Math in the kitchen

Cooking times

Some dishes take longer to cook than others. When preparing a meal, it's important to plan carefully so that all the dishes finish cooking at the same time. If dinner will be served at 6:30 P.M. for the menu below, what time does each dish need to be put in the oven so that everything will be done cooking at 6:30?

1. Put the dishes in sequential order, beginning with the first dish that needs to go into the oven.

What's for Dinner	
Dish	**Cooking Time (in minutes)**
Cheese potatoes	75
Glazed carrots	30
Bread pudding	60
Roast chicken	120
Buttermilk biscuits	20
Pumpkin bread	50

Additional project idea: cook a meal with different dishes and make sure to cook them in the proper order so that each part of the meal is finished at the right time.

Converting recipes

Oatmeal raisin cookies

- 1 egg
- 1 cup brown sugar
- $1\frac{1}{2}$ cups oats
- $\frac{1}{2}$ cup butter
- 2 tablespoons milk
- $\frac{1}{4}$ cup raisins

French toast

- 4 slices bread
- 2 eggs
- $\frac{1}{2}$ cup milk
- 2 tablespoons butter

2. Double the recipe for oatmeal raisin cookies and half the recipe for French toast.

Additional project idea: make a double batch of cookies or convert another recipe and make that.

Math in the kitchen

Food safety - Keeping cool

Food must be kept cold enough so that it stays fresh and safe to eat for as long as possible. Fresh vegetables, milk, and meat need to be kept refrigerated at a temperature no higher than 41°F. Dry goods can be stored in the pantry at a temperature up to 70°F. Seafood needs to be kept refrigerated at a temperature no higher than 34°F.

In the table below, these items are currently at the temperature listed at the right. Does the temperature need to be lowered for any items? Which ones and how much? Are there items that could safely be stored at a higher temperature? Which ones and how much?

Food and Temperature	
Food	**Temperature (in degrees F)**
Roast Beef	48
Shrimp	60
Lettuce	51
Flour	45
Sugar	60

Additional project idea: obtain your food handlers permit by taking a food handlers permit class.

Food safety - Safe Minimum Cooking Temperatures

Use this chart and a food thermometer to ensure that meat, poultry, seafood, and other cooked foods reach a safe minimum internal temperature.

Remember, you can't tell whether meat is safely cooked by looking at it. Any cooked, uncured red meats – including pork – can be pink, even when the meat has reached a safe internal temperature.

Why the Rest Time is Important

After you remove meat from a grill, oven, or other heat source, allow it to rest for the specified amount of time. During the rest time, its temperature remains constant or continues to rise, which destroys harmful germs.

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Category	Food	Temperature (°F)	Rest Time
Ground Meat & Meat Mixtures	Beef, Pork, Veal, Lamb	160	None
	Turkey, Chicken	165	None
Fresh Beef, Veal, Lamb	Steaks, roasts, chops	145	3 minutes
Poultry	Chicken & Turkey, whole	165	None
	Poultry breasts, roasts	165	None
	Poultry thighs, legs, wings	165	None
	Duck & Goose	165	None
	Stuffing (cooked alone or in bird)	165	None
Pork and Ham	Fresh pork	145	3 minutes
	Fresh ham (raw)	145	3 minutes
	Precooked ham (to reheat)	140	None
Eggs & Egg Dishes	Eggs	Cook until yolk and white are firm	None
	Egg dishes	160	None
Leftovers & Casseroles	Leftovers	165	None
	Casseroles	165	None
Seafood	Fin Fish	145 or cook until flesh is opaque and separates easily with a fork.	None
	Shrimp, lobster, and crabs	Cook until flesh is pearly and opaque.	None
	Clams, oysters, and mussels	Cook until shells open during cooking.	None
	Scallops	Cook until flesh is milky white or opaque and firm.	None

3. The meat thermometer inserted into a piece of chicken reads 150°F. Is the piece of chicken safe to eat?

4. The meat thermometer inserted into a piece of steak reads 150°F. Is the steak safe to eat?

Additional project idea: cook a piece of meat and use a cooking thermometer to test for doneness.

Math and Canning food

Since about 1825, canning has provided a way for people to store foods for extremely long periods of time. In canning, you boil the food in the can to kill all the bacteria and seal the can (either before or while the food is boiling) to prevent any new bacteria from getting in. Since the food in the can is completely sterile, it does not spoil. Once you open the can, bacteria enter and begin attacking the food, so you have to "refrigerate the contents after opening" (you see that label on all sorts of food products -- it means that the contents are sterile until you open the container).

We generally think of "cans" as being metal, but any sealable container can serve as a can. Glass jars, for example, can be boiled and sealed.

Botulism is an illness caused by eating toxin produced by the growth of the Clostridium botulinum bacteria. It is fatal if left untreated. Clostridium botulinum grows in moist, low-acid food, when stored between 40°F and 120°F. This bacteria can even grown in the absence of air, which means it can continue to grow in a vacuum sealed container. Processing food at temperatures above 240°F destroys this bacteria then it can be canned and remain safe for long periods of time. This can be done at home in glass jars using a water bath canner. Foods need to be processed (remain submerged in boiling water) for a certain amount of time to bring internal temperatures above 240°F. Processing times are carefully regulated by the USDA to ensure food safety.

Another way to protect food is to keep it in the freezer which is too cold for bacteria and inhibits growth. Foods can be safely stored in the refrigerator for a short amount of time, but even food stored in the fridge can go bad after a period of time. Red meat and pork can remain in the refrigerator up to 5 days and can be frozen for 4-12 months. Leftover cooked meat will last 3-4 days in the refrigerator and 2-6 months in the freezer. Ground meats (beef, veal, pork, or poultry) can be refrigerated for 1-2 days and frozen for 3-4 months.

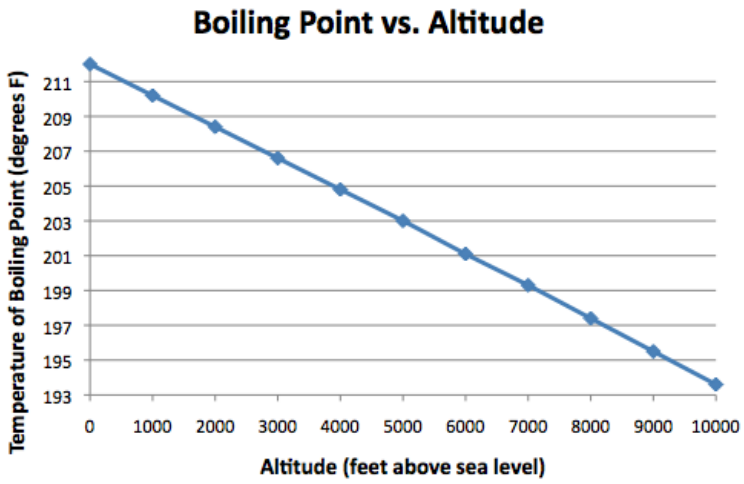
Are these foods safe? Why or why not?

5. Meat that has been stored in the freezer for 3 months at 0°F.
6. Meat that has been stored in the fridge for 10 days.
7. Meat that has been brought to a boiling point and then vacuum sealed in a canner.

Since the boiling point at sea level is only 212°F, it is not enough to kill botulism which can continue to grow even in a sealed container. Since killing all bacteria, including botulism, is critical to our safety, the canning process is carefully monitored, here is a case where getting the numbers right can literally be the difference between life and death.

Written in mathematical terms, $30°\text{F} < x < 240°\text{F}$, where x represents the temperature range where botulism and most other harmful bacteria may survive.

Another complication is that water boils at a lower temperature at higher altitude because there is less atmospheric pressure. Thus, more time is required to raise the internal temperature of foods that are being processed. In order to kill the bacteria, the processing time must be increased. The following chart shows the temperature at which water boils.



Standard canning recipes show processing times for sea level where water boils at 212°F. For higher altitudes, you must increase the processing time. Foods will spoil in a sealed jar if the processing time or temperature is not adjusted for altitude.

The following chart shows the relationship between altitude and increased processing time.

Altitude	**Increase time**
1,001 - 3,000 ft	Add 5 minutes
3,001 - 6,000 ft	Add 10 minutes
6,001 - 8,000 ft	Add 15 minutes
8,001 - 10,000 ft	Add 20 minutes

8. You are living in Utah at an altitude of 4,600 ft. You decide to can the peaches from your tree in the backyard. The recipe says to process the peaches for 30 minutes. How long do you need to process the peaches in order for them to be safe?

9. You are living in Rhode Island at an altitude of 1,300 ft. You decide to can the peaches from your tree in the backyard. The recipe says to process the peaches for 30 minutes. How long do you need to process the peaches in order for them to be safe?

10. You are living in Colorado at an altitude of 7,400 ft. You decide to can the peaches from your tree in the backyard. The recipe says to process the peaches for 30 minutes. How long do you need to process the peaches in order for them to be safe?

There is another way to raise the internal temperature of the food besides extra cooking time, it is using a pressure canner. Pressure canners increase atmospheric pressure which makes water boil at a higher temperature. In a regular pot, the heat of your cooking is limited to the boiling point of water (212°F). But with the steam's pressure now the boiling point can get as high as 250°F. This higher heat helps the food to cook faster. For some foods, pressure canning is the only way to get the internal temperature high enough to kill all the bacteria. Pressure cookers can also be used to cook regular meals faster because they reach higher temperatures and the pressure forces liquid into the foods causing them to cook faster.

Additional project idea: preserve food by canning (follow all USDA guidelines and procedures carefully) or cook a meal using a pressure cooker.

Basic grocery shopping

Whenever we use money, we're using math.

Food Items and Costs	
Item	**Cost**
4 chickens	$17.00
8 fresh trout	$24.00
2 bags red potatoes	$12.00
6 avocados	$17.00
10 bunches carrots	$20.00
6 baskets strawberries	$24.00
6 baskets cherries	$35.00

11. With a budget of $70 to spend, and using the table above, which of the following three groups of items can you buy while staying within your budget?

    Group 1: chicken, potatoes, avocados, strawberries
    Group 2: chicken, avocados, carrots, cherries
    Group 3: trout, carrots, avocados, strawberries

Additional project idea: using a set budget, go to the store and purchase the ingredients for a meal and then prepare the meal.

Math in the kitchen

Cooking for a crowd

Caterers make a career out of cooking for crowds. A caterer has been hired for a wedding with 100 guests. The client needs to choose which dinner menu she wants to serve. The caterer charges a set fee for each guest's dinner that the client orders.

> Menu 1: Roast chicken, rice, green beans, fresh fruit with chocolate cake for dessert
> Fee: $20.00 per guest
>
> Menu 2: Steak, baked potato, salad, French bread with cheese cake for dessert
> Fee: $40.00 per guest
>
> Menu 3: Fresh fish, carrots, salad, dinner roll with carrot cake for dessert
> Free: $25.00 per guest

12. If the client selects Menu 2, how much will the caterer charge?
13. If the client selects Menu 3, how much will the caterer charge?
14. How much less will Menu 1 cost the client than Menu 2?
15. If the client orders 50 Menu 1 dinners, and 50 Menu 2 dinners, what will the caterer charge?

Even if you don't become a caterer, there will be times when you'll need to cook for a crowd. The following example is from an assignment to make dinner for 120 people at girl's camp with a limited budget of $200.

The first step is to decide what to serve. Some questions to consider are food preferences of the people who will be eating, it this something that will taste good? How expensive will it be to make? How difficult will it be to prepare and serve? I chose taco salad as something that would be inexpensive, taste good and be relatively easy to cook and serve to a large group.

The next step is to list all the ingredients and calculate the needed quantity for each ingredient. Figure out how much is needed for a single serving and multiply that by the number of people being served. Many packages include serving size information which is helpful, but sometimes what they consider a "serving" isn't very realistic. Have you ever noticed a small package of brownies that said it makes 24 servings? Yes, that may be true if all 24 people are on a diet since the pieces will be microscopic, but it's not realistic to assume that one small package of brownie mix will really satisfy 24 people. So as you make your calculations, think about the people that you will be serving.

Portion size guide				
Cheese	1 oz		Lettuce	2 oz
Ground beef	4 oz		Salsa	2 oz
Tortilla chips	2 oz		Sour cream	1 oz
Lettuce	2 oz		Taco seasoning	?

Math in the kitchen

Then calculate how much of each ingredient to buy and calculate the cost. Using the portion size guide given, complete the table below. Remember, you're planning on 120 people and have a budget of $200.

Ingredient	Size	Cost per item	How many needed	Total cost
Tortilla chips	3 lb bag at Costco	$3.89		
Ground beef	10 lb chub at Walmart	$23.98		
Shredded cheese	5 lb bag at Costco	$12.69		
Lettuce	3 lb bag at Costco	$2.29		
Salsa	4 lb bottle at Costco	$4.96		
Sour cream	3 lb tub at Costco	$3.89		
Taco seasoning	24 oz container - says it contains 113 servings	$3.99		
			Total	

16. Did you stay within budget?

17. What is the approximate cost per person?

18. Is there money left over for dessert? If so, what do you recommend be served for dessert?

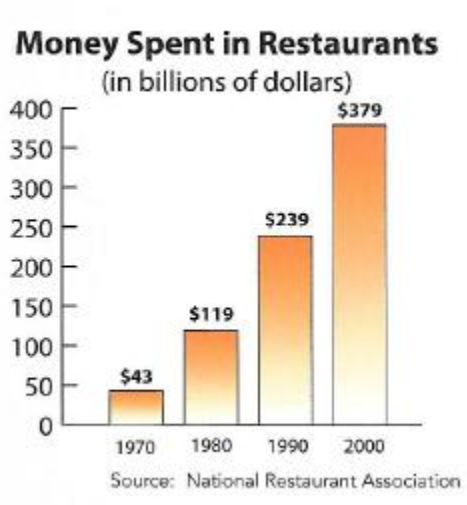
19. What would you choose for dessert if the budget were raised to $250?

Additional project idea: using a set budget, make a plan to serve a crowd. Here are a few questions to consider: Is this a wedding, a birthday party, a family reunion, refreshments for book club, a luncheon for a funeral, a blue and gold banquet for cub scouts, etc? Is it formal or casual? What is your budget? Can you afford to have it catered? What is the difference in cost between having it catered and doing it yourself? Are you serving a full dinner or just refreshments? How many people will be coming? Choose a menu and calculate how much you need to buy and calculate the cost.

Math in the kitchen

Eating out

Many people enjoy going out to eat at restaurants. The bar graph at the right shows how much money people spent in restaurants across the United States in the years 1970, 1980, 1990, and 2000. Use the graph to answer the following questions.



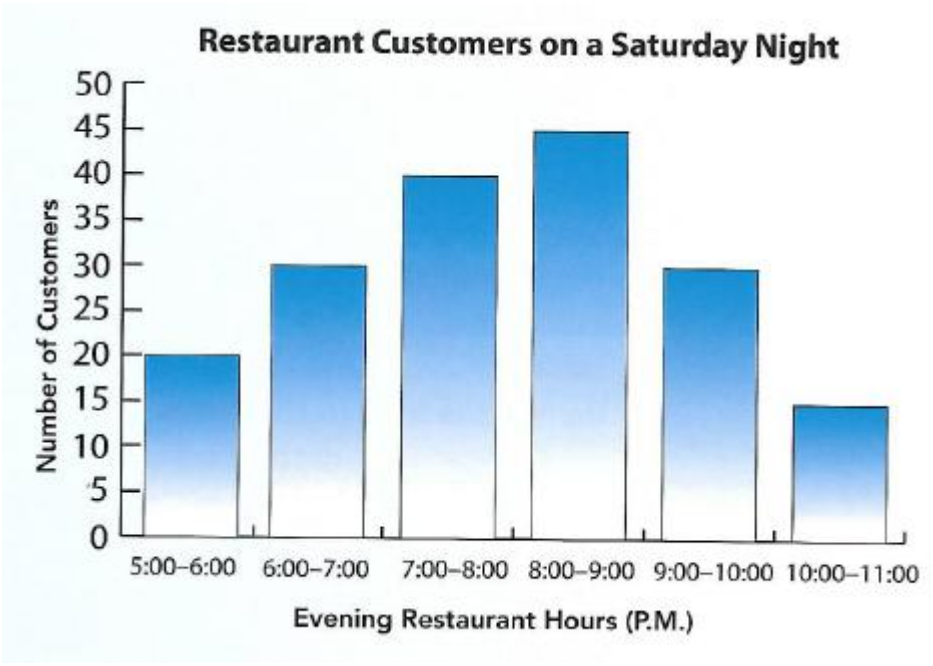
20. How much more money was spent in restaurants in 2000 than in 1990?

21. What was the increase in the amount of money spent between 1970 and 1980?

22. What is the difference in the amounts of money spent in the year with the greatest amount of sales and in the year with the least amount of sales.

23. How many years does the graph cover?

The next graph shows the number of customers on a busy Saturday night. Use the graph to answer the questions on the following page.



24. In which one-hour time period did the most customers come into the restaurant?
25. In which one-hour time period did the fewest customers come into the restaurant?
26. How many people in all came into the restaurant on this Saturday night?

Tipping

In the United States, the federal minimum wage for waiters and other tipped employees is only $2.13. However with tips, a waiter's hourly wage must reach at least $7.25. In busy, upscale restaurants, an experienced waiter can make $30 an hour or more. If people don't pay tips then waiters would only make $2.13 so tipping is important. The standard expectation for tipping is $\{15\% \leq x \leq 20\%\}$ so budget that expense as part of the meal cost.

What is an appropriate tip for the following meal costs:

27. $21.75
28. $15.39
29. $39.08
30. $53.47

Restaurant workers

How much can restaurant workers make?

How much could different types of restaurant workers earn for an 8-hour work shift? Use the table of wages below to answer the questions.

Worker	**Hourly wage**
Busboy	$8.00
Assistant chef	$20.00
Server (including tips)	$9.00
Line cook	$12.00
Greeter	$10.00

31. Which type of worker listed in the table will earn the greatest amount of money in an 8-hour shift?
32. Which type of worker will earn the least amount of money?
33. For an 8-hour work shift, how much less does a line cook earn than the assistant chef?
34. How much will a server earn in one week if the server works, 5 days, 8 hours each day?

Math in the kitchen

How much should the chef charge?

The purpose of restaurants is to make a profit for the business owner or chef. The costs not only include the expense of the food ingredients, but also the wages of all workers and overhead such as the building rent and ultilities. Assuming a chef needs to charge $10.00 more for each dinner than the cost of the ingredients in order to make a profit. Look at the cost of each item and calculate the total cost for each dinner. Then calculate what the chef needs to charge in order to make a profit.

Dinner #1

Ingredients	Cost
Salmon	$6.00
Rice	$1.00
Carrots	$1.50
Sliced tomatoes	$1.50
Bread	$2.00

Dinner #2

Ingredients	Cost
Pork chops	$3.00
Cheese potatoes	$1.50
Peas with onions	$1.00
Applesauce	$0.50
Biscuits	$1.00

Making change

Maybe you're not the owner, perhaps you're the cashier at a restaurant. As customers pay for their dinner, you need to give them change. Look at the table of customers and what each customer's check is. If each customer hands you a $100 bill, how much change will you give each person?

Customer	**Check amount**	**Change**
Customer A	$65.00	
Customer B	$38.00	
Customer C	$82.00	
Customer D	$71.00	
Customer E	$44.00	

Making candy

Math is critical in candy making. The numbers make all the difference in how the candy will turn out. As a sugar syrup is cooked, water boils away, the sugar concentration increases, and the temperature rises. The highest temperature that the sugar syrup reaches tells you what the syrup will be like when it cools. In fact, that's how each of the temperature stages discussed below is named. For example, at 235° F, the syrup is at the "soft-ball" stage. That means that when you drop a bit of it into cold water to cool it down, it will form a soft ball.

Most candy recipes will tell you to boil your sugar mixture until it reaches one of the stages below. For the best results and most accuracy, use both a candy thermometer and the cold water test. It's also a good idea to test your thermometer's accuracy by placing it in plain boiling water. At sea level, it should read 212° F. If it reads below this number, make the necessary adjustments when cooking your candy syrup. For example, if it reads 210° then subtract 2° from all specified temperatures.

Note: The temperatures specified here are for sea level. At higher altitudes, subtract 1° F from every listed temperature for each 500 feet above sea level.

Thread Stage
230° F–235° F
sugar concentration: 80%

At this relatively low temperature, there is still a lot of water left in the syrup. When you drop a little of this syrup into cold water to cool, it forms a liquid thread that will not ball up. Cooking sugar syrup to this stage gives you not candy, but syrup—something you might make to pour over ice cream.

Soft-Ball Stage
235° F–240° F
sugar concentration: 85%

At this temperature, sugar syrup dropped into cold water will form a soft, flexible ball. If you remove the ball from water, it will flatten like a pancake after a few moments in your hand. Fudge, pralines, and fondant are made by cooking ingredients to the soft-ball stage.

Firm-Ball Stage
245° F–250° F
sugar concentration: 87%

Drop a little of this syrup in cold water and it will form a firm ball, one that won't flatten when you take it out of the water, but remains malleable and will flatten when squeezed. Caramels are cooked to the firm-ball stage.

Hard-Ball Stage
250° F–265° F
sugar concentration: 92%

At this stage, the syrup will form thick, "ropy" threads as it drips from the spoon. The sugar concentration is rather high now, which means there's less and less moisture in the sugar syrup. A little of this syrup dropped into cold water will form a hard ball. If you take the ball out of the water, it won't flatten. The ball will be hard, but you can still change its shape by squashing it. Nougat, marshmallows, gummies, divinity, and rock candy are cooked to the hard-ball stage.

Soft-Crack Stage
270° F–290° F
sugar concentration: 95%

As the syrup reached soft-crack stage, the bubbles on top will become smaller, thicker, and closer together. At this stage, the moisture content is low. When you drop a bit of this syrup into cold water, it will solidify into threads that, when removed from the water, are flexible, not brittle. They

will bend slightly before breaking. Saltwater taffy and butterscotch are cooked to the soft-crack stage.

Hard-Crack Stage
300° F–310° F
Sugar concentration: 99%

The hard-crack stage is the highest temperature you are likely to see specified in a candy recipe. At these temperatures, there is almost no water left in the syrup. Drop a little of the molten syrup in cold water and it will form hard, brittle threads that break when bent. CAUTION: To avoid burns, allow the syrup to cool in the cold water for a few moments before touching it! Toffee, nut brittles, and lollipops are all cooked to the hard-crack stage.

Caramelizing Sugar

If you heat a sugar syrup to temperatures higher than any of the candy stages, you will be on your way to creating caramelized sugar (the brown liquid stage)—a rich addition to many desserts.

Clear-Liquid Stage
320° F
sugar concentration: 100%

At this temperature all the water has boiled away. The remaining sugar is liquid and light amber in color.

Brown-Liquid Stage
338° F
sugar concentration: 100%

Now the liquefied sugar turns brown in color due to carmelization. The sugar is beginning to break down and form many complex compounds that contribute to a richer flavor. Caramelized sugar is used for dessert decorations and can also be used to give a candy coating to nuts.

Burnt-Sugar Stage
350° F
sugar concentration: 100%

Watch out! Above about 350° F, the sugar begins to burn and develops a bitter, burnt taste.

Additional project idea: make candy with adult supervision. Before beginning, make sure to test your candy thermometer by placing it in boiling water. This shows you the necessary adjustments you need to make when cooking. For example if the thermometer reads 209°F when the water is boiling (212° - 209° = 3), then you need to subtract 3 degrees from all the measurements in the recipe. So a firm-ball stage (245° - 250°) will read 242° - 247° on your thermometer. Use both the thermometer and the cold water test to ensure accuracy.