

Mathematical Patterns in the Natural World

Pre-Calculus · Answer Key · 8 Questions

1. The spiral pattern of a nautilus shell can be modeled by a logarithmic spiral. If the polar equation is $r = a * e^{(b*\theta)}$, what represents the rate of expansion?

A) The constant b

B) The variable θ

C) The initial value a

D) The eccentricity

2. Many tree species, such as the spruce, exhibit growth patterns that follow the Fibonacci sequence. Which function best approximates the growth of these structures as n approaches infinity?

A) Linear function

B) Binet's formula

C) Quadratic equation

D) Step function

3. The population growth of a bacteria colony in an oxygen-rich environment is modeled by $N(t) = N_0 * e^{(rt)}$. What is the specific term for 'r' in this continuous exponential growth equation?

A) Doubling period

B) Malthusian parameter

C) Logistic capacity

D) Half-life

4. The intensity of sound produced by a cicada is measured in decibels using the formula $L = 10 * \log_{10}(I/I_0)$. This is an example of what type of mathematical scale?

A) Logarithmic

B) Arithmetic

C) Hyperbolic

D) Trigonometric

5. In the study of phyllotaxis, the divergence angle between successive leaves on a stem is approximately 137.5 degrees, derived from the golden ratio. What is the approximate value of this ratio (ϕ)?

A) 1.414

B) 2.718

C) 1.618

D) 3.141

6. The predator-prey relationship between lynx and hares follows cyclical oscillations often modeled by systems of periodic trigonometric functions. Which function would best model a repeating seasonal oscillation?

A) $f(x) = x^2$

B) $f(x) = A \sin(Bx + C)$

C) $f(x) = e^x$

D) $f(x) = 1/x$

7. Honeycombs are constructed in hexagonal prisms to minimize surface area for a given volume. If the volume V is fixed, the surface area A is minimized when the hexagonal cells are arranged in a pattern where the side length ' s ' satisfies what relationship?

A) $V = 6s^3$

B) $V = 3s^2h$

C) $V = 2.598s^2h$

D) $V = s^3$

8. The carbon-14 dating method used to determine the age of organic matter in environmental samples utilizes an exponential decay function $N(t) = N_0 * e^{(-?t)}$. What does '?' represent?

A) The decay constant

B) The atmospheric carbon concentration

C) The initial mass of the sample

D) The time elapsed