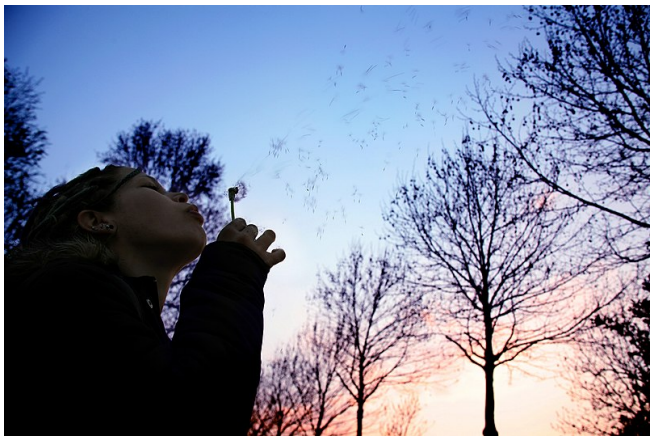
Problems with Purpose

Volume 1

October 23, 2023




Source: Top left photo: https://commons.wikimedia.org/wiki/File:Woman_blowing_dandelion_seeds_in_Paris.jpg

Source: Top right photo: https://commons.wikimedia.org/wiki/File:Sierra%27s_birthday,_campfire_(16209461406).jpg

Source: Bottom left photo: https://commons.wikimedia.org/wiki/File:As08-16-2593.jpg

Source: Bottom right photo by Judith Koeller

Contents

Introduction

The Centre for Education in Mathematics and Computing is situated on the traditional territory of the Neutral, Anishinaabeg and Haudenosaunee peoples. As part of the University of Waterloo campus, the CEMC is located on the Haldimand Tract, the land promised and given to the Six Nations, that includes six miles on either side of the Grand River. We seek to work in the spirit of the University of Waterloo's Indigenous Strategic Plan and the Faculty of Math's EDI-R & I Principles. We partner with educators and work with students who are located across Turtle Island and around the world.

Source: Photos in the Grand River watershed by Judith Koeller

Over the last few years, the Centre for Education in Mathematics and Computing has had many conversations with teachers who are Indigenous, and teachers who teach in Indigenous communities. We talked with folks both from Six Nations and across Turtle Island about how the CEMC could support the calls of the Truth and Reconciliation Commission.

A recurring theme was the importance of exploring mathematics through hands-on activities, with concrete connections to the world around us, experiencing mathematics as a tool that helps communities and the world. In fact, these themes resonate for many students of mathematics, whether or not they are Indigenous.

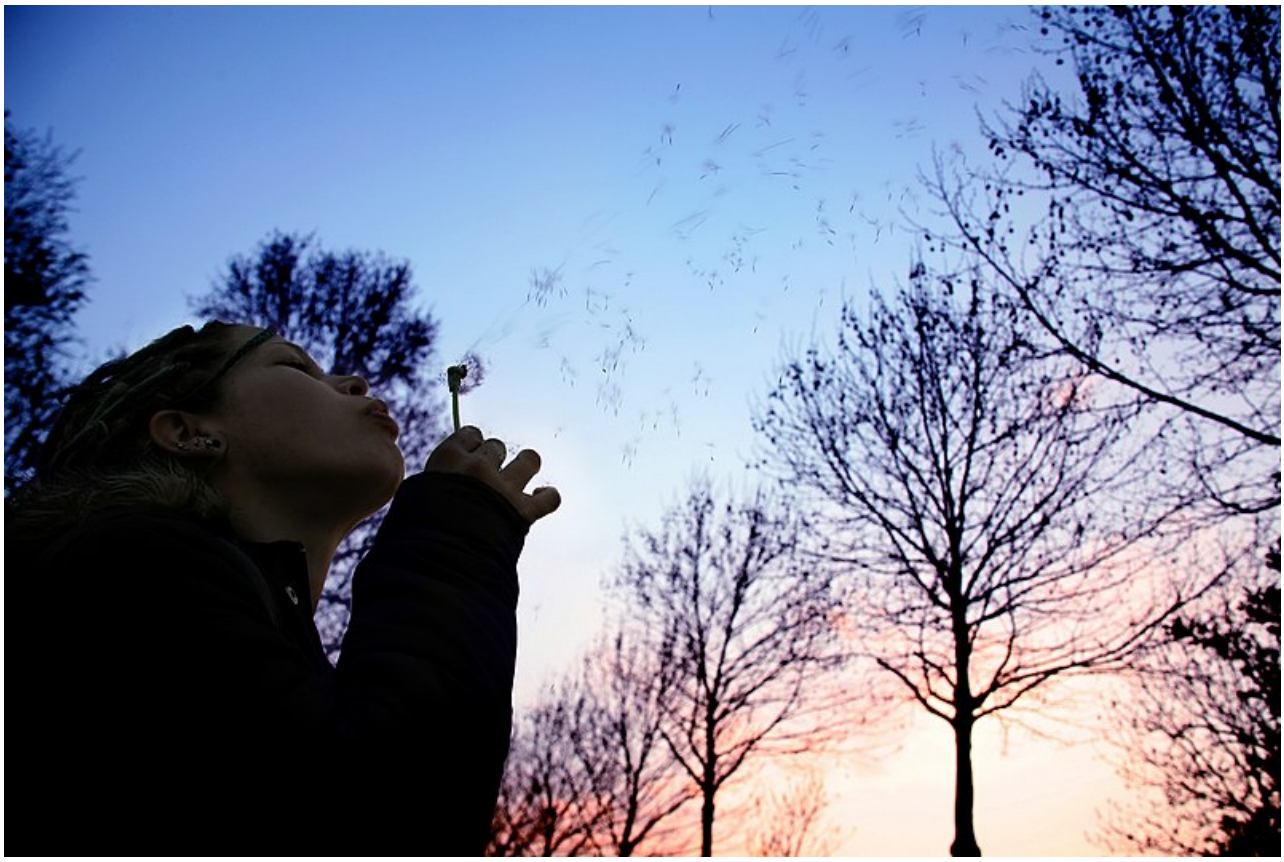
Problems With Purpose is a collection of mathematical problems to be used in grades 4 to 12. Each problem is meant to highlight the connection between mathematics and our collective responsibility to present and future generations. Topics include drinking water, sustainable fishing practices, word searches in the Cree language, demographic trends, and reducing poverty. We welcome your feedback at cemc@uwaterloo.ca.

Acknowledgements

We are grateful to the many folks whose insights, ideas and skills contributed to this project:

Advisory:	Jean Becker	Kathleen Couch	Edward Doolittle	Nathan Rowbottom
	Mark Skanks	Rachel White		
CEMC:	Sandra Emms-Jones	Rob Gleeson	Brian Ingalls	Judith Koeller
	Ryan McGrath	Jen Nelson	Lata Punetha	Nicholas Rollick
	Ian VanderBurgh	Christine Vender		

1 Air

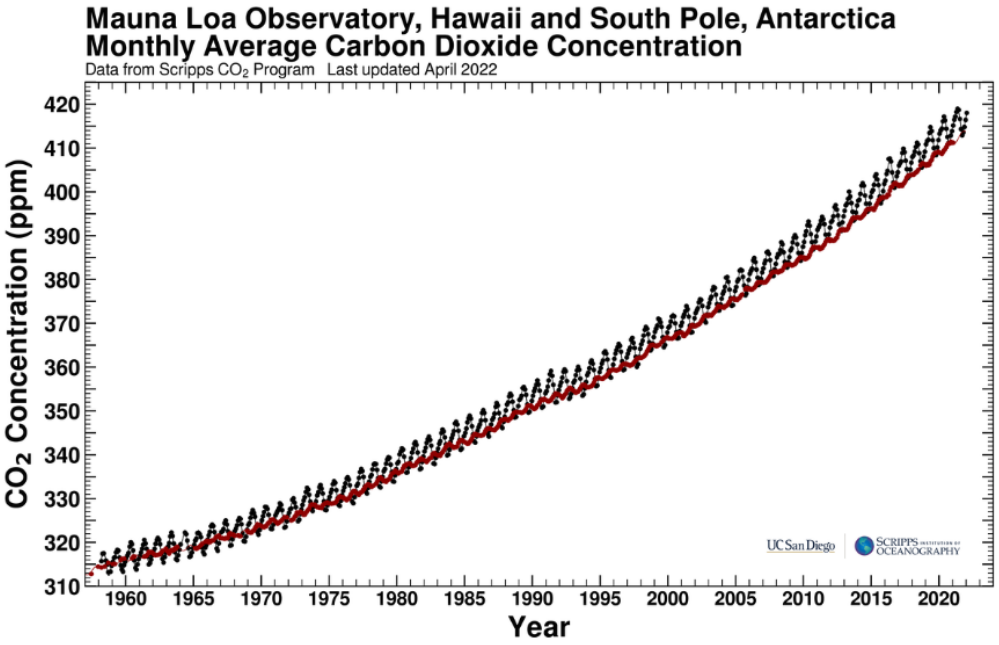


Source: https://commons.wikimedia.org/wiki/File:Woman_blowing_dandelion_seeds_in_Paris.jpg

Climate Change and Mauna Loa

In the graph below, the black curve shows monthly average atmospheric carbon dioxide (CO_2) concentration versus time at Mauna Loa Observatory, Hawaii (20 °N, 156 °W) in parts per million (ppm). Monthly data up to 2022 are shown as dots and connected with straight lines. The black curve goes up and down every year because plants reduce CO_2 levels when in season.
The red curve shows monthly average CO_2 concentration at the South Pole in ppm. Monthly data points are shown as dots and connected approximately by a smooth curve.

Source: https://scrippsco2.ucsd.edu/graphics_gallery/mauna_loa_and_south_pole/mauna_loa_and_south_pole.html



Source: https://scrippsco2.ucsd.edu/graphics_gallery/mauna_loa_and_south_pole/mauna_loa_and_south_pole.html

(a) Why don't the CO_2 levels at the South Pole (red curve) go up and each year, the way that the black curve does?

(b) The climate organization 350.org takes its name from "350 parts per million - the safe concentration of carbon dioxide in the atmosphere".

Source: https://350.org/about/

According to this graph, what is the first year in which the CO_2 concentration reached 350 ppm in Mauna Loa? At the South Pole?

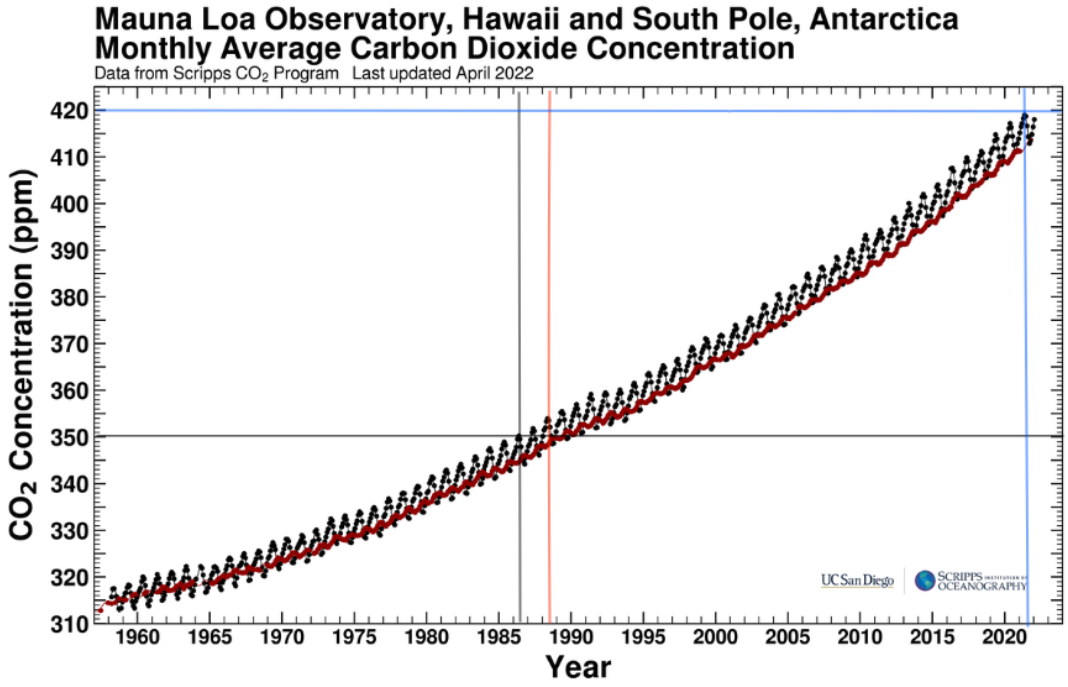
(c) According to the graph, what was the highest CO_2 concentration observed at Mauna Loa in 2021?

(d) Search for the latest data. Do you see significant changes beyond 2022?
https://scrippsco2.ucsd.edu/graphics_gallery/mauna_loa_and_south_pole/mauna_loa_and_south_pole.html

Solution to Climate Change and Mauna Loa

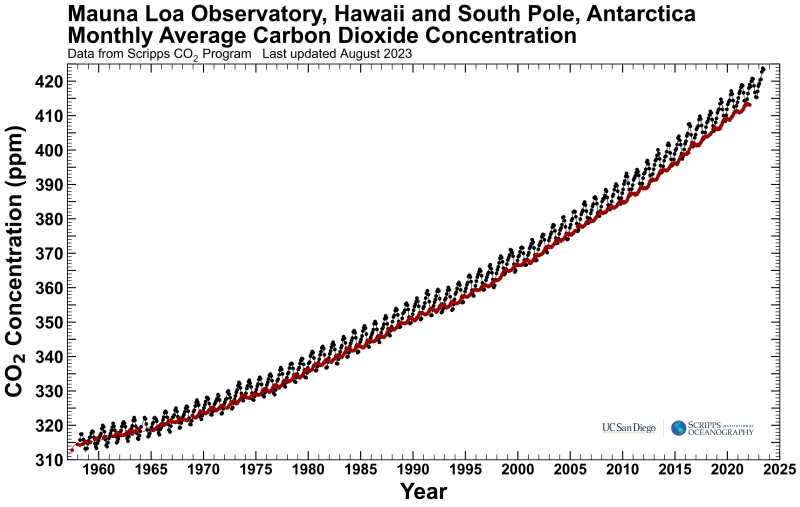
(a) The CO_2 levels at the South Pole (red curve) do not go up and down because there are no plants at the South Pole that could come into season and reduce the CO_2 levels.

(b) The black horizontal line through 350 shows that the CO_2 concentration reached 350 ppm in Mauna Loa in 1986 (black vertical line), and at the South Pole in 1988 (red vertical line).



(c) In the graph above, the blue vertical lines shows CO_2 levels at Mauna Loa reaching as high as 420 ppm in 2021.

(d) This graph downloaded in September 2023 suggests that CO_2 levels continue to increase steadily.



2 Water

Source: https://commons.wikimedia.org/wiki/File:Ocean_water_on_sand.jpg

Fish Wheels

Fish wheels are devices mounted in rivers that are powered by the current of water, much like watermills. Multiple baskets rotate to catch fish and carry them unharmed into submerged holding baskets. Fish wheels have been used for centuries by some Indigenous peoples to catch and monitor fish populations.

Fish wheels are used in K'alii Aksim Lisims, also known as the Nass River, which is one of British Columbia's richest river systems. The Nisga'a Fisheries Management Program uses fish wheels and other technologies for salmon monitoring, tagging, and data collection. The program aims to preserve the river's resources, to provide for Nisga'a citizens, and to support a modern, sustainable fishing industry. For more information, please visit: https://www.nisgaanation.ca/fisheries-management or watch this short video.

A mark-recapture method uses fish wheels to estimate the size of a fish population, as follows. First, a sample of fish are caught, marked, and then released. Later, another sample of fish are caught, and the marked fish in this second sample are counted. If we assume the percentage of marked fish in the second sample is the same as the percentage of marked fish in the population, then we can estimate the population size.

(a) In the first sample, 3150 sockeye salmon were caught, marked, and released. In the second sample, 2050 sockeye salmon were caught. Of these, 180 had been marked. Use these values to estimate the population of sockeye salmon in this river.

(b) In order to avoid overfishing, the local fishery aims to harvest at most 15% of the population of sockeye salmon each year. At most, how many fish should they catch?

(c) If the population of sockeye salmon drops by more than 80% from one year to the next, the fishery closes temporarily so that the fish population has a chance to recover. In the second sample of 2050 fish, what number of marked fish would signal the fishery to close, if the population of sockeye salmon had been 42 350 the previous year?

Source: https://www.nisgaanation.ca/fisheries-management

Solution to Fish Wheels

(a) Let n be the population of sockeye salmon in the river. Since the percentage of marked fish in the second sample is the same as the percentage of marked fish in the population, it follows that:

$$\begin{aligned} \frac{180}{2050} &= \frac{3150}{n} \\ 180n &= 2050 \times 3150 \\ n &= 35875 \end{aligned}$$

Thus, the population of sockeye salmon in the river is approximately 35875.

(b) Since $0.15 \times 35875 = 5381.25$, it follows that they should aim to catch approximately 5381 sockeye salmon.

(c) Since $0.2 \times 42350 = 8470$, that means that if the population of sockeye salmon fell below 8470, the fishery should close temporarily. Let p be the number of marked fish in the second sample, if the population of sockeye salmon is 8470.

$$\begin{aligned} \frac{p}{2050} &= \frac{3150}{8470} \\ 8470p &= 2050 \times 3150 \\ p &= 762.397 \end{aligned}$$

Thus, if the number of marked fish in the second sample was less than or equal to 762, then that would signal the fishery to close temporarily.

Tap Water

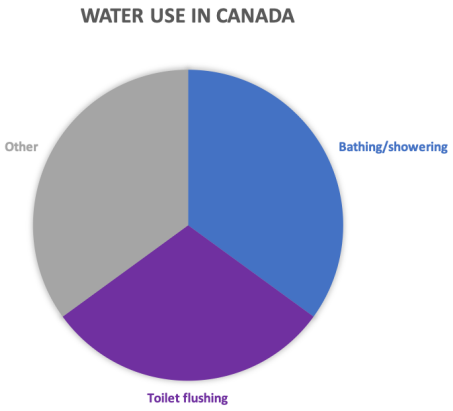
Have you ever wondered how much water your household uses?

1. What types of activities in your home use water from the tap?
2. How many times per week do you take a shower?
   (a) If you take showers, how long is each shower, on average?
   (b) A "standard" showerhead releases water at a rate of approximately 9.5 L/min. (https://www.ecohome.net/guides/2192/are-low-flow-shower-heads-worth-it/) How much water would you use in a single shower with a standard showerhead? How much water would you use in a week taking showers with such a showerhead?
   (c) Low-flow showerheads release water at a lower rate, with some as low as 6.6 L/min. How much water would you save in a single shower by using a low-flow showerhead instead?
   (d) You can measure the flow rate of your own shower by holding a container under the showerhead while it's running and measuring the number of seconds it takes to fill the container. If you use a container with volume of x L , and it takes y seconds to fill the container, how would you calculate the flow rate of your shower, in L/min?

https://commons.wikimedia.org/wiki/File:Drinking_water.jpg

3. How many times per week do you take a bath?
   (a) An average bath can use 100 L of water or more. If you take baths during the week, how many litres of water do you use, assuming each bath is 100 L?
   (b) Using a standard showerhead (9.5 L/min), how long would you have to shower to use more water than a 100 L bath? How about with a low-flow showerhead (6.6 L/min)?
4. How many times per day would you estimate you flush the toilet? (One average figure is 5 flushes per day.)
   (a) Older toilets use as much as 13 L of water for a single flush. If you had an older-model toilet like this, how much water would you use per day on flushing? How much water would you use each week?
   (b) In the Canadian province of British Columbia, provincial policy requires that all new houses have low-flow toilets, with no more than 4.8 L of water per flush (https://www.crd.bc.ca/low-flow-toilet-brochure). If your toilet used 4.8 L of water per flush, how much water would you use per day on flushing? How much water would you save in a day by using one of these toilets instead of a 13 L-per-flush toilet?

5. According to McGill University, bathing and showering accounts for about 35% of all household water use in Canada, and toilet flushing accounts for 30%. The report indicates that, on average, Canadians use about 329 L of water per day.



Source: https://www.mcgill.ca/waterislife/waterathome/how-much-are-we-using

(a) On average, how much water do Canadians use on bathing and showering per week? Is your weekly use more or less than that?

(b) On average, how much water do Canadians use on toilet flushing per week? Is your weekly amount more or less than that?

(c) On average, how many litres of water do Canadians use in a year? Convert your answer to m^3, using the fact that 1 m^3 is equal to 1000 L.

(d) If there are 38 million people in Canada, what is the average yearly water demand for all the people in Canada? How many Olympic swimming pools could this water fill, if one Olympic swimming pool contains 2.5 million L of water?

Solution to Tap Water

1. Some of the most common water-using activities in the home are baths/showers, washing clothes, using the toilet, washing dishes, and watering plants.

2. Answers may vary.

   (a) Suppose each shower is 8 minutes long, on average.

   (b) A single 8 minute shower would use $9.5 \times 8 = 76$ L of water. If we shower 4 times per week, then this would use a total of $76 \times 4 = 304$ L of water.

   (c) A single 8 minute shower with a low-flow showerhead would use $6.6 \times 8 = 52.8$ L of water. This would save $76 - 52.8 = 23.2$ L of water.

   (d) You would calculate $x \div y \times 60$ to obtain the flow rate in L/min.

3. Answers may vary.

   (a) Two baths per week would use a total of 200 L of water.

   (b) Using a standard showerhead, you would use 100 L of water in $100 \div 9.5 = 10.52$ min. Using a low-flow showerhead, it would take $100 \div 6.6 = 15.15$ min.

4. Answers may vary.

   (a) Assuming 5 flushes per day, an older-model toilet would use $13 \times 5 = 65$ L of water per day. This is equal to $65 \times 7 = 455$ L per week.

   (b) Assuming 5 flushes per day, a low-flow toilet would use $4.8 \times 5 = 24$ L of water per day. This would save $65 - 24 = 41$ L of water per day.

5. Answers may vary

   (a) Since $0.35 \times 329 = 115.15$, it follows that on average, Canadians use 115.15 L of water per day for bathing and showering. From question 2, we use less than that.

   (b) Since $0.3 \times 329 = 98.7$, it follows that on average, Canadians use 98.7 L of water per day for toilet flushing. From question 3, we use less than that.

   (c) In one year, Canadians use an average of $329 \times 365 = 120\,085$ L of water. This is equivalent to $120\,085 \div 1000 \approx 120$ m^3 of water.

   (d) The average yearly water demand for all the people in Canada is
   38 million $\times\ 120\,085$L $= 4\,563\,230$ million L.
   This amount of water could fill $4\,563\,230 \div 2.5 = 1\,825\,292$ Olympic swimming pools.

3 Earth

Source: https://commons.wikimedia.org/wiki/File:Grib_skov.jpg

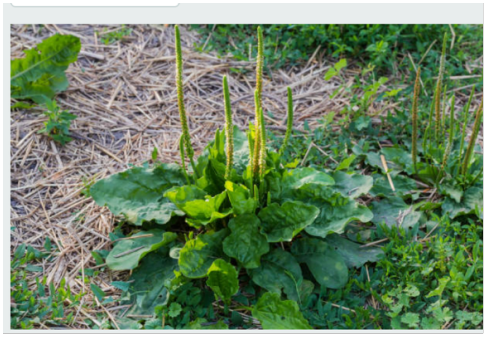
Plant Sampling

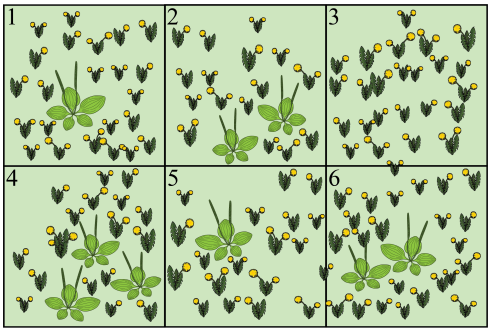
Plant Sampling helps us to understand the interactions of plants, and to determine how fertile soil is.

A quadrat is a square frame that can be placed directly on top of vegetation.

Image Source: https://www.webpages.uidaho.edu/veg_measure/Modules/Lessons/Module%205(Density)/5_2_Plot-based_Techniques.htm

A common perennial is *Plantago Major* (also called broadleaf plantain). It is not closely related to the fruit plantain, which is a kind of banana.





1. The diagram shows six quadrats, some of which contain Plantago Major plants. What proportion of quadrats have at least one Plantago Major plant?

2. Each of the six quadrats measures 1 m by 1 m. For each quadrat, what is the **density** of Plantago Major (that is, how many plants/m^2 are in each of the quadrats)? What is the average density?

3. Plantago Major has a low rosette of basal leaves, that almost completely cover a circle with an average diameter of 20 cm. In each quadrat, determine the area covered by Plantago Major. What is the average area covered? What percentage of the area of each quadrat is covered? What is the average percentage of the area that is covered?

4. When the plant material is weighed, a single Plantago Major plant has an average **biomass** of 1.5 g. Determine the total biomass of Plantago Major plants in each quadrat. Determine the average biomass in g/m^2.

5. **You try it!** Select a common plant species to sample in a "green" section of your school yard (perhaps 20 m by 50 m). Toss a metre stick into the yard. Create a square quadrat by attaching three more metre sticks to the first. Count the number of plants of that species in your quadrat. Use that information to estimate the number of plants of that species in the whole yard. Have classmates perform the same task. Compare your estimates with them. https://www2.nau.edu/lrm22/lessons/quadrat/quadrat.html

Did you know...?
Some species of plantain have been used in the traditional medicine of some Indigenous peoples.

Solution to Plant Sampling

1. The proportion of quadrats that contain at least one Plantago Major plant is $\frac{5}{6}$.

2. The table below shows the density of Plantago Major in each quadrat.

Quadrat	Density (plants / m^2)
1	1
2	2
3	0
4	3
5	1
6	2

   The average density is therefore $(1 + 2 + 0 + 3 + 1 + 2) \div 6 = 9 \div 6 = 1.5$ plants/m^2.

3. The radius of an average Plantago Major plant is $20 \div 2 = 10$ cm. The area covered by an average Plantago Major plant is therfore $\pi \times 10^2 = 100\pi \approx 314$ cm^2. The area of each quadrat is 100 cm $\times$ 100 cm $= 10000$ cm^2.

   The table below shows the area covered by Plantago Major in each quadrat as well as the percentage of each quadrat that is covered by Plantago Major.

Quadrat	Area Covered (cm^2)	Percentage of Quadrat Covered
1	314	$314 \div 10000 \times 100 = 3.14$
2	628	$628 \div 10000 \times 100 = 6.28$
3	0	0
4	942	$942 \div 10000 \times 100 = 9.42$
5	314	$314 \div 10000 \times 100 = 3.14$
6	628	$628 \div 10000 \times 100 = 6.28$

   The average area covered is therefore $(314+628+0+942+314+628) \div 6 = 2826 \div 6 = 471$ cm^2.

   The average percentage of each quadrat covered is therefore $(3.14 + 6.28 + 0 + 9.42 + 3.14 + 6.28) \div 6 = 28.26 \div 6 = 4.71$.

4. The table below shows the total biomass of Plantago Major plants in each quadrat.

Quadrat	Total biomass (g / m^2)
1	1.5
2	3
3	0
4	4.5
5	1.5
6	3

   The average density is therefore $(1.5 + 3 + 0 + 4.5 + 1.1 + 3) \div 6 = 13.5 \div 6 = 2.25$ g/m^2.

Polar Bears

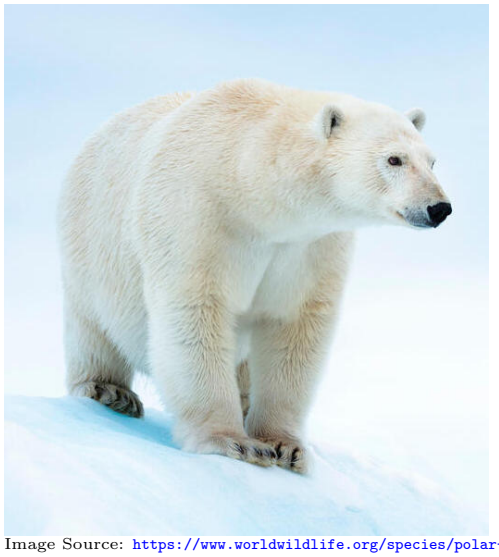


Image Source: https://www.worldwildlife.org/species/polar-bear

A team of biologists wish to estimate the size of a polar bear population within a specific region of the Arctic. On their first visit, they capture, tag and release 40 polar bears. On their second visit, they capture and release 60 polar bears, of which 15 already have tags.

(a) What is the minimum polar bear population size possible? Can we determine a maximum?

(b) Give a realistic estimate for the total polar bear population. What assumptions does your estimate reply upon?

Solution to Polar Bears

(a) Since they captured and released 60 polar bears on their second visit, we can conclude that the polar bear population size must be at least 60. However we cannot determine a maximum with the information given.

(b) In order to estimate the population size, we will assume that the proportion of polar bears with tags in the second sample is the same as the proportion of all polar bears in the population with tags. Let p be the polar bear population size. Thus,

$$\begin{aligned} \frac{15}{60} &= \frac{40}{p} \\ 15p &= 60 \times 40 \\ 15p &= 2400 \\ p &= 2400 \div 15 = 160 \end{aligned}$$

Thus, we can estimate that the polar bear population size in that region is approximately 160.

4 People

Source: https://commons.wikimedia.org/wiki/File:Sierra%27s_birthday,_campfire_(16209461406).jpg

Cree Word Search

Dr. Edward Doolittle uses his skills in mathematics to promote the Cree language by creating Word Search puzzles. Given a list of Cree words, his computer programs place those words into a grid. This activity explores some of the computational thinking it takes to create a word search.
Note: There are two ways to write Cree words: Roman orthography (as in questions 1 and 4), and Cree syllabic (as in questions 2 and 3).

1. Find the following six Cree words in the grid to the right. The words are arranged L-R (left to right) or U-D (up to down), but not along the diagonal.
Note: ā is different from a, and ē is different from e.

m	i	s	t	ā	p	o	s	ā
w	ā	p	i	s	i	w	s	w
a	m	a	m	i	s	k	i	ā
c	ē	w	ā	p	o	s	h	p
a	m	n	i	k	i	k	k	i
s	i	k	ā	k	w	a	o	s
k	m	a	s	k	w	a	s	t
s	ā	k	w	ē	s	i	w	ā
n	i	k	w	a	c	ā	s	n

Cree / **English**				
Cree	amisk	mistāpos	wāpistān	
English	beaver	jackrabbit	martin	
Cree	sihkos	nikik	sikāk	
English	weasel	otter	skunk	

2. The following 3 by 3 grid includes words arranged L-R (left to right) or U-D (up to down), but not along the diagonal. Find all the words listed.

ᐊ	ᓂ	ᑭ
ᓂ	ᐌ	ᐦ
ᒪ	ᐦ	ᖆ

Cree / **English**					
Cree	ᐊᓂᒪ	ᒪᐦᖆ	ᑭᐦᖆ	ᐊᓂᑭ	ᓂᐌᐦ
English	that	let's see	the best	those	my heart

Why was the ᐊ placed in the top left of the grid?
Why was the ᖆ placed in the bottom right?

3. Fill in the grid so that the following words appear either L-R or U-D.
Hint: The character ᐁ is important because it comes at the beginning of the word ᐁᐧᐸᐣ and at the end of the word ᒐᓂᐁ.

Cree / **English**					
Cree	ᒐᓂᐁ	ᐁᐧᐸᐣ	ᓂᐸᐸ	ᑲᐸᐣ	ᒐᓂᑲ
English	where is she?	it's white	my father	he comes ashore	would that

4. Can a 3 by 3 grid include all the following words either L-R or U-D?

Cree / **English**				
Cree	āta	itē	ēha	ōyā
English	although	there	yes	that one is no longer there

Fill in the grid or explain why it is impossible to do so.

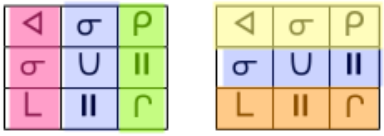
Sources: Dr. E. Doolittle's talk http://www.birs.ca/events/2012/5-day-workshops/12w5076/videos/watch/201211210914-Doolittle.html at 1:10:00, and some translations from the Online Cree Dictionary. Thank you to Dr. E. Doolittle for sharing Cree language word searches and resources, and for providing advice on this topic.

Solution to Cree Word Search

1.

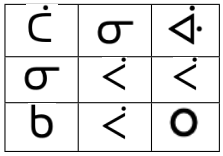
m	i	s	t	ā	p	o	s	ā
w	ā	p	i	s	i	w	s	w
a	m	a	m	i	s	k	i	ā
c	ē	w	ā	p	o	s	h	p
a	m	n	i	k	i	k	k	i
s	i	k	ā	k	w	a	o	s
k	m	a	s	k	w	a	s	t
s	ā	k	w	ē	s	i	w	ā
n	i	k	w	a	c	ā	s	n

2.



The ᐊ was placed in the top left of the grid because it is the first character in the word ᐊᓂᒪ (arranged U-D), and ᐊ is also the first character in the word ᐊᓂᐢ (arranged L-R).
The ᕀ was placed in the bottom right of the grid because it is the last character in the word ᐢᐦᕀ (arranged U-D), and ᕀ is also the last character in the word ᒪᐦᕀ (arranged L-R).

3.



4. It is impossible to include all the words in a 3 by 3 grid.
The four 3-letter words total 12 letters, and the grid contains 9 letters. That means there must be at least 3 letters that appear both U-D in one word and L-R in another word. Only the following letters have two words in common, and at least three of those letters must be placed as described.

Letter	ā	t	a	ē
Placement in one word	1st	2nd	3rd	1st
Placement in the other word	3rd	2nd	3rd	3rd

In order for the character "a" to appear 3rd in two words, the letters must appear in one of the ways shown to the right. In order to place the word "ōyā" we would need an ō in the top left, but in order to place the word "itē", we would need an i in the top left.

		ā
		t
ē	h	a

or

		ē
		h
ā	t	a

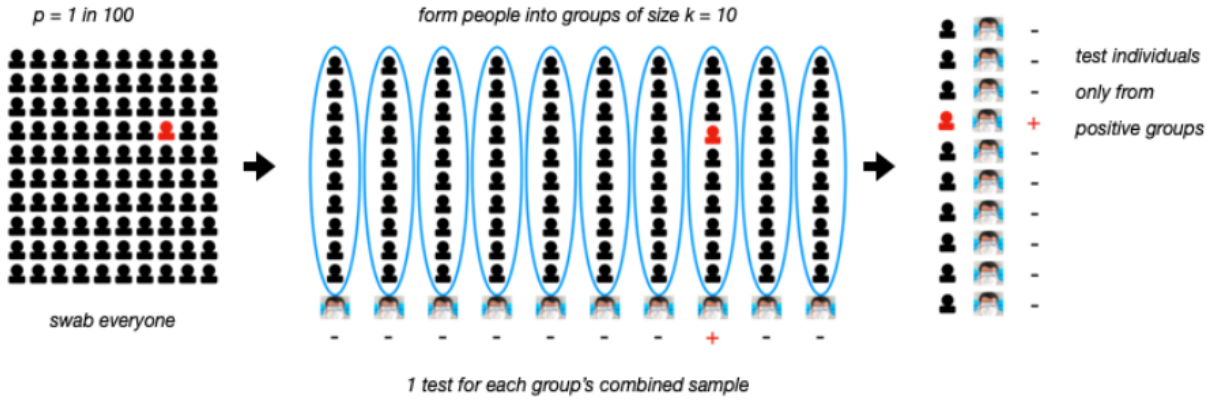
Efficient Testing for COVID-19

During the COVID-19 pandemic, did you ever wonder whether you had COVID but found it difficult to get a test? Dr. Wayne Oldford uses his math skills to help test more people for disease, using a smaller number of tests. This technique is called **Block Testing**.

At some points in the COVID-19 pandemic, the **test positivity rate** was predictable. Suppose for example, that of people tested, about 1 in 100 were infected. This information could be used to *Block Test* 100 people using fewer than 100 tests; that is, the **number of tests needed per person** could be less than 1. The lower the number of tests needed per person, the better.

Source: https://commons.wikimedia.org/wiki/File:Groupe_de_tubes_dans_%C3%A0_Cotonou_07.jpg

When testing 100 people, the samples would be combined into 10 groups, each containing $k = 10$ people. Each of the 10 combined samples would be tested (using 10 tests). Whichever group tested positive would then have each of its ten members tested individually (using 10 more tests). Since only 20 tests were needed to test 100 people, there were $\frac{20 \text{ tests}}{100 \text{ people}} = 0.2$ tests needed per person.



(a) *Block Testing* uses fewer tests to test the same number of people. Why is this good?

(b) Suppose that the test positivity rate was 1 in 100, and 1,200 people were to be *Block Tested* using groups of size $k = 10$. How many groups would be needed? How many people would we expect to be infected?

(c) What is the highest possible number of tests that could be needed? How many tests would be needed per person in this case?

(d) What is the lowest possible number of tests that could be needed? How many tests would be needed per person in this case?

Source: https://www.math.uwaterloo.ca/~rwoldfor/COVID19/poolingSamples.html

Solution to Efficient Testing for COVID-19

(a) If the number of tests available is limited, then Block Testing allows more people to be tested using that limited number of tests. It also reduces the environmental impact from producing and processing all of the tests.

(b) The number of groups would be $1,200/10 = 120$.

The number of people we would expect to be infected is $1,200/100 = 12$.

(c) The highest number of tests would be needed if each of the 12 infected people were in a different group. We would first test each of the 120 groups. There would be 12 groups whose combined samples were infected, so then we would test each of the $12 \times 10 = 120$ individuals in those groups. The total number of tests would be $120 + 120 = 240$.

Since this is used to test a total of 1,200 people, the number of tests per people would be $\dfrac{240 \text{ tests}}{1,200 \text{ people}} = 0.2$ tests needed per person.

(d) The lowest number of tests would be needed if the 12 infected people were initially in the same groups. Since the group size is $k = 10$, the 12 infected people could all be within 2 of the groups. We would first test each of the 120 groups. There would be 2 groups whose combined samples were infected, so then we would test each of the $2 \times 10 = 20$ individuals in those groups. The total number of tests would be $120 + 20 = 140$.

Since this is used to test a total of 1,200 people, the number of tests per people would be $\dfrac{140 \text{ tests}}{1,200 \text{ people}} \approx 0.117$ tests needed per person.

Poverty and the Market Basket Measure

For a country to develop strategies for reducing poverty, it is helpful to understand how widespread poverty is. The infographic to the right depicts the 2015 Market Basket Measure, which is the typical cost for necessities of life in Canada in 2015.

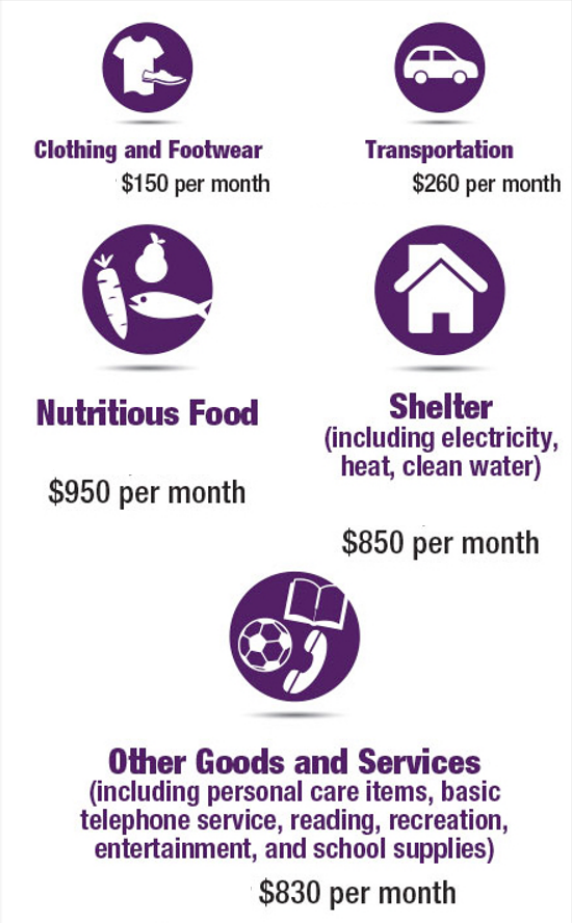
(a) What is the total cost per month of the five categories in the 2015 Market Basket Measure?

(b) Which of the five categories is the most expensive?

(c) What percentage of the total monthly cost goes to Nutritious Food? What percentage goes to Shelter?

(d) Minimum wage in Ontario was $11.25 per hour in 2015. A full-time worker typically works 8 hours per day for about 21 days per month. Is this enough to earn your amount in #1? How many 8-hour days per month would a minimum wage earner need to work to earn your amount in #1?

(e) Search for "Market Basket Measure" to find more recent average costs. How did the total cost per month change?



(f) Minimum wage is now higher than it was in 2015. Search for the current minimum wage, and use more recent Market Basket Measure numbers. If a person earning minimum wage works the same number of hours as in #4, do they earn enough for these monthly costs? What would the minimum wage need to be in order to afford the necessities in the Market Basket Measure?

Source: https://www.canada.ca/en/employment-social-development/programs/poverty-reduction/reports/strategy.html

Solution to Poverty and the Market Basket Measure

(a) The total cost per month is $\$150 + \$260 + \$950 + \$850 + \$830 = \$3,040$.

(b) The most expensive category is nutritious food, as $950 per month.

(c) Nutritious food takes $\frac{\$950}{\$3,040} \times 100\% \approx 31\%$ of the total monthly cost.

Shelter takes $\frac{\$950}{\$3,040} \times 100\% \approx 28\%$ of the total monthly cost.

(d) A full-time worker works $8 \times 21 = 168$ hours per month.

In a month at minimum wage, they earn $168 \text{ h} \times \$11.25/\text{h} = \$1,890$. This is considerably less than the monthly cost of the Market Basket Measure, which is $3,040.

In order to earn $3,040 while being paid $11.25 per hour, the number of hours worked would need to be $\frac{\$3,040}{\$11.25/h} \approx 270.2$ hours. The number of 8-hour days worked would need to be $270.2/8 \approx 33.8$, and there aren't that many days in a month.

(e) The yearly Market Basket Measure (MBM) rates are list at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1110006601 for each region of Canada. In 2022 for Ontario, population 500,000 and over, the yearly MBM is $51,468, so the monthly MBM is

$\frac{\$51,468}{12} = \$4,289$, up significantly from $3,040 in 2015.

(f) As of March 2023, Ontario's minimum wage was $16.55 per hour. We saw earlier that a full-time worker works $8 \times 21 = 168$ hours per month. In a month at minimum wage, they earn $168 \text{ h} \times \$16.55/\text{h} = \$2,780.40$. This is still much lower than the 2022 MBM of $4,289.

In order for someone working full-time at minimum wage to earn the 2022 Market Basket Measure, they would need to earn $4,289 in 168 hours. Minimum wage would need to be $\frac{\$4,289}{168} \approx \$25.53$.

Counting People by Age Group

According to Statistics Canada, the number of people in Canada in 2021 in each age range is shown in the table to the right.

0 to 4 years	1,831,195
5 to 9 years	2,054,895
10 to 14 years	2,126,700
15 to 19 years	2,012,975
20 to 24 years	2,202,260
25 to 29 years	2,421,505
30 to 34 years	2,518,830
35 to 39 years	2,511,350
40 to 44 years	2,399,400
45 to 49 years	2,304,175
50 to 54 years	2,368,355
55 to 59 years	2,647,325
60 to 64 years	2,571,585
65 to 69 years	2,210,975
70 to 74 years	1,847,580
75 to 79 years	1,260,935
80 to 84 years	840,550
85 to 89 years	525,440
90 to 94 years	258,035
95 to 99 years	68,385
100 years and over	9,540
Total	36,991,990

(a) From 2021-2026, we can expect people aged 15 to 19 years to enter the work force, while the people aged 60 to 64 years will leave it. Will this result in the number of people in the work force going up or down? By how many?

(b) What impact might we expect this to have on the job market?

(c) From 2021-2026, we can expect the people aged 0 to 4 years to begin attending school, while the people aged 15 to 19 years will leave it. Will the number of people in school go up or down? By how many?

(d) How might school boards use the above information to plan ahead?

(e) Which age range has the most people in it? What percent of the total Canadian population does that age group comprise?

(f) Look for more recent census data from Statistics Canada about the number of people by age group. Which age group has changed the most compared to the 2021 data?

Source:

Statistics Canada. Table 98-10-0020-01 Age (in single years), average age and median age and gender: Canada, provinces and territories, census metropolitan areas and census agglomerations with parts

https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=9810002001

Source: https://commons.wikimedia.org/wiki/File:Hmong_people_old_young.jpg

Solution to Counting People by Age Group

(a) If the 2,012,975 people aged 15 to 19 years old enter the work force while the 2,571,585 people aged 60 to 64 years old leave it, then the number of people in the work force will go down by 2,571,585 - 2,012,975 = 558,610 people.

(b) If this is the only change to the work force, it will create more job vacancies. However, there are many other influences to the number of jobs, like immigration, self-checkouts, artificial intelligence and more.

(c) If the 1,831,195 people aged 0 to 4 years old begin attending school while the 2,012,975 people aged 15 to 19 years old leave school, then the number of people in school will go down by 2,012,975 - 1,831,195 = 181,780 people.

(d) School boards might plan by closing schools, building fewer new schools, or offering early retirement to teachers.

(e) The age range with the most people is from 55 to 59 years old. They represent $\frac{2,647,325}{36,991,990} \times 100\% \approx 7.2\%$ of the total Canadian population.

(f) As of Fall 2023, this is the most recent data.

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