

**BACCALAURÉAT GÉNÉRAL ET TECHNOLOGIQUE
ÉPREUVE SPÉCIFIQUE DES SECTIONS EUROPÉENNES
MATHÉMATIQUES – ANGLAIS**

SUJET 12 – Bode's law

Thèmes : Mathematics and astronomy, distances, sequences

Ce sujet comporte 2 pages. L'usage de la calculatrice est autorisé.

In 1766 a German astronomer named Johann Daniel Tietz (Titius) discovered a very mysterious connection between the distances of planets to the Sun. The sequence starts with the numbers 0, 3, 6, 12, 24 etc to which you add 4 which you then divide by 10. Those numbers were very close to the actual distances of planets to the Sun when measured in astronomical units.

Johann Elert Bode, another German astronomer, adopted this formula with so much enthusiasm that it came to be known as Bode's law. The table below compares some approximate actual distances with the distances given by the formula:

Planet	Actual Distance	Distances given by the formula
Mercury	0.39	0.4
Venus	0.72	0.7
Earth	1.00	1.0
Mars	1.52	1.6
?		2.8
Jupiter	5.20	5.2
Saturn	9.55	10.0

Note that neither Uranus nor Neptune were known at the time. However, there was an anomaly with the formula, predicting that a planet should exist at 2.8 AU. Bode urged that a search be made for this planet. In 1801, an Italian astronomer named Giuseppe Piazzi actually discovered Ceres, an asteroid at 2.77 AU from the Sun. Despite many years of investigation, no explanation has been found for any underlying reason that planets should or do follow this formula, and most scientists now regard the Titius-Bode formula as just an interesting near coincidence with reality.

Astronomical unit (or AU): distance between the Earth and the Sun which is approximatively 149,597,870 km.

*Adapted from various Wikipedia pages
and from the website spaceacademy.net.au*

1. Read the first five lines of the text ending with "measured in astronomical units".
2. Explain what the text deals with and comment it.
Don't forget to talk about the different characters.

Exercise

1. Compute the distance between Mercury and the Sun in kilometres.
2.
 - a. The astronomer William Herschel discovered Uranus in 1781 at 19.22 AU from the Sun. Is the formula still working for Uranus?
 - b. Same question with Neptune (discovered by Johann Galle in 1846) and Pluto (discovered by Percival Lowell and Clyde Tombaugh in 1930) respectively at 30.11 AU and 39.50 AU from the Sun.
 - c. What can we conclude from these examples?
3. We can notice that the numbers 3, 6, 12, 24 etc are the terms of a sequence (u_n) defined by $u_n = 3 \times 2^n$ for a natural number.

Work out a closed formula for Bode's sequence.
Don't forget to check your answer.

4. According to Bode's formula, what would be the distance between the 20th planet and the Sun?
Give your answer in AU then in million kilometres.