Advances in Pure Mathematics, 2024, 14, 321-332
https://www.scirp.org/journal/apm
ISSN Online: 2160-0384
ISSN Print: 2160-0368

Origin of Sexy Prime Numbers, Origin of Cousin Prime Numbers, Equations from Supposedly Prime Numbers, Origin of the Mersenne Number, Origin of the Fermat Number

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How to cite this paper: Ndiaye, M. (2024) Origin of Sexy Prime Numbers, Origin of Cousin Prime Numbers, Equations from Supposedly Prime Numbers, Origin of the Mersenne Number, Origin of the Fermat Number. *Advances in Pure Mathematics*, **14**, 321-332.
https://doi.org/10.4236/apm.2024.145018

Received: February 1, 2024
Accepted: May 5, 2024
Published: May 8, 2024

Abstract

We have found through calculations that the differences between the closest supposed prime numbers other than 2 and 3 defined in the articles are: 2; 4: and 6. For those whose difference is equal to 6, we showed their origin then we classified them into two categories according to their classes, we showed in which context two prime numbers which differ from 6 are called sexy and in what context they are said real sexy prime. For those whose difference is equal to 4, we showed their origin then we showed that two prime numbers which differ from 4, that is to say two cousin prime numbers, are successive. We made an observation on the supposed prime numbers then we established two pairs of equations from this observation and deduced the origin of the Mersenne number and that of the Fermat number.

Keywords

Cousin Prime Numbers, Sexy Prime Numbers, Real Sexy Prime Numbers, Equations from Supposed Prime Numbers, Mersenne Number, Fermat Number, Supposed Prime Numbers, Prime Numbers

1. Introduction

The origin of cousin prime numbers and that of sexy prime numbers and their classes are misunderstood by mathematicians and their solution is the subject of mathematical conjecture.

This article has raised a venomous thorn under the feet of scientists, namely the understanding of cousin prime numbers and that of sexy prime numbers.

In this article we have demonstrated the origin and class of sexy primes and those of cousin primes. We have shown that there are two types of sexy prime numbers according to their classes. We have shown in which context a pair of prime numbers which differ from 6 is said to be sexy and in which context it is said to be real sexy.

We have shown that two prime numbers which differ from 4 or even two cousin prime numbers follow one another. An observation made on the supposedly prime numbers allowed us to establish two pairs of equations which are the subject of mathematical conjectures, their resolutions of which are made available to researchers in the field, then we deduced from these equations the origin of the number of Mersenne and the origin of Fermat is number.

The rest of the article is organized as follows, 2. Origin of sexy prime numbers; 3. Origin of cousin prime numbers; 4. Equations from supposedly prime numbers; 5. Origin of the Mersenne number; 6. Origin of the Fermat number; 7. Conclusion followed by bibliography and acknowledgments.

2. Origin of Sexy Prime Numbers

2.1. Definition

Sexy prime numbers are pairs of prime numbers that differ from 6. The real sexy prime numbers are pairs of successive prime numbers that differ from 6 [1].

Remark:

The interestiong thing about sexy primes is that not only do they form pairs, but also triplets and quardruplets.

As for what concerns us for the remainder of this article, we will focus on pairs of sexy primes.

2.2. Set of Supposed Prime Numbers Noted E_{sp}

According to the Euclidean division theorem for positive integers, we have

$$\forall(a,b)\in N\times N^{*},\ \exists q,r\in N\,/\,a=bq+r \text{ and } r<b$$

$$N=\{a\in N\}=\{bq+r \text{ with } b\in N^{*};\, q,r\in N \text{ and } r<b\}$$

We then write:

$$N=\{an+b \text{ with } a\in N^{*} \text{ and } n,b\in N \text{ such that } b<a \text{ and } b \text{ is between 0 and } a-1\}$$

We can write:

$$N=\bigcup_{b=0}^{a-1}\{an+b \text{ with } a\in N^{*}, n\in N\}$$

Example:

- If $a = 1$

$$N=\bigcup_{0}^{0}\{n,n\in N\}=\{n,n\in N\}$$

- If $a = 2$

$$N=\{2n,n\in N\}\cup\{2n+1,n\in N\}$$

- If $a = 3$

$$N = \{3n, n \in N\} \cup \{3n+1, n \in N\} \cup \{3n+2, n \in N\}$$

- If $a = 4$

$$N = \{4n, n \in N\} \cup \{4n+1, n \in N\} \cup \{4n+2, n \in N\} \cup \{4n+3, n \in N\}$$

- If $a = 5$

$$N = \{5n, n \in N\} \cup \{5n+1, n \in N\} \cup \{5n+2, n \in N\} \\ \cup \{5n+3, n \in N\} \cup \{5n+4, n \in N\}$$

- If $a = 6$

$$N = \{6n, n \in N\} \cup \{6n+1, n \in N\} \cup \{6n+2, n \in N\} \cup \{6n+3, n \in N\} \\ \cup \{6n+4, n \in N\} \cup \{6n+5, n \in N\}$$

Consider the set

$$N = \{6n, n \in N\} \cup \{6n+1, n \in N\} \cup \{6n+2, n \in N\} \cup \{6n+3, n \in N\} \\ \cup \{6n+4, n \in N\} \cup \{6n+5, n \in N\}$$

Note1:

The elements of $\{6n, n \in N\}$ are even.

The elements of $\{6n+2, n \in N\}$ are even.

The elements of $\{6n+3, n \in N\}$ are multiples of 3.

The elements of $\{6n+4, n \in N\}$ are even.

When we eliminate these four previous sets in N we are left with the following two sets:

$\{6n+1, n \in N\}$ and $\{6n+5, n \in N\}$.

Consequently the set $\{6n+1, n \in N\} \cup \{6n+5, n \in N\}$ contains all the prime numbers except 2 and 3.

Note2:

$$\{6n+1, n \in N\} = \{1\} \cup \{6n+1, n \in N^*\}.$$

Demonstrate that $\{6n+1, n \in N^*\} = \{6n+7, n \in N\}$ Let $p = n-1$ with $n \in N^*$ so $p \in N$ and $n = p+1$

$$6n+1 = 6(p+1)+1 = 6p+6+1 = 6p+7, p \in N$$

Then $\{6n+1, n \in N\} = \{1\} \cup \{6n+1, n \in N^*\}$.

So: $\{6n+1, n \in N\} = \{1\} \cup \{6n+1, n \in N^*\} = \{1\} \cup \{6n+7, n \in N\}$

$$\{6n+1; 6n+5, n \in N\} = \{1\} \cup \{6n+5; 6n+7, n \in N\}$$

We note that the set $\{6n+5; 6n+7, n \in N\}$ contains all prime numbers except 2 and 3. Name E_{sp}: The Set of supposedly prime numbers,

$E_{sp} = \{2; 3; 6n+5; 6n+7 \text{ with } n \in N\}$ contains all prime numbers [2].

Remark:

Prime numbers other than 2 and 3 are generated by the formulas $U_n = 6n+5$ and $V_n = 6n+7$ with $n \in N$.

A prime number other than 2 and 3 can be written in the form $6n+5$ or

$6n+7$ with $n \in N$.

2.3. Class of a Supposed Prime Number other than 2 and 3

$U_n = 6n+5$ with $n \in N$ then $\frac{U_n - 5}{6} = n$ with $n \in N$

$V_n = 6n+7$ with $n \in N$ then $\frac{V_n - 7}{6} = n$ with $n \in N$

Consequence:

A supposed prime number N is of class U if and only if $\frac{N-5}{6} = n$ with $n \in N$

A supposedly prime number N is of class V if and only if $\frac{N-7}{6} = n$ with $n \in N$

2.4. Arrangement of Supposed Prime Numbers other than 2 and 3

$U_n = 6n+5$ with $n \in N$ and $V_n = 6n+7$ with $n \in N$

$U_{n+1} = 6(n+1)+5 = 6n+11$ with $n \in N$

$V_{n+1} = 6(n+1)+7 = 6n+13$ with $n \in N$

We have: $U_n < V_n < U_{n+1} < V_{n+1}$, for fixed *n*.

2.5. Class *U* Sexy Prime Numbers

$U_n = 6n+5$ with $n \in N$

$$U_{n+1} - U_n = 6(n+1)+5-(6n+5) = 6$$

$$U_n < V_n < U_{n+1} < V_{n+1}$$

Consequence:

$(U_n;U_{n+1})$ is prime sexy if and only if U_n is prime and U_{n+1} is prime $(U_n;U_{n+1})$ is real prime sexy if and only if U_n is prime, U_{n+1} is prime and V_n not prime.

Statement:

Let $U_n = 6n+5$ with $n \in N$ and $V_n = 6n+7$ with $n \in N$ sexy primes of class U are the couples $(U_n;U_{n+1})$ such that U_n is prime, U_{n+1} is prime.

The Real sexy primes of class U are pairs $(U_n;U_{n+1})$ such that U_n is prime, U_{n+1} is prime and V_n is not prime.

Example:

a) Determine the class of the couple (47; 53)

b) Show that it is sexy

c) Show that it is a real sexy

Solution

a) $\frac{47-5}{6} = 7$ with $7 \in N$ so 47 is class U

$\frac{53-5}{6} = 8$ with $8 \in N$ so 53 is class U

Hence the couple (47; 53) is class U

b) 47 is prime and 53 is prime (1)

53 − 47 = 6 (2)

(1) and (2) so (47; 53) is prime sexy

c) $n = \frac{47-5}{6} = 7$ then $V_7 = 6 \times 7 + 7 = 49$

But 49 is a non-prime number so (47; 53) is a real sexy (47 and 53 follow one another) and class U.

Counter-example:

a) Determine the class of the couple (5; 11)

b) Show that it is sexy

c) Show that it is not a real sexy

Solution:

a) $\frac{5-5}{6} = 0$ with $0 \in N$ so 5 is class U

$\frac{11-5}{6} = 1$ with $1 \in N$ so 11 is class U

Hence the couple (5; 11) is of class U.

b) 5 is prime and 11 is prime (1)

11 − 5 = 6 (2)

(1) and (2) so (5; 11) is prime sexy

c) $n = \frac{5-5}{6} = 0$ then $V_0 = 6 \times 0 + 7 = 7$

But 7 is a prime number so (5; 11) is not a real sexy prime because 5 and 11 do not follow each other (there is 7 in the middle).

2.6. Class V Sexy Prime Numbers

$V_n = 6n + 7$ with $n \in N$

$$V_{n+1} - V_n = 6(n+1) + 7 - (6n+7) = 6$$

$$U_n < V_n < U_{n+1} < V_{n+1}$$

Consequence:

$(V_n; V_{n+1})$ is prime sexy if and only if V_n is prime and V_{n+1} is prime.

$(V_n; V_{n+1})$ is real prime sexy if and only if V_n is prime and V_{n+1} is prime and U_{n+1} not prime.

Statement:

Let $U_n = 6n + 5$ with $n \in N$ and $V_n = 6n + 7$ with $n \in N$ sexy primes of class V are the couples $(V_n; V_{n+1})$ such that V_n is prime, V_{n+1} is prime.

The Real sexy primes of class V are pairs $(V_n; V_{n+1})$ such that V_n is prime, V_{n+1} is prime and U_{n+1} is not prime.

Noticed:

$U_n < V_n < U_{n+1} < V_{n+1}$, for fixed n.

Example:

1. Determine the class of the couple (61; 67)
2. Show that it is sexy

3. Show that it is a real sexy

Solution:

a) $\frac{61-7}{6}=9$ with $9 \in N$ so 61 is class V

$\frac{67-7}{6}=10$ with $10 \in N$ so 67 is class V

Hence the couple (61; 67) is class V

b) 61 is prime and 67 is prime (1)

67 - 61 = 6 (2)

(1) and (2) so (61; 67) is prime sexy

c) $n=\frac{61-7}{6}=9$ then $U_{9+1}=U_{10}=6\times 10+5=65$

But 65 is a non-prime number so (61; 67) is a real sexy prime of class V.

Counter-example:

a) Determine the class of the couple (7; 13)

b) Show that it is sexy

c) Show that it is not a real sexy

Solution:

a) $\frac{7-7}{6}=0$ with $0 \in N$ so 7 is class V

$\frac{13-7}{6}=1$ with $1 \in N$ so 13 is class V

Hence the couple (7; 13) is class V

b) 7 is prime and 13 is prime (1)

13 − 7 = 6 (2)

(1) and (2) so (7; 13) is prime sexy of class V

c) $n=\frac{7-7}{6}=0$ then $U_{0+1}=U_1=6\times 1+5=11$

But 11 is a prime number so (7; 13) is not real sexy prime because 7 and 13 do not follow each other (there is 11 in the middle).

3. Origin of Prime Cousin Numbers

3.1. Definition

Cousin prime numbers are pairs of prime numbers that differ from 4 [3].

3.2. Cousin prime numbers

$U_n = 6n+5$ with $n \in N$ and $V_n = 6n+7$ with $n \in N$

$U_{n+1} = 6(n+1)+5 = 6n+11$ with $n \in N$

$$U_{n+1} - V_n = 6(n+1)+11-(6n+7)=4$$

$$U_n < V_n < U_{n+1} < V_{n+1}$$

Consequence:

$(V_n;U_{n+1})$ is cousin prime if and only if V_n is prime and U_{n+1} is prime.

Statement:

Let $U_n = 6n+5$ with $n \in N$ and $V_n = 6n+7$ with $n \in N$ cousin primes are pairs $(V_n;U_{n+1})$ such that V_n is prime, U_{n+1} is prime.

Noticed :

$U_n < V_n < U_{n+1} < V_{n+1}$, for n fixed therefore V_n and U_{n+1} are two supposedly prime which therefore follow each other:

If $(V_n;U_{n+1})$ is cousin prime then V_n and U_{n+1} are two prime numbers that follow each other.

Example:

The following three pairs are cousin prime pairs (7; 11), (13; 17), (19; 23).

Counter-example:

When two prime numbers do not follow each other they cannot be cousins. To give counter examples, simply choose two non-successive prime numbers.

4. Equations from Supposedly Prime Numbers

4.1. Second form of Writing the Set of Supposed Prime Numbers

Consider E_{sp} the set of supposed prime numbers.

$$E_{sp} = \{2;3;6n+5;6n+7 \text{ with } n \in N\}$$

Supposedly prime numbers other than 2 and 3 are generated by the following two formulas:

$U_n = 6n+5$ with $n \in N$ and $V_n = 6n+7$ with $n \in N$

Noticed:

- Let $p = n-1$ with $n \in N^*$ therefore $p \in N$ and $n = p+1$

$$6n+1 = 6(p+1)+1 = 6p+6+1 = 6p+7,\ p \in N$$

so:

$$\{6n+1, n \in N^*\} = \{6n+7, n \in N\}$$

- Let $p = n-1$ with $n \in N^*$ therefore $p \in N$ and $n = p+1$

$$6n-1 = 6(p+1)-1 = 6p+6-1 = 6p+5,\ p \in N$$

therefore $\{6n-1, n \in N^*\} = \{6n+5, n \in N\}$.

So $\{6n+5;6n+7 \text{ with } n \in N^*\} = \{6n-1;6n+1 \text{ with } n \in N^*\}$

From where

$E_{sp} = \{2;3;6n+5;6n+7 \text{ with } n \in N\}$ or $E_{sp} = \{2;3;6n-1;6n+1 \text{ with } n \in N^*\}$

Noticed:

$U_n = 6n-1$ with $n \in N^*$ and $V_n = 6n+1$ with $n \in N^*$

We have: $\dfrac{U_{n+1}}{6} = n$ **and** $\dfrac{V_{n-1}}{6} = n$ **with** $n \in N^*$.

Consequence :

A number N is a supposed prime number other than 2 and 3 if and Only if $\dfrac{N+1}{6} \in N^*$ or $\dfrac{N-1}{6} \in N^*$

4.2. Observation

We found through calculations that:

1. The formula $2^n + 3^m$ with $n, m \in N^*$ only gives supposedly prime numbers.

2. The formula $|2^n - 3^m|$ with $n, m \in N^*$, with the exception of 1, only gives supposedly prime numbers.

3. Formulas $|2^n \pm 3^m|$ with $n, m \in N^*$ do not all give supposed prime numbers.

NB:

This observation was made through in-depth calculations up to the supposedly very high first ones but nothing proves it to us through demonstrations.

Let us accept that this hypothesis is true, we will therefore have

$$\left\{2^n + 3^m; |2^n - 3^m| \text{ with } n, m \in N^*\right\} \setminus \{1\} \subset \left\{2; 3; 6n - 1; 6n + 1 \text{ with } n \in N^*\right\}$$

$\left\{2^n + 3^m; |2^n - 3^m| \text{ with } n, m \in N^*\right\} \setminus \{1\}$ is a subset of the set of presumed prime numbers denoted by E_{sp}.

Result :

1. $2^n + 3^m$ with $n, m \in N^*$ are supposed primes other than 2 and 3 so $2^n + 3^m$ with $n, m \in N^*$ is written in the form $6k - 1$ with $k \in N^*$ or $6k + 1$ with $k \in N^*$.

2. $|2^n - 3^m|$ with $n, m \in N^*$ are supposed prime numbers other than 2 and 3 more $|2^n - 3^m|$ gives 1 for $n = 1$, $m = 1$ or $n = 3$, $m = 2$ and 6n + 1 gives 1 for n = 0 therefore $|2^n - 3^m|$ with $n, m \in N^*$ can be written as $6k - 1$ with $k \in N^*$ or $6k + 1$ with $k \in N$.

States :

- For all non-zero integers n and m, there exists a non-zero integer k verifying the equation:

$$2^n + 3^m = 6k - 1 \quad \text{or} \quad 2^n + 3^m = 6k + 1$$

- For all non-zero integers n and m, there exists a non-zero integer k and an integer p verifying the equation:

$$|2^n - 3^m| = 6k - 1 \quad \text{or} \quad |2^n - 3^m| = 6p + 1$$

These two pairs of equations are made available to researchers in the field for their demonstrations.

Noticed:

- The formula $2^n + 3^m$ with $n, m \in N^*$ gives an infinity of prime numbers and an infinity of non-prime numbers.
- The formula $|2^n - 3^m|$ with $n, m \in N^*$, with the exception of 1, gives an infinity of prime numbers and an infinity of non-prime numbers.
- Not all prime numbers are written in the form $|2^n \pm 3^m|$ with $n, m \in N^*$.

NB: (for verification)

1. To verify that the formula $2^n + 3^m$ with $n, m \in N^*$, gives only supposed primes, just choose two integers n_1 and n_2 then:

- Calculate $2^{n_1} + 3^{n_2}$ which gives M_1
- Check that: $\frac{M_1 + 1}{6} \in N^*$ or $\frac{M_2 - 1}{6} \in N^*$

Example:

if $n = 2$; $m = 2$

$$\left|2^2 - 3^2\right| = |4 - 9| = 5$$

$\frac{5-5}{6} = 0 \in N$ so 5 is a supposedly prime

if $n = 2$; $m = 3$

$$\left|2^2 - 3^3\right| = |4 - 27| = 23$$

$\frac{23-5}{6} = 9 \in N$ so 23 is a supposedly prime

if $n = 2$; $m = 4$

$$\left|2^2 - 3^4\right| = |4 - 81| = 77$$

$\frac{77-5}{6} = 12 \in N$ so 77 is a supposedly prime.

We can continue the verifications by assigning larger numbers to n and m, and we will see that we will always have supposedly prime numbers.

2. To verify that the formula $\left|2^n - 3^m\right|$ with $n, m \in N^*$, gives only supposed primes, just choose two integers n_1 and n_2 then:

- Calculate $\left|2^{n_1} - 3^{n_2}\right|$ which gives M_2
- Check that: $\frac{M_2+1}{6} \in N^*$ or $\frac{M_2-1}{6} \in N^*$

Example:

if $n = 1$, $m = 1$

$2^1 + 3^1 = 2 + 3 = 5$ and 5 is a supposedly prime number

if $n = 2$, $m = 2$

$$2^2 + 3^2 = 4 + 9 = 13$$

$\frac{13-7}{6} = 1 \in N$ so 13 is a supposedly prime number

if $n = 2$, $m = 3$

$$2^2 + 3^3 = 4 + 27 = 31$$

$\frac{31-7}{6} = 3 \in N$ so 31 is a supposedly prime number

if $n = 2, m = 4$

$$2^2 + 3^4 = 4 + 81 = 85$$

$\frac{85-7}{6} = 13 \in N$ so 85 is a supposedly prime number.

We can continue the verifications by assigning larger numbers to n and m, and we will see that we will always have supposedly prime numbers.

5. Origine of the Mersenne Number

5.1. Definition

In mathematics and more precisely in arithmetic, a Mersenne number is a number of the form $2^n - 1$ (often denoted M_n), where n is a natural number not zero; a Mersenne prime (or prime Mersenne number) is therefore a prime number of this form. These numbers owe their name to the erudite French religious and mathematician Marin Mersenne of the 17th century; but, nearly 2,000 years earlier, Euclid was already using them to study perfect numbers. Before Mersenne, and even for some time after him, the search for Mersenne primes is intrinsically linked to that of perfect numbers [4].

5.2. Demonstration of the Origin of the Mersenne Number

Consider the formula $|2^n - 3^m|$ with $n, m \in N^*$.

Let $|2^n - 3^m|$ with $n, m \in N$.

So this formula generates an infinity of supposed prime nombers and an infinity of multiple numbers of 2 or/and 3.

If we set $m = 0$, we will have $|2^n - 3^0| = |2^n - 1|$.

$2^n - 1 \geq 0$ for $n \in N$ therefore $|2^n - 1| = 2^n - 1$ with $n \in N$, this is the Mersenne number.

6. Origin of the Fermat Number

6.1. Definition

A Fermat number is a number that can be written in the form $2^{2n} + 1$, with n a natural number. The Fermat number of rank n, $2^{2n} + 1$, is denoted F_n.

The sequence (F_n), which begins with 3, 5, 17, 257, 65537, 4294967297, 18446744073709551617 is listed as sequence A000215 in the EIS.

These numbers owe their name to Pierre de Fermat, who made the conjecture that all of these numbers were prime. This conjecture turned out to be false, F5 being composite, as are all the following ones up to F_{33}. It is not known whether the numbers from F33 onwards are prime or composite. Thus, the only known Fermat primes are five in number, namely the first five F_0, F_1, F_2, F_3 and F_4, which are respectively 3, 5, 17, 257 and 65,537.

Fermat numbers have interesting properties, generally arising from modular arithmetic. In particular, the Gauss-Wantzel theorem establishes a link between these numbers and the construction with a ruler and compass of regular polygons: a regular polygon with n sides can be constructed with a ruler and compass if and only if n is a power of 2, or the product of a power of 2 and distinct Fermat primes [5].

6.2. Demonstration of the Origin of Fermat's Number

Consider the formula $2^n + 3^m$ with $n, m \in N^*$.

Let $2^n + 3^m$ with $n, m \in N$.

So this formula generates an infinity of supposed prime nombers and an infinity of multiple numbers of 2 or/and 3.

If we set $m = 0$ and we choose $n = 2k$ with $k \in N$.

We will have: $2^{2k} + 3^0 = 2^{2k} + 1$ with $k \in N$, this is Fermat's number.

Noticed:

Concerning the origins of other formulas of the past, it will be necessary to make a limited development of $\left|2^n \pm 3^m\right|$ with $n, m \in N^*$.

7. Conclusion

The formulas established in this article have penetrated the secret causes of prime cousin numbers, sexy prime numbers, the Mersenne number and those of the Fermat number. The two pairs of equations established in the article are objects of mathematical conjectures whose resolutions are available to mathematicians. I plan to publish another article very soon which will focus on the pseudo-periodicity of prime numbers.

Biography

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Acknowledgement

I thank:

Prof. Mamadou Barry, Department of Mathematics and Computer Science, Faculty of Science and Technology, Cheikh Anta Diop University of Dakar (UCAD).

Prof. Mamadou Sangar, Department of Mathematics and Computer Science, Faculty of Science and Technology, Cheikh Anta Diop University of Dakar (UCAD).

Prof. Aboubaker Shedikh Beye, Department of Physics, Faculty of Science and Technology, Cheikh Anta Diop University of Dakar (UCAD).

Prof. Omar Sakho, Department of Physics, Faculty of Science and Technology, Cheikh Anta Diop University of Dakar (UCAD).

Dr. Abdoulaye Diop, Department of Physics, Faculty of Science and Technology, Cheikh Anta Diop University of Dakar (UCAD).

All the doctors and doctoral students who attended my presentations by observations and suggestions.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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