Lecture 1:

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

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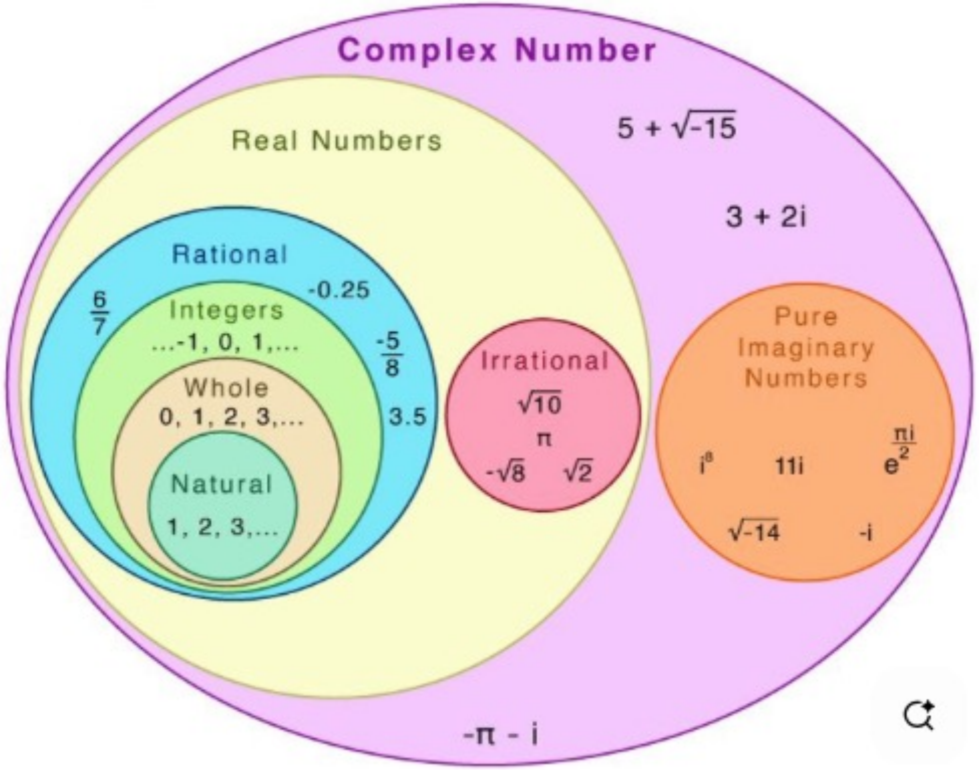
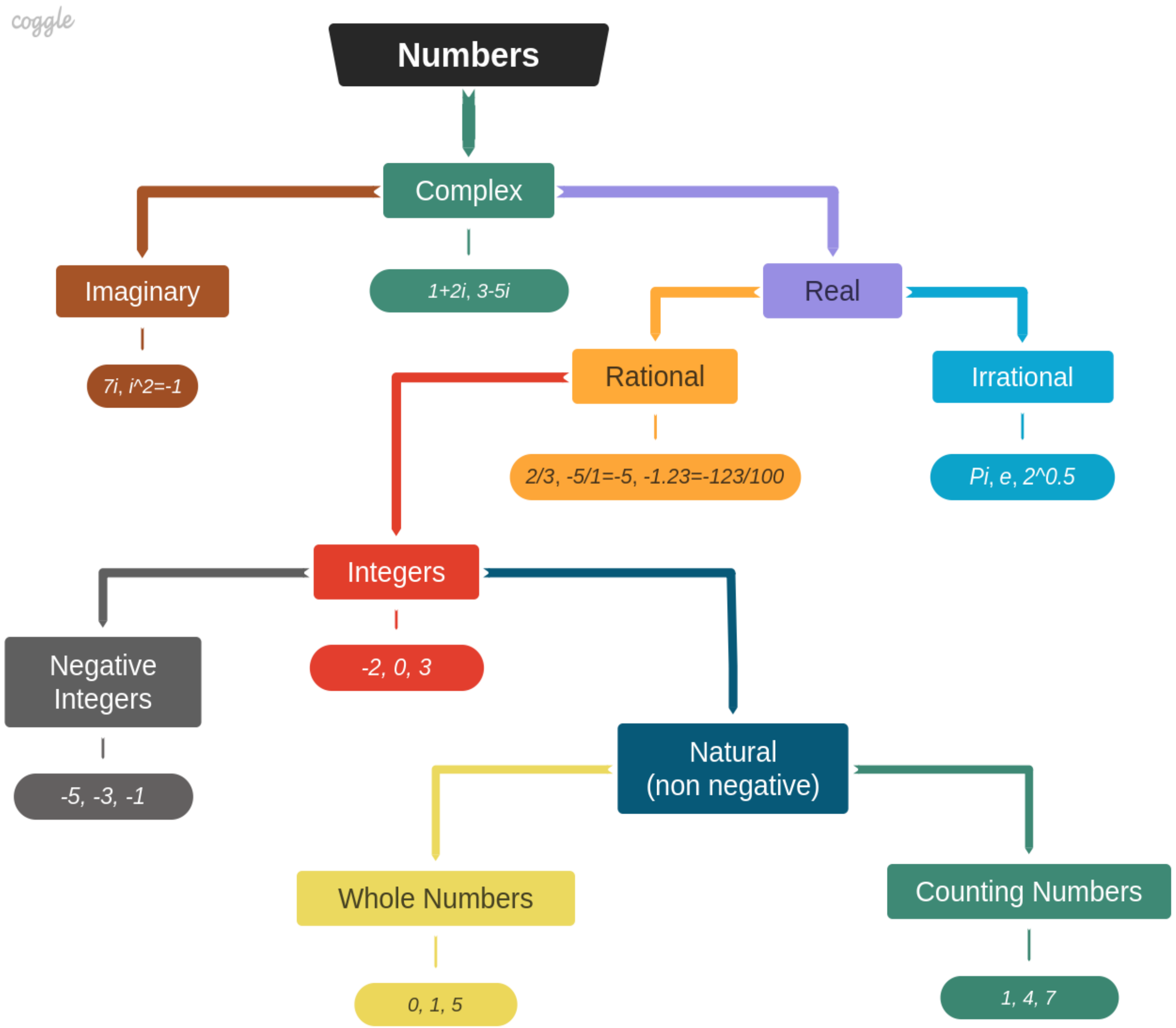
Number Classifications

- ✓ $\mathbb{N} = \{1,2,3,\ldots\}$ – natural numbers.
- ✓ $\mathbb{W}(\mathbb{N}_0) = \{0, 1, 2, 3, \ldots\}$ – whole numbers.
- ✓ $\mathbb{Z} = \{0, \pm 1, \pm 2, \pm 3, \ldots\}$ – integer numbers.
  - $Z^+ = \{0, 1, 2, 3, \ldots\}$ – non-negative integers
  - $Z^- = \{0, -1, -2, -3, \ldots\}$ – non-positive integers
- ✓ $\mathbb{Q} = \left\{\frac{a}{b} \middle| a, b \in Z, b \neq 0\right\}$ – rational numbers.

  For example: $\left\{\frac{1}{2}, \frac{3}{4}, 2, 5, 0, -\frac{7}{11}, -12, \ldots\right\}$.
- ✓ $\mathbb{I}\mathrm{r}(\mathbb{R}\backslash\mathbb{Q})$ = Examples include $\sqrt{2}$, π, $\sqrt{3}$, … - irrational numbers.

➢ $\mathbb{R}$ **(Real numbers)** - <u>set of</u> rational numbers and irrational numbers.




coggle
Numbers
Complex
1+2i, 3-5i
Imaginary
7i, i^2=-1
Real
Rational
2/3, -5/1=-5, -1.23=-123/100
Irrational
Pi, e, 2^0.5
Integers
-2, 0, 3
Negative Integers
-5, -3, -1
Natural (non negative)
Whole Numbers
0, 1, 5
Counting Numbers
1, 4, 7

Remark:

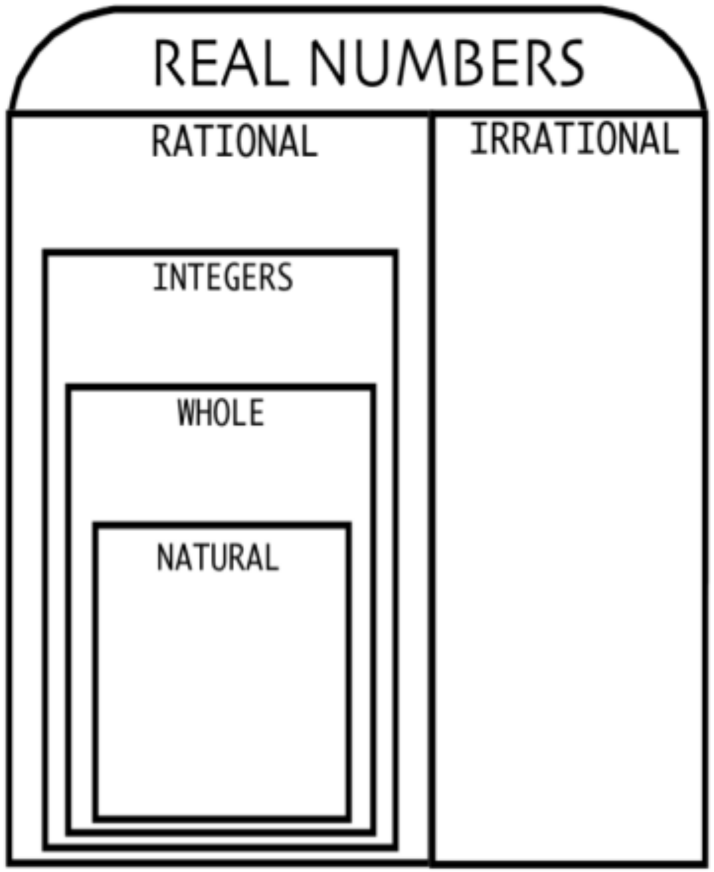
- Rational numbers have **finite** or **repeating decimals**.
  - **Finite**: $\frac{1}{2} = 0.5$.
  - **Repeating**: $\frac{1}{3} = 0.333\ldots = 0.\overline{3}$.

- Note that $\frac{7}{0}$ is **not rational** because division by zero is undefined.

$\Pi = 3.141592653589$
$e = 2.7182818284590$

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

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



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

a) $\sqrt{10}$ ______________________________

b) -44 ______________________________

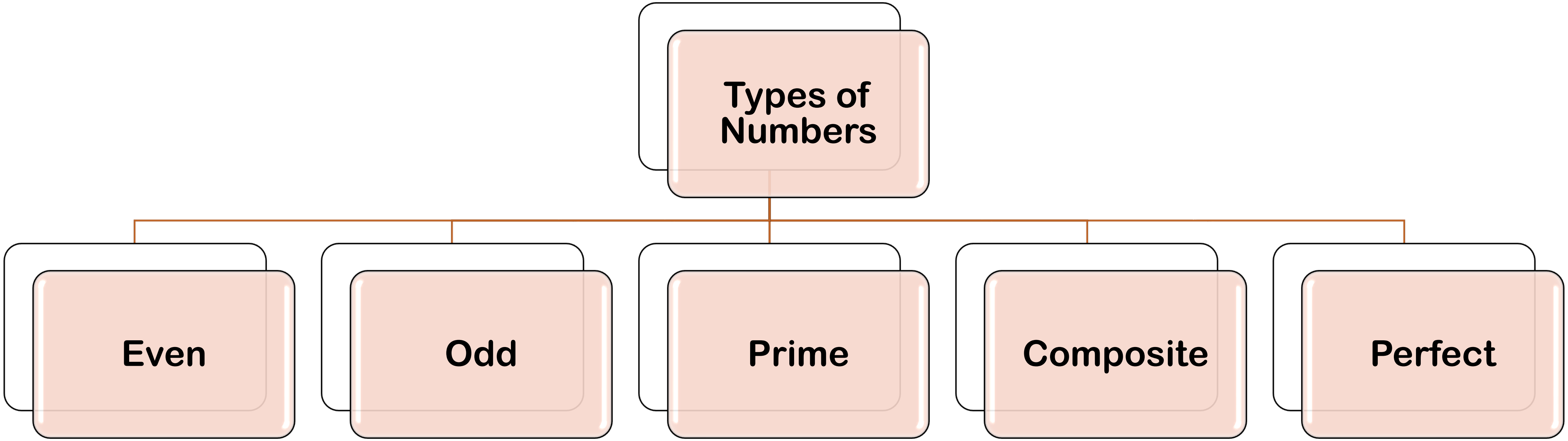
c) 3 ______________________________

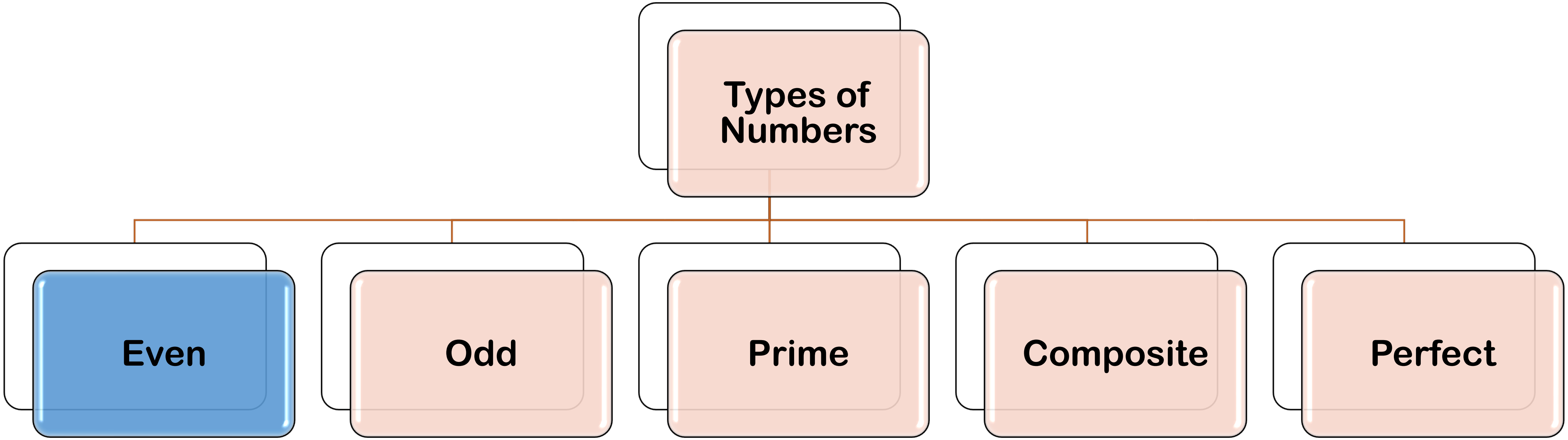
d) $-6/11$ ______________________________

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						

practice makes progress


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?

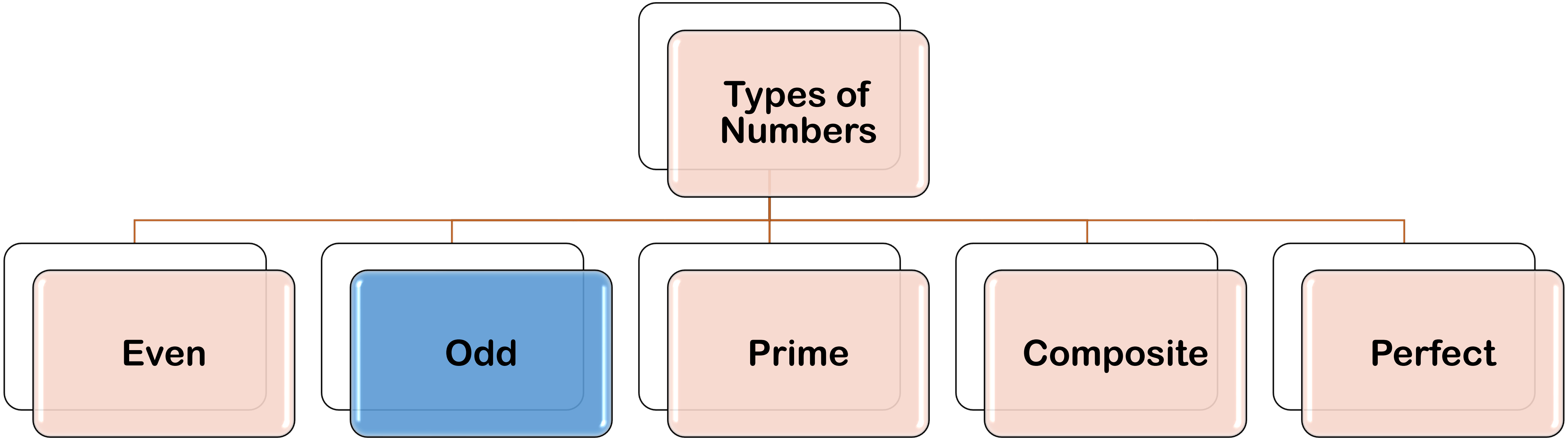
→ State true or false: 0 is an even number.

→ 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

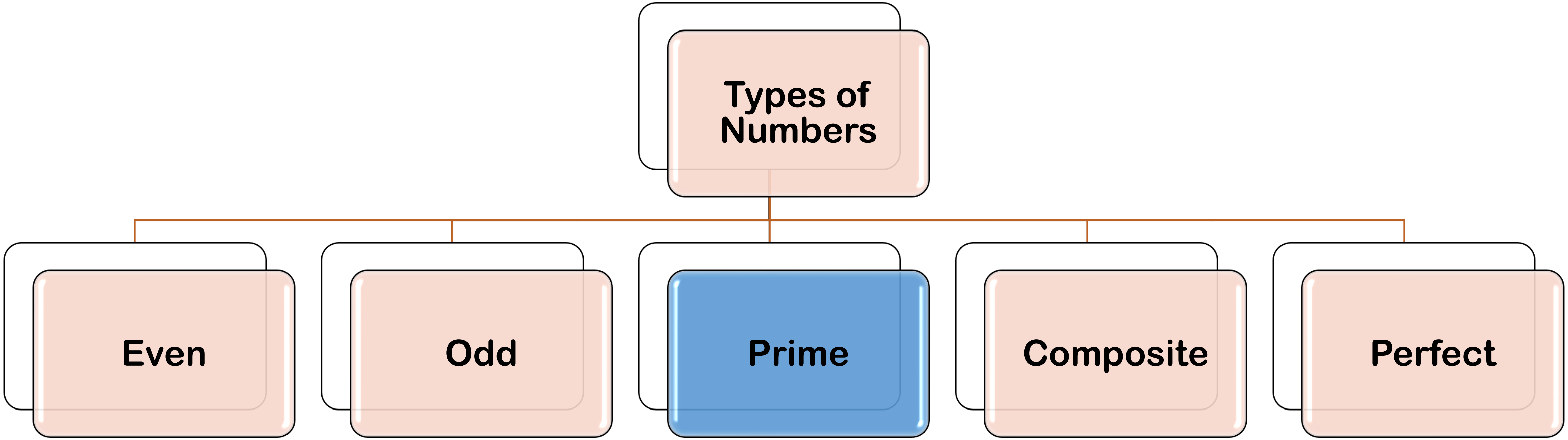
→ When you buy a dozen bananas, are you getting an even number or an odd number of bananas?

→ 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 **prime number** is a **natural number greater than 1** that has **exactly two distinct positive divisors, 1** and **itself**.

- **Ex: 2, 3, 5, 7, 11, 13, …**
- **Note**: The number 2 is the only even prime number.

Quick check

To test if a number n is prime:

1. Check divisibility by numbers from 2 up to $\sqrt{n}$.

2. If none divide evenly → prime.

Note: A number a **divides evenly** into a number b if when you divide b by a, there is **no remainder**.

3. Otherwise → composite.

Prime numbers are crucial in Cryptography and IT security

- Modern encryption, like **RSA encryption**, relies on **large prime numbers**.
- Large primes are used to **generate keys** that are very hard to factor.

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.

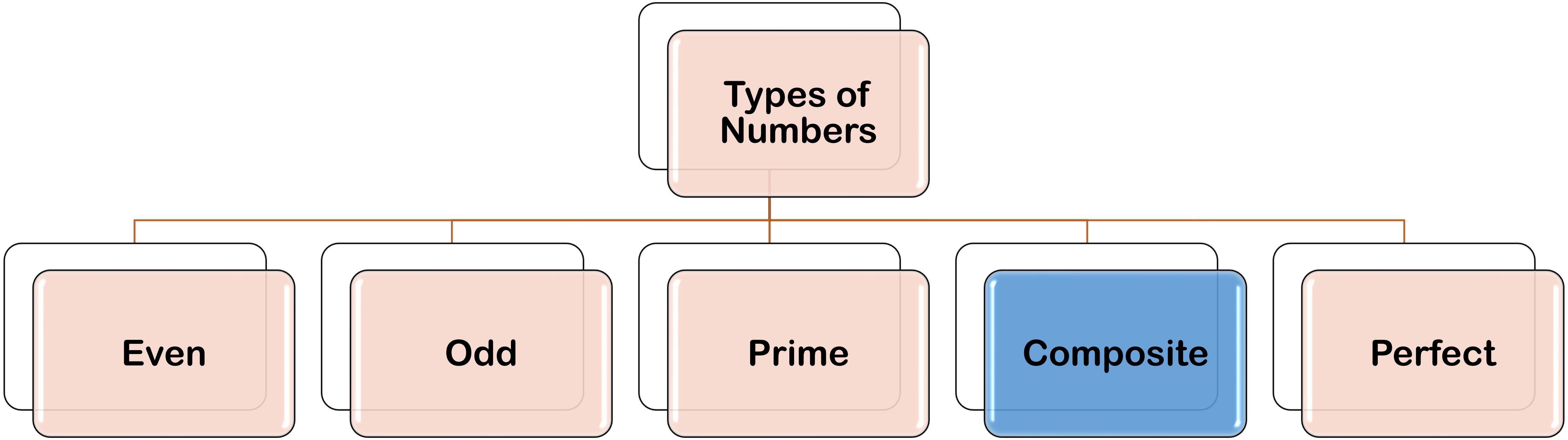
a.) 1 is a prime number.
b.) The only even prime number is 2.
c.) The first five prime numbers are 2, 3, 5, 7, and 9.
d.) All prime numbers are odd.

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 __.

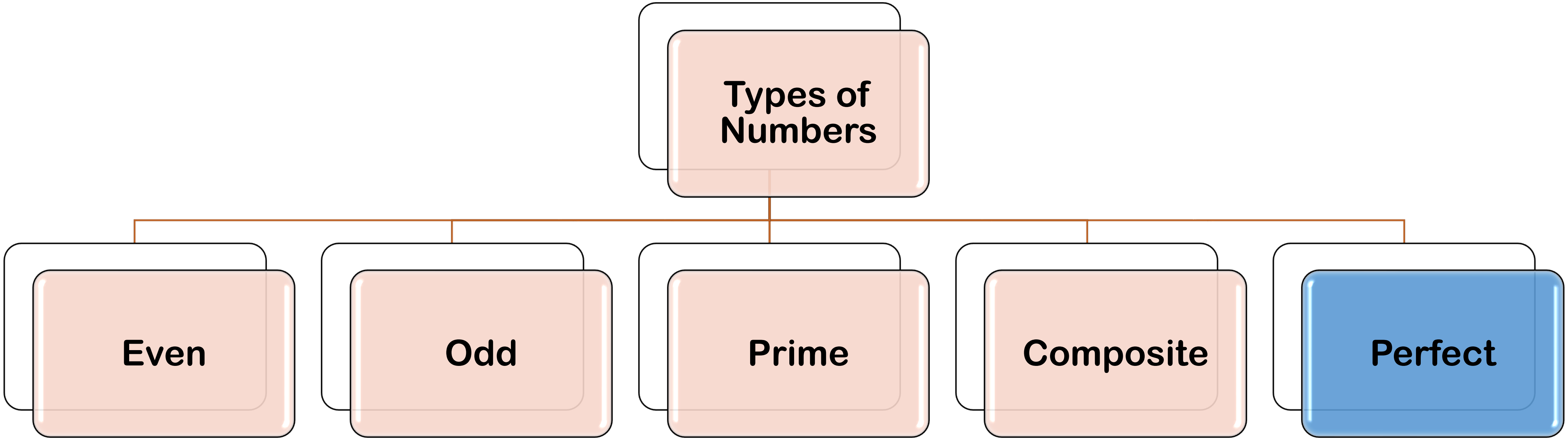
→ State true or false with respect to composite numbers.
a.) All even numbers are composite numbers.
b.) 1 is a composite number.

→ 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 <u>odd numbers</u>.

→ 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

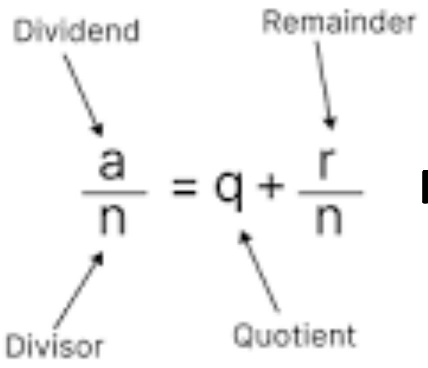
- What will be the area of a square having a side of 16 meters?

Modulo Operator

- **Mod is also known as modulus or modulo.** For an integers a and a positive n,

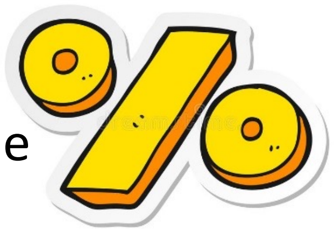
$$a \bmod n = \text{the remainder when } a \text{ is divided by } n.$$

- **It gives the remainder after dividing one number by another number.**



Note: Always, $0 \leq r < n$.

Modulo in programming



Most programming languages use the symbol **%.**

Example (Python / C / Java):

17 % 5 = 2.

Common uses of the modulo operator mod

1. Checking even or odd numbers

- **Even**: $n \mod 2 = 0$.
- **Odd**: $n \mod 2 = 1$.

2. Cycles and repeating patterns

Used in clocks, calendars, and loops:

Clock arithmetic:

$15 \mod 12 = 3$ (3 o’clock)

3. Divisibility test

If $a \bmod b = 0$, then b **divides** a **exactly.**

Common uses of the modulo operator mod

4. Mathematical view

Modulo defines **congruence**:

$$a \equiv b(\text{mod}\, n) \Leftrightarrow a = nq_1 + r \;\; and \;\; b = nq_2 + r.$$

- means a and b have the same **remainder** when divided by n.

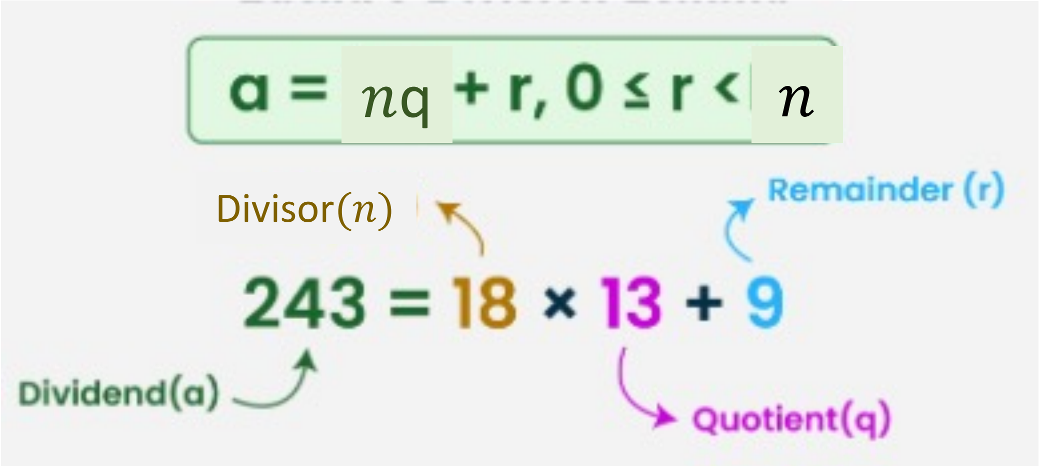
Equivalently

- n **divides the difference** $a - b$.

Example: $17 \equiv 5(\text{mod}\ 12)$

- $17 = 12 \cdot 1 + 5$

and $5 = 12 \cdot 0 + 5$



- It is clear 12 divides $17 - 5 = 12$

Remember, **division algorithm** says

$$\frac{a}{n} = q + \frac{r}{n} \Leftrightarrow \boldsymbol{a = nq + r}$$

Examples

Other notations include a: b

$$27 \bmod 4 = 27:4 \Rightarrow 4 \cdot 6 + 3$$

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

$$0 \le r < n$$

$$-15:4 \Rightarrow -4 \cdot 4 + 1 = -15$$ ✓

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

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

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

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

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

Remember, **division algorithm** says

$$\frac{a}{n} = q + \frac{r}{n} \Leftrightarrow \boldsymbol{a = nq + r}$$

-9 mod 9 = 0

-8 mod 9 = 1

-7 mod 9

-4 mod 9 = 5

-2 mod 9

-1 mod 9 = 8

What is -6 mod 18 ? = 12

What is -4 mod 9?

What is -9 mod 6?

What is -13 mod 1? = 0

What is 17 mod 7? = 3

What is -49 mod 5?

What is -14 mod 2? = 0

What is -29 mod 4?

What is -29 mod 3? = 1

What is 6 mod 18?

What is 9 mod -6? = 3

What is 4 mod 9?

What is -6 mod 18? = 12

What is 7 mod 6?

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

$-\mathbf{8}:\mathbf{9} = -\mathbf{8}\ \mathbf{mod}\ \mathbf{9} = \boldsymbol{r}$ wher $-8 = q \cdot 9 + r$

The largest negative integer is $-\mathbf{8}$.

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

Answer: 1

Homework

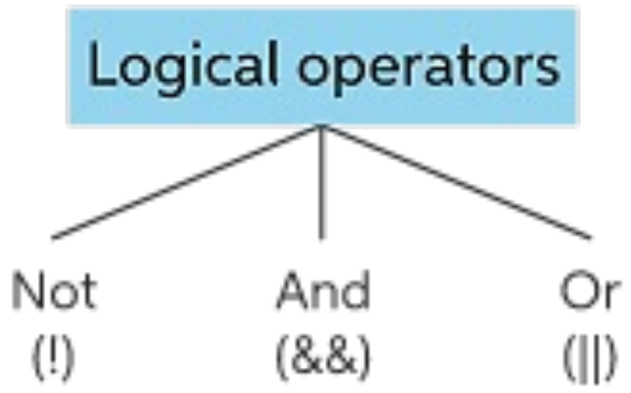
What is the remainder value:

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

- Find 11 mod 8.
- Find -3 mod 8.
- Find 49 mod 5.

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

Specific roles in IT

- **Software Developer / Software Engineer** – writes and designs programs
- **Programmer** – writes code
- **Systems Analyst** – analyzes and designs IT systems
- **Network Engineer** – manages networks
- **Database Administrator (DBA)** – manages databases
- **Cybersecurity Analyst** – protects systems and data
- **Data Scientist** – analyzes data using math and computing

FYI

```
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
```

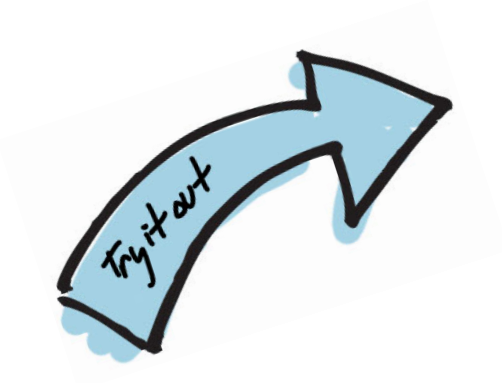
Given

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

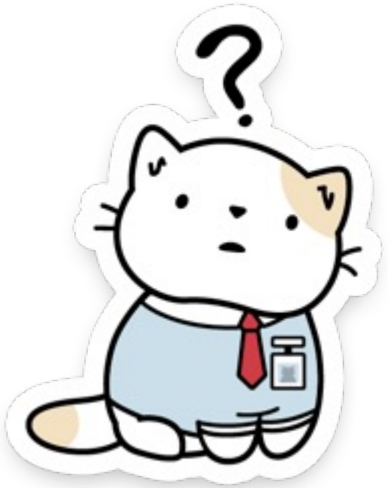
evaluate each expression as True or False.

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



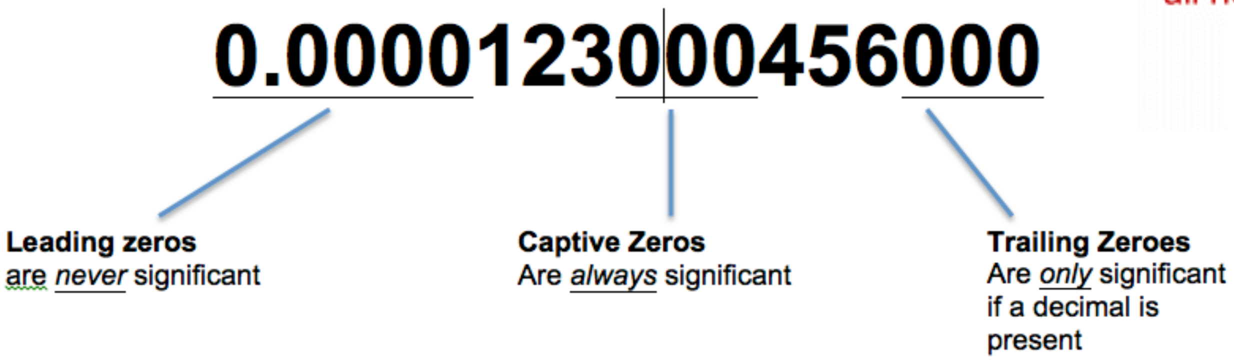
SigFigs

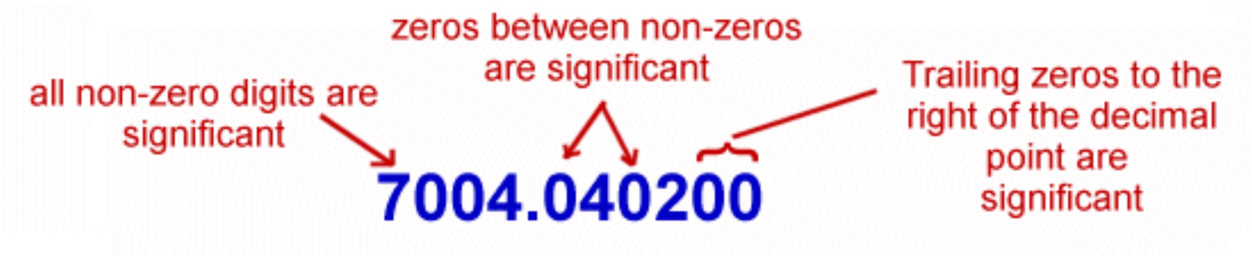
Significant figures are important to show the precision of your answer. This is important in science and engineering because no measuring device can make a measurement with 100% precision. Using Significant figures allows the scientist to know how precise the answer is, or how much uncertainty there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





Rules for counting significant figures

1. **Non-zero digits are always significant**
    1. Example: 123 → 3 sig. figs.
    2. 56.7 → 3 sig. figs.
2. **Leading zeros are NOT significant (zeros in front of numbers)**
    1. Example: 0.0045 → 2 sig. figs.
    2. 0.00076 → 2 sig. figs.
3. **Zeros between non-zero digits are significant (captive zeros)**
    1. Example: 1002 → 4 sig. figs.
    2. 3.005 → 4 sig. figs.
4. **Trailing zeros after a decimal point are significant**
    1. Example: 45.00 → 4 sig. figs.
    2. 0.0200 → 3 sig. figs.
5. **Trailing zeros in a whole number without a decimal point are ambiguous**
    1. Example: 1500 → could be 2, 3, or 4 sig. figs. (writing 1.5×10^3 clarifies 2 sig. figs.)

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

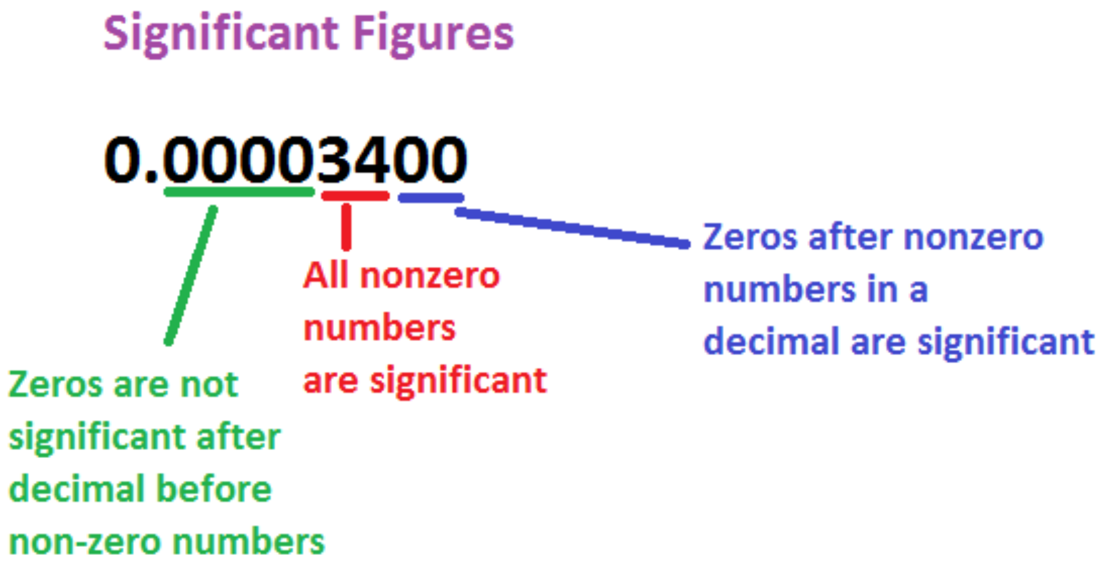
1.23 has _3 significant_ figures

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

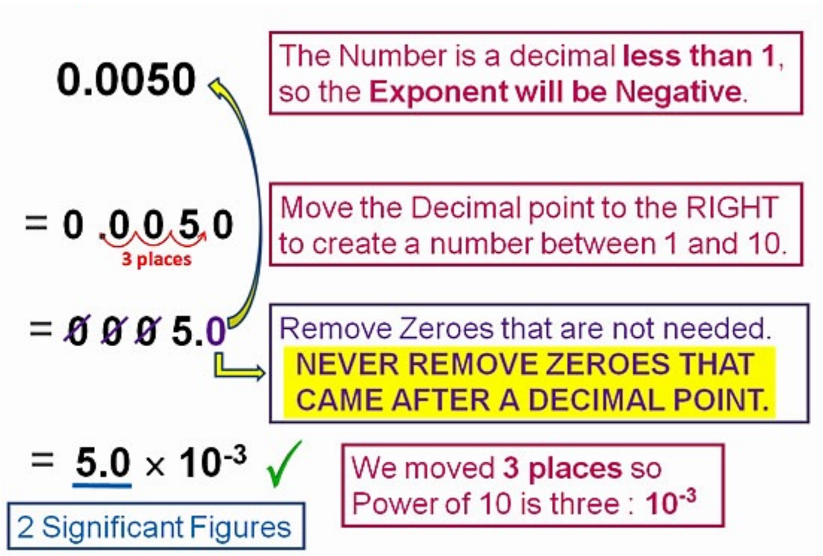
- $193.034 = 1.93034 \times 10^{2}$
- $0.003040 = 3.040 \times 10^{-3}$

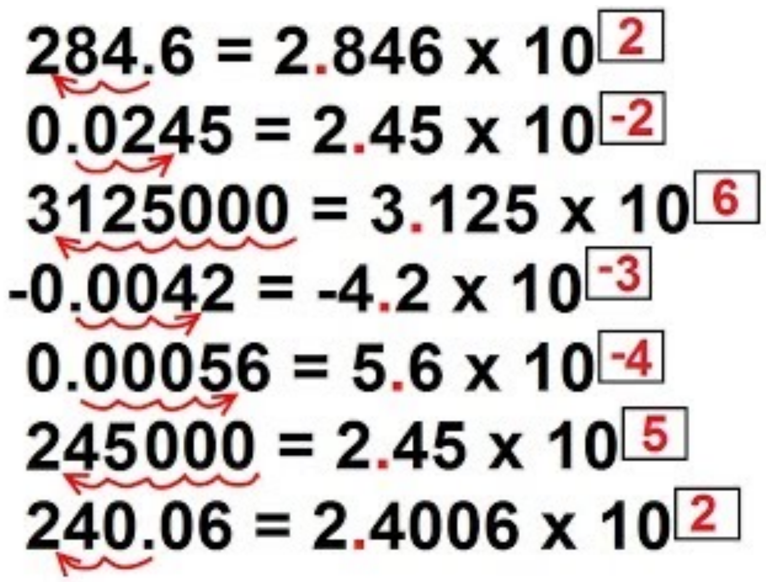
2×10^{9}

2.000000000

1 2 3 4 5 6 7 8 9

2,000,000,000





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

$$\mathbf{0! = 1}$$
$$1! = 1$$
$$2! = 2 \times 1 = 2$$
$$3! = 3 \times 2 \times 1 = 6$$
$$4! = 4 \times 3 \times 2 \times 1 = 24$$
$$5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$$

Example 1.

Simplify this factorial expression.

$$3!$$

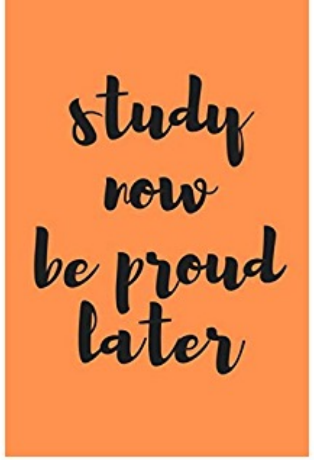
Solution.

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

$$n! = n \bullet (n-1) \bullet (n-2) \bullet \cdots \bullet 1$$

- **Calculate the factorial expression.**

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



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) $3\times\frac{11!}{7!4!}$

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

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

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

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

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

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

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

- $\dfrac{10!}{12!}$
- $\dfrac{3!4!}{6!}$
- $\dfrac{16\cdot15\cdot14\cdot13}{20!}$
- $\dfrac{(8!+7!)(6!+5!)}{(8!-7!)(6!-5!)}$

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

2) $6!+(-3\times5!)$

3) $9-2!$

4) $(3!)!$

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

6) $-35+0!+7$

7) $25-5!-1!$

8) $10\times3!$

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

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

11) $5!+16$

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

1) $4!$

2) $8!$

3) $7!$

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

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

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

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

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

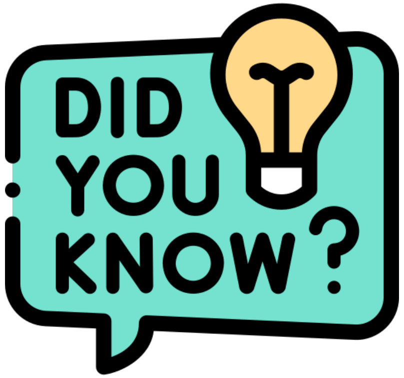
9) $\frac{7!}{3!2!}$

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



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