

# $\pi$ in China

## Ancient China

Comparing calculations of  $\pi$  made in ancient times is a key measure of the development level of a nation's mathematics. China certainly reached a high level of achievement in this regard.

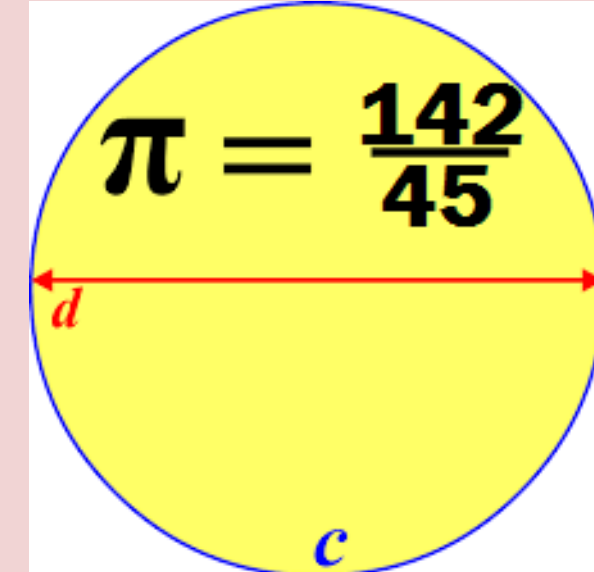
### Zhang Heng (张衡) (130 AD)



Zhang Heng gave  $\sqrt{10}$  for the value of  $\pi$ . He deduced this value from the ratio of  $\frac{8}{5}$  for the volume of a cube to that of an inscribed sphere. His estimate remained very popular throughout Asia for centuries.

### Wang Fan (王蕃) (250 AD)

Wang Fan introduced his “magic numbers”: if a circle has a circumference of 142, then it has a diameter of 45. This implies that  $\pi$  is approximately 3.156.



### Liu Hui (刘辉) (263 AD)

Liu Hui employed an 192 sided polygon to show that  $3.141024 < \pi < 3.142074$ .

To contextualize these bounds, Archimedes used both a circumscribed and an inscribed polygon of 96 sides to obtain his  $\pi$  inequalities. Liu Hui used only one inscribed 96-gon to obtain his inequality and his results were more accurate than Archimedes'.



### Zu Chongzhi (祖冲之) and Zu Geng (祖暅之) (480 AD)

In the 5th century AD, the father-son team Zu Chongzhi and Zu Geng used inscribed polygons to calculate  $\pi$  as  $\frac{355}{113} \simeq 3.1415929$ , the most accurate value we would see from China for a thousand years.



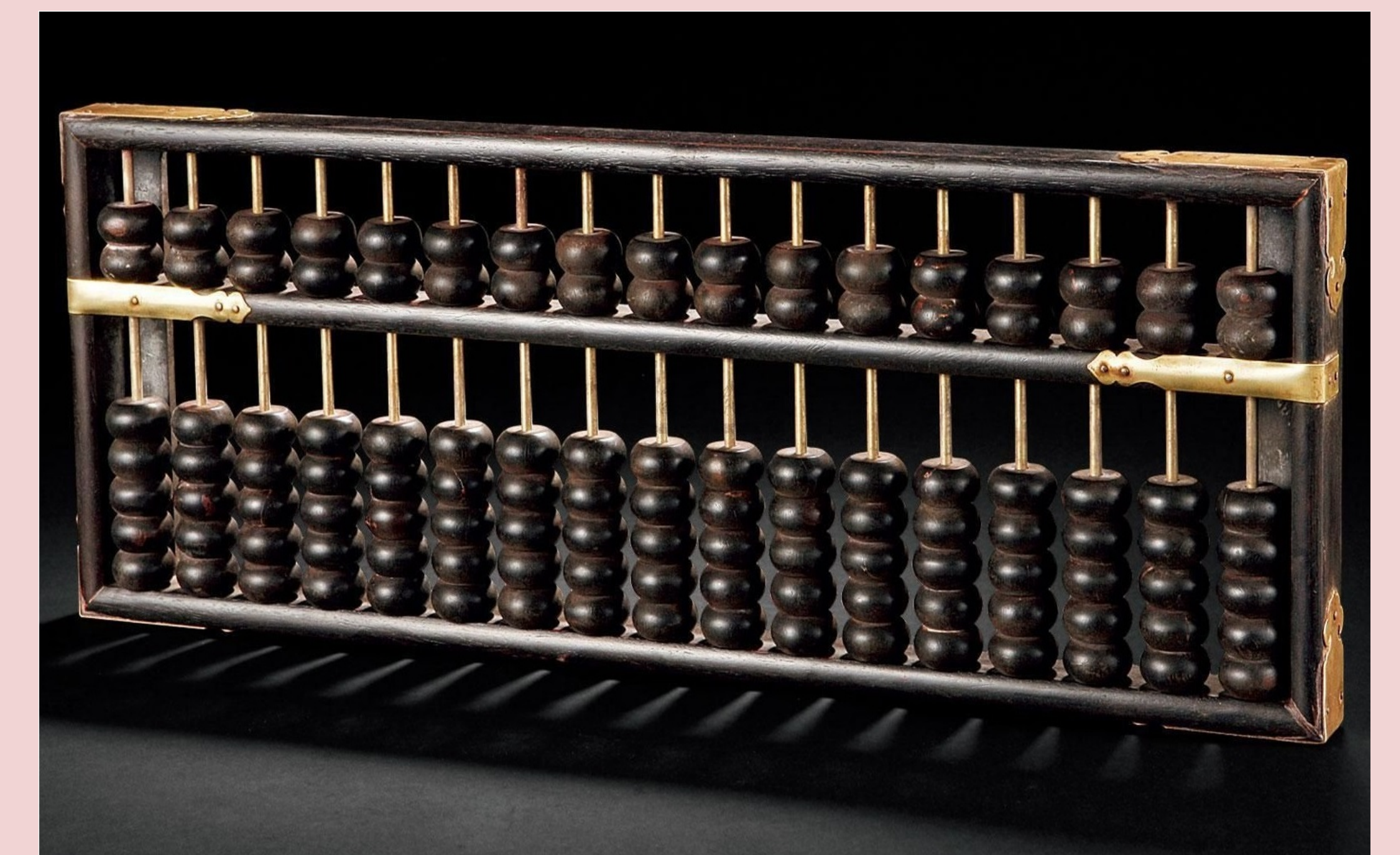
## Classical China

After the work of Zu Chongzhi, the development of  $\pi$  was halted for centuries. It was not until the 14th century when people once again consider the value of  $\pi$ . One such mathematician was Zhao Youqin (赵友钦), who followed the method of inscribed polygons with a regular polygon of 6,384 sides to confirm Zu's accuracy.

### Ming Mathematicians

After the overthrow of the Yuan Dynasty, China became suspicious of knowledge it used. The Ming Dynasty turned away from math and physics in favor of botany and pharmacology.

At this period, the abacus overtook the counting rods and became the preferred computing device. During the Ming dynasty, mathematicians were fascinated with perfecting algorithms for the abacus. Zu Chongzhi had made his calculation of  $\pi$  before the invention of the abacus and had done all the work using nothing more than wooden counting sticks. Interest turned to the evaluation of  $\pi$  in order to see if improvements could be made using this popular counting tool. However, none were as accurate as Zu's Value.



With the dual publication of Euclid's Elements in 1607 by Xu Guangqi (徐光启) and Italian Jesuit Matteo Ricci, a revival of mathematics began in China. In the Early 1700s Jesuit missionaries further pushed the revival by providing the key to measuring polygons. In 1713, by imperial order, a book containing the ever popular polygon method was published. In 1874, using Gregory's series and

$$\frac{\pi}{4} = \arctan\left(\frac{1}{2}\right) + \arctan\left(\frac{1}{3}\right),$$

Zeng Jihong (曾纪鸿) found 100 digits of  $\pi$ .