

LEELAVATHI

The legend is well-known. When Bhaskaracharya cast his daughter Leelavathi's horoscope, he discovered to his horror that her stars foreboded an early widowhood. Unless her marriage was performed at one particular *muhurtha* when the planets were placed in an exceptionally propitious configuration. Accordingly, when his daughter was about to be married, Bhaskara constructed an accurate water-clock that would precisely mark the arrival of the auspicious hour. But the little bride, chancing upon the novel apparatus, proceeded to examine it closely prompted by her childish curiosity. Absorbed in her scrutiny, she failed to notice a pearl drop down from her necklace and lodge itself in the cistern of water. The pearl slowed down the flow of water, the awaited moment passed and the marriage rites were completed at the wrong time. Too late the hapless father discovered the fatal error. Within the year Leelavathi returned home bearing the sorrow of widowhood as had been prophesied. In order to educate his young and intelligent child as well as keep her entertained Bhaskara rendered his mathematics in poetic form. Naturally, he named the collection of these verses 'Leelavathi' after his little girl for whom they had been composed.

Bhaskaracharya or Bhaskara II, celebrated astronomer and mathematician, head of the astronomical observatory at Ujjain, was born in 1114 in a small town near the Sahyadri Range in the Western Ghats. He was widely acclaimed during his own lifetime and later not only for his outstanding achievements in astronomy and mathematics, but also for his extraordinary skill in mechanical arts. By his own statement, Bhaskara completed his masterpiece Siddhanta-shiromani in the year 1150 when he was thirty-six years of age. Four chapters of the original work have survived. Of these the Beejaganitha deals with algebra while the chapters Ganithadhyaya and the Goladhyaya are devoted to astronomy. Problems in arithmetic, geometry and to some extent algebra are incorporated in the first chapter—the Leelavathi.

Packed into about two hundred and twenty-seven stanzas of the Leelavathi are a number of topics in mathematics known at the time of Bhaskara. These include—among other things—squares and square roots, rates of interests, proportion, division by zero, quadratic and indeterminate equations, arithmetic and geometric progressions, permutations and so on. Each stanza testifies to Bhaskara's consummate mastery of poetry besides his brilliance as a mathematician. Without doubt these verses were intended to be studied for their mathematical content and enjoyed for their poetic grace and vivid imagery.

We present here a few of the more picturesque examples from the Leelavathi, the original Sanskrit text and its free translation. This is followed by the solutions to the mathematical problems they pose.

'Joy and happiness is indeed ever increasing in this world for those who have Leelavathi clasped to their throats, decorated as the members are with neat reduction of fractions, multiplication and involution, pure and perfect as are the solutions, and tasteful as is the speech which is exemplified'.

— The Leelavathi of Bhaskara

To augment wisdom and strengthen confidence, read, do read, mathematician, this abridgement elegant in style, easily understood by youth, comprising the whole essence of computation, and containing the demonstration of its principles, replete with excellence and void of defect'.

— The Beeja ganitha of Bhaskara.

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1

अस्ति स्तंभतले विलं
 तदुपरि क्रीडा शिखण्डी स्थितः।
 स्तंभे हस्त नवोच्छते
 त्रिगणित स्तंभ प्रमाणान्तरे।।
 दृष्ट्वाहिं विलमात्रजन्तम—
 — पततिर्यक् स तस्योपरि।
 प्किप्रं ब्रूहि तयोर्विलात्
 कतिमितैः साम्येन गत्योर्युतः।।



A peacock swooped down from its perch atop a pillar, nine feet high, on seeing a snake gliding towards his hole at the foot of the pillar. The snake was at a distance thrice the pillar's height

from his hole when the peacock sighted him. If they both travelled at the same speed, tell me quickly, how far from the pillar did the peacock and the snake meet?

2

आद्ये दिने द्रम्म चतुष्टयं यो
 दत्त्वा द्विजेभ्योर्नुदिनं प्रवृत्तः।
 दातु मखे पञ्च चयेन पक्षे
 द्रम्मा वद द्राक्वनि तेन दत्तः।।



Once a king offered gifts to brahmins for fifteen consecutive days. On the first day he gave them four coins, nine on the second, and so on, my

friend, increasing the amount by five coins each day. How many coins in all did the brahmins receive?

3

चक्र क्रौञ्चाकूलित मलिले
 क्वापि दृष्टं तडागे।
 तोयादूर्ध्वं कमलकलिका—
 —ग्रं वितस्ति प्रमाणम्।।
 मन्दं मन्दं चलितमनिले—
 —नाहतं हस्तयुग्मम्।
 तस्मिन् मग्नं गणक कथय
 क्षिप्रमम्भः प्रमाणम्।।



In a lake teeming with birds like the Chakravaka and the Krouncha a lotus swayed softly in the gentle breeze. When erect it was half a foot

above water and was submerged when pushed aside by two feet. Compute quickly then the depth of the water.

4

पार्थः कर्णवधायः मार्गणगणं
 कृद्धो रणे सन्दधे।
 तस्यार्धेन निवार्य तच्छरगणं
 मूल्यैश्चतुर्भिर्हयान्।।
 शल्यं षाड्भिरथेषुभि -
 - स्त्रिभिरपिच्छत्रं ध्वजं कामुकम्।
 चिच्छेदास्य शिरः शरेण
 कतिते यान्यर्जुनः सन्दधे



Consumed with fury Partha stood in the battle-field resolved to slay Karna. With half the arrows in his quiver he destroyed those of his adversary; with four times the square root of the total he killed his horses. Six were needed to bring down

Shalya. With three he cut down Karna's royal umbrella, his standard and bow. With the last arrow rolled Karna's head. How many arrows were there in Arjuna's quiver?

5

पाशाङ्कुशाहि इमरुह कपाल शूलैः।
 खट्वाङ्ग शक्ति शर चापयुतेर्भवन्ति।।
 अन्योन्य हस्त कलितैः कति मूर्ति भेदाः।
 शंभोहरिख गदारि सरोज शंखैः।।



Lord Shambhu holds ten attributes in his ten hands, namely, 'pasha' the rope, 'ankusha' the elephant's hook, 'sarpa' the serpent, 'damaru' the drum, 'kapala' the skull, 'trishula' the trident, 'khatvanga' the club, 'shakthi' the dagger, 'shara' the arrow and 'chapa' the bow. Were these attributes to be distributed in all possible ways among

the ten hands, how many distinct images of the Lord can be made? Likewise, how many variations of form are possible in the case of Lord Hari if he holds in his four hands 'gada' the mace, 'chakra' the discus, 'saroja' the lotus and 'shankha' the conch?

6

हारस्नारस्तरुण्या निधुवनकलहे
 मौक्तिकानां विशीर्णां
 भूमौयातस्त्रिभागः शयनतलगतः
 पञ्चमांशस्य दृष्टः।
 प्राप्तः षष्ठः सुकेश्या गणक
 दशमकः संगृहीतः प्रियेण
 दृष्टं षट्कं च सूत्रे कथय
 कतिपर्यमौक्तिकैरेष हारः।।



The pearl necklace of a young woman broke during an amorous tussle. One third of the pearls rolled away on the floor and one fifth were on the bed. A sixth were found on her person while a

tenth were gathered by her beloved. Only six remained dangling from the broken string. Say, how many pearls did the necklace contain.