Using grains in medieval Sanskrit Mathematical texts

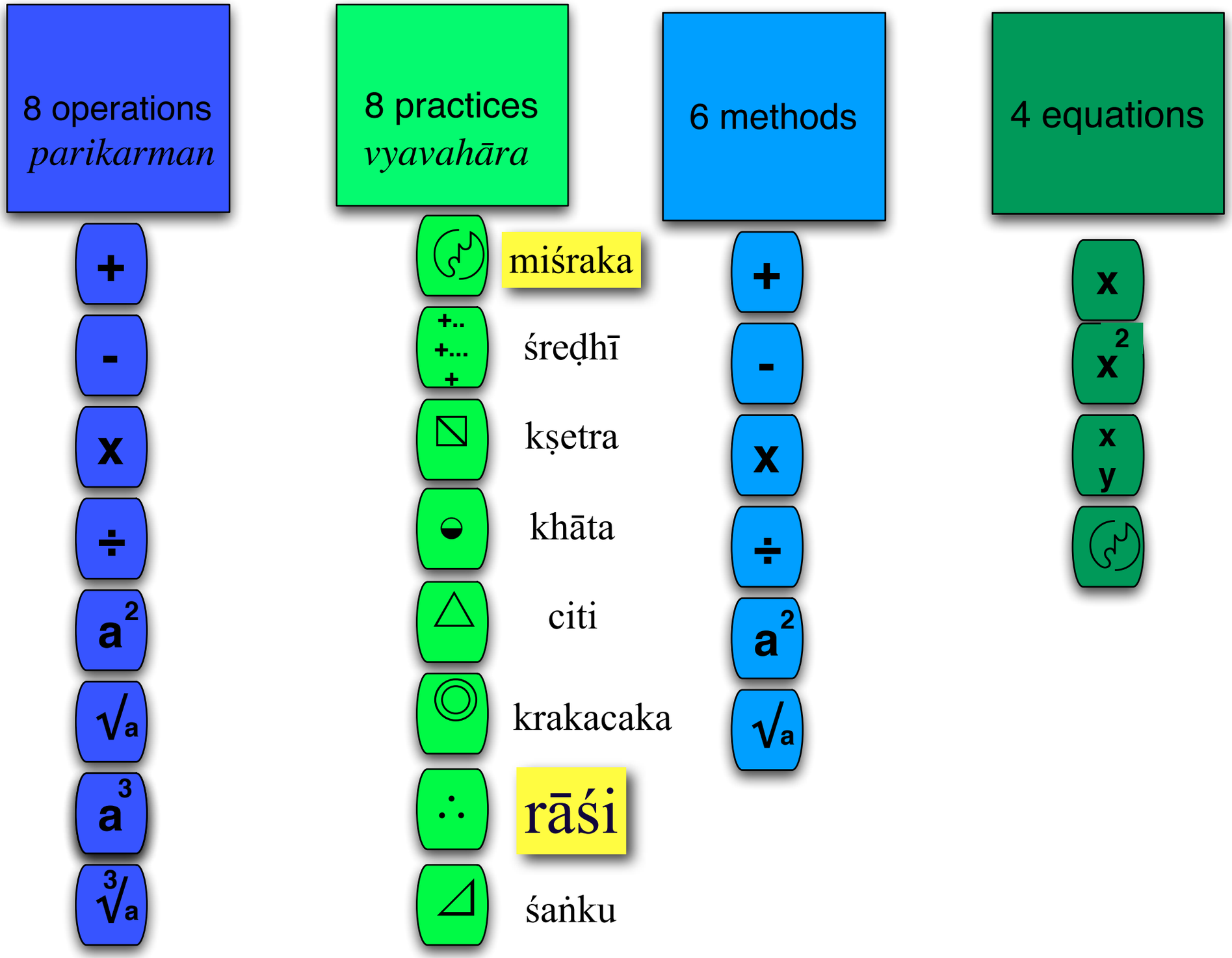
A. Keller

Saw workshop

03/2012

Structure of the Līlāvatī

Structure of the Bijagaṇita



Proportionate distribution

(*prakṣyepaka*) *miśraka-vyavahāra*

GSK. 3.7 Divide the mixed amount (harvest) by the sum of the parts (investments) having equal denominators, after having multiplied by each part (investment). This is the method of investments, <by means of which> one should know the fuits (shares) from the mixed amount (harvest).

GSK.3.8 Two, three, five, and four *maṇas* of seeds were thrown together (or invested). This produced two hundred and ten <*maṇas*>. What is the share (*bhinna-phala*) of the harvest of each one.

SaKHYa (S.R. Sarma, Takanori Kusuba, Takao Hayashi Michio Yano), *Gaṇitasārakaumudī, The moonlight of the essence of mathematics by Ṭhakkura Pherū, Edited with introduction, Translation, and Mathematical Commentary,* Manohar, 2009, p. 19, 62, 135.

Proportionate distribution

(*prakṣyepaka*) *miśraka-vyavahāra*

GSK. 3.7 Divide the mixed amount (*juī*-harvest) by the sum of the parts (investments) having equal denominators, after having multiplied by each part (*aṃśa*- investment). This is the method of investments, <by means of which> one should know the fruits (shares, *phala*) from the mixed amount (*jei*- harvest).

GSK.3.8 Two, three, five, and four *maṇas* of seeds were (*bīya*, skt *bīja*) thrown together (or invested). This produced two hundred and ten <*maṇas*>. What is the share (*bhinna-phala*) of the harvest of each one.

harvest *halahari dinnāṇa* «of those given by the plough-holder» (farmer)

PG 59 a To obtain the individual shares (of the partners) in the produce (*phalāvāptyai*), the seeds (contributed by the partners), as divided by their sum, should be severally multiplied by the produce (*phala*).

svayuti-hṛta-prakṣepāt phalena hanyāt pṛthak phalāvāptyai/

K. S. Shukla. *Pāṭīgaṇita of Śrdharācarya*. Lucknow University, Lucknow, 1959. (skt 73, ,eng. 49-50

$$p_i = \frac{M \quad a_i}{\sum_{j=1}^{n} a_j}$$

Let a_i be the investments

M the total grain,

p_i the share of each

BSS.12.16a, BM N1, Tr 38a, GSS vi 79 1/2, MS 15.36, SS 13.19a, L94, GK2.1a, GSK 3.7, PV X16

PG 59 a To obtain the individual shares (of the partners) in the produce (*phalāvāptyai*), the seeds (contributed by the partners, *prakṣepa*), as divided by their sum, should be severally multiplied by the produce (*phala*).

svayuti-hṛta-prakṣepāt phalena hanyāt pṛthak phalāvāptyai/

APG. 59 a prakṣipyate upyate santanyate iti prakṣepo bījaṃ, tatutpatiḥ phalam

***prakṣepa* is what is hurled (*prakṣip*), sowed (*vap*), stretched (*saṃtan*), that is seed (*bīja*). *phala* is its yield.**

***prakṣepaka* the sum invested by each member of a commercial company**

miśraka-vyavahāra

PG. 59 ex.1 Two, three, five, and four *prastha*s of seeds (are the contributions of the partners) and two hundred and ten is the produce; what are the shares (of the partners) seperately?

dvau trayaḥ pañca catvāraḥ prasthā bījasya tatphalam/
śatadvayaṃ daśopetaṃ tatra kiṃ syāt pṛthak pṛthak //

$a_1=2$

$a_2=3$

$a_3=5$

$a_4=4$

prasthas of seeds $p_i = \frac{M \quad a_i}{\sum_{j=1}^{n} a_j}$

$M=210$

$\sum_{j=1}^{n} a_j=14$

$p_1=30$

$p_2=45$

$p_3=75$

$p_4=60$

prasthas of seeds

Mounds of grain
rāśi-vyavahāra

L 227 The tenth part of the circumference is equal to the depth/height (*vedha*) in the case of coarse grain (*anaṇu*), the eleventh part, in that of fine (*aṇu*), and the ninth in the instance of bearded corn (*śūkadhānya*). A sixth of the circumference being squared and multiplied by the depth/height, the product will be the solid cubits: and they are Māgadhā *khāryas*.

BSS 12.50, Tr 61-62, SS 13.51, L. 227, PV A29-31

like, a measure, which contains a solid cubit, is called technically a khārikā of Māgdha

hastonmitaiḥ vistṛtidairdhyapiṅdaiḥ yad dvādaśāsraṃ ghanahastasaṃjñam/
dhānyādike yat ghanahastamānaṃ śāstroditā māgdhakhārikā//

L 8 A droṇa is the sixteenth part of a khārī, and an āḍhaka is a quarter of a droṇa/
A prastha is a fourth of an āḍhaka; and a kuḍava is by ancients termed a quarter of a prastha//

droṇastu khāryāḥ khalu ṣoḍaśāṃśaḥ syād āḍhako droṇacaturthabhāgaḥ/
prasthaś caturthāṃśa ihāḍhakasya prasthāṅghrirādyaiḥ kuḍavaḥ pradiṣṭaḥ//

one khārī ≈ 32kg

khārī ← 16 ← droṇa ← 4 ← āḍhaka ← 4 ← prastha ← 4 ← kuḍava

Mounds of grain

rāśi-vyavahāra

GSK. 3.96 A mound of grain heaped (*anna-rāśi*) on an even ground. The square of one sixth of its circumference, multiplied by the height, gives <the volume of grain in> cubic *hatthas*. One cubic *hattha* is a *patta*.

GSK.3.97 In the case of <fine> grains like sesamum (*tila*) and Kuddava, the height of the mound is one-ninth of its circumference; in the case of mung pulses (*mugga*) and wheat (*gohuma*), one tenth; in the case of Vora and horse beans (*kulattha*) one eleventh.

SaKHYa (S.R. Sarma, Takanori Kusuba, Takao Hayashi Michio Yano), *Gaṇitasārakaumudī, The moonlight of the essence of mathematics by Ṭhakkura Pherū, Edited with introduction, Translation, and Mathematical Commentary,* Manohar, 2009, p. 72, 158

BSS 12.50, Tr 61-62, SS 13.51, L. 227, PV A29-31

Mounds of grain
rāśi-vyavahāra

GSK. 3.96 A mound of grain heaped (*anna-rāśi*) on an even ground. The square of one sixth of its circumference, multiplied by the height, gives <the volume of grain in> cubic *hatthas*. One cubic *hattha* is a *patta*.

Let C be the circumference

h the height

both in *hatthas*

$$V = (\frac{C}{6})^2 \times h$$

cubic *hatthas*

Mounds of grain
rāśi-vyavahāra

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Let C be the circumference in *hatthas*

$$h = \frac{C}{ß}$$

in *hatthas*

ß=9,10,11

Mounds of grain
rāśi-vyavahāra

GSK. 3.98-99 A circular mound is standing like a peak of a mountain. Its height is four and circumference thirty-six <*kara*s>. If the mound is piled agains the side of a wall the circumfrence is half; if against the inside of a corner, it is a quarter; if against the outside of a corner, the circumference is less by a quarter. Know that the height is the same. Tell what will be the volumes of these mounds separately in <cubic> *kara*s.

GSK.3.100 Having multiplied the half, the quarter, and the quarter-less circumferences by two, four, and one and one-third, respectively, obtain the volumes as before and then divide <the results> by the respective multipliers.

Mounds of grain
rāśi-vyavahāra

$$V = (\frac{C}{6})^2 \times h$$

GSK. 3.98-99 A circular mound is standing like a peak of a mountain. Its height is four and circumference thirty-six <*karas*>. If the mound is piled agains the side of a wall the circumfrence is half; if against the inside of a corner, it is a quarter; if against the outside of a corner, the circumference is less by a quarter. Know that the height is the same. Tell what will be the volumes of these mounds separately in <cubic> *karas*.

Ref: Tr 102,104,105

C =36

h =4

both in *karas*

$$V = (\frac{36}{6})^2 \times 4 = 144$$

cubic *karas*

C' =C/2=18

h =4

both in *karas*

$$V = (\frac{18}{6})^2 \times 4 = 72$$

cubic *karas*

Yield of Grains

GSK.5.2. Grain grows everywhere, but because of the quality of the soil, there is much difference <in the yield>. Delhi, Hansi and Narhad: know that these are irrigated regions.

GSK.5.4-8. The yield (phala) of food-grains is obtained at harvest from <an area of> one *vīgaha* of twenty *visuvas* as follows. Know sixty *maṇa*s of kodrava grains (kuddava), twenty-four of kidney beans, twenty-two *maṇa*s of chaula beans, sixteem of sesame, eighteen of mung, twenty of italian millet, fifteen of millet and 'horses' of rice king, sixteen *maṇa*s of cotton, forty of Indian millet, ten of flax, and so also for sugar-cane. <These are> the autumn havrest. Know, from now on the spring harvest. Forty-five <*maṇa*s> of wheat, thirty-two of rice, lentil, and chickpeas, fifty-six *maṇa*s of barley, ten of mustard, linseed and sfflower, fourteen *maṇa*s of val pulses, Indian rape, and horse grains. etc.