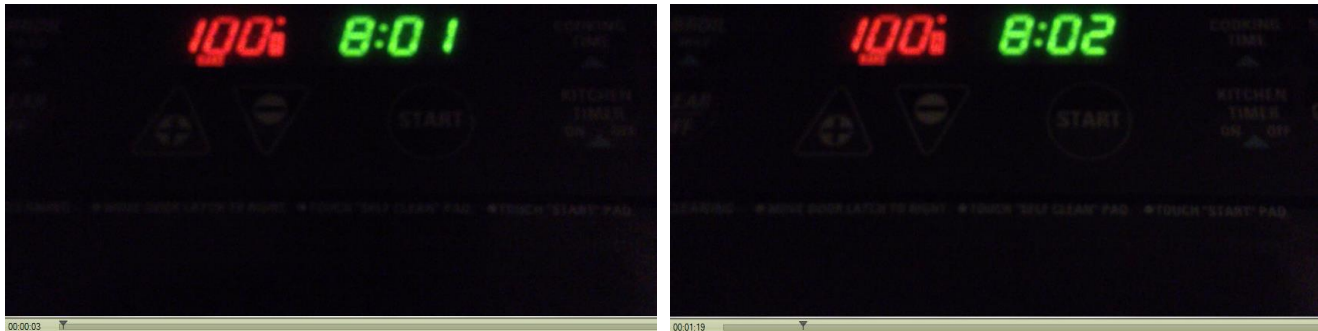# Preheating the Oven

Suppose you need to preheat a gas oven to 400° Fahrenheit. How long will it take? This 5-Part task will help you to organize your thinking to answer this question.

Part 1 – What Information Do You Need?

Consider the screen shots shown below. Note that the time in the first image is 0:03 and note that at 1:19, the temperature remains listed at 100°. How long do you think it will take to heat the oven to 400°? What additional information would you like to have to answer this question? Explain/describe how this additional information would be used to answer the question "how long will it take to preheat the oven to 400°?"

Teachers – you may choose to make this activity more dramatic by playing the beginning of the video (http://youtu.be/l2ooIWFAcII) and asking students to think about how long it will take for the oven to preheat to 400°.

The intent of Part 1 is to get students to think about what information they would need to know in order to answer the question. For example,

- What is the explanation for why the temperature remains 100° for so long?
- Once the temperature starts increasing from 100°, what is the rate at which the temperature changes?
- Does the rate of temperature increase remain constant throughout the pre-heating process?

To answer the first question, one explanation is that it takes over one minute for the temperature to reach 100° but the temperature display only shows temperatures greater than or equal to 100°.

Note that the goal is for students to not only to articulate what information they would like to have but also to articulate how they would use that information to answer the question. Also, students should make their best guess possible in answering the question.

Important note to teachers – students should be given each page of this task one at a time so that they are encouraged to think about the information that they would like to have before it is given to them! Distribute each Part of the activity one at a time as students progress through each part.

Part 2 – Additional Information

Next, you are shown snapshots of the elapsed time (notice the bottom left hand corner of each image) and temperature. At 1:19, the temperature is 100°. At 4:03, the temperature is 200°. How long will it take to preheat the oven to 400°? Justify your response by clearly revealing your mathematical thinking.

How confident are you in your response? Is there different or additional information you would like to have? Explain what different or additional information you would like to have and how you would use this information to answer the question.
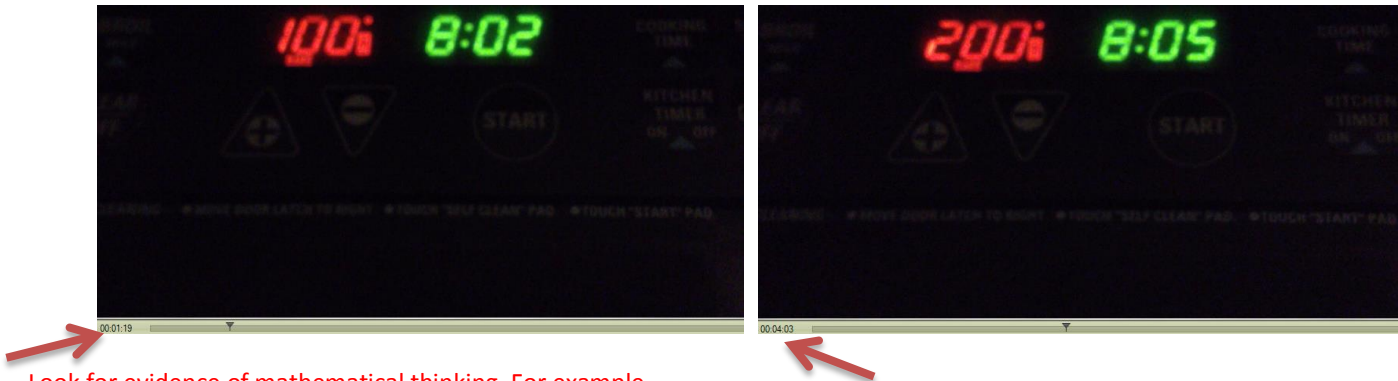
Look for evidence of mathematical thinking. For example,

- Since it took 2 minutes and 44 seconds for the temperature to double from 100° to 200°, it will take another 2 minutes and 44 seconds to double from 200° to 400° thus the total time is 5 minutes and 28 seconds. We must add this to the 1:19 that brought us to this stage – total time of 6 minutes and 47 seconds.
- Since it took 2 minutes and 44 seconds for the temperature to increase by 100°, we assume an average rate of approximately 1.64 seconds per degree. At this constant rate, it will take 1.64 seconds per each additional 200° or 328 seconds for the temperature to reach 400°. This is about 5 minutes and 30 seconds. We must add this to the 1:19 that brought us to this stage – total time of 6 minutes and 40 seconds.
- Since it took 2 minutes and 44 seconds for the temperature to increase by 100°, we assume an average rate of approximately 0.61 degrees per second. At this constant rate, we need to find out how long it will take for the temperature to rise another 200o. That is, how many 0.61 degrees are in 200 degrees? Since each 0.61 degrees takes 1 second, it will take 200/0.61 or about 327.9 seconds for the temperature to reach 400°. This is about 5 minutes and 30 seconds. We must add this to the 1:19 that brought us to this stage – total time of 6 minutes and 40 seconds.

Note that students are encouraged to consider the reasonableness of their response. They should be encouraged to justify the reasonableness of assuming that the temperature will continue to double…that is, will the temperature continue to increase at an ever increasing rate? Or, justify the idea of a constant rate of change throughout.

Based on this discussion, students are encouraged to think again about other information that they may like to know. Likely, they will want to see more data!

Important mathematical note for teachers: push students to fully explain why they perform the computations that they perform in each case and to focus on the units used in their computations. For example:

- Why do they double the time in the first case? What is the thinking behind this? Note that we want them to realize that they are assuming a multiplicative relationship between the elapsed time and the temperature.
- Why do they multiply in the second case? Focus on the idea of the assumed constant rate of 1.64 second per degree…thus we need 200 additional copies of 1.64 seconds…thus multiplication is required.
- Why do they divide in the third case? Focus on the idea of the assumed constant rate of 0.61 degrees per second…thuse we need to know how many copies of 0.61 are in the additional 200 degrees required…thus division is required.

Part 3 – Even More Information

Now, two new screenshots show the time and the temperature. Use this information to refine your answer to the question, "how long will it take to preheat the oven to 400°?" Again, justify your response by clearly revealing your mathematical thinking.
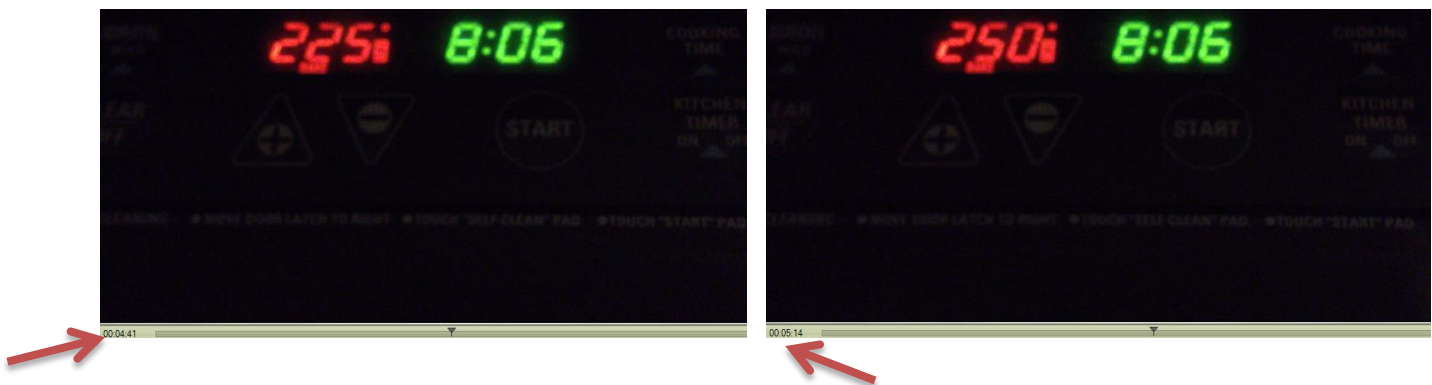
Now we see that the temperature has increased by 25° in 33 seconds for an average increase of approximately 0.76 degrees per second or 1.32 seconds per degree. Either way, assuming a constant rate of change, we find that it will take an additional 3 minutes and 51 seconds for the temperature to reach 400°. Since the temperature was 225° at 4:41, we can estimate that the oven will reach 400° after 8 minutes and 32 seconds.

At this point, students might realize that the oven temperature must not be increasing at a constant rate since the estimated time is now about 8.5 minutes compared to about 5.5 minutes previously. Push students to think about what this means and how we might find a more accurate result. What information do we need? Again, students might say…we need more data!

In Part 4, we give them more data!

Part 4 – The Last Estimation

The mathematical intent of this activity was to focus on ways that you can make predictions about the time it takes to preheat the oven and to think about the information you may need in order to accurately answer the question.

One idea regarding the needed information could have been to have more data showing the time elapsed and the temperature. For this last estimation, you are provided with partial data showing the elapsed time and the oven temperature. Once again, refine or confirm your answer to the question, "how long will it take to preheat the oven to 400°?" Again, justify your response by clearly revealing your mathematical thinking.

Time Elapsed (in seconds)	Oven Temperature (°F)
0	100
10	100
20	100
30	100
40	100
50	100
60	100
70	100
80	100
90	106
100	112
110	118
120	125
130	130
140	135
150	140
160	146
170	153
180	159
190	165
200	170
210	177
220	183
230	190
240	198
250	205
260	211
270	218
280	225
290	232
300	240
310	248
320	255
330	261
340	267
350	274
360	280
370	286
380	290
390	298
400	303
410	308
420	314
430	320
440	326
450	331
460	335
470	340
480	346
490	350
500	355
510	359
520	365
530	368
540	372

This is intentionally open ended. One possible solution follows.

Let's start analyzing the data starting with 80 seconds since we see the first jump in the temperature from 80 to 90 seconds.

Let's find the average increase in oven temperature for each 10 second interval: approximately 5.91 degrees per 10 seconds or 0.591 degrees per second.

Using the data showing that temperature is 100 degrees after 80 seconds, we need to find out how long it will take the temperature to increase an additional 300 degrees at a rate of 0.591 degrees per second.

Again, push students to articulate why they will perform the computations needed. In this case, we need to find how many 0.591 degrees are in 300 degrees since each 0.591 degrees takes 1 second. This is a division problem: 300/0.591 is approximately 507.61 seconds.

We add the additional 507.61 seconds to the 80 seconds to get 587.61 seconds or about 9 minutes 47.61 seconds.

Part 5 – Conclusion

To check your answer, watch the complete video at http://youtu.be/I2ooIWFAcII and see how long it takes to heat the oven to 400°. Write a brief concluding statement that explains the ways of thinking and strategies that worked for you or describe why you think your final result was not correct.

The image below shows that the temperature reached 400° after 10 minutes and 15 seconds.
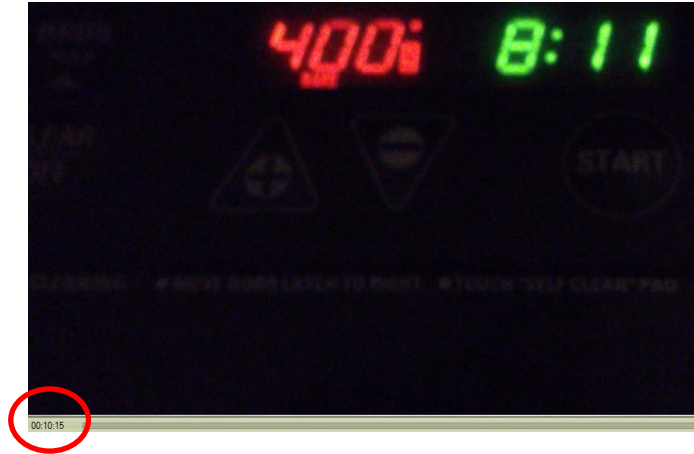
Note to teacher: You may decide how much time you want to take to play the video. Perhaps you play the video at normal speed while you continue to work on other tasks. Students can watch to see and predict how close their answer is to reality. Or, you may let it play for a couple of minutes and then fast forward to the end if time is an issue.

Note that this part of the activity encourages students to reflect on their work and to think about the mathematics used in the task. For example:

- Assumptions matter! Are we assuming a constant rate of change? A constant percent of change?
- Accuracy increases with additional data! The more data, the better!
- Label all quantities with appropriate units (degrees per second…seconds per degree…).
- Think about computations and why they were done (why multiply? Why divide?)
- What does average mean?