

Mathematics in Sanskrit Poetry

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Sanskrit vowels

Devanāgarī	Telugu	ITRANS
अ	అ	a
आ	ఆ	A/aa
इ	ఇ	i
ई	ఈ	I/ii
उ	ఉ	u
ऊ	ఊ	U/uu
	ఎ	e
ए	ఏ	E/ee
ऐ	ఐ	ai
	ఒ	o
ओ	ఓ	O/oo
औ	ఔ	au
ऋ	ఋ	RRi/R^i
ॠ	ౠ	RRi/R^I
ऌ	ల	LLi/L^i
ॡ	ల	LLi/L^I
अं(added as anusvāra)	అం	M/N/.m
अः	అః	G
अँ		.N
्(virāma/halant)	్	.h
s(avagraha:elision during sandhi)		.a
Om symbol	ఓం	OM, AUM



Sanskrit consonants

	voiced		unvoiced		
	unasp.	aspirated	unasp.	aspirated	
guttural (in the back of the throat)	क ka	ख kha	ग ga	घ gha	
palatal (tongue against hard palate)	च ca	छ cha	ज ja	झ jha	
retroflex/cerebral (tongue up at soft palate)	ट ṭa	ठ ṭha	ड ḍa	ढ ḍha	
dental (tongue at the teeth)	त ṭa	थ ṭha	द ḍa	ध ḍha	
labial (with the lips)	प pa	फ pha	ब ba	भ bha	



क	ख	ग	घ	ङ	Velar
ka	kha	ga	gha	~Na	
च	छ	ज	झ	ञ	Palatal
cha	Cha	ja	jha	~na	
ट	ठ	ड	ढ	ण	Retroflex
Ta	Tha	Da	Dha	Na	
त	थ	द	ध	न	Dental
ta	tha	da	dha	na	
प	फ	ब	भ	म	Labial
pa	pha	ba	bha	ma	
य	र	ल	व		Semi-vowel
ya	ra	la	va/wa		
श	ष	स	ह		Fricative
sha	Sha	sa	ha		

Sanskrit syllables - guru, laghu

 Laghu
 Guru

अ	आ	इ	ई	उ	ऊ	ऋ	ॠ	ऌ	ॡ	ए	ऐ	ओ	औ	अं	अँ	अः
a	ā	i	ī	u	ū	ṛ	ṝ	ḷ	ḹ	e	ai	o	au	aṁ	aṁ̄	aḥ
[ʌ]	[a:]	[i]	[i:]	[u]	[u:]	[r]	[r:]	[l]	[l:]	[e:]	[a:i]	[o]	[a:u]	[aŋ]	[ə]	[əh]
प	पा	पि	पी	पु	पू	पृ	पृ	प्लू	प्लू	पे	पै	पो	पौ	पं	पाँ	पः
pa	pā	pi	pī	pu	pū	pṛ	pṝ	pl̄	pl̄̄	pe	pai	po	pau	paṁ	paṁ̄	paḥ

क	ka	[kʌ]	ख	kha	[kʰʌ]	ग	ga	[gʌ]	घ	gha	[gʱʌ]	ङ	ṅa	[ŋʌ]
च	ca	[cʌ]	छ	cha	[cʰʌ]	ज	ja	[ʃʌ]	झ	jha	[ʃʱʌ]	ञ	ña	[ɲʌ]
ट	ṭa	[ʈʌ]	ठ	ṭha	[ʈʰʌ]	ड	ḍa	[ḍʌ]	ढ	ḍha	[ḍʱʌ]	ण	ṇa	[ɳʌ]
त	ta	[tʌ]	थ	tha	[tʰʌ]	द	da	[dʌ]	ध	dha	[dʱʌ]	न	na	[nʌ]
प	pa	[pʌ]	फ	pha	[pʰʌ]	ब	ba	[vʌ]	भ	bha	[bʱʌ]	म	ma	[mʌ]
य	ya	[jʌ]	र	ra	[rʌ]	ल	la	[lʌ]	व	va	[vʌ]			
श	śa	[ʃʌ]	ष	ṣa	[ʃʱʌ]	स	sa	[sʌ]						
ह	ha	[ɦʌ]	ळ	ḷa	[ʌ]									

Note: In Telugu, 'e' is
Laghu, 'E' is Guru

Sanskrit syllables - guru, laghu

Light and heavy syllables

In most of Sanskrit poetry the primary determinant of a meter is the number of syllables in a unit of verse, called the **pāda** ("foot", not to be confused with the "foot" of Western prosody). Meters of the same length are distinguished by the pattern of **laghu** ("light") and **guru** ("heavy") syllables in the *pāda*.

The rules distinguishing **laghu** and **guru** syllables are the same as are specified in Vedic texts such as the Pratīśākhyas. They can be summarized as:

1. A syllable is *laghu* only if its vowel is **hrasva** ("short") and followed by at most one consonant before another vowel is encountered.
2. A syllable with an anusvara ('ṁ') or a visarga ('ḥ') is always *guru*.
3. All other syllables are *guru*, either because the vowel is **dīrgha** ("long"), or because the *hrasva* vowel is followed by a consonant cluster.
4. The *hrasva* vowels are the short monophthongs: 'a', 'i', 'u', 'ṛ' and 'ḷ'.
5. All other vowels are *dīrgha*: 'ā', 'ī', 'ū', 'ṛī', 'e', 'ai', 'o' and 'au'. (Note that, morphologically, the last four vowels are actually the diphthongs 'ai', 'āi', 'au' and 'āu', as the rules of sandhi in Sanskrit make clear. So, while an original 'ai', for example, had been shortened to an 'e' sound in practice, it was still to be treated as long metrically. The original short 'e' and short 'o' sounds had already been assimilated into short 'a' in the Proto-Indo-Iranian period of the language.)
6. Gangadasa Pandita states that the last syllable in each foot may be considered **guru**: सानुस्वारश्च दीर्घश्च विसर्गो च गुरुर्भवेत् । वर्णः संयोगपूर्वश्च तथा पादान्तगोऽपि वा ॥. But a **guru** at the end of a foot is never counted as **laghu**.

For measurement by morae, laghu syllables count as one unit, and guru syllables as two units.

Laghu syllables:

1. Normally, all short vowels – a, i, u, ṛ, ḷ.

Guru syllables:

2. All long vowels – ā, ī, ū, ṛī.
3. Any short vowel followed by the anusvāra (ṁ).
4. Any short vowel followed by the visarga (ḥ).
5. Any short vowel followed by a double consonant.

(The exceptions to this rule are the double consonants pr, br, kr and those starting with h. In these four cases, the preceding short vowel can optionally remain short.)

6. Optionally, any short vowel at the end of a pāda

Sanskrit meters - anushTup

Each line of a *shloka* (Sanskrit poem) is called a *pAda*. Many popular *shlokas* are written in the *anushTup* meter (*chandas*), which has 4 *pAdas*, with 8 syllables in each *pAda*:

गुरुर् ब्रह्मा गुरु विष्णु
गुरुर् देवो महेश्वरः
गुरुस्साक्षात् परब्रह्मा
तस्मै श्री गुरवे नमः

गु रुर् ब्र ह् मा गु रुर् विष् णु
0 1 1 1 0 1 1 1
गु रुर् दे वो म हेश् व रः
0 1 1 0 0 1 0 1
गु रुस् साक् षात् प रब् र्ह मा
0 1 1 1 0 1 1 1
तस् मै श्री गु र वे न मः
1 1 1 0 0 1 0 1

सरस्वती नमस्तुभ्यं
वरदे कामरूपिणीं
विद्यारंभम् करिष्यामि
सिद्धिर् भवतु मे सदा

स रस् व ती न मः तुभ् यं
0 1 0 1 0 1 1 1
व र दे का म रू पि णीं
0 0 1 1 0 1 0 1
विद् या रं भम् क रिश् या मि
1 1 1 1 0 1 1 1
सिद् धिर् भ व तु मे स दा
1 1 0 0 0 1 0 1

शुक्लाम्बरधरं विष्णुं
शशिवर्णम् चतुर्भुजं
प्रसन्न वदनम् ध्यायेत्
सर्व विघ्नोपशान्तयेत्

शुक् लाम् ब र ध रं विष् णुं
1 1 0 0 0 1 1 1
श शि वर् णम् च तुर् भु जं
0 0 1 1 0 1 0 1
प्र सन् न व द नम् ध्या येत्
1 1 0 0 0 1 1 1
सर् व विघ् नो प शान् त येत्
1 0 1 1 0 1 0 1

Sanskrit meters

The formula for anuShTup meter is:

pancamaM laghu sarvatra saptamaM dvicaturthayoH /
(5th is laghu everywhere) (7th (is laghu) in the 2nd and 4th)

shhashhTam guru vijAnlyAt etat shlokasya lakshanam //
(6th is guru)

This itself is written in the anuShtup meter:

पंचमं लघु सर्वत्र सप्तमं द्विचतुर्थयोः ।
पं च मं ल घु सर् वत् र सप् त मद् वि च तु र् थ योः
1 0 1 0 0 1 1 0 | 1 0 1 0 0 1 0 1

शष्टम् गुरु विजानीयात् एतत् श्लोकस्य लक्षणम् ॥
शष् टम् गु रु वि जा नी यात् ए तत्श् लो कस् य लक् ष नम्
1 1 0 0 0 1 1 1 | 1 1 1 1 0 1 0 1

Sanskrit meters

<u>chandas (meter)</u>	<u>pāda (lines)</u>	<u>aksara (syllables)</u>
gāyatrī	3	8, 8, 8
uṣṇik	3	8, 8, 12
anuṣṭubh	4	8, 8, 8, 8
br̥hatī	4	9, 9, 9, 9
pañkti	4	10, 10, 10, 10
triṣṭubh	4	11, 11, 11, 11
jagatī	4	12, 12, 12, 12

Several of these meters is are found with other variations. For example, br̥hatī could also be 8, 8, 8, 12 or 8, 8, 12, 8; and pañkti could also be 8, 8, 8, 8.

Sanskrit meters - 19 per pAda

Saraswati Vandana mantra:

या कुंदेदु तुषार हार धवला, या शुभ्र वस्त्रा वृता ।

या वीणा वरदण्ड मंडित करा, या श्वेत पद्मासना ॥

या ब्रह्मा अच्युत शंकर प्रभृतिभिः देवैः सदा वन्दिता ।

सा माम् पातु सरस्वति भगवति निःशेष जाड्यापहा ॥

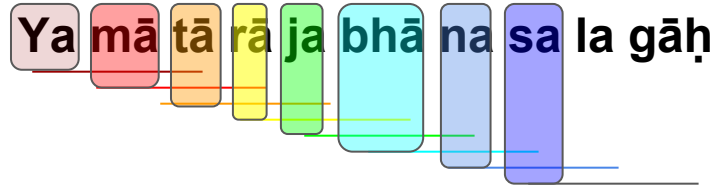
या	कुन्	देन्	दु	तु	षा	र	हा	र	ध	व	ला	या	शुभ्र	र	वस्त्	राव्	रु	ता	
1	1	1	0	0	1	0	1	0	0	0	1	1	1	0	1	1	0	1	
या	वी	णा	व	र	दन्	ड	मन्	डि	त	क	रा	या	श्वे	त	पद्	मा	स	ना	
1	1	1	0	0	1	0	1	0	0	0	1	1	1	0	1	1	0	1	
या	ब्रह्	मा	च्यु	त	शन्	क	र	प्	र	ब्रु	ति	भिः	दे	वै	स	दा	पू	जि	तां
1	1	1	0	0	1	0	1	0	0	0	1	1	1	0	1	1	0	1	
सा	माम्	पा	तु	स	रस्	व	ती	भ	ग	व	ती	निस्	से	श	जाड्	या	प	ह	
1	1	1	0	0	1	0	1	0	0	0	1	1	1	0	1	1	0	1	

Sanskrit gaNas

Triplets of syllables are important in sanskrit poetry, they are called gaNas.

The set of all gaNas of laghu and guru syllables have been summarized as:

YamAtArAjabhAnasalagAH



- **ya-gaṇa:** ya-mā-tā = L-G-G = 0 1 1
- **ma-gaṇa:** mā-tā-rā = G-G-G = 1 1 1
- **ta-gaṇa:** tā-rā-ja = G-G-L = 1 1 0
- **ra-gaṇa:** rā-ja-bhā = G-L-G = 1 0 1
- **ja-gaṇa:** ja-bhā-na = L-G-L = 0 1 0
- **bha-gaṇa:** bhā-na-sa = G-L-L = 1 0 0
- **na-gaṇa:** na-sa-la = L-L-L = 0 0 0
- **sa-gaṇa:** sa-la-gā = L-L-G = 0 0 1

Notice how all the binary numbers have been sorted to make only 1 bit different between every two consecutive numbers. Makes for easy remembrance!

Sanskrit meters

Other meters have been defined with the respective syllable and gaNa orders:

OTHER COMMON METERS

No. of syllables in each quarter	Triad sequence	Name of the meter (vRRittaM)	Examples
11	SLS / LLS /SLS /LL	Upendra-vajra	1. Namah-shivAbhyAM nava-yauvanAbhyAM 2. manojavaM mAruta tulyavegaM (ma-no-ja-/vaM-mA-ru-/ta-tul-ya-/ve-gaM) 3. avaimi cainAM anagheti kim tu 4. namostu rAmAya salakshmaN'Aya
	LLS/LLS/SLS/LL <i>ta-ta-ja-gu,gu</i>	Indra-vajra	1. astyuttarasyAM dishi devatAtmA 2. shri vaidyanAthAya namaH shivAya 3. vAsAmsi jIrNAni yathA vihAya 4. syAdindravajra tatajAstatogau
	LSL/SSS/LSL/SL	Rathoddhata	1. yatra yatra raghun.Atha-kIrtanaM
	LLL/LLS/LLS/LL	ShAlinI	1. ekodevah keshavo vA shivo vA 2. rUpaM yattat-prAhuravyaktam-AdyaM
12	SLL/SLL/SLL/SLL <i>ya-ya-ya-ya</i>	Bhujangaprayata	1. kumAreshasUno guha-skanda-senA 2. sadA rAma rAmeti rAmAmRtaM te 3. bhujangaprayAtashcaturbhir-yakAratH
	SSS/LSS/LSS/LSL	Druta-vilambita	1. vara-parAshara-gotra-samudbhavaM 2. nigamakalpa-tarorgallitaM phalaM
	SLS/LLS/SLS/LSL	Vamshastha	1. tvameva tAvatparicintaya svayaM
13	SLL/LLL/LSL/LSL/L	ChandriNI	1. suvarNapraAkAre'shAnyadigbhittibAge

14	LLS/LSS/SLS/SLS/LL <i>ta-bha-ja-ja-gu,gu</i>	Vasanta-tilaka	1. tvaM niyamukta-parishuddha vibuddha AtmA 2. mAtA mameti nagarAja sutorupIThaM 3. jneyaM vasantatilakaM ta-bha-ja jagau gaH
17	LLL/LSS/SSS/LLS/LLS/LL	MandAkrAnta	1. kascit kAntA virahaguruNA svAdhikArAt pramattaH 2. shAntAkAraM bhujagashayanaM padmanAbhaM sureshaM
	SLL/LLL/SSS/SSL/LSS/SL	ShikharinI	1. shivaH shaktyAyukto yadi bhavati shaktaH prabhavituM
19	LLL/SSL/SLS/SSL/LLS/LLS/L	ShArdUla-vikrIditaM	1. yAkundendu tushAraHA davaLA yA shubra- vastrAvRta 2. vishvaM darpaNa dRshyamAna-nagarI tulyaM nijAntargataM
21	LLL/LSL/LSS/SSS/SLL/SLL/SLL	Sragdhara	1. kshirodanvatpradeshe suchimaNivilasatsaikatair-mauktikAnAM

Sanskrit meters

https://en.wikipedia.org/wiki/Sanskrit_prosody#Chandas_and_mathematics

<https://www.scribd.com/document/330365258/Sanskrit-Metres-Chandas>

http://www.krishnamurthys.com/profvk/Sanskrit_meters.html

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<http://cs.annauniv.edu/insight/Reading%20Materials/chhandas/pages/typepage.htm>

Halayudha triangle

<https://en.wikipedia.org/wiki/Halayudha>