Math 1112

Unit 4: Numbers in Action

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Numbers as quantities: and Introduction.

There is an ongoing tension in mathematics between the abstract and the concrete. To be sure mathematicians and non-mathematicians use abstract constructions (like exponential functions) to think about various aspects of the world around them (like the growth of number of new cases of covid-19), but mathematicians also use phenomena in the concrete world around them to think about abstract mathematics and create new mathematical objects when the existing ones are shown to be inadequate.

In units 1-3 we focused our energy on studying numbers and their relations. Then we took a quick peek at more complex abstract mathematical (algebraic) objects and their relations. From this unit until the end of the course we will use numbers and other abstract objects to think about the concrete world around us. The magic of numbers (and other mathematical objects) happens when they represent quantities and the behaviours of

Numbers can represent quantities as **counts of counts of concrete objects** (3 carrots left in the fridge) or **portions of concrete objects** (3 and a half carrots left in the fridge)**.**

The objects that get counted can be **concrete** objects (10 000 protesters in the streets) or **abstract** objects, like standardized units of measure (my head circumference is 52cm, or the volume of my head is 3.3 litres).

Numbers can also represent relations between, or combinations of 2 or more quantities (25 ventilators per hospital, or 3.7 new cases of covid-19 per 100 000 population, or 5.1 km per hour). These are called **rates, ratios, and proportions**.

What you will do:

I. Practice distinguishing between types of quantities
II. Change representations of various quantities to and from simplest form
III. Make comparisons of objects or populations of objects (data), read and interpret charts and graphs (especially contingency tables), examine growth or reduction over time, and make simple inferences based on given scenarios

Though not every concrete situation in this unit will be familiar to you, you will practice deciphering them as puzzles using the basic number and algebra skills you reviewed in Units 1-3 and other abstract tools (like contingency tables) to organize the information provided.

I have tried to create problems in health care and other contexts that will be accessible, even when unfamiliar to you.

Exercise 1: distinguish between types of quantities On the previous page you read about and saw examples of how numbers can represent counts of concrete or abstract objects. Read each of the following statements and decide whether it is:

I. a count of concrete objects,
II. a count of abstract objects as units of measurement of one or more concrete objects,
III. a combination of concrete and abstract.

Give one reason to support that your answer is correct.

a. The average Canadian male has a higher BMI than the average Icelandic male.

b. 51 out of 85 campers are hungry

c. He was traveling 345 km per hour

d. Yesterday in Ontario we had 163 new cases of covid-19

e. How much water is needed for the recipe?

f. One 5lb bag of onions is consumed per week in our household

g. Our family eats 30 onions per week

h. The Score in the basketball game was 109 to 87

i. His mark on the test was 39 out of 57

j. Medication dose is 2 tablets 3 times a day

k. Waterflow of a river is 24 000 litres per second

Exercise 2: Some quantities are counts of whole objects, while others can be represented by parts of wholes. Identify the following statements as 'whole objects' or ones that can exist as wholes or as parts of wholes.

a) cans of tuna

b) protesters at a rally

c) time to complete this page of questions

d) 345,278 rolls of toilet paper for 12 panic shoppers

e) 874 of 895 beds are occupied

Rate and Ratio as related quantities The terms rate and ratio are used interchangeably and can be expressed in a variety of ways: most often with a colon between the 2 values (ratio # of females to #of males in HIM program is 3:2) or as numbers with numerator and denominator 3/2 or $\frac{3}{2}$. They are typically reduced to lowest terms or presented in a format that makes them meaningful in the context in which they are being used (e.g. 7.3km per hour rather than $\frac{146\ km}{20\ hrs}$).

Rate and Ratio quantities: 3 scenario types

I. ***Quantity as Portion of Whole:*** 85 out of 102 students who come to class end up with a mark > 70. This can be expressed mathematically in multiple ways to make the rate clearer. It could be simplified to lowest terms (5 out of 6 or $\frac{5}{6}\ students$ ...); or more likely to per cent (83.33% of students…).

II. ***Quantity per Individual:*** Imagine that there are 50 charts coded by 15 coders. This can be expressed mathematically in multiple ways: in lowest terms (which is not very elegant), as 10 charts per 3 coders ($since\ \frac{50}{15} = \frac{10}{3}$); or simplified to $3.33\dot{3}$ charts per 1 coder which makes more sense.

III. ***Quantity per population***: Health statistics like rates of disease in a population are often represented with denominator as a factor of 10 (usually 10,000 or 100,000 – depending on how rare the disease is). In 2006 in Canada there were 1,456 new cases of AIDS in an adult population of 32 million. The incidence rate of AIDS (1,456 per 32 million) is typically transformed (by dividing numerator and denominator by same number – 320) to a ratio of 4.55 per 100,000 as a simpler form.

Exercise 1: (simplify rates and ratios and identify ratio type):

Identify as type I, II, or III:

	Narrative	**Identify type as I, II, or III**
a	51 out of 85 campers are hungry	
b	49 campers to 5 campsites	
c	7700 campsites for 14,500,000 Ontario residents	
d	59% of visitors to Algonquin park went canoeing	
e	Water flow of Magnetawan River in June is 24,000L per second	

<u>Restate rate/ratio into appropriate simpler form</u> Use your mastery of number thinking tools from units 1 and 2 to complete the following exercise.

<u>Exercise 1:</u> (simplify rates and ratios and identify ratio type) Identify each narrative as type I (portion of whole), type II (quantity per person) and type III (quantity per population) then rewrite the rate/ratio quantities in simpler form:

a) 51 out of 85 campers are hungry

b) 49 campers to 5 campsites

c) 345,278 teenagers out of 500, 000citizens

d) 456km : 5 hours

e) 345,278 citizens to 12 doctors

f) 874 of 895 beds are occupied

g) 756 existing cases in a population of 345,000 {rewrite per 100,000}

h) 12 new cases in a population of 145,000,000 {rewrite per 100,000}

<u>Exercises: Use 'Percent as a portion of' in classroom context</u>: Use your mastery of number tools from units 1 and 2 to complete the following exercises.

<u>Exercise 1:</u> You receive 37/44 on a test. What is that in %?

<u>Exercise 2:</u> You received 37 out of 51 on test 1. You would like to maintain your average mark with the second test. What mark must you get on test 2 (which is out of 73 marks) in order to maintain your average?

<u>Exercise 3:</u> You need 60% on your final exam to pass the course. The exam is out of 75. How many marks do you need to pass the course?

<u>Exercise 4:</u> You have 23 marks out of 50 in your term work going into the final exam of a math course. The final exam is worth 50 marks. If the exam itself is out of 77, and you get 42, what will be your final grade in the course? Would you pass if the passing mark is 60?

<u>Exercise 5:</u> You have 37 marks out of 60 possible going into the final exam of a math course. The final exam is worth 40 marks. If the exam itself is out of 83, what score do you need in order to get a 60 in the course?

<u>Exercise 6:</u> You have 80% in your term work – worth 60 marks towards your final grade. The final exam is worth 40 marks. If the exam itself is out of 70, what score do you need in order to get a 60 in the course?

<u>Exercise 7:</u> You have earned 35 marks out of 60 in your term work. On the final exam (which is worth 40 marks towards your final grade) you get 45/67.

a. how many marks (out of 40) did you earn on the final exam?
b. Calculate your final grade
c. Did you pass the course? Passing mark is 60.

Exercises: Use 'Percent as a portion of' in health contexts: Use your mastery of number tools from units 1 and 2 to complete the following exercises.

Exercise 1: The rate of infection in newborns at hospital Y is 2.83%. Given that there were 777 births in the hospital in 2010, how many newborns had an infection?

Exercise 2: The Canadian Cancer Society claims that 2.1% of the population of Canada has had cancer. If the population of Canada is 33,390,141, how many people have had cancer?

Exercise 3: The occupancy rate of a hospital is defined as the % of beds occupied at midnight. 96.05% of available beds.

a. If the occupancy rate of Happy Hospital on Sept. 7^{th} 2013 is 96.05% and the hospital has 937 beds in total, how many beds are free?

b. If 7 people are discharged from the hospital and 5 are admitted, what is the new occupancy rate?

Exercise 4: Another (smaller) hospital has 444 beds, but only 12 are free. What is its occupancy rate?

Exercise 5: Bed occupancy in a hospital is 90.56%. The hospital is staffed for 975 beds. How many beds are occupied?

Exercises: Use 'Percent as a portion of' in contexts with money: Use your mastery of number tools from units 1 and 2 to complete the following exercises.

Exercise 1: Your paycheque should increase with inflation. Inflation is at about 2.1%. If your pay is $450 per week, what will be your pay after the increase if you get a raise at the rate of inflation?

Exercise 2: If there is a discount of 25% on a used textbook that retails for $77, how much is the discount?

Exercise 3: You have just been approved for a two part raise from your boss. 2% right now, and 3% in 6 months. If you are making $1,234 before the approval, how much will you be making in 6 months?

Exercise 4: If The Canadian Government dropped the GST from 7% to 6% in July, 2006. How much money would you save on buying a bicycle that sells for $254.77?

Exercise 5: Which is cheaper? Coat#1 retails for $44 and is 25% off. Coat #2 retails for 60$ and is 40% off.

<u>Compare Quantities: Raw and Percent Differences:</u> use skills you have reviewed in units 1 and 2 to build your understanding of how to do the following.

<u>Example 1: think about this number relation</u>

Given that 13 is 108.333% of 12, the following must also be true: 13 is 8.333% greater than 12.

<u>Exercise 1:</u> 7. Joe is 177cm tall and Belinda is 145cm tall.

a. How much taller is Joe than Belinda (raw difference)? How much shorter is Belinda than Joe?

b. Convert that difference to a percentage: Joe is ____% taller than Belinda.

c. Belinda is _____ % shorter than Joe – not the same as answer for b☺

<u>Exercise 2:</u> On July 1st of 2007, the Toronto Stock Exchange (TSX) index was at a high of 14,625.76 points. By mid July it fell to 12,848.7 points.

(a) what was the percentage drop?

(b) what percentage must the TSX increase to get back to its high of 14,625.76 points.

<u>Exercise 3:</u> In 2007, the average price of a waterfront home in Brevard County, Florida was $1,004,000. In 2008 it fell to $678,000.

(a) what is the percent drop?

(b) what percentage must the average house price increase to get back to 2007 levels?

Compare rates/ratio quantities by restating into simplest form: Different approaches are needed for the different scenario types but in each one you'll see that having both rates in the same unit makes difference easier to see. Solutions are presented as arguments justifying the reason for each decision and procedure used.

Example type I: Algys got 74 out of 97, while his cousin Saama got 12 out of 15 on a similar test that was graded differently in another section of the same course. Who did better on the test?

This is a type 1 problem as test scores are portions of wholes, meaning that we can simply convert both scores to % to do the comparison.

Aljus got 74 out of 97, which converts to 76.3% i.e. 76.3 points out of 100 possible; while Saama got 12 out of 15 which converts to 80% i.e. 80 points out of 100 possible;

We can see that Saama did better on the test as her percentage score was higher.

Example type II: Which car is faster? car1- traveling at 100km/hr; or car2 - traveling at 3m/s;

This is a type II problem as speed is expressed as a quantity of distance per unit of time. Start by converting to common units; we'll start with car 1.

Distance: 100km = 100 000m. Time 1 hour = 60mins = 3600s

The speed of car 1 then is $\frac{100\ km}{1\ hour} = \frac{100000m}{3600s}$

Next: Convert that speed to distance per 1 second

$$\frac{100\ 000\text{m}}{3600\text{s}} = \frac{100\ 000m \div 3600}{3600s \div 3600} = 27.78\text{m/s}$$

Then: Reword the question with common units in simplified form: Which is faster car1 - traveling at 27.78 m/s; or car2 - traveling at 3m/s?

Finally: Car1 travelling at 100km/hr (= 27.8m/s) is faster than car2 at 3m/s.

Example type III: Which country had a higher rate of death from Covid-19 as of June 18, 2020 (in deaths per million population)? Sweden (4939 deaths per 10,230,000) or Canada (8213 deaths per 37,590,000);

Sweden: divide 10,230,000 by 10.23 to get 1 million; and thus divide 4939 by 10.23 to get #deaths per million (482.8)

Canada: divide 37,590,000 by 37.59 to get 1 million; and thus divide 8213 by 37.59 to get #deaths per million (218.49)

This allows us to see that the Swedish death rate as of June 18 (482.8 per million) was quite a bit higher than Canada's (218.5 per million)

Exercises: compare rates   type I

Exercise 1: One test 1 your mark was 45 out of 67; in test 2 it was 32 out of 46. Your teacher tells you that you need to choose which test counts towards your final mark. Which test do you choose?

Exercise 2: Which team has the best winning percentage? Team A won 457 out of 621 games, while Team B won 823 out of 912 games.

Exercise 3: A trial was conducted in which two exema drugs were compared for success in reducing symptoms from severe to mild form after a 6 month trial.
422 individuals with severe exema were entered into the experiment. 145 tried drug A (with 82 deemed successful) the rest used Drug B (with 100 deemed to be successful). Which drug had a higher rate of success? How much more successful was it? Describe whether the difference is large enough for you to believe one drug is more effective that the other.

Exercise 4: Hospital A has 456 out of 462 beds occupied, while Hospital B has 2345 out of 2443 beds occupied. Which hospital has a higher bed occupancy rate? Is the difference significant?

Exercises: compare rates   type II

Exercise 1: . Which is faster car A: traveling at 50km per hour or car B: at 12.7m/s - by how much?

Exercise 2: Which cheese is cheaper Gouda @ $4.25 per pound (454g) or Cheddar @ $0.99 per 100g and by how much?

Exercise 3: Which is slower car A: traveling at 120 km per hour or car B: at 5m/s - by how much?

Exercise 4: Which is more expensive corn chips $1.00 per 64g or potato chips $2.65 per 150g and by how much?

Exercise 5 : Which is cheaper, a German beer at $2.20 for 500ml or the Canadian at $10.00 for a six pack (345ml each)?   How much cheaper is it?

Exercises: compare rates type III

Exercise 1: In 2010 Hospital Q had 55 people die out of 9994 admitted, while Hospital R (a much smaller hospital) had 12 people die out of 1127 admitted.

a. How many more people died in hospital Q compared with hospital R in 2010? Why is this not a fair measure of their success in keeping people alive?

b. Which hospital had a higher mortality (per 1000 admitted)? How much higher was it?

c. Did you notice anything else about the death rates when comparing them?

Exercise 2: In hospital X there are 7 deaths per 1445 admissions, while in hospital Y there are 9 deaths per 1555 admissions. Which hospital has the higher gross death rate? How much higher is it?

Exercise 3: In hospital A 334 out of 450 beds are occupied, in hospital B 447 out of 500. Which has a higher rate of occupancy? How much higher is it?

Exercise 4: The incidence rate of pancreatic cancer in Toronto is 4.5 per 100 000 population while in Bangalore Maine it is 0.37 per 10 000. Which city has the higher incidence rate? How much higher is it?

<u>Decision making with rates</u>

Slow thinking question

Tuna X sells for $1.39 for a 225g can; Tuna Y sells for $1.22 for a 150g can. Assume that they are comparable quality.

a. Come up with a scenario in which it makes sense to buy Tuna X.

b. Come up with a scenario in which it makes sense to buy Tuna Y.

c. Which is cheaper (per 100g)?

d. Is the price difference (from c) enough to influence your purchase decision? Explain.

Contingency Tables: helps us organize information where we are looking at 2 characteristics of a group of individuals simultaneously. We can then break these individuals into groups for comparison purposes!

Example 1: Let's look at data from the Canadian Community Health Survey. 670 randomly sampled Canadians were asked whether they had diabetes, and whether they had ever smoked daily. The data was tabulated into a contingency table and the results are below. Answer the questions below the table by extracting the information from the table.
Solutions are to the right.

Ever smoked daily * Diabets crosstabulation

		Had diabetes		Total
		YES	NO	
Ever smoked daily	YES	59	532	591
	NO	4	75	79
Total		63	607	670

a. How many Canadians are included in this survey?
b. How many respondents ever smoked daily and have diabetes?
c. How many respondents ever smoked daily?
d. How many respondents did not ever smoke and have diabetes?
e. What is the ratio of those who have diabetes to all those asked?
f. What ratio of those who 'ever smoked' got diabetes?

Example 1 answers.
a 670; b 59; c 591; d 4; e 63/670; f 59/591

Exercise 1: 727 randomly sampled Canadians were asked how much alcohol they consumed, and whether they used a seatbelt when they were in a car. The data was tabulated into a contingency table and the results are below. Answer the questions below the table by extracting the information from the table.

Seatbelt use vs alcohol consumption crosstabulation

		high alcohol consumption		Total
		YES	NO	
Using the seatbelt	YES	30	580	610
	NO	67	50	117
Total		97	630	727

a. How many Canadians are included in this survey?
b. How many respondents said that they consume a high amount of alcohol and do not use their seatbelt?
c. How many respondents use their seatbelt?
d. How many respondents do not consume a lot of alcohol and do not use their seatbelt?
e. What portion of those who said they consume a lot of alcohol use their seatbelt?
f. What portion of those who said they do not consume a lot of alcohol use their seatbelt?
g. Which group has a higher ratio of seatbelt use, those with high alcohol consumption or those with low alcohol consumption?

Practice with using Contingency Tables to calculate and compare rates:

Exercise 2: 560 randomly sampled 5 cm tall tomato plants were selected for an experiment. 220 received compost, and the rest received nothing. All were planted in the same plot of land and watered in the same way. It was thought that the plants receiving compost would be less likely to develop botrytis (gray mold). Results are outlined below.

		Mold		Total
		yes	no	
Compost	YES	30	190	220
	NO	60	280	340
Total		90	470	560

a. How many Tomato plants received compost?
b. What is the rate of mold for all tomato plants?
c. What is the rate of mold in tomato plants who received compost?
d. Did tomato plants who received compost have a lower rate of mold?

Exercise 3: 999 urban vs rural Canadians were asked whether they were happy. It was thought that rural Canadians would have a higher rate of responding yes.

		happy		Total
		YES	NO	
residence	rural	356	221	577
	urban	301	121	422
Total		657	342	999

a. How many rural Canadians are included in this survey?
b. What is the rate of happiness among rural Canadians?
c. What is the rate of happiness among urban Canadians?
d. Who has a higher rate of happiness rural or urban Canadians?
e. What is the rate of rural residents among happy Canadians?

Practice with using Contingency Tables to calculate and compare rates:

Exercise 4: 1100 randomly sampled Toronto residents (all 18 years of age and over) were asked whether they had a family doctor and whether they had a job. Results are outlined below.

		Family Doctor		Total
		yes	no	
Have Job	YES	820	130	950
	NO	54	96	150
Total		874	226	1100

a. What % of those Toronto residents with a job have a family doctor?

b. What % of those Toronto residents with no family doctor have a job?

c. Who had a higher chance of having a family doctor, those with a job or those without?

d. Who had a higher chance of having a job, those with a family doctor or those without?

Exercise 5: 377 residents of two neighbourhoods (Parkdale and Roncesvalles village) in Toronto were asked if they swam at Sunnyside beach. It was thought that those living in Parkdale would have be more likely to responding yes because they live slightly closer to the lake.

		Swam at Sunnyside		Total
		YES	NO	
Neighbourhood of residence	Parkdale	12	110	122
	Roncesvalles	23	232	255
Total		35	342	377

a. What is the likelihood that a Parkdale resident swam at Sunnyside beach?

b. What is the likelihood that a Roncesvalles resident swam at Sunnyside beach?

c. From which neighbourhood are residents more likely to swim at Sunnyside beach?

Use contingency tables to organize information

Exercise 1: On a hot summer day of 435 emergency room patients at Hopeful Science Hospital 350 were assessed for some sort of injury that happened outdoors. Of those only 129 were admitted, while 57 of the rest (indoor injury,) were admitted.

a. Fill in the blank contingency table given the above information.

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b. How many of those who were assessed did not have what could be called an 'outdoor injury'?

c. Which group had a higher rate of admission? Justify your answer by comparing rates

Exercise 2: 200 inpatients at Hopeful Science Hospital were asked the following questions:
Q1. Why did you choose this hospital? (a. I live close by; b. it is the best hospital in the city.)
Q2. Have you been an inpatient here previously? (a. yes; b. no)

a. Fill in the blank contingency table given the following partial information.
120 chose a for question 1; 37 answered a to both questions; 14 chose b to both questions;

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b. How many inpatients answered yes to Question 2.

c. Which group had a higher rate of thinking this is the best hospital in the city: those who had been to the hospital previously or those who had not? Justify your answer using a comparison of rates.

Notation: Metric System

The system of measurement we use at this time - the metric system - is closely related to positive and negative powers of 10.

Mass is measured in grams [g], distance in metres [m], and volume in litres [L].

Instead of using long numbers, mathematicians devised a short-cut way to talk about measurements using prefixes. In the metric system each prefix represents a number.

For example "hecto" means 100. Thus 5 hectolitres = 500 litres. In short form we would write this as 5 hL. `**h**' representing hecto and `**L**' representing litres.

The table below shows the most commonly used prefixes their short forms and the numbers they represent.

Prefix	**symbol**	**Number**	**Prefix**	**symbol**	**Number**
kilo	k	10^3 or 1000	milli	m	$\frac{1}{1000}$ or 10^{-3} or 0.001
hecto	h	10^2 or 100	centi	c	$\frac{1}{100}$ or 10^{-2} or 0.01
deca	da	10^1 or 10	deci	d	$\frac{1}{10}$ or 10^{-1} or 0.1

Example 1: convert the following to number form

a) 3 kilometres b) 5 decigrams c) 3.5 hL d) 45 mg

Solution:

a) 3 kilometres $= 3 \times 1000$ metres

$= 3\ 000$ metres

b) 5 decigrams $= \frac{5}{1} \times \frac{1}{10}$ grams

$= \frac{5 \div 5}{10 \div 5}$ grams

$= \frac{1}{2}$ of a gram (or 0.5g)

c) 3.5hL $= 3.5 \times 100$ L

$= 3\ 50$ L

d) 45 mg $= \frac{45}{1} \times \frac{1}{1000}$ g

$= \frac{45 \div 5}{1000 \div 5}$ g

$= \frac{9}{200}$ g (or 0.045g)

<u>Exercise 1:</u> use the information in the table above to rewrite the following in symbols.

a) kilometre b) decagram c) decilitre d) centigram

e) hectolitre f) millimetre g) milligram h) decalitre

<u>Execise 2:</u> convert the following to number form

a) 5 hectograms b) 72 kilolitres c) 500 millimetres d) 12 dag

e) 25 centimetres f) 12.7 hL g) 20 dg h) 29km

Procedure: Metric System conversions.

Metric conversion chart – you can use the chart below or your understanding of the metric system and powers of 10.

Example 1: convert 5 dam to mm. 5 dam = 50m; 1 m = 1000mm;
Therefore 5dam = 50×1000mm = 50 000mm

Or use the chart below – I like the first way better as it forces you to understand what it is that you are finding.

kilo	hecto	deca	Unit (m, L g)	deci	centi	milli	*Example 1:* Convert 5 dam to mm Step 1: enter the 5 under deca Step 2: enter 0s all the way to milli Step 3: decimal goes after the last 0 and that is the answer 5dam = 50000 mm
		5	0	0	0	0	
		0	0	0	0	5	Example 2: convert 5mm to dam Step 1: enter 5 under milli Step 2: enter 0s to the left until deca Step 3: decimal goes before the first 0 5mm = 0.00005 dam

Exercise 1: Replace the ___ in each of the following with the correct value.
Use the above table and the table on page 6 for prefixes you are not sure about.

a) 6m = ___ cm

b) 4L = ___ mL

c) ___ m = 390 cm

d) 6 kg = ___ g

e) ___ mm = 48.2 cm

f) 3986 cm = ___ m

g) 4963 mL = ___ L

h) ___ kg = 683 g

i) 96.2 mm = ___ cm

j) 1969 m = ___ km

k) 4.98 m = ___ kg

l) ___ cm = 428 mm

m) 4869 g = ___ kg

n) 9.6 kL = ___ L

o) 9869 mL = ___ L

p) 3.89 kg = ___ g