Planning

Introduction

In this experiment I hope to find out how the increase in clothes on a body prevents heat loss. To put this experiment easier to make we shall use test tubes as the body and increase the number of cotton layers around it to represent the clothes.

We shall plan a strategic method to calculate the heat loss in each test tube over a certain period of time. We shall observe how fast the body decreases in temperature by recording the temperature every 30 seconds.

Safety

In this experiment we shall be working with a lot of glass therefore we have to be careful in the presence of test tubes. The thermometers are also very fragile and the mercury may be harmful if released.

Fair Test

Constants	Variables
Temperature of water surrounding the body	No of layers on the test tube
Temperature of body at the start of the experiment	Temperature of the body (will be measured)
Time that body is left in the h2o	
How far the body is submerged in the water	
Volume of water in the body	
Length of consecutive times to check it	

To keep the experiment fair, we have to keep everything the same except for the one variable we alter. This will then give us accurate results and help us find out what we intend to without altering the results.

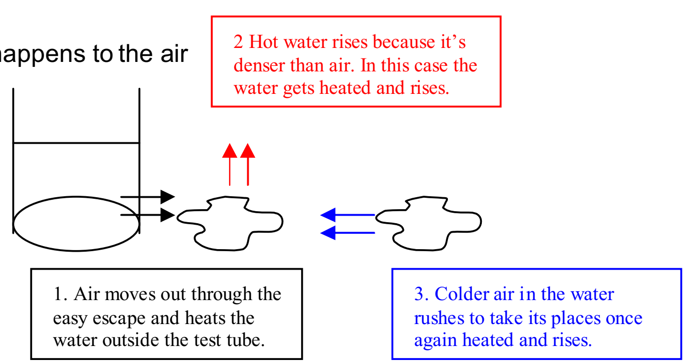
Prediction

I predict that the more layers the test tube will have around it, the less heat it will lose in a certain period of time. The heat will be lost more slowly. I shall backup my prediction with my scientific knowledge.

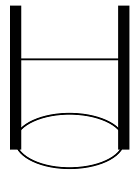
There are 3 ways in which heat travels: convection, conduction and radiation. Conduction mainly happens in solids where one row of particles are vibrating and then pass on to the next row making them vibrate and so on. Radiation happens when there is a hot object and a darker coloured one next to it that attracts the heat. Convection is all to do with hot air rising and colder air taking its place, they go round in a cycle.

But the theory of convection is the one used mainly in this experiment.

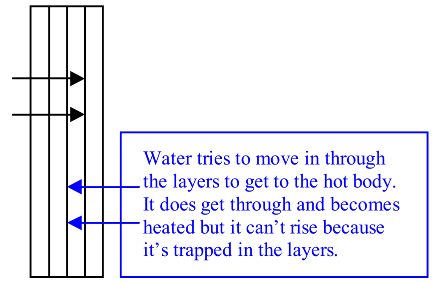
This diagram explains exactly what happens to the air when the water inside the test tube is hotter than the surrounding water. So when the human body is submerged in the ocean, it is hotter than the water around it. And the heat is loss to the ocean heating up the water around it.
This hot water then moves up to the surface and the colder water around that moves closer to the body where once again heat is given out heating



the water and starting the cycle all over again.
However when there are layers around the body the heat loss processes becomes much harder. Again from the diagram we can see that the water that gets heated finds it hard to rise because of the layers. And therefore no cold water can replace its place and get heated. So there will be just little heat loss to the primary water and then I predict there should be no dramatic change after that.

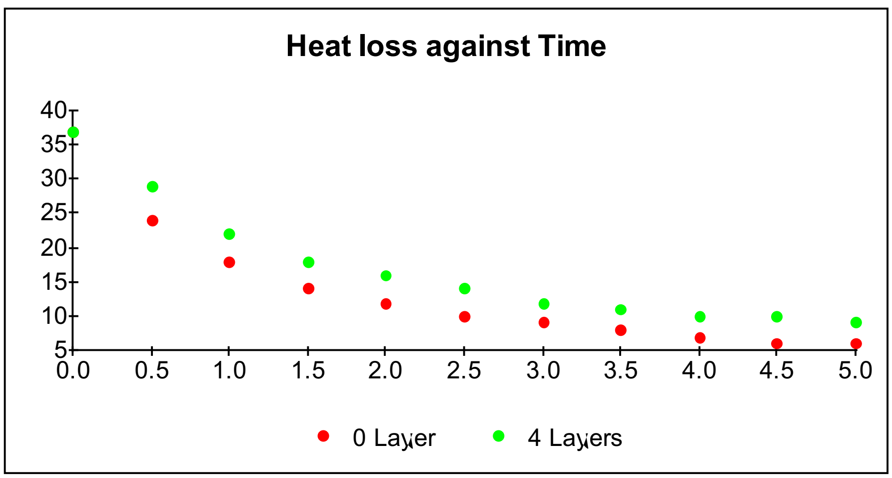


1. Air tries to move out but gets trapped in the layers.



The difference in the number of layers will determine how long it will take for the water to escape and how much water escapes in the first place. The more layers the harder it will be for the water to rise therefore the harder it will be for heat to get lost.

I predict my graph will look like the following because it's more likely the insulated body will maintain the heat longer.



Preliminary

In the very first lesson we had with the equipment, we worked to justify our method. This experiment helped us decide on the measurements we take and the procedure in which we carry out the experiment. It also justified the temperatures. For example we found out that we had to keep the surrounding temperature in the pot constant throughout the whole experiment. The temperature didn't change dramatically through one experiment but we saw that sometimes we had to add or remove ice when needed.
We also found out that 30seconds were a good enough length of time to keep checking the test tube temperature. Because at 10seconds there was hardly much change in the temperature and at 40 there was too much change. So we had to pick between 20 and 30 seconds but we thought 30seconds was sufficient enough, this wasn't neither too quick or too slow. And it also gave us enough time to check if the surrounding temperature was still at 5 C.

The preliminary work helped us justify our use of times and equipment with the most appropriate behaviour.

Time (seconds)	Temperature
0	37
0.5	28
1	23
1.5	17
2	16
2.5	15
3	10
3.5	9
4	8
4.5	9
5	9

These are the results we got out of the preliminary which gave us a brief out look on the general expectations we were to look out for.

Method

- Fill a container with cold water and ice to reach desired temperature (5 C)
- Mix boiling hot water and cold water in a beaker to reach body temperature (37 C)
- Place a thermometer in the surrounding water and another in the test tube
- Fill the first test tube (no layers) with 10cm3 of water of the mixture
- Place the test tube in the container and begin stop watch
- Every 30 seconds prompt, check the temperature in the body and record the reading
- In between each 30 seconds, check the container's water to verify that it has the same temperature as when the experiment started (5 C)
- Continue this until 5minutes are up when u can clean up for the experiment
- Repeat for each of the other test tubes until I have a table of results to compare

Obtaining

Time(min)	0 Layers		1 Layer		2 layers		3 Layers		4 layers	
0.5	20	21	22	23	23	22	24	23	24	25
1	16	17	17	19	18	20	19	20	19	23
1.5	13	14	16	15	16	15	17	15	18	20
2	11	12	15	12	16	14	16	14	17	19
2.5	9	11	12	12	13	13	14	13	14	17
3	8	10	11	11	13	12	12	12	13	15
3.5	7	9	9	10	12	12	11	12	13	15
4	6	8	7	9	9	11	9	11	13	14
4.5	5	7	7	8	8	10	9	10	12	14
5	5	7	6	7	7	9	8	9	12	14

These are the results we noted from our experiment. We made sure that we measured the thermometer accurately without taking it out of the test tube long enough for it to cool down. We also double-checked the reading on the thermometer to make sure we have read it right. Also we repeated the experiment to make sure we have a good set of results for which we can take the average from them.

Time(min)	0 Layers	1 Layer	2 Layers	3 Layers	4 layers
0.5	20.5	22.5	22.5	23.5	24.5
1	16.5	18	19	19.5	21
1.5	13.5	15.5	15.5	17.5	19

2	11.5	13.5	15	16	18
2.5	10	12	13	15	15.5
3	9	11	12.5	13.5	14
3.5	8	9.5	12	12.5	14
4	7	8	10	11.5	135
4.5	6	7.5	9	10.5	13
5	6	6.5	8	10	13

I will proceed to plot these results on a graph and compare the differences.

Analysis

I have found out that the more layers on the test tube we put the more time it took for the body to cool down. The temperatures we recorded for the one without any layers drops quickly compared to the one with 5 layers on. The temperature decreases slowly and not as much.

If one looks at the graph, one can see that the test tube with no layers around it cools the quickest, as it has the steepest gradient, and the test tube with four layers is the one that retains the heat for the longest. Whereas when there were no layers on the, the body took a lot less time for its temperature to drop. For example at 30seconds it had dropped to 20.5 but with 4 layers on it was 4 C higher to 24.5.

I can see this from the graph, to show how it cools quicker at first, then slower. I can see that there is a steep line, which then curves to a much shallower gradient. The non- insulated curve is also lower on the graph than the insulated ones. At the beginning all the lines start fairly close, and then they come apart, going lower according to how much insulation they had (the less, the lower on the graph) and then towards the end the lines become flatter.

This tells me that the non- insulated bodies loose heat a lot faster than insulated ones, and that the more insulation a body has, the slower it is to loose heat. This is shown by the fact that bodies with less insulation are lower on the graph, as they loose heat quicker than the higher ones, which have more insulation. It also shows that they all loose heat rapidly at first, and then slow down as they become nearer room temperature until they eventually will stop, the steep gradient at the beginning flattening to an almost flat line at the end and the gradient decreasing as the experiment goes on. The gradient is the speed of which they lose heat. This is clearly shown by one of the curves on the graph produced, with no layers of insulation.

The lower lines on the graph lost heat quicker because there was no insulation to stop convection and conduction, which are two main ways that heat is transferred, and in this case more insulation meant that the water in the test tube – the body – would cool slower. The insulation stops convection by keeping the trapped particles, of water and maybe some air, still.

So this experiment did backup my prediction. In the tubes with layers on, as I predicted the cold water got trapped in the layers and couldn't get in to cool down the hot water when there was layers around the body. The layers had prevented the heated water from losing its heat to the cold water. The layers around the body helped prevent the water from rising and escaping. However when it had no layers on, the cold water was easily in touch with the body and therefore the heat got through the easy escape and heated the water out side which then rose. Then hot water rose because it's denser and the other cold water rushes to take its place. Where again the cycle begins and the hot water escapes through the glass in convection. And the water outside the body gets heated and rises and so forth.

But when the particles are kept still, it is difficult for convection to occur, and the insulation does this. When convection does occur within insulation and escapes, there might be another layer of insulation, which may stop the convection. So the more insulation there is the more convection is prevented, so less heat is lost that way.

The little heat loss at the beginning is the heat being given to the primary water, which got through the layers and since no more water could replace the primary volume there was no major heat loss after that and it seemed to remain quite constant.

The insulation also can stop conduction, which is heated being transferred by vibrating particles. Heat from inside the body may leave through a chain of particles, one particle vibrating with the energy (the heat has changed to kinetic energy) will make the particle next to it vibrate. And that one will make the particle next to it vibrate and so on.

This insulation can slow conduction, although it does not stop it completely, as heat does escape from insulated bodies as the graph shows, just slower. The stillness of particles trapped in the insulation makes it harder for particles to bump into each other, therefore limiting the number of particles one vibrating one can come into contact with, and slowing it down.

To conclude, from this investigation, and the graphs produced, I can see that the more insulation a body has, the slower it will lose heat due to lack of convection and conduction.

The graphs below present my results in a way in which I can compare them.

Evaluation

My experiment

During the experiment I was pretty accurate in checking the temperature of the surrounding water and made sure that it maintained at 3 C throughout the whole experiment.
I kept it a fair test by using the table I made in the planning as a guideline for the constants I should be aware of.

The quality of the results seemed to be high, I can see this in a number of ways. Firstly, they agreed with other experiments like this. There were anomalous results such as the one at 2 layers of insulation at 30 seconds, but I repeated this and it then fitted in with the trend. Repeating the investigation definitely helped as from it I can see that they are accurate results as I got the same thing twice. The average of the two is very close to both sets of results.

Also they seem to be quite accurate results, as the results all are very close to the lines of best fit, so they all fit to make a regular pattern, which was the pattern expected. One layer of insulation was especially accurate, as each of the results are on the line of best fit, which means that the procedure worked. I used the same procedure for all of them to make it fair, so the others should be just as good quality. On the other hand, though, at times the results become very close and there is almost an overlap.

My graph followed a neat trend, which related to my prediction. The results I took were double-checked before being noted. There were some anomalous results that I had to repeat individually; these aren't recorded in the table above. For example in the 2^{nd} experiment for the 2 layered test tube at 30 seconds I found that it got to 19 in just 30 seconds. I realised this was an anomalous result because it had dropped quicker than both the non layered and the one layered this was obviously in accurate so I redid the whole thing and came out with 22 which is a much better result in comparison with my other two.

However most of my other results were reliable enough to base a conclusion upon. Because I had taken the average of the two experiments, I built my graph upon the two experiments linked. The graph shows an expected trend that backs up my prediction.

There is an obvious pattern, which shows that my results were accurate enough to show the difference in heat loss in a bare test tube and one which has several layers around it.
As that was the main aim I think my results are reliable enough to build a fair judgement upon.
The more layers you have on the body, the stronger the decrease in heat loss.

Improvements

To improve my experiment, I would have tried to improve the reading of the thermometer because it was difficult to read it without having to take the thermometer out of the body to read and then return. This may have had some effect because the thermometer would have cooled down and then have to take time to measure the temperature again. Also the thermometers we used were hard to use.

The measurements of solutions could be improved by using burettes although that would take a lot more time. Possibly the gauze even started wet, and the water evaporating may have taken heat energy with it. The thermometer was read manually, too, which may account for a loss of accuracy. There may have been cold or hot spots in the test tube water, so the thermometer read them, or the sea and air around it may have been slightly warmer or cooler, speeding or slowing the rate of cooling.

To improve the experiment, I would try to avoid these above in a variety of ways. I could do another experiment exactly the same, but stir the water, which would ensure that there were no cooler or warmer spots in the test tube. This would make the results even more reliable. Checking that there is no draught, or that the water and air around the test tubes were the same for all of them would help make it fairer. To be more accurate with the results, I could repeat the experiment but take more measurements which could make the pattern even stronger and anomalous. Unreliable results would not affect the conclusion, and be more careful, perhaps getting two or three people to take the same measurement and get the average, or to use a digital thermometer. This would avoid mistakes made as before, with the anomalous result.

Also, I could try the investigation using another type of “body”, or try using a different type of insulation. I could, for example, use bubble wrap to insulate the test tubes, instead of the gauze. This could be done using exactly the same sea temperature and timings, but it may make the pattern easier to identify, and make a stronger pattern, by making the lines on the graph more apart. I tried to make the results I collected as useful as possible by keeping the test as fair as possible. I believe I achieved this, but there were difficulties in the investigation, where variables we had not much control over changed, like the temperature of the room changing and so on. But these did not affect the investigation so much that valid results were not available.

To take my experiment further I would repeat the experiment with a real life person in a pool of some sort where they can control the temperature electronically. Where the humans body’s temperature is both measured using machines and the pool’s temperature is altered using pumps and water mixers and heaters like in swimming pools at the present time. The experiment would have to be repeated with the same human and the same kindof clothing each time. Technology would help take this experiment further if one felt the need to.

Overall, the investigation I did does show that insulation affects the cooling rate of a body in water - that the more insulation there is, the slower it cools.