What is the base in math

Decoding the Base: Unveiling the Foundation of Mathematical Systems

We encounter numbers daily, from calculating groceries to navigating complex financial models. But have you ever stopped to consider the fundamental structure that underpins these seemingly simple calculations? This structure, often unnoticed, is the "base" of a number system. Understanding the base unlocks a deeper appreciation for the elegance and power of mathematics. This delves into the fascinating world of bases, exploring their significance, implications, and applications.

Unveiling the Concept of a Base

At its core, a base in mathematics represents the number of unique digits used in a positional numeral system. Imagine a simple counting system. We naturally use the base-10 system, utilizing the digits 0 through 9. This means each position in a number represents a power of 10. For example, in the number 345, the '3' represents $3 * 10^2$ (3 hundreds), the '4' represents $4 * 10^1$ (4 tens), and the '5' represents $5 * 10^0$ (5 ones). This principle extends to other bases. In base-2 (binary), we use only 0 and 1, and each position represents a

power of 2. Base-8 (octal) utilizes the digits 0 through 7, while base-16 (hexadecimal) employs 0 through 9 and the letters A through F, representing values 10 through 15 respectively.

Visualizing Bases: A Comparative Approach

Consider the following table illustrating the representation of the number 10 in different bases: | Base | Representation | ||| | 10 | 10 | | 2 (Binary) | 1010 | | 8 (Octal) | 12 | | 16 (Hexadecimal) | A | This table vividly demonstrates how the same numerical value (10) can be represented differently depending on the chosen base.

Exploring the Advantages of Different Bases

Understanding different bases isn't merely an academic exercise. They offer substantial advantages across various fields: • Efficiency in Computer Science: Binary (base-2) is fundamental to computer operations. Computers utilize binary digits (bits) to represent data, providing a direct representation of logic gates and efficient processing. • **Simplifying Complex Calculations:** Certain conversions between bases can significantly simplify computations. For instance, converting between decimal (base-10) and binary can facilitate faster calculations for electronic circuitry. • *Improved Problem Solving:* Working with different bases fosters critical thinking and problem-solving skills, as it requires understanding of place value and powers. • **Enhanced Understanding of Number Systems:** This foundational understanding is crucial for comprehending other advanced mathematical concepts.

Challenges and Considerations

While bases offer significant advantages, some potential disadvantages need consideration:

Base Conversions: The Art of Translation

Understanding Decimal-to-Base-N Conversion

The process of converting a number from base-10 (decimal) to another base is fundamental. For example, converting the decimal number 25 to binary: 1. Repeated Division: Divide 25 by 2 repeatedly, noting the remainders. 2. Reading Remainders: The remainders, read in reverse order, form the binary representation. 25 ÷ 2 = 12 Remainder 1 12 ÷ 2 = 6 Remainder 0 6 ÷ 2 = 3 Remainder 0 3 ÷ 2 = 1 Remainder 1 1 ÷ 2 = 0 Remainder 1 Thus, 25 in decimal is 11001 in binary.

Base-N to Decimal Conversion

The reverse conversion (base-N to decimal) involves multiplying each digit by the corresponding power of the base and summing the results. For example, converting the binary number 1101 to decimal: (1 * 2^3) + (1 * 2^2) + (0 * 2^1) + (1 * 2^0) = 8 + 4 + 0 + 1 = 13 Therefore, 1101 in binary is 13 in decimal.

Applications Across Diverse Fields

Computer Science: The Binary Foundation

Binary code forms the bedrock of all modern computer operations. The language of 0s and 1s allows computers to perform complex calculations and execute instructions.

Mathematics: Exploring Patterns and Principles

The concept of a base transcends numerical representation. It can be applied to understanding abstract mathematical systems and algebraic structures.

Engineering: Enabling Precise Measurements

Hexadecimal (base-16) is frequently used in computer engineering to represent memory addresses and color codes, offering a compact way to represent binary data.

Beyond Numerical Representations

The base concept extends beyond mere number representation. It influences fundamental coding schemes and data structures, demonstrating its pervasive influence.

Actionable Insights

• *Embrace Different Bases:* Engage with binary, octal, and hexadecimal representations. • Master Conversion Techniques: Practice converting numbers between different bases. • *Apply the Concept:* Look for applications of bases in computer science, engineering, and other fields.

Advanced FAQs

1. **Can a base be negative?** No, the base must be a positive integer greater than 1. 2. **What is the significance of base-0?** Base-0 does not exist, as it would require infinitely many digits. 3. **How do bases relate to modular arithmetic?** Modular arithmetic provides a structure for representing remainders in divisions, closely related to understanding bases. 4. *What are the applications of bases in cryptography?* Bases underpin cryptographic systems, such as hashing and encryption algorithms. 5. **Are there non-positional number systems?** Yes, there are non-positional systems, like Roman numerals, but they lack the consistent positional value of base-based systems. This exploration into the concept of base unveils its profound impact on various aspects of mathematics and beyond. By grasping the fundamentals of bases, we gain a deeper understanding of the elegance and efficiency inherent in mathematical systems, empowering us to solve problems and appreciate the beauty of numbers in diverse fields.

What is the Base in Math?

Unpacking the Foundation of Our Number System

Ever stopped to wonder about the magic behind the numbers we use every single day? From counting your change to calculating the distance to the moon, numbers are the language of the universe. But have you ever paused to consider the fundamental building blocks of this language? That's where the concept of a 'base' in mathematics comes in. It's a seemingly simple idea, yet it's absolutely crucial to understanding how we represent and manipulate numbers. Think of it like this: if you're building with LEGOs, you have different brick sizes, right? You can build a small structure with just a few bricks, or a towering skyscraper with thousands. The size of the bricks you choose, and how you combine them, dictates the final outcome. In math, the 'base' is analogous to the size of those LEGO bricks, or more accurately, the number of unique digits available to construct our numerical expressions. So, what exactly *is* the base in math? In its simplest form, the base of a number system tells us how many unique digits are used before we need to 'carry over' and start a new place value. It's the foundation upon which our entire numerical understanding is built.

The Familiar World of Base-10: Our Everyday Number System

Let's start with the system we're all most familiar with: **base-10**, also known as the **decimal system**. Why is it called base-10? Because it uses ten unique digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. When we write a number like 547, we're not just stringing digits together randomly. Each digit has a specific value determined by its position. This is the concept of **place value**. In 547: * The '7' is in

the **ones place**, meaning it represents 7 * 10^0 (which is 7 * 1 = 7). * The '4' is in the **tens place**, representing 4 * 10^1 (which is 4 * 10 = 40). * The '5' is in the **hundreds place**, representing 5 * 10^2 (which is 5 * 100 = 500). Add them all up (500 + 40 + 7), and you get our familiar 547. The '10' in base-10 signifies that each place value is a power of ten. This is why, after we reach the digit '9' in the ones place, we can't simply add another unique digit. Instead, we 'carry over' and start a new place value, the tens place. This fundamental principle is what makes our decimal system so effective and intuitive for everyday use. The ubiquity of base-10 is often attributed to our ten fingers, which have historically been used for counting. It's a system that has evolved over millennia and is deeply ingrained in our culture and education. Understanding this concept of place value and the role of the base is the first step to unlocking the broader world of number systems.

Beyond Base-10: Exploring Other Number Bases

While base-10 is our go-to, it's far from the only base out there. In fact, the world of mathematics and computer science utilizes many different number bases. Exploring these other bases helps us understand the underlying principles more deeply and appreciate the elegance of different numerical representations.

Base-2: The Language of Computers (Binary System)

Perhaps the most important non-decimal base, especially in the modern world, is **base-2**, also known as the **binary system**. This is the fundamental language of all computers. Why? Because computers operate on electrical signals that are either 'on' or 'off', which can be represented by two states: 0 and 1. The binary system uses only two digits: 0 and 1. Just like in base-10, each position in a

binary number represents a power of the base. In this case, the powers are powers of 2. Let's look at a binary number, for example, 1011: * The rightmost '1' is in the 2^0 place (ones place): $1 * 2^0 = 1 * 1 = 1$ * The next '1' is in the 2^1 place (twos place): $1 * 2^1 = 1 * 2 = 2$ * The '0' is in the 2^2 place (fours place): $0 * 2^2 = 0 * 4 = 0$ * The leftmost '1' is in the 2^3 place (eights place): $1 * 2^3 = 1 * 8 = 8$ Adding these up (1 + 2 + 0 + 8) gives us 11 in base-10. So, $1011_2 = 11_{10}$. The efficiency of binary is incredible. Simple on/off switches, or 'bits' (binary digits), can be combined to represent any number, perform complex calculations, and store vast amounts of information. This is why understanding binary is so crucial for anyone interested in computer science, engineering, or digital technology.

Base-16: The Hexadecimal System for Programmers

Another important base, particularly in computer programming and data representation, is **base-16**, known as the **hexadecimal system**. This system uses 16 unique symbols. We use our familiar digits 0-9, but we need six more. To represent these, we use the letters A, B, C, D, E, and F. Here's how the hexadecimal digits map to their decimal equivalents: * 0-9 represent themselves (0-9) * A represents 10 * B represents 11 * C represents 12 * D represents 13 * E represents 14 * F represents 15 In hexadecimal, each place value is a power of 16. Let's convert a hexadecimal number, say 2AF, to base-10: * The 'F' is in the 16^0 place (ones place): $15 * 16^0 = 15 * 1 = 15$ * The 'A' is in the 16^1 place (sixteens place): $10 * 16^1 = 10 * 16 = 160$ * The '2' is in the 16^2 place (two hundred fifty-sixes place): $2 * 16^2 = 2 * 256 = 512$ Adding these up (15 + 160 + 512) gives us 687 in base-10. So, $2AF_{16} = 687_{10}$. Hexadecimal is often used because it provides a more compact way to represent binary data. For instance, four binary digits (bits) can be represented by a single hexadecimal digit. This makes it easier for programmers to read and write long strings of binary code.

Base-8: The Octal System (Less Common Now)

The **octal system**, or **base-8**, uses eight unique digits: 0, 1, 2, 3, 4, 5, 6, and 7. Each place value is a power of 8. While less prevalent today than binary or hexadecimal, octal was historically used in some computing contexts, especially with older mainframe systems. It also has a relationship with binary, where three binary digits can be represented by one octal digit. Let's convert an octal number, 732, to base-10: * The '2' is in the 8^0 place: $2 * 8^0 = 2 * 1 = 2$ * The '3' is in the 8^1 place: $3 * 8^1 = 3 * 8 = 24$ * The '7' is in the 8^2 place: $7 * 8^2 = 7 * 64 = 448$ Adding these up (2 + 24 + 448) gives us 474 in base-10. So, $732_8 = 474_{10}$.

Why Does the Base Matter? The Importance of Understanding Numerical Systems

Understanding different number bases is more than just a mathematical exercise; it's fundamental to grasping how information is represented and processed. Here's why the concept of 'base' is so important: * **Foundation of Computing:** As we've seen, binary (base-2) is the bedrock of all digital technology. Understanding bases is essential for anyone working with computers, from software developers to hardware engineers. * **Data Representation:** Different bases offer varying levels of compactness and readability for representing data. Hexadecimal, for example, is favored for its conciseness in showing binary patterns. * **Algorithmic Thinking:** Exploring different bases can sharpen your problem-solving skills and enhance your ability to think abstractly. Converting between bases requires understanding place value and exponents, which are core mathematical concepts. * **Historical Context:** Understanding the evolution of number

systems, from early tally marks to modern positional notation, provides valuable insight into human ingenuity and the development of civilization. * **Mathematical Abstraction:** The ability to work with and understand numbers in bases other than ten demonstrates a deeper comprehension of mathematical principles and allows for greater flexibility in problem-solving.

Converting Between Bases: A Practical Skill

The ability to convert numbers from one base to another is a practical skill that solidifies your understanding of the base concept. Let's briefly touch upon the general methods:

Converting from Any Base to Base-10

This is the method we've used throughout the examples. You take each digit in the given number, multiply it by the base raised to the power of its position (starting from 0 on the right), and then sum up all the results. For a number $d_n d_{n-1} ... d_1 d_0$ in base b, its base-10 equivalent is: $d_n * b^n + d_{n-1} * b^{n-1} + ... + d_1 * b^1 + d_0 * b^0$

Converting from Base-10 to Any Other Base

This typically involves repeated division and recording the remainders. You repeatedly divide the base-10 number by the target base. The remainders, read from bottom to top, form the digits of the number in the new base. For example, to convert 25 (base-10) to binary (base-2): * 25 / 2 = 12 remainder 1 * 12 / 2 = 6 remainder 0 * 6 / 2 = 3 remainder 0 * 3 / 2 = 1 remainder 1 * 1 / 2 = 0 remainder 1 Reading the remainders from bottom to top: 11001. So, $25_{10} = 11001_2$.

The Enduring Significance of the Base

The 'base' in math is a foundational concept that underpins our entire numerical world. It's not just about the digits we use, but about the structured way we assign value and build upon those values. From the intuitive ten fingers that shaped our base-10 system to the binary logic that powers our digital age, understanding bases is key to unlocking a deeper appreciation for mathematics and its applications. So, the next time you look at a number, whether it's 100 or 101101, remember the powerful concept of the base that gives it meaning. It's a simple idea, but one that carries immense weight in the grand tapestry of mathematics and technology. It’s the silent architect behind every calculation, every data point, and every technological marvel we encounter.

The Concept of Base in Mathematics: Foundations and Understanding

In mathematics, the idea of “base” plays a crucial role in shaping how we represent and interpret numbers, particularly in positional numeral systems. At its core, a base determines the number of unique digits, or symbols, used to construct numbers within a given numbering system. For example, the decimal system—commonly used in everyday life—operates on a base of ten, employing ten distinct digits from 0 to 9. Each position in a decimal number represents a power of ten, meaning the value of a digit depends on both its face value and its placement. This foundation allows for efficient arithmetic and clear communication of quantities across diverse contexts.

The Significance of Base in Number Representation

Understanding base goes beyond merely recognizing digits—it reveals how numerical values are constructed and manipulated. In a base-n system, each place value is a power of n, starting from zero at the rightmost digit. For instance, in base 2, the binary system used extensively in computing, only two symbols—0 and 1—are needed, and each digit's value corresponds to a power of two. This means the number 1011 in binary translates to $1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0$, equaling 11 in decimal. This positional structure simplifies complex calculations and forms the backbone of digital electronics, data encoding, and computer science.

Applications and Real-World Impact of Base Systems

The concept of base extends far beyond abstract mathematics, deeply influencing technology, science, and daily life. Binary (base 2), for example, is fundamental in computing because electronic circuits naturally represent two states: on and off. Similarly, hexadecimal (base 16), which uses sixteen symbols—digits 0–9 and letters A–F—serves as a compact and human-readable way to express binary data, widely used in programming, memory addressing, and web design. Other bases, such as octal (base 8) and ternary (base 3), find niche applications in specialized computing and theoretical research. Each base offers a unique lens through which numerical information is encoded, optimized, and processed.

Advantages and Educational Value of Mastering Base Concepts

Grasping the idea of base enhances mathematical intuition and fosters problem-solving skills. It encourages learners to think flexibly about numbers, recognizing patterns and relationships that transcend specific numeral systems. This foundational knowledge simplifies conversions between bases, supports algorithmic thinking, and strengthens comprehension of place value—the cornerstone of arithmetic operations. In education, teaching bases nurtures logical reasoning and prepares students for advanced topics in computer science, cryptography, and engineering, where base representations are essential tools.

The Future of Base Systems in an Evolving Technological Landscape

As technology advances, the principles of base continue to evolve and expand. Emerging fields such as quantum computing introduce novel base systems and non-integer bases to model complex phenomena beyond classical limits. Additionally, research into alternative numeral systems aims to improve computational efficiency, data compression, and error correction. The enduring relevance of base underscores its role not just as a mathematical concept, but as a dynamic framework that adapts to new challenges. Ultimately, understanding base remains vital for navigating a world increasingly driven by digital innovation and information processing.

Unpacking the Concept: What is the Base in Math?

In the realm of mathematics, fundamental concepts often underpin a vast array of more complex ideas. One such concept, seemingly simple yet profoundly important, is the 'base'. You've likely encountered it when discussing number systems, exponents, or even the everyday quantities we measure. But what exactly is the base in math, and why does it matter so much? This detailed exploration will delve into the essence of the base, its various applications, and its crucial role in how we understand and represent numbers.

The Foundation of Number Systems: Understanding the Base

At its core, the 'base' of a number system refers to the number of unique digits or symbols used to represent numbers within that system. Think of it as the radix – the fundamental quantity upon which the entire system is built. Every number we encounter is, in essence, a representation within a specific base. While we are most accustomed to the decimal system, understanding other bases unlocks a deeper appreciation for the structure of numbers.

The Decimal System (Base-10): Our Everyday Language of Numbers

The number system we use daily, the decimal system, is a base-10 system. This means it utilizes ten unique digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. The power of this system lies in its positional notation.

Each digit's value is determined by its position within the number, multiplied by a power of the base (10). For example, in the number 345:

1. The '5' is in the ones place, representing 5×10^0 (which is $5 \times 1 = 5$).
2. The '4' is in the tens place, representing 4×10^1 (which is $4 \times 10 = 40$).
3. The '3' is in the hundreds place, representing 3×10^2 (which is $3 \times 100 = 300$).

Summing these values (300 + 40 + 5) gives us 345. This positional value is a direct consequence of the base-10 structure. This intrinsic understanding of base-10 is so ingrained that we often don't consciously think about it – it's simply how we count and quantify.

Beyond Base-10: Exploring Other Number Bases

While base-10 is ubiquitous, other number bases are crucial in various fields, particularly in computer science and engineering. Understanding these alternative bases illuminates the universality of the base concept.

Binary (Base-2): The Language of Computers

The binary system is a base-2 system, using only two digits: 0 and 1. This is the fundamental language of computers, as electronic circuits can easily represent these two states (on/off, high/low voltage). In binary, each position represents a power of 2. For instance, the binary number 1011:

1. $1 \times 2^0 = 1$
2. $1 \times 2^1 = 2$
3. $0 \times 2^2 = 0$

4. $1 \times 2^3 = 8$

Summing these (1 + 2 + 0 + 8) gives us 11 in base-10. This conversion process demonstrates how a number represented in one base can be expressed in another. The concept of a 'bit' (binary digit) is a direct product of this base-2 system.

Octal (Base-8): A Bridge Between Binary and Decimal

The octal system is a base-8 system, using digits 0 through 7. It was historically used in computing as a more compact way to represent binary numbers. Since 8 is 2^3, three binary digits can represent one octal digit. The octal number 547:

1. $7 \times 8^0 = 7$
2. $4 \times 8^1 = 32$
3. $5 \times 8^2 = 5 \times 64 = 320$

Adding these (7 + 32 + 320) yields 359 in base-10. While less common now, understanding octal highlights the relationships between different bases and their powers.

Hexadecimal (Base-16): Efficiency in Data Representation

The hexadecimal system is a base-16 system, using digits 0 through 9 and then the letters A through F to represent values 10 through 15. This system is widely used in computer programming and data representation because it is even more compact than octal. Since 16 is 2^4, four binary digits can represent one hexadecimal digit. The hexadecimal number 2A5F:

1. F (15) $\times 16^0 = 15$
2. $5 \times 16^1 = 80$
3. A (10) $\times 16^2 = 10 \times 256 = 2560$
4. $2 \times 16^3 = 2 \times 4096 = 8192$

Summing these (15 + 80 + 2560 + 8192) gives us 10847 in

base-10. Hexadecimal is commonly seen in memory addresses, color codes (like #FFFFFF for white), and error messages. Its efficiency in representing large binary numbers is invaluable.

The Mathematical Significance of the Base

The concept of the base is not merely an academic curiosity; it's fundamental to several areas of mathematics:

Exponents and Powers: The Building Blocks of Value

As we've seen, the base is intrinsically linked to exponents. In an expression like x^n, 'x' is the base and 'n' is the exponent. The base dictates the fundamental value being multiplied by itself. Understanding the base is crucial for comprehending how exponents work, how numbers grow or shrink, and for performing operations involving powers. For example, 5^3 means 5 multiplied by itself 3 times (5 x 5 x 5 = 125). The base (5) is the number being repeatedly multiplied.

Logarithms: The Inverse of Exponentiation

Logarithms are the inverse operation of exponentiation. The base of a logarithm is equally as important as the base in exponentiation. A logarithm answers the question: "To what power must the base be raised to produce a given number?" For instance, $\log_{10}(100) = 2$ because $10^2 = 100$. Here, 10 is the base. Similarly, $\log_2(8) = 3$ because $2^3 = 8$. The base of the logarithm determines the scale of the relationship.

Polynomials: Expressions Built on Bases

Polynomials, which are expressions involving variables and

coefficients, can also be understood through the lens of bases. While not always explicitly stated as a 'base' in the same way as number systems, the variable itself often acts as the base. For example, in the polynomial $3x^2 + 2x + 1$, 'x' is the variable base. When we substitute a numerical value for 'x', we are essentially evaluating the polynomial in a specific number base. Understanding the properties of different bases can help in analyzing and manipulating polynomials.

Number Theory: Exploring Properties and Patterns

In number theory, the properties of numbers are often studied in relation to their representation in different bases. Concepts like divisibility rules can be generalized or understood differently when viewed through the lens of an alternative base. For instance, the divisibility rule for 3 in base-10 (sum of digits divisible by 3) is a consequence of base-10 structure, and similar rules exist for other bases.

The Ubiquitous Nature of the Base Concept

Beyond formal mathematics, the concept of a base subtly influences our understanding of measurement and representation:

Units of Measurement

While not a direct numerical base, our systems of measurement often have inherent 'bases'. For example, the metric system is largely base-10 (kilograms, meters, liters), making conversions straightforward. In contrast, older systems like the imperial system can have less intuitive relationships between units (e.g., 12 inches in a foot, 3 feet in a yard), suggesting a more complex underlying

'base' for conversion.

Financial Systems

Our currency systems are almost universally base-10. We have units of 1, 10, 100, and so on, making calculations and transactions intuitive. The way we represent monetary values relies heavily on this base-10 structure.

Conclusion: The Enduring Importance of the Base

The 'base' in mathematics is far more than just a technical term. It is the fundamental principle that dictates how we represent and interpret numbers. From the familiar decimal system that shapes our daily lives to the binary and hexadecimal systems that power our digital world, understanding the base is key to unlocking deeper mathematical comprehension. Whether you're working with exponents, logarithms, or simply counting your change, the concept of the base is an ever-present, foundational element that underpins our numerical reality.

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Questions & Answers About what is the base in math

No	Question	Answer
1	What's the 'base' in math, and why should I care?	The 'base' in math refers to the number of unique digits used in a numeral system. For example, our everyday system (decimal) has a base of 10 (digits 0-9). Understanding the base is crucial for interpreting numbers in different systems, like binary (base 2) used in computers, or hexadecimal (base 16) used in programming.
2	Is 'base 10' the only base mathematicians use?	Definitely not! While base 10 is our standard, mathematicians frequently work with other bases. Binary (base 2), octal (base 8), and hexadecimal (base 16) are common in computer science and digital electronics. Understanding these other bases helps explain how computers 'think' and process information.
3	How do I read a number if it's not in base 10?	When a number isn't in base 10, it's usually indicated by a subscript. For instance, 101_2 means '101 in base 2'. To read it, you interpret each digit's value based on its position and the base. In 101_2, the rightmost '1' is 1 x 2^0, the middle '0' is 0 x 2^1, and the leftmost '1' is 1 x 2^2. So, 101_2 = 1x4 + 0x2 + 1x1 = 5 in base 10.

4	What's the most common place I'll encounter bases other than 10 in real life?	The most common place is technology! Computers and digital devices operate using binary (base 2). You'll also see hexadecimal (base 16) in programming, web design (like color codes), and memory addresses. Sometimes, older measurement systems or specific scientific fields might use bases like 12 or 60.
5	Can you explain the relationship between bases and place value?	Absolutely! The base dictates the place value of each digit. In any base, the rightmost digit represents the base raised to the power of 0 (which is always 1). Moving left, the next digit represents the base to the power of 1, then the base to the power of 2, and so on. The base determines how quickly the value of each position increases.
6	Is there a limit to what a 'base' can be in mathematics?	Mathematically, there's no strict upper limit to what a base can be. We can conceive of a base 37 system, for example. However, practical bases tend to be smaller and more manageable, especially when dealing with physical systems or programming. The key requirement is that the number of unique digits used must be equal to the base itself.

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