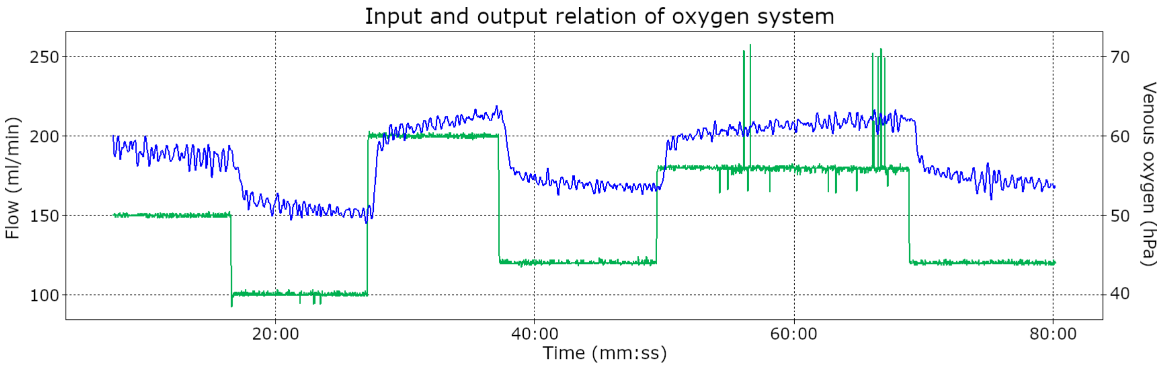

Figure 22: Plots of the input and resulting output of the full system during a series of step inputs. Input in carbogen flow (ml/min) depicted in green, output in venous oxygen level (hPa) depicted in blue.

In similar fashion as during the experiment in section 5.3.2 a mathematical model was created. This model will be used to calculate the three gains required for the PID controller. The response of the mathematical model and the actual response are plotted in figure 23:

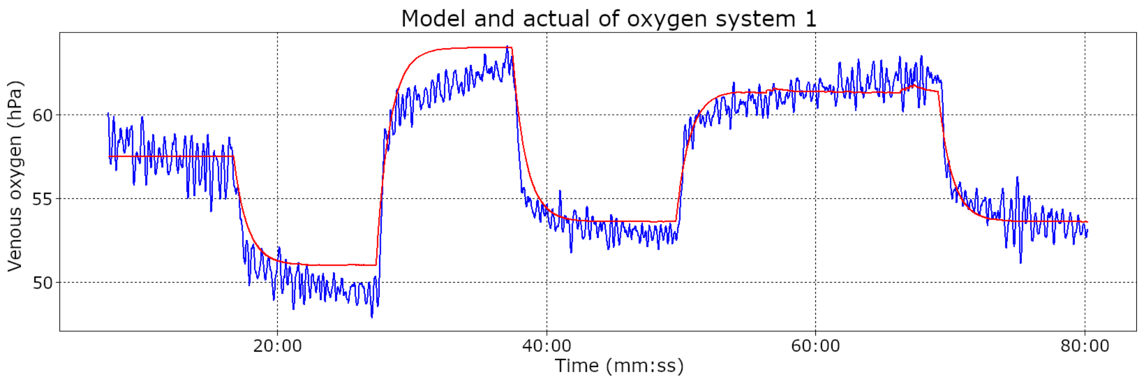

Figure 23: Plots of the response of the mathematical model and the actual reponse given the same input, for the full system. Mathematical model depicted in red, actual reponse in blue.

The process above was repeated for a total of three different kidneys, in order to find three different sets of PID gains. The actual response to the step inputs and the response of the mathematical model of the second kidney can be seen in figure 24. This second set of data includes one small difference. The kidney during the second run was the same kidney after a pilot of the validation experiment of section 5.4.2. This was done for financial reasons as well as time efficiency. During this pilot the kidney endured multiple ischemic periods due to technical difficulties. Consequently the expected metabolic rate is lower than what it would have been at the beginning of the pilot.

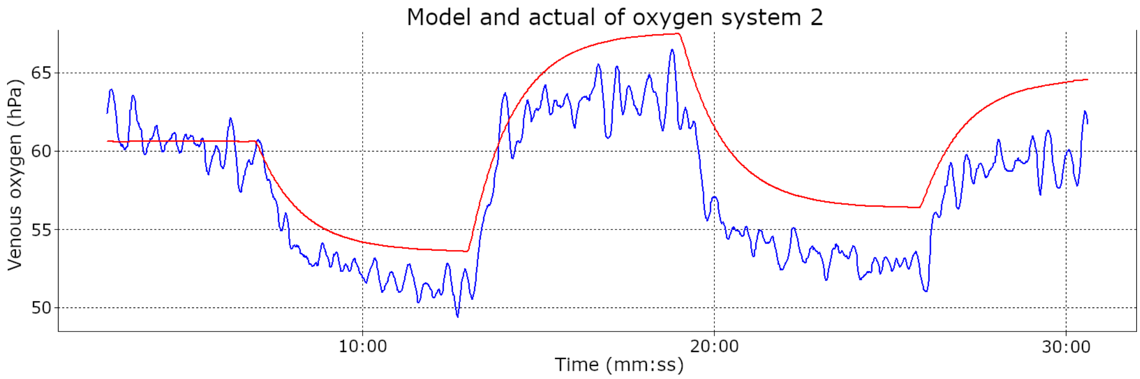

Figure 24: Second set of plots of the response of the mathematical model and the actual reponse given the same input, for the full system. Mathematical model depicted in red, actual model in blue. Kidney endured multiple ischemic periods and data of the last step impulse was lost due to technical difficulties.

Even though the two kidneys of figure 23 and 24 experienced identically oxygenated arterial blood, their response does differ. The highest data points in figure 24 are higher than those of figure 23. Perhaps this could be explained by the less expected metabolic rate of the kidney of figure 24, as less oxygen consumption at the same arterial oxygen delivery would result into a higher venous oxygen level.

The resulting gains of all three kidneys can be found in table 12:

	Proportional gain	**Integral gain**	**Derivative gain**
Kidney 1	5.7	0.89	0.12
Kidney 2	5.8	1.2	0.088
Kidney 3	7.0	1.7	0.0084
Mean	6.2	1.3	0.072

Table 12: Table of gains from three different kidneys subjected to identical step inputs.

The above sets of gains show quite a bit of variety. Preferably the sets of gains would have been close together, for all kidneys under all circumstances. However, the above observed variety shows that this is not the case. This does not necessarily have to mean that this approach of feedback control will not work. It will however at least hurt the performance of the resulting prototype, assuming the system is not retuned continuously. More on this in the discussion in section 6.

5.4.2 Outer loop validation

Using the mean of the PID gains of kidney 1 and 2, found in the previous section 5.4.1, the outer loop of this experiment was tuned. The kidney used in this experiment is the same kidney as kidney 3 of section 5.4.1. In order to guarantee the results of this experiment to be independent of the results of the tuning experiment the set of gains of kidney 3 have been excluded in this experiment. With the double PID controller in place the system was tasked to achieve a stable 45 hPa oxygen level. Figure 25 shows the resulting venous oxygen level:

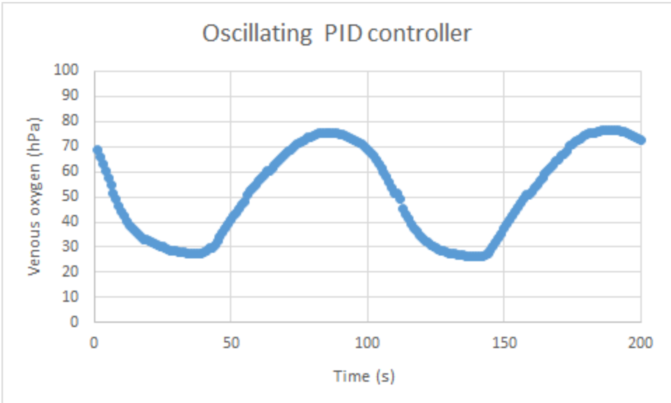

Figure 25: PID controller failing to achieve a stable oxygen level.

The clear oscillating behaviour is a result of an incorrectly tuned PID controller. A controller that is too aggressive in changing its control according to an error will overshoot its desired level and thus create a new error, potentially creating a vicious circle. Clearly this is undesired behaviour.

Seemingly functioning gains were found after a series of trial and error. The gains used during the new attempt can be seen in table 13:

Proportional gain	Integral gain	Derivative gain
3	0.1	0

Table 13: Gains found after a series of trial and error.

As these gains were found to not have the undesired oscillating behaviour the validation experiment was continued with the above gains.

The following results are all obtained using the newly found gains from table 13. All of the data was measured simultaneous, meaning that all horizontal axes are identical for all the graphs in figure 26:

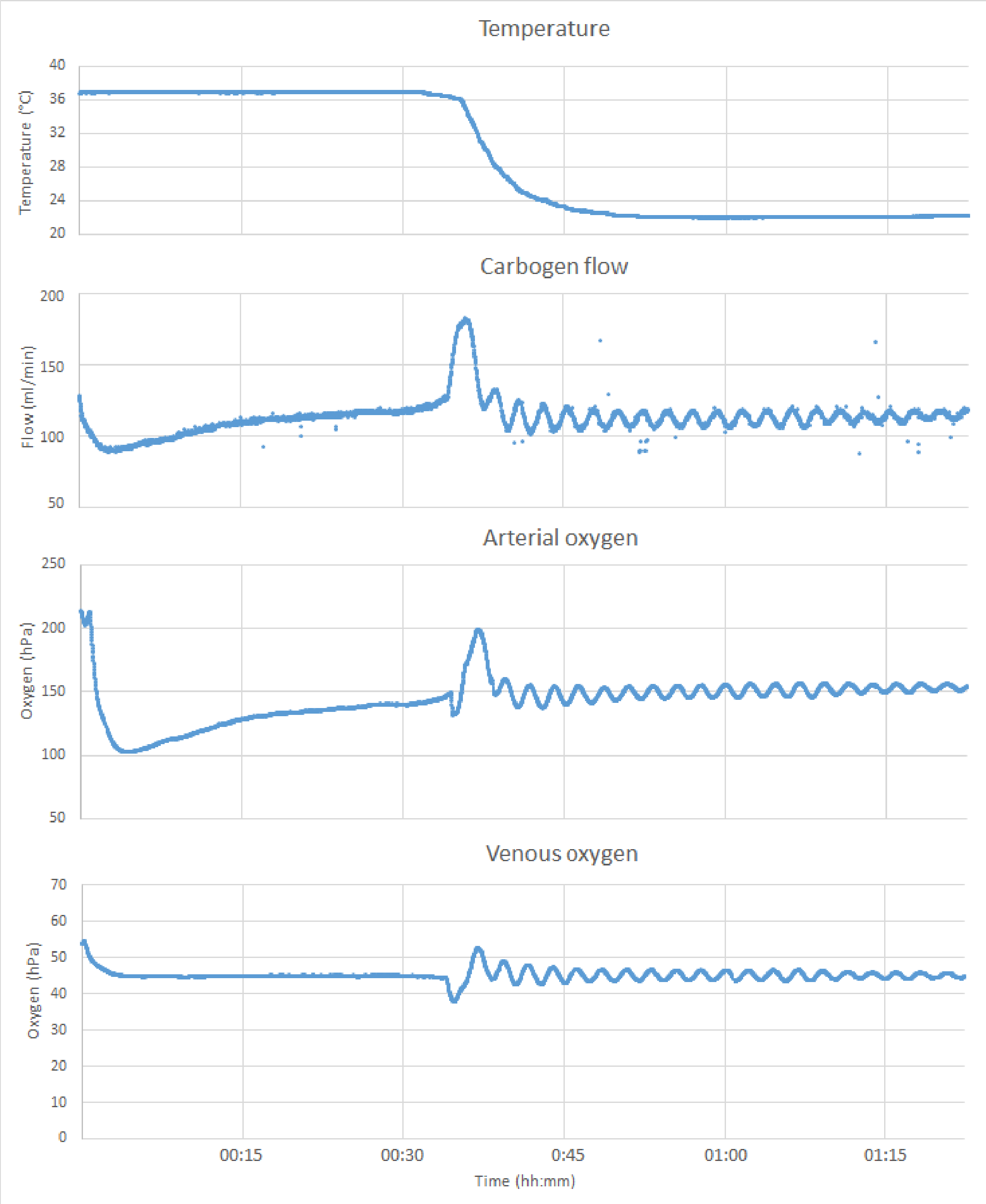

Figure 26: Graph with data of the outer loop validation, using the newly found PID gains. Includes temperature, carbogen flow, arterial and venous oxygen levels.

With the newly found gains the system was able to achieve its aim of 45 hPa venous oxygen, as can be seen during the first 30 minutes of figure 26. The system was able to decrease the oxygen level to the desired 45 hPa, from a 53 hPa which happened to be its initial state. This adjustment was done without overshoot and within 5 minutes. Once a stable 45 hPa was achieved the highest measured oxygen level was 45.17 hPa, whereas the lowest measured oxygen level was 44.21 hPa. Completing an error of $\pm$ 0.79 hPa. During the stable period the system did have to change its control, as can be seen in the first 30 minutes of the carbogen flow. Meaning that the system was able to keep a stable venous oxygen level for the duration of 25 minutes in which no drastic changes in metabolic rate were expected.

Interesting to see is how closely the arterial oxygen level follows the carbogen flow. This suggests that the concentration of oxygen supplied to the oxygenator dictates the arterial oxygen level, regardless of the oxygen level of the venous blood that the oxygenator takes in.

The change in temperature, measured inside the perfusion solution, was no accident. Due to this change in temperature a change in metabolic rate was expected. The ideal response of the system was to correct for the change in metabolism and keep the venous oxygen level at or close to a stable 45 hPa. However the system became unstable due this change, as can be seen from the data after 35 minutes in figure 26. The system moved into an oscillating state, similar to the behaviour of the beginning of this subsection. This means that the change in temperature made such changes to the input and output relation that even using the newly found PID gains were too aggressively compensated for a given error. A controller that is too aggressive in changing its control according to an error will overshoot its desired level and thus create a new error. This means that the system failed creating the desired stable oxygen level in the perfusion solution during the drastic temperature change.

Figure 27 and 28 were taken during the validation experiment:

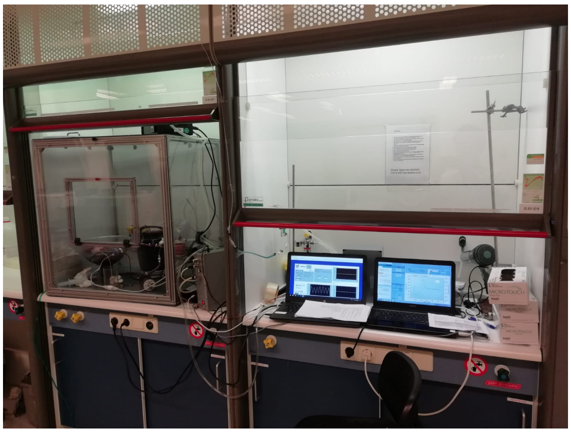

Figure 27: Photo of the entire setup during the validation experiment.

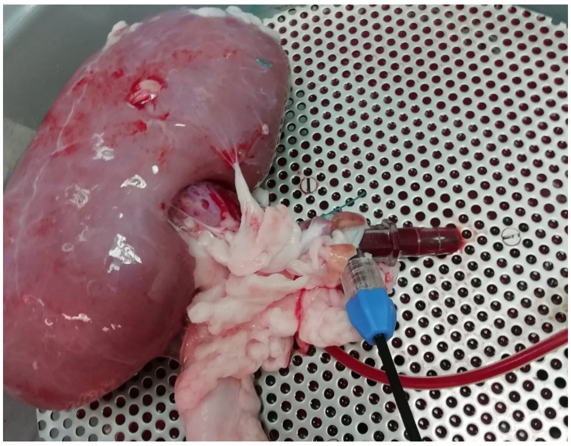

Figure 28: Photo of the kidney during the validation experiment.

6 Discussion

During the validation of section 5.4.2 it was observed that the gains found in section 5.4.1 were incorrect. Most likely does the method of PID tuning in section 5.4.1 require change. After the original tuning process of kidney 3 the same kidney was used during the validation. However, comparing the original PID gains of kidney 3 to the trial and error based gains found for the same kidney can be concluded that the original gains were non-functional. It may be the case that the input and output relation was too non-linear for the original gains to properly work. This non-linearity means that the error-based corrections the system makes, will have a different weight to its correction, based on where on the input and output relation it currently operates. Another potential reason for the same challenge comes from the delay between control and the corresponding result. For the scope of this project that is the time it takes for the oxygen level in the perfusion solution to change after changing the openness of the proportional valve. This delay can create an oscillating behaviour, as the error will remain to be measured for the duration of the delay, while in the mean time the control is being changed in a cumulative manner. By the time the oxygen level has changed the experienced change in control was too drastic for the actual error, creating a new error and starting the oscillation. Regardless of the reason, the result is similar, in order to stop this undesired behaviour the PID gains need to be lower. However, this will mean that reacting to errors will happen slower, potentially increasing the total error the system will have as a performance.

Section 5.2, which aimed to find a desired ratio between nitrogen and carbogen, only has 1 repetition per data point. Typically experiments are repeated multiple times, but due to time constraints this was not done for said experiment. The combination of data points did however point towards a linear relation, as a group. It did not seem to be unreasonable to think that the actual relation is linear, as the concentration of gaseous oxygen may dictate the oxygen level measured in the arterial perfusion solution. Much later, in section 5.4.2, can be observed that the carbogen flows stayed close to the previously found nitrogen and carbogen ratio. Meaning that in hindsight the n=1 of section 5.2 did not result in incorrect decision making.

The combination of results of this project only partially answers the last research sub-question. "How can the system adjust for the different oxygen requirements of the kidney?". Although the document proposes an idea and also implements it, it remains unknown whether it is beneficial to the health of the kidney. In order to answer that more research is required.

7 Conclusion

From literature and within the scope of the project the dissolved oxygen sensors appeared to be the best fit for oxygen monitoring. The experiments first showed the perfusion solution flow to influence the response time of the sensor, but regardless of this it was shown that the dissolved oxygen sensor PreSens FTC-PSt3 meets the response time requirement of at least 325.8 hPa/min. This sensor was used in the prototype.

After which a desired gas ratio was found of 500:175 nitrogen:oxygen, for a 133.3 hPa oxygen level in the perfusion solution. A decision for the AWM3300V gas flow sensor could then be made, in combination with the proportional valve Bürkert 274910. This allowed the gas flow subsystem to successfully combine a constant nitrogen flow to a dynamic oxygen flow using a PID control.

All of this allowed the realization of the conceptual model in which the above mentioned gaseous mixture was able to control the oxygen level in the venous perfusion solution. The concept of measuring and adjusting over the venous oxygen levels may to adjust for the change in metabolic rate of the kidney (see section 6).

In conclusion this project has achieved to add to the current perfusion machine a system that can dynamically control the oxygen level and may adjust to the metabolic rate of the kidney. During validation the resulting prototype of this project was able keep a stable (± 0.79) 45 hPa venous oxygen level, tested on one individual kidney. However, more research regarding the success of the implementation is required (see section 6 and 7.1).

7.1 Future recommendations

As discussed in the first paragraph of section 6, the outer loop PID tuning of section 5.4.1 needs to be reevaluated. During the validation found in section 5.4.2 was found that the previously found gains were non-functional. As a consequence said validation would also have to be redone. This way, presumably lower gains will have to be found, as discussed in section 6.

After finding new and better gains for the outer loop, an experiment regarding the effectiveness of the prototype is in place. Even though the literature seems to be clear on the necessity of avoiding non-physiological oxygen levels, some sort of quantification regarding the usefulness of this project could provide information for the decision to continue this project can be made.

If a decision for continuing the development of this project is made the first area of improvement might be a more complex control for the outer loop. Perhaps the world of artificial intelligence could provide a better control solution.

8 List of definitions

Anemia - A condition in which there is a deficiency of red cells or of hemoglobin in the blood, resulting in pallor and weariness.
DNA - Deoxyribonucleic acid.
Graft - A piece of living tissue that is transplanted surgically.
HMP - Hypothermic machine perfusion.
Hyperoxia - An excess in the amount of oxygen reaching the tissue.
Hypothermia - The condition of having an abnormally low body temperature.
IRI - ischemia-reperfusion injury.
Ischemia - An inadequate blood and oxygen supply to an organ or part of the body, especially the heart muscles.
MP - Machine perfusion.
NMP - Normothermic machine perfusion.
Normothermia - Normal body temperature; the condition of having a normal body temperature.
ODC - Oxygen dissociation curve.
Perfusion - The passage of blood, a blood substitute, or other fluid through the blood vessels or other natural channels in an organ or tissue.
Supraphysiological - Higher in value than is normal in an animal or plant.
RAM - Random access memory.
Respiratory quotient - The ratio of the volume of carbon dioxide evolved to that of oxygen consumed by an organism, tissue, or cell in a given time.
RNA - Ribonucleic acid.
ROS - Reactive oxygen species.
RQ - Respiratory quotient.
UMCG - University Medical Center Groningen.

9 References

[1] Nederlandse Transplantatie Stichting. *Cijfers over donatie en transplantatie*. Mar. 26, 2019. URL: https://www.transplantatiestichting.nl/cijfers-over-donatie-en-transplantatie (visited on 06/18/2019).

[2] Nederlandse Transplantatie Stichting. *Donatie en transplantatie: alle cijfers weefsels en organen*. Mar. 26, 2019. URL: https://www.transplantatiestichting.nl/cijfers/organen-cijfers-van-de-afgelopen-jaren (visited on 06/18/2019).

[3] Nederlandse Transplantatie Stichting. *Wachtlijsten voor organen*. Mar. 26, 2018. URL: https://www.transplantatiestichting.nl/cijfers/organen-jaarcijfers/wachtlijsten-voor-organen (visited on 05/19/2019).

[4] Patrizia Burra et al. "EASL clinical practice guidelines: liver transplantation". In: *Journal of hepatology* 64.2 (2016), pp. 433–485.

[5] Anne-Hélène Querard et al. "Comparison of survival outcomes between Expanded Criteria Donor and Standard Criteria Donor kidney transplant recipients: a systematic review and meta-analysis". In: *Transplant International* 29.4 (2016), pp. 403–415.

[6] H Groen et al. "Cost-effectiveness of hypothermic machine preservation versus static cold storage in renal transplantation". In: *American Journal of Transplantation* 12.7 (2012), pp. 1824–1830.

[7] J Moritz Kaths et al. "Ex vivo machine perfusion for renal graft preservation". In: *Transplantation Reviews* 32.1 (2018), pp. 1–9.

[8] Panxin Peng et al. "Hypothermic Machine Perfusion Versus Static Cold Storage in Deceased Donor Kidney Transplantation: A Systematic Review and Meta-Analysis of Randomized Controlled Trials". In: *Artificial organs* (2018).

[9] Jens Brockmann et al. "Normothermic perfusion: a new paradigm for organ preservation". In: *Annals of surgery* 250.1 (2009), pp. 1–6.

[10] Constantino Fondevila et al. "Superior preservation of DCD livers with continuous normothermic perfusion". In: *Annals of surgery* 254.6 (2011), pp. 1000–1007.

[11] Sarah A Hosgood and Michael L Nicholson. "Normothermic kidney preservation". In: *Current opinion in organ transplantation* 16.2 (2011), pp. 169–173.

[12] Nicholas Gilbo and Diethard Monbaliu. "Temperature and oxygenation during organ preservation: friends or foes?" In: *Current opinion in organ transplantation* 22.3 (2017), pp. 290–299.

[13] Christopher JE Watson et al. "Normothermic Perfusion in the Assessment and Preservation of Declined Livers Before Transplantation: Hyperoxia and Vasoplegia—Important Lessons From the First 12 Cases". In: *Transplantation* 101.5 (2017), p. 1084.

[14] Ministerie van Natuur en Voedselkwaliteit Landbouw. *Dierproeven*. visited on 2019-04-26. Mar. 2017. URL: https://www.ncadierproevenbeleid.nl/dierproeven-en-3V-methoden/d/dierproeven.

[15] Benjamin Dekel et al. "Human and porcine early kidney precursors as a new source for transplantation". In: *Nature medicine* 9.1 (2003), p. 53.

[16] Cyril Moers et al. "Machine perfusion or cold storage in deceased-donor kidney transplantation". In: *New England Journal of Medicine* 360.1 (2009), pp. 7–19.

[17] *Hilite 800 LT Serie Hilite 100 Serie. Instructions for use.* Medos Medizintechnik AG. Stolberg Germany, Aug. 2015.

[18] P. W. Atkins. *Chemical Principles.* W.H. Freeman & Company, 2013. ISBN: 1464120676.

[19] Julie-Ann Collins et al. "Relating oxygen partial pressure, saturation and content: the haemoglobin–oxygen dissociation curve". In: *Breathe* 11.3 (2015), pp. 194–201.

[20] Ranjan K Dash, Ben Korman, and James B Bassingthwaighte. “Simple accurate mathematical models of blood HbO 2 and HbCO 2 dissociation curves at varied physiological conditions: evaluation and comparison with other models”. In: *European journal of applied physiology* 116.1 (2016), pp. 97–113.

[21] C Bohr, K Hasselbalch, and A Krogh. “Concerning a biologically important relationship–the influence of the carbon dioxide content of blood on its oxygen binding”. In: *Skand. Arch. Physiol* 16 (1904), pp. 402–412.

[22] Donald Voet, Judith G. Voet, and Charlotte W. Pratt. *Fundamentals of Biochemistry: Life at the Molecular Level*. Wiley, 2008. ISBN: 0470129301.

[23] N Naeraa et al. “pH and molecular CO2 components of the Bohr effect in human blood”. In: *Scandinavian journal of clinical and laboratory investigation* 18.1 (1966), pp. 96–102.

[24] Neil A. Campbell. *Biology: A Global Approach*. Pearson Education Limited, 2014. ISBN: 1292008652.

[25] Amy Uber et al. “Preliminary observations in systemic oxygen consumption during targeted temperature management after cardiac arrest”. In: *Resuscitation* 127 (2018), pp. 89–94.

[26] Robert Brooker. *Genetics: Analysis and Principles*. McGraw-Hill Science/Engineering/Math, 2011. ISBN: 0073525286.

[27] Jeremy PT Ward. “Oxygen sensors in context”. In: *Biochimica et Biophysica Acta (BBA)-Bioenergetics* 1777.1 (2008), pp. 1–14.

[28] Kimberly J Dunham-Snary et al. “A mitochondrial redox oxygen sensor in the pulmonary vasculature and ductus arteriosus”. In: *Pflügers Archiv-European Journal of Physiology* 468.1 (2016), pp. 43–58.

[29] Iris Schmidt. “Universitair Medisch Centrum Groningen (UMCG)-designed oxygenator as a low-budget oxygenator for kidney perfusion - a prospective study”. unpublished. 2016.

[30] HH Dijstelbergen. “Rotameter dynamics”. In: *Chemical Engineering Science* 19.11 (1964), pp. 853–865.

[31] G Rollmann. “Calculation of correction factors for variable area flow meters at deviating working conditions”. In: *Cerca con Google* ().

[32] J Moritz Kaths et al. “Ex vivo machine perfusion for renal graft preservation”. In: *Transplantation Reviews* 32.1 (2018), pp. 1–9.

[33] Przemyslaw David Kosinski. “MR-Based Mapping of Cerebral Hemodynamics in Children with Sickle Cell Disease”. PhD thesis. 2016.

[34] John W Severinghaus and Poul B Astrup. “History of blood gas analysis. VI. Oximetry”. In: *Journal of clinical monitoring* 2.4 (1986), pp. 270–288.

[35] James E Sinex. “Pulse oximetry: principles and limitations”. In: *The American journal of emergency medicine* 17.1 (1999), pp. 59–66.

[36] Stephen Bell and Frank Dunand. “A comparison of amperometric and optical dissolved oxygen sensors in power and industrial water applications at low oxygen levels”. In: *Power Plant Chemistry* 12.5 (2010), pp. 296–303.

[37] Stephen Bell et al. “Optical dissolved oxygen measurement in power plants—A comparison of amperometric and optical dissolved oxygen sensors for applications at low oxygen levels”. In: *VGB PowerTech* 92.9 (2012), p. 119.

[38] *NeoFox Phase Fluorometer Installation and Operation Manual*. Ocean Optics Inc. Dunedin USA, 2010.

[39] *Optical Oxygen Sensors & Meters*. PreSens Precision Sensing. Regensburg Germany, Jan. 2018.

[40] *Flow-Through Cells with Optical Oxygen and Temperature Sensor*. PyroScience GmbH. Aachen Germany.

[41] *Miniature proportional volume flow regulator PVK*. AirCom Pneumatic GmbH. Ratingen Germany, 2011.

[42] *Miniature-proportional-flow-valve PV202*. AirCom Pneumatic GmbH. Ratingen Germany, 2011.

[43] *2/2 Brass & Stainless*. Baccara. Geva Israel, 2010.

[44] *Direct-acting 2-way standard solenoid control valve*. Bürkert Contromatic BV. Breda the Netherlands, May 2018.

[45] *VSO Low Flow*. Parker Hannifin Corp. Cleveland USA, May 2017.

[46] *Airflow Sensors AWM3000 Series*. Honeywell Inc. Freeport USA.

[47] *D6F-P*. Omron. Schaumburg Germany.

[48] *D6F-01A1 -02A1*. Omron. Schaumburg Germany.

[49] *Lone Wolf. Normally Open Miniature Proportional Valve*. Parker Hannifin Corp. Cleveland USA, Mar. 2019.

[50] *Airflow Sensors. AWM3000 Series*. Honeywell. Morristown United States of America.

[51] PAS Global. *TuneWizard*. URL: `https://www.pas.com/products-services/operations-management/tunewizard` (visited on 06/19/2019).

10 Appendix

A Sniffing the random access memory for data acquisition

Rather than the actual EOM-O2-FOM mentioned in table 2, the lab owns the Fibox 4. These products are both meant as interfacing modules for the PreSens dissolved oxygen sensor. Unfortunately, the Fibox 4 is meant to exclusively communicate with a standard computer, in contrast to the EOM-O2-FOM. Additionally, the software that comes with the Fibox does not have functionality that allows real-time communication with external hardware. Therefore another solution to this challenge has to be found, as the project does not have the budget to solve this by purchasing the required hardware.

Software that is installed on a computer is saved on the hard drive, or more recently on a solid state drive. Which function identical within the scope of this project. Whenever the software is loaded it gets stored onto the random access memory (RAM). The reason for this is that the RAM is much quicker, thus improving the responsiveness of the system. Unfortunately RAM is more expensive and loses the data that is stored in it once it is shut down. In the context of the PreSens software, the measurement lives somewhere in the RAM once the user has opened the software and has started measuring. Which means it is possible to read out the RAM and obtain the current measurement. However, this is more complex then it might appear.

Whenever the user opens software the operation system, Windows in this case, is asked to assign a certain amount of RAM to the software. Which addresses of the RAM get assigned to the software is dynamic, as different portions of the RAM might be open at the instance of opening the software. Fortunately, with the right amount of administrator privileges a process can request the addresses assigned to specific software.

However the address of the measurement within the assigned addresses is also dynamic. A solution to this challenge is to find a certain pathway from a static address that will lead towards the dynamic measurement address. Software called Cheat Engine allows to search for this pathway. This can be done by opening the PreSens software and doing one measurement. Then load Cheat Engine, attach it to the Presens software and start searching for the mesaured value. Now, in the PreSens software a new measurement is taken. From all of the previously found addresses in Cheat Engine search for the new measurement. Repeat this process until one address remains.

Now that the correct address is found we could use this to read the hPa value with exernal software. However, would the PreSens software be closed and reopened the address the current measurement lives is on different address, rendering the old address useless for the intended purposes. In order to solve this Cheat Engine can be tasked to find all address that access the address of interest. Not only can it search for the addresses that access the found address, it can do this for the addresses that access those new addresses as well. This can easily repeat itself multiple levels deep. This list of addresses and corresponding pointers to the deeper level addresses is saved. Now the Presens software should be closed and reopened. Once the entire process of finding the value of interest and creating the list of addresses and pointers is completed two lists have been obtained.

These two lists, after adjusting for the offsets of the dynamically assigned starting address by the operating system, are essentially the same. The only difference between the two lists are the differences created by the dynamicity of the software. By comparing the two lists and removing all of the previously mentioned differences one lists remains. This new list starts with a static addresses and pointers that move through multiple levels to eventually all lead towards the address of the measurement.

By using one of the found pathways to the measurement newly written software should be able to consistently find the measurement value in the RAM. First the new software has to obtain the address assigned by the operating system and then use the pathway to find the value of interest. Additionally this software can then send the value to external hardware.

Cheat Engine software source: https://www.cheatengine.org/

B Protocol of preparing kidney and corresponding setup

Ewout's Oxygen Kidney Protocol

Ewout Bergsma

April 2019

1 Introduction

1.1 Background

A dramatic shortage of donor organs has led to an increased use of extended-criteria and donation after circulatory death donor grafts. Respectively, these are donor grafts older than 60 or in some situations 50 years old and donor grafts that have experienced a loss of blood flow. These types of donor organs are more susceptible to ischemia-reperfusion injury (IRI) [1, 2]. IRI is damage caused by reperfusion after a period of restriction of blood flow called ischemia or lack of oxygen. This has led to a growing interest in research aimed at oxygenation during machine perfusion (MP). Oxygenation is a tool used in MP research to decrease the risk of IRI. This project aims at providing researchers with a new tool to pursue their research in oxygenation during MP.

Currently oxygenation typically happens at supraphysiological levels, which are levels higher than normally found in the body. Only few studies were designed to compare different oxygenation settings within models, even tough non-excessive oxygen delivery might be of utmost benefit during normothermic machine perfusion (NMP) [3, 4]. This discrepancy might be the consequence of a lack of available tools that allow controlled oxygen levels.

Also, it appears to be the case that there is no default oxygen supply requirement by grafts. Instead it should be tailored for specific needs of grafts of different quality, this includes kidneys [3]. This knowledge emphasizes the need of a system that can deliver different amounts of oxygen.

Additionally, one can hypothesize that specific needs of kidneys change during MP. Perhaps induced by chemical substances supplemented by the researcher, a change in the environment such as temperature or any other change in the metabolic rate. A tool that can dynamically change to the current requirements of the kidney could potentially be a solution to enhance the health of the kidney during MP.

1.2 Goal

Using the development surrounding the previous experiments a prototype was built. This prototype has the potential to monitor and control the oxygen level in the perfusate. However, it missing key information regarding the transfer function of the controller and its corresponding influence. Therefore, the goal of this experiment is to find the corresponding constants in regards to the PID-control.

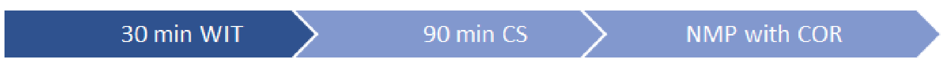

Figure 1: Course of MP actions, warm ischemic time (WIT), cold storage (CS), normothermic machine perfusion (NMP), controlled oxygenated rewarming (COR).

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3 Materials Slaughterhouse

3.1 Blood

- 5L beaker
- 5L barrel
- 5ml/25000 IE Heparine (Apotheek; 14179857)
- 5ml syringe
- 20G needle

3.2 Kidneys

- 2x Gauze (10x10cm)
- Surgical Blade
- 2x Surgical scissors (sharp!)
- 2x Surgical forceps
- 2x Surgical clamps
- 1L NaCl for flush (bottle versylene NaCl 0.9% Fresenius >sterile; Inkoop; 15226352)
- Syringe 60 ml (wond/blaasspuit)
- Normal 60 ml syringe
- Catheter (5cm) for flush
- 2x 10ml syringe
- 2x 5ml syringe
- 2x 20G needle
- Ice box (for inspecting the kidneys)
- Gloves
- Trash bags
- Pen + Case Report Form (CRF)

3.3 Cold storage

- Styrofoam box
- Ice (to fill bottom of box)
- UW-CS

4 Method slaughterhouse

4.1 Before leaving the lab

1. Fill Styrofoam box with ice
2. Collect UW-CS and NaCl from the cold room
3. Pack slaughterhouse bags (see materials)

4.2 Blood

1. Put the Heparin (25000 IE) in the 5L beaker with the syringe.
2. The butcher takes the beaker to the animal and takes approximately 2-3 liters of blood from the pig.
3. Pour the blood in a 5L barrel.

4.3 Kidneys

1. Put a trash bag around the ice box to protect it from the blood.
2. Fill the ice box with ice and place a gauze on top. Use a syringe and some NaCl to wet the gauze.
3. The butcher brings the kidney pair. Lay them down on the table with the aorta facing upwards.
4. Throughout the entire preparation, make sure to keep the veins as intact as possible. The vein will have to be cannulated in the lab.
5. Cut the aorta lengthwise in half and search the renal arteries. Check the renal arteries for branching. Choose the kidney with no branching or branching closest to the kidney. Locate the ureter.
6. Remove the contralateral kidney.
7. Remove excessive fat.
8. When the kidney is all prepared for the next steps, take a photo.
9. Fill the 60 ml syringe with cold NaCl and attach the catheter. Check for arterial leakage.
10. After 30 minutes of WIT. Place kidneys on ice and start flush. Place the catheter carefully in the renal artery and flush slowly. Be careful not to apply excessive pressure with the syringe!
11. Use a total of 180 ml for the flush.
12. Remove the catheter.

4.4 Cold storage

1. Put some UW-CS solution in the smallest organ bag. Put the kidney in the bag and make sure that the kidney is surrounded by the solution.
2. Add a second bag for possible leakage.
3. Put the whole package in the styrofoam box and make sure that ice is surrounding the total package for optimal cooling.

5 Materials lab

5.1 Perfusate

Perfusion solution	**Amount**
Ringers Lactate	280 mL
Amoxicillin/Clavulaanzuur (1000 mg/200 mg)	1 ampul
8.4% Sodium Bicarbonate	10 mL
5% glucose	10 mL
Dexamethasone (20 mg/ml)	333 ul
Leukocyte depleted blood	500 mL
Sodium Nitroprusside (20 mg/ml) ADD LAST MINUTE!	100 uL
Insulin (100 IU/ml)	0,186 ml

Table 1: Perfusate composition.

- Catheter bag (2L)
- Funnel
- Leukocyte filter (BioR O2 plus BS PF, Fresenius Kabi, Bad Homburg, Germany; A2BB0080)
- Tie wraps
- Silicone tubing to connect catheter bag to leukofilter
- Clamps
- Parafilm

5.2 Normothermic machine perfusion

- Ewout's oxygen prototype + flow sensor
- SophistiKate + pump + pressure sensor + organ chamber + temperature sensor
- Heater and thermostat
- Corresponding tubing for the above three items
- Laptop
- Centrifugal pump head (Deltastream DP3, MEDOS Medizintechnik AG, Stolberg, Germany)
- Clamp-on flow sensor (ME7PXL clamp, Transonic Systems Inc., Ithaca, NY)
- Oxygenator with integrated heat exchanger (HILITE 1000, MEDOS Medizintechnik AG, Stolberg, Germany)
- Heat exchanger water bath (Julabo MP-5, Labortechnik, Seelbach, Germany)
- Tie wraps
- 500 ml leukocyte depleted blood
- Sample line (for blood gas)
- 5ml tubes (perfusate samples)
- 2 PreSens Fibox 4
- Carbogen and nitrogen gas fitting including corresponding pressure reducing valves

6 Method lab

6.1 Preparing perfusate

1. Attach the leukocyte filter to the outlet of the catheter bag. And attach a funnel to the top of the tubing.
2. Put the tie wraps to the top sides of the catheter bag.
3. Close all the tubing underneath the bag and fill the bag with approximately 1L of blood.
4. Fill the leukocyte filter and de-air by holding it upside down.
5. Attach the system to a suspension hook and place the beaker underneath. Attach the tube to the beaker with the red clip.
6. Open the outlet of the catheter bag and de-air the leukocyte filter, by keeping it upside down until blood leaves the filter.
7. When the blood has passed the filter, close the clamp.
8. Combine the leukocyte depleted blood with the remaining perfusate solutions components, excluding the sodium nitroprusside. See table 1.

6.2 Perfusion circuit

1. The entire setup should be placed in the fume chamber.
2. Put the heater and thermostat in the fume chamber. Make sure to put heater on oscillating.
3. Connect the following components using corresponding tubing in this order: oxygenator blood outlet > PreSens oxygen sensor > pressure sensor > blood sample line > arterial cannula > kidney > venous cannula > PreSens oxygen sensor > let leak in water bath > pump head > flow sensor > blood inlet oxygenator.
4. Connect the sensors to the corresponding SophisiKate or Ewout's Oxygen prototype, consecutively connect those to the laptop.
5. Load corresponding software.
6. Connect heat exchanger to oxygenator.
7. Place the SophistiKate temperature sensor in the organ chamber, in the perfusate.
8. Connect the carbogen and nitrogen to the prototype.
9. Adjust the pressure of the carbogen such that a maximum flow of ... l/min is achieved. Use the built in flow sensor (not the rotameter) to read the flow.
10. Using the rotameter, adjust the flow of the nitrogen to a static 0.5 l/min.
11. Using the prototype, achieve a 133 hPa arterial oxygen pressure.

6.3 Normothermic machine perfusion

1. Add the perfusate to the perfusion circuit. Make sure no air remains in the circuit.
2. Prime the pressure sensor and the blood sample line.
3. Take the kidney out of the CS.
4. Place a cannula inside the ureter and tie 2-0 braided suture around the distal end of ureter to make sure it remains in the same place.
5. Tie suture around the ureter cannula to complete fixation.
6. Place a cannula inside the renal artery, secure it with suture.
7. *In similair fashion, cannulate the vein.*
8. Flush kidney with 50 ml NaCl for the removal of UW-CS and check for leakage.

9. Add the sodium nitroprusside to the perfusion solution in the circuit.
10. Place the prepared kidney in the organ chamber.
11. Check is the system is still free of air bubbles. If not, remove them.
12. Using the SophistiKate, find a pressure that achieves around 150-200 ml/min of perfusate flow. Do not exceed 120 mmHg.
13. Do not use sinusoidal pressure.
14. Fill up the arterial cannula with perfusion solution and connect kidney to the perfusion circuit. Make sure to keep the system and kidney air free.
15. Pause the pump.
16. Calibrate pressure sensor by clicking on calibrate pressure sensor. This takes a couple of seconds.
17. Resume the pump.
18. Fill up the arterial cannula with perfusion solution and connect to the perfusion circuit. Make sure to keep the system air free.
19. Click on timer and start data log immediately after. Fill in the histology number as the file name. Do NOT open the excel files during the experiment!
20. Close the fume chamber.

6.4 Controlled oxygenated rewarming

1. Perfuse at room temperature for a total of 15 minutes.
2. Put the thermostat and water bath heat exchanger to 29°C.
3. Once the temperature is achieved, perfuse for 15 minutes.
4. Put the thermostat and water bath heat exchanger to 37°C.
5. Wait until temperature is achieved.

7 References

[1] Patrizia Burra et al. “EASL clinical practice guidelines: liver transplantation”. In: *Journal of hepatology* 64.2 (2016), pp. 433–485.

[2] Anne-Hélène Querard et al. “Comparison of survival outcomes between Expanded Criteria Donor and Standard Criteria Donor kidney transplant recipients: a systematic review and meta-analysis”. In: *Transplant International* 29.4 (2016), pp. 403–415.

[3] Nicholas Gilbo and Diethard Monbaliu. “Temperature and oxygenation during organ preservation: friends or foes?” In: *Current opinion in organ transplantation* 22.3 (2017), pp. 290–299.

[4] Christopher JE Watson et al. “Normothermic Perfusion in the Assessment and Preservation of Declined Livers Before Transplantation: Hyperoxia and Vasoplegia—Important Lessons From the First 12 Cases”. In: *Transplantation* 101.5 (2017), p. 1084.

C Raw data of section 5.1.1

	150 ml/min					575 ml/min					Accuracy at 21C
Time (s)	1	2	3	4	5	1	2	3	4	5	and 1 atm.:
0	189.31	190.08	190.92	190.47	189.62	190.84	189.94	189.63	189.83	190.72	±3.95hPa
1	189.59	190.23	190.9	190.1	189.66	191.06	189.63	189.6	189.86	190.91	
2	189.22	188.41	190.35	189.78	189.43	191.27	189.25	187.98	189.65	190.97	
3	186.8	185.66	189.11	188.81	188.85	191.24	188.63	186.74	188.88	190.98	
4	187.62	187.39	188.28	187.34	187.64	191.26	189.4	186.12	187.42	190.06	
5	196.7	200.48	194.77	200.75	193.35	198.65	212.29	198.74	208.53	208.49	
6	221.62	226.58	217.61	226.52	212.44	231.58	265.86	240.97	257.54	258.94	
7	250.18	255.69	245.71	253.47	238.33	273.53	317.61	292.09	307.2	310.08	
8	278.89	283.39	274.61	279.89	266.73	317.71	361.93	338.21	351.25	354.08	
9	306.69	308.57	301.69	305.28	293.01	359.33	398.91	377.9	387	391.68	
10	331.9	332.25	326.72	329.42	317.28	396.69	428.67	410.67	418.3	424.74	
11	354.83	353.75	348.04	350.95	339.65	427.74	455.16	436.8	445.79	449.8	
12	376	374.34	369.67	370.9	361.34	455.74	476.64	461.46	466.83	473.6	
13	394.98	391.08	388.91	389.99	378.28	477.86	494.16	480.93	486.24	491.96	
14	413.2	408.48	405.96	406.51	396.3	496.2	508.56	496.96	503.01	508.2	
15	428.49	424.04	422.88	422.79	412.73	513.64	521.61	512	516.44	520.68	
16	442.55	437.47	436.87	436.77	427.85	526.78	532.14	523.03	527.15	530.81	
17	456.34	448.99	449.51	449.71	440.48	535	540.4	533.28	534.43	541.3	
18	468.91	461	462.65	462.22	453.66	543.84	549.61	540.33	543.12	547.04	
19	480.9	472.79	473.34	472.46	465.12	553.45	556.05	548.62	549.28	553.71	
20	490.14	481.01	483.93	483.76	476.49	558.54	559.21	555.85	555.32	559.41	
21	497.62	490.66	492.27	492.96	486.43	562.66	563.95	559	558.26	563.2	
22	506.3	497.91	501.32	501.97	494.3	567.98	569.63	563.2	564.7	566.81	
23	515.18	505.77	508.52	509	502.61	570.87	572.4	567.43	567.64	571.35	
24	520.52	512.2	516.27	517.44	511.89	575.11	571.56	569.84	569.77	573.16	
25	526.86	518.73	522.68	522.37	517.5	576.36	577.34	572.81	572.19	575.31	
26	534.19	524.55	529.69	529.44	522.93	580.29	577.34	573.51	574.83	579.38	
27	538.81	528.43	534.26	535.15	530.32	582.2	578.25	577.2	576.71	580.29	
28	544.38	534.83	538.42	540.09	532.98	581.85	580.65	576.85	578.96	581.28	
29	548.71	538.74	544.64	543.14	541.45	582.77	583.19	579.8	579.8	582.2	
30	550.09	543.4	547.65	547.85	544.83	583.83	583.69	580.57	580.43	582.06	
31	554.6	546.54	552.6	553.47	546.73	583.83	582.34	583.9	580.79	583.83	
32	557.75	548.64	555.47	555.47	552.34	584.75	583.05	583.05	582.27	583.97	
33	559.97	552.61	558.55	560.24	553.87	588.54	585.82	581.49	581.28	583.76	
34	563.9	556.27	561.79	562.06	557.74	589.83	585.54	584.75	582.84	584.54	
35	566.43	556.94	564.38	563.08	561.25	588.11	586.25	584.11	583.69	584.39	
36	566.09	559.9	564.51	566.15	563.62	588.68	584.04	584.04	583.19	584.82	
37	570	562.34	569.17	567.79	565.6	588.82	586.53	583.76	584.4	586.17	
38	572.84	563.9	570.89	570.06	568.48	587.18	586.46	585.25	582.48	586.46	
39	574.71	566.84	570.27	571.79	569.44	590.33	587.32	584.4	585.11	588.03	
40	575.62	568.76	573.73	574.08	572.07	588.54	587.03	585.39	584.25	587.67	
41	575.13	571.1	574.92	575.47	572.07	591.49	588.9	586.6	583.54	587.17	
42	577.23	572.21	577.85	575.96	575.82	590.41	586.53	585.32	584.54	586.39	
43	579.47	572.21	576.38	577.99	575.33	589.18	587.89	584.75	583.9	587.82	
44	578.77	573.11	578.48	576.8	577.64	589.04	588.11	586.39	586.53	587.46	
45	582.29	574.99	579.47	580.31	579.68	590.05	588.25	586.32	585.68	588.39	
46	582.22	574.99	580.74	581.09	579.18	591.05	588.32	586.75	585.53	588.1	
47	582.44	578.21	581.58	581.37	579.75	590.69	588.04	587.6	584.89	587.67	
48	583.78	577.78	582.93	581.65	579.82	589.61	588.75	585.61	586.03	585.25	
49	584.07	577.64	582.36	582.78	582.71	589.54	588.11	585.75	584.68	587.96	
50	583.5	579.26	584.35	584.2	583.28	589.9	588.61	585.53	585.25	588.25	
51	585.13	577.93	582.57	584.56	584.34	592.14	587.75	588.61	585.04	586.39	
52	584.99	581.3	587.48	586.05	583.42	588.75	589.25	587.32	585.32	588.1	
53	587.41	579.26	583.21	585.77	585.27	589.11	587.39	586.39	586.32	587.96	
54	586.56	579.96	585.56	584.63	586.69	589.69	587.46	587.75	587.1	587.53	
55	586.7	580.24	585.06	586.13	586.05	588.83	589.11	586.11	587.39	587.53	
56	586.99	582.08	586.98	585.77	586.12	589.69	588.04	586.32	585.89	586.39	
57	586.99	582.15	586.91	587.05	586.62	589.69	590.48	587.82	586.39	587.46	
58	587.92	583.28	588.2	585.98	588.41	589.69	588.18	587.18	586.46	589.04	
59	587.7	582.57	588.84	588.05	586.77	590.69	589.04	585.11	585.25	589.32	
60	591.44	583.43	586.77	586.84	586.41	590.69	588.75	585.96	586.18	590.04	
61	587.63	583.21	588.92	588.77	589.2	589.69	586.96	585.11	585.89	587.17	
62	588.49	584.49	589.99	588.99	586.98	590.98	588.54	585.89	586.25	588.03	
63	588.92	584.78	587.41	589.2	587.19	589.33	586.53	585.75	586.6	586.89	
64	589.28	585.56	588.2	589.13	588.91	590.98	589.68	585.68	586.75	589.04	
65	589.57	586.34	589.71	588.77	587.91	589.897	588.531	586.093	586.305	588.091	Average last 10
66	588.06	586.48	590.42	588.63	587.19	585.947	584.581	582.143	582.355	584.141	minus accuracy
67	588.56	586.13	589.06	588.05	590.14	29	29	27	30	30	Response time
68	589.49	586.13	588.77	590.35	589.2						

69	588.92	585.7	588.77	589.42	590.14
70	589.28	586.98	590.78	589.06	590.78
71	590	585.7	590.5	590.64	591.5
72	591.51	586.2	589.56	589.49	590.71
73	590	586.91	589.99	590.06	590.35
74	589.56	586.84	590.21	589.2	591.29
75	589.71	586.7	589.13	590.93	591.14
76	589.56	586.63	589.56	589.49	590.57
77	588.49	587.7	591.29	589.85	590.35
78	590.14	586.99	590.93	589.99	589.7
79	590	587.34	588.13	588.63	592.37
80	589.71	587.56	591.65	591.72	591.65
81	588.99	586.98	591.07	589.2	593.96
82	591.72	588.77	590.35	589.06	592.15
83	588.77	586.98	589.78	590.21	592.95
84	591.65	589.13	591.43	590.49	592.8
85	590.14	588.06	591.94	589.85	590.85
86	590.64	587.13	590.64	589.92	591.94
87	591.15	588.49	592.37	589.78	593.6
88	590.07	587.84	591.36	589.34	590.35
89	592.45	586.63	590.57	590.85	592.95
90	591.65	588.56	590.42	589.56	591.72
91	591.44	588.56	592.73	591.07	590.93
92	590.21	587.13	590.21	589.63	592.51
93	590.5	587.13	589.49	589.63	592.08
94	591.15	588.34	590.5	589.42	592.08
95	591.58	589.06	589.35	590.71	595.41
96	591.22	589.49	591.5	589.13	593.53
97	592.01	589.56	591.87	589.49	592.08
98	592.3	588.34	590.57	590.28	592.01
99	591.65	587.56	592.52	590.35	594.32
100	591.73	588.42	590.93	590.42	589.56
Average last 10:	590.9871	588.0819	591.0119	590.0052	592.3538
minus accuracy	587.0371	584.1319	587.0619	586.0552	588.4038
Response time:	49	58	48	51	54

D Raw data of section 5.1.2

	Δ300 hPa					Δ350					Δ400					Δ610					Accuracy at 21C
Time (s)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	and 1 atm.:
0	190.56	189.69	189.97	189.69	188.49	190.26	188.7	189.69	189.94	189.47	189.31	190.08	190.92	190.47	189.62	189.16	190.21	189.88	190.01	189.81	±3.95hPa
1	190.08	189.39	187.81	189.51	188.31	190.36	188.74	189.48	189.79	189.51	189.59	190.23	190.9	190.1	189.66	189.81	190.25	189.53	190.05	189.85	
2	189.6	188.05	185.83	189.58	186.76	190.12	187.81	186.93	189.23	188.24	189.22	188.41	190.35	189.78	189.43	189.39	189.83	189.51	189.63	189.42	
3	187.32	187.88	185.69	188.93	184.95	188.74	187.37	184.95	188.05	186.03	186.8	185.66	189.11	188.81	188.85	185.81	188.01	189.55	187.81	187.57	
4	188.11	193.18	186.26	186.73	192.35	190.01	191.59	190.86	191.93	189.97	187.62	187.39	188.28	187.34	187.64	185.18	182.11	185.65	181.92	181.55	
5	197.33	203.69	197.07	192.51	206.2	194.78	211.85	205.36	209.91	207.4	196.7	200.48	194.77	200.75	193.35	216.83	204.78	204.89	204.58	204.67	
6	211.39	221.26	211.95	199.91	226.87	212.34	236.23	225.33	235.32	231.13	221.62	226.58	217.61	226.52	212.44	259.73	249.8	227.24	249.58	250.59	
7	231.14	240.03	233.19	219.21	247.97	238.38	262.42	249.98	261.05	255.1	250.18	255.69	245.71	253.47	238.33	304.24	294.14	266.63	293.90	295.82	
8	251.18	257.73	254.31	239.86	267.47	263.25	285.62	274.27	284.74	277.95	278.89	283.39	274.61	279.89	266.73	344.21	337.2	307.47	336.94	339.74	
9	270.51	273.86	274.33	260.94	285.42	286.28	308.32	298.22	306.19	299.68	306.69	308.57	301.69	305.28	293.01	382.92	375.86	345.65	375.59	379.17	
10	287.76	288.65	292.69	279.32	302.43	308.51	328.17	318.1	325.77	318.98	331.9	332.25	326.72	329.42	317.28	418.09	412.76	381.79	412.47	416.81	
11	305.52	303.38	309.2	297.57	318.31	329.4	347.27	338.46	344.91	336.17	354.83	353.75	348.04	350.95	339.65	449.88	444.35	416.55	444.05	449.03	
12	320.14	315.86	325.15	313.63	332.95	347.87	364.47	356.12	363.07	352.5	376	374.34	369.67	370.9	361.34	477.9	473.74	446.88	473.43	479.01	
13	334.74	328.84	339.05	329.09	345.8	364.23	380.66	373.42	378.65	368.08	394.98	391.08	388.91	389.99	378.28	506.43	504.48	477.69	504.16	510.36	
14	347.46	340.99	351.74	342.05	358.42	379.45	394.75	387.99	392.55	383.24	413.2	408.48	405.96	406.51	396.3	528.81	527.26	501.96	526.93	533.60	
15	360.12	351.66	364.15	354.97	369.58	393.56	407.82	402.05	405.81	396.46	428.49	424.04	422.88	422.79	412.73	556.23	549.07	525.52	548.73	555.85	
16	370.81	362.2	375.53	366.63	379.7	406.77	419.96	413.7	418.25	407.54	442.55	437.47	436.87	436.77	427.85	572.4	571.85	550.96	571.50	579.08	
17	381.72	371.54	385.84	377.1	389.37	419.01	430.58	425.47	429.35	419.86	456.34	448.99	449.51	449.71	440.48	592.77	591.77	568.78	591.41	599.40	
18	390.77	379.99	394.92	386.96	398.29	430.19	439.11	436.01	438.36	428.96	468.91	461	462.65	462.22	453.66	610.61	609.79	593.7	609.43	617.78	
19	399.14	388.3	403.32	395.63	407.46	439.72	449.81	445.29	449.65	439.16	480.9	472.79	473.34	472.46	465.12	626.8	625.27	606.4	624.90	633.57	
20	407.65	396.21	409.8	403.91	414.59	448.32	456.8	453.29	457.49	446.46	490.14	481.01	483.93	483.76	476.49	638.4	637.54	619.81	637.16	646.09	
21	415.11	402.96	417.83	411.79	420.87	457.6	464.09	463.39	463.87	455.64	497.62	490.66	492.27	492.96	486.43	651.07	655.17	637.23	654.79	664.07	
22	422.74	409.02	423.79	418.3	424.94	464.2	470.86	468.63	470.43	461.25	506.3	497.91	501.32	501.97	494.3	664.61	665.43	650.19	665.04	674.53	
23	428.19	414.87	429.99	425.09	432.55	471.14	477.98	474.99	477.42	467.81	515.18	505.77	508.52	509	502.61	671.88	673.64	661.74	673.25	682.91	
24	433.34	420.58	436.06	430.19	438.31	479.6	481.62	482.24	485.06	474.65	520.52	512.2	516.27	517.44	511.89	685.27	685.27	675.81	684.87	694.77	
25	438.32	428.19	441.33	435.27	442.19	483.48	487.62	487.79	488.53	478.98	526.86	518.73	522.68	522.37	517.5	693.17	697.59	683.4	697.19	707.34	
26	442.55	432.11	446.06	440.82	446.21	489	493.25	492.61	493.71	483.81	534.19	524.55	529.69	529.44	522.93	702.4	703.02	697.59	702.62	712.88	
27	448.68	435.57	450.07	445.95	451.62	493.72	496.5	496.44	498.2	490.25	538.81	528.43	534.26	535.15	530.32	713.48	714.65	706.9	714.24	724.74	
28	451.37	440.32	453.76	448.06	454.81	496.86	500.55	500.66	501.08	494.35	544.38	534.83	538.42	540.09	532.98	717.88	718.43	707.52	718.02	728.59	
29	455.92	444.83	455.7	453.5	457.91	502.8	503.86	504.1	506.18	497.61	548.71	538.74	544.64	543.14	541.45	723.86	727.52	717.16	727.11	737.87	
30	458.45	447.24	460.62	456.96	460.56	503.98	506.06	508.16	509.9	501.84	550.09	543.4	547.65	547.85	544.83	731.84	732.12	720.5	731.71	742.56	
31	461.96	450.9	463.02	460.41	463.77	508.76	510.08	510.14	511.29	504.45	554.6	546.54	552.6	553.47	546.73	733.69	738.43	729.45	738.01	748.99	
32	463.35	453.19	466.41	461.74	466.63	511.96	511.65	514.02	514.26	507.43	557.75	548.64	555.47	555.47	552.34	737.31	741.42	736.38	741.00	752.04	
33	465.88	456.86	469.12	464.95	468.03	513.47	515.91	516.33	517.13	510.32	559.97	552.61	558.55	560.24	553.87	741.23	746.88	743.02	746.46	757.61	
34	469.02	461.15	470.65	468.14	471.08	516.09	515.97	519.4	519.71	512.98	563.9	556.27	561.79	562.06	557.74	753.82	752.49	751.63	752.07	763.33	
35	470.82	461.85	472.13	469.34	472.18	518.85	519.65	521.19	521.38	516.27	566.43	556.94	564.38	563.08	561.25	750.39	754.5	749.92	754.08	765.39	
36	473.29	464.04	475.27	472.73	473.83	520.27	520.51	523.18	523.49	518.29	566.09	559.9	564.51	566.15	563.62	758.43	763.66	754.59	763.23	774.73	
37	475.22	467.28	477.26	473.17	475.76	523.06	523.3	523.67	525.67	518.72	570	562.34	569.17	567.79	565.6	758.05	760.56	757.76	760.13	771.57	
38	475.27	468.74	478.99	474.88	478.21	522.93	523.55	527.36	526.42	522.68	572.84	563.9	570.89	570.06	568.48	765.31	763.17	766	762.74	774.23	
39	476.71	470.54	479.88	475.82	479.77	526.36	525.23	527.11	527.11	521.87	574.71	566.84	570.27	571.79	569.44	765.12	769.52	769.62	769.09	780.71	
40	479.22	471.91	481.29	478.04	480.22	528.18	524.86	529.12	529.31	523.48	575.62	568.76	573.73	574.08	572.07	769.03	774.34	765.22	769.01	780.62	
41	478.21	473.56	482.3	479.32	481.17	530.01	528.18	530	530.7	523.98	575.13	571.1	574.92	575.47	572.07	774.64	775.13	773.95	769.80	781.43	
42	480.23	475.32	482.92	481.12	483.37	531.02	528.93	531.71	532.73	527.04	577.23	572.21	577.85	575.96	575.82	769.91	776.22	769.71	770.89	782.54	
43	482.13	476.99	484.33	481.62	482.35	531.09	530.76	533.62	532.54	526.73	579.47	572.21	576.38	577.99	575.33	772.76	777.31	774.44	771.98	783.65	
44	483.32	477.04	484.27	483.48	484.55	530.71	529.94	532.41	533.11	527.67	578.77	573.11	578.48	576.8	577.64	777.31	776.52	778.61	771.19	782.85	
45	485.13	478.82	484.89	484.67	484.67	533.24	530.58	535.09	535.6	529.43	582.29	574.99	579.47	580.31	579.68	777.31	782.5	778.91	777.17	788.95	
46	484.62	480.45	486.14	483.82	484.33	532.23	531.27	536.04	535.85	531.2	582.22	574.99	580.74	581.09	579.18	779.7	784	785.51	778.67	790.48	
47	483.94	479.89	487.57	484.78	486.25	534.71	531.71	535.72	535.41	531.58	582.44	578.21	581.58	581.37	579.75	781.4	777.31	782.5	771.98	783.65	
48	485.07	481.74	488.65	486.6	486.25	534.71	531.84	535.02	536.49	532.03	583.78	577.78	582.93	581.65	579.82	788.73	782.8	782.8	777.47	789.25	
49	486.55	480.33	488.82	487	487.17	536.24	535.21	536.04	535.85	534.38	584.07	577.64	582.36	582.78	582.71	778.61	784.1	782.3	778.77	790.58	
50	487.12	481.4	489	487.28	487.28	534.64	532.92	535.47	539.06	534.7	583.5	579.26	584.35	584.2	583.28	785.81	788.73	786.51	783.39	795.3	
51	485.7	483.31	490.49	486.37	486.43	535.09	533.87	538.55	539.13	535.59	585.13	577.93	582.57	584.56	584.34	790.66	784.8	788.23	779.47	791.29	
52	488.03	484.56	489.91	488.31	487.57	535.79	533.87	539.71	538.29	534.76	584.99	581.3	587.48	586.05	583.42	785.81	788.03	796.46	782.69	794.59	
53	488.49	484.95	491.7	488.65	488.19	534.71	535.02	538.42	538.74	536.49	587.41	579.26	583.21	585.77	585.27	787.42	792.38	793.5	787.04	799.02	
54	487.74	485.63	491	487.79	488.76	536.63	535.85	538.29	539.97	534.89	586.56	579.96	585.56	584.63	586.69	789.24	788.13	789.85	782.79	794.69	
55	487.4	485.63	490.66	490.2	488.77	537.65	536.81	539.39	540.23	535.66	586.7	580.24	585.06	586.13	586.05	793.7	788.94	788.63	783.60	795.51	
56	487.97	486.77	492.21	488.31	489.22	535.73	537.84	539.52	539.52	537.58	586.99	582.08	586.98	585.77	586.12	788.63	791.47	792.18	786.13	798.09	
57	488.89	487	492.39	488.94	490.54	537.01	536.37	538.93	539.45	535.66	586.99	582.15	586.91	587.05	586.62	791.47	793.67	796.1	791.33	800.4	
58	488.72	487.4	492.56	489.45	489.62	536.31	535.21	540.1	540.61	537.39	587.92	583.28	588.2	585.98	588.41	789.74	794.01	794.32	788.67	800.69	
59	489.29	486.66	492.39	490.6	489.91	538.04	535.28	539.45	540.94	540.67	587.7	582.57	588.84	588.05	586.77	790.25	790.36	790.76	788.02	803.08	
60	489.12	487.11	494.12	490.26	491.87	538.88	536.88	540.16	539.19	539.25	591.44	583.43	586.77	586.84	586.41	794.03	790.05	793.4	784.71	796.65	
61	489.8	486.71	493.6	489.57	490.66	537.59	537.71	540.16	542.1	535.53	587.63	583.21	588.92	588.77	589.2	790.66	793.87	795.08	791.53	803.6	
62	489.4	488.25	493.43	491.41	491.35	538.3	536.56	541.33	543.47	538.93	588.49	584.49	589.99	588.99	586.98	794.1	793.59	796.06	792.25	804.34	
63	490.44	487.28	493.49	490.6	491.81	538.62	536.11	540.35	542.56	538.67	588.92	584.78	587.41	589.2	587.19	792.15	792.69	790.66	787.35	799.34	
64	490.55	487.4	494.36	491	490.31	539.26	538.81	540.55	543.86	536.68	589.28	585.56	588.2	589.13	588.91	792.38	789.14	795.77	783.80	795.72	
65	491.01	487.97	493.31	490.49	490.77	539.2	537.71	540.55	541.39	539.45	589.57	586.34	589.71	588.77	587.91	790.66	794.42	802.63	789.08	801.1	
66	490.9	488.71	495.75	491.29	489.85	539.07	537.71	541.13	543.4	538.54	588.06	586.48	590.42	588.63	587.19	800.15	792.48	796.87	787.14	799.12	
67	491.07	487.74	493.43	491.35	490.6	538.1	538.87	540.29	540.42	538.67	588.56	586.13	589.06	588.05	590.14	792.99	800.05	797.79	794.71	806.85	
68	490.49	487.91	495.23	491.75	490.2	538.81	537.65	540.81	541.33	538.67	589.49	586.13	588.77	590.35	589.2	794.21	792.18	794.11	786.84	799.82	
69	491.18	489.91	494.07	491.29	491.46	539.13	539.32	540.16	542.62	539.06	588.92	585.7	588.77	589.42	590.14	790.45	800.36	797.9	795.02	807.16	
70	490.21	488.25	494.53	491.18	490.54	539.13	538.48	542.17	541.07	538.35	589.28	586.98	590.78	589.06	590.78	797.69	797.89	796.67	792.55	804.64	
71	490.95	488.03	494.7	490.26	489.39	537.07	539.84	541.07	543.66	539.96	590	585.7	590.5	590.64	591.5	798.3	801.29	802.94	795.95	808.11	
72	489.75	488.2	494.94	491.75	491.41	538.94	537.46	542.62	541.65	538.99	591.51	586.2	589.56	589.49	590.71	799.33	794.42	798	789.08	801.1	
73	490.9	489.17	495.63	491.52	492.85	537.91	538.16	543.34	541.84	539.7	590	586.91	589.99	590.06	590.35	799.64	801.39	797.38	796.05	808.21	
74	491.36	489.86	494.76	492.21	491.69	537.85	539.19	542.49	544.05	541.51	589.56	586.84	590.21	589.2	591.29	796.15	801.29	798.41	795.95	808.11	
75	489.98	488.88	493.25	492.16	490.49	541.33	535.98	543.47	542.04	540.67	589.71	586.7	589.13	590.93	591.14	798.1	798.2	801.6	792.86	804.96	
76	490.67	489.11	495.52	492.5	491.46	539.13	537.26	542.23	542.69	541.45	589.56	586.63	589.56	589.49	590.57	798.51	798.92	799.44	793.58	805.69	
77	489.75	487.28	495.28	492.21	491.29	539.71	536.11	540.68	542.75	540.93	588.49	587.7	591.29	589.85	590.35	798.41	797.28	793.3	791.94	804.02	
78	491.41	489.28	494.01	493.08	490.77	538.75	538.16	540.29	542.49	540.28	590.14	586.99	590.93	589.99	589.7	795.44	802.83	794.32	797.49	809.68	
79	491.01	488.65	494.59	492.21	490.6	539.33	536.75	540.03	544.31	541.45	590	587.34	588.13	588.63	592.37	792.99	798.72	798.92	793.38	805.49	
80	489.29	488.83	495.34	492.16	489.97	539.78	536.62	542.75	543.92	538.86	589.71	587.56	591.65	591.72	591.65	800.77	797.18	803.14	791.84	803.92	
81	490.84	488.71	495.23	492.73	492.44	540.29	539.39	541.97	543.34	540.03	588.99	586.98	591.07	589.2	593.96	795.44	794.01	803.04	788.67	800.69	
82	490.84	489.28	494.59	492.68	491.92	540.04	537.58	542.43	544.84	539.7	591.72	588.77	590.35	589.06	592.15	797.79	798.92	799.74	793.58	805.69	
83	491.53	489.63	494.12	490.89	491.81	539.07	537.58	543.6	543.21	539.9	588.77	586.98	589.78	590.21	592.95	798.71	799.13	797.79	793.79	805.91	
84	491.76	488.48	495.58	491.52	492.44	540.36	539.9	544.58	542.69	539.77	591.65	589.13	591.43	590.49	592.8	796.87	800.05	799.33	794.71	806.85	
85	491.41	488.77	494.76	492.96	492.44	538.42	537.58	542.04	543.6	540.8	590.14	588.06	591.94	589.85	590.85	799.74	801.08	801.18	795.74	807.9	
86	490.95	488.48	494.76	492.21	492.1	538.94	538.55	541.39	544.9	539.32	590.64	587.13	590.64	589.92	591.94	796.67	792.99	798.2	787.65	799.64	
87	490.49	489	495.69	493.14	490.6	539.78	537.39	543.66	543.14	540.61	591.15	588.49	592.37	589.78	593.6	799.33	798.61	800.05	793.27	805.38	
88	490.21	488.31	494.07	492.68	490.83	539.52	538.29	542.23	543.73	541	590.07	587.84	591.36	589.34	590.35	795.03	795.95	794.01	790.61	802.66	
89	490.49	490.2	494.41	491.52	491.12	538.17	538.48	540.87	543.79	539.51	592.45	588.63	590.57	590.85	592.95	795.03	798.72	800.46	793.38	805.49	
90	490.84	488.83	495.81	491.81	490.03	540.1	536.68	542.62	542.43	541.51	591.65	588.56	590.42	589.56	591.72	796.26	791.16	801.39	785.82	797.78	
91	490.78	489.05	495.17	492.79	491.17	539.26	539.51	540.42	542.95	540.93	591.44	588.56	592.73	591.07	590.93	795.24	800.87	799.43	795.53	807.68	
92	491.36	487.91	494.35	491.12	492.27	540.81	537.78	543.34	543.86	539.57	590.21	587.13	590.21	589.63	592.51	798.61	797.28	799.64	791.94	804.02	
93	492.34	487.51	495.58	493.43	491.18	541.65	538.48	542.04	543.21	540.48	590.5	587.13	589.49	589.63	592.08	798.92	800.87	800.67	795.53	807.68	
94	491.41	488.6	494.36	492.5	491.75	538.68	538.03	541.39	543.47	541.77	591.15	588.34	590.5	589.42	592.08	793.5	804.18	804.49	798.84	811.06	
95	491.59	490.09	494.59	493.08	491.41	539.26	539.71	543.01	544.25	538.54	591.58	589.06	589.35	590.71	595.41	803.25	796.87	797.9	791.53	803.6	
96	492.62	490.26	495.58	491.58	491.12	537.27	539.77	540.42	542.88	540.8	591.22	589.49	591.5	589.13	593.53	797.89	799.54	798	794.20	806.33	
97	490.95	490.03	494.7	492.79	491.29	539.78	539.58	542.04	542.69	541.32	592.01	589.56	591.87	589.49	592.08	798.61	798.92	801.49	793.58	805.69	
98	491.3	490.2	493.43	492.56	491.29	540.04	541.26	544.25	544.18	541.32	592.3	588.34	590.57	590.28	592.01	799.43	796.97	796.26	791.63	803.7	
99	491.59	489.17	496.04	491.18	490.83	541.26	538.56	542.17	541.71	539.9	591.65	587.56	592.52	590.35	594.32	804.59	795.03	800.15	789.69	801.73	
100	490.72	489.57	496.39	492.1	492.79	540.29	538.29	540.29	541.03	540.09	591.73	588.42	590.93	590.42	589.56	800.15	799.43	805.73	794.09	806.21	
Average last 10	491.11	489.091	494.9786	492.2586	491.4667	539.6557	538.5233	542.2624	543.3248	540.2729	590.9871	588.0819	591.0119	590.0052	592.3538	798.1824	797.9886	800.0995	792.6486	804.7433	
minus accuracy	487.16	485.141	491.0286	488.3086	487.5167	535.7057	534.5733	538.3124	539.3748	536.3229	587.0371	584.1319	587.0619	586.0552	588.4038	794.2324	794.0386	796.1495	788.6986	800.7933	
Response time	46	50	49	48	48	48	45	47	50	49	49	58	48	51	54	62	60	61	57	55	

E Raw data of section 5.3.2

Run 1			Run 2			Run 3		
Time (s)	Input (0-1023)	Flow (ml/min)	Time (s)	Input (0-1023)	Flow (ml/min)	Time (s)	Input (0-1023)	Flow (ml/min)
1	600	0	1	600	0.52	1	600	0
2	600	0	2	600	0.52	2	600	0.52
3	600	0.52	3	600	0	3	600	0
4	600	0	4	600	0	4	600	0
5	600	0	5	600	0	5	600	0
6	600	0	6	600	0	6	600	0
7	600	0	7	600	0	7	600	0
8	600	0	8	600	0	8	600	0
9	600	0	9	600	0	9	600	0
10	600	0	10	600	0	10	600	0
11	600	0.52	11	600	0	11	600	0
12	600	0.52	12	600	1.04	12	600	0
13	600	0	13	600	0	13	600	0
14	600	1.04	14	600	0	14	600	0
15	600	0	15	600	0	15	600	0
16	600	0.52	16	600	0	16	600	0
17	600	0	17	600	1.04	17	600	0
18	600	1.04	18	600	1.56	18	600	0
19	600	0	19	600	0	19	600	0
20	600	1.04	20	600	0	20	600	0.52
21	600	2.09	21	600	0	21	600	0
22	600	0.52	22	600	0	22	600	0
23	600	0	23	600	0	23	600	0
24	600	0.52	24	600	0	24	600	0
25	600	0	25	600	0	25	600	0
26	600	1.56	26	600	0	26	600	0
27	600	0.52	27	600	0	27	600	0
28	600	0	28	600	0	28	600	0
29	600	0	29	600	1.04	29	600	0
30	600	1.04	30	600	0	30	600	0
31	600	0.52	31	600	0.52	31	600	0
32	600	0.52	32	600	0	32	600	0.52
33	600	0.52	33	600	0	33	600	0
34	600	0	34	600	0.52	34	600	0
35	600	0	35	600	0	35	600	0
36	600	0.52	36	600	0	36	600	0
37	600	0	37	600	0	37	600	0
38	600	0.52	38	600	0	38	600	0
39	600	0	39	600	0.52	39	600	0
40	600	0.52	40	600	1.56	40	600	0
41	600	0	41	600	0	41	600	0
42	600	0	42	600	0	42	600	0
43	600	0	43	600	0	43	600	0
44	600	1.04	44	600	0	44	600	0
45	600	0	45	600	0	45	600	0.52
46	600	0	46	600	0.52	46	600	0.52
47	600	0	47	600	0.52	47	600	0
48	600	0	48	600	0	48	600	0
49	600	0	49	600	0	49	600	0.52
50	600	0	50	600	0	50	600	0
51	600	0	51	600	0.52	51	600	0
52	600	0	52	600	0	52	600	0
53	600	0	53	600	0	53	600	0
54	600	0.52	54	600	0.52	54	600	0
55	600	0.52	55	600	0	55	600	0
56	600	0	56	600	0	56	600	0
57	600	0	57	600	0	57	600	0
58	600	0	58	600	0	58	600	0
59	600	0	59	600	0	59	600	0

60	600	0	60	600	1.04	60	600	0
61	600	0	61	600	0.52	61	600	0
62	600	0.52	62	600	0	62	600	0.52
63	600	0.52	63	600	0	63	600	0.52
64	600	0	64	600	0	64	600	0
65	600	0	65	600	0	65	600	0
66	600	0.52	66	600	0	66	600	0
67	600	0.52	67	600	0	67	600	0
68	600	0	68	600	1.04	68	600	0.52
69	600	1.56	69	600	1.04	69	600	0
70	600	0.52	70	600	0	70	600	0
71	600	0	71	600	0	71	600	0
72	600	0	72	600	0	72	600	0
73	600	0.52	73	600	1.04	73	600	1.04
74	600	0	74	600	0	74	600	0
75	600	0	75	600	0	75	600	0
76	600	1.56	76	600	0	76	600	0
77	600	0	77	600	0	77	600	0
78	600	0	78	600	0	78	600	0
79	600	0	79	600	0	79	600	0.52
80	600	0	80	600	0.52	80	600	0
81	600	0	81	600	0	81	600	0.52
82	600	1.04	82	600	0.52	82	600	0
83	600	0.52	83	600	0	83	600	0
84	600	0	84	600	0	84	600	0
85	600	0.52	85	600	0	85	600	0
86	600	0	86	600	0	86	600	0
87	600	0.52	87	600	0	87	600	0
88	600	0	88	600	0	88	600	1.04
89	600	0	89	600	0	89	600	0
90	600	0	90	600	0	90	600	0
91	600	0.52	91	600	0	91	600	0
92	600	1.56	92	600	0.52	92	600	0
93	600	1.04	93	600	0	93	600	0
94	600	0.52	94	600	0	94	600	0.52
95	600	1.04	95	600	0.52	95	600	0
96	600	0.52	96	600	0	96	600	0
97	600	0.52	97	600	0	97	600	0
98	600	0	98	600	0.52	98	600	0
99	600	0.52	99	600	0	99	600	0.52
100	600	1.04	100	600	0.52	100	600	0.52
101	600	0	101	600	0	101	600	0
102	600	0	102	600	0	102	600	0
103	600	0	103	600	0	103	600	0
104	600	1.04	104	600	0	104	600	0
105	600	0	105	600	0	105	600	0
106	600	0	106	600	0	106	600	0.52
107	600	0	107	600	0	107	600	0
108	600	0	108	600	0.52	108	600	0.52
109	600	1.04	109	600	0.52	109	600	0
110	600	0	110	600	0	110	600	0
111	600	1.04	111	600	0	111	600	0
112	600	0.52	112	600	0	112	600	0
113	600	0	113	600	0	113	600	0
114	600	0.52	114	600	0	114	600	0
115	600	1.04	115	600	0.52	115	600	0
116	600	1.56	116	600	1.04	116	600	0
117	600	0.52	117	600	0.52	117	600	1.56
118	600	0.52	118	600	0	118	600	0
119	600	0	119	600	0.52	119	600	0
120	600	1.56	120	600	0	120	600	0.52

121	700	261.1	121	700	260.26	121	700	251.03
122	700	262.78	122	700	258.59	122	700	251.87
123	700	263.62	123	700	259.42	123	700	251.87
124	700	262.78	124	700	258.59	124	700	251.03
125	700	260.26	125	700	255.23	125	700	250.19
126	700	258.59	126	700	255.23	126	700	248.51
127	700	259.42	127	700	253.55	127	700	249.35
128	700	258.59	128	700	253.55	128	700	248.51
129	700	259.42	129	700	254.39	129	700	248.51
130	700	259.42	130	700	256.07	130	700	248.51
131	700	259.42	131	700	255.23	131	700	249.35
132	700	260.26	132	700	256.91	132	700	249.35
133	700	261.1	133	700	256.91	133	700	248.51
134	700	261.1	134	700	256.07	134	700	249.35
135	700	261.94	135	700	257.75	135	700	250.19
136	700	262.78	136	700	257.75	136	700	250.19
137	700	262.78	137	700	256.91	137	700	251.03
138	700	261.94	138	700	256.91	138	700	251.87
139	700	262.78	139	700	256.91	139	700	251.87
140	700	263.62	140	700	256.91	140	700	251.03
141	700	261.94	141	700	257.75	141	700	251.03
142	700	263.62	142	700	259.42	142	700	251.03
143	700	262.78	143	700	259.42	143	700	253.55
144	700	264.46	144	700	260.26	144	700	251.03
145	700	265.3	145	700	258.59	145	700	252.71
146	700	264.46	146	700	258.59	146	700	251.87
147	700	261.94	147	700	258.59	147	700	251.87
148	700	262.78	148	700	257.75	148	700	253.55
149	700	263.62	149	700	258.59	149	700	251.87
150	700	263.62	150	700	258.59	150	700	251.87
151	700	266.14	151	700	259.42	151	700	251.87
152	700	262.78	152	700	258.59	152	700	251.87
153	700	263.62	153	700	260.26	153	700	254.39
154	700	265.3	154	700	260.26	154	700	251.87
155	700	263.62	155	700	259.42	155	700	252.71
156	700	263.62	156	700	260.26	156	700	252.71
157	700	266.14	157	700	259.42	157	700	252.71
158	700	264.46	158	700	258.59	158	700	252.71
159	700	262.78	159	700	259.42	159	700	251.87
160	700	263.62	160	700	261.1	160	700	252.71
161	700	263.62	161	700	261.1	161	700	252.71
162	700	263.62	162	700	260.26	162	700	252.71
163	700	264.46	163	700	259.42	163	700	253.55
164	700	264.46	164	700	259.42	164	700	254.39
165	700	264.46	165	700	259.42	165	700	253.55
166	700	264.46	166	700	259.42	166	700	252.71
167	700	264.46	167	700	260.26	167	700	253.55
168	700	265.3	168	700	261.1	168	700	254.39
169	700	266.14	169	700	260.26	169	700	253.55
170	700	263.62	170	700	259.42	170	700	253.55
171	700	265.3	171	700	261.1	171	700	255.23
172	700	266.14	172	700	261.1	172	700	253.55
173	700	264.46	173	700	261.1	173	700	254.39
174	700	265.3	174	700	261.94	174	700	255.23
175	700	266.14	175	700	260.26	175	700	255.23
176	700	266.98	176	700	261.94	176	700	253.55
177	700	264.46	177	700	259.42	177	700	255.23
178	700	264.46	178	700	259.42	178	700	253.55
179	700	265.3	179	700	261.94	179	700	255.23
180	700	266.14	180	700	260.26	180	700	255.23
181	700	265.3	181	700	261.1	181	700	254.39

182	700	264.46	182	700	261.1	182	700	253.55
183	700	266.14	183	700	260.26	183	700	255.23
184	700	264.46	184	700	259.42	184	700	254.39
185	700	265.3	185	700	259.42	185	700	254.39
186	700	266.14	186	700	259.42	186	700	253.55
187	700	266.14	187	700	260.26	187	700	255.23
188	700	266.98	188	700	259.42	188	700	254.39
189	700	265.3	189	700	260.26	189	700	254.39
190	700	264.46	190	700	259.42	190	700	254.39
191	700	266.14	191	700	260.26	191	700	253.55
192	700	264.46	192	700	259.42	192	700	256.07
193	700	265.3	193	700	260.26	193	700	255.23
194	700	266.14	194	700	260.26	194	700	254.39
195	700	265.3	195	700	261.94	195	700	253.55
196	700	266.98	196	700	260.26	196	700	256.07
197	700	266.98	197	700	260.26	197	700	254.39
198	700	266.14	198	700	259.42	198	700	254.39
199	700	265.3	199	700	261.94	199	700	255.23
200	700	266.98	200	700	261.94	200	700	253.55
201	700	264.46	201	700	260.26	201	700	254.39
202	700	265.3	202	700	261.1	202	700	253.55
203	700	266.14	203	700	259.42	203	700	255.23
204	700	264.46	204	700	260.26	204	700	253.55
205	700	265.3	205	700	260.26	205	700	254.39
206	700	264.46	206	700	261.94	206	700	256.07
207	700	265.3	207	700	261.94	207	700	255.23
208	700	265.3	208	700	260.26	208	700	256.07
209	700	265.3	209	700	260.26	209	700	254.39
210	700	265.3	210	700	260.26	210	700	254.39
211	700	264.46	211	700	261.94	211	700	254.39
212	700	266.98	212	700	261.94	212	700	254.39
213	700	266.98	213	700	259.42	213	700	254.39
214	700	265.3	214	700	262.78	214	700	253.55
215	700	266.14	215	700	261.94	215	700	254.39
216	700	266.98	216	700	260.26	216	700	254.39
217	700	266.14	217	700	260.26	217	700	253.55
218	700	265.3	218	700	259.42	218	700	254.39
219	700	266.98	219	700	262.78	219	700	254.39
220	700	264.46	220	700	260.26	220	700	254.39
221	700	266.98	221	700	260.26	221	700	254.39
222	700	264.46	222	700	262.78	222	700	256.07
223	700	266.14	223	700	260.26	223	700	256.91
224	700	266.14	224	700	259.42	224	700	256.07
225	700	265.3	225	700	260.26	225	700	254.39
226	700	264.46	226	700	261.1	226	700	254.39
227	700	264.46	227	700	260.26	227	700	253.55
228	700	264.46	228	700	260.26	228	700	255.23
229	700	266.14	229	700	260.26	229	700	255.23
230	700	265.3	230	700	261.1	230	700	256.07
231	700	265.3	231	700	262.78	231	700	256.91
232	700	267.82	232	700	261.94	232	700	254.39
233	700	265.3	233	700	260.26	233	700	254.39
234	700	266.14	234	700	261.94	234	700	255.23
235	700	266.98	235	700	260.26	235	700	253.55
236	700	266.14	236	700	260.26	236	700	254.39
237	700	266.98	237	700	260.26	237	700	255.23
238	700	266.98	238	700	259.42	238	700	255.23
239	700	265.3	239	700	260.26	239	700	254.39
240	700	267.82	240	700	261.94	240	700	256.07
241	700	265.3	241	700	260.26	241	700	255.23
242	650	163.33	242	650	155.3	242	650	149.27

243	650	160.65	243	650	155.3	243	650	149.27
244	650	159.31	244	650	153.96	244	650	149.27
245	650	159.31	245	650	154.63	245	650	147.26
246	650	159.31	246	650	153.96	246	650	147.26
247	650	159.98	247	650	154.63	247	650	147.26
248	650	160.65	248	650	153.96	248	650	149.27
249	650	161.32	249	650	154.63	249	650	147.93
250	650	159.98	250	650	153.96	250	650	147.93
251	650	161.32	251	650	154.63	251	650	147.26
252	650	160.65	252	650	155.3	252	650	149.27
253	650	160.65	253	650	155.97	253	650	147.93
254	650	161.32	254	650	155.3	254	650	149.27
255	650	161.99	255	650	155.97	255	650	148.6
256	650	161.99	256	650	155.3	256	650	149.27
257	650	161.32	257	650	155.3	257	650	149.27
258	650	161.99	258	650	156.64	258	650	149.94
259	650	161.99	259	650	154.63	259	650	149.27
260	650	161.99	260	650	155.3	260	650	148.6
261	650	161.32	261	650	155.3	261	650	149.27
262	650	161.32	262	650	155.3	262	650	148.6
263	650	161.32	263	650	155.97	263	650	148.6
264	650	161.32	264	650	155.97	264	650	148.6
265	650	161.32	265	650	156.64	265	650	148.6
266	650	161.32	266	650	155.3	266	650	149.94
267	650	161.32	267	650	156.64	267	650	149.27
268	650	162.66	268	650	154.63	268	650	148.6
269	650	161.32	269	650	155.3	269	650	149.94
270	650	160.65	270	650	154.63	270	650	149.27
271	650	161.99	271	650	155.3	271	650	148.6
272	650	160.65	272	650	155.3	272	650	149.27
273	650	160.65	273	650	155.97	273	650	147.93
274	650	159.98	274	650	155.3	274	650	148.6
275	650	162.66	275	650	155.3	275	650	147.93
276	650	160.65	276	650	154.63	276	650	149.94
277	650	161.99	277	650	154.63	277	650	147.93
278	650	161.32	278	650	155.97	278	650	149.27
279	650	161.99	279	650	155.97	279	650	148.6
280	650	160.65	280	650	155.97	280	650	148.6
281	650	160.65	281	650	155.3	281	650	147.93
282	650	161.32	282	650	154.63	282	650	149.27
283	650	160.65	283	650	155.3	283	650	147.26
284	650	160.65	284	650	155.97	284	650	148.6
285	650	161.99	285	650	156.64	285	650	147.93
286	650	159.31	286	650	155.3	286	650	148.6
287	650	160.65	287	650	155.97	287	650	149.27
288	650	161.32	288	650	155.3	288	650	148.6
289	650	160.65	289	650	155.97	289	650	147.93
290	650	160.65	290	650	155.3	290	650	148.6
291	650	160.65	291	650	155.3	291	650	147.93
292	650	160.65	292	650	155.97	292	650	148.6
293	650	159.98	293	650	155.3	293	650	147.93
294	650	159.98	294	650	154.63	294	650	148.6
295	650	160.65	295	650	154.63	295	650	149.27
296	650	161.32	296	650	155.3	296	650	149.27
297	650	159.98	297	650	155.3	297	650	147.93
298	650	159.98	298	650	154.63	298	650	149.94
299	650	159.98	299	650	155.97	299	650	147.93
300	650	159.98	300	650	155.3	300	650	148.6
301	650	160.65	301	650	155.97	301	650	148.6
302	650	159.98	302	650	154.63	302	650	148.6
303	650	162.66	303	650	154.63	303	650	147.93

304	650	159.98	304	650	155.3	304	650	148.6
305	650	160.65	305	650	154.63	305	650	147.93
306	650	161.32	306	650	155.3	306	650	147.93
307	650	161.32	307	650	155.97	307	650	149.27
308	650	159.98	308	650	155.97	308	650	149.94
309	650	160.65	309	650	155.3	309	650	148.6
310	650	160.65	310	650	155.97	310	650	149.27
311	650	160.65	311	650	155.3	311	650	147.93
312	650	161.99	312	650	155.3	312	650	148.6
313	650	160.65	313	650	155.3	313	650	149.94
314	650	160.65	314	650	156.64	314	650	150.61
315	650	161.32	315	650	155.3	315	650	149.94
316	650	159.98	316	650	155.97	316	650	149.27
317	650	160.65	317	650	155.3	317	650	147.93
318	650	161.32	318	650	156.64	318	650	147.93
319	650	160.65	319	650	156.64	319	650	148.6
320	650	160.65	320	650	154.63	320	650	148.6
321	650	161.32	321	650	157.3	321	650	150.61
322	650	160.65	322	650	154.63	322	650	149.27
323	650	160.65	323	650	156.64	323	650	148.6
324	650	160.65	324	650	155.3	324	650	148.6
325	650	161.99	325	650	155.97	325	650	149.94
326	650	161.32	326	650	154.63	326	650	149.27
327	650	160.65	327	650	155.97	327	650	148.6
328	650	160.65	328	650	155.3	328	650	149.27
329	650	159.98	329	650	154.63	329	650	148.6
330	650	161.99	330	650	155.3	330	650	149.27
331	650	160.65	331	650	155.3	331	650	149.94
332	650	159.98	332	650	155.3	332	650	149.94
333	650	160.65	333	650	155.97	333	650	149.27
334	650	161.32	334	650	155.3	334	650	148.6
335	650	160.65	335	650	155.3	335	650	148.6
336	650	160.65	336	650	155.97	336	650	149.94
337	650	161.32	337	650	155.3	337	650	149.94
338	650	160.65	338	650	156.64	338	650	149.27
339	650	161.32	339	650	155.97	339	650	149.27
340	650	160.65	340	650	155.97	340	650	148.6
341	650	161.99	341	650	155.3	341	650	148.6
342	650	160.65	342	650	156.64	342	650	150.61
343	650	161.99	343	650	155.97	343	650	149.27
344	650	159.98	344	650	155.97	344	650	149.27
345	650	159.98	345	650	155.3	345	650	149.94
346	650	161.32	346	650	155.97	346	650	150.61
347	650	160.65	347	650	155.3	347	650	150.61
348	650	160.65	348	650	155.3	348	650	150.61
349	650	160.65	349	650	156.64	349	650	149.27
350	650	160.65	350	650	155.3	350	650	151.28
351	650	161.99	351	650	156.64	351	650	150.61
352	650	160.65	352	650	155.3	352	650	149.27
353	650	161.99	353	650	155.97	353	650	149.94
354	650	161.32	354	650	155.97	354	650	149.27
355	650	161.99	355	650	156.64	355	650	149.27
356	650	161.32	356	650	155.3	356	650	149.27
357	650	160.65	357	650	157.3	357	650	151.28
358	650	161.99	358	650	156.64	358	650	150.61
359	650	160.65	359	650	156.64	359	650	151.28
360	650	161.99	360	650	156.64	360	650	149.27
361	650	161.99	361	650	155.97	361	650	150.61
362	650	161.32	362	650	157.3	362	650	149.94
363	800	541.72	363	800	529.07	363	800	522.74
364	800	533.28	364	800	524.85	364	800	522.74

365	800	522.74	365	800	516.42	365	800	507.99
366	800	520.64	366	800	512.21	366	800	514.31
367	800	524.85	367	800	518.53	367	800	507.99
368	800	524.85	368	800	518.53	368	800	510.1
369	800	526.96	369	800	520.64	369	800	514.31
370	800	529.07	370	800	518.53	370	800	518.53
371	800	535.39	371	800	520.64	371	800	518.53
372	800	529.07	372	800	526.96	372	800	512.21
373	800	539.61	373	800	524.85	373	800	516.42
374	800	533.28	374	800	520.64	374	800	516.42
375	800	533.28	375	800	526.96	375	800	514.31
376	800	535.39	376	800	526.96	376	800	514.31
377	800	533.28	377	800	520.64	377	800	516.42
378	800	537.5	378	800	522.74	378	800	520.64
379	800	531.18	379	800	522.74	379	800	514.31
380	800	539.61	380	800	531.18	380	800	522.74
381	800	533.28	381	800	522.74	381	800	520.64
382	800	533.28	382	800	524.85	382	800	516.42
383	800	533.28	383	800	522.74	383	800	516.42
384	800	533.28	384	800	531.18	384	800	516.42
385	800	533.28	385	800	522.74	385	800	522.74
386	800	531.18	386	800	529.07	386	800	518.53
387	800	529.07	387	800	531.18	387	800	516.42
388	800	531.18	388	800	524.85	388	800	514.31
389	800	539.61	389	800	522.74	389	800	518.53
390	800	537.5	390	800	522.74	390	800	516.42
391	800	533.28	391	800	653.85	391	800	518.53
392	800	533.28	392	800	529.07	392	800	514.31
393	800	531.18	393	800	655.38	393	800	514.31
394	800	537.5	394	800	524.85	394	800	514.31
395	800	531.18	395	800	522.74	395	800	522.74
396	800	531.18	396	800	529.07	396	800	516.42
397	800	535.39	397	800	533.28	397	800	514.31
398	800	535.39	398	800	522.74	398	800	518.53
399	800	539.61	399	800	522.74	399	800	522.74
400	800	531.18	400	800	522.74	400	800	514.31
401	800	531.18	401	800	522.74	401	800	522.74
402	800	531.18	402	800	529.07	402	800	516.42
403	800	533.28	403	800	524.85	403	800	518.53
404	800	537.5	404	800	522.74	404	800	514.31
405	800	537.5	405	800	526.96	405	800	520.64
406	800	541.72	406	800	522.74	406	800	516.42
407	800	533.28	407	800	522.74	407	800	514.31
408	800	533.28	408	800	520.64	408	800	522.74
409	800	533.28	409	800	531.18	409	800	514.31
410	800	531.18	410	800	520.64	410	800	512.21
411	800	535.39	411	800	526.96	411	800	512.21
412	800	541.72	412	800	522.74	412	800	514.31
413	800	531.18	413	800	529.07	413	800	514.31
414	800	533.28	414	800	526.96	414	800	512.21
415	800	535.39	415	800	522.74	415	800	510.1
416	800	537.5	416	800	524.85	416	800	520.64
417	800	539.61	417	800	516.42	417	800	514.31
418	800	535.39	418	800	522.74	418	800	518.53
419	800	533.28	419	800	526.96	419	800	510.1
420	800	533.28	420	800	518.53	420	800	514.31
421	800	533.28	421	800	516.42	421	800	512.21
422	800	531.18	422	800	520.64	422	800	510.1
423	800	533.28	423	800	522.74	423	800	518.53
424	800	535.39	424	800	518.53	424	800	507.99
425	800	533.28	425	800	520.64	425	800	516.42

426	800	541.72	426	800	520.64	426	800	514.31
427	800	535.39	427	800	522.74	427	800	510.1
428	800	541.72	428	800	518.53	428	800	507.99
429	800	535.39	429	800	518.53	429	800	512.21
430	800	533.28	430	800	524.85	430	800	516.42
431	800	659.95	431	800	518.53	431	800	514.31
432	800	531.18	432	800	520.64	432	800	514.31
433	800	537.5	433	800	524.85	433	800	512.21
434	800	529.07	434	800	522.74	434	800	518.53
435	800	531.18	435	800	518.53	435	800	516.42
436	800	531.18	436	800	524.85	436	800	516.42
437	800	531.18	437	800	524.85	437	800	507.99
438	800	535.39	438	800	526.96	438	800	512.21
439	800	533.28	439	800	522.74	439	800	512.21
440	800	531.18	440	800	526.96	440	800	514.31
441	800	531.18	441	800	520.64	441	800	512.21
442	800	529.07	442	800	520.64	442	800	514.31
443	800	531.18	443	800	522.74	443	800	510.1
444	800	529.07	444	800	522.74	444	800	516.42
445	800	541.72	445	800	518.53	445	800	514.31
446	800	533.28	446	800	524.85	446	800	505.88
447	800	531.18	447	800	529.07	447	800	512.21
448	800	535.39	448	800	520.64	448	800	510.1
449	800	535.39	449	800	526.96	449	800	507.99
450	800	529.07	450	800	520.64	450	800	505.88
451	800	535.39	451	800	522.74	451	800	512.21
452	800	539.61	452	800	522.74	452	800	510.1
453	800	537.5	453	800	526.96	453	800	507.99
454	800	529.07	454	800	526.96	454	800	514.31
455	800	531.18	455	800	520.64	455	800	514.31
456	800	531.18	456	800	522.74	456	800	512.21
457	800	531.18	457	800	518.53	457	800	507.99
458	800	526.96	458	800	520.64	458	800	514.31
459	800	529.07	459	800	522.74	459	800	507.99
460	800	529.07	460	800	516.42	460	800	510.1
461	800	531.18	461	800	520.64	461	800	510.1
462	800	526.96	462	800	520.64	462	800	512.21
463	800	533.28	463	800	520.64	463	800	510.1
464	800	535.39	464	800	516.42	464	800	510.1
465	800	535.39	465	800	520.64	465	800	512.21
466	800	529.07	466	800	520.64	466	800	507.99
467	800	531.18	467	800	516.42	467	800	507.99
468	800	537.5	468	800	518.53	468	800	507.99
469	800	529.07	469	800	518.53	469	800	507.99
470	800	531.18	470	800	518.53	470	800	514.31
471	800	533.28	471	800	518.53	471	800	505.88
472	800	529.07	472	800	516.42	472	800	505.88
473	800	531.18	473	800	518.53	473	800	507.99
474	800	529.07	474	800	516.42	474	800	514.31
475	800	533.28	475	800	516.42	475	800	507.99
476	800	533.28	476	800	522.74	476	800	507.99
477	800	531.18	477	800	516.42	477	800	512.21
478	800	535.39	478	800	516.42	478	800	507.99
479	800	529.07	479	800	516.42	479	800	514.31
480	800	524.85	480	800	514.31	480	800	510.1

F Raw data of section 5.3.3

	Run 1			Run 2			Run 3		
Time (s)	Setpoint (ml/min)	Measured (ml/min)	Time (s)	Setpoint (ml/min)	Measured (ml/min)	Time (s)	Setpoint (ml/min)	Measured (ml/min)	Average (ml/min)
1	100	99.07	1	100	101.75	1	100	98.55	99.79
2	100	100.41	2	100	100.41	2	100	100.41	100.41
3	100	99.07	3	100	99.74	3	100	99.74	99.51666667
4	100	102.42	4	100	100.41	4	100	98.55	100.46
5	100	99.74	5	100	100.41	5	100	98.55	99.56666667
6	100	100.41	6	100	99.74	6	100	98.55	99.56666667
7	100	98.55	7	100	99.07	7	100	98.55	98.72333333
8	100	99.07	8	100	99.07	8	100	99.74	99.29333333
9	100	102.42	9	100	99.74	9	100	99.07	100.41
10	100	99.74	10	100	99.07	10	100	98.03	98.94666667
11	100	99.07	11	100	101.75	11	100	99.07	99.96333333
12	100	99.74	12	100	99.07	12	100	99.07	99.29333333
13	100	99.74	13	100	99.74	13	100	98.03	99.17
14	100	99.74	14	100	100.41	14	100	98.55	99.56666667
15	100	99.74	15	100	99.07	15	100	95.94	98.25
16	100	99.74	16	100	99.74	16	100	97.5	98.99333333
17	100	99.74	17	100	99.07	17	100	99.74	99.51666667
18	100	100.41	18	100	99.07	18	100	98.03	99.17
19	100	99.74	19	100	99.74	19	100	99.07	99.51666667
20	100	100.41	20	100	103.08	20	100	98.03	100.5066667
21	100	99.07	21	100	99.07	21	100	98.03	98.72333333
22	100	100.41	22	100	100.41	22	100	98.55	99.79
23	100	101.08	23	100	100.41	23	100	99.74	100.41
24	100	101.08	24	100	99.74	24	100	99.07	99.96333333
25	100	100.41	25	100	100.41	25	100	100.41	100.41
26	100	100.41	26	100	101.08	26	100	98.03	99.84
27	100	99.07	27	100	99.74	27	100	99.07	99.29333333
28	100	99.07	28	100	99.07	28	100	99.74	99.29333333
29	100	99.07	29	100	99.74	29	100	99.74	99.51666667
30	100	101.75	30	100	99.74	30	100	99.74	100.41
31	100	100.41	31	100	100.41	31	100	103.08	101.3
32	100	98.55	32	100	101.08	32	100	99.74	99.79
33	100	99.74	33	100	101.08	33	100	102.42	101.08
34	100	99.07	34	100	99.07	34	100	99.74	99.29333333
35	100	100.41	35	100	100.41	35	100	99.74	100.1866667
36	100	101.75	36	100	101.08	36	100	100.41	101.08
37	100	99.07	37	100	100.41	37	100	99.74	99.74
38	100	101.08	38	100	101.08	38	100	99.74	100.6333333
39	100	101.75	39	100	100.41	39	100	99.74	100.6333333
40	100	99.74	40	100	102.42	40	100	105.09	102.4166667
41	100	99.74	41	100	100.41	41	100	102.42	100.8566667
42	100	100.41	42	100	101.75	42	100	101.08	101.08
43	100	102.42	43	100	99.07	43	100	99.74	100.41
44	100	99.74	44	100	99.74	44	100	99.74	99.74
45	100	100.41	45	100	101.08	45	100	99.74	100.41
46	100	100.41	46	100	99.74	46	100	99.74	99.96333333
47	100	99.74	47	100	101.08	47	100	101.08	100.6333333
48	100	99.74	48	100	100.41	48	100	100.41	100.1866667
49	100	99.07	49	100	100.41	49	100	99.07	99.51666667
50	100	99.74	50	100	101.75	50	100	99.74	100.41
51	100	99.74	51	100	101.08	51	100	99.74	100.1866667
52	100	100.41	52	100	99.74	52	100	100.41	100.1866667
53	100	99.74	53	100	99.74	53	100	99.74	99.74
54	100	99.74	54	100	98.55	54	100	100.41	99.56666667
55	100	101.08	55	100	99.74	55	100	100.41	100.41
56	100	100.41	56	100	99.74	56	100	100.41	100.1866667
57	100	100.41	57	100	101.08	57	100	101.75	101.08
58	100	99.74	58	100	99.74	58	100	99.74	99.74
59	100	99.74	59	100	100.41	59	100	100.41	100.1866667
60	100	100.41	60	100	100.41	60	100	101.08	100.6333333
61	100	100.41	61	100	101.08	61	100	101.08	100.8566667
62	100	101.08	62	100	101.75	62	100	100.41	101.08
63	100	100.41	63	100	100.41	63	100	101.08	100.6333333
64	100	100.41	64	100	100.41	64	100	102.42	101.08
65	100	101.08	65	100	100.41	65	100	99.07	100.1866667
66	100	99.07	66	100	99.74	66	100	99.74	99.51666667
67	100	99.74	67	100	100.41	67	100	101.08	100.41
68	100	99.74	68	100	100.41	68	100	99.07	99.74
69	100	99.74	69	100	100.41	69	100	99.74	99.96333333
70	100	99.74	70	100	99.07	70	100	99.74	99.51666667
71	100	100.41	71	100	99.07	71	100	99.74	99.74
72	100	100.41	72	100	99.07	72	100	100.41	99.96333333
73	100	101.08	73	100	101.08	73	100	100.41	100.8566667
74	100	99.74	74	100	99.07	74	100	104.42	101.0766667
75	100	99.74	75	100	99.07	75	100	99.74	99.51666667
76	100	100.41	76	100	101.08	76	100	99.74	100.41
77	100	99.74	77	100	102.42	77	100	99.74	100.6333333
78	100	101.08	78	100	100.41	78	100	100.41	100.6333333

79	100	100.41	79	100	101.08	79	100	99.74	100.41
80	100	99.74	80	100	99.74	80	100	100.41	99.96333333
81	100	100.41	81	100	100.41	81	100	101.08	100.6333333
82	100	100.41	82	100	101.08	82	100	101.75	101.08
83	100	100.41	83	100	99.74	83	100	100.41	100.1866667
84	100	100.41	84	100	105.09	84	100	101.08	102.1933333
85	100	100.41	85	100	101.75	85	100	100.41	100.8566667
86	100	101.08	86	100	100.41	86	100	101.08	100.8566667
87	100	100.41	87	100	100.41	87	100	100.41	100.41
88	100	99.07	88	100	100.41	88	100	101.08	100.1866667
89	100	101.08	89	100	99.74	89	100	102.42	101.08
90	100	99.07	90	100	101.08	90	100	99.74	99.96333333
91	100	99.07	91	100	99.74	91	100	100.41	99.74
92	100	99.74	92	100	100.41	92	100	100.41	100.1866667
93	100	99.07	93	100	101.08	93	100	100.41	100.1866667
94	100	101.75	94	100	101.08	94	100	99.74	100.8566667
95	100	100.41	95	100	101.08	95	100	99.07	100.1866667
96	100	101.08	96	100	100.41	96	100	101.08	100.8566667
97	100	99.74	97	100	101.75	97	100	99.74	100.41
98	100	101.08	98	100	101.08	98	100	109.78	103.98
99	100	99.74	99	100	100.41	99	100	100.41	100.1866667
100	100	99.74	100	100	100.41	100	100	101.08	100.41
101	100	99.74	101	100	100.41	101	100	100.41	100.1866667
102	100	100.41	102	100	99.74	102	100	99.74	99.96333333
103	100	99.74	103	100	99.74	103	100	101.08	100.1866667
104	100	101.08	104	100	100.41	104	100	101.08	100.8566667
105	100	99.74	105	100	100.41	105	100	100.41	100.1866667
106	100	100.41	106	100	101.08	106	100	100.41	100.6333333
107	100	100.41	107	100	101.08	107	100	100.41	100.6333333
108	100	99.74	108	100	100.41	108	100	100.41	100.1866667
109	100	101.75	109	100	100.41	109	100	101.08	101.08
110	100	99.74	110	100	100.41	110	100	101.08	100.41
111	100	101.08	111	100	101.08	111	100	99.07	100.41
112	100	100.41	112	100	101.08	112	100	100.41	100.6333333
113	100	98.55	113	100	100.41	113	100	98.55	99.17
114	100	99.74	114	100	101.08	114	100	98.55	99.79
115	100	100.41	115	100	101.08	115	100	99.74	100.41
116	100	100.41	116	100	99.07	116	100	98.55	99.34333333
117	100	99.74	117	100	99.74	117	100	98.55	99.34333333
118	100	99.74	118	100	99.07	118	100	98.03	98.94666667
119	100	99.07	119	100	99.74	119	100	99.07	99.29333333
120	100	101.75	120	100	99.74	120	100	99.07	100.1866667
121	100	101.08	121	100	101.08	121	100	99.74	100.6333333
122	100	101.75	122	100	99.74	122	100	99.07	100.1866667
123	100	100.41	123	100	99.74	123	100	98.55	99.56666667
124	100	99.07	124	100	100.41	124	100	100.41	99.96333333
125	100	99.07	125	100	99.07	125	100	100.41	99.51666667
126	100	99.74	126	100	99.74	126	100	100.41	99.96333333
127	100	100.41	127	100	100.41	127	100	99.74	100.1866667
128	100	99.74	128	100	100.41	128	100	101.08	100.41
129	100	99.74	129	100	99.74	129	100	99.74	99.74
130	100	101.08	130	100	99.74	130	100	146.59	115.8033333
131	100	99.74	131	100	100.41	131	100	98.55	99.56666667
132	100	100.41	132	100	102.42	132	100	101.08	101.3033333
133	100	99.74	133	100	101.08	133	100	101.08	100.6333333
134	100	99.74	134	100	100.41	134	100	101.08	100.41
135	100	99.74	135	100	101.08	135	100	98.55	99.79
136	100	100.41	136	100	99.07	136	100	101.08	100.1866667
137	100	100.41	137	100	99.07	137	100	99.74	99.74
138	100	100.41	138	100	98.55	138	100	99.74	99.56666667
139	100	101.08	139	100	100.41	139	100	98.55	100.0133333
140	100	100.41	140	100	101.08	140	100	101.08	100.8566667
141	100	100.41	141	100	99.07	141	100	101.08	100.1866667
142	100	101.08	142	100	101.08	142	100	101.08	101.08
143	100	99.74	143	100	100.41	143	100	99.74	99.96333333
144	100	101.08	144	100	101.08	144	100	99.74	100.6333333
145	100	99.74	145	100	101.75	145	100	100.41	100.6333333
146	100	98.55	146	100	99.07	146	100	99.07	98.89666667
147	100	99.07	147	100	99.74	147	100	98.55	99.12
148	100	99.74	148	100	99.07	148	100	100.41	99.74
149	100	100.41	149	100	100.41	149	100	100.41	100.41
150	100	99.74	150	100	97.5	150	100	101.08	99.44
151	100	99.07	151	100	99.74	151	100	99.74	99.51666667
152	100	99.07	152	100	99.07	152	100	100.41	99.51666667
153	100	99.07	153	100	98.55	153	100	101.08	99.56666667
154	100	99.74	154	100	98.55	154	100	100.41	99.56666667
155	100	99.74	155	100	98.55	155	100	101.08	99.79
156	100	99.07	156	100	99.07	156	100	100.41	99.51666667
157	100	98.55	157	100	99.74	157	100	101.08	99.79
158	100	99.07	158	100	100.41	158	100	100.41	99.96333333

159	100	99.07	159	100	98.55	159	100	100.41	99.34333333
160	100	99.07	160	100	99.07	160	100	100.41	99.51666667
161	100	101.75	161	100	101.08	161	100	100.41	101.08
162	100	100.41	162	100	99.07	162	100	99.07	99.51666667
163	100	99.74	163	100	100.41	163	100	100.41	100.1866667
164	100	100.41	164	100	101.08	164	100	101.75	101.08
165	100	99.74	165	100	99.74	165	100	100.41	99.96333333
166	100	99.74	166	100	101.08	166	100	99.74	100.1866667
167	100	99.74	167	100	100.41	167	100	101.75	100.6333333
168	100	99.74	168	100	101.08	168	100	100.41	100.41
169	100	100.41	169	100	99.74	169	100	101.75	100.6333333
170	100	99.74	170	100	98.55	170	100	99.74	99.34333333
171	100	99.74	171	100	100.41	171	100	101.08	100.41
172	100	100.41	172	100	99.74	172	100	99.74	99.96333333
173	100	101.08	173	100	100.41	173	100	100.41	100.6333333
174	100	99.74	174	100	99.74	174	100	99.74	99.74
175	100	101.08	175	100	100.41	175	100	99.74	100.41
176	100	99.74	176	100	100.41	176	100	99.74	99.96333333
177	100	100.41	177	100	99.74	177	100	100.41	100.1866667
178	100	99.74	178	100	99.74	178	100	100.41	99.96333333
179	100	101.08	179	100	100.41	179	100	101.08	100.8566667
180	100	100.41	180	100	101.08	180	100	101.75	101.08
181	100	100.41	181	100	99.07	181	100	100.41	99.96333333
182	100	101.08	182	100	98.55	182	100	99.07	99.56666667
183	100	100.41	183	100	100.41	183	100	100.41	100.41
184	100	101.08	184	100	100.41	184	100	98.55	100.0133333
185	100	99.74	185	100	98.55	185	100	99.07	99.12
186	100	99.74	186	100	99.07	186	100	99.07	99.29333333
187	100	101.08	187	100	101.08	187	100	101.08	101.08
188	100	101.08	188	100	101.08	188	100	101.08	101.08
189	100	101.08	189	100	101.75	189	100	99.07	100.6333333
190	100	99.74	190	100	101.08	190	100	99.07	99.96333333
191	100	100.41	191	100	101.08	191	100	99.07	100.1866667
192	100	99.07	192	100	99.07	192	100	101.75	99.96333333
193	100	101.08	193	100	99.74	193	100	99.07	99.96333333
194	100	99.74	194	100	98.55	194	100	102.42	100.2366667
195	100	100.41	195	100	90.2	195	100	99.74	96.78333333
196	100	100.41	196	100	98.55	196	100	101.75	100.2366667
197	100	99.07	197	100	98.55	197	100	99.74	99.12
198	100	101.08	198	100	99.07	198	100	99.74	99.96333333
199	100	101.08	199	100	98.55	199	100	99.74	99.79
200	100	99.74	200	100	98.55	200	100	100.41	99.56666667
201	100	99.74	201	100	101.08	201	100	100.41	100.41
202	100	100.41	202	100	101.75	202	100	99.74	100.6333333
203	100	100.41	203	100	101.08	203	100	99.74	100.41
204	100	100.41	204	100	99.74	204	100	100.41	100.1866667
205	100	99.74	205	100	99.07	205	100	100.41	99.74
206	100	101.08	206	100	101.08	206	100	101.08	101.08
207	100	99.74	207	100	99.07	207	100	100.41	99.74
208	100	99.07	208	100	98.55	208	100	101.08	99.56666667
209	100	100.41	209	100	98.55	209	100	100.41	99.79
210	100	101.08	210	100	99.07	210	100	100.41	100.1866667
211	100	101.08	211	100	99.74	211	100	101.08	100.6333333
212	100	100.41	212	100	99.07	212	100	99.74	99.74
213	100	99.74	213	100	99.74	213	100	100.41	99.96333333
214	100	100.41	214	100	101.08	214	100	101.75	101.08
215	100	100.41	215	100	101.75	215	100	99.07	100.41
216	100	100.41	216	100	99.74	216	100	99.74	99.96333333
217	100	100.41	217	100	99.74	217	100	100.41	100.1866667
218	100	99.74	218	100	99.74	218	100	99.07	99.51666667
219	100	99.74	219	100	100.41	219	100	100.41	100.1866667
220	100	99.07	220	100	99.74	220	100	101.75	100.1866667
221	100	99.07	221	100	101.08	221	100	99.07	99.74
222	100	99.07	222	100	99.07	222	100	101.08	99.74
223	100	100.41	223	100	99.74	223	100	100.41	100.1866667
224	100	99.07	224	100	99.74	224	100	100.41	99.74
225	100	101.75	225	100	101.75	225	100	99.74	101.08
226	100	100.41	226	100	101.75	226	100	101.08	101.08
227	100	101.08	227	100	98.55	227	100	99.74	99.79
228	100	99.07	228	100	98.55	228	100	100.41	99.34333333
229	100	100.41	229	100	99.74	229	100	101.08	100.41
230	100	99.07	230	100	99.74	230	100	100.41	99.74
231	100	99.07	231	100	100.41	231	100	99.74	99.74
232	100	100.41	232	100	101.08	232	100	100.41	100.6333333
233	100	99.74	233	100	101.75	233	100	101.08	100.8566667
234	100	100.41	234	100	100.41	234	100	101.08	100.6333333
235	100	99.07	235	100	100.41	235	100	100.41	99.96333333
236	100	99.74	236	100	100.41	236	100	100.41	100.1866667
237	100	99.74	237	100	101.08	237	100	99.74	100.1866667
238	100	99.74	238	100	101.08	238	100	100.41	100.41

239	100	99.74	239	100	99.07	239	100	99.74	99.51666667
240	100	99.74	240	100	101.75	240	100	99.07	100.1866667
241	100	100.41	241	100	99.74	241	100	102.42	100.8566667
242	100	100.41	242	100	101.08	242	100	99.74	100.41
243	100	100.41	243	100	101.08	243	100	98.55	100.0133333
244	100	100.41	244	100	100.41	244	100	101.75	100.8566667
245	100	99.74	245	100	99.74	245	100	101.08	100.1866667
246	100	101.08	246	100	100.41	246	100	100.41	100.6333333
247	100	99.74	247	100	91.25	247	100	99.74	96.91
248	100	100.41	248	100	99.74	248	100	99.07	99.74
249	100	99.74	249	100	100.41	249	100	99.07	99.74
250	100	101.08	250	100	100.41	250	100	101.08	100.8566667
251	100	100.41	251	100	99.74	251	100	99.74	99.96333333
252	100	100.41	252	100	99.07	252	100	100.41	99.96333333
253	100	101.08	253	100	99.74	253	100	99.07	99.96333333
254	100	101.08	254	100	101.08	254	100	101.08	101.08
255	100	101.08	255	100	99.74	255	100	100.41	100.41
256	100	99.74	256	100	98.55	256	100	100.41	99.56666667
257	100	101.08	257	100	99.74	257	100	100.41	100.41
258	100	101.75	258	100	99.74	258	100	100.41	100.6333333
259	100	99.74	259	100	99.07	259	100	99.74	99.51666667
260	100	99.07	260	100	99.07	260	100	101.75	99.96333333
261	100	99.74	261	100	99.07	261	100	101.08	99.96333333
262	100	100.41	262	100	101.08	262	100	100.41	100.6333333
263	100	100.41	263	100	101.08	263	100	100.41	100.6333333
264	100	101.08	264	100	101.08	264	100	100.41	100.8566667
265	100	99.07	265	100	101.08	265	100	100.41	100.1866667
266	100	99.74	266	100	99.74	266	100	99.07	99.51666667
267	100	101.08	267	100	99.07	267	100	101.08	100.41
268	100	100.41	268	100	101.08	268	100	98.55	100.0133333
269	100	102.42	269	100	99.07	269	100	101.08	100.8566667
270	100	101.08	270	100	99.07	270	100	101.08	100.41
271	100	99.74	271	100	101.08	271	100	99.74	100.1866667
272	100	98.55	272	100	99.74	272	100	101.08	99.79
273	100	99.07	273	100	101.08	273	100	99.07	99.74
274	100	99.07	274	100	99.07	274	100	99.07	99.07
275	100	101.08	275	100	99.07	275	100	100.41	100.1866667
276	100	99.07	276	100	99.74	276	100	99.07	99.29333333
277	100	101.08	277	100	100.41	277	100	99.07	100.1866667
278	100	100.41	278	100	101.08	278	100	101.08	100.8566667
279	100	100.41	279	100	100.41	279	100	101.08	100.6333333
280	100	99.74	280	100	99.74	280	100	99.74	99.74
281	100	102.42	281	100	99.74	281	100	99.74	100.6333333
282	100	103.08	282	100	100.41	282	100	99.74	101.0766667
283	100	100.41	283	100	99.74	283	100	100.41	100.1866667
284	100	99.74	284	100	101.08	284	100	99.07	99.96333333
285	100	99.74	285	100	101.75	285	100	99.74	100.41
286	100	99.07	286	100	100.41	286	100	99.74	99.74
287	100	99.74	287	100	99.74	287	100	99.74	99.74
288	100	99.74	288	100	100.41	288	100	102.42	100.8566667
289	100	99.74	289	100	100.41	289	100	99.74	99.96333333
290	100	100.41	290	100	101.08	290	100	100.41	100.6333333
291	100	99.74	291	100	100.41	291	100	100.41	100.1866667
292	100	100.41	292	100	101.08	292	100	102.42	101.3033333
293	100	100.41	293	100	100.41	293	100	101.08	100.6333333
294	100	101.08	294	100	99.74	294	100	101.08	100.6333333
295	100	99.74	295	100	100.41	295	100	100.41	100.1866667
296	100	100.41	296	100	100.41	296	100	99.74	100.1866667
297	100	100.41	297	100	101.08	297	100	100.41	100.6333333
298	100	100.41	298	100	99.74	298	100	101.08	100.41
299	100	100.41	299	100	101.08	299	100	99.07	100.1866667
300	100	99.74	300	100	102.42	300	100	100.41	100.8566667
301	200	127.85	301	200	130.53	301	200	129.19	129.19
302	200	150.61	302	200	147.26	302	200	146.59	148.1533333
303	200	168.01	303	200	161.99	303	200	160.65	163.55
304	200	180.73	304	200	172.7	304	200	172.03	175.1533333
305	200	186.76	305	200	179.39	305	200	180.06	182.07
306	200	192.11	306	200	188.77	306	200	186.09	188.99
307	200	195.46	307	200	189.43	307	200	188.77	191.22
308	200	196.8	308	200	193.45	308	200	190.77	193.6733333
309	200	196.8	309	200	196.13	309	200	193.45	195.46
310	200	198.14	310	200	195.46	310	200	195.46	196.3533333
311	200	201.5	311	200	196.13	311	200	198.14	198.59
312	200	200.66	312	200	196.8	312	200	198.14	198.5333333
313	200	198.98	313	200	198.98	313	200	197.47	198.4766667
314	200	202.33	314	200	199.82	314	200	201.5	201.2166667
315	200	201.5	315	200	199.82	315	200	198.14	199.82
316	200	202.33	316	200	199.82	316	200	199.82	200.6566667
317	200	201.5	317	200	198.14	317	200	199.82	199.82
318	200	201.5	318	200	200.66	318	200	199.82	200.66

319	200	201.5	319	200	200.66	319	200	197.47	199.8766667
320	200	202.33	320	200	200.66	320	200	199.82	200.9366667
321	200	203.17	321	200	202.33	321	200	199.82	201.7733333
322	200	201.5	322	200	202.33	322	200	200.66	201.4966667
323	200	200.66	323	200	200.66	323	200	198.98	200.1
324	200	199.82	324	200	199.82	324	200	198.98	199.54
325	200	201.5	325	200	200.66	325	200	199.82	200.66
326	200	200.66	326	200	198.98	326	200	199.82	199.82
327	200	199.82	327	200	200.66	327	200	201.5	200.66
328	200	199.82	328	200	199.82	328	200	200.66	200.1
329	200	200.66	329	200	198.98	329	200	201.5	200.38
330	200	199.82	330	200	201.5	330	200	199.82	200.38
331	200	201.5	331	200	199.82	331	200	200.66	200.66
332	200	199.82	332	200	200.66	332	200	199.82	200.1
333	200	200.66	333	200	200.66	333	200	199.82	200.38
334	200	201.5	334	200	199.82	334	200	202.33	201.2166667
335	200	200.66	335	200	199.82	335	200	201.5	200.66
336	200	199.82	336	200	198.98	336	200	199.82	199.54
337	200	198.98	337	200	199.82	337	200	198.14	198.98
338	200	199.82	338	200	201.5	338	200	201.5	200.94
339	200	200.66	339	200	200.66	339	200	198.98	200.1
340	200	198.98	340	200	198.98	340	200	200.66	199.54
341	200	198.14	341	200	201.5	341	200	199.82	199.82
342	200	201.5	342	200	198.14	342	200	198.98	199.54
343	200	200.66	343	200	200.66	343	200	202.33	201.2166667
344	200	199.82	344	200	198.98	344	200	200.66	199.82
345	200	198.98	345	200	198.98	345	200	201.5	199.82
346	200	201.5	346	200	201.5	346	200	201.5	201.5
347	200	199.82	347	200	198.98	347	200	200.66	199.82
348	200	200.66	348	200	201.5	348	200	200.66	200.94
349	200	199.82	349	200	199.82	349	200	198.98	199.54
350	200	199.82	350	200	200.66	350	200	200.66	200.38
351	200	199.82	351	200	198.98	351	200	201.5	200.1
352	200	198.98	352	200	199.82	352	200	199.82	199.54
353	200	201.5	353	200	200.66	353	200	198.98	200.38
354	200	202.33	354	200	201.5	354	200	200.66	201.4966667
355	200	199.82	355	200	201.5	355	200	200.66	200.66
356	200	200.66	356	200	200.66	356	200	201.5	200.94
357	200	198.98	357	200	199.82	357	200	198.98	199.26
358	200	201.5	358	200	199.82	358	200	199.82	200.38
359	200	199.82	359	200	199.82	359	200	201.5	200.38
360	200	199.82	360	200	200.66	360	200	202.33	200.9366667
361	200	199.82	361	200	199.82	361	200	200.66	200.1
362	200	198.98	362	200	200.66	362	200	200.66	200.1
363	200	199.82	363	200	199.82	363	200	201.5	200.38
364	200	199.82	364	200	200.66	364	200	198.98	199.82
365	200	199.82	365	200	200.66	365	200	199.82	200.1
366	200	201.5	366	200	199.82	366	200	200.66	200.66
367	200	199.82	367	200	199.82	367	200	200.66	200.1
368	200	200.66	368	200	199.82	368	200	201.5	200.66
369	200	199.82	369	200	201.5	369	200	199.82	200.38
370	200	199.82	370	200	198.98	370	200	202.33	200.3766667
371	200	200.66	371	200	199.82	371	200	201.5	200.66
372	200	199.82	372	200	200.66	372	200	198.98	199.82
373	200	200.66	373	200	199.82	373	200	197.47	199.3166667
374	200	198.98	374	200	199.82	374	200	200.66	199.82
375	200	201.5	375	200	198.98	375	200	200.66	200.38
376	200	199.82	376	200	198.98	376	200	199.82	199.54
377	200	200.66	377	200	198.98	377	200	199.82	199.82
378	200	200.66	378	200	198.14	378	200	200.66	199.82
379	200	198.14	379	200	201.5	379	200	198.14	199.26
380	200	199.82	380	200	201.5	380	200	202.33	201.2166667
381	200	199.82	381	200	200.66	381	200	200.66	200.38
382	200	200.66	382	200	199.82	382	200	198.98	199.82
383	200	202.33	383	200	199.82	383	200	198.98	200.3766667
384	200	200.66	384	200	201.5	384	200	199.82	200.66
385	200	200.66	385	200	199.82	385	200	199.82	200.1
386	200	202.33	386	200	200.66	386	200	199.82	200.9366667
387	200	200.66	387	200	200.66	387	200	199.82	200.38
388	200	198.98	388	200	201.5	388	200	200.66	200.38
389	200	199.82	389	200	199.82	389	200	200.66	200.1
390	200	200.66	390	200	199.82	390	200	202.33	200.9366667
391	200	201.5	391	200	200.66	391	200	200.66	200.94
392	200	200.66	392	200	199.82	392	200	199.82	200.1
393	200	198.98	393	200	199.82	393	200	201.5	200.1
394	200	198.98	394	200	198.98	394	200	201.5	199.82
395	200	200.66	395	200	198.98	395	200	198.98	199.54
396	200	200.66	396	200	199.82	396	200	199.82	200.1
397	200	202.33	397	200	202.33	397	200	200.66	201.7733333
398	200	198.98	398	200	199.82	398	200	198.98	199.26

399	200	198.98	399	200	198.98	399	200	199.82	199.26
400	200	199.82	400	200	199.82	400	200	200.66	200.1
401	200	200.66	401	200	199.82	401	200	198.98	199.82
402	200	199.82	402	200	199.82	402	200	198.98	199.54
403	200	200.66	403	200	201.5	403	200	200.66	200.94
404	200	200.66	404	200	199.82	404	200	199.82	200.1
405	200	198.98	405	200	198.98	405	200	198.98	198.98
406	200	198.98	406	200	199.82	406	200	201.5	200.1
407	200	201.5	407	200	198.98	407	200	200.66	200.38
408	200	198.98	408	200	201.5	408	200	200.66	200.38
409	200	199.82	409	200	200.66	409	200	199.82	200.1
410	200	199.82	410	200	199.82	410	200	198.98	199.54
411	200	199.82	411	200	199.82	411	200	198.98	199.54
412	200	199.82	412	200	201.5	412	200	199.82	200.38
413	200	198.98	413	200	201.5	413	200	199.82	200.1
414	200	199.82	414	200	199.82	414	200	200.66	200.1
415	200	199.82	415	200	198.98	415	200	198.98	199.26
416	200	200.66	416	200	199.82	416	200	199.82	200.1
417	200	199.82	417	200	199.82	417	200	200.66	200.1
418	200	199.82	418	200	201.5	418	200	199.82	200.38
419	200	198.98	419	200	199.82	419	200	200.66	199.82
420	200	198.98	420	200	200.66	420	200	198.98	199.54
421	200	200.66	421	200	198.98	421	200	198.98	199.54
422	200	200.66	422	200	200.66	422	200	199.82	200.38
423	200	199.82	423	200	201.5	423	200	201.5	200.94
424	200	199.82	424	200	200.66	424	200	198.98	199.82
425	200	198.98	425	200	199.82	425	200	199.82	199.54
426	200	199.82	426	200	201.5	426	200	201.5	200.94
427	200	200.66	427	200	200.66	427	200	199.82	200.38
428	200	199.82	428	200	199.82	428	200	198.98	199.54
429	200	198.98	429	200	199.82	429	200	201.5	200.1
430	200	200.66	430	200	198.98	430	200	199.82	199.82
431	200	199.82	431	200	199.82	431	200	199.82	199.82
432	200	199.82	432	200	200.66	432	200	198.98	199.82
433	200	199.82	433	200	200.66	433	200	199.82	200.1
434	200	199.82	434	200	199.82	434	200	201.5	200.38
435	200	201.5	435	200	198.98	435	200	202.33	200.9366667
436	200	201.5	436	200	200.66	436	200	199.82	200.66
437	200	200.66	437	200	201.5	437	200	198.98	200.38
438	200	200.66	438	200	198.98	438	200	198.98	199.54
439	200	198.14	439	200	199.82	439	200	201.5	199.82
440	200	199.82	440	200	200.66	440	200	199.82	200.1
441	200	199.82	441	200	200.66	441	200	201.5	200.66
442	200	199.82	442	200	199.82	442	200	199.82	199.82
443	200	199.82	443	200	198.98	443	200	199.82	199.54
444	200	201.5	444	200	199.82	444	200	201.5	200.94
445	200	199.82	445	200	199.82	445	200	200.66	200.1
446	200	200.66	446	200	200.66	446	200	201.5	200.94
447	200	199.82	447	200	198.98	447	200	198.14	198.98
448	200	201.5	448	200	199.82	448	200	199.82	200.38
449	200	202.33	449	200	200.66	449	200	200.66	201.2166667
450	200	200.66	450	200	202.33	450	200	201.5	201.4966667
451	200	201.5	451	200	202.33	451	200	202.33	202.0533333
452	200	198.98	452	200	200.66	452	200	199.82	199.82
453	200	200.66	453	200	200.66	453	200	199.82	200.38
454	200	198.14	454	200	201.5	454	200	199.82	199.82
455	200	202.33	455	200	201.5	455	200	199.82	201.2166667
456	200	199.82	456	200	198.98	456	200	199.82	199.54
457	200	200.66	457	200	200.66	457	200	200.66	200.66
458	200	200.66	458	200	198.98	458	200	200.66	200.1
459	200	199.82	459	200	199.82	459	200	202.33	200.6566667
460	200	198.98	460	200	198.98	460	200	201.5	199.82
461	200	200.66	461	200	200.66	461	200	200.66	200.66
462	200	199.82	462	200	200.66	462	200	198.98	199.82
463	200	201.5	463	200	200.66	463	200	201.5	201.22
464	200	200.66	464	200	199.82	464	200	199.82	200.1
465	200	199.82	465	200	200.66	465	200	198.98	199.82
466	200	200.66	466	200	198.98	466	200	201.5	200.38
467	200	202.33	467	200	198.98	467	200	199.82	200.3766667
468	200	200.66	468	200	199.82	468	200	198.14	199.54
469	200	198.98	469	200	199.82	469	200	200.66	199.82
470	200	200.66	470	200	199.82	470	200	199.82	200.1
471	200	200.66	471	200	198.14	471	200	198.98	199.26
472	200	199.82	472	200	200.66	472	200	200.66	200.38
473	200	200.66	473	200	198.98	473	200	200.66	200.1
474	200	199.82	474	200	200.66	474	200	200.66	200.38
475	200	199.82	475	200	201.5	475	200	198.98	200.1
476	200	200.66	476	200	200.66	476	200	201.5	200.94
477	200	200.66	477	200	198.98	477	200	200.66	200.1
478	200	199.82	478	200	200.66	478	200	199.82	200.1

479	200	200.66	479	200	202.33	479	200	198.98	200.6566667
480	200	200.66	480	200	199.82	480	200	201.5	200.66
481	200	199.82	481	200	200.66	481	200	198.98	199.82
482	200	200.66	482	200	199.82	482	200	198.98	199.82
483	200	200.66	483	200	199.82	483	200	201.5	200.66
484	200	198.98	484	200	200.66	484	200	198.98	199.54
485	200	200.66	485	200	199.82	485	200	198.98	199.82
486	200	199.82	486	200	201.5	486	200	198.98	200.1
487	200	200.66	487	200	198.98	487	200	200.66	200.1
488	200	198.98	488	200	199.82	488	200	199.82	199.54
489	200	199.82	489	200	203.17	489	200	203.17	202.0533333
490	200	198.98	490	200	200.66	490	200	198.98	199.54
491	200	201.5	491	200	199.82	491	200	200.66	200.66
492	200	199.82	492	200	198.98	492	200	201.5	200.1
493	200	200.66	493	200	200.66	493	200	199.82	200.38
494	200	198.98	494	200	199.82	494	200	198.98	199.26
495	200	198.98	495	200	200.66	495	200	200.66	200.1
496	200	200.66	496	200	198.98	496	200	200.66	200.1
497	200	199.82	497	200	198.98	497	200	201.5	200.1
498	200	199.82	498	200	198.98	498	200	198.14	198.98
499	200	198.98	499	200	200.66	499	200	199.82	199.82
500	200	199.82	500	200	199.82	500	200	199.82	199.82
501	200	199.82	501	200	200.66	501	200	201.5	200.66
502	200	201.5	502	200	199.82	502	200	199.82	200.38
503	200	199.82	503	200	201.5	503	200	201.5	200.94
504	200	201.5	504	200	201.5	504	200	201.5	201.5
505	200	201.5	505	200	199.82	505	200	198.98	200.1
506	200	199.82	506	200	200.66	506	200	199.82	200.1
507	200	199.82	507	200	199.82	507	200	198.98	199.54
508	200	199.82	508	200	201.5	508	200	202.33	201.2166667
509	200	201.5	509	200	199.82	509	200	201.5	200.94
510	200	201.5	510	200	200.66	510	200	198.98	200.38
511	200	198.98	511	200	198.98	511	200	198.98	198.98
512	200	200.66	512	200	201.5	512	200	200.66	200.94
513	200	198.98	513	200	199.82	513	200	201.5	200.1
514	200	201.5	514	200	201.5	514	200	199.82	200.94
515	200	199.82	515	200	198.98	515	200	198.98	199.26
516	200	199.82	516	200	200.66	516	200	198.98	199.82
517	200	199.82	517	200	199.82	517	200	199.82	199.82
518	200	200.66	518	200	199.82	518	200	198.98	199.82
519	200	199.82	519	200	200.66	519	200	200.66	200.38
520	200	199.82	520	200	200.66	520	200	201.5	200.66
521	200	199.82	521	200	199.82	521	200	200.66	200.1
522	200	199.82	522	200	201.5	522	200	198.98	200.1
523	200	199.82	523	200	199.82	523	200	199.82	199.82
524	200	200.66	524	200	198.98	524	200	198.98	199.54
525	200	199.82	525	200	198.98	525	200	199.82	199.54
526	200	201.5	526	200	198.14	526	200	198.98	199.54
527	200	200.66	527	200	200.66	527	200	199.82	200.38
528	200	199.82	528	200	199.82	528	200	200.66	200.1
529	200	201.5	529	200	199.82	529	200	198.98	200.1
530	200	199.82	530	200	198.14	530	200	200.66	199.54
531	200	200.66	531	200	200.66	531	200	200.66	200.66
532	200	199.82	532	200	199.82	532	200	199.82	199.82
533	200	198.14	533	200	198.98	533	200	200.66	199.26
534	200	198.14	534	200	199.82	534	200	199.82	199.26
535	200	200.66	535	200	199.82	535	200	198.98	199.82
536	200	199.82	536	200	199.82	536	200	201.5	200.38
537	200	199.82	537	200	200.66	537	200	201.5	200.66
538	200	199.82	538	200	198.98	538	200	200.66	199.82
539	200	201.5	539	200	199.82	539	200	199.82	200.38
540	200	198.14	540	200	201.5	540	200	199.82	199.82
541	200	199.82	541	200	200.66	541	200	200.66	200.38
542	200	200.66	542	200	198.98	542	200	199.82	199.82
543	200	200.66	543	200	199.82	543	200	200.66	200.38
544	200	201.5	544	200	200.66	544	200	201.5	201.22
545	200	199.82	545	200	200.66	545	200	201.5	200.66
546	200	199.82	546	200	198.98	546	200	201.5	200.1
547	200	200.66	547	200	201.5	547	200	200.66	200.94
548	200	200.66	548	200	201.5	548	200	199.82	200.66
549	200	200.66	549	200	199.82	549	200	199.82	200.1
550	200	198.98	550	200	198.98	550	200	199.82	199.26
551	200	199.82	551	200	199.82	551	200	200.66	200.1
552	200	199.82	552	200	199.82	552	200	201.5	200.38
553	200	201.5	553	200	198.98	553	200	198.98	199.82
554	200	200.66	554	200	200.66	554	200	199.82	200.38
555	200	199.82	555	200	198.98	555	200	199.82	199.54
556	200	198.98	556	200	198.98	556	200	198.14	198.7
557	200	198.98	557	200	199.82	557	200	198.98	199.26
558	200	201.5	558	200	198.98	558	200	198.14	199.54

559	200	199.82	559	200	200.66	559	200	201.5	200.66
560	200	199.82	560	200	199.82	560	200	200.66	200.1
561	200	198.98	561	200	198.98	561	200	199.82	199.26
562	200	200.66	562	200	199.82	562	200	199.82	200.1
563	200	198.98	563	200	199.82	563	200	199.82	199.54
564	200	199.82	564	200	200.66	564	200	199.82	200.1
565	200	200.66	565	200	198.98	565	200	198.14	199.26
566	200	199.82	566	200	201.5	566	200	199.82	200.38
567	200	198.98	567	200	199.82	567	200	200.66	199.82
568	200	198.98	568	200	201.5	568	200	199.82	200.1
569	200	198.98	569	200	199.82	569	200	199.82	199.54
570	200	200.66	570	200	199.82	570	200	200.66	200.38
571	200	199.82	571	200	199.82	571	200	201.5	200.38
572	200	199.82	572	200	200.66	572	200	199.82	200.1
573	200	203.17	573	200	202.33	573	200	200.66	202.0533333
574	200	199.82	574	200	198.98	574	200	200.66	199.82
575	200	198.98	575	200	200.66	575	200	200.66	200.1
576	200	198.98	576	200	199.82	576	200	198.98	199.26
577	200	198.14	577	200	202.33	577	200	198.14	199.5366667
578	200	198.98	578	200	201.5	578	200	200.66	200.38
579	200	199.82	579	200	200.66	579	200	201.5	200.66
580	200	198.98	580	200	198.98	580	200	201.5	199.82
581	200	198.98	581	200	198.98	581	200	199.82	199.26
582	200	201.5	582	200	200.66	582	200	199.82	200.66
583	200	200.66	583	200	198.98	583	200	201.5	200.38
584	200	201.5	584	200	198.98	584	200	201.5	200.66
585	200	199.82	585	200	198.14	585	200	201.5	199.82
586	200	199.82	586	200	201.5	586	200	199.82	200.38
587	200	199.82	587	200	198.98	587	200	202.33	200.3766667
588	200	198.98	588	200	198.98	588	200	198.14	198.7
589	200	199.82	589	200	200.66	589	200	200.66	200.38
590	200	198.98	590	200	199.82	590	200	202.33	200.3766667
591	200	198.98	591	200	202.33	591	200	200.66	200.6566667
592	200	198.98	592	200	200.66	592	200	202.33	200.6566667
593	200	199.82	593	200	198.98	593	200	199.82	199.54
594	200	200.66	594	200	201.5	594	200	199.82	200.66
595	200	200.66	595	200	198.98	595	200	202.33	200.6566667
596	200	200.66	596	200	200.66	596	200	199.82	200.38
597	200	200.66	597	200	199.82	597	200	200.66	200.38
598	200	198.98	598	200	199.82	598	200	200.66	199.82
599	200	201.5	599	200	198.98	599	200	198.98	199.82
600	200	202.33	600	200	202.33	600	200	199.82	201.4933333
601	300	233.4	601	300	240.95	601	300	244.31	239.5533333
602	300	256.07	602	300	260.26	602	300	260.26	258.8633333
603	300	272.86	603	300	271.18	603	300	268.66	270.9
604	300	279.57	604	300	277.9	604	300	277.9	278.4566667
605	300	286.29	605	300	282.93	605	300	283.77	284.33
606	300	289.65	606	300	289.65	606	300	287.97	289.09
607	300	294.69	607	300	288.81	607	300	292.17	291.89
608	300	297.21	608	300	293.85	608	300	293.85	294.97
609	300	297.21	609	300	293.85	609	300	296.37	295.81
610	300	298.29	610	300	296.37	610	300	294.69	296.45
611	300	302.65	611	300	296.37	611	300	296.37	298.4633333
612	300	299.38	612	300	300.47	612	300	297.21	299.02
613	300	300.47	613	300	296.37	613	300	298.29	298.3766667
614	300	300.47	614	300	299.38	614	300	299.38	299.7433333
615	300	300.47	615	300	301.56	615	300	299.38	300.47
616	300	300.47	616	300	298.29	616	300	298.29	299.0166667
617	300	300.47	617	300	297.21	617	300	299.38	299.02
618	300	301.56	618	300	301.56	618	300	303.74	302.2866667
619	300	299.38	619	300	299.38	619	300	299.38	299.38
620	300	300.47	620	300	300.47	620	300	297.21	299.3833333
621	300	299.38	621	300	301.56	621	300	302.65	301.1966667
622	300	299.38	622	300	302.65	622	300	300.47	300.8333333
623	300	302.65	623	300	299.38	623	300	300.47	300.8333333
624	300	298.29	624	300	298.29	624	300	301.56	299.38
625	300	299.38	625	300	301.56	625	300	299.38	300.1066667
626	300	372.32	626	300	301.56	626	300	299.38	324.42
627	300	301.56	627	300	302.65	627	300	299.38	301.1966667
628	300	300.47	628	300	302.65	628	300	299.38	300.8333333
629	300	301.56	629	300	301.56	629	300	299.38	300.8333333
630	300	299.38	630	300	299.38	630	300	302.65	300.47
631	300	301.56	631	300	300.47	631	300	300.47	300.8333333
632	300	303.74	632	300	299.38	632	300	299.38	300.8333333
633	300	302.65	633	300	299.38	633	300	301.56	301.1966667
634	300	299.38	634	300	300.47	634	300	300.47	300.1066667
635	300	298.29	635	300	299.38	635	300	300.47	299.38
636	300	300.47	636	300	302.65	636	300	299.38	300.8333333
637	300	300.47	637	300	299.38	637	300	301.56	300.47
638	300	301.56	638	300	299.38	638	300	301.56	300.8333333

639	300	299.38	639	300	299.38	639	300	301.56	300.1066667
640	300	301.56	640	300	301.56	640	300	300.47	301.1966667
641	300	300.47	641	300	299.38	641	300	300.47	300.1066667
642	300	300.47	642	300	299.38	642	300	300.47	300.1066667
643	300	298.29	643	300	299.38	643	300	302.65	300.1066667
644	300	298.29	644	300	298.29	644	300	299.38	298.6533333
645	300	300.47	645	300	302.65	645	300	301.56	301.56
646	300	301.56	646	300	298.29	646	300	298.29	299.38
647	300	301.56	647	300	300.47	647	300	299.38	300.47
648	300	299.38	648	300	301.56	648	300	301.56	300.8333333
649	300	300.47	649	300	299.38	649	300	300.47	300.1066667
650	300	298.29	650	300	300.47	650	300	299.38	299.38
651	300	301.56	651	300	299.38	651	300	300.47	300.47
652	300	298.29	652	300	299.38	652	300	302.65	300.1066667
653	300	301.56	653	300	299.38	653	300	299.38	300.1066667
654	300	299.38	654	300	299.38	654	300	301.56	300.1066667
655	300	300.47	655	300	301.56	655	300	299.38	300.47
656	300	301.56	656	300	299.38	656	300	298.29	299.7433333
657	300	301.56	657	300	299.38	657	300	301.56	300.8333333
658	300	301.56	658	300	301.56	658	300	299.38	300.8333333
659	300	302.65	659	300	300.47	659	300	301.56	301.56
660	300	300.47	660	300	299.38	660	300	299.38	299.7433333
661	300	299.38	661	300	298.29	661	300	299.38	299.0166667
662	300	299.38	662	300	299.38	662	300	299.38	299.38
663	300	301.56	663	300	299.38	663	300	299.38	300.1066667
664	300	299.38	664	300	299.38	664	300	302.65	300.47
665	300	302.65	665	300	300.47	665	300	299.38	300.8333333
666	300	300.47	666	300	299.38	666	300	299.38	299.7433333
667	300	301.56	667	300	298.29	667	300	300.47	300.1066667
668	300	298.29	668	300	299.38	668	300	299.38	299.0166667
669	300	301.56	669	300	300.47	669	300	299.38	300.47
670	300	302.65	670	300	301.56	670	300	299.38	301.1966667
671	300	298.29	671	300	299.38	671	300	302.65	300.1066667
672	300	300.47	672	300	299.38	672	300	300.47	300.1066667
673	300	302.65	673	300	299.38	673	300	299.38	300.47
674	300	298.29	674	300	301.56	674	300	299.38	299.7433333
675	300	299.38	675	300	299.38	675	300	301.56	300.1066667
676	300	300.47	676	300	301.56	676	300	299.38	300.47
677	300	299.38	677	300	300.47	677	300	301.56	300.47
678	300	300.47	678	300	301.56	678	300	300.47	300.8333333
679	300	301.56	679	300	299.38	679	300	298.29	299.7433333
680	300	298.29	680	300	300.47	680	300	298.29	299.0166667
681	300	301.56	681	300	298.29	681	300	298.29	299.38
682	300	299.38	682	300	299.38	682	300	299.38	299.38
683	300	301.56	683	300	303.74	683	300	300.47	301.9233333
684	300	299.38	684	300	298.29	684	300	299.38	299.0166667
685	300	297.21	685	300	299.38	685	300	298.29	298.2933333
686	300	297.21	686	300	301.56	686	300	302.65	300.4733333
687	300	301.56	687	300	301.56	687	300	302.65	301.9233333
688	300	300.47	688	300	299.38	688	300	301.56	300.47
689	300	298.29	689	300	299.38	689	300	298.29	298.6533333
690	300	297.21	690	300	300.47	690	300	299.38	299.02
691	300	298.29	691	300	299.38	691	300	299.38	299.0166667
692	300	299.38	692	300	301.56	692	300	301.56	300.8333333
693	300	298.29	693	300	299.38	693	300	298.29	298.6533333
694	300	298.29	694	300	301.56	694	300	299.38	299.7433333
695	300	301.56	695	300	300.47	695	300	298.29	300.1066667
696	300	299.38	696	300	298.29	696	300	302.65	300.1066667
697	300	299.38	697	300	298.29	697	300	302.65	300.1066667
698	300	299.38	698	300	298.29	698	300	300.47	299.38
699	300	300.47	699	300	302.65	699	300	302.65	301.9233333
700	300	300.47	700	300	299.38	700	300	300.47	300.1066667
701	300	301.56	701	300	299.38	701	300	299.38	300.1066667
702	300	302.65	702	300	300.47	702	300	299.38	300.8333333
703	300	300.47	703	300	298.29	703	300	301.56	300.1066667
704	300	299.38	704	300	300.47	704	300	296.37	298.74
705	300	301.56	705	300	299.38	705	300	301.56	300.8333333
706	300	298.29	706	300	300.47	706	300	302.65	300.47
707	300	301.56	707	300	300.47	707	300	299.38	300.47
708	300	300.47	708	300	299.38	708	300	299.38	299.7433333
709	300	298.29	709	300	301.56	709	300	298.29	299.38
710	300	298.29	710	300	298.29	710	300	300.47	299.0166667
711	300	299.38	711	300	301.56	711	300	300.47	300.47
712	300	299.38	712	300	301.56	712	300	300.47	300.47
713	300	299.38	713	300	299.38	713	300	302.65	300.47
714	300	300.47	714	300	302.65	714	300	300.47	301.1966667
715	300	300.47	715	300	299.38	715	300	299.38	299.7433333
716	300	298.29	716	300	299.38	716	300	300.47	299.38
717	300	299.38	717	300	299.38	717	300	298.29	299.0166667
718	300	301.56	718	300	301.56	718	300	296.37	299.83

719	300	299.38	719	300	298.29	719	300	300.47	299.38
720	300	301.56	720	300	302.65	720	300	301.56	301.9233333
721	300	298.29	721	300	298.29	721	300	299.38	298.6533333
722	300	299.38	722	300	301.56	722	300	300.47	300.47
723	300	299.38	723	300	298.29	723	300	298.29	298.6533333
724	300	300.47	724	300	299.38	724	300	298.29	299.38
725	300	298.29	725	300	302.65	725	300	298.29	299.7433333
726	300	298.29	726	300	302.65	726	300	295.53	298.8233333
727	300	301.56	727	300	297.21	727	300	299.38	299.3833333
728	300	298.29	728	300	300.47	728	300	298.29	299.0166667
729	300	299.38	729	300	300.47	729	300	299.38	299.7433333
730	300	300.47	730	300	299.38	730	300	302.65	300.8333333
731	300	301.56	731	300	301.56	731	300	298.29	300.47
732	300	300.47	732	300	300.47	732	300	302.65	301.1966667
733	300	302.65	733	300	301.56	733	300	299.38	301.1966667
734	300	299.38	734	300	300.47	734	300	301.56	300.47
735	300	300.47	735	300	298.29	735	300	299.38	299.38
736	300	299.38	736	300	300.47	736	300	299.38	299.7433333
737	300	302.65	737	300	300.47	737	300	301.56	301.56
738	300	299.38	738	300	299.38	738	300	300.47	299.7433333
739	300	298.29	739	300	302.65	739	300	303.74	301.56
740	300	298.29	740	300	301.56	740	300	299.38	299.7433333
741	300	300.47	741	300	300.47	741	300	299.38	300.1066667
742	300	298.29	742	300	300.47	742	300	302.65	300.47
743	300	301.56	743	300	299.38	743	300	299.38	300.1066667
744	300	299.38	744	300	299.38	744	300	299.38	299.38
745	300	298.29	745	300	299.38	745	300	298.29	298.6533333
746	300	301.56	746	300	298.29	746	300	300.47	300.1066667
747	300	297.21	747	300	301.56	747	300	301.56	300.11
748	300	300.47	748	300	298.29	748	300	302.65	300.47
749	300	299.38	749	300	299.38	749	300	299.38	299.38
750	300	298.29	750	300	301.56	750	300	302.65	300.8333333
751	300	298.29	751	300	301.56	751	300	300.47	300.1066667
752	300	299.38	752	300	302.65	752	300	298.29	300.1066667
753	300	298.29	753	300	302.65	753	300	301.56	300.8333333
754	300	299.38	754	300	300.47	754	300	298.29	299.38
755	300	299.38	755	300	298.29	755	300	300.47	299.38
756	300	297.21	756	300	300.47	756	300	300.47	299.3833333
757	300	301.56	757	300	300.47	757	300	299.38	300.47
758	300	301.56	758	300	301.56	758	300	301.56	301.56
759	300	301.56	759	300	297.21	759	300	298.29	299.02
760	300	298.29	760	300	300.47	760	300	301.56	300.1066667
761	300	301.56	761	300	298.29	761	300	298.29	299.38
762	300	302.65	762	300	298.29	762	300	298.29	299.7433333
763	300	301.56	763	300	299.38	763	300	299.38	300.1066667
764	300	298.29	764	300	303.74	764	300	300.47	300.8333333
765	300	298.29	765	300	300.47	765	300	301.56	300.1066667
766	300	299.38	766	300	299.38	766	300	298.29	299.0166667
767	300	301.56	767	300	299.38	767	300	299.38	300.1066667
768	300	299.38	768	300	301.56	768	300	298.29	299.7433333
769	300	299.38	769	300	299.38	769	300	300.47	299.7433333
770	300	300.47	770	300	298.29	770	300	302.65	300.47
771	300	301.56	771	300	301.56	771	300	299.38	300.8333333
772	300	299.38	772	300	301.56	772	300	299.38	300.1066667
773	300	299.38	773	300	298.29	773	300	298.29	298.6533333
774	300	299.38	774	300	298.29	774	300	299.38	299.0166667
775	300	300.47	775	300	301.56	775	300	302.65	301.56
776	300	299.38	776	300	300.47	776	300	299.38	299.7433333
777	300	299.38	777	300	302.65	777	300	299.38	300.47
778	300	300.47	778	300	300.47	778	300	302.65	301.1966667
779	300	299.38	779	300	302.65	779	300	298.29	300.1066667
780	300	299.38	780	300	302.65	780	300	301.56	301.1966667
781	300	298.29	781	300	300.47	781	300	298.29	299.0166667
782	300	298.29	782	300	298.29	782	300	299.38	298.6533333
783	300	298.29	783	300	299.38	783	300	299.38	299.0166667
784	300	298.29	784	300	299.38	784	300	299.38	299.0166667
785	300	298.29	785	300	302.65	785	300	301.56	300.8333333
786	300	300.47	786	300	299.38	786	300	299.38	299.7433333
787	300	299.38	787	300	300.47	787	300	302.65	300.8333333
788	300	300.47	788	300	301.56	788	300	298.29	300.1066667
789	300	300.47	789	300	301.56	789	300	301.56	301.1966667
790	300	300.47	790	300	298.29	790	300	299.38	299.38
791	300	299.38	791	300	298.29	791	300	302.65	300.1066667
792	300	299.38	792	300	301.56	792	300	300.47	300.47
793	300	300.47	793	300	299.38	793	300	298.29	299.38
794	300	299.38	794	300	299.38	794	300	301.56	300.1066667
795	300	302.65	795	300	299.38	795	300	301.56	301.1966667
796	300	301.56	796	300	299.38	796	300	299.38	300.1066667
797	300	302.65	797	300	299.38	797	300	300.47	300.8333333
798	300	299.38	798	300	299.38	798	300	299.38	299.38

799	300	300.47	799	300	299.38	799	300	300.47	300.1066667
800	300	298.29	800	300	302.65	800	300	299.38	300.1066667
801	300	300.47	801	300	298.29	801	300	299.38	299.38
802	300	298.29	802	300	299.38	802	300	299.38	299.0166667
803	300	299.38	803	300	299.38	803	300	300.47	299.7433333
804	300	299.38	804	300	299.38	804	300	298.29	299.0166667
805	300	299.38	805	300	302.65	805	300	301.56	301.1966667
806	300	300.47	806	300	300.47	806	300	299.38	300.1066667
807	300	298.29	807	300	300.47	807	300	301.56	300.1066667
808	300	300.47	808	300	299.38	808	300	301.56	300.47
809	300	302.65	809	300	299.38	809	300	299.38	300.47
810	300	301.56	810	300	299.38	810	300	300.47	300.47
811	300	298.29	811	300	299.38	811	300	298.29	298.6533333
812	300	297.21	812	300	299.38	812	300	300.47	299.02
813	300	298.29	813	300	300.47	813	300	299.38	299.38
814	300	298.29	814	300	301.56	814	300	301.56	300.47
815	300	301.56	815	300	301.56	815	300	299.38	300.8333333
816	300	299.38	816	300	302.65	816	300	299.38	300.47
817	300	299.38	817	300	301.56	817	300	300.47	300.47
818	300	298.29	818	300	300.47	818	300	300.47	299.7433333
819	300	302.65	819	300	299.38	819	300	298.29	300.1066667
820	300	299.38	820	300	299.38	820	300	299.38	299.38
821	300	300.47	821	300	299.38	821	300	299.38	299.7433333
822	300	300.47	822	300	300.47	822	300	298.29	299.7433333
823	300	301.56	823	300	299.38	823	300	300.47	300.47
824	300	302.65	824	300	301.56	824	300	301.56	301.9233333
825	300	301.56	825	300	299.38	825	300	299.38	300.1066667
826	300	299.38	826	300	299.38	826	300	298.29	299.0166667
827	300	301.56	827	300	299.38	827	300	299.38	300.1066667
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829	300	300.47	829	300	301.56	829	300	299.38	300.47
830	300	298.29	830	300	299.38	830	300	301.56	299.7433333
831	300	299.38	831	300	300.47	831	300	298.29	299.38
832	300	298.29	832	300	301.56	832	300	298.29	299.38
833	300	299.38	833	300	299.38	833	300	298.29	299.0166667
834	300	300.47	834	300	300.47	834	300	300.47	300.47
835	300	299.38	835	300	299.38	835	300	301.56	300.1066667
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837	300	299.38	837	300	299.38	837	300	298.29	299.0166667
838	300	298.29	838	300	299.38	838	300	298.29	298.6533333
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840	300	300.47	840	300	299.38	840	300	300.47	300.1066667
841	300	299.38	841	300	298.29	841	300	299.38	299.0166667
842	300	285.45	842	300	302.65	842	300	301.56	296.5533333
843	300	298.29	843	300	299.38	843	300	299.38	299.0166667
844	300	298.29	844	300	299.38	844	300	299.38	299.0166667
845	300	301.56	845	300	299.38	845	300	299.38	300.1066667
846	300	299.38	846	300	298.29	846	300	298.29	298.6533333
847	300	300.47	847	300	299.38	847	300	299.38	299.7433333
848	300	299.38	848	300	300.47	848	300	298.29	299.38
849	300	299.38	849	300	298.29	849	300	298.29	298.6533333
850	300	298.29	850	300	301.56	850	300	298.29	299.38
851	300	301.56	851	300	299.38	851	300	300.47	300.47
852	300	298.29	852	300	302.65	852	300	300.47	300.47
853	300	299.38	853	300	297.21	853	300	299.38	298.6566667
854	300	300.47	854	300	299.38	854	300	300.47	300.1066667
855	300	298.29	855	300	299.38	855	300	299.38	299.0166667
856	300	301.56	856	300	301.56	856	300	300.47	301.1966667
857	300	299.38	857	300	299.38	857	300	299.38	299.38
858	300	299.38	858	300	301.56	858	300	299.38	300.1066667
859	300	287.97	859	300	298.29	859	300	303.74	296.6666667
860	300	298.29	860	300	299.38	860	300	300.47	299.38
861	300	299.38	861	300	300.47	861	300	301.56	300.47
862	300	298.29	862	300	301.56	862	300	301.56	300.47
863	300	299.38	863	300	299.38	863	300	303.74	300.8333333
864	300	300.47	864	300	299.38	864	300	302.65	300.8333333
865	300	298.29	865	300	299.38	865	300	302.65	300.1066667
866	300	299.38	866	300	298.29	866	300	298.29	298.6533333
867	300	298.29	867	300	301.56	867	300	298.29	299.38
868	300	297.21	868	300	297.21	868	300	300.47	298.2966667
869	300	300.47	869	300	301.56	869	300	300.47	300.8333333
870	300	302.65	870	300	299.38	870	300	298.29	300.1066667
871	300	301.56	871	300	300.47	871	300	299.38	300.47
872	300	301.56	872	300	299.38	872	300	299.38	300.1066667
873	300	298.29	873	300	301.56	873	300	301.56	300.47
874	300	300.47	874	300	299.38	874	300	299.38	299.7433333
875	300	297.21	875	300	301.56	875	300	301.56	300.11
876	300	301.56	876	300	299.38	876	300	301.56	300.8333333
877	300	300.47	877	300	298.29	877	300	298.29	299.0166667
878	300	301.56	878	300	299.38	878	300	300.47	300.47

879	300	297.21	879	300	298.29	879	300	298.29	297.93
880	300	301.56	880	300	299.38	880	300	299.38	300.1066667
881	300	298.29	881	300	301.56	881	300	298.29	299.38
882	300	299.38	882	300	299.38	882	300	299.38	299.38
883	300	297.21	883	300	302.65	883	300	299.38	299.7466667
884	300	299.38	884	300	299.38	884	300	299.38	299.38
885	300	302.65	885	300	299.38	885	300	299.38	300.47
886	300	300.47	886	300	299.38	886	300	300.47	300.1066667
887	300	299.38	887	300	302.65	887	300	298.29	300.1066667
888	300	299.38	888	300	299.38	888	300	298.29	299.0166667
889	300	299.38	889	300	300.47	889	300	301.56	300.47
890	300	300.47	890	300	302.65	890	300	300.47	301.1966667
891	300	301.56	891	300	299.38	891	300	299.38	300.1066667
892	300	298.29	892	300	299.38	892	300	300.47	299.38
893	300	301.56	893	300	301.56	893	300	302.65	301.9233333
894	300	298.29	894	300	301.56	894	300	299.38	299.7433333
895	300	298.29	895	300	299.38	895	300	300.47	299.38
896	300	299.38	896	300	302.65	896	300	301.56	301.1966667
897	300	298.29	897	300	300.47	897	300	299.38	299.38
898	300	298.29	898	300	301.56	898	300	299.38	299.7433333
899	300	301.56	899	300	300.47	899	300	301.56	301.1966667
900	400	341.84	900	400	300.47	900	400	298.29	313.5333333
901	400	355.99	901	400	344.02	901	400	345.11	348.3733333
902	400	370.15	902	400	360.35	902	400	359.26	363.2533333
903	400	377.77	903	400	369.06	903	400	366.88	371.2366667
904	400	383.21	904	400	374.5	904	400	378.85	378.8533333
905	400	387.56	905	400	386.48	905	400	384.3	386.1133333
906	400	388.65	906	400	391.92	906	400	393.01	391.1933333
907	400	394.1	907	400	394.1	907	400	395.18	394.46
908	400	395.18	908	400	401.15	908	400	397.9	398.0766667
909	400	401.15	909	400	404.39	909	400	406.02	403.8533333
910	400	396.27	910	400	406.02	910	400	406.02	402.77
911	400	397.9	911	400	406.02	911	400	407.64	403.8533333
912	400	401.15	912	400	402.77	912	400	404.39	402.77
913	400	399.52	913	400	402.77	913	400	404.39	402.2266667
914	400	401.15	914	400	409.27	914	400	406.02	405.48
915	400	402.77	915	400	406.02	915	400	404.39	404.3933333
916	400	399.52	916	400	404.39	916	400	402.77	402.2266667
917	400	401.15	917	400	406.02	917	400	402.77	403.3133333
918	400	399.52	918	400	401.15	918	400	404.39	401.6866667
919	400	397.9	919	400	402.77	919	400	402.77	401.1466667
920	400	397.9	920	400	404.39	920	400	406.02	402.77
921	400	399.52	921	400	401.15	921	400	399.52	400.0633333
922	400	399.52	922	400	401.15	922	400	399.52	400.0633333
923	400	399.52	923	400	402.77	923	400	404.39	402.2266667
924	400	399.52	924	400	401.15	924	400	399.52	400.0633333
925	400	399.52	925	400	402.77	925	400	397.9	400.0633333
926	400	404.39	926	400	399.52	926	400	399.52	401.1433333
927	400	399.52	927	400	399.52	927	400	402.77	400.6033333
928	400	399.52	928	400	401.15	928	400	399.52	400.0633333
929	400	402.77	929	400	399.52	929	400	399.52	400.6033333
930	400	401.15	930	400	404.39	930	400	397.9	401.1466667
931	400	404.39	931	400	397.9	931	400	401.15	401.1466667
932	400	402.77	932	400	399.52	932	400	397.9	400.0633333
933	400	399.52	933	400	399.52	933	400	399.52	399.52
934	400	399.52	934	400	397.9	934	400	397.9	398.44
935	400	402.77	935	400	399.52	935	400	402.77	401.6866667
936	400	401.15	936	400	397.9	936	400	399.52	399.5233333
937	400	399.52	937	400	404.39	937	400	399.52	401.1433333
938	400	404.39	938	400	402.77	938	400	397.9	401.6866667
939	400	402.77	939	400	402.77	939	400	396.27	400.6033333
940	400	402.77	940	400	397.9	940	400	397.9	399.5233333
941	400	402.77	941	400	401.15	941	400	397.9	400.6066667
942	400	397.9	942	400	399.52	942	400	401.15	399.5233333
943	400	397.9	943	400	397.9	943	400	402.77	399.5233333
944	400	402.77	944	400	402.77	944	400	399.52	401.6866667
945	400	397.9	945	400	399.52	945	400	402.77	400.0633333
946	400	397.9	946	400	397.9	946	400	397.9	397.9
947	400	399.52	947	400	397.9	947	400	399.52	398.98
948	400	399.52	948	400	397.9	948	400	397.9	398.44
949	400	401.15	949	400	402.77	949	400	397.9	400.6066667
950	400	397.9	950	400	399.52	950	400	397.9	398.44
951	400	401.15	951	400	396.27	951	400	397.9	398.44
952	400	399.52	952	400	397.9	952	400	396.27	397.8966667
953	400	401.15	953	400	396.27	953	400	397.9	398.44
954	400	399.52	954	400	401.15	954	400	399.52	400.0633333
955	400	402.77	955	400	396.27	955	400	399.52	399.52
956	400	399.52	956	400	396.27	956	400	396.27	397.3533333
957	400	404.39	957	400	396.27	957	400	401.15	400.6033333
958	400	401.15	958	400	397.9	958	400	397.9	398.9833333

959	400	397.9	959	400	397.9	959	400	399.52	398.44
960	400	397.9	960	400	396.27	960	400	402.77	398.98
961	400	399.52	961	400	397.9	961	400	402.77	400.0633333
962	400	397.9	962	400	401.15	962	400	402.77	400.6066667
963	400	404.39	963	400	397.9	963	400	401.15	401.1466667
964	400	399.52	964	400	402.77	964	400	401.15	401.1466667
965	400	397.9	965	400	402.77	965	400	397.9	399.5233333
966	400	399.52	966	400	402.77	966	400	401.15	401.1466667
967	400	399.52	967	400	397.9	967	400	397.9	398.44
968	400	399.52	968	400	397.9	968	400	399.52	398.98
969	400	399.52	969	400	402.77	969	400	399.52	400.6033333
970	400	402.77	970	400	396.27	970	400	402.77	400.6033333
971	400	399.52	971	400	397.9	971	400	399.52	398.98
972	400	399.52	972	400	396.27	972	400	401.15	398.98
973	400	402.77	973	400	399.52	973	400	401.15	401.1466667
974	400	402.77	974	400	401.15	974	400	397.9	400.6066667
975	400	399.52	975	400	397.9	975	400	399.52	398.98
976	400	399.52	976	400	404.39	976	400	396.27	400.06
977	400	402.77	977	400	402.77	977	400	399.52	401.6866667
978	400	399.52	978	400	396.27	978	400	404.39	400.06
979	400	401.15	979	400	397.9	979	400	397.9	398.9833333
980	400	404.39	980	400	397.9	980	400	401.15	401.1466667
981	400	401.15	981	400	401.15	981	400	399.52	400.6066667
982	400	404.39	982	400	397.9	982	400	402.77	401.6866667
983	400	402.77	983	400	397.9	983	400	397.9	399.5233333
984	400	397.9	984	400	399.52	984	400	397.9	398.44
985	400	396.27	985	400	397.9	985	400	397.9	397.3566667
986	400	399.52	986	400	397.9	986	400	401.15	399.5233333
987	400	402.77	987	400	399.52	987	400	397.9	400.0633333
988	400	399.52	988	400	399.52	988	400	397.9	398.98
989	400	397.9	989	400	399.52	989	400	399.52	398.98
990	400	399.52	990	400	399.52	990	400	401.15	400.0633333
991	400	397.9	991	400	399.52	991	400	397.9	398.44
992	400	404.39	992	400	399.52	992	400	397.9	400.6033333
993	400	397.9	993	400	402.77	993	400	399.52	400.0633333
994	400	399.52	994	400	402.77	994	400	397.9	400.0633333
995	400	402.77	995	400	397.9	995	400	397.9	399.5233333
996	400	397.9	996	400	396.27	996	400	402.77	398.98
997	400	399.52	997	400	399.52	997	400	402.77	400.6033333
998	400	397.9	998	400	397.9	998	400	399.52	398.44
999	400	402.77	999	400	397.9	999	400	401.15	400.6066667
1000	400	401.15	1000	400	397.9	1000	400	401.15	400.0666667
1001	400	401.15	1001	400	402.77	1001	400	401.15	401.69
1002	400	397.9	1002	400	399.52	1002	400	397.9	398.44
1003	400	397.9	1003	400	401.15	1003	400	397.9	398.9833333
1004	400	397.9	1004	400	401.15	1004	400	399.52	399.5233333
1005	400	399.52	1005	400	402.77	1005	400	397.9	400.0633333
1006	400	404.39	1006	400	402.77	1006	400	399.52	402.2266667
1007	400	399.52	1007	400	399.52	1007	400	402.77	400.6033333
1008	400	402.77	1008	400	399.52	1008	400	397.9	400.0633333
1009	400	397.9	1009	400	404.39	1009	400	404.39	402.2266667
1010	400	397.9	1010	400	399.52	1010	400	399.52	398.98
1011	400	402.77	1011	400	402.77	1011	400	399.52	401.6866667
1012	400	397.9	1012	400	402.77	1012	400	401.15	400.6066667
1013	400	399.52	1013	400	399.52	1013	400	401.15	400.0633333
1014	400	399.52	1014	400	397.9	1014	400	397.9	398.44
1015	400	397.9	1015	400	397.9	1015	400	404.39	400.0633333
1016	400	401.15	1016	400	397.9	1016	400	401.15	400.0666667
1017	400	397.9	1017	400	401.15	1017	400	404.39	401.1466667
1018	400	399.52	1018	400	401.15	1018	400	399.52	400.0633333
1019	400	401.15	1019	400	397.9	1019	400	404.39	401.1466667
1020	400	401.15	1020	400	397.9	1020	400	399.52	399.5233333
1021	400	399.52	1021	400	401.15	1021	400	397.9	399.5233333
1022	400	402.77	1022	400	397.9	1022	400	397.9	399.5233333
1023	400	399.52	1023	400	396.27	1023	400	402.77	399.52
1024	400	396.27	1024	400	397.9	1024	400	396.27	396.8133333
1025	400	399.52	1025	400	401.15	1025	400	399.52	400.0633333
1026	400	397.9	1026	400	401.15	1026	400	402.77	400.6066667
1027	400	397.9	1027	400	399.52	1027	400	402.77	400.0633333
1028	400	397.9	1028	400	397.9	1028	400	397.9	397.9
1029	400	397.9	1029	400	399.52	1029	400	399.52	398.98
1030	400	401.15	1030	400	396.27	1030	400	396.27	397.8966667
1031	400	399.52	1031	400	396.27	1031	400	401.15	398.98
1032	400	399.52	1032	400	397.9	1032	400	397.9	398.44
1033	400	397.9	1033	400	401.15	1033	400	397.9	398.9833333
1034	400	397.9	1034	400	399.52	1034	400	397.9	398.44
1035	400	399.52	1035	400	397.9	1035	400	402.77	400.0633333
1036	400	397.9	1036	400	402.77	1036	400	397.9	399.5233333
1037	400	399.52	1037	400	401.15	1037	400	404.39	401.6866667
1038	400	404.39	1038	400	396.27	1038	400	397.9	399.52

1039	400	402.77	1039	400	397.9	1039	400	399.52	400.0633333
1040	400	402.77	1040	400	399.52	1040	400	397.9	400.0633333
1041	400	401.15	1041	400	397.9	1041	400	397.9	398.9833333
1042	400	399.52	1042	400	395.18	1042	400	401.15	398.6166667
1043	400	399.52	1043	400	397.9	1043	400	401.15	399.5233333
1044	400	397.9	1044	400	402.77	1044	400	402.77	401.1466667
1045	400	399.52	1045	400	397.9	1045	400	397.9	398.44
1046	400	401.15	1046	400	397.9	1046	400	401.15	400.0666667
1047	400	397.9	1047	400	401.15	1047	400	402.77	400.6066667
1048	400	399.52	1048	400	399.52	1048	400	399.52	399.52
1049	400	397.9	1049	400	402.77	1049	400	399.52	400.0633333
1050	400	397.9	1050	400	402.77	1050	400	399.52	400.0633333
1051	400	404.39	1051	400	399.52	1051	400	401.15	401.6866667
1052	400	397.9	1052	400	401.15	1052	400	402.77	400.6066667
1053	400	399.52	1053	400	397.9	1053	400	401.15	399.5233333
1054	400	404.39	1054	400	397.9	1054	400	401.15	401.1466667
1055	400	401.15	1055	400	399.52	1055	400	396.27	398.98
1056	400	401.15	1056	400	397.9	1056	400	396.27	398.44
1057	400	404.39	1057	400	396.27	1057	400	399.52	400.06
1058	400	397.9	1058	400	399.52	1058	400	396.27	397.8966667
1059	400	397.9	1059	400	399.52	1059	400	397.9	398.44
1060	400	401.15	1060	400	397.9	1060	400	399.52	399.5233333
1061	400	399.52	1061	400	399.52	1061	400	402.77	400.6033333
1062	400	399.52	1062	400	397.9	1062	400	397.9	398.44
1063	400	402.77	1063	400	402.77	1063	400	399.52	401.6866667
1064	400	401.15	1064	400	399.52	1064	400	401.15	400.6066667
1065	400	397.9	1065	400	401.15	1065	400	399.52	399.5233333
1066	400	397.9	1066	400	402.77	1066	400	397.9	399.5233333
1067	400	399.52	1067	400	404.39	1067	400	402.77	402.2266667
1068	400	397.9	1068	400	397.9	1068	400	397.9	397.9
1069	400	401.15	1069	400	399.52	1069	400	399.52	400.0633333
1070	400	404.39	1070	400	399.52	1070	400	397.9	400.6033333
1071	400	399.52	1071	400	401.15	1071	400	401.15	400.6066667
1072	400	397.9	1072	400	401.15	1072	400	397.9	398.9833333
1073	400	399.52	1073	400	406.02	1073	400	397.9	401.1466667
1074	400	402.77	1074	400	399.52	1074	400	399.52	400.6033333
1075	400	399.52	1075	400	399.52	1075	400	402.77	400.6033333
1076	400	402.77	1076	400	404.39	1076	400	397.9	401.6866667
1077	400	399.52	1077	400	397.9	1077	400	401.15	399.5233333
1078	400	399.52	1078	400	402.77	1078	400	397.9	400.0633333
1079	400	401.15	1079	400	397.9	1079	400	402.77	400.6066667
1080	400	404.39	1080	400	399.52	1080	400	397.9	400.6033333
1081	400	399.52	1081	400	397.9	1081	400	401.15	399.5233333
1082	400	401.15	1082	400	399.52	1082	400	401.15	400.6066667
1083	400	402.77	1083	400	404.39	1083	400	401.15	402.77
1084	400	397.9	1084	400	401.15	1084	400	404.39	401.1466667
1085	400	397.9	1085	400	399.52	1085	400	402.77	400.0633333
1086	400	401.15	1086	400	399.52	1086	400	404.39	401.6866667
1087	400	396.27	1087	400	399.52	1087	400	397.9	397.8966667
1088	400	402.77	1088	400	402.77	1088	400	396.27	400.6033333
1089	400	397.9	1089	400	407.64	1089	400	401.15	402.23
1090	400	397.9	1090	400	401.15	1090	400	399.52	399.5233333
1091	400	397.9	1091	400	399.52	1091	400	399.52	398.98
1092	400	401.15	1092	400	397.9	1092	400	399.52	399.5233333
1093	400	402.77	1093	400	399.52	1093	400	401.15	401.1466667
1094	400	397.9	1094	400	397.9	1094	400	402.77	399.5233333
1095	400	401.15	1095	400	399.52	1095	400	397.9	399.5233333
1096	400	399.52	1096	400	396.27	1096	400	401.15	398.98
1097	400	404.39	1097	400	397.9	1097	400	397.9	400.0633333
1098	400	397.9	1098	400	399.52	1098	400	397.9	398.44
1099	400	404.39	1099	400	401.15	1099	400	399.52	401.6866667
1100	400	404.39	1100	400	397.9	1100	400	401.15	401.1466667
1101	400	399.52	1101	400	404.39	1101	400	399.52	401.1433333
1102	400	397.9	1102	400	397.9	1102	400	397.9	397.9
1103	400	401.15	1103	400	397.9	1103	400	397.9	398.9833333
1104	400	397.9	1104	400	399.52	1104	400	396.27	397.8966667
1105	400	402.77	1105	400	399.52	1105	400	396.27	399.52
1106	400	397.9	1106	400	397.9	1106	400	397.9	397.9
1107	400	397.9	1107	400	397.9	1107	400	402.77	399.5233333
1108	400	399.52	1108	400	397.9	1108	400	399.52	398.98
1109	400	397.9	1109	400	404.39	1109	400	397.9	400.0633333
1110	400	401.15	1110	400	399.52	1110	400	399.52	400.0633333
1111	400	399.52	1111	400	399.52	1111	400	401.15	400.0633333
1112	400	397.9	1112	400	401.15	1112	400	401.15	400.0666667
1113	400	402.77	1113	400	397.9	1113	400	401.15	400.6066667
1114	400	399.52	1114	400	402.77	1114	400	399.52	400.6033333
1115	400	401.15	1115	400	404.39	1115	400	396.27	400.6033333
1116	400	397.9	1116	400	399.52	1116	400	397.9	398.44
1117	400	397.9	1117	400	399.52	1117	400	397.9	398.44
1118	400	397.9	1118	400	396.27	1118	400	397.9	397.3566667

1119	400	399.52	1119	400	401.15	1119	400	399.52	400.0633333
1120	400	399.52	1120	400	399.52	1120	400	401.15	400.0633333
1121	400	399.52	1121	400	401.15	1121	400	397.9	399.5233333
1122	400	399.52	1122	400	397.9	1122	400	396.27	397.8966667
1123	400	401.15	1123	400	396.27	1123	400	396.27	397.8966667
1124	400	399.52	1124	400	397.9	1124	400	401.15	399.5233333
1125	400	399.52	1125	400	397.9	1125	400	396.27	397.8966667
1126	400	397.9	1126	400	396.27	1126	400	399.52	397.8966667
1127	400	397.9	1127	400	401.15	1127	400	401.15	400.0666667
1128	400	402.77	1128	400	397.9	1128	400	397.9	399.5233333
1129	400	401.15	1129	400	402.77	1129	400	396.27	400.0633333
1130	400	402.77	1130	400	399.52	1130	400	397.9	400.0633333
1131	400	399.52	1131	400	397.9	1131	400	396.27	397.8966667
1132	400	399.52	1132	400	397.9	1132	400	397.9	398.44
1133	400	397.9	1133	400	401.15	1133	400	401.15	400.0666667
1134	400	399.52	1134	400	396.27	1134	400	397.9	397.8966667
1135	400	397.9	1135	400	399.52	1135	400	401.15	399.5233333
1136	400	402.77	1136	400	397.9	1136	400	396.27	398.98
1137	400	402.77	1137	400	396.27	1137	400	397.9	398.98
1138	400	397.9	1138	400	404.39	1138	400	397.9	400.0633333
1139	400	397.9	1139	400	402.77	1139	400	402.77	401.1466667
1140	400	402.77	1140	400	399.52	1140	400	401.15	401.1466667
1141	400	397.9	1141	400	397.9	1141	400	397.9	397.9
1142	400	399.52	1142	400	397.9	1142	400	397.9	398.44
1143	400	397.9	1143	400	397.9	1143	400	401.15	398.9833333
1144	400	404.39	1144	400	397.9	1144	400	401.15	401.1466667
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1146	400	404.39	1146	400	397.9	1146	400	397.9	400.0633333
1147	400	399.52	1147	400	399.52	1147	400	404.39	401.1433333
1148	400	401.15	1148	400	402.77	1148	400	401.15	401.69
1149	400	397.9	1149	400	399.52	1149	400	402.77	400.0633333
1150	400	397.9	1150	400	402.77	1150	400	396.27	398.98
1151	400	397.9	1151	400	397.9	1151	400	396.27	397.3566667
1152	400	399.52	1152	400	399.52	1152	400	397.9	398.98
1153	400	402.77	1153	400	402.77	1153	400	397.9	401.1466667
1154	400	397.9	1154	400	404.39	1154	400	399.52	400.6033333
1155	400	397.9	1155	400	399.52	1155	400	404.39	400.6033333
1156	400	402.77	1156	400	402.77	1156	400	397.9	401.1466667
1157	400	402.77	1157	400	397.9	1157	400	402.77	401.1466667
1158	400	397.9	1158	400	397.9	1158	400	396.27	397.3566667
1159	400	399.52	1159	400	404.39	1159	400	397.9	400.6033333
1160	400	402.77	1160	400	399.52	1160	400	401.15	401.1466667
1161	400	397.9	1161	400	402.77	1161	400	397.9	399.5233333
1162	400	397.9	1162	400	397.9	1162	400	401.15	398.9833333
1163	400	396.27	1163	400	399.52	1163	400	399.52	398.4366667
1164	400	401.15	1164	400	399.52	1164	400	399.52	400.0633333
1165	400	397.9	1165	400	399.52	1165	400	401.15	399.5233333
1166	400	399.52	1166	400	397.9	1166	400	399.52	398.98
1167	400	395.18	1167	400	397.9	1167	400	399.52	397.5333333
1168	400	397.9	1168	400	404.39	1168	400	404.39	402.2266667
1169	400	402.77	1169	400	397.9	1169	400	401.15	400.6066667
1170	400	399.52	1170	400	401.15	1170	400	404.39	401.6866667
1171	400	402.77	1171	400	404.39	1171	400	404.39	403.85
1172	400	397.9	1172	400	399.52	1172	400	402.77	400.0633333
1173	400	397.9	1173	400	401.15	1173	400	397.9	398.9833333
1174	400	401.15	1174	400	404.39	1174	400	399.52	401.6866667
1175	400	404.39	1175	400	397.9	1175	400	404.39	402.2266667
1176	400	397.9	1176	400	401.15	1176	400	402.77	400.6066667
1177	400	396.27	1177	400	399.52	1177	400	402.77	399.52
1178	400	399.52	1178	400	397.9	1178	400	401.15	399.5233333
1179	400	399.52	1179	400	396.27	1179	400	397.9	397.8966667
1180	400	399.52	1180	400	399.52	1180	400	399.52	399.52
1181	400	402.77	1181	400	397.9	1181	400	404.39	401.6866667
1182	400	395.18	1182	400	402.77	1182	400	404.39	400.78
1183	400	401.15	1183	400	397.9	1183	400	404.39	401.1466667
1184	400	401.15	1184	400	402.77	1184	400	397.9	400.6066667
1185	400	397.9	1185	400	399.52	1185	400	399.52	398.98
1186	400	397.9	1186	400	397.9	1186	400	397.9	397.9
1187	400	397.9	1187	400	402.77	1187	400	399.52	400.0633333
1188	400	397.9	1188	400	401.15	1188	400	399.52	399.5233333
1189	400	396.27	1189	400	399.52	1189	400	402.77	399.52
1190	400	401.15	1190	400	397.9	1190	400	404.39	401.1466667
1191	400	397.9	1191	400	404.39	1191	400	397.9	400.0633333
1192	400	396.27	1192	400	397.9	1192	400	399.52	397.8966667
1193	400	397.9	1193	400	399.52	1193	400	397.9	398.44
1194	400	397.9	1194	400	399.52	1194	400	399.52	398.98
1195	400	397.9	1195	400	397.9	1195	400	401.15	398.9833333
1196	400	399.52	1196	400	399.52	1196	400	399.52	399.52
1197	400	396.27	1197	400	396.27	1197	400	399.52	397.3533333
1198	400	396.27	1198	400	401.15	1198	400	399.52	398.98

1199	400	396.27	1199	400	397.9	1199	400	399.52	397.8966667
1200	500	445	1200	500	427.13	1200	500	433.63	435.2533333
1201	500	457.99	1201	500	446.62	1201	500	451.49	452.0333333
1202	500	469.36	1202	500	457.99	1202	500	461.24	462.8633333
1203	500	483.97	1203	500	474.23	1203	500	470.98	476.3933333
1204	500	485.6	1204	500	479.1	1204	500	475.85	480.1833333
1205	500	493.72	1205	500	480.73	1205	500	482.35	485.6
1206	500	492.09	1206	500	483.97	1206	500	490.47	488.8433333
1207	500	501.67	1207	500	490.47	1207	500	487.22	493.12
1208	500	507.99	1208	500	490.47	1208	500	487.22	495.2266667
1209	500	499.56	1209	500	495.34	1209	500	488.85	494.5833333
1210	500	505.88	1210	500	495.34	1210	500	492.09	497.77
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1212	500	499.56	1212	500	495.34	1212	500	501.67	498.8566667
1213	500	499.56	1213	500	497.45	1213	500	493.72	496.91
1214	500	505.88	1214	500	493.72	1214	500	493.72	497.7733333
1215	500	497.45	1215	500	495.34	1215	500	499.56	497.45
1216	500	505.88	1216	500	501.67	1216	500	497.45	501.6666667
1217	500	507.99	1217	500	493.72	1217	500	497.45	499.72
1218	500	497.45	1218	500	492.09	1218	500	497.45	495.6633333
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1220	500	499.56	1220	500	495.34	1220	500	495.34	496.7466667
1221	500	497.45	1221	500	493.72	1221	500	497.45	496.2066667
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1223	500	505.88	1223	500	499.56	1223	500	503.77	503.07
1224	500	503.77	1224	500	503.77	1224	500	499.56	502.3666667
1225	500	503.77	1225	500	501.67	1225	500	501.67	502.37
1226	500	497.45	1226	500	497.45	1226	500	503.77	499.5566667
1227	500	497.45	1227	500	495.34	1227	500	598.98	530.59
1228	500	499.56	1228	500	497.45	1228	500	499.56	498.8566667
1229	500	497.45	1229	500	503.77	1229	500	497.45	499.5566667
1230	500	503.77	1230	500	497.45	1230	500	497.45	499.5566667
1231	500	499.56	1231	500	499.56	1231	500	499.56	499.56
1232	500	499.56	1232	500	495.34	1232	500	503.77	499.5566667
1233	500	499.56	1233	500	495.34	1233	500	497.45	497.45
1234	500	505.88	1234	500	499.56	1234	500	495.34	500.26
1235	500	495.34	1235	500	497.45	1235	500	501.67	498.1533333
1236	500	501.67	1236	500	497.45	1236	500	501.67	500.2633333
1237	500	503.77	1237	500	497.45	1237	500	497.45	499.5566667
1238	500	499.56	1238	500	495.34	1238	500	501.67	498.8566667
1239	500	507.99	1239	500	497.45	1239	500	501.67	502.37
1240	500	499.56	1240	500	497.45	1240	500	495.34	497.45
1241	500	497.45	1241	500	499.56	1241	500	487.22	494.7433333
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1243	500	497.45	1243	500	501.67	1243	500	499.56	499.56
1244	500	503.77	1244	500	503.77	1244	500	497.45	501.6633333
1245	500	503.77	1245	500	507.99	1245	500	501.67	504.4766667
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1247	500	503.77	1247	500	503.77	1247	500	497.45	501.6633333
1248	500	497.45	1248	500	501.67	1248	500	497.45	498.8566667
1249	500	501.67	1249	500	503.77	1249	500	499.56	501.6666667
1250	500	499.56	1250	500	499.56	1250	500	495.34	498.1533333
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1252	500	497.45	1252	500	503.77	1252	500	497.45	499.5566667
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1254	500	507.99	1254	500	501.67	1254	500	497.45	502.37
1255	500	503.77	1255	500	499.56	1255	500	503.77	502.3666667
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1259	500	501.67	1259	500	503.77	1259	500	505.88	503.7733333
1260	500	495.34	1260	500	497.45	1260	500	497.45	496.7466667
1261	500	499.56	1261	500	507.99	1261	500	495.34	500.9633333
1262	500	501.67	1262	500	501.67	1262	500	503.77	502.37
1263	500	505.88	1263	500	499.56	1263	500	501.67	502.37
1264	500	497.45	1264	500	503.77	1264	500	495.34	498.8533333
1265	500	499.56	1265	500	499.56	1265	500	600.51	533.21
1266	500	497.45	1266	500	497.45	1266	500	495.34	496.7466667
1267	500	503.77	1267	500	501.67	1267	500	503.77	503.07
1268	500	503.77	1268	500	497.45	1268	500	501.67	500.9633333
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1273	500	501.67	1273	500	501.67	1273	500	495.34	499.56
1274	500	503.77	1274	500	499.56	1274	500	499.56	500.9633333
1275	500	499.56	1275	500	503.77	1275	500	495.34	499.5566667
1276	500	497.45	1276	500	497.45	1276	500	497.45	497.45
1277	500	499.56	1277	500	497.45	1277	500	495.34	497.45
1278	500	485.6	1278	500	497.45	1278	500	501.67	494.9066667

1279	500	503.77	1279	500	499.56	1279	500	495.34	499.5566667
1280	500	497.45	1280	500	497.45	1280	500	497.45	497.45
1281	500	499.56	1281	500	497.45	1281	500	501.67	499.56
1282	500	495.34	1282	500	499.56	1282	500	497.45	497.45
1283	500	505.88	1283	500	497.45	1283	500	501.67	501.6666667
1284	500	497.45	1284	500	503.77	1284	500	499.56	500.26
1285	500	497.45	1285	500	499.56	1285	500	503.77	500.26
1286	500	497.45	1286	500	497.45	1286	500	503.77	499.5566667
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1288	500	499.56	1288	500	499.56	1288	500	501.67	500.2633333
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1290	500	497.45	1290	500	503.77	1290	500	501.67	500.9633333
1291	500	497.45	1291	500	497.45	1291	500	499.56	498.1533333
1292	500	501.67	1292	500	497.45	1292	500	501.67	500.2633333
1293	500	497.45	1293	500	497.45	1293	500	499.56	498.1533333
1294	500	493.72	1294	500	501.67	1294	500	501.67	499.02
1295	500	497.45	1295	500	499.56	1295	500	493.72	496.91
1296	500	499.56	1296	500	503.77	1296	500	497.45	500.26
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1298	500	495.34	1298	500	499.56	1298	500	495.34	496.7466667
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1300	500	600.51	1300	500	499.56	1300	500	495.34	531.8033333
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1303	500	503.77	1303	500	497.45	1303	500	497.45	499.5566667
1304	500	497.45	1304	500	499.56	1304	500	493.72	496.91
1305	500	499.56	1305	500	501.67	1305	500	503.77	501.6666667
1306	500	501.67	1306	500	501.67	1306	500	495.34	499.56
1307	500	499.56	1307	500	501.67	1307	500	499.56	500.2633333
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1309	500	497.45	1309	500	505.88	1309	500	497.45	500.26
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1312	500	499.56	1312	500	499.56	1312	500	503.77	500.9633333
1313	500	497.45	1313	500	503.77	1313	500	499.56	500.26
1314	500	499.56	1314	500	501.67	1314	500	501.67	500.9666667
1315	500	499.56	1315	500	501.67	1315	500	495.34	498.8566667
1316	500	507.99	1316	500	499.56	1316	500	501.67	503.0733333
1317	500	497.45	1317	500	499.56	1317	500	497.45	498.1533333
1318	500	505.88	1318	500	495.34	1318	500	503.77	501.6633333
1319	500	501.67	1319	500	503.77	1319	500	501.67	502.37
1320	500	497.45	1320	500	503.77	1320	500	497.45	499.5566667
1321	500	503.77	1321	500	499.56	1321	500	499.56	500.9633333
1322	500	501.67	1322	500	497.45	1322	500	495.34	498.1533333
1323	500	495.34	1323	500	497.45	1323	500	503.77	498.8533333
1324	500	499.56	1324	500	497.45	1324	500	497.45	498.1533333
1325	500	499.56	1325	500	499.56	1325	500	602.03	533.7166667
1326	500	497.45	1326	500	503.77	1326	500	499.56	500.26
1327	500	505.88	1327	500	503.77	1327	500	499.56	503.07
1328	500	499.56	1328	500	501.67	1328	500	499.56	500.2633333
1329	500	503.77	1329	500	499.56	1329	500	499.56	500.9633333
1330	500	497.45	1330	500	497.45	1330	500	495.34	496.7466667
1331	500	495.34	1331	500	501.67	1331	500	495.34	497.45
1332	500	503.77	1332	500	499.56	1332	500	497.45	500.26
1333	500	503.77	1333	500	499.56	1333	500	495.34	499.5566667
1334	500	497.45	1334	500	499.56	1334	500	499.56	498.8566667
1335	500	503.77	1335	500	503.77	1335	500	495.34	500.96
1336	500	499.56	1336	500	493.72	1336	500	499.56	497.6133333
1337	500	497.45	1337	500	499.56	1337	500	497.45	498.1533333
1338	500	499.56	1338	500	503.77	1338	500	497.45	500.26
1339	500	497.45	1339	500	499.56	1339	500	499.56	498.8566667
1340	500	497.45	1340	500	503.77	1340	500	499.56	500.26
1341	500	507.99	1341	500	497.45	1341	500	503.77	503.07
1342	500	501.67	1342	500	497.45	1342	500	499.56	499.56
1343	500	497.45	1343	500	495.34	1343	500	499.56	497.45
1344	500	495.34	1344	500	503.77	1344	500	505.88	501.6633333
1345	500	505.88	1345	500	499.56	1345	500	503.77	503.07
1346	500	501.67	1346	500	497.45	1346	500	499.56	499.56
1347	500	505.88	1347	500	499.56	1347	500	495.34	500.26
1348	500	501.67	1348	500	503.77	1348	500	497.45	500.9633333
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1352	500	497.45	1352	500	503.77	1352	500	501.67	500.9633333
1353	500	495.34	1353	500	503.77	1353	500	497.45	498.8533333
1354	500	501.67	1354	500	499.56	1354	500	499.56	500.2633333
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1357	500	497.45	1357	500	501.67	1357	500	503.77	500.9633333
1358	500	501.67	1358	500	507.99	1358	500	497.45	502.37

1359	500	501.67	1359	500	499.56	1359	500	449.87	483.7
1360	500	495.34	1360	500	499.56	1360	500	499.56	498.1533333
1361	500	497.45	1361	500	497.45	1361	500	448.24	481.0466667
1362	500	503.77	1362	500	497.45	1362	500	505.88	502.3666667
1363	500	503.77	1363	500	503.77	1363	500	485.6	497.7133333
1364	500	503.77	1364	500	499.56	1364	500	497.45	500.26
1365	500	505.88	1365	500	497.45	1365	500	499.56	500.9633333
1366	500	501.67	1366	500	497.45	1366	500	505.88	501.6666667
1367	500	499.56	1367	500	480.73	1367	500	495.34	491.8766667
1368	500	499.56	1368	500	499.56	1368	500	499.56	499.56
1369	500	501.67	1369	500	503.77	1369	500	495.34	500.26
1370	500	497.45	1370	500	497.45	1370	500	501.67	498.8566667
1371	500	499.56	1371	500	503.77	1371	500	497.45	500.26
1372	500	497.45	1372	500	501.67	1372	500	503.77	500.9633333
1373	500	501.67	1373	500	503.77	1373	500	499.56	501.6666667
1374	500	497.45	1374	500	503.77	1374	500	503.77	501.6633333
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1381	500	497.45	1381	500	497.45	1381	500	608.13	534.3433333
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1383	500	499.56	1383	500	503.77	1383	500	499.56	500.9633333
1384	500	505.88	1384	500	501.67	1384	500	497.45	501.6666667
1385	500	501.67	1385	500	501.67	1385	500	505.88	503.0733333
1386	500	499.56	1386	500	497.45	1386	500	495.34	497.45
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1388	500	497.45	1388	500	497.45	1388	500	493.72	496.2066667
1389	500	499.56	1389	500	497.45	1389	500	501.67	499.56
1390	500	501.67	1390	500	499.56	1390	500	497.45	499.56
1391	500	497.45	1391	500	499.56	1391	500	495.34	497.45
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1396	500	503.77	1396	500	503.77	1396	500	497.45	501.6633333
1397	500	499.56	1397	500	497.45	1397	500	503.77	500.26
1398	500	501.67	1398	500	497.45	1398	500	503.77	500.9633333
1399	500	505.88	1399	500	497.45	1399	500	497.45	500.26
1400	500	501.67	1400	500	501.67	1400	500	501.67	501.67
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1402	500	497.45	1402	500	501.67	1402	500	497.45	498.8566667
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1411	500	505.88	1411	500	499.56	1411	500	495.34	500.26
1412	500	503.77	1412	500	501.67	1412	500	497.45	500.9633333
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1416	500	495.34	1416	500	497.45	1416	500	497.45	496.7466667
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1418	500	497.45	1418	500	501.67	1418	500	495.34	498.1533333
1419	500	505.88	1419	500	507.99	1419	500	493.72	502.53
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1421	500	495.34	1421	500	497.45	1421	500	495.34	496.0433333
1422	500	501.67	1422	500	501.67	1422	500	499.56	500.9666667
1423	500	499.56	1423	500	499.56	1423	500	501.67	500.2633333
1424	500	501.67	1424	500	497.45	1424	500	503.77	500.9633333
1425	500	505.88	1425	500	497.45	1425	500	497.45	500.26
1426	500	497.45	1426	500	497.45	1426	500	499.56	498.1533333
1427	500	497.45	1427	500	499.56	1427	500	503.77	500.26
1428	500	501.67	1428	500	499.56	1428	500	495.34	498.8566667
1429	500	495.34	1429	500	499.56	1429	500	495.34	496.7466667
1430	500	495.34	1430	500	501.67	1430	500	493.72	496.91
1431	500	499.56	1431	500	497.45	1431	500	495.34	497.45
1432	500	505.88	1432	500	497.45	1432	500	499.56	500.9633333
1433	500	495.34	1433	500	499.56	1433	500	497.45	497.45
1434	500	499.56	1434	500	497.45	1434	500	493.72	496.91
1435	500	503.77	1435	500	501.67	1435	500	505.88	503.7733333
1436	500	495.34	1436	500	497.45	1436	500	497.45	496.7466667
1437	500	499.56	1437	500	497.45	1437	500	497.45	498.1533333
1438	500	501.67	1438	500	499.56	1438	500	495.34	498.8566667

1439	500	503.77	1439	500	499.56	1439	500	495.34	499.5566667
1440	500	497.45	1440	500	497.45	1440	500	507.99	500.9633333
1441	500	505.88	1441	500	497.45	1441	500	501.67	501.6666667
1442	500	505.88	1442	500	503.77	1442	500	499.56	503.07
1443	500	501.67	1443	500	503.77	1443	500	505.88	503.7733333
1444	500	495.34	1444	500	497.45	1444	500	503.77	498.8533333
1445	500	501.67	1445	500	501.67	1445	500	499.56	500.9666667
1446	500	501.67	1446	500	499.56	1446	500	499.56	500.2633333
1447	500	497.45	1447	500	501.67	1447	500	497.45	498.8566667
1448	500	503.77	1448	500	499.56	1448	500	497.45	500.26
1449	500	499.56	1449	500	501.67	1449	500	499.56	500.2633333
1450	500	499.56	1450	500	499.56	1450	500	505.88	501.6666667
1451	500	501.67	1451	500	499.56	1451	500	501.67	500.9666667
1452	500	501.67	1452	500	499.56	1452	500	505.88	502.37
1453	500	497.45	1453	500	501.67	1453	500	503.77	500.9633333
1454	500	499.56	1454	500	499.56	1454	500	497.45	498.8566667
1455	500	497.45	1455	500	495.34	1455	500	497.45	496.7466667
1456	500	501.67	1456	500	497.45	1456	500	501.67	500.2633333
1457	500	499.56	1457	500	495.34	1457	500	501.67	498.8566667
1458	500	499.56	1458	500	501.67	1458	500	497.45	499.56
1459	500	507.99	1459	500	501.67	1459	500	497.45	502.37
1460	500	505.88	1460	500	499.56	1460	500	503.77	503.07
1461	500	503.77	1461	500	497.45	1461	500	497.45	499.5566667
1462	500	497.45	1462	500	501.67	1462	500	505.88	501.6666667
1463	500	505.88	1463	500	499.56	1463	500	501.67	502.37
1464	500	497.45	1464	500	499.56	1464	500	501.67	499.56
1465	500	505.88	1465	500	503.77	1465	500	499.56	503.07
1466	500	499.56	1466	500	499.56	1466	500	505.88	501.6666667
1467	500	501.67	1467	500	497.45	1467	500	497.45	498.8566667
1468	500	497.45	1468	500	499.56	1468	500	501.67	499.56
1469	500	497.45	1469	500	497.45	1469	500	499.56	498.1533333
1470	500	501.67	1470	500	497.45	1470	500	497.45	498.8566667
1471	500	501.67	1471	500	497.45	1471	500	499.56	499.56
1472	500	501.67	1472	500	497.45	1472	500	501.67	500.2633333
1473	500	497.45	1473	500	499.56	1473	500	501.67	499.56
1474	500	501.67	1474	500	499.56	1474	500	505.88	502.37
1475	500	497.45	1475	500	503.77	1475	500	503.77	501.6633333
1476	500	497.45	1476	500	499.56	1476	500	501.67	499.56
1477	500	501.67	1477	500	497.45	1477	500	505.88	501.6666667
1478	500	497.45	1478	500	497.45	1478	500	497.45	497.45
1479	500	503.77	1479	500	499.56	1479	500	499.56	500.9633333
1480	500	503.77	1480	500	503.77	1480	500	501.67	503.07
1481	500	503.77	1481	500	497.45	1481	500	495.34	498.8533333
1482	500	497.45	1482	500	497.45	1482	500	499.56	498.1533333
1483	500	499.56	1483	500	499.56	1483	500	501.67	500.2633333
1484	500	497.45	1484	500	499.56	1484	500	499.56	498.8566667
1485	500	497.45	1485	500	503.77	1485	500	493.72	498.3133333
1486	500	499.56	1486	500	503.77	1486	500	492.09	498.4733333
1487	500	497.45	1487	500	503.77	1487	500	493.72	498.3133333
1488	500	505.88	1488	500	497.45	1488	500	495.34	499.5566667
1489	500	503.77	1489	500	495.34	1489	500	493.72	497.61
1490	500	503.77	1490	500	495.34	1490	500	495.34	498.15
1491	500	497.45	1491	500	497.45	1491	500	499.56	498.1533333
1492	500	497.45	1492	500	497.45	1492	500	495.34	496.7466667
1493	500	497.45	1493	500	495.34	1493	500	495.34	496.0433333
1494	500	505.88	1494	500	501.67	1494	500	497.45	501.6666667
1495	500	499.56	1495	500	495.34	1495	500	495.34	496.7466667
1496	500	495.34	1496	500	497.45	1496	500	495.34	496.0433333
1497	500	499.56	1497	500	497.45	1497	500	493.72	496.91
1498	500	497.45	1498	500	495.34	1498	500	495.34	496.0433333
1499	500	505.88	1499	500	499.56	1499	500	495.34	500.26
1500	500	499.56	1500	500	495.34	1500	500	495.34	496.7466667

G Raw data of section 5.4.1 and 5.4.2

Data available on request.