UW Math Circle

Week 13

This week we are studying linguistics. In each of the following problems, you will study a language that you likely do not know, but you will use your mathematical problem solving skills to learn more about each language!

Some strategies to keep in mind:

- Keep track of the translations you know, and add to your list as you learn more!
- The way languages describe certain concepts may be different than from English! For instance, not all languages count in base 10.

Aryabhata

Aryabhata (476-550 CE) was one of the first major classical Indian mathematician-astronomers. He wrote a major astronomical treatise, the *Aryabhatiya*, using Sanskrit syllables to represent numbers (potentially up to 10^{18}).

Below is a list of numbers written in Aryabhata's numerical notation, transcribed using the Latin alphabet:

ka	1	ki	100	gakiku	10,103
kha	2	kaki	101	kakigu	30,101
ga	3	dakhi	218	baghitu	160,423
da	18	badhi	1,923	du	180,000
pa	21	ni	2000	japipu	212,108

What are the following numbers in Aryabhata's notation?

kakiku tajidu nanu

Stop here. Request the next page from your instructor when your group is done.

Scouting the Andes

Quipu were invented by the Incan civilization as a means of recording numbers (census information, measurements, etc.). Given to you are two example sets of quipu, each with five strings, and one set of quipu with one of the strings missing its knots. Each string represents a three-digit number. Can you work out what sequence of knots should go on the last string?

Stop here. Request the next page from your instructor when your group is done.

Majoring in Memory

The *Major system* is a scheme for memorizing long numbers, named after Major Bartlomiej Benikowski, who published the method in a self-help book in 1845 (although the ideas behind the scheme are much older). In this system, every digit is converted into a *sound*, which are then expanded into words.

Here is a list of examples of numbers converted into words using the Major system.

314,159,265,358 meteor tail banshee lime loaf 75,141,195 cluttered table
701,894 ghost vapor 99,501,247 pebble stone rock
7,512,026 golden snitch 8 hive 854 flower
2,394,429 number rainbow 6,096 cheese bush

1. What numbers are expressed by:

   moon cash cat dog gray elephant short striped zebra

2. To ten decimal places, *Euler's constant* e is 2.7182818284. Using the Major system, come up with a short phrase encoding the digits of this constant and tell it to an instructor.

Stop here. Request the next page from your instructor when your group is done.

The Knights Who Say Ni

Danish is a North Germanic language spoken by about six million people, principally in and around Denmark. Communities of Danish speakers are also found in Greenland, the Faroe Islands, and the northern German region of Southern Schleswig, where it has minority language status.

Here are some numbers in Danish:

fire	4	toogtyve	22	ni	9
enogfirs	81	fem	5	nioghalvfjerds	79
seksogtres	66	syvoghalvtreds	57	tre	3

1. What are the following numbers?

seks	nioghalvtreds	treogtyve
halvfjerds	toogtres	femoghalvfems

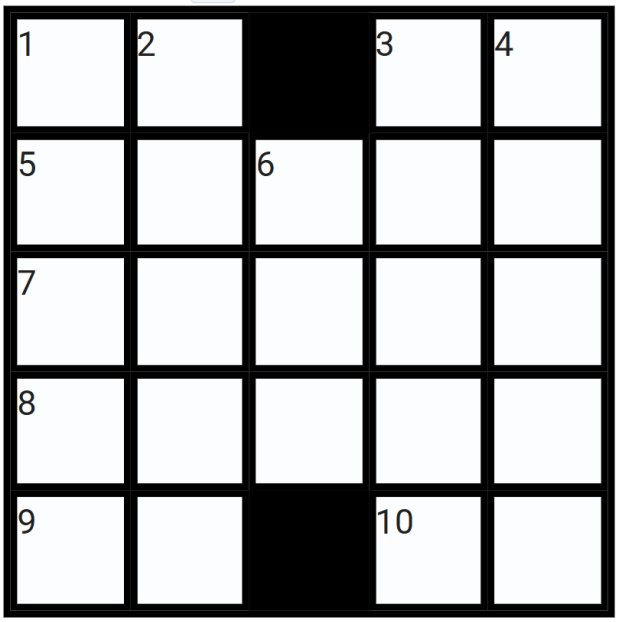
2. Write the numbers 37 and 96 in Danish. (The Danish word for 30 is actually *tredive*, contrary to what you might expect!)

Stop here. Request the next page from your instructor when your group is done.

Down and Across in Antananarivo

Malagasy is an Austronesian language spoken by about 25 million people in Madagascar and the Comoros. The standard version of the language is one of the official languages of Madagascar, alongside French.

Below are the clues of a *crossnumber* puzzle – similar to a crossword, except all of the clues are numbers (written in Malagasy), and each square is a digit. Fill in the corresponding crossnumber grid, using these clues:



Across

Dimy	Efatra amby enimpolo sy telonjato sy sivy alina
Fito	Dimy ambin'ny folo sy roanjato sy arivo sy fito alina
Folo	Iraika amby fitopolo
Iray	Fito amby fitopolo
Sivy	Folo
Telo	Fito ambin'ny folo
Valo	Valo amby enimpolo sy sivinjato sy dimy arivo sy alina

Down

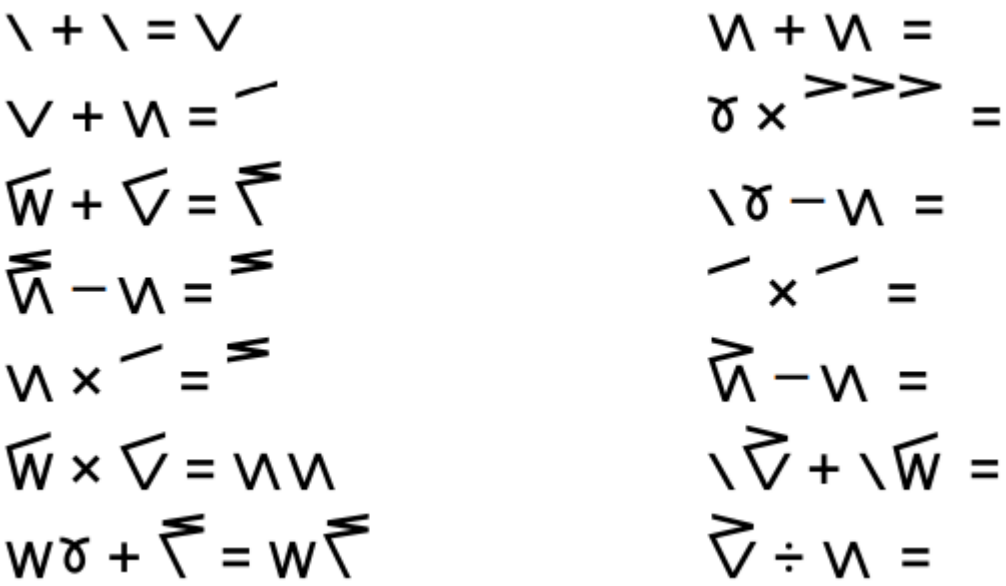
Efatra	Iraika amby valopolo sy dimanjato sy efatra arivo sy fito alina
Enina	Sivy amby roapolo sy telonjato
Iray	Iraika ambin'ny folo sy fitonjato sy sivy arivo sy fito alina
Roa	Dimampolo sy zato sy fito alina
Telo	Fito amby enimpolo sy zato sy enina arivo sy alina

Stop here. Request the next page from your instructor when your group is done.

Arctic Arithmetic

Inuktitut is one of the main Inuit languages, spoken in many of the northern provinces and territories of Canada. It is an official language in the territory of Nunavut and has about 38,000 native speakers.

Inuit students in the town of Kaktovik invented a writing system for numbers in a manner most suitable to the needs of the Inuktitut language. Below is a partial table of computations using these *Kaktovik numerals*:



1. Complete the right-hand column of the table, using Kaktovik numerals.

2. Write today's date (01/20) using Kaktovik numerals.

Stop here. Request the next page from your instructor when your group is done.

The Long Count

The ceremonial *Tzolk'in* calendar of the Maya gives a different way of labeling all of the days of the year, but with less than 365 different glyphs total. Each symbol representing a day consists of two glyphs, one on the left and one on the right. Each of these glyphs repeats in a cycle, with cycle length at most 20 for each of these glyphs.

Given is a part of the Tzolk'in calendar corresponding to the months of August and September.

1. There are two symbols attached that correspond to days appearing on this calendar. Place them in the correct positions.

2. Two dates in September are marked with a "?". Draw the Mayan symbols for these days.

Stop here. Request the next page from your instructor when your group is done.

Telling Time in Tanzania

Swahili is a Bantu language spoken by approximately 150 million people along the east coast of Africa, primarily in Tanzania, Kenya, and Mozambique. Here is a list of the same set of days and times in both English and Swahili:

1. Sunday, 1:00 AM	(a) jumamosi, saa moja usiku
2. Sunday, 7:30 AM	(b) jumamosi, saa mbili na robu usiku
3. Sunday, 9:15 AM	(c) jumamosi, saa nne na nusu asubuhi
4. Tuesday, 12:15 PM	(d) jumamosi, saa saba usiku
5. Tuesday, 11:30 PM	(e) jumanne, saa sita na robu asubuhi
6. Saturday, 10:30 AM	(f) jumanne, saa tano na nusu usiku
7. Saturday, 7:00 PM	(g) jumapili, saa moja na nusu asabuhi
8. Saturday, 8:15 PM	(h) jumapili, saa tatu na robu asabuhi

1. Match each Swahili time to the correct English translation.

2. What day of the week is jumatatu?

Stop here. Request the next page from your instructor when your group is done.

Ok Computer

Tifal is a language in the Ok family spoken in the Sandaun Province of Papua New Guinea, with about 4,000 native speakers.

Here are some equations involving numbers in Tifal, where the operations $+, -, \times, =$ have their normal meanings. No number given is higher than 30.

asumano × aleeb = bokob
asumano × ataling = tadang
bokob × ataling = ataling madi
bokob × asumano = nakal madi
asumano × feet = feet madi
ataling × ataling = tadang madi
asumano + ataling = feet
feet + milt = feet madi
tadang + ataling = tadang madi

(**Hint:** Starting with the equation ataling × ataling = tadang madi might help.)

1. Translate the following equations into standard Arabic numerals (the digits of the Arabic numerals are $0, 1, 2, 3, 4, 5, 6, 7, 8, 9$):

   beeti + nakal = beeti madi
   bokob + maakob = feet
   awok × awok = asumano madi

2. Evaluate tadang + milt and ataling madi − aleeb.

Stop here. Request the next page from your instructor when your group is done.

Going Around the Mountain

Manam Pile is an Austronesian language spoken primarily on the volcanic island of Manam, northeast of New Guinea, with about 8,000 native speakers. The island of Manam has an active volcano that erupts frequently. Given is a map of the island of Manam with some houses marked.

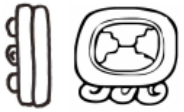
A Manam islander would say the following about the relative positions of these houses:

1. Onkau pera kana auta ieno, Kulu pera kana ilau ieno.
2. Mombwa pera kana ata ieno, Kulu pera kana awa ieno.
3. Tola pera kana auta ieno, Sala pera kana ilau ieno.
4. Sulung pera kana awa ieno, Tola pera kana ata ieno.
5. Sala pera kana awa ieno, Mombwa pera kana ata ieno.
6. Pita pera kana ilau ieno, Sulung pera kana auta ieno.
7. Sala pera kana awa ilau ieno, Onkau pera kana ata auta ieno.
8. Butokang pera kana awa auta ieno, Pita pera kana ata ilau ieno.

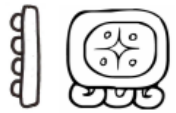
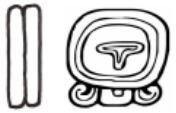
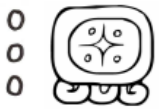
Using this information and the map of the island given, who lives in each of the houses marked A, B, C, D, and E?

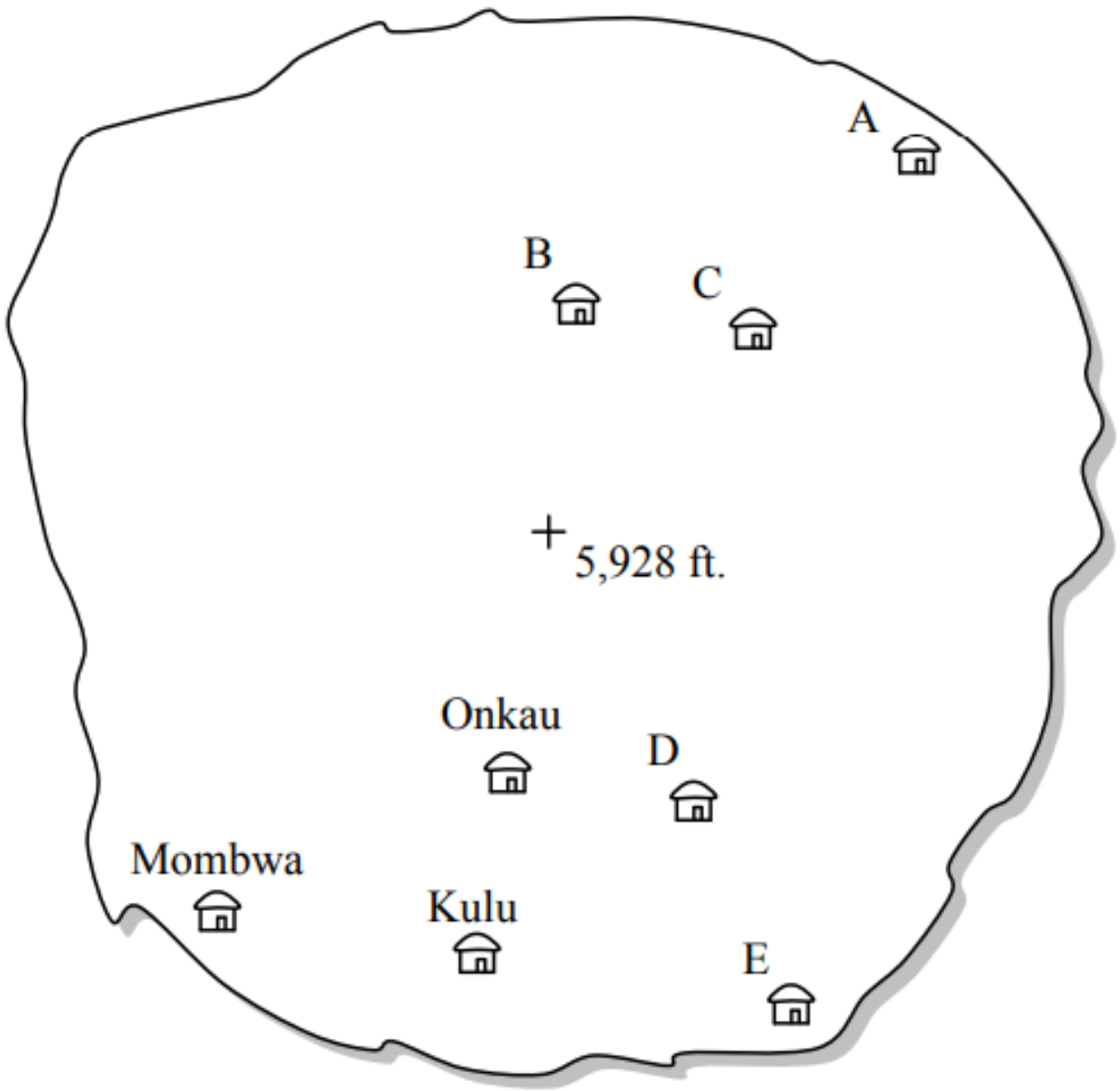
(**Hint:** The Manam islanders center their descriptions of directions on the volcano.)

AUGUST

SEPTEMBER

	?					
						
						
					?	


A
B
C
5,928 ft.
Onkau
D
Mombwa
Kulu
E