MATHEMATICS · GRADES 10-12

Identifying prime polynomials

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you know when an expression simply cannot be factored any further, so you stop hunting for brackets that do not exist and move on. A prime polynomial is one that will not split into simpler factors, no matter how long you look, and recognising it saves you wasted time and wrong answers. It matters when you are solving equations or simplifying expressions, because trying to factor something that cannot be factored will only send you in circles.



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Rule

Prime polynomials: a polynomial is prime over the real numbers if it cannot be factored into simpler factors with real numbers.

Check first for a common factor. For a quadratic, if the discriminant $b^2 - 4ac$ is negative, there are no real roots, so it has no real linear factors and is prime. A sum of squares, such as $x^2 + 1$, has no difference of squares pattern, so it is prime.

Worked examples

EXAMPLE 1

Q Is $x^2 + 1$ prime over the real numbers?

SOLUTION

Try the difference of squares pattern: it needs a minus sign, and here there is a plus sign.

$__ \times __ = 1$

$__ + __ = 0$

No two real numbers fit both lines.

So $x^2 + 1$ does not factor over the real numbers: it is prime.

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EXAMPLE 2

Q Is $x^2 + x + 1$ prime over the real numbers?

SOLUTION

For $x^2 + x + 1$, the discriminant is $b^2 - 4ac = 1 - 4 = -3$

A negative discriminant means no real roots, so it has no real linear factors.

So $x^2 + x + 1$ is prime over the real numbers.

Practice questions

1 Is $x^2 + 4$ prime over the real numbers? Answer prime or not prime.

- A prime
- B not prime

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2 Can $x^2 - 4$ be factored over the real numbers? Answer prime or not prime.

- A prime
- B not prime

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3 Is $x^2 + 6x + 9$ prime over the real numbers? Answer prime or not prime.

- A prime
- B not prime

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4 Is $x^2 + 2x + 5$ prime over the real numbers? Answer prime or not prime.

- A prime
- B not prime

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5 Is $x^2 - 9$ prime over the real numbers? Answer prime or not prime.

- A prime
- B not prime

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6 Is $2x + 4$ prime over the real numbers? Answer prime or not prime.

- A prime
- B not prime

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7 Which of these is prime over the real numbers?

- A $x^2 + 3x + 2$
- B $x^2 + 3x + 5$

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8 Is $x^2 + 9$ prime over the real numbers? Answer prime or not prime.

- A prime
- B not prime

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9 Which of these is NOT prime over the real numbers?

- A $x^2 - 5x + 6$
- B $x^2 + 5$

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10 Is $x^2 + 4x + 5$ prime over the real numbers? Answer prime or not prime.

- A prime
- B not prime

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ANSWER KEY

1. prime

2. not prime

3. not prime

4. prime

5. not prime

6. not prime

7. $x^2 + 3x + 5$

8. prime

9. $x^2 - 5x + 6$

10. prime

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