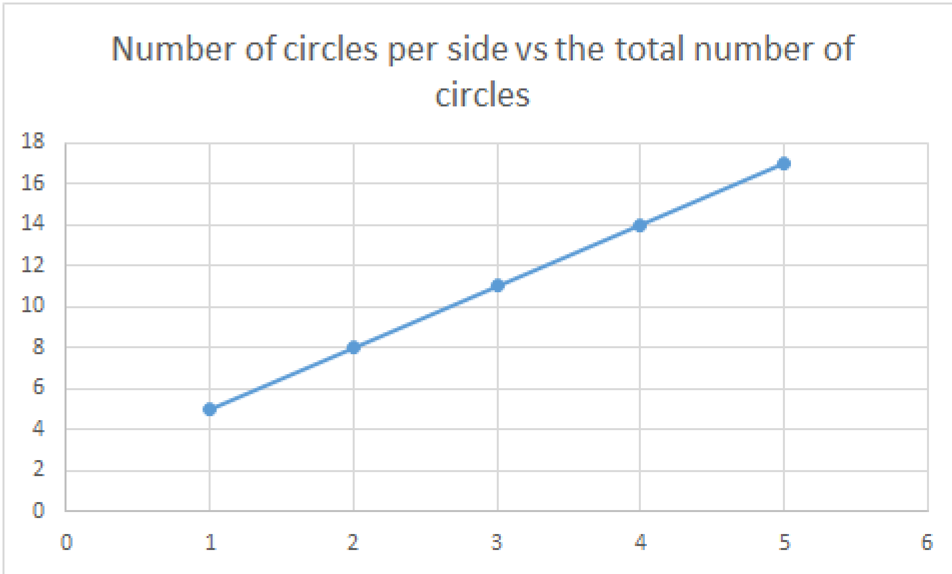
Predicting melting of ice species

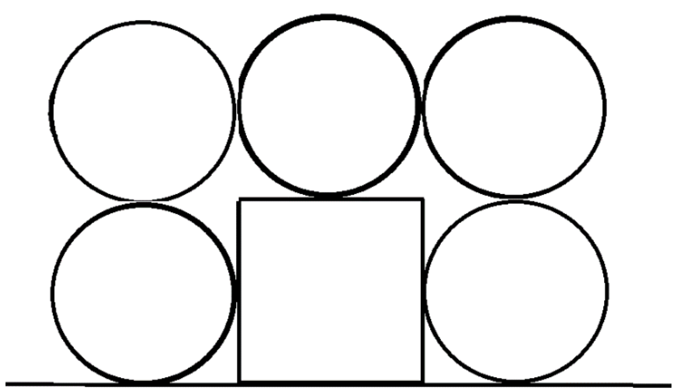
This IA will explore the different effects of different types of systems on a unit of ice. These systems include determining how a cube of ice will melt in response to the stimuli. This will be done with respect to the diffusion of energy from the gas surrounding the ice. Additionally it will explore how the surface area of the ice affects the ways ice can melt. The overall assumption behind this paper is that by changing starting parameters of the ice species one could still determine how it will melt.

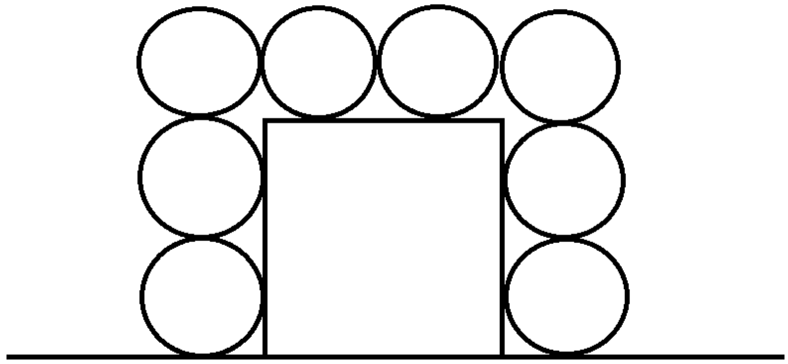
This paper will assume that the ice is a cube which has an initial temperature of 0 degrees Celsius and the surrounding gas and table temperature is constant. It will also assume that the ice starts out as a solid cube. The reason for this is because changing the temperature would make my calculations too difficult for me. Additionally the reason it is a cube is because by looking at one shape I will be able to focus more on the patterns of each molecule of ice melting. Additionally the ice will be evenly frozen meaning there are no air bubbles in it.

The transfer of heat to the ice is done through two different modes. First the direct air to solid will transfer heat as the air transfers energy into the ice. This will happen only when contact is made. Additionally due to the properties of atoms the air will only make contact on the outer layer of ice. The ice which is a cube will initially receive equal amounts of energy on all flat parts of the cube. But around sharp edges more air molecules can make contact. This value is determined by looking at the number of circles that can fit around the cube, and then focusing on how many circles go with each local point. This can be explained using a linear graph.



The model that corresponds with this graph shows how the circles are formatted around the square in a 2D plane. This model does not include how a 3d model would act. The 3D ice model would act in a similar way as the 2d model with the exception of the corners of the cube. These corners have a larger gap between itself and the cube. This is due to the corner molecule being pushed further away by the 3 side molecules it is next to.





These models represent how the air molecules can connect to the ice. Because I had to make these models there are only this many circles but for the sake of consistency I am going to use 100 circles per side. To determine the relative effect of these air molecules or circles on the ice species the proximity of each circle to the ice will be calculated. Initially I planned on calculating the actual values of heat transfer, but because the temperature is constant the only difference between each air molecule is its proximity to the cube. To determine the relative proximity the distance between the circle and the cube needs to be determined. The first variable that needs to be defined is the radius of each circle.

If X= the number of circles per side of the square,

And, s= the side of the square,

Then the radius, r= $\frac{s}{2x}$

So for when the square has 100 circles per side,

$$r=\frac{s}{200}$$

Where the spheres on the cube face will be able to affect the ice at a similar rate the sides and corners will each have different rates based on how many disconnected air molecules surround it. A disconnected air molecule is one that isn't directly making contact with the ice. The relative effectiveness of the air molecules on the side can be represented as:

$$Y, \text{ where } Y= 2r + \sqrt{r}$$

The 2r represents the effect of each face molecule, and the $\sqrt{r}$, represents the effectiveness of the molecule on the side. When looking at the corner pieces the same concept applies. The relative effectiveness of the air molecules on the corner can be represented as:

$$Z, \text{ Where } Z= 3r + 3\sqrt{r} + \sqrt[3]{r}$$

The r and $\sqrt{r}$ represent what they did in the previous equation and the $\sqrt[3]{r}$ represents the relative effectiveness of the corner molecule. Overall the effect of the corner and side molecules is less than that of a molecule of air touching the face of the ice, but because at these points there are many face molecules in addition the side and corner molecules affecting the ice it will melt significantly faster at these points.

Overall if the speed at which each point melts can be compared relatively

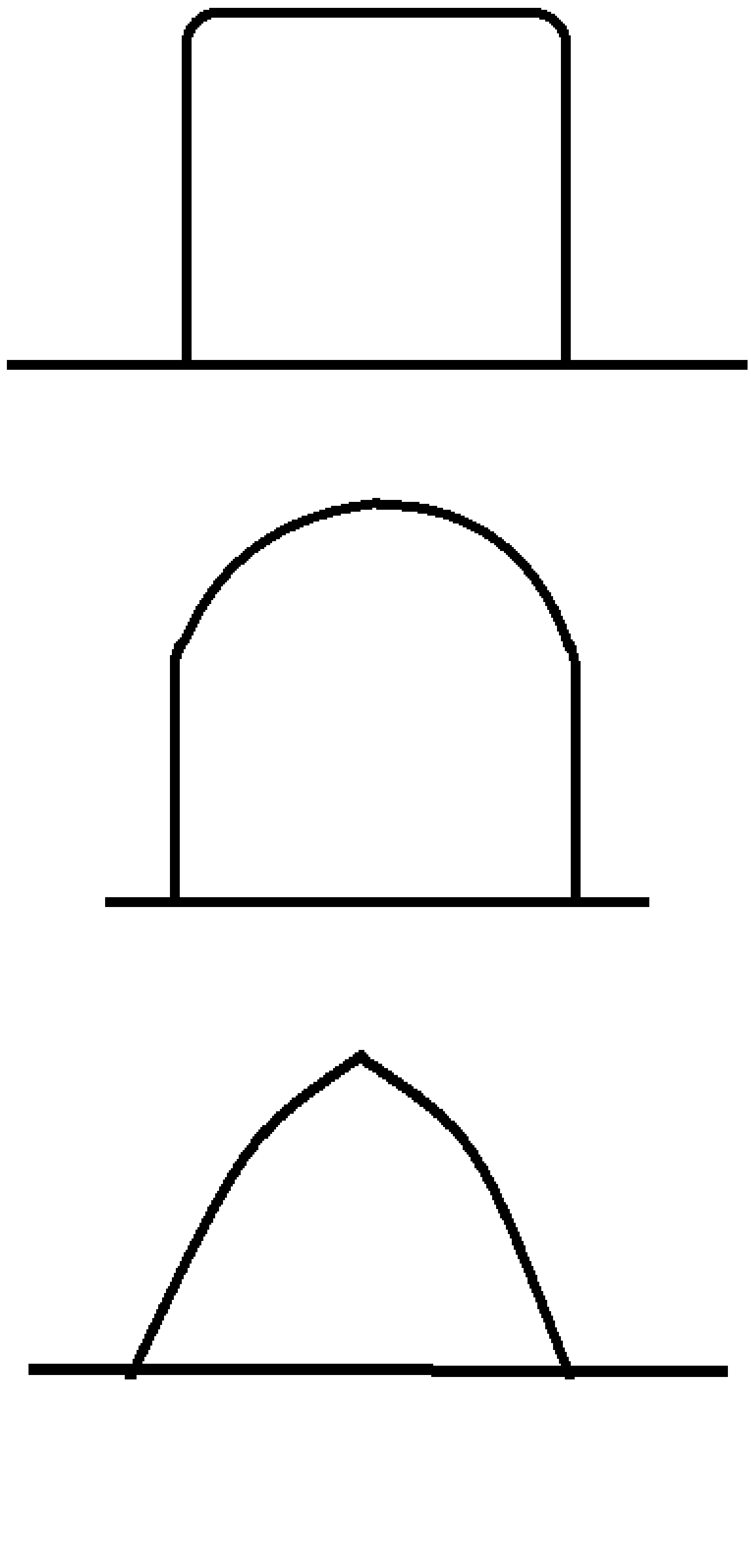
Z=100%

Y= 42%

And R= 14%

The effect of this is that the ice molecules are collapsing at a rate far faster on the corners, and slightly faster on the sides. So as the corner piece melts it exposes other molecules. The molecules that are exposed then become either a corner piece or a side piece. When taking this into account when the first corner melts the exposed molecules will have 42% of the energy needed to melt and the face molecules will have 14% of the energy needed. As a result the ice will melt along the corners and sides at an exponential rate. This will cause the ice to melt into a rounded off shape as it shrinks. This pattern will continue until all of the ice has melted. When looking at the cube it begins to melt at the top 4 corners and collapses in from there. This deduction may seem like a hypothesis but because the melting ice is represented relative to each other it can be assumed that it will melt according to these models.

Initial Corners melted



The overall assumption of this exploration is that the melting of ice can be predicted with certain constants in mind, but when adding different variables the answer becomes harder to define. Specifically in my investigation the ice will melt with respect to its many corners and sides and will form to a rounded shape as much as it can.

While I created this paper I looked at many different aspects and initially wanted to account for different ideas such as the effect of the already melted water on the system, but I quickly realized that the math that I needed to do that would be beyond me. With that in mind I decided to make my paper using a relativity scale. This scale made the math significantly easier. While it did make the math easier it doesn’t account for everything that would actually occur in real life. For instance when the ice melts it will have air bubbles or the temperature will be different at separate points. This could be explored if I had more math techniques to use, but because I didn’t the relativity was the best option. At the beginning I chose to do this investigation because I wondered how the melting of the glaciers could be predicted, but due to all of the limitations this exploration more accurately represents ice one would get from a freezer. If I were to have more knowledge or help I would try to replicate the melting of a glacier and try to predict it. Another aspect that made the paper more difficult is that I didn’t have any previous work to take anything from, therefore I had to make my own models, and I had to make some assumptions based on my own knowledge.

Assessment criteria:

Criterion		Comments *	Achievement level: Teacher	Moderator	Senior moderator
A	Communication	No sources were cited, and no mention was made of how or where info and equations came from. Introductory information was limited, and the setup was unclear as to what was actually being explored.	**0-4** 0		
B	Mathematical presentation	A variety of visual representations was given, but did not really add to the understanding of the paper. Key terms needed to be defined, as well as why circles were the chosen shape.	**0-3** 1		
C	Personal engagement	The topic itself was creative and interesting. Exploring the physical properties of melting materials could have potential extensions. But, only passing mention was made of real-world applications.	**0-4** 1		
D	Reflection	The student seemed well aware of the limitations, both physically in terms of 2D vs 3D and other restrictions, and his own mathematical. But few adjustments were made to account for these.	**0-3** 1		
E	Use of mathematics	Other than a couple equations and a passing mention of percentages, no mathematics was present in the paper. Even for the numbers given, no work was shown.	**0-6** 0		
		Total:	**0-20** 3		