Panini Linguistics Olympiad 2017

Seniors (Class IX to XII)

Round 1, 22nd January 2017

Question Booklet

Maximum Marks: 100 **Total Time: 4 hours**

Instructions:

1. There are 8 printed pages in this question booklet, including this page. If your booklet has less than 8 printed pages, report to the invigilator immediately.
2. There are 5 problems of 20 marks each. The problems have many sub-parts, all of which must be answered to receive full credit.
3. The Answer Booklet provided to you has specific space for writing down the objective solutions of each problem. **You MUST write down the precise answers or solutions to the problems in the space provided.** The assignments for which at least a part of the answer needs to be written down in the answer booklet have been specifically indicated.
4. The details and explanations of your answers and the rules of the language should be written in separate sheets.
5. While explaining your answers in separate sheets, you need not rewrite the solutions that you have already provided in the Answer Booklet.
6. Write down your explanations to each problem on a new sheet or sheets of paper. On each sheet, indicate the **number of the problem**, your **roll number**, and your **name**. Otherwise, your work may be mislaid or misattributed.
7. Do not copy the statements of the problem.
8. **All answers must be well-argumented. Even a perfectly correct answer will receive a low score unless accompanied by an explanation.**
9. Each problem has been thoroughly checked by linguists 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 analytical skills. You don't need to have prior knowledge of linguistics or these languages in order to solve them.
10. The question paper has been designed to ensure that very few people will solve all these problems completely in the time allotted. Don't be discouraged if you don't finish everything.
11. Use of calculators, mobile phones and any other electronic devices is strictly prohibited. No books, notebooks or other printed materials can be consulted during the contest.

Good luck!

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1. Akamu's Table (20 marks)

Adapted from "Compilation of Russian Olympiad problems between 1965 and 1975" by Vladimir Belikov, Elena Muravenko, Alekseev Mikhail Egorovic

"Did you know that the Hawaiian language and the Maori language spoken by the Maori people of your country are related?" said Akamu, the tourist guide, to Tia, the tourist from New Zealand, who was visiting Hawaii for the first time. "That's impossible!" exclaimed Tia. "The two archipelagos are separated by 7500 km of water. How could the two languages spoken in islands so far apart be similar?" Akamu smiled. "Well, it is not only these two languages. There are at least 30 other languages spread across the islands of the Pacific Ocean that evolved from the same common ancestor. Linguists call this the *Polynesian family of languages*". He took out a piece of paper and wrote down the words for the cardinal numbers (first, second, third etc.) in 5 Polynesian languages that he could recall. He handed it over to Tia and said "You don't have to believe me; see it for yourself. How would a set of unrelated languages have so similar words for the cardinal numbers?"

Tia looked at Akamu's table with utmost surprise (' and wh are specific consonants):

Language	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Hawaiian	*kahi*	*lua*	***(a)***	*ha*	*lima*	*ono*	*hiku*	*walu*	***(b)***
Maori	*tahi*	*rua*	*toru*	*wha*	***(c)***	*ono*	*whitu*	*waru*	*iwa*
Nuku Hiva	*tahi*	***(d)***	*to'u*	*ha*	***(e)***	*ono*	***(f)***	*va'u*	***(g)***
Rarotonga	*ta'i*	***(h)***	***(i)***	*'a*	*rima*	*ono*	*'itu*	*varu*	*iva*
Samoa	*tasi*	*lua*	***(j)***	***(k)***	*lima*	*ono*	*fitu*	***(l)***	*iva*

It was not hard to see the pattern. Akamu had forgotten some of the words – the gray cells in the table. Tia could fill in the gaps simply by studying the pattern. She showed Akamu her guesses, and Akamu exclaimed "Woah! You got everything right. When did you learn all these languages?" "It's actually simple", said Tia.

Assignment 1 [Answer Booklet]: Guess the 12 missing words.

Assignment 2: Explain the rules that you used to convert words from one language to another. Here is one example rule (as well as a hint) for you: 'the consonant *l* in Hawaiian is transformed to *r* in Maori'.

2. Circles and Dots (20 marks)

Problem designed by Anindya Sharma and Monojit Choudhury

Inspired by Sherlock Holmes in "The Adventure of the Dancing Men", Golu and his best friend Hammie decided to invent a code language for writing letters to each other. How cool, they thought, it would be to have a language that only they understood! However, they soon realized that drawing the 26 dancing men figures, a different one for each letter of the English alphabet, was not their cup of tea. Golu then had this brilliant idea that they could instead use fewer and simpler symbols: a dot (•), a circle (○) and a circle with a dot (⊙), and each English letter could be defined by a unique sequence of these symbols. He came up with the following scheme for encoding the first 7 letters of the alphabet:

Scheme 1 – A: •○○⊙, B: •○⊙, C: ••○, D: ○○⊙, E: ○•, F: ○○, G: ⊙

In this scheme, they would encode the word CAB as: ••○•○○⊙•○⊙

Hammie's elder brother Shan, who was studying computer science, happened to pass by. He saw Golu's code and immediately pointed out that this coding *scheme* won't work. They would be in trouble, though he left it for Golu and Hammie to figure out why it won't work and what scheme would work. Not sure of the solution, Golu and Hammie thought of designing 4 more coding schemes:

Scheme 2 – A: ○⊙, B: ⊙•, C: ⊙⊙, D: ○○○, E: ⊙•⊙, F: ○○⊙•, G: ○○⊙

Scheme 3 – A: •, B: ○, C: ⊙, D: ••, E: •○, F: •⊙, G: ○•

Scheme 4 – A: ○•, B: ○○, C: ⊙⊙, D: ••, E: ⊙○, F: ⊙•, G: ○⊙

Scheme 5 – A: ⊙•○, B: ⊙•⊙, C: ⊙○⊙, D: ⊙•○⊙, E: ⊙••, F: ⊙○○, G: ○○

They went to Shan, who now said that schemes 2 and 4 were fine; but schemes 3 and 5 have the same problem as scheme 1, and should not be used. Golu looked at the 5 schemes carefully and exclaimed: "Eureka! I know what the problem is with schemes 1, 3 and 5. I feel so stupid to have come up with such schemes!"

Shan was not sure though if Golu really understood the problem. He showed them 3 more schemes and asked them to figure out which of these would work.

Scheme 6 – A: ••, B: •○, C: •○⊙, D: ○•, E: ○○, F: ○⊙, G: ••○

Scheme 7 – A: ⊙⊙, B: ⊙○, C: ⊙•, D: ○•, E: ○○, F: ○⊙, G •

Scheme 8 – A: •○○, B: •○⊙⊙○, C: ○⊙⊙○⊙, D: ○⊙⊙•, E: ○•••••, F: ○⊙○•, G: •○•○

Assignment 1: What do you think is the problem with the schemes 1, 3 and 5, that schemes 2 and 4 do not have?

Assignment 2 [Answer Booklet]: Among the schemes 6, 7 and 8, which one(s) has/have the same problem as 1, 3 and 5?

Golu had indeed got his answers right. But now that Hammie and he had to extend their scheme for the remaining 19 letters, they needed a systematic process for designing coding schemes which would avoid the problem found in schemes 1, 3 and 5. Shan gave them a hint. He said "of the first 5 schemes, scheme 4 is special because none of the codes is a prefix of the code for another letter." Such codes are called

prefix codes. Scheme 3, for example, is not a prefix code because the code for A is a prefix of the code for D and E; similarly the code for B is a prefix of the code G.

Assignment 3 [Answer Booklet]**:** Is it true that any prefix code will avoid the problem that schemes 1, 3 and 5 have? Explain why or why not.

Assignment 4 [Answer Booklet]: Is it true that for a code to be useful, it must be a prefix code? Explain why or why not.

Notes: This problem is based on *Coding theory* which is the study of the properties of coding schemes and their fitness for a specific application. Codes are used for data compression, cryptography, error-correction, and networking. Codes are studied by various scientific disciplines—such as information theory, electrical engineering, mathematics, linguistics, and computer science. In 1948, scientist Claude Shannon published an article - "A Mathematical Theory of Communication" which laid the foundations of coding theory. Marcel J. E. Golay of *Golay code* fame and Richard Hamming who lent his name to *Hamming codes, Hamming windows, Hamming numbers,* and *Hamming distance* were some of the pioneers of this field.

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3. The Matses Hunter Boy (20 marks)

Problem designed by Abhishek Dedhe

Deep in the Peruvian Amazon, there is a small village inhabited by members of the Matses tribe. Read the following story about a young (and slightly arrogant) Matses boy called Abhishek.

A) One fine day, Abhishek decides to go hunting in the woods. He comes across fresh footprints of wild pigs on the ground. Being an accomplished hunter, he infers that wild pigs had passed by not long ago. Shortly after that (within a few hours), he meets a group of friends who are also hunting wild pigs and says to them – "**They passed by**."

B) The next day, Abhishek decides to go hunting again. This time he comes across old footprints of wild pigs. He realizes that these are from the last hunting season. A few hours later, he meets his friends who have also decided to spend the day hunting wild pigs (again)! Abhishek tells his friends – "**They passed by**."

C) Next year, Abhishek attends a Hunting Seminar. While boasting about his skills as a hunter, he tells the Committee about the time he had discovered fresh footprints of wild pigs and how he had inferred that – "**They passed by**".

D) During the meeting, Abhishek realizes that the Seminar is being held in a hut that was very recently built by a different Native American tribe (not the Matses Tribe). Abhishek observes – "**Non-Matses Indians built a hut**."

E) After the Seminar ends, Abhishek goes to Lima, the capital of Peru. He sees a cathedral, and finds out that it was built by the Spanish during the colonial era. He exclaims – "**Foreigners built a hut.**"

F) When he returns to his village after a year, he tells his friends about the cathedral he had seen in Lima – "**Foreigners built a hut.**"

The translations of the Abhishek's sentences (A-E) are given below (in no particular order):

1. *matses-utsi bëste-wa-ak-o-ṣh*
2. *chotac bëste-wa-nëdak-onda-ṣh*
3. *chotac bëste-wa-nëdak-o-ṣh*
4. *kuen-nëdak-o-ṣh*
5. *kuen-ak-onda-ṣh*
6. *kuen-ak-o-ṣh*

Assignment 1 [Answer-Booklet]: Determine the correct correspondences.

Assignment 2 [Answer-Booklet]: Give the Matses translations of Abhishek's sentences (in bold) from the scenarios described below.

a) During the Hunting Seminar, Abhishek describes to the Committee how he was able to identify the footprints of wild pigs that were very old (from the last hunting season). He boasts that he was able to infer that – "**They passed by.**"

b) During his tour of Peru, Abhishek goes to see the Machu Picchu (an ancient architectural marvel - often counted among the Seven Wonders of the World). Having grown up in a very small village, Abhishek does not know anything about the Machu Picchu, and thus decides to read about its history from a tourist brochure. He learns that it was built by the Inca people. However, Abhishek is unimpressed, and immediately makes an arrogant comment about the Machu Picchu - "**Non-Matses Indians built a hut**."

c) After touring Peru for more than a year, Abhishek returns to his village. He is dismayed to see that his lavish mansion had fallen into ruins. In its place is a small, shabby hut. Abhishek is told that this hut was built by the kind-hearted locals just a few days ago. Humbled and ashamed, Abhishek falls to his knees and cries out – "**Matses Indians built a hut.**"

Assignment 3: Translate this sentence to English: "Abhishek bëste-wa-nëdak-onda-şh". Let your imagination run wild and come up with an appropriate context in which you might utter this sentence! (Try to avoid ambiguous scenarios).

Assignment 4: Explain your solution.

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4. Yash in Rwanda (20 marks)

Problem designed by Yash Sinha

Yash, who is studying linguistics in the University of Chicago, went to Rwanda on a field trip. His task was to analyze the Kinyarwanda language, which is one of the three official languages of Rwanda along with French and English. What flummoxed him though is while some English sentences had only one translation in Kinyarwanda, some had two and some even more. To crack the mystery, Yash collected the Kinyarwanda translations of a few English sentences from the locals, though he could not make his subjects speak out all the possible translations (after all they were not linguists and said whatever came to their mind). Yash prepared the following table of Kinyarwanda sentences and their English sentences and also made some notes of how many translations he thought the English sentence actually had for cases where he did not get all possible translations.

1.	*Umugabo arakora*	The man is working.
2.	*Abogore baragenda*	The women are going.
3.	*Umugabo arabona umugore*	The man is seeing the woman.
4.	*Umugore arabonwa numugabo*	
5.	*Umuhungu arabonwa nabogore*	The women are seeing the boy.
6.	*Abogore barabona umuhungu*	
7.	*Abogabo baraandika ibaruwa nikarumu*	The men are writing the letter with the pen. [There are 2 more possible translations in Kinyarwanda]
8.	*Abogabo baraandikiisha ikarumu ibaruwa*	
9.	*Umuhungu arabona abogore nijisho*	The boy is seeing the women with the eye. [there are 2 more possible translations in Kinyarwanda]
10.	*Ijisho araboniishwa abogore numuhungu*	
11.	*Umualimu araandikera umuhungu igitabo*	The teacher is writing the book for the boy. [there are 2 more possible translations in Kinyarwanda]
12.	*Umualimu araandika igitabo kuumuhungu.*	

Yash realized that for every pair of Kinyarwanda sentences that mean the same thing, the two forms mean the same thing. *However, they do not necessarily have the same structure.*

Assignment 1: Explain how the same meaning can be expressed in multiple ways.

Assignment 2 [Answer-booklet]: Translate the following sentences into English

a) *Ibaruwa araandikwa nabogabo*
b) *Ibaruwa araandikwa numugore kuabogabo*
c) *Abogabo barabonera umugore abohungu*

Assignment 3 [Answer-booklet]: Now translate the two sentences below. Consider the verb form carefully.

d) *Ikarumu araandiishwa ibaruwa numagabo*
e) *Abogore barabonerwa abohungu numugabo*

Assignment 4 [Answer-booklet]: Provide Kinyarwanda translations for these two English sentences. See instructions besides each sentence for the number of translations you are expected to provide.

f) The boys are writing the book. (Give ***two*** Kinyarwanda equivalents)
g) The boy is writing the book for the women. (Give ***four*** Kinyarwanda equivalents)

5. Aryabhat's Enigma (20 marks)

Problem designed by Apoorva Bhagwat and Angikar Ghoshal

Lenny was studying number theory from an old Sanskrit tome, when he came across the following curious shloka (left, transcribed using Latin script from the original Devanagari script):

tukā nātha kabīra ete ādikavayah |	*Tuka*, *Nath* and *Kabir* were the original poets.
nāmā gadimā kintu dwijakavīdvayah ||	*Nama* and *Gadima* were both born twice.
gula ravi thākūra gāliba trimūrtī |	*Gulzar*, *Ravi Thakur* and *Galib* were a trio.
bahiṇā ekamevā caturastrā kavayitrī ||	*Bahina* was the sole versatile poet.

Lenny soon realized that the shloka was referring to several Indian poets: Tukaram, Eknath, Kabir, Namdeo, G. D. Madgulkar (*gadimā*), Gulzar, Ravindranath Thakur, Mirza Galib and Bahinabai Chaudhari. Being a good student of Sanskrit, Lenny promptly translated the shloka, and came up with this slightly nonsensical translation (shown in the right above).

Realizing that there was something fishy about this shloka, Lenny took it to Prof Arya Bhat, and asked him what the shloka meant. "Ah, a classic Aryabhata numeration shloka", said the professor, pulling out a piece of paper from his drawer. "Each poet represents an integer with a different number of distinct prime factors", he said.

Poet	Integer	Number of distinct prime factors	Poet	Integer	Number of distinct prime factors
tukā	160001	1	*gula*	30050	3
nātha	37	1	*ravi*	6040	3
kabīra	2341	1	*thākūra*	10052	3
nāmā	45	2	*gāliba*	5026	3
gadimā	1828	2	*bahiṇā*	10038	4

"The numbers are represented by the words according to a scheme called the *Aryabhata numeration*. I do not exactly remember how the scheme works, but I'm confident the numbers on this paper are correct. Perhaps you can try to reverse-engineer the scheme!" While you do not need to know the Devanagari script to decipher the scheme (the Latin transcriptions have all the information you need), the organization of the letters in the Devanagari alphabet might be useful:

Vowels: *a ā i ī u ū ṛ ṝ ḷ ḹ e ai o au*

Consonants: *k kh g gh ṅ c ch j jh ñ ṭ ṭh ḍ ḍh ṇ t th d dh n p ph b bh m y r l v ś ṣ s h*

Assignment 1 [Answer-Booklet]: Write down the numbers corresponding to the following words:
a) *jāveda*, b) *kāli*, c) *tulasī*, d) *dāsa*, e) *sāhira*

Assignment 2 [Answer-Booklet]: Write down words representing the following numbers (if there are multiple valid representations, any single one is acceptable)
f) 230019, g) 7070, h) 21000017

Assignment 3: Explain the Aryabhata numeration scheme.

----------END OF QUESTION BOOKLET----------