Lecture 1:

- Numbers
- Logical Operators
- Significant Figures
- Scientific Notation
- Factorial

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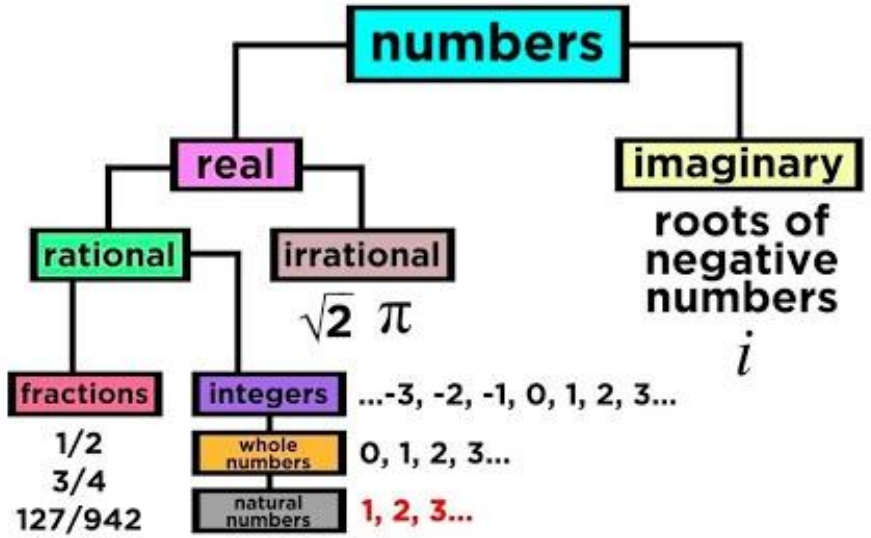
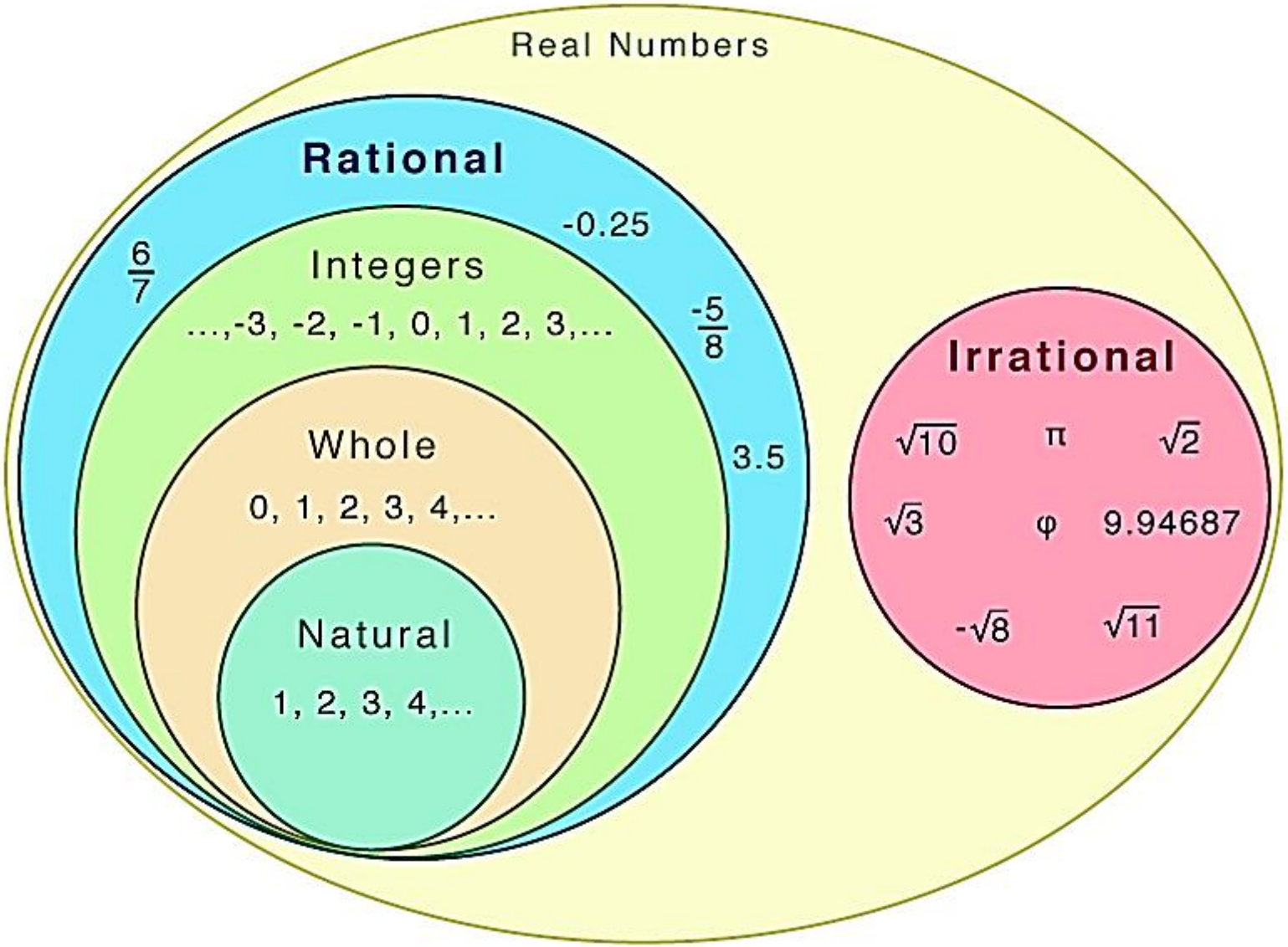
Number Classifications

- ✓ $Q = \left\{\frac{1}{2}, \frac{3}{4}, 2, 5, 0, -\frac{7}{11}, -12, \dots\right\}$ – rational numbers $\left\{\frac{a}{b} \middle| a, b \in Z, b \neq 0\right\}$
- ✓ $Z = \{0, \pm 1, \pm 2, \pm 3, \dots\}$ – integers
  - → $Z^+ = \{0, 1, 2, 3, \dots\}$ – non-negative integers
  - → $Z^- = \{0, -1, -2, -3, \dots\}$ – non-positive integers
- ✓ $W = \{0, 1, 2, 3, \dots\}$ – whole numbers
- ✓ $N = \{1, 2, 3, \dots\}$ – natural numbers/counting numbers



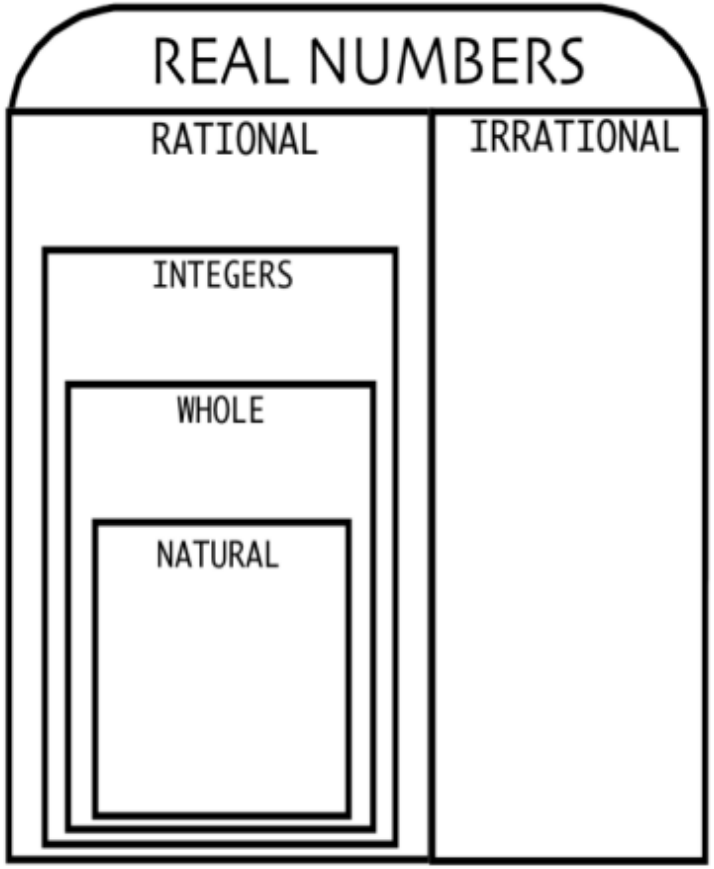
- ✓ $\sqrt{2}$, π, $\sqrt{3}$, … - irrational numbers

- ➢ Real numbers - set of irrational numbers & rational numbers


Real Numbers
Rational
-0.25
6/7
-5/8
3.5
Integers
...,-3, -2, -1, 0, 1, 2, 3,...
Whole
0, 1, 2, 3, 4,...
Natural
1, 2, 3, 4,...
Irrational
√10
π
√2
√3
φ
9.94687
-√8
√11

1) **Re–write each number in the Venn Diagram where it belongs.**

-19	$1.\overline{2}$	0	3
$\sqrt{10}$	$\sqrt{81}$	3.456	$-{}^{6}/_{11}$
$-1.48298\ldots..$		$\Pi + 3$	-44



2) **List all classifications of the number.**

a) $\sqrt{10}$ _____

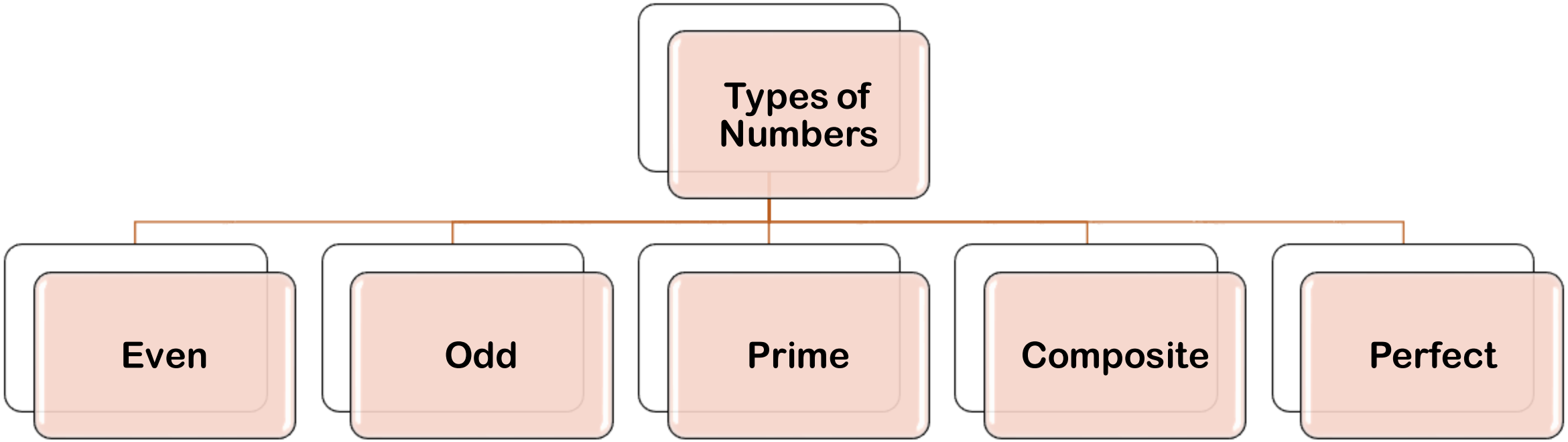
b) -44 _____

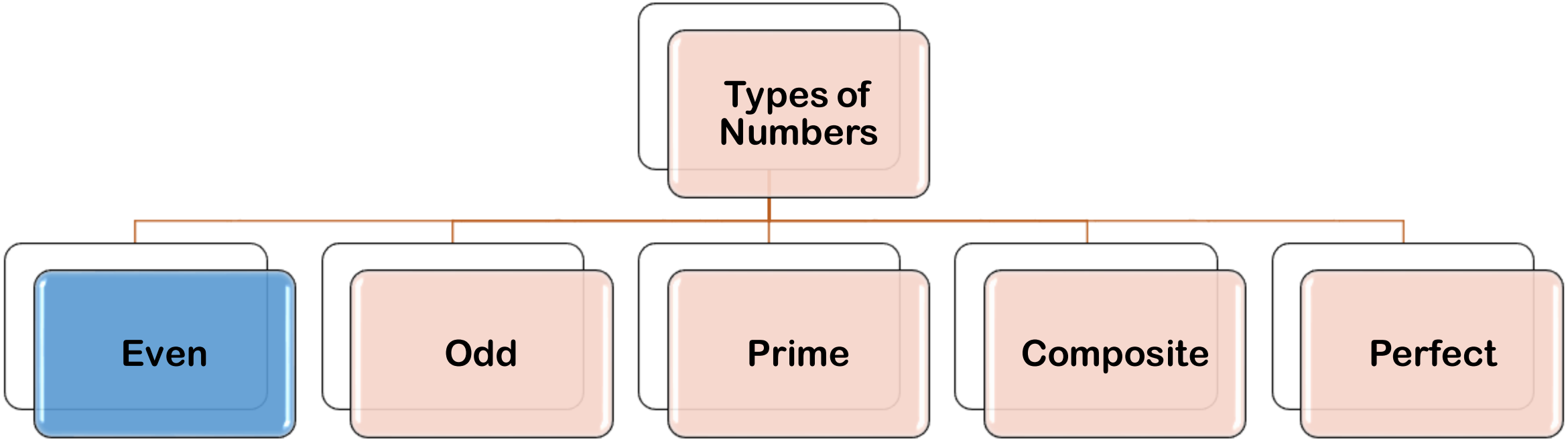
c) 3 _____

d) $-6/11$ _____

3) **Check all boxes that apply to the number.**

		Natural	Whole	Integer	Rational	Irrational	Real
a)	$\sqrt{81}$						
b)	$1.\overline{2}$						
c)	0						
d)	13						


Types of Numbers
Even
Odd
Prime
Composite
Perfect



- A number that can be exactly divided by 2.
- Even numbers always end up with the last digit as 0, 2, 4, 6 or 8.
- The general form of even numbers is given by $2k$, where $k \in Z$

- Ahmad has 30 pencils. He distributed 14 of those among his friends. Will he have an even number of pencils left? How do you know?

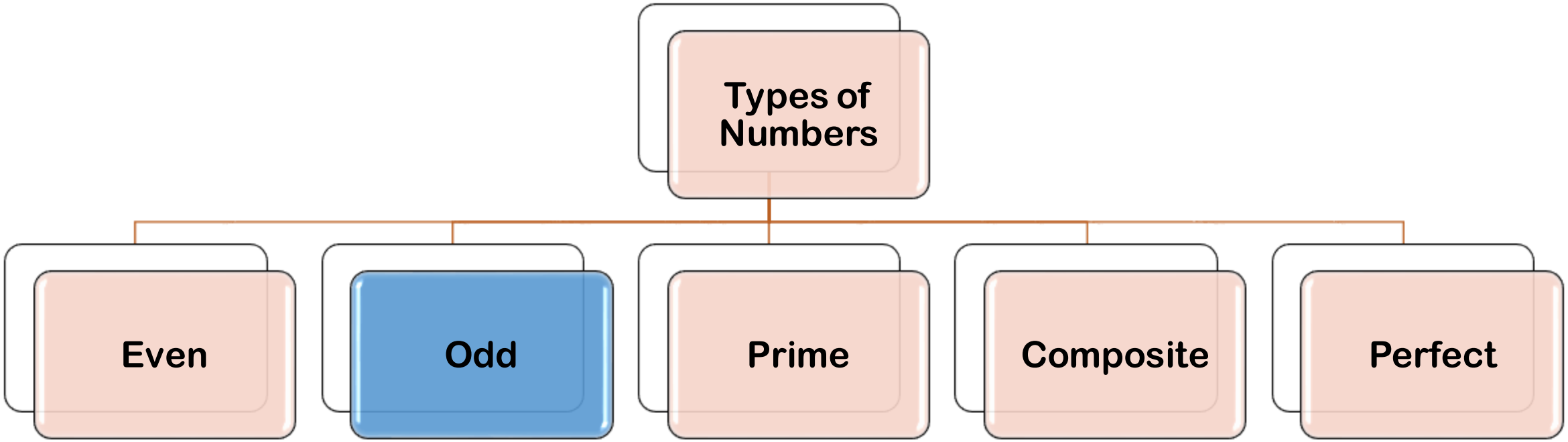
- State true or false: 0 is an even number.

- Select the pair of consecutive even numbers from the following:

  a) 24 and 28
  b) 91 and 93
  c) 84 and 86
  d) 39 and 42

- When you buy a dozen bananas, are you getting an even number or an odd number of bananas?

- Select the even numbers from the following:
  a.) 778
  b.) 912
  c.) 223



- A number which is not divisible by 2.
- An odd number always ends in 1, 3, 5, 7, or 9.
- The general form of odd numbers is given by $2k + 1$, where $k \in Z$

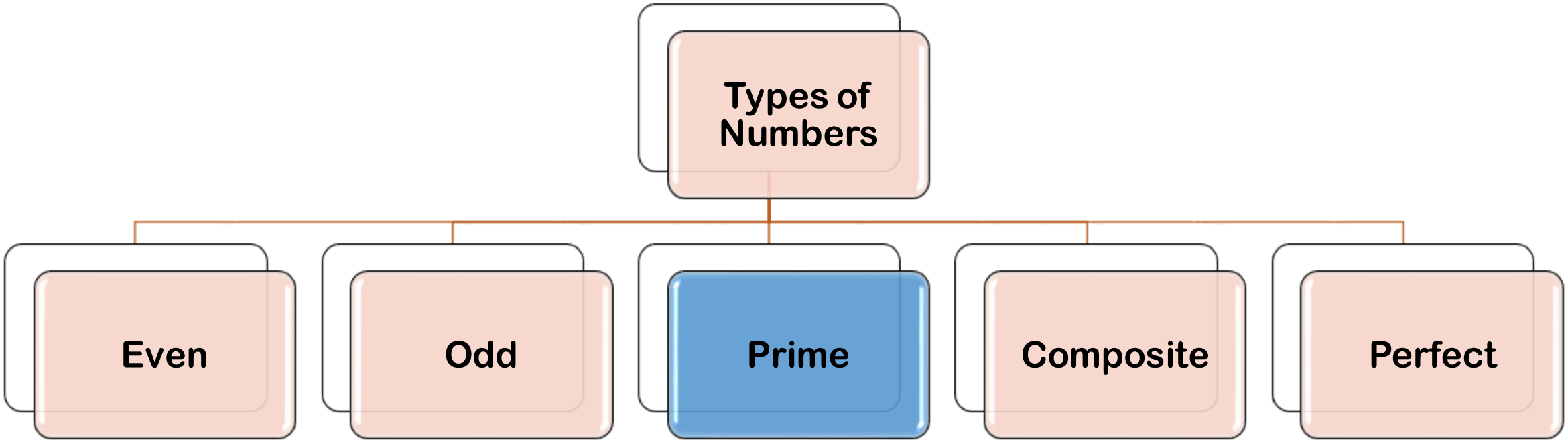
- Determine whether 135 is an odd number or not.

- Is 350 an odd number or an even number?

- Will the sum of 23 + 35 result in an odd number?

- Answer the following questions with reference to odd numbers:
  a.) 1 is odd or even?
  b.) Which is the smallest 4 digit odd number?
  c.) What is the sum of any two odd numbers?
  d.) Is 2 an odd number?

- State true or false with respect to odd numbers.
  a.) The sum of two odd numbers is always an even number.
  b.) The smallest odd number is 5.
  c.) 9 is an odd number.



- A natural number that are divisible by only 1 and the number itself.
- Ex: 2, 3, 5, 7, 11, 13, …

- Which of the two numbers is a prime number, 13 or 15?

- Why is 20 not a prime number?

- State true or false with respect to prime numbers.

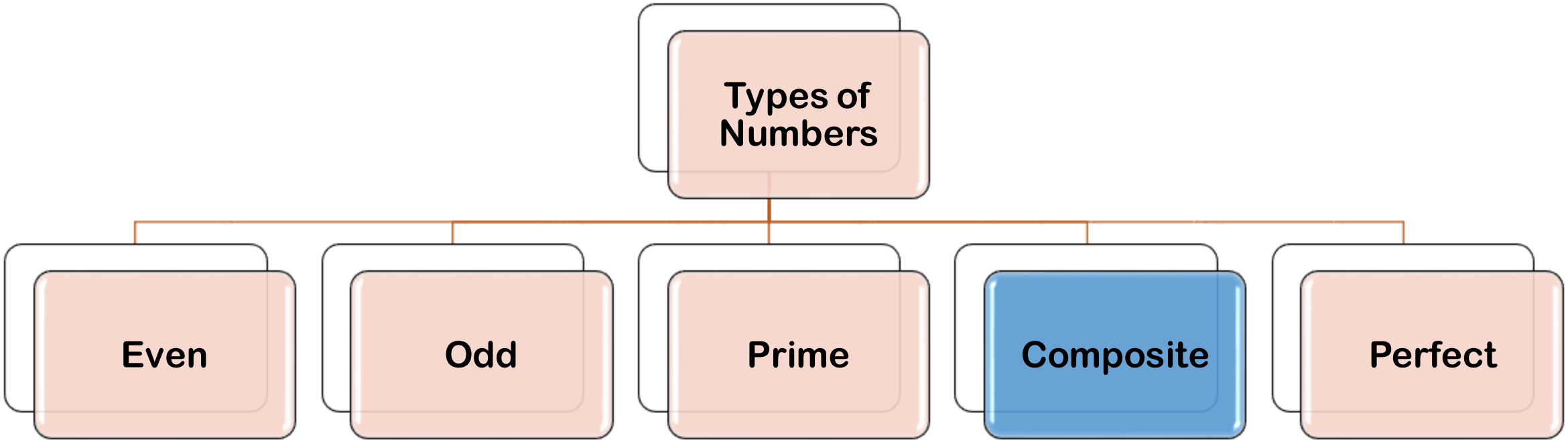
a.) 1 is a prime number.
b.) The only even prime number is 2.
c.) The first five prime numbers are 2, 3, 5, 7, and 9.
d.) All prime numbers are odd.

- Which of the following numbers is a prime number?

a) 4
b) 10
c) 33
d) 43

- Choose true/false against each statement.

	True	False
2 is the only even prime number.	○	○
3 is the smallest prime number.	○	○
97 is the largest prime number.	○	○
All prime numbers are odd.	○	○



- A natural number or a positive integer which has more than two factors.
- Ex: 15 has factors 1, 3, 5 and 15.

Always remember that **1** is neither prime nor composite

- Which of the following is a composite number?

  a) 34
  b) 31
  c) 39

- Fill in the blanks:

  a.) The smallest composite number is __.
  b.) The smallest odd composite number is __.

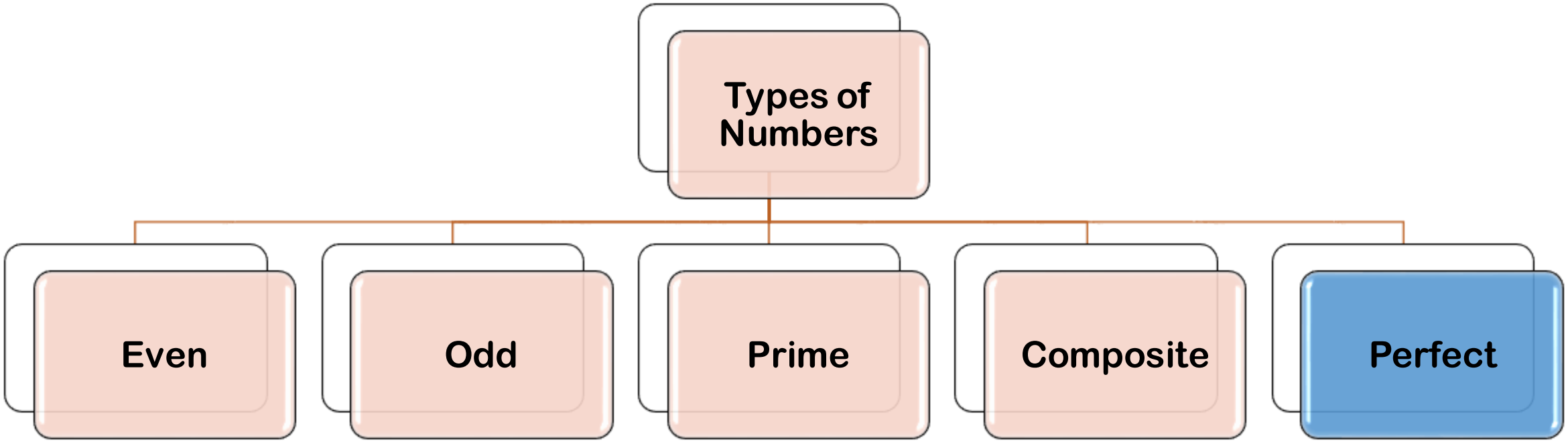
- State true or false with respect to composite numbers.
  a.) All even numbers are composite numbers.
  b.) 1 is a composite number.

- Aya is listing all the composite numbers between 3 and 10. Can you help her choose the correct option?

  a) 4, 6, 8, 9
  b) 4, 9
  c) 4, 5, 6, 7, 8, 9
  d) 4, 8, 9

- The smallest composite number is 2.

  a) True
  b) False



- A positive integer that is equal to the sum of its positive factors, excluding the number itself.
- Ex: 6, 28, 496, 8128, 33550336, …
- All the perfect numbers are also complete numbers.

- Is 28 a perfect number?

- Select the perfect numbers from the following.

  a) 5
  b) 6
  c) 32
  d) 28
  e) 9

- State true or false:
  a.) Perfect numbers are the positive integers that are equal to the sum of its factors except for the number itself.
  b.) All the perfect numbers are odd numbers.

- Check whether the given numbers are perfect numbers or not by finding the sum of their factors:
  a.) 8
  b.) 25

- Write true or false against each statement.

	True	False
All the perfect numbers known till now are even.	○	○
All perfect numbers can be written as the sum of its proper divisors.	○	○
The smallest perfect number is 9.	○	○

Even + Even = Even

Odd + Odd = Even

Even + Odd = Odd

Even × Even = Even

Even × Odd = Even

Odd × Odd = Odd.

Perfect Square Numbers

- Perfect squares are the squares of a whole number (when a number is multiplied by itself two times).

Perfect Square Formula

$$N = X^2$$

$1^2 = 1$	$11^2 = 121$	$21^2 = 441$
$2^2 = 4$	$12^2 = 144$	$22^2 = 484$
$3^2 = 9$	$13^2 = 169$	$23^2 = 529$
$4^2 = 16$	$14^2 = 196$	$24^2 = 576$
$5^2 = 25$	$15^2 = 225$	$25^2 = 625$
$6^2 = 36$	$16^2 = 256$	$26^2 = 676$
$7^2 = 49$	$17^2 = 289$	$27^2 = 729$
$8^2 = 64$	$18^2 = 324$	$28^2 = 784$
$9^2 = 81$	$19^2 = 361$	$29^2 = 841$
$10^2 = 100$	$20^2 = 400$	$30^2 = 900$

- Is 100 a perfect square number?

- In an auditorium, the number of rows is the same as the number of columns. If there are 60 chairs in a row, how many chairs are there in the auditorium?

- What smallest whole number is to be added to 75 to make it a perfect square?

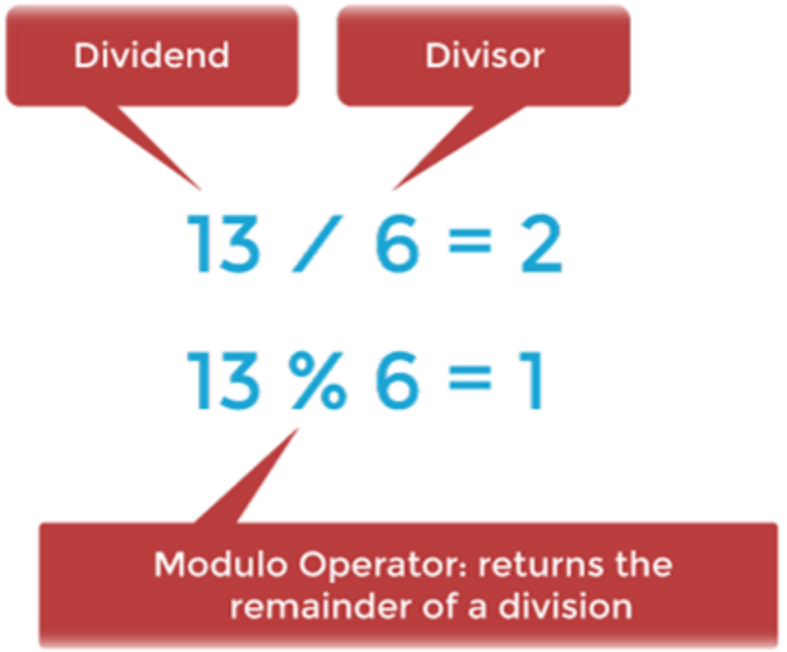
- Which of the following is not a perfect square?

  a) 900
  b) 800
  c) 400
  d) 100

- What will be the area of a square having a side of 16 meters?

Modulo Operator

- Mod is also known as modulus or modulo.
- It gives the remainder after dividing one number by another number.
- Modulus of any real number x will always give positive value as it's output.



$a: b\ (a \div b)$

$$a, b, q, r \in Z, \qquad b \neq 0, \qquad 0 \leq r \leq |b|$$

$$a = b \cdot q + r$$

$27\ mod\ 4 = 27:4 \Longrightarrow\ 4 \cdot 6 + 3$

$-15:4 \Longrightarrow -3 \cdot 4 + (-3) = -15$

$0 \leq r \leq |b|$

$-15:4 \Longrightarrow\ -4 \cdot 4 + 1 = -15$

$113:(-3) \Longrightarrow\ -37 \cdot (-3) + 2$

$-15:(-7) \Longrightarrow\ 3 \cdot (-7) + 6$

$-5\ mod\ 9 = -1 \cdot 9 + 4$

$-19\ mod\ 9 = -3 \cdot 9 + 8$

$$3 \bmod 10 = 3$$
$$13 \bmod 10 = 3$$
$$23 \bmod 10 = 3$$
$$33 \bmod 10 = 3$$

-9 mod 9 = 0

-8 mod 9 = 1

-7 mod 9 = 2

-4 mod 9 = 5

-2 mod 9 = 7

-1 mod 9 = 8

What is -6 mod 18 ? = 12

What is -4 mod 9? = 5

What is -9 mod 6? = 3

What is -13 mod 1? = 0

What is 17 mod 7? = 3

What is -49 mod 5? = 1

What is -14 mod 2? = 0

What is -29 mod 4? = 3

What is -29 mod 3? = 1

What is 6 mod 18? = 6

What is 9 mod -6? = 3

What is 4 mod 9? = 4

What is -6 mod 18? = 12

What is 7 mod 6? = 1

Find the largest negative integer that when divided by nine leaves a remainder of one.

$$10 : 9 = 1 \cdot 9 + 1$$

$$1 : 9 = 0 \cdot 9 + 1$$

$$-8 : 9 = -1 \cdot 9 + 1$$

The largest negative integer is -8 .

When a certain integer is divided by 12, the remainder is 5. What remainder is obtained when this number is divided by 4?

1) **What is the remainder value:**

- **108 is divided by 3.**
- **129 is divided by 7.**

- **Find the product $23 \cdot 43$ modulo 8**
- **Find 11 mod 8.**
- **Find -3 mod 8.**
- **Find 49 mod 5.**

2) Perform the modular arithmetic operation

What is $13 \bmod 1 =$

What is $-17 \bmod 7 =$

What is $-4 \bmod 9 =$

What is $4 \bmod 9 =$

What is $-7 \bmod 6 =$

What is $49 \bmod 5 =$

What is $-49 \bmod 5 =$

What is $25+37 \bmod 12 =$

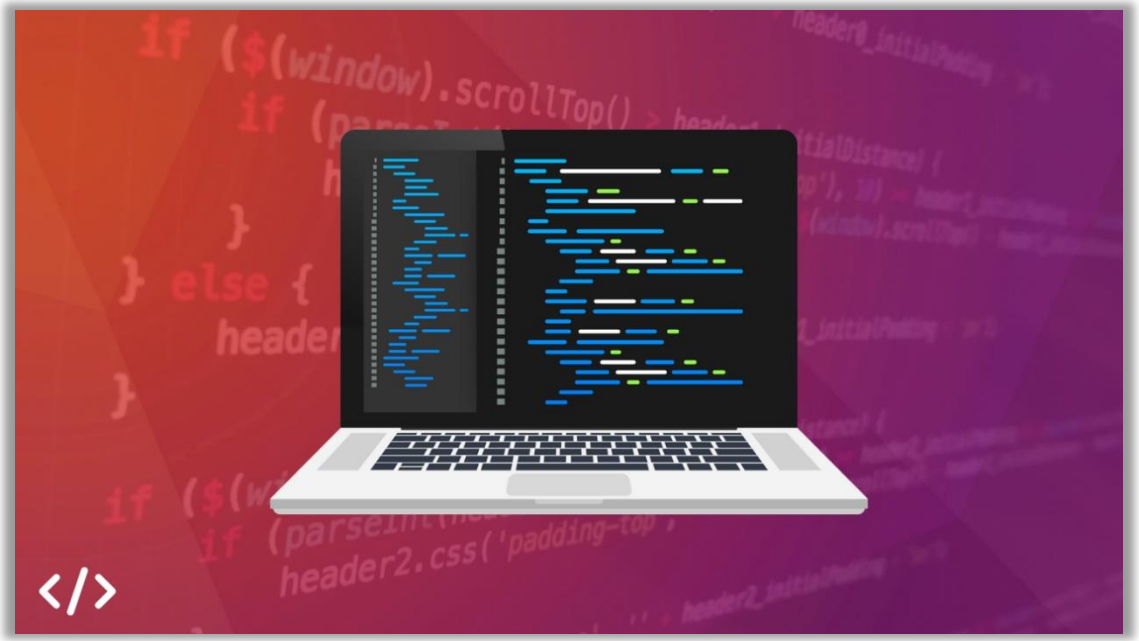
3) Given that $5x \equiv 6 \pmod 8$, find x.

MOD in programming languages and calculators

- Many programming languages, and calculators, have a mod operator, typically represented with the % symbol. If you calculate the result of a negative number, some languages will give you a negative result.

```
-5 % 3 = -2
```

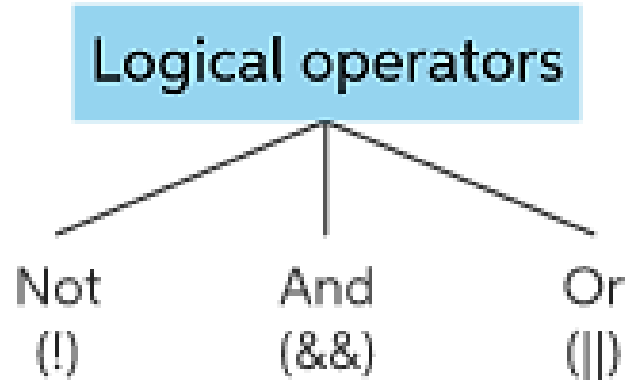
Modulus of any real number x will always give positive value as it's output.



Logical Operators

- Logical operators are useful when we want to test multiple conditions.
- There are 3 types of logical operators and they work the same way as the boolean AND, OR and NOT operators.
- && - Logical AND
  - All the conditions must be true for the whole expression to be true.
  - Example: if (a == 10 && b == 9 && d == 1)

    means the *if* statement is only true when *a* == 10 **and** *b* == 9 **and** *d* == 1.



Logical Operators

- || - Logical OR
  - The truth of one condition is enough to make the whole expression true.
  - Example: if (a == 10 || b == 9 || d == 1)

    means the *if* statement is true when **either one** of *a, b* or *d* has the right value.
- ! - Logical NOT (also called logical negation)
  - Reverse the meaning of a condition
  - Example: if (!(points > 90))

    means if points not bigger than 90.

Logical Operator

Expression	Expression Equivalent
!(a == b)	a != b
!(a == b || a == c)	a != b && a != c
!(a == b && c > d)	a != b || c <= d

Answer for the following questions: **True** or **False**

If $x = -2, y = 5, z = 0$, and $t = -4$, what is the value of each of the following expressions:

1. $x + y < z + 1$
2. $x - 2 * y + y < z * 2/3$
3. $3 * y/4\%5 < 8 \;\&\&\; y >= 4$
4. $t > 5 || z < (y + 5) \&\& y < 3$
5. $!(4 + 5 * y >= z - 4) \&\& (z - 2 < 7)$

If the numerator is **smaller than** the denominator, then the remainder is equal to the numerator. 3 % 10 =3

```
3 % 5 = 3
5 % 10 = 5
78 % 112 = 78
```

If x = -2, y = 5, z = 0 , and t = -4, what is the value of each of the following logical expressions?

1. x + y < z + 1
2. x - 2 * y + y < z * 2 / 3
3. 3 * y / 4 < 8 && y >= 4
4. t > 5 || z < 2
5. x * y < 10 || y * z < 10
6. (y + 2) / 3 > 3 && t < 0
7. x * 3 > 0 || y + 5 / t < 2
8. !(x > 0)
9. !(x * t < 10) || y / x * 4 < y * 2
10. t > 5 || z < (y + 5) && y < 3
11. !(4 + 5 * y >= z - 4) && (z - 2 < 7)

Order of Operations

- ()
- *, /, % Multiplicative operators
- +, - Additive operators
- <, >, >=, <= Relational operators
- ==, != Then do any comparisons for equality and inequality
- && Logical and
- || Logical or
- = Assignment operator

Write syntactically correct logical expressions for the following conditions:

1. m is less than 100
2. n is positive and greater than m
3. m is between 5 and 10 (inclusive)
4. k is less than 1 or greater than 2
5. j and k are both negative
6. i is an even number

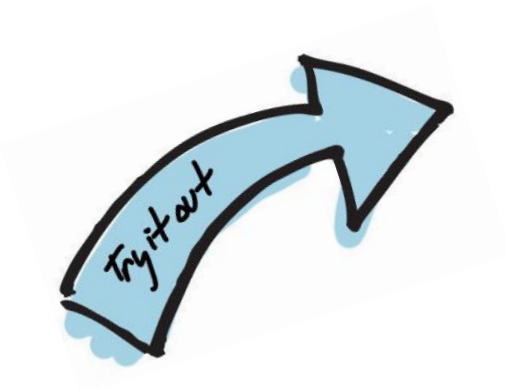
Given

```
int a = 5, b = 7, c = 17 ;
```

evaluate each expression as True or False.

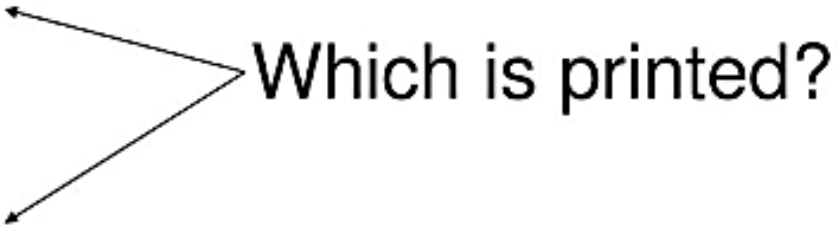
1. c / b == 2
2. c % b <= a % b
3. b + c / a != c - a
4. (b < c) && (c == 7)
5. (c + 1 - b == 0) || (b = 5)

- Assume a=5, b=2, c=4, d=6, and e=3. Determine the value of each of the following expressions:
  - a > b
  - a != b
  - d % b == c % b
  - a * c != d * b
  - a % b * c



- 25 < 7 || 15 > 36
- 15 > 36 || 3 < 7
- 14 > 7 && 5 <= 5
- 4 > 3 && 17 <= 7
- ! false
- ! (13 != 7)
- 9 != 7 && ! 0
- 5 > 1 && 7

```
int x, y;
X = 0 ;
y = 1 ;
if ( x < y || y < 5 && x == 3 )
{
   printf (“True \n”);
{
else
{
   printf(“False \n “);
{
```



7. $z + \frac{3}{5} = \frac{z}{5}$

8. $\frac{y}{6} = y + 5$

9. $\frac{7}{4}h = \frac{1}{4}h - 12w$

10. $\frac{4}{9}w + 5 = \frac{5}{9}$

11. $w + \frac{1}{7} = \frac{6w}{7} - 1$

12. $6 + \frac{x}{5} = \frac{4x}{5} - 3$

13. $\frac{y}{8} + 6 = 6 - \frac{5y}{8}$

14. $\frac{m}{2} + 2 = \frac{4m}{5} + 2$

15. $2 - \frac{n}{8} = 4n + \frac{5}{8}$

16. $\frac{w}{3} + 5 = \frac{8w}{3} - 2$

17. $\frac{5y}{2} - 9 = \frac{2y}{3} + 2$

18. $p - \frac{p}{8} = \frac{p}{4} - 10$

19. $1 - \frac{5}{8}x = 2 - \frac{2}{3}x$

20. $y + \frac{3}{4} = \frac{y}{4} + \frac{7}{8}$

Practice

1) $\frac{3}{5}(1+p)=\frac{21}{20}$

2) $-\frac{1}{2}=\frac{3}{2}k+\frac{3}{2}$

3) $0=-\frac{5}{4}(x-\frac{6}{5})$

4) $\frac{3}{2}n-\frac{8}{3}=-\frac{29}{12}$

5) $\frac{3}{4}-\frac{5}{4}m=\frac{113}{24}$

6) $\frac{11}{4}+\frac{3}{4}r=\frac{163}{32}$

7) $\frac{635}{72}=-\frac{5}{2}(-\frac{11}{4}+x)$

8) $-\frac{16}{9}=-\frac{4}{3}(\frac{5}{3}+n)$

9) $2b+\frac{9}{5}=-\frac{11}{5}$

10) $\frac{3}{2}-\frac{7}{4}v=-\frac{9}{8}$

11) $\frac{3}{2}(\frac{7}{3}n+1)=\frac{3}{2}$

12) $\frac{41}{9}=\frac{5}{2}(x+\frac{2}{3})-\frac{1}{3}x$

13) $-(-\frac{5}{2}x-\frac{3}{2})=-\frac{3}{2}+x$

14) $\frac{45}{16}+\frac{3}{2}n=\frac{7}{4}n-\frac{19}{16}$

15) $\frac{3}{2}(v+\frac{3}{2})=-\frac{7}{4}v-\frac{19}{6}$

16) $\frac{47}{9}+\frac{3}{2}x=\frac{5}{3}(\frac{5}{2}x+1)$

17) $-\frac{7}{2}(\frac{5}{3}a+\frac{1}{3})=\frac{11}{4}a+\frac{25}{8}$

18) $-\frac{8}{3}-\frac{1}{2}x=-\frac{4}{3}x-\frac{2}{3}(-\frac{13}{4}x+1)$

19) $\frac{1}{3}n+\frac{29}{6}=2(\frac{4}{3}n+\frac{2}{3})$

Answers to check

1) $\frac{3}{4}$

2) $-\frac{4}{3}$

3) $\frac{6}{5}$

4) $\frac{1}{6}$

5) $-\frac{19}{6}$

6) $\frac{25}{8}$

7) $-\frac{7}{9}$

8) $-\frac{1}{3}$

9) -2

10) $\frac{3}{2}$

11) 0

12) $\frac{4}{3}$

13) -2

14) 16

15) $-\frac{5}{3}$

16) $\frac{4}{3}$

17) $-\frac{1}{2}$

18) $-\frac{3}{2}$

19) $\frac{3}{2}$

SigFigs

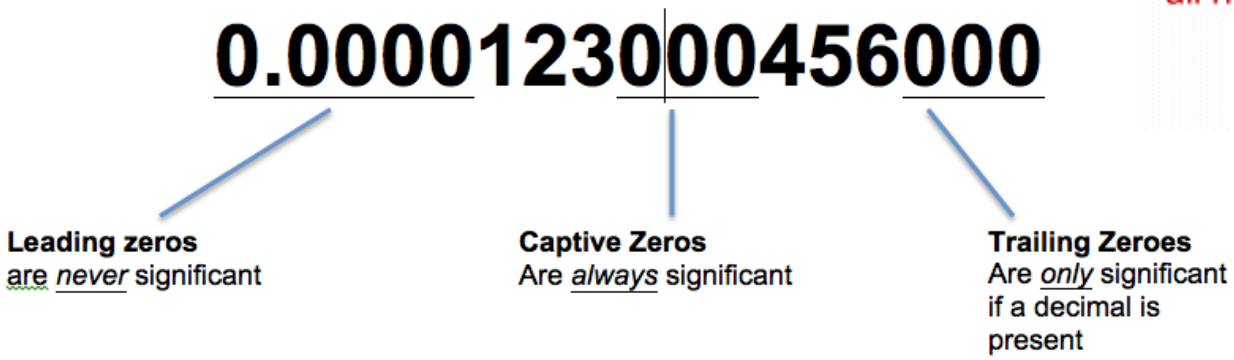
Significant figures are important to show the precision of your answer. This is important in science and engineering because no measuring device can make a measurement with 100% precision. Using Significant figures allows the scientist to know how precise the answer is, or how much uncertainty there is.

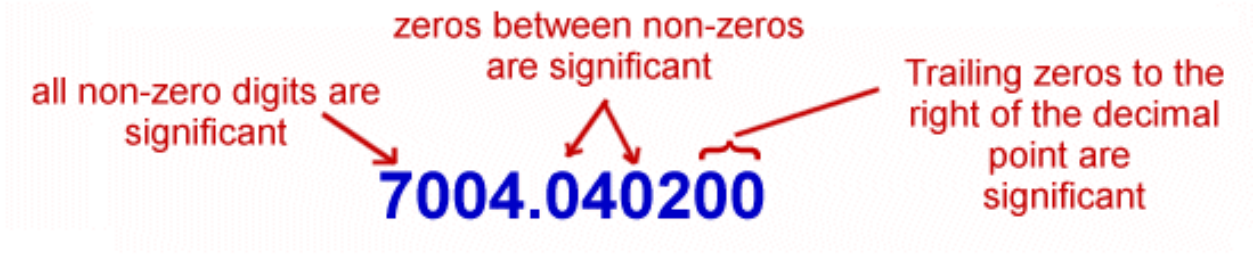
2002 has two significant zeroes, but 0.0103 has only 1 significant zero.

Significant Figures

- The number of digits counted to the right from the leftmost positive digit is called the *number of significant figures*. For example,

26.103, 0.00304, 202.000 and 0.003040 are quoted to 5, 3, 6, 4 significant figures respectively.





Significant Figures Rules:

- All non-zero digits **DO** count.
  - 24 = 2
  - 3.56 = 3

- Leading zeros **DON'T** count.
  - (zeros in front of numbers)
  - 0.0025 = 2

- Captive Zeros **DO** count.
  - (zeros between non-zero numbers)
  - 1502 = 4 1.008 = 4

- Trailing Zeros **DO** count **IF** the number contains a **DECIMAL**.
  - (zeros at the end of numbers)
  - 100 = 1 2306.0 = 5 $1.00 \times 10^3 = 3$

Sometimes, you'll be asked to round with significant figures. Significant figures have to do with the number of digits known with a degree of certainty. Keeping track of this number is important when gathering data from an experiment because it minimizes error. Here are the rules for significant figures:

1. All nonzero digits are significant.
2. All zeroes between nonzero digits are significant.
3. Trailing zeroes to the right of a decimal point are significant.
4. Leading zeroes to the left of the first non-zero number are not significant.

Here are some examples. Can you see which rule applies?

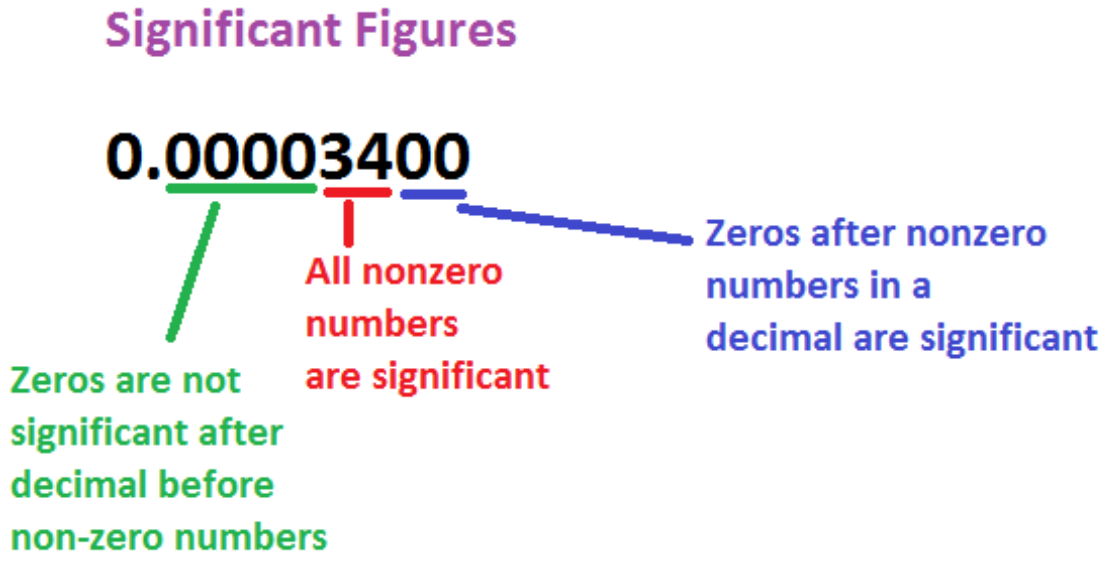
1.23 has 3 significant figures

1001 has 4 significant figures

2.03 has 3 significant figures

0.033 has 2 significant figures

0.20 has 2 only significant figures



1. Find the number of significant figure in each of the following:

(a) 7.3

(b) 162.5 m

(c) 306 g

(d) 3.57 m

(e) 7.005 kg

(f) 0.045 km

(g) 0.00234 l

(h) 82.030 mg

2. Round off each of the following correct up to 3 significant figures:

(a) 56.4517 g

(b) 5.20763 kg

(c) 33.311 km

(d) 50.001 cm

(e) 0.0012485 m

(f) 0.0013020 l

Scientific Notation

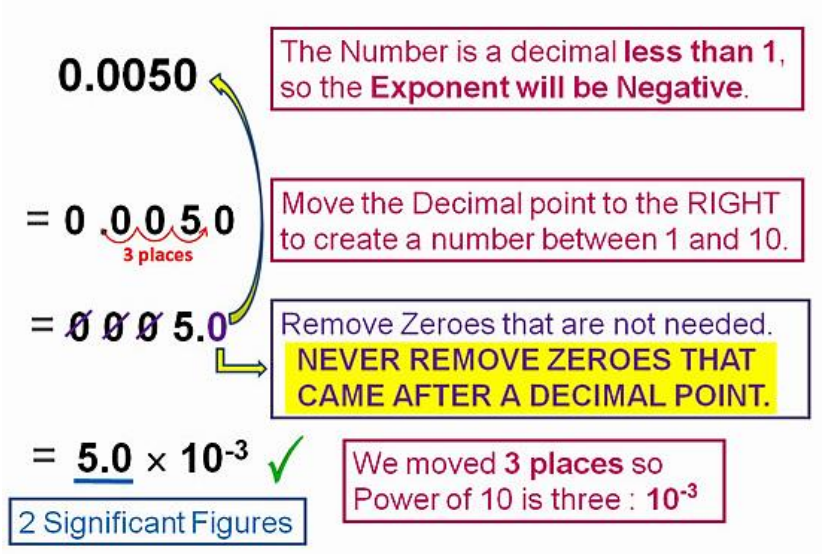
$$2 \times 10^9$$

2.000000000

1 2 3 4 5 6 7 8 9

2,000,000,000

- $193.034 = 1.93034 \times 10^2$
- $0.003040 = 3.040 \times 10^{-3}$



284.6 = 2.846 x 10 2

0.0245 = 2.45 x 10 -2

3125000 = 3.125 x 10 6

-0.0042 = -4.2 x 10 -3

0.00056 = 5.6 x 10 -4

245000 = 2.45 x 10 5

240.06 = 2.4006 x 10 2

Convert the following numbers into scientific notation:

1) 923 __ **9.23×10^{2}** _____

2) 0.00425 __ **4.25×10^{-3}** _____

3) 4523000 __ **4.523×10^{6}** _____

4) 0.94300 __ **9.4300×10^{-1}** _____

5) 6750. __ **6.750×10^{3}** _____

6) 92.03 __ **9.203×10^{1}** _____

7) 7.80 __ **7.80×10^{0}** _____

8) 0.00000032 ___ **3.2×10^{-7}** _____

Convert the following numbers into standard notation:

9) 3.92400×10^{5} ____ **392400** _____

10) 9.2×10^{6} _____ **9200000** _____

11) 4.391×10^{-3} _____ **0.004391** _____

12) 6.825×10^{-4} _____ **0.0006825** _____

13) 4.6978×10^{4} _____ **46978** _____

14) 8.36×10^{1} _____ **83.6** _____

15) 2.46×10^{-5} _____ **0.0000246** _____

16) 8.8×10^{2} _____ **880** _____

Factorial

exclamation mark

study now be proud later

Example 1.

Simplify this factorial expression.

$$3!$$

Solution.

- **Use this formula to calculate a factorial expression:**

$$n! = n \cdot (n-1) \cdot (n-2) \cdot \ldots \cdot 1$$

- **Calculate the factorial expression.**

$$3! = 3 \cdot 2 \cdot 1$$

$$= 6$$

$0! = 1$

$1! = 1$

$2! = 2 \times 1 = 2$

$3! = 3 \times 2 \times 1 = 6$

$4! = 4 \times 3 \times 2 \times 1 = 24$

$5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$

practice MAKES progress

Match each expression on the left with an equivalent expression on the right.

A	$\frac{14!}{13!}$
B	$\frac{52!}{51!}$
C	$\frac{101!}{99!}$
D	$20 \times 19!$
E	$90 \times 8!$
F	$30 \times 4!$

Letter		
	1	10100
	2	6!
	3	52
	4	10!
	5	14
	6	20!

Determine the value for each expression. Simplify fully before using a calculator.

a) $\frac{10!}{5!}$ b) $\frac{21!}{14!}$ c) $\frac{9!}{3!6!}$ d) $\frac{12!}{8!4!}$ e) $\frac{7!}{2!5!}+\frac{7!}{4!3!}$

f) $\frac{15!}{9!6!}+\frac{15!}{10!5!}$ g) $2\times\frac{5!}{2!3!}$ h) $3\times\frac{11!}{7!4!}$

$\frac{(n-1)!\cdot n!}{(n!)^2}$

$\frac{88!}{90!}$

$\frac{(4-1)!}{4!}$

$\frac{38!\cdot 3!}{39!}$

$\frac{(n+5)!}{(n+1)!}$

$\frac{(2\cdot 3)!}{3!}$

$\frac{77!\cdot 2!}{78!}$

- $\frac{10!}{12!}$
- $\frac{3!4!}{6!}$
- $\frac{16 \cdot 15 \cdot 14 \cdot 13}{20!}$
- $\frac{(8! + 7!)(6! + 5!)}{(8! - 7!)(6! - 5!)}$

1) $\frac{(6 - 2!)!}{4!}$

2) $6! + (-3 \times 5!)$

3) $9 - 2!$

4) $(3!)!$

5) $\frac{18!}{16!}$

6) $-35 + 0! + 7$

7) $25 - 5! - 1!$

8) $10 \times 3!$

9) $\frac{14!}{13!} \div \frac{7!}{6!}$

10) $4!\,2! + 40$

11) $5! + 16$

12) $\frac{22!}{19!\,8!}$

1) $4!$

2) $8!$

3) $7!$

4) $\frac{4!}{3!}$

5) $\frac{6!}{1!}$

6) $\frac{6!}{4!}$

7) $\frac{6!}{4!2!}$

8) $\frac{5!}{2!2!}$

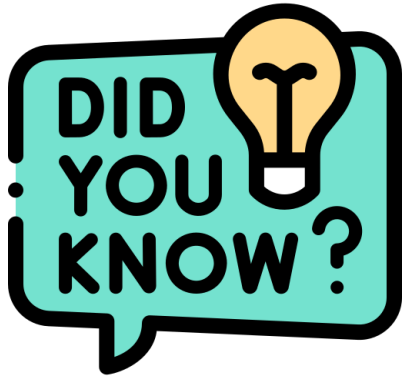
9) $\frac{7!}{3!2!}$

10) $\frac{6!}{(5-3)!3!}$

11) $\frac{7!}{(7-4)!4!}$

12) $\frac{4!}{(4-1)!1!}$

Answers: 1) 24 2) 40320 3) 5040 4) 4 5) 720 6) 30 7) 15 8) 30 9) 420 10) 60 11) 35 12) 4



What makes a good life? Lessons from the longest study on happiness

Robert Waldinger

What keeps us healthy and happy as we go through life?

https://www.youtube.com/watch?v=8KkKuTCFvzI