



PHASE 1 PACKAGE

Scientific Track – NSMO

Junior Mathematics

Mathematics Scientific Team



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Introduction

Dear Gifted Students,

This is the first stage of the **National Gifted Olympiad – Scientific Track (NSMO)**. It marks the beginning of a training journey designed to develop the mathematical thinking skills of students in **Grade 7 and Grade 8**.

The competition consists of **four successive stages**.

This training package aims to build a strong foundation in four main branches of mathematics: **Combinatorics, Geometry, Algebra, and Number Theory**.

It covers topics such as counting using **Venn diagrams and fundamental counting principles**, properties of triangles and angles, integers and factorization, introductory concepts in number theory, as well as rational numbers and operations on them.

These topics help develop students' logical reasoning and mathematical analysis skills, enabling them to approach problems creatively and systematically. This stage serves as their first gateway toward excellence in the upcoming stages of the competition.

We wish you continued creativity and success.

Scientific Team of the National Gifted Olympiad – Scientific Track (NSMO) – Mathematics Track

First Unit: ALGEBRA



1- Integers and Their Properties

1-1 Sets of Numbers:

Set of Natural Numbers:

$$N = \{1, 2, 3, \dots\}$$

Set of Whole Numbers:

$$W = \{0, 1, 2, 3, \dots\}$$

Set of Integers:

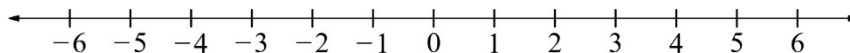
$$Z = \{\dots, -3, -2, -1, 0, 1, 2, 3, \dots\}$$

Integers can be divided into three groups:

- Positive integers.
- Zero.
- Negative integers.

Note that the number $+1$ is usually written simply as 1 , meaning that the positive sign is often omitted and not pronounced. On the other hand, the negative sign is written and pronounced. Also note that zero is neither positive nor negative.

1-2 The Number Line:



A number line is used to illustrate the order of integers.

As we move to the right, the value of the integer increases, and as we move to the left, the value decreases.

This means that any positive integer is greater than any negative integer, and zero is greater than any negative number but less than any positive number.

For the numbers 5 and -5 , each is the additive inverse (or opposite) of the other.

In general, for any integer a , its opposite $-a$ is its additive inverse, while zero is the additive inverse of itself.

On the number line, an integer and its additive inverse are represented by two points that are the same distance from zero but on opposite sides of it.

1–3 The Absolute Value of an Integer:

The absolute value of an integer a is denoted by $|a|$.

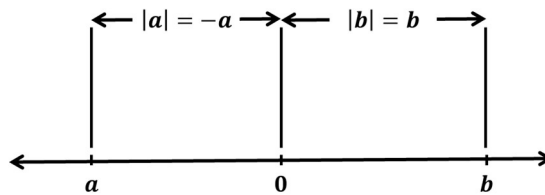
For example:

$$|5| = 5, \quad |-5| = 5, \quad |0| = 0$$

Geometrically, each integer is represented by a point on the number line.

The expression $|a|$ represents the distance between the point representing the integer a and the (zero) on the number line.

In general, $|a - b|$ represents the distance between the points representing the two integers a and b .



When finding the absolute value of an algebraic expression, if the result is negative, it is made non-negative by removing the negative sign (-).

1–4 Fundamental Rules of Addition, Subtraction, Multiplication, and Division:

Commutative Property:

- $a + b = b + a$
- $ab = ba$

Associative Property:

- $(a + b) + c = a + (b + c)$
- $(ab)c = a(bc)$

Distributive Property:

- $a(b + c) = (b + c)a = ab + ac$
- $a(b - c) = (b - c)a = ab - ac$

Closure Property:

The closure property holds for **addition**, **subtraction**, and **multiplication**, but not for **division**.

For any two integers a and b , the results of $a + b$, $a - b$, and $a \times b$ are always integers.

However, $a \div b$ is **not necessarily** an integer.

Additive Identity Property:

For any integer $a \in \mathbb{Z}$, the number 0 is the additive identity, because:

- $a + 0 = 0 + a = a$

Additive Inverse Property:

For every integer $a \in \mathbb{Z}$, there exists an integer $-a \in \mathbb{Z}$ such that:

- $a + (-a) = (-a) + a = 0$

1–5 Exponents:

An exponent is used to represent repeated multiplication.

For example:

$$2 \times 2 \times 2 = 2^3$$

In general:

$$a^n = \overbrace{a \times a \times a \times \dots \times a}^{n \text{ times}}$$

Properties of Exponents (Powers):

If $x, y > 0$ and $m, n \in \mathbb{Z}$, then:

$$\begin{array}{lll} (1) x^m \cdot x^n = x^{m+n} & (2) \frac{x^m}{x^n} = x^{m-n} & (3) (x^m)^n = x^{mn} \\ (4) (xy)^n = x^n y^n & (5) \left(\frac{x}{y}\right)^n = \frac{x^n}{y^n} & (6) x^0 = 1 \\ (7) x^{-1} = \frac{1}{x} \end{array}$$

1–6 Rule for Removing Parentheses:

For any two integers x and y :

$$\begin{array}{ll} (1) x + (y) = x + y & , \quad x + (-y) = x - y \\ (2) x - (y) = x - y & , \quad x - (-y) = x + y \\ (3) x(-y) = (-x)y = -xy & , \quad (-x)(-y) = xy \end{array}$$

$$(4) \begin{cases} (-1)^n = -1 & \text{if } n \text{ is an odd integer.} \\ (-1)^n = 1 & \text{if } n \text{ is an even integer.} \end{cases}$$

Examples:

(1) Find the value of each expression:

$$a) (-2) + 12 =$$

$$b) (-3) + (-6) + 5 =$$

$$c) -3 - 11 - 31 =$$

$$d) (-5) \times (-4) =$$

$$e) (-4) \times 8 =$$

$$f) (-1) \times 2 \times 2 =$$

Solution:

$$a) (-2) + 12 = 10$$

$$b) (-3) + (-6) + 5 = [(-3) + (-6)] + 5 \\ = (-9) + 5 = -4$$

$$c) -3 - 11 - 31 = -(3 + 11 + 31) = -45$$

$$d) (-5) \times (-4) = 20$$

$$e) (-4) \times 8 = -32$$

$$f) (-1) \times 2 \times 2 = -4$$

(2) Find the value of each expression:

$$a) |-2| + (-2) =$$

$$b) (-3)^2 - 3 =$$

$$c) (a^2)^3 \times a^3 =$$

$$d) \frac{x^3 \times x}{x^2} =$$

Solution:

$$a) |-2| + (-2) = 2 - 2 = 0$$

$$b) (-3)^2 - 3 = 9 - 3 = 6$$

$$c) (a^2)^3 \times a^3 = a^6 \times a^3 = a^9$$

$$d) \frac{x^3 \times x}{x^2} = \frac{x^4}{x^2} = x^2$$

(3) Simplify: $3a + \{-4b - [4a - 7b - (-4a - b)] + 5a\}$

Solution:

$$\begin{aligned} 3a + \{-4b - [4a - 7b - (-4a - b)] + 5a\} &= 3a + \{-4b - [4a - 7b + 4a + b] + 5a\} \\ &= 3a + \{-4b - [8a - 6b] + 5a\} \\ &= 3a + \{-4b - 8a + 6b + 5a\} \\ &= 3a + \{2b - 3a\} \\ &= 2b + (3a - 3a) \\ &= 2b \end{aligned}$$

Exercises:

(1) Find the value of each expression:

a) $(-4) + 9 =$

b) $-42 \div 7 =$

c) $(2)^5 =$

d) $(-4)^3 =$

e) $(-5)^2 =$

f) $|0| =$

g) $(-4) \times (-8) =$

h) $-8 - (-5) =$

i) $-1 - 4 + 7 =$

j) $2 \times 4 + 6 \times 5 =$

k) $|-6| =$

m) $|-3| - |-7| =$

(2) Find the value of each expression:

a) $a^2 \times a^5 =$

b) $x^7 \div x^3 =$

c) $(a^3)^4 =$

d) $(x^2)^3 \times (x^4)^5 =$

e) $\frac{a^3 \times a^7}{a^2 \times a^6} =$

f) $\frac{a^4 \times a^5}{a^3 \times a^6} =$

(3) Compute:

a) $(-7) + (-12) - (-14) - (-15) - (-18) - (-38)$

b) $(-5)^2 + |-6| - (-1)^{1447}$

Challenge Problems:

(1) Compute:

$$-1 - (-1)^1 - (-1)^2 - (-1)^3 - \dots - (-1)^{99} - (-1)^{100}$$

(2) Find the value of:

$$1234 \times 9999 = \dots$$

(3) Simplify:

$$5\{(2a - 3) - [7(4a - 1) - 20]\} - (3 - 8a)$$

(4) A satellite completes one full orbit around the Earth every 7 hours.

How many times will the satellite orbit the Earth in one week?

(5) Six fair dice were rolled. The sum of the numbers shown on all six faces is 32.

What is the smallest possible number that could appear on one of the dice?

(6) Compute:

$$1 - 2 + 3 - 4 + \dots - 100 + 101$$

2-Rational Numbers $\mathbb{Q}$

A **rational number** is any number that can be written in the form

$$\frac{a}{b}$$

where a and b are integers, and $b \neq 0$.

The number a is called the numerator, and b is called the denominator.

From this definition, we can conclude that every integer is a rational number.

For example:

$$0 = \frac{0}{1}, -4 = \frac{-4}{1}, 5 = \frac{5}{1}$$

Also, the mixed number

$$5\frac{1}{2} = \frac{11}{2}$$

is a rational number because it can be written as a fraction.

And so on...

Terminating decimals are rational numbers. For example:

$$0.3 = \frac{3}{10}, 1.7 = \frac{17}{10}, 2.03 = \frac{203}{100}$$

Non-terminating decimals are of two types:

Repeating decimals:

$$0.333 \dots = 0.\overline{3}, 0.521521521 \dots = 0.\overline{521}$$

These are rational numbers because their digits repeat in a predictable pattern.

Non-repeating decimals:

$$0.345674215677589 \dots$$

These are irrational numbers, because their digits continue infinitely without any repeating pattern.

Note:

The number pi (π) is an irrational number.

It is approximately equal to 3.14, or sometimes represented as $\frac{22}{7}$ which is only an approximation.

2–1 Properties of Addition and Subtraction of Rational Numbers

The properties of addition for rational numbers are the same as those for integers.

But wait—when adding or subtracting two rational numbers, why do we always hear that we must “find a common denominator”? Let’s explore this question.

Actually, the answer is not as simple as it seems. Let’s take a closer look.

We all know that the sum of three camels and five camels is eight camels. In general:

$$3x + 5x = 8x$$

where the symbol x represents the **same quantity**.

Now, suppose we divide a pizza into seven equal and identical parts. Each part is called **one-seventh** and is written as:

$$\frac{1}{7}$$

However, when we use symbols, things may appear different:

$$2\left(\frac{1}{7}\right) + 3\left(\frac{1}{7}\right) = 5\left(\frac{1}{7}\right)$$

Since $2\left(\frac{1}{7}\right)$ can be written as $\frac{2}{7}$, we can express the equation in a simpler form:

$$\frac{2}{7} + \frac{3}{7} = \frac{5}{7}$$

Here, we added numerators because the **denominators are the same**.

(Notice that many students mistakenly try to add denominators as well – but denominators must remain the same!)

By similar reasoning, you can conclude that subtracting two rational numbers also requires the **same denominator**.

But what if the denominators are **different**?

How do we add or subtract rational numbers then?

We’ll soon find the answer after studying the next property of rational numbers.

2–2 The Property of Equivalent Rational Numbers

If $\frac{a}{b}$ is a rational number and k is a nonzero integer, then:

$$\frac{a}{b} = \frac{a \cdot k}{b \cdot k} = \frac{a \div k}{b \div k}$$

This means that a rational number can be written in many equivalent forms.

For example:

$$\frac{1}{2} = \frac{2}{4} = \frac{3}{6} = \frac{5}{10} = \dots$$

$$\frac{18}{24} = \frac{9}{12} = \frac{3}{4}$$

A rational number whose numerator and denominator have no common factor (other than 1) is said to be in **simplest form**.

The simplest form of a rational number is the most convenient to use in calculations.

Therefore, it is always recommended to express any rational number in its simplest form.

Notice: Now You Can Add Two Rational Numbers with Different Denominators!

For example, when adding

$$\frac{2}{3} + \frac{1}{5}$$

we first look for a **common multiple** of the denominators 3 and 5 (preferably the least common multiple).

It is easy to see that 15 is a multiple of both 3 and 5.

Now, we rewrite the fractions as **equivalent fractions** with a common denominator:

$$\frac{2 \times 5}{3 \times 5} + \frac{1 \times 3}{5 \times 3}$$

That is,

$$\frac{2}{3} + \frac{1}{5} = \frac{10}{15} + \frac{3}{15}$$

and this equals

$$\frac{13}{15}$$

Subtraction is handled in the **same way** as addition.

2–3 Definition of Multiplication and Division in Rational Numbers:

How do we multiply two rational numbers, and what does that mean?

For example, when we ask, “What is half of 100?” you immediately answer **50** – as if you divided **100** by **2**.

Now, if we ask, “What is three halves of 100?” it’s not difficult to find the answer: you first divide by **2**, then multiply the result by **3**.

Let’s ask a more complex question:

What is three halves of the number $\frac{1}{7}$?

We need to divide the number by **2**, and then multiply the result by **3**.

But what is the result of dividing $\frac{1}{7}$ by 2?

$$\frac{1}{7} = \frac{2}{14} = 2\left(\frac{1}{14}\right)$$

So, if the result of dividing $\frac{1}{7}$ by 2 is $\frac{1}{14}$ (that is, only the denominator is multiplied by 2), then multiplying by 3 means making three copies of that result:

$$3\left(\frac{1}{14}\right) = \frac{3}{14}$$

Let’s express what we found symbolically:

$$100 \times \frac{3}{2} = 50 \times 3 = 150$$

Similarly,

$$\frac{1}{7} \times \frac{3}{2} = \frac{1 \times 3}{7 \times 2} = \frac{3}{14}$$

In general, if $\frac{a}{b}$ and $\frac{c}{d}$ are two rational numbers, then:

$$\frac{a}{b} \times \frac{c}{d} = \frac{a \times c}{b \times d}$$

Finally, since division is the inverse operation of multiplication, we can justify the following definition:

If $\frac{a}{b}$ and $\frac{c}{d}$ are two rational numbers, then:

$$\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \times \frac{d}{c} = \frac{ad}{bc}$$

2-4 Properties of Multiplication of Rational Numbers:

1. Closure Property:

The product of any two rational numbers is also a rational number.

2. Commutative Property:

Changing the order of the factors does not change the product.

$$\frac{a}{b} \times \frac{c}{d} = \frac{c}{d} \times \frac{a}{b}$$

3. Associative Property:

The way the factors are grouped does not affect the product.

4. Multiplicative Identity:

The number 1 is the multiplicative identity because multiplying any rational number by 1 does not change its value.

5. Multiplicative Inverse:

For every non-zero rational number $\frac{a}{b}$, there exists a number $\frac{b}{a}$ called its **multiplicative inverse**, such that:

$$\frac{a}{b} \times \frac{b}{a} = \frac{b}{a} \times \frac{a}{b} = 1$$

6. Distributive Property of Multiplication over Addition and Subtraction

2-5 Writing a Repeating Decimal as a Rational Number

Example:

Write the repeating decimal $0.\overline{7}$ as a rational number.

Solution:

Let

$$x = 0.\overline{7} = 0.7777 \dots$$

Multiply both sides by 10:

$$10x = 7.7777 \dots = 7 + 0.7777 \dots$$

Now we can write:

$$10x = 7 + x$$

Subtract x from both sides:

$$9x = 7$$

Finally, divide both sides by 9 to find:

$$x = \frac{7}{9}$$

Practice:

Write the repeating decimal $0.\overline{17}$ as a rational number.

Hint: Follow the same steps as in the example, but this time you will need to multiply by 100 instead of 10.

A Quick Method for Writing a Repeating Decimal as a Rational Number

(The proof is not difficult.)

We can write a repeating decimal as a fraction directly, provided that the repeating part starts immediately after the decimal point.

To do this, place the repeating digits in the numerator, and write as many nines in the denominator as there are repeating digits.

For example:

$$0.\overline{7} = \frac{7}{9}, \quad 0.\overline{73} = \frac{73}{99}, \quad 0.\overline{732} = \frac{732}{999}, \quad \text{and so on.}$$

This method can also be extended to write any other repeating decimal as a rational number.

For example:

$$\begin{aligned} 0.1\overline{7} &= 0.1 + 0.0\overline{7} \\ &= \frac{1}{10} + \frac{1}{10} \times \frac{7}{9} \\ &= \frac{1}{10} + \frac{7}{90} \\ &= \frac{9}{90} + \frac{7}{90} \\ &= \frac{16}{90} \\ &= \frac{8}{45} \end{aligned}$$

Exercises:

(1) Find the value of each of the following:

$$(a) \frac{2}{5} + \frac{1}{6} =$$

$$(f) \frac{1}{9} - \frac{1}{10} =$$

$$(b) \frac{1}{2} - \frac{1}{3} =$$

$$(g) (-3) \div 4 \times 6 \div (-5) =$$

$$(c) \frac{-3}{8} \times \frac{4}{9} =$$

$$(h) \frac{-6}{35} \div \frac{2}{7} =$$

$$(d) \frac{-3}{5} - \left(-\frac{1}{2}\right)$$

$$(i) \left(\frac{-1}{2}\right)^5 =$$

$$(e) 1 \div 3 \div 4 \div 5 =$$

(2) Write each of the following repeating decimals as a rational number:

$$a) 0.\bar{2}$$

$$b) 0.\overline{37}$$

$$c) 1.\overline{823}$$

(3) Majed claims that dividing by an integer is equivalent to multiplying by its multiplicative inverse.

Can you prove or disprove this claim?

(4) Saleh claims that between any two rational numbers, there is always another rational number.

He also states that this property is called the **density of rational numbers**.

Can you give an example that supports his claim, or provide a counterexample if you think otherwise?

(5) Arrange the following numbers in ascending order:

$$-0.3, -0.23, -\frac{1}{3}$$

Challenge Problems:

(1) Find a fraction that is greater than $\frac{1}{6}$ and less than $\frac{1}{3}$, with a denominator of 15.

(2) Saad divided a number N by 8 and got 0.25, while Khaled multiplied the same number N by 8. What result will Khaled obtain?

(3) Haitham went jogging outside his house. He has already completed $\frac{3}{5}$ of the second half of his route. What fraction of the entire route has he completed?

(4) Compute: $(1 - \frac{1}{2}) + (\frac{1}{2} - \frac{1}{3}) + (\frac{1}{3} - \frac{1}{4}) + \dots + (\frac{1}{9} - \frac{1}{10})$

(5) Compute: $\frac{1}{2} \cdot \frac{2}{3} \cdot \frac{3}{4} \cdot \frac{4}{5} \cdot \dots \cdot \frac{79}{80}$

(6) Adel has a card containing 14 digits. If the sum of any 3 consecutive digits (starting from the left) is 20, he wrote down the digits on his card as shown below. What number should be written in the square labeled A?

A		7									7		4
---	--	---	--	--	--	--	--	--	--	--	---	--	---

(7) Today is the birthday of Laila and her two daughters, Shahd and Amal.

Laila is 32 years old, Shahd is 4 years old, and Amal is 1 year old.

How old will Laila be when her age becomes equal to the sum of Shahd's and Amal's ages?

(8) My uncle lives far away in an isolated place, and his letters to us always contain riddles. In one of his letters, he told us that there are **three local teams** in his area: the **Ants (A)**, the **Bees (B)**, and the **Cats (C)**. Each year, they play a **local league**, where every team plays against each of the others **at most once**. The league table for this year began as follows:

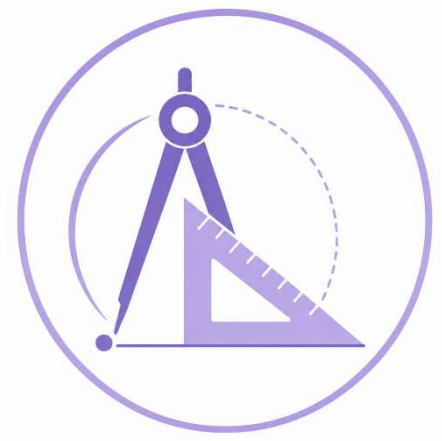
Team	Played	Won	Drawn	Lost	Goals For	Goals Against
A	1	0	0	1	4	2
B	2	1	1	0	2	2
C	2	1	0	1	3	1

When we pointed out that these numbers were impossible, my uncle admitted that **every number in the**

table was incorrect, but that **each number should either have 1 added to it or 1 subtracted from it**.

Find the **correct table**, and explain clearly **how you deduced your results**.

Second Unit: Geometry



Summary: In this file, we will review a set of basic geometric concepts, such as the types of angles, parallel lines and transversals, then the types of triangles and their properties, and finally the properties of quadrilaterals.

1-Points, Lines, and Angles

Geometry starts with three simple objects: points, lines, and angles. They are so simple that you already see them every day, but so powerful that they can build entire worlds. Let us start slowly and make friends with them.

Definitions:

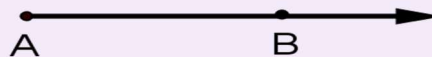
Definition 1.1

A line is a perfectly straight path that extends without end in both directions. It has no thickness and no boundaries.



Definition 1.2

A *ray* begins at one point (called its *endpoint*) and extends forever in one direction. It is like a flashlight beam: it starts at the bulb and travels infinitely forward.



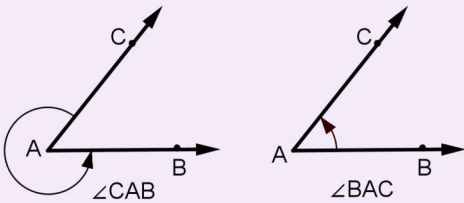
Definition 1.3

A *segment* is the part of a line between two points. It has a beginning and an end, just like a stick you can hold.



Definition 1.4

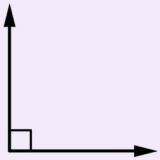
An *angle* is formed when two rays meet at a common endpoint (the *vertex*). Angles can be measured in two directions: clockwise (CW) and counterclockwise (CCW). To avoid confusion, mathematicians usually use CCW as the “positive” direction.



Types of angles:

Acute: less than 90° (sharp like a needle).

Right: exactly 90° (corner of a book).



Obtuse: between 90° and 180° (wide and open).

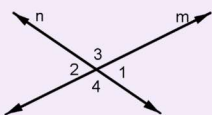
Straight: exactly 180° (a line).



Complementary: two angles adding up to 90° .

Supplementary: two angles adding up to 180° .

Adjacent: angles sharing a vertex and a side.

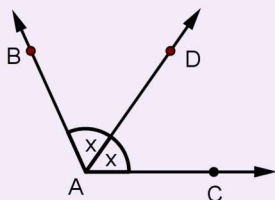


Vertical: opposite angles formed when two lines cross; they are always equal.



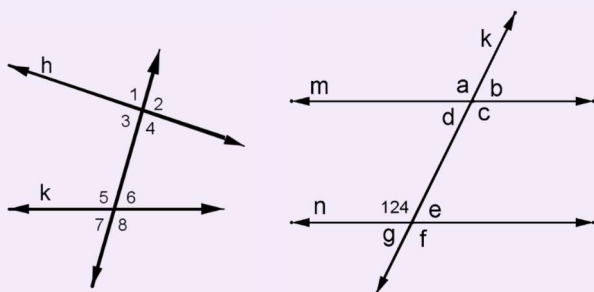
Definition 1.5

An *angle bisector* is a ray that divides an angle into two equal smaller angles. It is the “fair splitter” of angles.



Definition 1.6

Two lines are *parallel* if they never meet, no matter how far they are extended.



Definition 1.7

A *transversal* cuts across another figure (such as a circle), touching it at two points.

Definition 1.8

When a line (called a *transversal*) crosses parallel lines, many special angles appear:

Corresponding angles: same side, same position. (like $\angle 1$ and $\angle 5$ or $\angle 2$ and $\angle 6$)

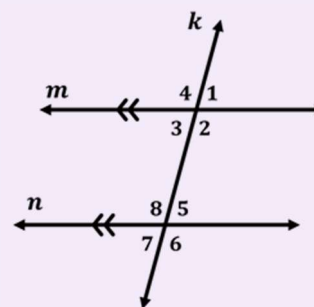
Alternate interior angles: opposite sides of the transversal, between the parallels. (like $\angle 3$ and $\angle 5$ or $\angle 2$ and $\angle 8$)

Alternate exterior angles: opposite sides of the transversal, outside the parallels. (like $\angle 1$ and $\angle 7$ or $\angle 4$ and $\angle 6$)

Consecutive interior angles: same side of transversal, between the parallels. (like $\angle 2$ and $\angle 5$ or $\angle 3$ and $\angle 8$)

Theorem 1: If two lines are parallel, then corresponding angles are equal.

Theorem 2: If corresponding angles are equal, then the lines are parallel.

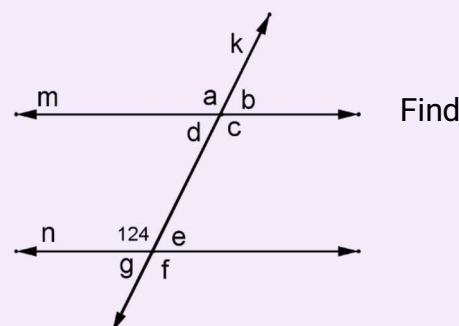


Example

On the provided figure, lines m, n are parallel. And k is a transversal line. We have a measure of one angle as shown.

the measure of the angles:

$$\angle a, \angle b, \angle c, \angle d, \angle e, \angle f, \angle g$$



Solution:

Since m, n are parallel, we have the following measures:

$$\angle a = 124^\circ \quad \text{corresponding angle}$$

$$\angle b = 56^\circ \quad \text{supplementary to } \angle a$$

$$\angle c = 124^\circ \quad \text{vertical angle to } \angle a$$

$$\angle d = 56^\circ \quad \text{supplementary to } \angle a$$

$$\angle e = 12 \quad \text{corresponding to angle } \angle b$$

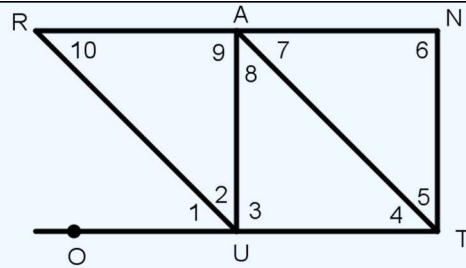
$$\angle f = 124^\circ \quad \text{corresponding to angle } \angle c$$

$$\angle g = 56^\circ \quad \text{corresponding to angle } \angle d$$

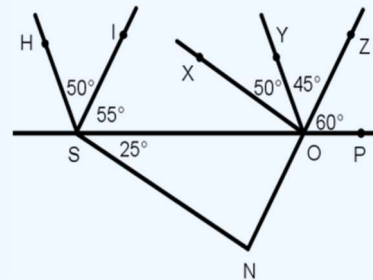
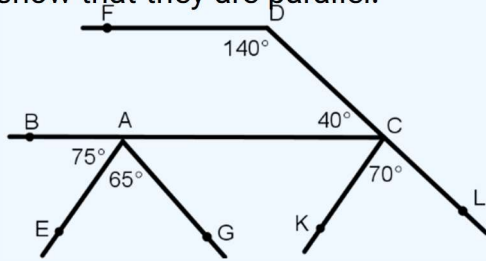
Exercises

(1) On the figure below, find all pairs of parallel lines in each of the following cases:

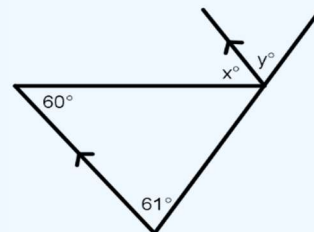
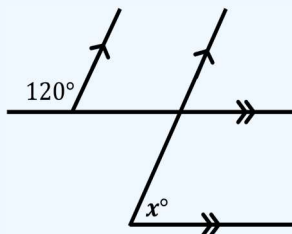
- $\angle 1 \cong \angle 4$
- $\angle 2 \cong \angle 10$
- $\angle 5 \cong \angle 7$
- $\angle 5 \cong \angle 8$
- $\angle 6 \cong \angle 9 = 90^\circ$
- $\angle 6 \cong \angle 3 = 90^\circ$
- $\angle 7 \cong \angle 10 \cong \angle 1$



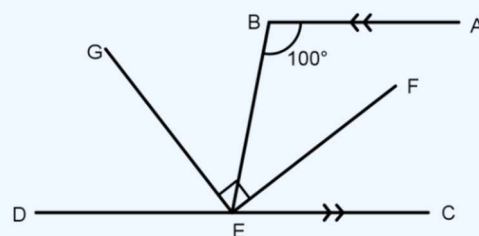
(2) In the following figures, find the parallel lines and determine which angles were used to show that they are parallel:



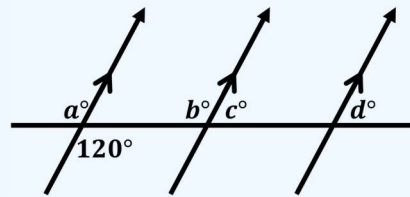
(3) In the following figures, find the measure of the unknown angles:



(4) In the following figure, we have $AB \parallel DC$. And EF bisects $\angle BEC$. Find the measure of $\angle BEG$, $\angle DEG$.

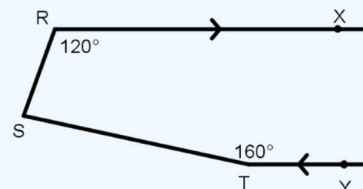


(5) In the following figure, Find the measure of $\angle d$.

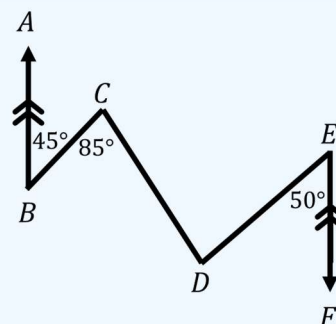


(6) In the following figure, Find the measure of $\angle RST$.

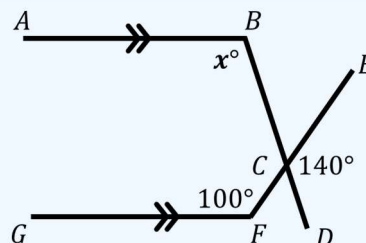
(Hint, draw a line passing through S and parallel to lines $\overline{RX}$, $\overline{TY}$.)



(7) In the following figure, we have $\overline{BA} \parallel \overline{EF}$, find the measure of $\angle CDE$.



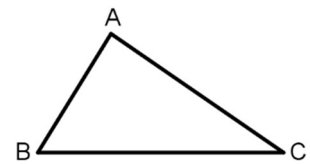
(8) In the following figures, find the measure of $\angle x$:

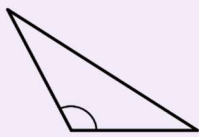
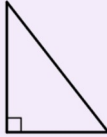
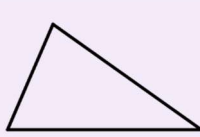
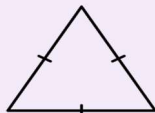
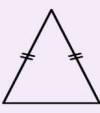
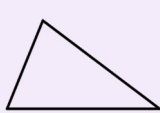


2-Triangles

Triangles are one of the core shapes in geometry and is a special case of polygons.

The symbol $\triangle$ is usually used to denote a triangle. The triangle is built using three different segments. The three vertices connecting the segments are usually called A, B, C and the three segments are called sides and usually denoted by $\overline{AB}, \overline{BC}, \overline{CA}$. Finally, the three angles of the triangle are denoted by $\angle A, \angle B, \angle C$.

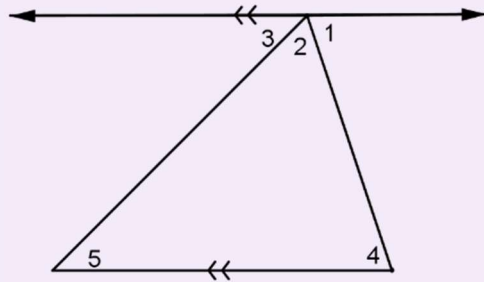


Obtuse Triangle	Right Triangle	Acute Triangle
		
one angle greater than 90°	one angle is exactly 90°	all angles less than 90°
	The side opposite to the 90° angle is called the hypotenuse while both of the other sides adjacent to the 90° angle are called legs	
Equilateral Triangle	Isosceles Triangle	Scalene Triangle
		
all three sides equal	two equal sides	all three sides different
In this case, all angles are equal to 60°	The two angles opposite to the equal sides are also equal. The two equal sides are called legs while the third side is called the base.	

Theorem:

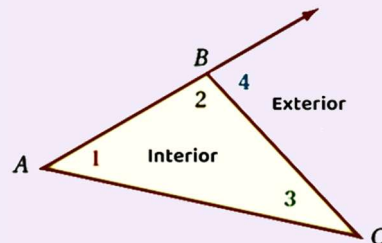
The three interior angles of any triangle add up to 180° .

Proof. To prove that, draw a line passing through a vertex parallel to the side opposite to that vertex. Since angles $\angle 1, \angle 2, \angle 3$ lie on a straight line, they sum up to 180° . Finally, notice that $\angle 1 \simeq \angle 4$ and $\angle 3 \simeq \angle 5$ by alternate interior angles. Therefore $\angle 2 + \angle 4 + \angle 5 = 180^\circ$.



From this theorem, many facts follow naturally:

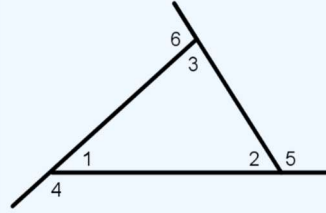
- Extending one side forms an exterior angle, which equals the sum of the two non-adjacent interior angles.
- If two angles are equal, the opposite sides are equal, and vice versa.
- A triangle can have at most one right or one obtuse angle.
- In a right triangle, the other two angles are acute and together add up to 90° .



Exercises

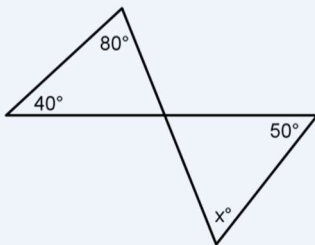
(1) Using the adjacent figure, calculate the following angles:

1. If $\angle 1 = 40^\circ$, $\angle 2 = 60^\circ$, then find $\angle 6$.
2. If $\angle 1 = 45^\circ$, $\angle 3 = 70^\circ$, then find $\angle 5$.
3. If $\angle 2 = 50^\circ$, $\angle 3 = 65^\circ$, then find $\angle 4$.
4. If $\angle 4 = 135^\circ$, $\angle 2 = 60^\circ$, then find $\angle 3$.
5. If $\angle 5 = 120^\circ$, $\angle 1 = 40^\circ$, then find $\angle 3$.
6. Find $\angle 4 + \angle 5 + \angle 6$

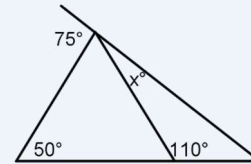


In (2 – 5) find the value of x from the given figure:

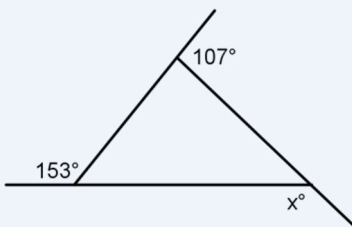
(2)



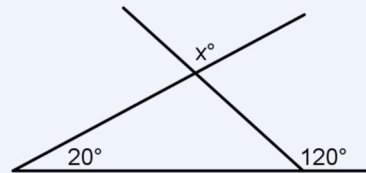
(3)



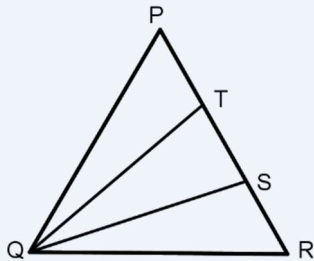
(4)



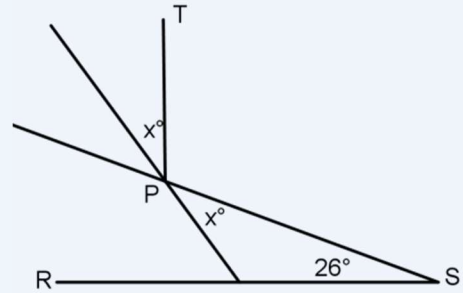
(5)



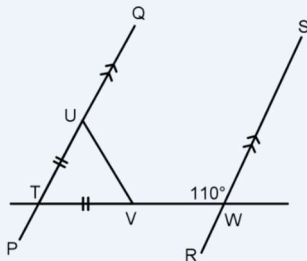
(6) In the adjacent figure: $\triangle QPR$ is an equilateral triangle. QT, QS divides $\angle PQR$ into three equal parts. Find the measure of $\angle QTP$.



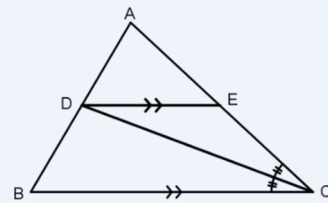
(7) In the adjacent figure: A light ray exits from point S , reflects at point P , and exits in the direction of point T such that RS is perpendicular to PT . Find the value of x .



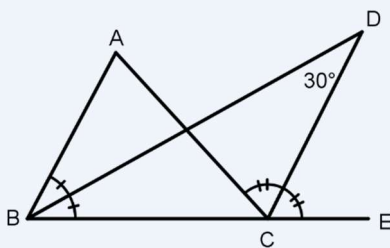
(8) In the adjacent figure, lines $RS \parallel PQ$, and $TU = TV$, and $\angle SWV = 110^\circ$. Find $\angle QUV$.



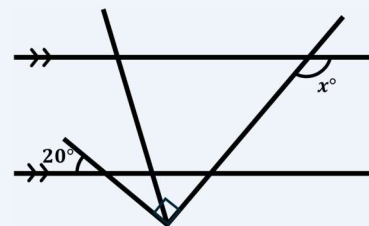
(9) In the adjacent figure: CD bisects $\angle ACB$, and $\angle ACB = 40^\circ$, and $\angle B = 70^\circ$, and $DE \parallel BC$. Find the measures of both of $\angle EDC, \angle BDC$.



(11) In the adjacent figure: find the value of x .

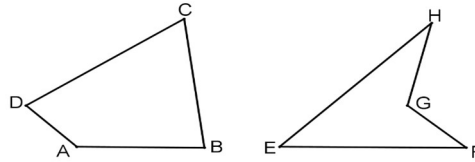


(10) In the adjacent figure: The bisector of $\angle ABC$ and the bisector of $\angle ACE$ intersect at point D . If $\angle BDC = 30^\circ$, find the measure of $\angle A$.



3-Polygons

A *polygon* is a closed figure made by joining straight segments end to end. The corners are called *vertices*, and the sides are the segments themselves. A *diagonal* is a segment joining two non-adjacent vertices.



Definition 3.1

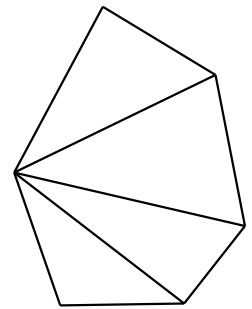
A polygon is *convex* if all its interior angles are less than 180° . If one of the interior angles is greater than 180° , it is *concave*.

Thus, a triangle is a 3-sided polygon, a quadrilateral has 4 sides, and so on.

Theorem 3.1

The sum of the interior angles of an n -sided polygon is $(n - 2) \times 180^\circ$.

Proof. Choose any of the polygon vertices, and draw all of its diagonals from that vertex.



This divides the polygon into $(n - 2)$ triangles. Each triangle has an angle sum of 180° . So, the total angle sum is:

$$(n - 2) \times 180^\circ$$

Definition 3.2

A polygon is *regular* if all its sides and all its angles are equal.

Theorem 3.2

Each interior angle of a regular n -sided polygon measures

$$\frac{(n - 2) \times 180^\circ}{n}.$$

Note: The sum of the exterior angles of a regular polygon is always 360° , no matter how many sides we have.

Exercises:

(1) Find the sum of interior angles of a polygons with number of sides:

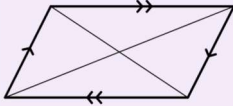
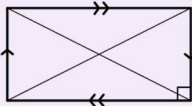
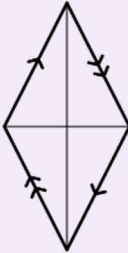
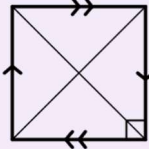
- a) 15
- b) 16
- c) 17

(2) Find the measure of the interior angle of a regular polygon of sides:

- a) 15
- b) 16
- c) 17

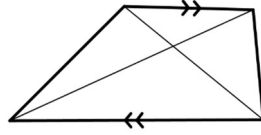
4-Quadrilaterals

Quadrilaterals are polygons with four sides. They come in many “personalities.”

	Parallelogram	Rectangle	Rhombus	Square
Shape				
Definition	A quadrilateral with both pairs of opposite sides parallel.	A parallelogram with one right angle; all angles are right angles.	A parallelogram with all sides equal.	A rectangle with all sides equal.
Sides	Opposite sides equal.	Opposite sides equal.	All sides equal.	All sides equal.
Angles	Opposite angles equal.	All angles are right (90°).	Opposite angles equal.	All angles are right (90°).
Diagonals	Bisect each other.	Equal and bisect each other.	Bisect at right angles; vertices-connecting diagonal bisects angles.	Equal, bisect each other, perpendicular, angle-bisecting.
Area	Base × height	Length × width	Base × height	Side ²
Perimeter	Sum of all sides	2 × (length + width)	4 × side	4 × side

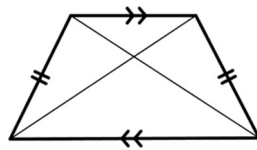
Definition 4.1

A trapezoid (or trapezium) is a quadrilateral with at least one pair of parallel sides.



Definition 4.2

If the non-parallel sides (the *legs*) are equal, the trapezoid is called *isosceles*.

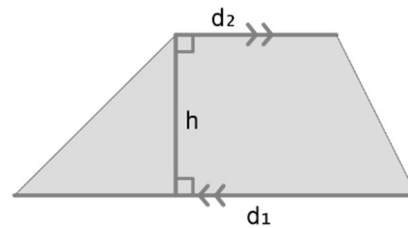
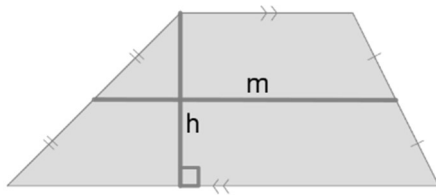


Theorem 4.1

The area of a trapezoid with bases b_1 and b_2 , and height h , is

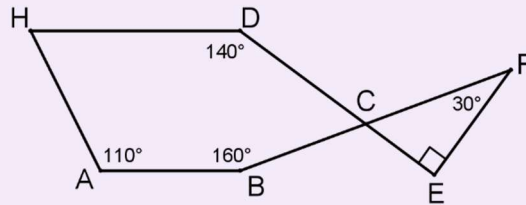
$$Area = \frac{(b_1 + b_2)}{2} \cdot h.$$

or using the mid-segment : $A = h \cdot m$



Example:

In the figure below: we have two lines DE, BF intersecting at point C , such that EF is perpendicular to DE , and $\angle ABC = 160^\circ$, and $\angle HAB = 110^\circ$. Prove that $AB \parallel HD$.



Solution:

In the right triangle $\triangle FEC$ at $\angle C$, since $\angle CFE = 30^\circ$,

$$\angle FCE = 180^\circ - (30^\circ + 90^\circ) = 60^\circ$$

So by vertical angles, $\angle DCB = 60^\circ$. And since the shape $ABCDH$ is a pentagon, then the sum of its interior angles is:

$$\angle A + \angle B + \angle C + \angle D + \angle H = 180^\circ(n - 2) = 180^\circ(5 - 2) = 180^\circ \cdot 3 = 540^\circ$$

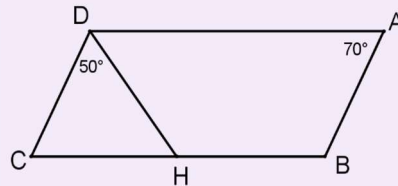
Therefore,

$$\angle H = 540^\circ - (110^\circ + 160^\circ + 60^\circ + 140^\circ) = 540^\circ - 470^\circ = 70^\circ$$

And since $\angle H + \angle A = 70^\circ + 110^\circ = 180^\circ$ and both are internal angles lying on the same side of the transversal AH , then $AB \parallel HD$.

Example:

In the figure: $ABCD$ is a parallelogram where H lies on side BC , and $\angle A = 70^\circ$, $\angle CDH = 50^\circ$. Find the measure of $\angle BHD$.



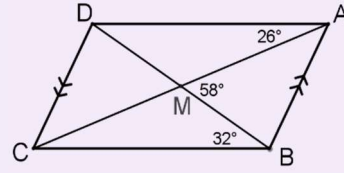
Solution:

Since $ABCD$ is a parallelogram, then $\angle C = \angle A = 70^\circ$ (opposite angles in a parallelogram). And since $\angle DHB$ lies outside $\triangle DHC$, then

$$\angle DHB = \angle C + \angle CDH = 70^\circ + 50^\circ = 120^\circ$$

Example:

In the figure: $ABCD$ is a quadrilateral with diagonals intersecting at M , and $AB \parallel CD$, $\angle AMB = 58^\circ$, $\angle MBC = 32^\circ$. Prove that $ABCD$ is a parallelogram.



Solution:

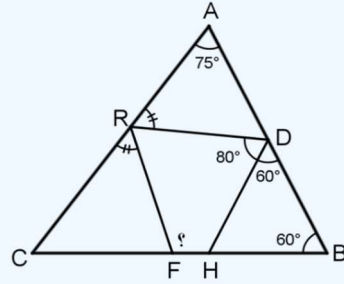
Since $\angle AMB$ lies outside triangle $\triangle CMB$, then $\angle AMB = \angle MBC + \angle MCB$. Therefore,

$$58^\circ = 32^\circ + \angle MCB \Rightarrow \angle MCB = 26^\circ$$

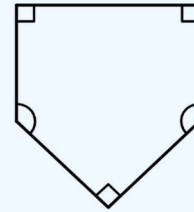
and $\angle CAD, \angle MCB$ are angles in an alternate position, so $AD \parallel BC$ and we already have from the given that $AB \parallel CD$ which implies $ABCD$ is a parallelogram.

Exercises

(1) In the figure: $\triangle ABC$, where $\angle BDH = \angle ABC = 60^\circ$ and $\angle HDR = 80^\circ = \angle BAC = 75^\circ$. Find the measure of $\angle HFR$.



(2) In American baseball, the base is shaped as a pentagon (as shown in the adjacent figure) consisting of three right angles and two congruent angles. Find the measure of these two angles.

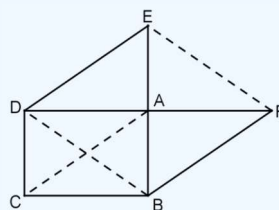


(3) The surface areas of a rhombus and an isosceles trapezoid are equal. If the side length of the rhombus is 10 and the length of the mid-base of the trapezoid is 15, find the ratio between their heights.

Note: The mid-base of a trapezoid is the segment connecting the midpoints of the non-parallel sides.

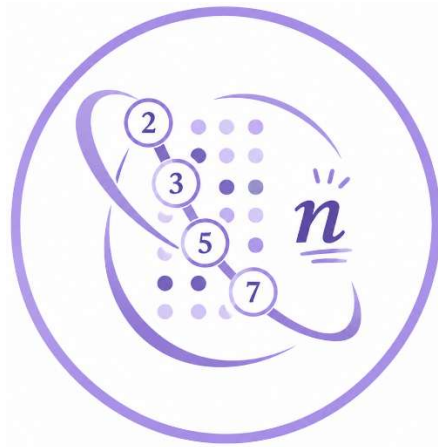
(4) A trapezoid with one of its parallel bases equal to 3 times the length of the other. If its height equals the length of its mid-base and its area is 100, find the lengths of the two parallel bases.

(5) In the figure below: $ABCD$ is a rectangle, and $ACBF$, $ACDE$ are parallelograms. Prove that $EF \parallel BD$.





Third Unit: Number Theory



Divisibility and Prime Factorization

Summary: This file is an introductory guide to the basic concepts of integer divisibility and prime factorization. We will review a set of practical divisibility rules, define prime and composite numbers, and establish the most important theorem in number theory: The Fundamental Theorem of Arithmetic. Finally, we will apply these concepts to show how factorization is a powerful tool for simplifying complex mathematical expressions.

1- Divisibility Rules

Before diving into factorization, it's useful to have a set of rules to quickly determine if a number is divisible by another. Formally, we say that an integer a divides an integer b , written as $a|b$, if there is an integer k such that $b=ak$.

Divisibility by 2: A number is divisible by 2 if its last digit is even (0, 2, 4, 6, or 8). **Example:** The number 538 is divisible by 2 because its last digit is 8.

Divisibility by 3: A number is divisible by 3 if the sum of its digits is divisible by 3.

Example: The number 741 is divisible by 3 because the sum of its digits is 12 ($7+4+1=12$), and 12 is divisible by 3.

- **Divisibility by 4:** A number is divisible by 4 if the number formed by its last two digits is divisible by 4.

Example: The number 1,824 is divisible by 4 because the number 24 is divisible by 4.

- **Divisibility by 5:** A number is divisible by 5 if its last digit is 0 or 5.

Example: The number 9,875 is divisible by 5 because its last digit is 5.

- **Divisibility by 6:** A number is divisible by 6 if it is divisible by both 2 and 3. **Example:** The number 432 is divisible by 6 because it is divisible by 2 (last digit is 2) and by 3 (sum of digits is 9).
- **Divisibility by 9:** A number is divisible by 9 if the sum of its digits is divisible by 9.

Example: The number 2,853 is divisible by 9 because the sum of its digits is 18, and 18 is divisible by 9.

- **Divisibility by 10:** A number is divisible by 10 if its last digit is 0.

Example: The number 12,340 is divisible by 10.

- **Divisibility by 11:** A number is divisible by 11 if the alternating sum (odd-placed digits minus even-placed digits) of its digits is divisible by 11.

Example: Let's take the number 54,384. The alternating sum is $5 - 4 + 3 - 8 + 4 = 0$. Since 0 is divisible by 11, the number 54,384 is divisible by 11.

Example question: You have three numbers. Each one is divisible by one of the following numbers: 7, 9, or 11. Match each number with its correct divisor. **The numbers are:**

- 819,045
- 792,143
- 16,926

Solution: To solve this problem, we will apply the divisibility rules to each number to identify the correct divisor.

1. **Testing the number 819,045,** we will start by testing for divisibility by 9 because it is the easiest. **Rule for divisibility by 9:** A number is divisible by 9 if the sum of its digits is divisible by 9. Sum of the digits of 819,045:

$$8 + 1 + 9 + 0 + 4 + 5 = 27.$$

Since 27 is divisible by 9, the number 819,045 is divisible by 9. Therefore, the number 819,045 is divisible by 9.

2. **Testing the number 792,143.** This number looks complicated, so the divisibility rule for 11 is a good candidate to test. **Rule for divisibility by 11:** A number is divisible by 11 if the alternating sum of its digits is divisible by 11. **Application:** Let's calculate the alternating sum of the digits of 792,143 (starting from the right with subtraction, then addition): $3 - 4 + 1 - 2 + 9 - 7 = -1 + 1 - 2 + 9 - 7 = 0 - 2 + 9 - 7 = -2 + 2 = 0$. **Result:** Since 0 is divisible by 11, the number 792,143 is divisible by 11. Therefore, the number 792,143 is divisible by 11.
3. **The number 16,926,** since we have found the numbers divisible by 9 and 11, it is logical that this number must be the one divisible by 7.

2- Prime Numbers

All integers greater than 1 are either prime numbers or are composite, made up of a product of prime numbers.

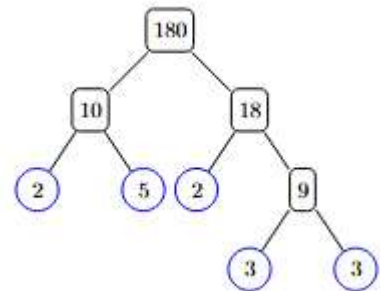
- **Definition (Prime Number):** A prime number is an integer greater than 1 whose only positive divisors are 1 and itself. Examples of prime numbers: (2, 3, 5, 7, 11, 47, 97).
- **Definition (Composite Number):** A composite number is an integer greater than 1 that is not prime. Examples of composite numbers: (4, 9, 15, 27, 180, 588).

The Fundamental Theorem of Arithmetic: Every integer greater than 1 is either a prime number or can be represented as a product of prime numbers, and this representation is unique, except for the order of the factors.

3- Methods of Prime Factorization

Factor Tree Method Example (Factoring the number 180):

- We break down the number 180 until we reach its prime factors. Note that 180 is the product of 10 and 18.
- We break down 18 into 9 and 2, and 10 into 2 and 5.
- We break down 9 into 3 and 3.
- Thus, the factorization of 180 is the product of the prime numbers $2^2 \times 3^2 \times 5$.



Repeated Division Method Example (Factoring the number 588):

We divide the number by the smallest prime that divides it until we reach 1. Then we count the divisors.

$588 \div 2 = 294$ $294 \div 2 = 147$ $147 \div 3 = 49$ $49 \div 7 = 7$ $7 \div 7 = 1$ So, $588 = 2^2 \times 3 \times 7^2$	It is sometimes easier to look at it in this way (<i>column factorization</i>): <table> <tr> <td>2</td><td>588</td></tr> <tr> <td>2</td><td>294</td></tr> <tr> <td>3</td><td>147</td></tr> <tr> <td>7</td><td>49</td></tr> <tr> <td>7</td><td>7</td></tr> <tr> <td></td><td>1</td></tr> </table>	2	588	2	294	3	147	7	49	7	7		1
2	588												
2	294												
3	147												
7	49												
7	7												
	1												

4-How Factorization Simplifies Calculations

The true power of factorization lies in its ability to reveal the internal structure of numbers, enabling us to simplify seemingly complex arithmetic operations like division, addition, and subtraction.

- **Simplifying Division (Fractions)** When dividing two large numbers (or simplifying a fraction), finding their common factors is the ideal method.

Example (Simplify the fraction):

$$\frac{396}{924}$$

We factor the numerator and the denominator using one of the methods to get:

$$396 = 2^2 \times 3^2 \times 11, \quad 924 = 2^2 \times 3 \times 7 \times 11$$

So, when dividing the two numbers, we can cancel out the common prime factors to get:

$$\frac{396}{924} = \frac{2^2 \times 3^2 \times 11}{2^2 \times 3 \times 7 \times 11} = \frac{2^2}{2^2} \times \frac{3^2}{3} \times \frac{1}{7} \times \frac{11}{11} = \frac{3}{7}$$

Exercises:

(1) What is the result of the calculation $(20 + 18) \div (20 - 18)$?

- (A) 18 (B) 19 (C) 20 (D) 34 (E) 36

(2) Which of the following numbers is closest to the result of the operation $\frac{17 \times 0.3 \times 20.16}{999}$?

- (A) 0.01 (B) 0.1 (C) 1 (D) 10 (E) 100

(3) Mustafa knows that $1111 \times 1111 = 1234321$. What result does he get when calculating 1111×2222 ?

- (A) 3456543 (B) 2345432 (C) 2234322 (D) 2468642 (E) 4321234

(4) What number must replace the star (*) to make the following equation true:

$$2 \cdot 18 \cdot 14 = 6 \cdot * \cdot 7$$

- (A) 8 (B) 9 (C) 10 (D) 12 (E) 15

(5) Which of the following fractions is smaller than 2?

- (A) $\frac{19}{8}$ (B) $\frac{20}{9}$ (C) $\frac{21}{10}$ (D) $\frac{22}{11}$ (E) $\frac{23}{12}$

(6) Which of the following statements is correct?

- (A) $\frac{4}{1} = 1.4$ (B) $\frac{5}{2} = 2.5$ (C) $\frac{6}{3} = 3.6$ (D) $\frac{7}{4} = 4.7$ (E) $\frac{8}{5} = 5.8$

(7) 2016 hours is how many weeks?

- (A) 6 (B) 8 (C) 10 (D) 12 (E) 16

(8) Hamza has 20 Riyals, and each of his four brothers has 10 Riyals. How much must Hamza give to each brother so that everyone has the same amount of money?

- (A) 2 (B) 4 (C) 5 (D) 8 (E) 10

(9) One-sixth of the audience in a children's theater are adults, the rest are children. Two-fifths ($\frac{2}{5}$) of the children are girls. What fraction of the total audience are boys?

- (A) $\frac{1}{2}$ (B) $\frac{1}{3}$ (C) $\frac{1}{4}$ (D) $\frac{1}{5}$ (E) $\frac{2}{5}$

(10) Four cousins are 3, 8, 12, and 14 years old. Fatima is younger than Kholoud. The sum of Salwa's and Fatima's ages is divisible by 5, and so is the sum of Salwa's and Kholoud's ages. What is the age of Inas (the fourth cousin)?

- (A) 14 (B) 12 (C) 8 (D) 3 (E) 1448

(11) If you multiply the three digits of a three-digit number, you get 135. What result do you get by adding these three digits?

- (A) 14 (B) 15 (C) 16 (D) 17 (E) 18

(12) A rectangle has an area of 12 cm². The lengths of its sides are natural numbers. Which perimeter could the rectangle have?

- (A) 20 cm (B) 26 cm (C) 28 cm (D) 32 cm (E) 48 cm

(13) Ahmed and Ali are playing a game: Ahmed writes three single-digit numbers on the board. Ali adds them and gets 15. Then he deletes one of the three numbers and replaces it with the number 3. Ahmed multiplies these three new numbers and gets 36. Which number could Ali have deleted in the second step of the game?

- (A) 6 (B) 7 (C) 8 (D) 6 or 7 (E) 7 or 8

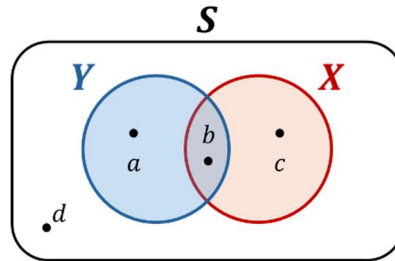
Forth Unit: Combinatorics



The mathematics of counting. Combinatorics

First: Counting using Venn diagrams

Venn diagrams are used to solve counting problems involving overlapping types in adjectives. Types are usually represented by overlapping circles, each of which has a number representing the number of elements of that type as shown in the figure:



a Achieves only the property Y

c Achieves only the property X

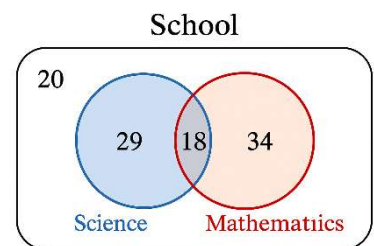
b Achieves both properties X and Y together

d does not achieve the property X and does not achieve the property Y (does not achieve nor property X or Y)

Example:

The following figure represents the numbers of students in a school who prefer a math class and who prefer a science class.

- How many students prefer math?
- How many students prefer science or math?
- How many students prefer science and math together?
- How many students prefer science only?
- How many students do not prefer science?
- How many students does the school have?



Solution

- $18 + 34 = 52$
- $29 + 18 + 34 = 81$
- 18
- 29
- $18 + 34 + 20 = 72$
- $18 + 34 + 29 + 20 = 101$

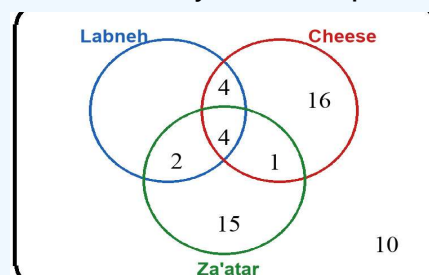
Exercises

(1) In one of our gifted classes, 35 students were offered to learn a foreign language, namely English and French. 15 students Choose an English language, and 5 students choose both languages. If we knew that any student chose to learn at least one of the two languages, how many students chose to learn only French?

(2) 40 People went on a trip, 18 of them prefer cheese pie and 15 of them prefer labneh pie, while 12 of them don't prefer either cheese or labneh. How many students prefer the two types together?

(3) A poll was conducted for a 50 students at a school to find out what type of sport they prefer, and the result was that 33 of them prefer soccer, 24 prefer basketball, and 11 prefer both. How many students don't prefer either two games?

(4) The figure shows the distribution of 60 students in a school, according to their preference for three types of pies. How many students prefer labneh?



(5) A factory manager conducted liked all three products from the factory, and found that 38 persons liked product A, 36 liked product B, 39 liked product C, 24 liked both products A and B, 20 liked both products C and A, 18 liked both products B and C, and finally 9 people liked all three products. How many people have liked only product C?

Second: Counting a list of numbers

It is easy to count numbers in the list $1, 2, 3, 4, \dots, 50$ and therefore it is called a simple list, hence it can be said that the list of numbers is simple if you meet the following conditions:

- 1- Starts with the number 1 2- has Consecutive contiguous numbers

Example:

How many numbers are in the list $3, 6, 9, \dots, 327$

Solution:

The list is not simple, but it can be converted into a simple list by dividing all the numbers in the list by 3

$\div 3$	$3, 6, 9, \dots, 327$	
	$1, 2, 3, \dots, 109$	Simple list

so, the number of numbers is equal to 109

Example: How many numbers are in the list $23, 28, 33, \dots, 548$

Solution: The list is not simple but can be converted into a simple list with the following steps

-3	$23, 28, 33, \dots, 548$	
$\div 5$	$20, 25, 30, \dots, 545$	
-3	$4, 5, 6, \dots, 109$	
	$1, 2, 3, \dots, 106$	Simple list

So, the number of numbers is equal to 106

Some lists can be converted to a simple list by performing an operation on all numbers in them, because operations on all numbers produce a list with the same number of numbers.

And we will see how to do that in the following exercises

Exercises

(1) How many numbers are in the following list $1, 2, 3, \dots, 1440$?

(2) How many numbers are in the following list $8, 9, \dots, 2019$?

(3) How many numbers are in the following list $5, 9, 13, \dots, 505$?

(4) How many positive even numbers are less than 2025 ?

(5) How many numbers are in the following list: $\frac{3}{7}, 1, \frac{11}{7}, \dots, 289$?

(6) How many numbers are there between 2023 , 63 so that it is a multiple of the number 3 ?

(7) How many positive integers are less than 600 so that it is a whole square?

(8) How many positive integers are less than 1447 so that it is multiple of both numbers 3 and 5?

(9) How many positive integers are less than 2025 which are multiples of the number 7 and not multiples of the number 5?

(10) How many positive integers are less than 500 which are multiples of the number 7 and not even?

Solutions



Algebra Solutions

Integers and Their Properties:

Exercises:

(1)

- a) 5
- b) - 6
- c) 32
- d) - 64
- e) 25
- f) 0
- g) 32
- h) - 3
- i) 2
- j) 38
- k) 6
- m) - 4

(2)

- a) a^7
- b) x^4
- c) a^{12}
- d) x^{26}
- e) a^2
- f) 1

(3)

$$a) (-7) + (-12) - (-14) - (-15) - (-18) - (-38)$$

$$= 32$$

Challenge Problems:

(1)

$$-1 - (-1)^1 - (-1)^2 - (-1)^3 - \dots - (-1)^{99} - (-1)^{100} \\ = -1$$

(2)

$$1234 \times 9999 \\ 12338766$$

(3)

$$5\{(2a - 3) - [7(4a - 1) - 20]\} - (3 - 8a) \\ = -122a + 117$$

(4)

$$24$$

(5)

$$2.$$

(6)

$$= 51$$

Rational Numbers $\mathbb{Q}$

Exercises:

(1)

a) $\frac{17}{30}$

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

c) $\frac{-1}{6}$

d) $\frac{-1}{10}$

e) $\frac{1}{60}$

f) $\frac{1}{90}$

g) $\frac{10}{9}$

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

i) $\frac{-1}{32}$

(2)

a) $0.\bar{2} = \frac{2}{9}$

b) $0.\overline{37} = \frac{37}{99}$

c) $1.8\overline{23} = \frac{361}{198}$

(3)

Yes, the claim is correct.

(4)

Therefore, there are infinitely many rational numbers between any two rational numbers.

(5)

$$-\frac{1}{3}, -0.3, -0.23$$

Challenge Problems:

(1)

To begin, notice that:

$$\frac{1}{6} = \frac{5}{30} \text{ and } \frac{1}{3} = \frac{10}{30}$$

Therefore, any fraction between them can be written in the form:

$$\frac{k}{30}$$

where k is an even number.

If we let k take the values **6** and **8**, we obtain only two fractions.

(2)

$$16$$

(3)

Haitham has covered $\frac{4}{5}$ of his journey.

(4)

$$\frac{9}{10}$$

(5)

$$\frac{1}{80}$$

(6)

A		7						e	d	c	7	b	4
---	--	---	--	--	--	--	--	---	---	---	---	---	---

$$b = 9.$$

$$c = 4.$$

$$d = 9 \text{ and } e = 7.$$

$$A = 9.$$

(7)

59 years.

(8)

the **correct table** is as follows:

Team	Played	Won	Drawn	Lost	Goals For	Goals Against
A	2	1	1	0	5	3
B	1	0	0	1	1	3
C	1	0	1	0	2	2

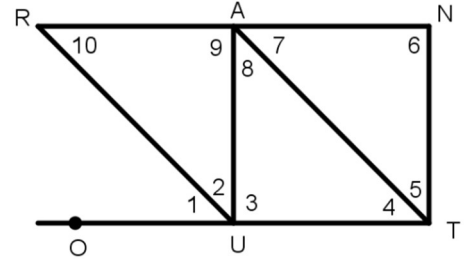
Geometry Solutions

Points, Lines, and Angles

Exercises

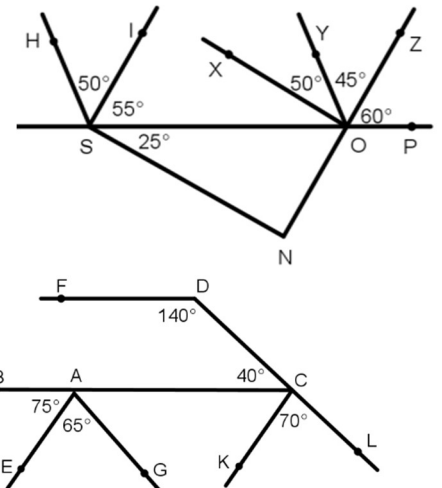
(1)

- a) $\angle 1 \cong \angle 4 \Rightarrow RU \parallel AT$.
 b) $m\angle 2 \cong m\angle 10 \Rightarrow$ no parallel lines needed
 d) $\angle 5 \cong \angle 7 \Rightarrow$ no parallel lines needed
 d) $\angle 5 \cong \angle 8 \Rightarrow AU \parallel NT$.
 e) $m\angle 6 = m\angle 9 = 90^\circ \Rightarrow AU \parallel NT$.
 f) $m\angle 6 = m\angle 3 = 90^\circ \Rightarrow$ no parallel lines needed
 g) $m\angle 7 = m\angle 10 = m\angle 1 \Rightarrow RU \parallel AT, RA \parallel OU$



(2)

$NS \parallel XO$
 $FD \parallel AC$
 $DC \parallel AG$

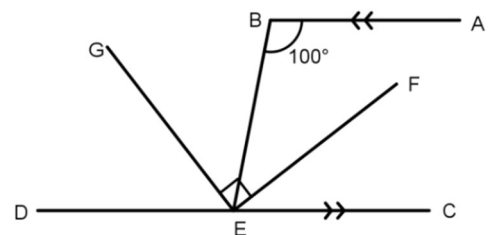


(3)

- a) $x = 60^\circ$
 b) $x = 60^\circ$, $y = 61^\circ$

(4)

$\angle BEG = 50^\circ$
 $\angle DEG = 50^\circ$

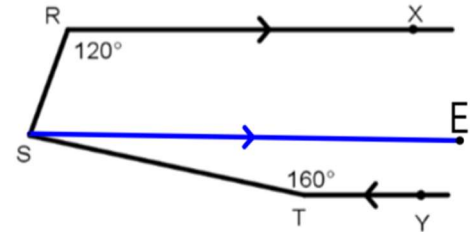


(5)

$$\angle d = 60^\circ$$

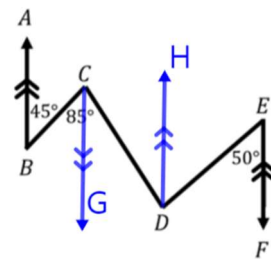
(6)

$$\angle TSR = 80^\circ$$



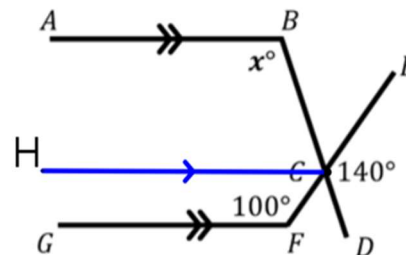
(7)

$$\angle CDE = 90^\circ$$



(8)

$$\angle HCB = 60^\circ$$



Triangles:

Exercises:

(1)

a) $m\angle 6 = 100^\circ$

b) $m\angle 5 = 115^\circ$

c) $m\angle 4 = 115^\circ$

d) $m\angle 3 = 75^\circ$

e) $m\angle 3 = 80^\circ$

f) $m\angle 4 + m\angle 5 + m\angle 6 = 360^\circ$

(2)

$= 70^\circ$

(3)

$x = 45^\circ$

(4)

$x = 100^\circ$

(5)

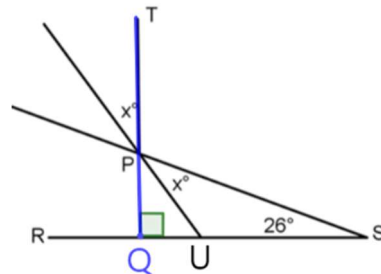
$x = 100^\circ$

(6)

$\angle QTP = 100^\circ$

(7)

$x = 32^\circ$



(8)

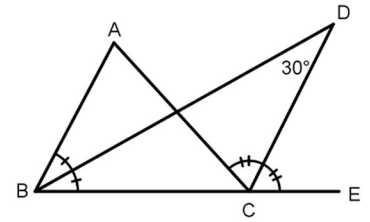
$\angle QUV = 125^\circ$

(9)

$\angle BDC = 90^\circ$

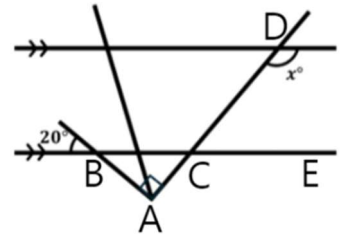
(10)

$$\angle A = 60^\circ$$



(11)

$$x = 110^\circ$$

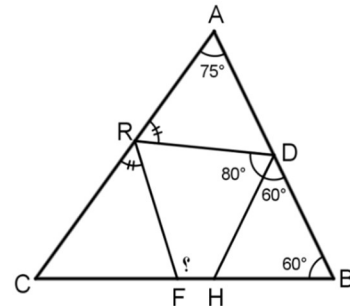


Quadrilaterals:

Exercises:

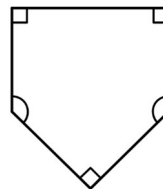
(1)

$$\angle HFR = 110^\circ$$



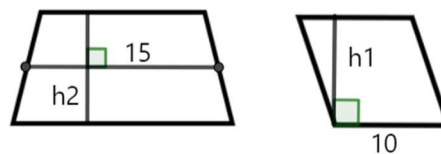
(2)

$$135^\circ$$



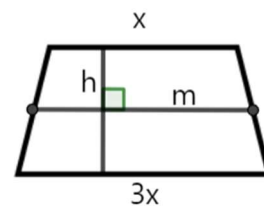
(3)

$$\frac{2}{3}$$



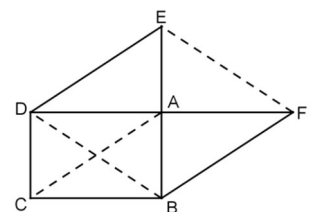
(4)

$$3x = 15$$



(5)

$$BF \parallel DE$$



Number Theory Solutions

(1)

19

(2)

0.1

(3)

2468642.

(4)

12.

(5)

The correct answer is $\frac{23}{12}$.

(6)

The correct answer is 2.5.

(7)

The correct answer is 12.

(8).

The correct answer is 2.

(9)

The correct answer is $\frac{1}{2}$.

(10)

The correct answer is 14.

(11)

The correct answer is 17.

(12)

The correct answer is 26 cm.

(13)

The correct answer is 7 or 8.

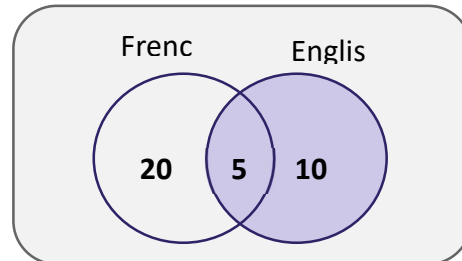
Combinatorics Solutions

Counting using Venn forms

Exercises:

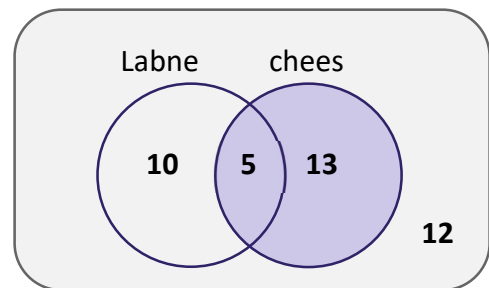
(1)

Number of people who choose to learn
French = $35 - 15 = 20$



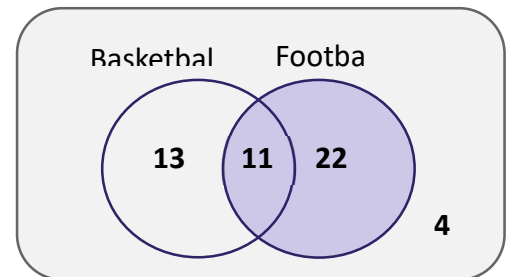
(2)

5



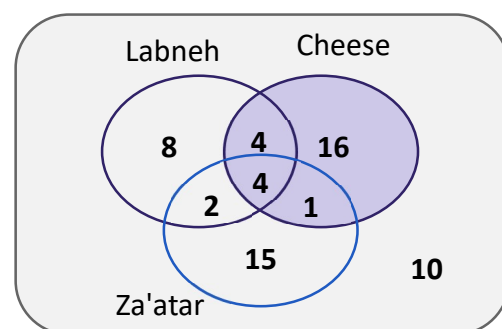
(3)

5



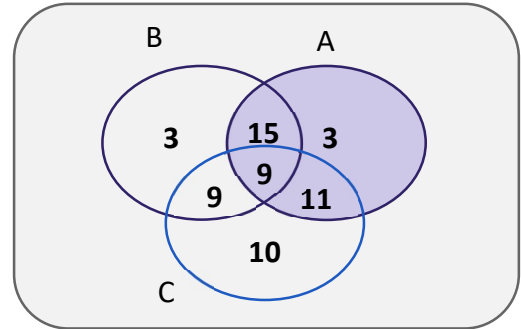
(4)

18



(5)

10



Counting a list of numbers

(1)

A simple list with 1440 numbers

(2)

A simple list with 2012 numbers

(3)

A simple list with 126 numbers

(4)

A simple list with 1012 numbers

(5)

A simple list with 506 numbers

(6)

A simple list with 653 numbers

(7)

A simple list with 24 numbers

(8)

(9)

232

(10)

36