The Seventh Annual
North American Computational Linguistics Olympiad
2013
www.naclo.cs.cmu.edu

Open Round
January 31, 2013
Contest Booklet

REGISTRATION NUMBER

Name: ___________________________________________

Contest Site: ________________________________________

Site ID: ____________________________________________

City, State: _________________________________________

Grade: ______

Start Time: _________________________________________

End Time: __________________________________________

Please also make sure to write your registration number and your name on each page that you turn in.

SIGN YOUR NAME BELOW TO CONFIRM THAT YOU WILL NOT DISCUSS THESE PROBLEMS WITH ANYONE UNTIL THEY HAVE BEEN OFFICIALLY POSTED ON THE NACLO WEBSITE IN LATE MARCH.

Signature: __________________________________________
Welcome to the seventh annual North American Computational Linguistics Olympiad! You are among the few, the brave, and the brilliant, to participate in this unique event. In order to be completely fair to all participants across North America, we need you to read, understand and follow these rules completely.

**Rules**

1. The contest is three hours long and includes eight problems, labeled A to H.
2. Follow the facilitators' instructions carefully.
3. If you want clarification on any of the problems, talk to a facilitator. The facilitator will consult with the jury before answering.
4. You may not discuss the problems with anyone except as described in items 3 & 12.
5. Each problem is worth a specified number of points, with a total of 100 points.
   In this year’s open round, no points will be given for explanations. Instead, make sure to fill out all the answer boxes properly.
6. We will grade only work in this booklet. All your answers should be in the spaces provided in this booklet. **DO NOT WRITE ON THE BACK OF THE PAGES.**
7. Write your name and registration number on each page:
   Here is an example: Jessica Sawyer #850
8. The top 100 participants (approximately) across the continent in the open round will be invited to the second round.
9. Each problem has been thoroughly checked by linguists and computer scientists as well as students like you for clarity, accuracy, and solvability. Some problems are more difficult than others, but all can be solved using ordinary reasoning and some basic analytic skills. You don’t need to know anything about linguistics or about these languages in order to solve them.
10. If we have done our job well, very few people will solve all these problems completely in the time allotted. So, don’t be discouraged if you don’t finish everything.
11. If you have any comments, suggestions or complaints about the competition, we ask you to remember these for the web-based evaluation. We will send you an email shortly after the competition is finished with instructions on how to fill it out.
12. **DO NOT DISCUSS THE PROBLEMS UNTIL THEY HAVE BEEN POSTED ONLINE! THIS MAY BE SEVERAL WEEKS AFTER THE END OF THE CONTEST.**

Oh, and have fun!
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The Inuit live in the Arctic regions of Canada and Greenland, and speak a language called Inuktitut. The Inuit used to be known as Eskimos, but this term is now considered insulting. The writing system used for the Inuktitut language is based on the one devised for writing Cree, a Native American language not related to Inuktitut. The writing system is highly regular and systematic, which should make your task all the easier.

One area of Canada where Inuit is spoken is called Nunavut and its capital is Iqaluit. Here is how these two words are written:

\[
\text{Nunavut} \quad \Delta^g_b \gamma^c \\
\text{Iqaluit} \quad \Delta^g_b \gamma^c
\]

English has borrowed some words from the Inuit, such as ‘igloo’ which in Inuktitut is written as \[\Delta^g\gamma\] and is pronounced ‘ihlu’: the ‘hl’ is a lateral fricative, like the LL sound in Welsh, a bit like an ‘s’ combined with an ‘l’. The ‘hl’ is treated as a single sound.

Your task is to look at the text below – it’s the first part of the Universal Declaration of Human Rights – and to transcribe the underlined words into Roman letters on the basis of the first four words which have been done for you.

silarjuarmiut
nalunaiqsiiutra
kinakkutunnait
pijunnauitingat

\[\text{Universal Declaration of Human Rights, 10, 1948}\]

This sound is also found in Zulu and the Mexican language Nahuatl, among others.
Note that Inuktitut uses the same numerals as English, and has the same punctuation marks (only commas and fullstops in this text) as in English. There is no distinction between upper case (capitals) and lower case letters. A dot above a symbol indicates that the vowel is long, which can be represented in transcription by doubling the vowel letter. The sequence ‘rk’ is used for the [q] sound, a uvular plosive (like a ‘k’, but further back in the throat) and should be transcribed as a ‘q’. The sequence ‘ng’ should be thought of as a single sound (a velar nasal, as in the English word "sing"). The letter ‘j’ represents a ‘y’ sound. (as in "yank").

**A1.** Write your answers here:

<p>| | | | | | | | | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| **A** | ӅԆԈӖӖӖӖӖӖӖӖӖӖӖӖӖӖӖӖӖӖӖӌӖӖӖӖӖӌӖӖӖӖӖӅӌӖӖӌӖӌӖӖӌӖӌӖӌӌӖӌӖӌӖӌӌӌӖӌӌӌӖӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌӌocrin

**n a c l o**
A2. Using the information you have extracted from the text, how would you write the following words in the Inuktitut writing system? Let’s start with two words for snow.\(^2\) Enter one character in each cell.

<table>
<thead>
<tr>
<th></th>
<th>Inuktitut</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>qanniq ‘snow as it is falling’</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>aput    ‘snow on the ground’</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>mukluk  ‘sealskin boot’</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>umiaq   ‘canoe’</td>
<td></td>
</tr>
</tbody>
</table>

A3. Finally, can you identify the English word borrowed from Inuktitut in A, and identify the place names in B and C? Enter the English word, one letter in each cell.

<table>
<thead>
<tr>
<th></th>
<th>Inuktitut</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ṣbtnb (a form of transport)</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>b螈c</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>ɬɬɬb</td>
<td></td>
</tr>
</tbody>
</table>

\(^2\)You may have heard that the Inuit (or Eskimos) have lots of different words for ‘snow’. In fact this is a kind of urban legend. Inuktitut has two main words for ‘snow’ although lots of shades of meaning can be expressed by adding endings – you will have noticed that Inuktitut words are very long.
Pali is a dead language, like Latin. It was a literary language related to Sanskrit, the ancestor of modern languages spoken in Northern India, such as Hindi. Pali was first written down around 100 BCE in Sri Lanka by Buddhist monks to preserve the teachings of the Buddha. Pali used to be written in the Brāmi script, but it is also written in the Roman alphabet (which we’ll be using here). Pali is still used by Buddhist monks and scholars (just as Latin is still used in the Vatican by Catholic priests and theologians).

Pali is a highly inflected language, which means that the main words such as nouns and verbs get a range of endings (called “suffixes”) or beginnings (called “prefixes”) attached to make it clear what role the word is playing in the sentence.

English also has some inflections, just not as many as Pali. Here are some examples of English inflections:

- **house** — **houses**. The **-s** added to the end of a noun like “house” indicates that there is more than one you are talking about.

- **John** — **John’s coat**. The **’s** is used after a noun to indicate possession.

- **I walk. You walked. He walks. She has been walking**. The suffixes added to the verb “walk” give you sense of a different person doing the walking, or the walking taking place at a different time — the past as opposed to the present.

Pali has different consonant and vowel sounds, which explains the use of diacritics (special symbols) on particular letters. These do not matter for solving this puzzle. Also, Pali texts do not use capital letters or punctuation.

Here are some sentences in Pali with their English translations:

<table>
<thead>
<tr>
<th>Pali</th>
<th>English Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>mahāmatto nisidati</td>
<td>The minister sits down.</td>
</tr>
<tr>
<td>mahāmatam upasamkamanti</td>
<td>They visit the minister.</td>
</tr>
<tr>
<td>samaṇo tathāgato hoti</td>
<td>The philosopher is enlightened.</td>
</tr>
<tr>
<td>samaṇe atthaṃ pucchanti</td>
<td>They ask the philosophers the meaning.</td>
</tr>
<tr>
<td>upāsako pucchati</td>
<td>The disciple asks.</td>
</tr>
<tr>
<td>loko mahāmatassa</td>
<td>The minister’s world.</td>
</tr>
</tbody>
</table>

---

(B) A Case of Pali (1/2) [10 points]
(B) A Case of Pali (2/2)

B1. Translate the following English sentences into Pali:

1. The minister asks the philosophers.

2. The philosopher sits down.

3. They sit down.

B2. Translate the following into English, using the vocabulary given here in its dictionary form (which is the same as the subject form, without any suffixes):

<table>
<thead>
<tr>
<th>Pali</th>
<th>English Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>rājo</td>
<td>king</td>
</tr>
<tr>
<td>devo</td>
<td>god</td>
</tr>
<tr>
<td>gāmo</td>
<td>village</td>
</tr>
</tbody>
</table>

1. rājo nisidati

2. rājo gāmassa devo hoti

B3. Translate the following into Pali, entering one letter in each box, ignoring the diacritics:

1. The minister asks the kings.

2. The lay disciple’s village.

3. The meaning of the world is god.
(C) The Heads and Tails of Huffman (1/2) [10 points]

When Deb gets mad, she sends her friend Ahab encoded messages using lines of pennies, each of which is either heads up (H) or tails up (T). Example:

```
THHHTHTT HTTTTHTHH
```

Deb also sends a decoding tree, which indicates how to read the message encoded by the pennies. A decoding tree starts with two branches, marked (H)eads and (T)ails. Each branch either leads to a letter in the message or another decoding tree. This type of tree is called a Huffman encoding tree, based on the name of its inventor.

Pennies are read from left to right, and each penny indicates which branch of the decoding tree to follow. Whenever a letter is reached, the next letter is decoded starting back at the top of the decoding tree. For example, the message above reads "BAD AHAB", where individual letters are placed in boxes below:

```
B  A  D  A  H  A  B
THH  H  THTT  H  TTTT  H  THH
```

C1. Decode the following messages using the decoding tree shown above:

A. TTTTTTHTTTTHTTTTHTTTTHTTTTHTTTTHTTTT
B. HTHTHHHTTTHTHTHTTTTTHTTTHTHTTTT

n a c l o
**C2.** The following English word from Deb is missing a penny somewhere in the middle. Mark the location and orientation (heads or tails) of the missing penny and decode the message.

```
TTTTTTHHTHTTTTHHTTT
```

Location of the new penny (counting from the left): __ orientation: __

**C3.** Deb doesn’t want to spend all of her allowance on messages. Design an encoding tree and write the corresponding encoding for each letter below, such that the encoding requires as few pennies as possible, but still correctly encodes the messages. Assume that the message only contains the letters in the example (e.g., MISP in the first example and ABCDR in the second one). In a Huffman encoding, the encoding of a letter cannot begin with the encoding of another letter. So, for instance, if some letter is encoded as H, then another one cannot be encoded as HT. In fact, if some letter is encoded as H, then the encoding for any other letter must start with T.

The two examples below are independent. There may be more than one optimal encoding per example. You only need to show one of them.

**MISSISSIPPI**

<table>
<thead>
<tr>
<th>Letter</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td></td>
</tr>
</tbody>
</table>

Total number of coins: __________

**ABRACADABRA**

<table>
<thead>
<tr>
<th>Letter</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>

Total number of coins: __________
Kwak’wala is the language of the Kwakwaka’wakw people, one of Canada’s many aboriginal nations. It is spoken on and around Vancouver Island, but only a few hundred fluent speakers remain. We’ve hidden 30 Kwak’wala words in the puzzle on the following page, horizontally, vertically, or diagonally, but we’ve only given you 10 of them. Your challenge is to find the remaining 20 words and match them to their meanings.
Notes: Some two-character sequences, like tl, dl, kw, gw, and ts, are treated as single letters in the Kwak’wala alphabet. a represents an “uh” sound. k and g are pronounced like “k” and hard “g”, but with the tongue further back in the mouth. x is pronounced like the “h” in “human”, and x like the “ch” in “Bach”. An apostrophe indicates that the sound is pronounced with increased pressure at the back of the throat.

Enter one character as it appears in the word search per cell.

| an iron | berry cakes | 'L  A  G  A  KW |
| bowl for candlefish oil | broom | X  I  GW  A  Y  U |
| deck of cards | dustpan | L  I  B  A  Y  U |
| expert card player | expert knitter |
| fisherman | K  I  T'L  I  N  U  X  W |
| fishing boat | food for dipping in oil | T'S  A  P  A  L  A  S |
| knitting basket | knitting needles |
| letter | pen or pencil | K'  A  D  A  KW |
| something knitted, such as a sweater | to be proud, to be a snob | TL  A  M  K  A |
| to catch fish with a net | to dip food in candlefish oil |
| to iron something | to iron something | 'M  A  KW  A |
| to knit | to knit |
| to make berry cakes | to make berry cakes |
| to play cards | to play cards |
| to sweep | to sweep |
| to write | to write | K'  A  T  A |
| tourist boat, cruise ship, ferry | tourist boat, cruise ship, ferry |
| wool | wool |
| wrinkled clothes | wrinkled clothes |
| writer | writer |
The author George Bernard Shaw (author of *Pygmalion*\(^1\), which was later adapted as the musical *My Fair Lady*) saw the use of the Latin (or Roman) alphabet for English as a waste of time – the alphabet simply was not suited to write English.

An infamous example of English pronunciation being at odds with its use of the Roman alphabet is the sequence –ough. Consider the different pronunciations of ough in the following words: rough, through, hiccough, though, and bough. This should give you an idea why a spelling reform may be needed.

Shaw left money in his will to the inventor of a new (and better) script for English. Kingsley Read, among many others, entered the competition, and his alphabet was chosen as the best response to Shaw's challenge in 1958. Read named his invention the “Shavian Alphabet” in honor of Shaw.

Some of the rules of Shavian:

- The majority of its characters simply represent an individual English sound. However, a few can be used as abbreviations for a word.

- Shavian is based on a Rhotic English accent – an accent in which all the r symbols are pronounced (such as American English where the word “rarer” is pronounced with 3 r-sounds).

- There are no capital “letters” in Shavian.

### E1. On the left below are some phrases rendered in Shavian, while on the right are their transliterations in the Roman alphabet, except they have been reordered. Work out which Roman transliterations match the Shavian phrases.

<table>
<thead>
<tr>
<th>Shavian alphabet</th>
<th>Roman Alphabet</th>
</tr>
</thead>
<tbody>
<tr>
<td>יט</td>
<td>A. this is Shavian</td>
</tr>
<tr>
<td>נ</td>
<td>B. the cat slept</td>
</tr>
<tr>
<td>ע</td>
<td>C. to learn</td>
</tr>
<tr>
<td>ש</td>
<td>D. we have cats</td>
</tr>
<tr>
<td>ק</td>
<td>E. for ever</td>
</tr>
</tbody>
</table>

\(^1\) *Pygmalion* is about a linguistics professor trying to correct the pronunciation of a Cockney flower seller called Eliza (Cockney being a dialect of British English used by Dick van Dyke in *Mary Poppins*). One of the first artificial intelligence programs, a chatbot, was named Eliza, after the character in *Pygmalion*. 
E2. Using your knowledge of Shavian so far, transliterate the following English phrases into Shavian alphabet. Instead of writing out the symbols yourself, refer to the table provided (e.g. for Ċ enter 3 in one cell):

Eve
Ian
turn left to sit
sleep for Steve

You may have noticed that Shavian has characters that are like the Roman alphabet’s ascenders (letters that stick out in an upwards direction from the line of writing such as “f” and “h”) and descenders (letters that go below the line of writing such as “g”). Ascenders are known as “tall characters” and descenders as “deep characters” in Shavian. Some tall and deep characters make deliberate pairs, such as:

S and (requestCode)
J and (requestCode)

E3. Work out what sounds the symbols in the pairings above represent. How would you write this sound using the Roman alphabet?

E4. What is the Shavian symbol for “b” (enter the code): (requestCode)
One way for computers to understand language is by parsing sentences to figure out the role of each word. A context free grammar (CFG) (also called phrase structure grammar) is a set of rules for forming sentences. Only sentences that can be generated using such a set of rules are then deemed grammatically correct and ‘well-formed’. Computer scientists and linguists use CFGs to define and parse languages, where a “language” is defined as any and all sentences that a given CFG can generate. S is the starting symbol for each sentence.

The following rules make up a simple CFG:

\[
S \rightarrow N \ V \\
N \rightarrow \text{children} \\
N \rightarrow \text{squirrels} \\
V \rightarrow \text{sing} \\
V \rightarrow \text{eat}
\]

Each rule says that the element to the left of the arrow can be expanded into the elements to the right of the arrow. By repeatedly replacing symbols, this CFG can expand the symbol S into “squirrels sing”, “children sing”, “squirrels eat”, and “children eat”. It cannot, however, generate “children eat squirrels” or “squirrels eat children” or just “children” – you can see that there is no possible sequence of replacements that turns S into any of these.

The following is another simple CFG. The rules have been numbered for your convenience, but the numbers are not part of the rules.

1. \( S \rightarrow \text{NP } \text{VP} \)  
2. \( \text{VP } \rightarrow \text{VP PP} \)  
3. \( \text{PP } \rightarrow \text{P} \)  
4. \( \text{IV } \rightarrow \text{runs} \)

5. \( \text{NP } \rightarrow \text{N} \)  
6. \( \text{VP } \rightarrow \text{VP CONJ VP} \)  
7. \( \text{PP } \rightarrow \text{P NP} \)  
8. \( \text{C } \rightarrow \text{that} \)

9. \( \text{NP } \rightarrow \text{D N} \)  
10. \( \text{N } \rightarrow \text{squirrel} \)  
11. \( \text{TV } \rightarrow \text{chases} \)  
12. \( \text{P } \rightarrow \text{in} \)

13. \( \text{NP } \rightarrow \text{NP CONJ NP} \)  
14. \( \text{N } \rightarrow \text{he} \)  
15. \( \text{TV } \rightarrow \text{eats} \)  
16. \( \text{P } \rightarrow \text{away} \)

17. \( \text{VP } \rightarrow \text{IV} \)  
18. \( \text{N } \rightarrow \text{John} \)  
19. \( \text{TV } \rightarrow \text{catches} \)  
20. \( \text{CONJ } \rightarrow \text{and} \)

21. \( \text{VP } \rightarrow \text{IV PP} \)  
22. \( \text{N } \rightarrow \text{Mary} \)  
23. \( \text{TV } \rightarrow \text{tells} \)  
24. \( \text{D } \rightarrow \text{the} \)

25. \( \text{VP } \rightarrow \text{TV NP} \)  
26. \( \text{N } \rightarrow \text{dog} \)  
27. \( \text{TV } \rightarrow \text{sees} \)

28. \( \text{VP } \rightarrow \text{TV C S} \)  
29. \( \text{N } \rightarrow \text{tree} \)  
30. \( \text{IV } \rightarrow \text{sits} \)

\( n \rightarrow a \rightarrow c \rightarrow l \rightarrow o \)
Here is a simple story. Several of the following sentences are, according to the above CFG, not well formed, meaning they cannot be derived from S by repeated substitution of symbols. List the sentences that the CFG above can generate in the box below; ignore the periods.

A. John sees the dog and Mary sees the dog.

B. The dog sees John and Mary.

C. The dog sees a squirrel.

D. The squirrel sits in the tree.

E. That squirrel sees the dog.

F. The squirrel was seen by the dog.

G. The dog runs.

H. The squirrel in the tree runs.

I. The dog chases the squirrel and eats the squirrel.

J. The dog eats.

K. John sees that the dog eats the squirrel.

L. John tells Mary that the dog eats the squirrel.

M. The dog sees that John sees that he eats the squirrel.

N. And the dog runs away.

O. Mary and John chase the dog.

P. John chases and catches the dog.

Q. John eats dog.
F2. Not all of the sentences that this CFG can generate are actually sentences of English. For example, “The dog and the squirrel sits” can be generated but this isn’t a correct sentence of English.

Give three more examples of sentences that can be generated by this CFG but are not correct English sentences; enter one word per box. Skip the periods at the end of the sentences.

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F3. One of the rules in the CFG above is redundant: any sentence that can be generated using this rule can already be generated by a combination of other rules. Write the number of the redundant rule below.
The Phoenician script can be dated at around 1050 BCE, and from it the Arabic, Hebrew and by extension Greek, Roman, and Cyrillic scripts evolved.

The Phoenician civilization was centered along the Mediterranean coast in an area known as Cana’an. The map below shows a number of Phoenician cities and nearby cities that were important trading partners. The spellings reflect their pronunciation in Phoenician. However, two of the cities on the map are shown with their modern names which are very different from what they were called in Phoenician times.

This map is copyright © mapsof.net and is reproduced under the Creative Commons Attribution-ShareAlike 1.0 Licence

On some black and white printers, the colors of the sea and the Phoenician territory are hard to tell apart. The Phoenician territory is the area that includes the following cities: Aynuk, Tripoli, Beritos, and Tsarephath.

**G1.** Match up the Phoenician names in the list below with the names on the map. Remember, two of the names will not match, so you should have two names left over.

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*(Note: The symbols above are representations of Phoenician letters. The actual symbols are not included in the text.)*
(G) Phoenician Fun (2/2)

Fill in the corresponding number, or use the letter X if it is one of the two left-over cities.

<table>
<thead>
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<th>Aynuk</th>
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<td>Beritos</td>
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Spoken language is one-dimensional — the words of a sentence are pronounced in some order. Standard writing systems merely record that order. But spoken language is often ambiguous. Written language might be clearer if we used Twodee, a two-dimensional writing system that places words on the cells of a rectangular grid. Here are all the ways to write “Frogs eat flies” in Twodee:

Why so many layout options? If a sentence or other phrase consists of two sub-phrases A and B, where A is spoken first, then Twodee lets you write A either to the left of B (as in ordinary writing) or above B. If A or B has multiple words, then it will have sub-phrases of its own. The diagrams below reveal how the four Twodee sentences above were put together.

Clear writers of Twodee usually try to choose layout options that will help their readers identify the sub-phrases A and B. Make sure you align the top edges as shown when placing the A and B rectangles side-by-side, or align the left edges as shown when stacking the A and B rectangles top-to-bottom. No extra space (blank columns or rows) is allowed between the two rectangles.

To write Twodee, you do need to know how to divide the phrase you’re writing into sub-phrases. That is mostly a matter of common sense, based on the intended meaning of the phrase. There are also some conventions, such as the traditional division of a sentence into subject (“Frogs”) and predicate (“eat flies,” which describes what frogs do).

While Twodee is intended as a better writing system, it can still be ambiguous. For example, the meaning of

is not clear because the sentence could have been constructed in at least two plausible ways:

(Spoken order: “The leaves fall each year.”)  (Spoken order: “The fall leaves each year.”)
H1. For each Twodee sentence (on the left), use the circles to enter the numbers of all its possible meanings (paraphrased on the right). Some circles may be left blank. **Hint:** You may find it helpful to identify the sub-phrases of a Twodee sentence by drawing boxes as above.

A.

Jack and Jill TM went up the hill.

1. The trademarked group known as “Jack and Jill” ascended the hill.

2. Jack ascended the hill with his trademarked companion, “Jill.”

B.

The citizens hugged the and soldiers. cheered

3. The citizens hugged the soldiers and cheered the soldiers.

4. The citizens hugged each other and cheered the soldiers.

5. The citizens hugged the soldiers and cheered.
C. 6. It’s not because his sweetheart was rich that John married her.

7. Because his sweetheart was rich, John didn’t marry her.

D. 8. Alice used the faulty data to attack the scientists.

9. Alice attacked the scientists who had faulty data.
E. Heavy farmers and heavy cattle are forbidden on this ramp.

10. Heavy farmers and heavy cattle are forbidden on this ramp.

11. Heavy farmers and cattle farmers are forbidden on this ramp.

12. Cattle and heavy farmers are forbidden on this ramp.

13. Cattle and heavy farmers are on this forbidden ramp.

F. Please shake in the raisins.

14. Please add the raisins by shaking them.

15. Please get into the raisins and shake yourself.

16. If you are going to shake yourself, please do it in the raisins.
G.

1. I was spooked out by the dark magician’s hut.
2. 17. The hut of the dark magician spooked me out.
3. 18. The dark hut of the magician spooked me out.
4. 19. Out by the hut of the dark magician, something spooked me.
5. 20. Out by the dark hut of the magician, something spooked me.

H.

1. The business sold things to the bank that was bought from the government.
2. 21. The business sold things to the bank that was bought from the government.
3. 22. The business that was sold to the bank bought things from the government.
H2. In April 2012, an entertainment reporter wrote:

“Zooey Deschanel left her husband Death Cab for Cutie frontman Ben Gibbard.”

The former husband, Ben Gibbard, was the frontman for a band called “Death Cab for Cutie.” However, an editor for ABC News incorrectly clarified the sentence and published the following:

“Deschanel filed for divorce from husband Death Cab, throwing him over for Cutie frontman Ben Gibbard.”

(The editor went on to add that “Deschanel and Cab were married for a little more than three years.”)

By using Twodee, how could the reporter have written the original sentence to avoid this confusion? Place the words of the original sentence in 12 different cells of this two-dimensional grid (starting with “Zooey” at the top left).

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H3. Recall that multiple Twodee layouts were possible for “Frogs eat flies.” Here is a completely horizontal Twodee sentence:

```
A    computer    can    count    things    if    told    how.
```

An editor is considering alternative arrangements of the words that might make the intended meaning more apparent. How many ways can this sentence be written in Twodee? Consider only ways that preserve the intended division into phrases and sub-phrases, for instance:

Answer: _______________

H4. Here are some Twodee sentences whose spoken order is not obvious, as in the “leaves fall”/“fall leaves” example. In each case, how many different spoken orders are possible? (We have just used letters to stand for the words, since the particular words don’t affect the answer.)

A. _______________

B. _______________

C. _______________

D. _______________
Extra Page - Enter the Problem Name Here: __________
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