Śivasūtra

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Normal Arrangement of Alphabet

Vowels	*a*	*ā*	*i*	*ī*	*u*	*ū*	*ṛ*	*ṝ*	*ḷ*	*e*	*ai*	*o*	*au*	*aṃ*	*aḥ*
Velar कण्ठ्य	*k*	*kh*	*g*	*gh*	*ṅ*										
Palatal तालव्य	*c*	*ch*	*j*	*jh*	*ñ*										
Retroflex मूर्धन्य	*ṭ*	*ṭh*	*ḍ*	*ḍh*	*ṇ*										
Dental दन्त्य	*t*	*th*	*d*	*dh*	*n*										
Labiel औष्ठ्य	*p*	*ph*	*b*	*bh*	*m*										
semi-vowel अन्तस्थ	*y*	*r*	*l*	*v*											
Fricative उष्म	*ś*	*ṣ*	*s*	*h*											

Pāṇini required several(41-44) subsets of this alphabet to describe various operations. Some of these subsets are:

All vowels
All consonants
All vowels + semivowels + nasals
The voiceless stops
stops and sibilants
Any of *ba ga ḍa da*
Any of *bha gha ḍha dha*
Any of *ya va ra la ña ma ṅa ṇa na ma jha bha*
....

pratyāhāra

41 sets Panini needed are as follows

- aṆ = {a i u}
  अ इ उ
- aK = {a i u ṛ ḷ}
  अ इ उ ऋ ऌ
- aC = {a i u ṛ ḷ e o ai au}
  अ इ उ ऋ ऌ ए ओ ऐ औ
- aṬ = {a i u ṛ ḷ e o ai au ha ya va ra}
  अ इ उ ऋ ऌ ए ओ ऐ औ ह य व र
- aṆ = {a i u ṛ ḷ e o ai au ha ya va ra la}
  अ इ उ ऋ ऌ ए ओ ऐ औ ह य व र ल
- aM = {a i u ṛ ḷ e o ai au ha ya va ra la ña ma ṅa ṇa na}
  अ इ उ ऋ ऌ ए ओ ऐ औ ह य व र ल ञ म ङ ण न
- aŚ = {a i u ṛ ḷ e o ai au ha ya va ra la ña ma ṅa ṇa na jha bha gha ḍha dha}
  अ इ उ ऋ ऌ ए ओ ऐ औ ह य व र ल ञ म ङ ण न झ भ घ ढ ध

- aL = {a i u ṛ ḷ e o ai au ha ya va ra la ña ma ṅa ṇa na jha bha gha ḍha dha ja ba ga ḍa da kha pha cha ṭha tha ca ṭa ta ka pa śa ṣa sa}
  अ इ उ ऋ ऌ ए ओ ऐ औ ह य व र ल ञ म ङ ण न झ भ घ ढ ध ज ब ग ड द ख फ छ ठ थ च ट त क प श ष स
- iK = {i u ṛ ḷ}
  इ उ ऋ ऌ
- iC = {i u ṛ ḷ e o ai au}
  इ उ ऋ ऌ ए ओ ऐ औ
- iṆ = {i u ṛ ḷ e o ai au ha ya va ra la}
  इ उ ऋ ऌ ए ओ ऐ औ ह य व र ल
- uK = {u ṛ ḷ}
  उ ऋ ऌ

- eṄ = {e o}
  ए ओ
- eC = {e o ai au}
  ए ओ ऐ औ
- haŚ = {ha ya va ra la ña ma ṅa ṇa na jha bha gha ḍha dha ja ba ga ḍa da}
  ह य व र ल ञ म ङ ण न झ भ घ ढ ध ज ब ग ड द
- haL = {ha ya va ra la ña ma ṅa ṇa na jha bha gha ḍha dha ja ba ga ḍa da kha pha cha ṭha tha ca ṭa ta ka pa śa ṣa sa}
  ह य व र ल ञ म ङ ण न झ भ घ ढ ध ज ब ग ड द ख फ छ ठ थ च ट त क प श ष स
- yaṆ = {ya va ra la}
  य व र ल
- yaM = {ya va ra la ña ma ṅa ṇa na}
  य व र ल ञ म ङ ण न
- yaÑ = {ya va ra la ña ma ṅa ṇa na jha bha}
  य व र ल ञ म ङ ण न झ भ

- yaY = {ya va ra la ña ma ṅa ṇa na jha bha gha ḍha dha ja ba ga ḍa da kha pha cha ṭha tha ca ṭa ta ka pa}
  य व र ल ञ म ङ ण न झ भ घ ढ ध ज ब ग ड द ख फ छ ठ थ च ट त क प
- yaR = {ya va ra la ña ma ṅa ṇa na jha bha gha ḍha dha ja ba ga ḍa da kha pha cha ṭha tha ca ṭa ta ka pa śa ṣa sa}
  य व र ल ञ म ङ ण न झ भ घ ढ ध ज ब ग ड द ख फ छ ठ थ च ट त क प श ष स
- vaŚ = {va ra la ña ma ṅa ṇa na jha bha gha ḍha dha ja ba ga ḍa da}
  व र ल ञ म ङ ण न झ भ घ ढ ध ज ब ग ड द
- vaL = {va ra la ña ma ṅa ṇa na jha bha gha ḍha dha ja ba ga ḍa da kha pha cha ṭha tha ca ṭa ta ka pa śa ṣa sa ha}
  य व र ल ञ म ङ ण न झ भ घ ढ ध ज ब ग ड द ख फ छ ठ थ च ट त क प श ष स ह

- raL = {ra la ña ma ṅa ṇa na jha bha gha ḍha dha ja ba ga ḍa da kha pha cha ṭha tha ca ṭa ta ka pa śa ṣa sa ha}
  र ल ञ म ङ ण न झ भ घ ढ ध ज ब ग ड द ख फ छ ठ थ च ट त क प श ष स ह
- maY = {ma ṅa ṇa na jha bha gha ḍha dha ja ba ga ḍa da kha pha cha ṭha tha ca ṭa ta ka pa}
  म ङ ण न झ भ घ ढ ध ज ब ग ड द ख फ छ ठ थ च ट त क प
- ṅaM = {ṅa ṇa na}
  ङ ण न
- jhaR = {jha bha gha ḍha dha}
  झ भ घ ढ ध
- jhaS = {jha bha gha ḍha dha ja ba ga ḍa da}
  झ भ घ ढ ध ज ब ग ड द

- jhaY = {jha bha gha ḍha dha ja ba ga ḍa da kha pha cha ṭha tha ca ṭa ta ka pa}
  झ भ घ ढ ध ज ब ग ड द ख फ छ ठ थ च ट त क प
- jhaR = {jha bha gha ḍha dha ja ba ga ḍa da kha pha cha ṭha tha ca ṭa ta ka pa śa ṣa sa}
  झ भ घ ढ ध ज ब ग ड द ख फ छ ठ थ च ट त क प श ष स
- jhaL = {jha bha gha ḍa dha ja ba ga ḍa da kha pha cha ṭha tha ca ṭa ta ka pa śa ṣa sa ha}
  झ भ घ ढ ध ज ब ग ड द ख फ छ ठ थ च ट त क प श ष स
- bhaR = {bha gha ḍha dha}
  भ घ ढ ध

- jaS = ja ba ga ḍa da
  ज ब ग ड द
- baS = ba ga ḍa da
  ब ग ड द
- CaV = cha ṭha tha ca ṭa ta
  छ ठ थ च ट
- KaY = kha pha cha ṭha tha ca ṭa ta ka pa
  छ ठ थ च ट त क प
- KaR = kha pha cha ṭha tha ca ṭa ta ka pa śa ṣa sa
  ख फ छ ठ थ च ट त क प श ष स
- caR = ca ṭa ta ka pa śa ṣa sa
  च ट त क प श ष स
- SaR = śa ṣa sa
  श ष स
- SaI = śa ṣa sa ha
  श ष स ह

Panini organised these partially overlapping sets in a linear order, and devised a naming scheme to remember the members of each set.

Simple Example

Let me take a small example with 6 members instead of 41, and explain what Pāṇini did.

In a certain class in a school there are 6 students who participate in various games. Let us name them from 'a' to 'f'.
The games they participate are as under.

- Cricket: b, c
- Tennis: d, e, f
- Football: a, d, f
- Chess: b, e, f

Students playing the same games want to sit next to each other. Now if these students sit in an alphabetic order then student 'b' can not talk with 'e' on chess, since he would be intervened by two other students 'c' and 'd'. Similarly 'a' will not be in a position to talk to his other friends 'd' and 'f' on football.

In what order should these students sit so that there are no cross-talks.

Simple Example ..

- Cricket: b, c
- Tennis: d, e, f
- Football: a, d, f
- Chess: b, e, f

If they are seated in the following order

c b e f d a

then everybody is happy. All the players having common interests are adjacent to each other.

Can we have some acronyms so that we can also remember which students play which games?

Simple Example ..

- Cricket: b, c
- Tennis: d, e, f
- Football: a, d, f
- Chess: b, e, f

We introduce markers M_1, M_2, M_3 and M_4 indicating the boundary for Cricket, Chess, Tennis and Football players respectively.

$$\text{c b } M_1 \text{ e f } M_2 \text{ d } M_3 \text{ a } M_4$$

The slice starting with 'c' and ending with M_1 gives us the names of players playing cricket. Let us name this slice by 'cM_1'. The slice 'bM_2' gives the names of Chess players, the slice 'eM_3' gives the names of Tennis players, and finally 'fM_4' gives the names of football players.

Such a naming scheme, which is a sort of abbreviation is called a **pratyāhāra**. In order to know the members of a set or to know the name of a set given the elements, one needs to memorise this linear list. That's all!

Simple Example ..

This is how Pāṇini solved his problem. He arranged 41 Sanskrit sounds in a linear order and inserted some markers (called *anubandha*s) or *it* markers, in between that serve as the right boundary. Pāṇini needed 14 markers in order to describe all 41 subsets.

How did Panini arrived at this śivasūtra?

Tradition: Legend

In recent years there are several efforts to justify this arrangement

Historically (Cardona)
Logically (Kiparsky, Staal)
Mathematically (Petersen).

Logical Approach

Logical approach to build the śivasūtra

From the given sets, we try to arrange the sets in a linear order with partial overlaps.
Let us try to decide the order from the 41 sets Panini needed.
Consider the following sets.

A = {a i u ṛ ḷ}
B = {i u ṛ ḷ}
C = {u ṛ ḷ}
D = {a i u}

This fixes the order as
a i u M_1 ṛ ḷ M_2

Logical Approach ...

Suppose, in addition to
A = {a i u ṛ ḷ}
B = {i u ṛ ḷ}
C = {u ṛ ḷ}
D = {a i u}

we also have

E = {a i u ṛ ḷ e o ai au}
F = { i u ṛ ḷ e o ai au}
G = { e o ai au}
H = { ai au}
I = { e o}

This fixes the order:
a i u M_1 ṛ ḷ M_2 {e o} M_3 {ai au} M_4, or as
a i u M_1 ṛ ḷ M_2 {ai au} M_4 {e o} M_3

or in short as
a i u M_1 ṛ ḷ M_2 {({e o} M_3) ({ai au} M_4)}
where order of elements within is not fixed.

Logical Approach ...

Now suppose, we consider the following sets
J = {y v r l}
K = {a i u ṛ ḷ e o ai au h y v r l}
L = { i u ṛ ḷ e o ai au h y v r l}
M = {a i u ṛ ḷ e o ai au h y v r}

This fixes the further order:
h {y v r} l order within is not fixed.

Thus so far we have the following order.
a i u M_1 ṛ ḷ M_2 {({e o } M_3) ({ai au } M_4) } h { y v r } l M_5

Logical Approach ...

Now consider following sets
N = {h y v r l .... }
O = { y v r l .... }
P = { v r l .... }
Q = { r l .... }

This fixes the order of y,v,r also, as
h y v r l

a i u M_1 ṛ ḷ M_2 {({e o} M_3) ({ai au} M_4)} h y v r l M_5

Following this process, we finally get the following order.

1	*a i u (Ṇ)*
2	*ṛ ḷ(K)*
3	*e o (Ṅ)*
4	*ai au (C)*
5	*ha ya va ra(Ṭ)*
6	*la (Ṇ)*
7	*ña ma ṅa ṇa na (M)*
8	*jha bha(Ñ)*
9	*gha ḍha dha (Ṣ)*
10	*ja ba ga ḍa da (Ś)*
11	*kha pha cha ṭha tha ca ṭa ta (V)*
12	*ka pa (Y)*
13	*ś ṣ s (R)*
14	*ha (L)*

There are 14 sūtras, which are also called pratyāhāra sūtras

It is not advisable to give 41 names to these sets.
It will be difficult to memorize the association.

Panini devised a special scheme for naming these sets.
ādiḥ antyena sahitā (1.1.71)
आदिरन्त्येन सहेता
An initial letter with an 'it' letter as a final, is the name of itself and of the intervening letters.
According to 'hal antyam', final 'hal' is an 'it'.
Thus in the above arrangement, all the letters marked in red color are 'it's.

The naming of the sets now is as follows.
The name consists of two letters: ādi (the first one) and the antya (the last one) which is an 'it'.

1 a i u (Ṇ)
2 ṛ ḷ(K)
3 e o (Ṅ)
4 ai au (C)
5 ha ya va ra(Ṭ)

For example **aC** represents all the letters that occur between (and including) 'a' and the 'it' marker 'C', i.e. the set {a i u ṛ ḷ e o ai au}
With this arrangement now it is trivial to associate the set names with its members.

Pratyāhāra

s A Pratyāhāra consists of a phoneme-letter (varṇa) and an anubandha (or a marker) and signify all of the intervening phonemes (more than one) from the śivasūtra, excluding the anubandha.

With 14 markers, how many Pratyāhāras are possible with the 14 śivasūtras?
There are 3 varṇas in the first sūtra viz. a,i,u. And there are 14 markers after these. So there are 14*3 possible pratyāhāras.
Similarly in the second sūtra, there are 2 varṇas, and 13 markers following it. So there are total 2*13 possible pratyāhāras.
Continuing in this way, we have
14*3 + 13*2 + 12*2 + 11*2 + 10*4 + 9*1 + 8*5 + 7*2 + 6*3 * 5*5 + 4*8 + 3*2 + 2*3 +1*1
possibilities. But of these, all pratyāhāras with single phoneme are to be deleted. Further, due to the duplication of 'h', the sets aR =aL, iR = iL, and so on. These are 10 in number with a,i,u,ṛ,ḷ,e,o,ai,au and h combining with either 'R' or 'L'. Thus there are 305-14-10 = 281 pratyāhāras possible. But Pāṇini needed only 41-44 of them.