

Master Lesson Plan
for
Introduction to Euclid's Geometry

Board	Standard	Subject	Chapter	Language
NCERT	STD IX	Mathematics	Introduction to Euclid's Geometry	English

CURRICULAR GOALS	CG-4: Analyses characteristics and properties of two-dimensional geometric shapes and develops mathematical arguments to explain geometric relationships
COMPETENCIES AS PER NCF/NIPUN BHARAT	C-4.2: Proves theorems using Euclid's axioms & and postulates for geometric shapes
SDG(Sustainable Development Goals)	SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Learning Teaching Materials	Square Paper Cuttings, Straw models
Technology aids	PPT
Cross-Cutting Themes	Educational Technology - PPTs for every component Values and Dispositions - VC_Nation First Indian Knowledge System - IA_Geometry in Sulbasutras

MS_Objectives_Euclids Geometry

Objective: Teacher will be able to get an overview of the asset objectives in the MLP for the chapter 'Introduction to Euclid's Geometry'.

Notes to the teacher: This asset lays down the proposed plan for transacting this chapter. It states the asset objectives of the MLP. This asset is for the teacher's reference and need not be taught to the students.

Students will be able to –

- infer that geometric terms like point, line, plane can be represented intuitively or explained through physical models
- state Euclid's seven axioms
- develop healthy respect for the motherland
- state Euclid's five postulates
- verify axioms and postulates through activity
- appreciate the uses of geometry in the ancient world
- prove theorems using Euclid's axioms and postulates
- recognise the application of Euclidean geometry in day-to-day life activities
- appreciate the interesting part of non Euclidean geometry
- apply appropriate axioms to answer the questions.

Time to teach	Asset type	Theme	Sub Theme
3 minutes	Main Script	Introduction to Euclid's Geometry	Development of geometry in the ancient world Discovery of Non-Euclidean geometries Equivalent version of Euclid's fifth postulate Euclid's axioms Euclid's five postulates Postulate and axiom Theorems and consistents Undefined terms(a point, a line and a plane)

IQ_Basic Definitions

Objective: Students will be able to infer that geometric terms like point, line, plane can be represented intuitively or explained through physical models.

Teaching Aids: PPT

Notes to the teacher: The teacher can use a stack of A4-sized sheets or a 200-page notebook. It stands out as a cuboid. Teachers may pose the following questions to the students, allow them to think and come out with as many answers as possible before arriving at a conclusion. If there is any difficulty in getting the answers, the teacher can ask leading questions as suggested.

1] How many dimensions does a cuboid have?

Answer: Three dimensions.

2] Name the dimensions of a cuboid.

Answer: Length, breadth and height.

3] How many surfaces does a cuboid have?

Answer: 6

4] What is obtained when a standing cuboid is **sliced very finely** in the horizontal direction?

Answers may be thin cuboids, rectangular slices, rectangular surfaces, rectangular planes or rectangles.

[Leading questions: Which dimension is sliced very finely here?

Answer: Height.

What is the correct option from your answers?

Answer: Rectangular surfaces.]

5] How many dimensions does a surface have?

Answer: Two

6] What is obtained when a rectangular surface is **cut very finely** along its length?

Answers may be thin rectangles, lines or line segments.

[Leading questions: Which dimension is cut very finely here?

Answer: Length.

What is the correct option from your answers?

Answer: Line segments or lines.

Does this rectangular surface have a definite size and definite shape?

Answer: Yes.

What is the correct option from line segments and lines?

Answer: Line segments.]

7] How many dimensions does a line segment have?

Answer: One

8] What is obtained when a line segment is **cut into very fine** pieces?

Answers may be very small pieces, dots or points.

[Leading questions: Which dimension is cut into very fine pieces here?

Answer: Length.

What is the correct option from your answers?

Answer: Points.]

9] How many dimensions does a point have?

Answer: None

10] Consider the steps of cutting a cuboid to a point [cuboid - rectangular surface - line segment - point]. At each step what is being lost regarding the structure of the cuboid?

Answer: **One dimension is lost at every step.**

11] When the cuboid discussed above is replaced by an imaginary limitless large solid, then

- a) By what term does the cuboid get replaced?
- b) By what term does the rectangular surface get replaced?
- c) By what term does the line segment get replaced?

Answers:

- a) Solid
- b) Plane surface
- c) Line

[Note to teacher: The teacher may give the following terms and tell the students to write as many definitions they can for each of them. This can be given as a home assignment.

Terms: Plane surface, line, line segment, point]

We understand that even though these are the most basic concepts, to define one thing, you need to define many other things, and you may get a long chain of definitions without an end. For such reasons, mathematicians agree to leave some geometrical terms *undefined*.

So, in geometry, we *take a point, a line and a plane (in Euclid's words a plane surface) as undefined terms*. The only thing is that we can represent them intuitively, or explain them with the help of 'physical models'.

Time to teach	Asset type	Theme	Sub Theme
8 minutes	Inquisitive Questions	Introduction to Euclid's Geometry	Undefined terms(a point, a line and a plane)

MS_Euclids Axioms

Objective: Students will be able to state Euclid's axioms.

Teaching Aids: PPT

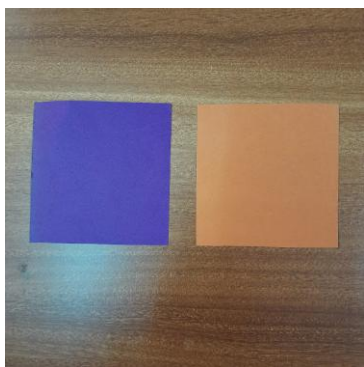
LTM 1 - Square Paper Cuttings

What do you need?: 1. Purple square coloured chart of size 20cm × 20cm

2. Orange coloured square chart of size 20cm × 20cm

3. Pair of scissors

Get Ready:- 1. Cut the required Square Paper Cuttings and keep them ready.



Source: OC

Notes to the teacher: Euclid's seven axioms are explained and presented through this asset. The PPT can be used to explain the first six axioms with examples and illustrations. The TLM-1 can be used while explaining axiom 7.

Euclid assumed certain properties, which were not to be proved. These assumptions are actually 'obvious universal truths'.

[Notes to the teacher : The teacher may give an introduction about Euclid if the students are not familiar with his name. Euclid was a great Greek mathematician also known as the Father of Geometry.]

These are divided into two types:-

1. Axioms: - Assumptions that were used throughout Mathematics and not specifically linked to Geometry. They are often referred to as 'common notions'.
2. Postulates: - Assumptions that were specific to Geometry.

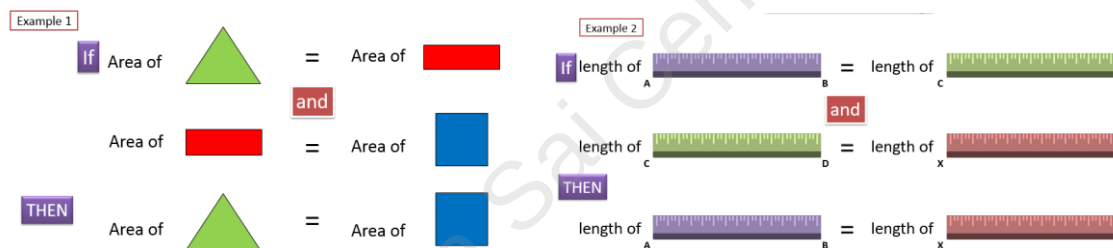
Euclid's Seven Axioms:

In the seven axioms given by Euclid, the 'common notions' refer to magnitudes of the same kind. Magnitudes of the same kind can be added, subtracted or compared. Magnitudes of different kinds cannot be added, subtracted or compared. For example, a line cannot be added to a square. An angle cannot be compared to a pentagon.

Axiom 1: Things which are equal to the same thing are equal to one another.

Example 1:- If an area of a triangle equals the area of a rectangle and the area of the rectangle is equal to the area of a square, then the area of the triangle is equal to the area of the square.

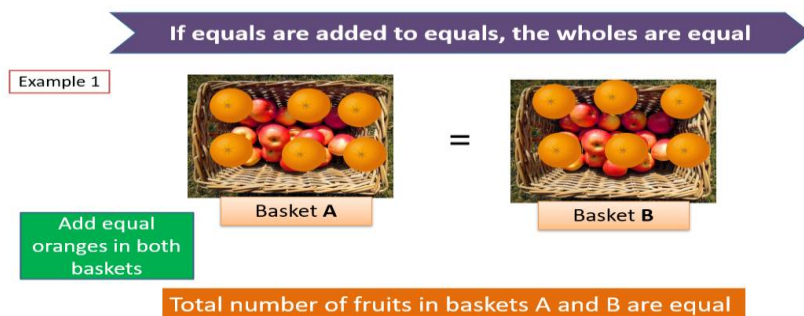
Example 2:- If length of a line segment AB equals length of line segment CD and length of line segment CD equals length of line segment XY, then length of line segment AB equals length of line segment XY.



Ruler: pixabay.com/vectors/ruler-measure-up-measure-school-3976069/ - Attribution: Kalle_89

Axiom 2: If equals are added to equals, the wholes are equal.

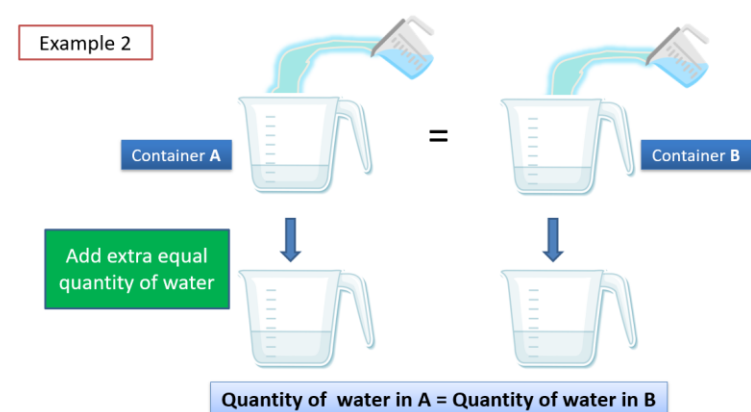
Example 1:- If basket A and basket B contain equal number of apples, and an equal number of oranges is put in both the baskets, then the total number of fruits in baskets A and B are equal.



Apple: pixabay.com/photos/apple-fruit-basket-red-yellow-2143631/ - Attribution: Crepessuzette

Orange: pixabay.com/vectors/orange-fruit-food-mandarin-citrus-158258/ - Attribution: OpenClipart-Vectors

Example 2: If the quantity of water in container A equals the quantity of water in container B and an extra equal quantity of water is poured into containers A and B, then the final quantities of water in containers A and B are again equal.



1. **Pouring Cup:** [freepik.com/icon/measuring-cup_16977749.htm](https://www.freepik.com/icon/measuring-cup_16977749.htm) - Attribution: rizky mauidhani
2. **2ml Measuring cup:** [freepik.com/free-vector/measuring-cup-sticker-white-background_16462199.htm](https://www.freepik.com/free-vector/measuring-cup-sticker-white-background_16462199.htm) - (Attribution: brgfx)
3. **3ml Measuring cup:** [freepik.com/free-vector/measuring-cup-sticker-white-background_16459934.htm](https://www.freepik.com/free-vector/measuring-cup-sticker-white-background_16459934.htm) - (Attribution: brgfx)

Axiom 3: If equals are subtracted from equals, the remainders are equal.

Example 1: If Ram and Shyam are paid an equal amount of salary, and both of them spend equal amounts of money, then their savings, that is the remaining amounts of salary are also equal.

Example 1

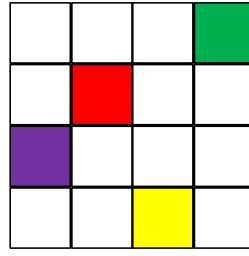
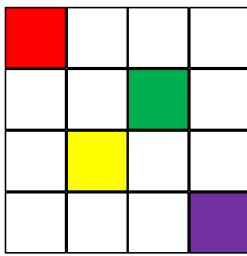
	Ram	Shyam
Ram & Shyam	In Rs	In Rs
Salary	50,000	50,000
Expenditure	30,000	30,000
Savings	20,000	20,000

Remainders are equal

Characters: [freepik.com/free-vector/group-young-people-characters_5825568.htm](https://www.freepik.com/free-vector/group-young-people-characters_5825568.htm) (Attribution: studiodstock)

Example 2: If there are two 4×4 grids and equal number of squares are filled with colours, then the remaining number of squares to be filled are also equal.

Example 2

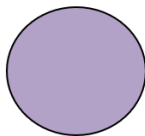


Equal number
of squares
filled in

Remaining number of squares to be filled are equal

Axiom 4: Things which coincide with one another are equal to one another.

Example 1: When circle A is superimposed on circle B, then circle A equals circle B.

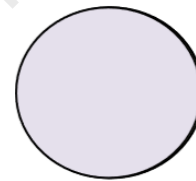


Circle A

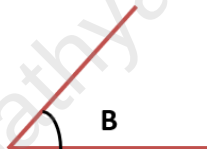
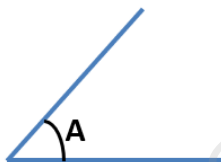


Circle B

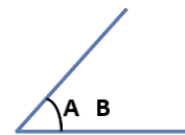
after superimpose it becomes



Example 2: If angle A is superimposed on angle B, then angle A equals angle B.



after superimpose it becomes

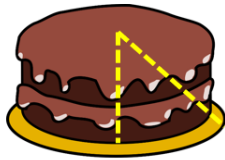


Axiom 5: The whole is greater than the part.

Example 1: Renu has a cake with her and she shares a part of it with Asmita.

The part which Asmita has is smaller than the original cake. And we observe that Asmita's share and Renu's share combine to form the original whole cake.

Example



Whole cake



Asmita's
Share(part)



Renu's
Share(part)

Cake: pixabay.com/vectors/cake-birthday-chocolate-cartoon-307466/ - Attribution: Ciker-Free-Vector-Images

Axiom 6: Things which are double of the same things are equal to one another.

Example 1: Kamala and Mala get 5 mangoes each from their father. If their mother gives double that number of mangoes to each of them, they will get an equal number of mangoes from their mother also.

Example 1



1. **Girl1**: freepik.com/free-vector/kawaii-character-collection_4280240.htm (Attribution: pikisuperstar)
2. **Girl2**: freepik.com/free-vector/set-multicultural-kids-character_4317356.htm (Attribution: brgfx)
3. **Mango**: freepik.com/free-vector/hand-drawn-mango-fruit-illustration_2582464.htm (Attribution: rawpixel.com)

Example 2: Ankit and Rohit walked for the same time of 20 minutes. If both of them double their time and start walking again, they will be spending an equal amount of increased time. In other words each of them will be walking for 40 minutes.

Example 2

Ankit and Rohit walked for the same time of **20 minutes**



Ankit



Rohit



Double the time and
Restart walking



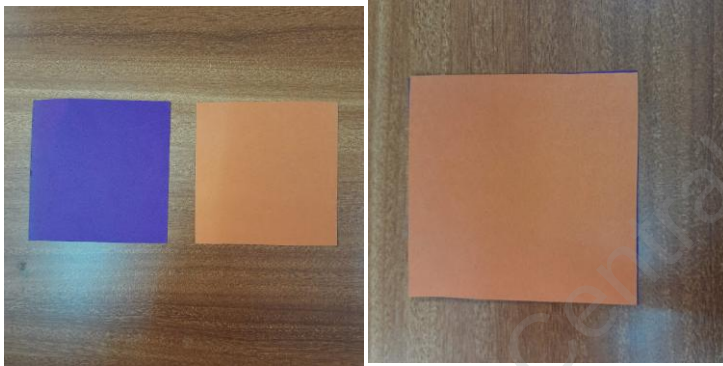
1. **Clock**: freepik.com/free-photo/clock-without-hands_944733.htm - (Attribution: onlyyoungj)
2. **Boys**: freepik.com/free-vector/faceless-boys-walking_7029939.htm - (Attribution: brgfx)

Axiom 7: Things which are halves of the same things are equal to one another.

If two equal squares are taken, and are cut at half by folding, their halves are also equal.

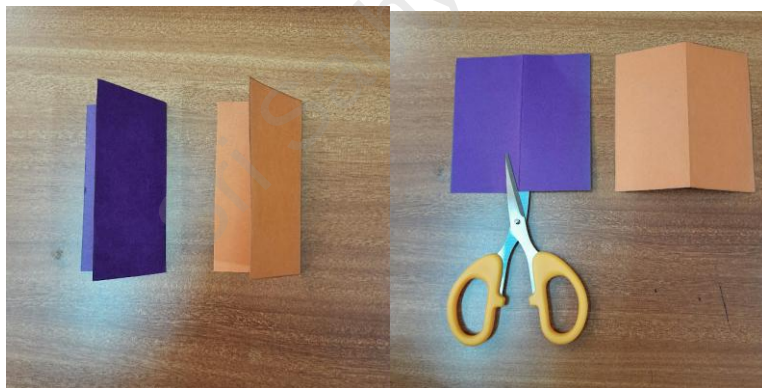
[Notes to the teacher: The teacher can use the TLM 1 here to explain the above axiom as given below.]

1. Show both square charts separately, then superimpose both the coloured charts, as shown in the image, showing both are equal.



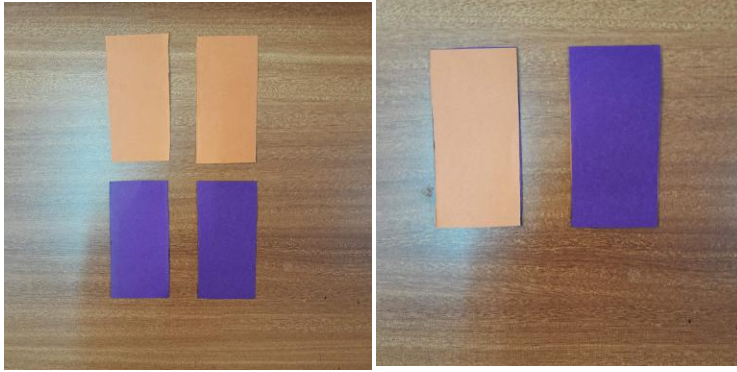
Source: OC

2. Fold both the coloured charts along their half line and cut along the fold as shown in the image.



Source: OC

3. Show the half cut rectangular chart pieces separately. Then superimpose orange and purple rectangles one over the other as shown in the image.



Source: OC

All 7 Axioms in one glance :

[Notes to the teacher: The teacher can wrap up by showing all the seven axioms which are listed in the last slide of the PPT.]

1. Things which are equal to the same thing are equal to one another.
2. If equals are added to equals, the wholes are equal.
3. If equals are subtracted from equals, the remainders are equal.
4. Things which coincide with one another are equal to one another.
5. The whole is greater than the part.
6. Things which are double of the same things are equal to one another.
7. Things which are halves of the same things are equal to one another.

Time to teach	Asset type	Theme	Sub Theme
20 minutes	Main Script	Introduction to Euclid's Geometry	Euclid's axioms

VC_Nation First

Objective: The student will be able to develop healthy respect for the motherland.

Teaching Aids: PPT

Notes to the teacher: This value content can be presented as given below after the teaching of Euclid's axioms.

Concept-Value Connection: One of the axioms listed by Euclid states that the whole is greater than the part. Each one of us is a part of the society and a part of our nation. Whenever we engage in some action, we must inquire as to whether it is in the larger interest of society or nation. Putting national interest above one's own interest is the hallmark of a true patriot.

Let us listen to this story about the life of Sri Aurobindo Ghose.

(The teacher narrates the story)

Story

Have you heard the life story of Sri Aurobindo Ghose? Most of us know of Sri Aurobindo as the founder of Sri Aurobindo ashram in Puducherry (Pondicherry), a great yogi and a master of international repute.

Do you know that Sri Aurobindo was a brilliant student? His father wanted Aurobindo and his two elder brothers to grow up with the best of western education and excel as the finest civil servants on par with the British officers. Therefore, he sent them to a convent school to study with children of the British officers and the elite. Later, he sent Aurobindo and his brothers to reputed schools in England where they could imbibe western languages and culture. Aurobindo eventually went to Cambridge University where he trained hard for the Indian Civil Service (ICS) examination. He qualified for the coveted service, but in a strange twist, chose not to join the service, but return to India!

While working for the Baroda state, he became aware of the conditions under which the British were exploiting India and its people. He felt that his country needed him and decided to plunge into political activity. He sacrificed a bright career and started writing for patriotic newspapers and magazines to educate Indian masses. He started youth groups to carry out secret campaigns against the British. After a trial for treason, he was imprisoned for one year and had to be let off, as evidence against him was insufficient. At that stage he chose to pursue a spiritual path to educate people of their true calling, that is aligned with ancient Indian Yogic wisdom.

Sri Aurobindo blazed a trail of patriotism and spirituality after forsaking personal success. He

put his country and countrymen ahead of himself and is remembered even today, for his valuable contributions to Indian society.

(Source: en.wikipedia.org/wiki/Sri_Aurobindo)

[Notes to the teacher: After the story has been narrated, please ask the class the following questions and allow the students to express their answers/views. There is no 'right' or 'wrong' answer for any of these questions. All views are respected.]

Discussion Questions:

1. It was Aurobindo's father's wish that Aurobindo became an ICS officer. Though Aurobindo qualified himself to be a civil servant, he chose not to join the service. Was he right in not fulfilling his father's wish? If yes, why? If not, why not?
2. Can you think of ways in which a common citizen can serve his/her country?

Points to Ponder/reflect:

1. A patriot is not necessarily the one who joins the armed forces, sacrifices his life for the country or sheds blood for his country.
2. A person who is concerned about the well-being of his fellow citizens, their material as well as their spiritual salvation, is also a true patriot.
3. Real greatness lies with the one who works for the society, relegating his/her own interests to secondary importance.
4. A person with a patriotic bent of mind performs his duties and responsibilities with a vision to make his Motherland a prosperous and advanced nation.

Time to teach	Asset type	Theme	Sub Theme
10 minutes	Value Content	Love	Patriotism

MS_Euclids Postulates

Objective: Students will be able to state Euclid's postulates.

Teaching Aids: PPT

Teaching Learning Material (TLM):

TLM 1 - Coloured straw model

What do you need?:

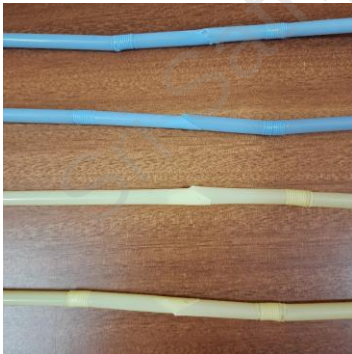
1. A cardboard or material from packing boxes that can be used.
2. Yellow coloured straws - 8
3. Blue coloured straws - 8
4. Ball pins - 2
5. Scissors

Get Ready: 1. Cut and keep 4 straws of each colour as shown in the image.



Source: OC

2. Insert the cut straw into the other straw as shown in the image.



Source: OC

3. Join the elongated straws one by one using the ball pin, as shown in the image.



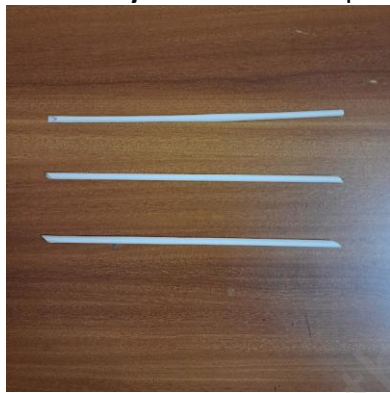
Source: OC

TLM 2 - White straw model

What do you need?:

1. A cardboard or material from packing boxes can be used.
2. White coloured straws - 8
3. Ball pins - 5
4. Scissors

Get Ready: 1. Cut and keep 3 straws ready as shown in the image.



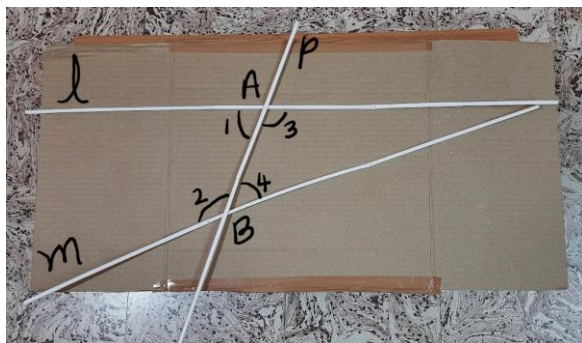
Source: OC

2. Insert them as shown in the image, to increase their length.



Source : OC

3. Keep the straws indicating line l and line m fixed with the help of ball pins.
4. Keep the straw indicating line p fixed at point A and its other end to move freely.
5. Arrange the straws as shown in the image.



Source: OC

Notes to the teacher: Euclid's five postulates are explained and presented through this asset. The PPT can be used to explain the second, third and fourth postulates with examples and illustrations. The TLM-1 can be used while explaining postulate 1 and TLM-2 can be used while explaining postulate 5.

Euclid's Five Postulates:

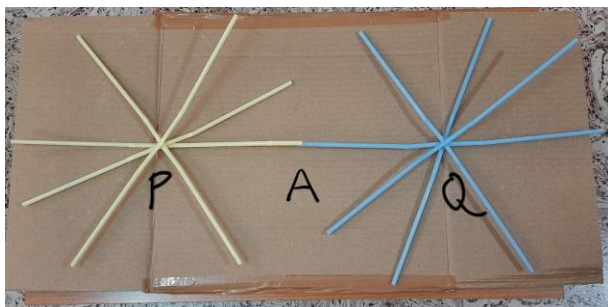
Postulate 1: A straight line may be drawn from any one point to any other point.

The postulate indicates that at least one straight line passes through two distinct points, but it does not say that there cannot be more than one such line. Euclid assumed that there is a unique line joining two distinct points. This result is given as an axiom below.

Axiom: Given two distinct points, there is a unique line that passes through them.

[**Notes to the teacher:** The teacher can use the TLM-1 here to explain the above axiom as given below.]

1. Now insert the ball pin into the cardboard such that the straws can rotate freely.
2. By just holding the yellow coloured straws using the ball pin, find out how many straws can pass through the ball pin and correlate with the number of lines passing through one point.
3. Let the point where the two straws meet be A.
4. Fix yellow colour straw at A. Rotate blue straws about Q in a clockwise direction.



Source : OC

5. Repeat steps 3 and 4, by changing the yellow straw.

Observation: In all 7 cases, when the free end of the blue straw comes near A, the straight line PAQ is formed.

[Notes to the teacher: In all 7 cases,

If the length of the blue straw $> AQ$, the yellow and blue straws overlap near A. Then cut the blue straw near its free end suitably to form line PAQ

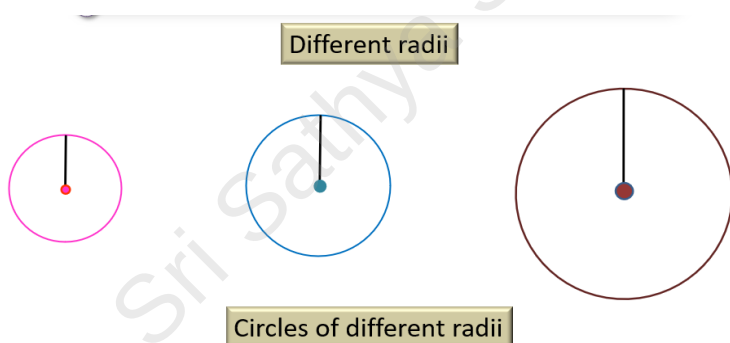
If the length of the blue straw $< AQ$, there will be some gap near A. Then elongate the blue straw near its free end or join its free end to A, using blue chalk to form line PAQ]

Postulate 2: A terminated line can be produced indefinitely.

A terminated line means a line segment. The second postulate states that a line segment can be extended on either side to form a line.



Postulate 3: A circle can be drawn with any centre and any radius.

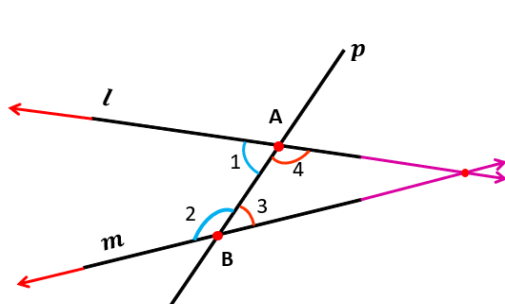


Postulate 4: All right angles are equal to one another.



Postulate 5: If a straight line falling on two straight lines makes the interior angles on the same side of it taken together less than two right angles, then the two straight lines, if produced indefinitely, meet on that side on which the sum of angles is less than two right angles.

[Notes to the teacher: The teacher can use the TLM 2 here to explain the above postulate as given below.]



1. The straw p [line p] is fixed at point A. It is positioned to intersect line m at point B.
2. The sum of the interior angles 3 and 4 is less than 180° on the right side of line p . And the lines l and m , when extended, intersect on the right side of line p .
3. The sum of the interior angles 1 and 2 is more than 180° on the left side of line p . And the lines l and m , when extended, do not intersect on the left side of line p .

[Notes to the teacher: The teacher can move the free end of the straw p , so that the above point 2 and point 3 can be generalised.]

All 5 Postulates in one glance:

[Notes to the teacher: The teacher can wrap up by showing all the five postulates which are listed in the last slide of the PPT.]

1. A straight line may be drawn from any one point to any other point.
2. A terminated line can be produced indefinitely.
3. A circle can be drawn with any centre and any radius.
4. All right angles are equal to one another.
5. If a straight line falling on two straight lines makes the interior angles on the same side of it taken together less than two right angles, then the two straight lines, if produced indefinitely, meet on that side on which the sum of angles is less than two right angles.

Time to teach	Asset type	Theme	Sub Theme
15 minutes	Main Script	Introduction to Euclid's Geometry	Euclid's five postulates

SA_Euclid axioms and postulates

Objective: Students will be able to verify Euclid's axioms and postulates through an activity.

Notes to the teacher: After completing the concepts of axioms and postulates, the teacher can use this activity for a thorough revision of the two concepts. Since this is an activity that is to be demonstrated by the students; no MM aid is provided.

Aim: To verify axioms and postulates through day-to-day as well as geometry based examples.

Resources Required: Paper Slips - 8

Setting for the Activity: Indoor

Type of Activity: Demonstration

Preparation of Activity:

[**Notes to teacher:** Teacher can announce this activity to the students on the previous day and ask the students to prepare and be ready for the demonstration the next day. Students can be encouraged to come up with their innovative examples and ideas for presentation.]

The teacher writes one axiom and one postulate on each paper slip.

The teacher divides the class into groups of 4 or 5 students each.

Each group can choose a name for themselves.

The number of paper slips should be equal to the number of groups.

One student from each group picks up one paper slip.

The members of the group discuss one utilitarian example and one geometry based example for the given axiom and a geometry-based example for the postulate.

They come prepared with the required materials for demonstration the next day.

Role of the Teacher: Facilitator

Procedure:

1. The teacher calls out each group one after the other.
2. The group that is called out comes to the front and they state their axiom and postulate on each paper slip one after the other and demonstrate the respective examples.

[**Notes to the teacher:** Some examples for teacher's reference are given below. Students can come up with innovative ideas to demonstrate the axioms and postulates]

Axioms	Examples
--------	----------

1] Things which are equal to the same thing are equal to one another	If length of a line segment AB equals length of line segment CD and length of line segment CD equals length of line segment XY, then length of line segment AB equals length of line segment XY.
2] If equals are added to equals, the wholes are equal.	If basket A and basket B contain an equal number of apples and an equal number of oranges is put in both the baskets, then the total number of fruits in baskets A and B are equal.
3] If equals are subtracted from equals, the remainders are equal.	If Ram and Shyam are each paid an equal amount of salary, and both of them spend equal amounts of money, then their savings, that is the remaining amounts of salary are also equal.
4] Things which coincide with one another are equal to one another.	When circle A is superimposed on circle B, then circle A equals circle B.
5] The whole is greater than the part.	Renu has a cake with her and she shares a part of it with Asmita. The part which Asmita has is smaller than the original cake. We observe that Asmita's share and Renu's share combine to form the original whole cake.
6] Things which are double of the same things are equal to one another.	Kamala and Mala get 5 mangoes each from their father. If their mother gives double that number of mangoes to each of them, they will get an equal number of mangoes from their mother also.
7] Things which are halves of the same things are equal to one another.	If two equal squares are taken, and are cut into half by folding, their halves are also equal.
Postulates	Examples
1] A straight line may be drawn from any one point to any other point.	Mark any two points at random. By trying to place a ruler to align both the points, a straight line joining them can be shown.
2] A terminated line can be produced indefinitely.	A line segment is drawn. And it can be extended from its end points.
3] A circle can be drawn with any centre and	Mark a few points at random. Taking each as

any radius.	centre, using different radii, draw circles.
4] All right angles are equal to one another.	The right angle portions of set-squares, scale and a notebook can be overlapped to show that the right angles of each are correspondingly equal.
5] If a straight line falling on two straight lines makes the interior angles on the same side of it taken together less than two right angles, then the two straight lines, if produced indefinitely, meet on that side on which the sum of angles is less than two right angles.	Take three pencils. Fix two pencils representing two lines on the blackboard in a V shape, not touching each other, using a tape. Now, holding the third pencil as a transversal on the two pencils, at different positions, the postulate can be demonstrated/shown.

Observation: The axioms and postulates are verified through the demonstrations.

Conclusion: The student appreciates the utilitarian value and the applications in geometry of the axioms and postulates.

Follow-up activity: Teacher can ask all the groups to observe the presentations by each group and provide feedback. If there are 8 groups, Group 8 can give feedback for group 1, group 7 can give feedback for group 2 and so on.

Time to teach	Asset type	Theme	Sub Theme
15 minutes	Suggested Activity	Introduction to Euclid's Geometry	Euclid's axioms Euclid's five postulates Postulate and axiom

IA_Geometry in Sulbasutras

Objective: Students will be able to appreciate the uses of geometry in the ancient world.

Teaching Aids: PPT

Notes to the teacher: The teacher may begin this content with this question. Did you know that the principles of geometry existed much before the time of mathematicians Euclid or Pythagoras? These principles of geometry were very much used by ancient Indians right from the Vedic period.

Many constructions were based on the concepts of geometry. The manuals of geometrical constructions were known as Sulbasutras. Sulba means measurement which is done by a measuring tool known as cord. These sutras contain detailed and comprehensive references to various aspects of construction of structures.

You may have seen altars or *homa kundas* (a pit in the ground in which a sacrificial fire is maintained for offering oblations to God) in Vedic rituals. It is interesting to know that mathematics has played an important role behind the construction of these altars.

- Altars were made according to their purpose with appropriate dimensions and shape.
- The Sulbasutra manuals provide clear guidelines on how to plan, align, measure, compute and construct Vedic altars.
- The shape, area and also the number of the bricks required for constructing the fire altars are also mentioned in the Vedic books.
- Square and circular altars were used for household rituals.
- Altars, whose shapes were combinations of rectangles, triangles and trapeziums, were required for public worship.
- One of the most common shapes of altar used for public worship was that of the falcon bird.



1. Altar – OC



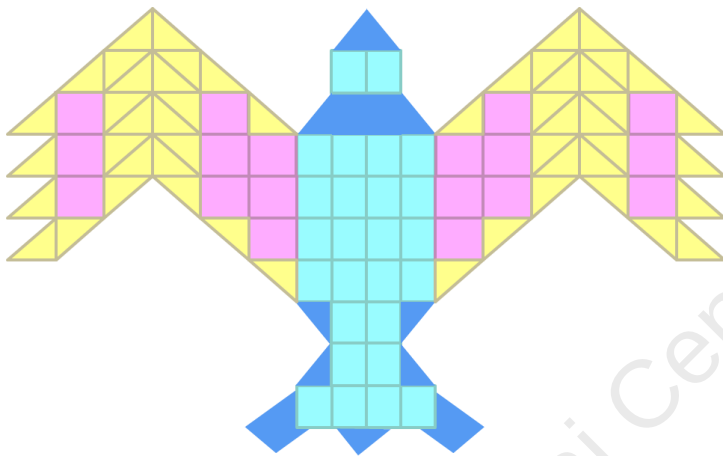
2. Homa kunda – OC

Measure of the altars:

- The unit of length was a '*Purusa*'. One *Purusa* is equivalent to the length of a man right

from the tips of his hands stretched upwards down to his feet.

- The area of the falcon shaped altar is 7.5 square *Purusas*.
- Whatever is the shape of the altar, the area of the altar remains the same as per the vedic texts.
- Transformation of shapes from circular to square and other shapes led to many geometric ideas and concepts. The notable among them was the evaluation of π .



Falcon shaped altar – OC

Time to teach	Asset type	Theme	Sub Theme
5 minutes	Interesting Asides	Introduction to Euclid's Geometry	Development of geometry in the ancient world

MS_Theorem and consistent

Objective: The student will be able to prove a few theorems after applying Euclid's axioms.

Teaching Aids: PPT

Notes to the teacher: A brief description about the words 'axiom' and 'postulate' can be given. Axioms are common notions which are used throughout mathematics. Postulates are self-evident truths used specifically in geometry.

CONJECTURE:

A conjecture is a statement which we believe is true, based on our mathematical understanding and experience, that is, our mathematical intuition.

A conjecture is a mathematical statement whose truth or falsity is yet to be established.

Example:

Take any three consecutive even numbers and add them, say,

$$2 + 4 + 6 = 12, 4 + 6 + 8 = 18, 6 + 8 + 10 = 24, 8 + 10 + 12 = 30, 20 + 22 + 24 = 66$$

Is there any pattern you can guess in these sums? What can you conjecture about them?

Solution:

One conjecture could be:

The sum of three consecutive even numbers is even.

Another could be:

The sum of three consecutive even numbers is divisible by 6.

A conjecture can be either true or false. If it can be proved, then it becomes a theorem.

THEOREM:

A mathematical statement whose truth has been established or proved is called a theorem.

Examples:

- 1] The sum of the interior angles of a triangle is 180° .
- 2] The product of two even natural numbers is even.
- 3] The product of any three consecutive even natural numbers is divisible by 16.

Euclid used his postulates and axioms, to prove more results by applying deductive reasoning. The statements that were proved are called **propositions or theorems**. Euclid deduced 465

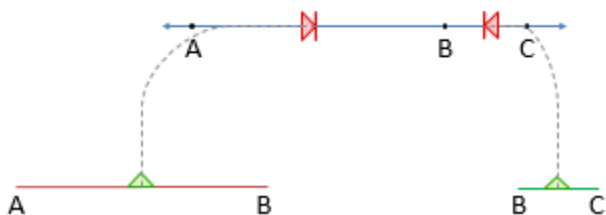
propositions.

Examples showing how Euclid used his axioms and postulates for proving some of the results:

Example 1: If A, B and C are three points on a line, and B lies between A and C, then prove that $AB + BC = AC$.

Proof:

AC coincides with AB + BC [observation from figure]



$AB + BC = AC$ [Deduction from Euclid's axiom - Things which coincide with one another are equal to one another]

[Notes to the teacher: Euclid's axiom, 'There is a unique line passing through two points', is also used here.]

Example 2: Prove that an equilateral triangle can be constructed on any given line segment.

Proof:

Given: Line segment AB

Taking A, B as centers, AB as radius draw two arcs which meet at C. Join AC, BC

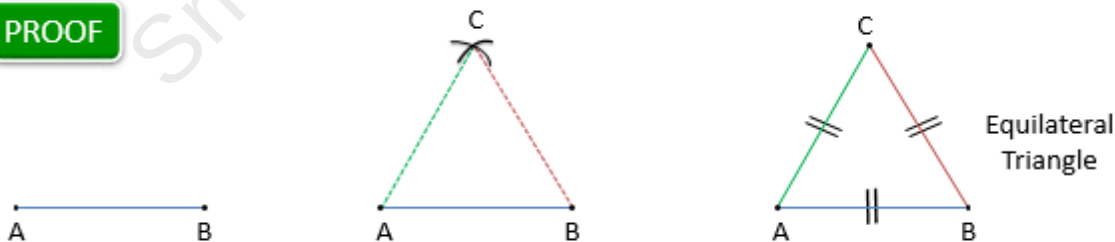
ABC is the equilateral triangle on line segment AB

To prove $\triangle ABC$ is equilateral, we prove $AB = AC = BC$

$AB = AC$ [radii of the same circle]

$AB = BC$ [radii of the same circle]

PROOF



So $AB = AC = BC$

[Deduction from Euclid's axiom - Things which are equal to the same thing are equal to one another]

So $\triangle ABC$ is an equilateral triangle.

[Notes to the teacher: Here, Euclid assumed that the two circles drawn with centres A and B

will meet each other at a point.]

Theorem: Prove that two distinct lines cannot have more than one point in common.

Proof:

Two lines l and m are given. To prove that l and m have only one point in common.

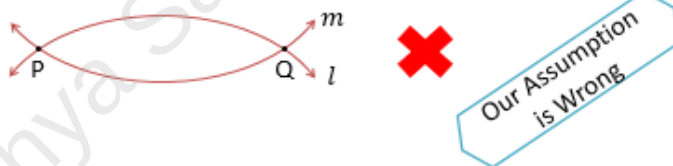
[**Notes to the teacher:** Firstly, the teacher shows the possibilities of putting two distinct lines on a plane surface. The two lines can either be put parallel or intersecting. When the lines are parallel, there is no point in common. Here the possibility of intersecting lines is discussed.]

PROOF

Two lines l and m are given



Assume that two lines l and m intersect at two distinct points P and Q



The two lines l and m intersect at two distinct points P and Q [our assumption]

So we have two lines passing through two distinct points. This statement clashes with the Euclid's axiom which states that 'only one line can pass through two distinct points'.

Hence, **our assumption is wrong**.

From this, it is concluded that two distinct lines cannot have more than one point in common.

From the above examples we conclude that a **theorem** is a mathematical statement whose truth has been logically established.

CONSISTENT:

A system of axioms is called consistent, if it is impossible to deduce from these axioms a statement that contradicts any axiom or previously proved statement. So, when any system of axioms is given, it needs to be ensured that the system is consistent.

[**Notes to the teacher:** System of axioms means a collection or a set of axioms considered.]

A collection of axioms is inconsistent, if we can use one axiom to show that another axiom is

not true.

Example: Consider the following statements. We will show that they are inconsistent.

Statement 1: No whole number is equal to its successor.

Statement 2: A whole number divided by zero is a whole number.

[Division by zero is not defined. But we assume and observe what happens in this example.]

From statement 2, we get $1/0 = a$, where a is some whole number.

This implies that $1 = 0 \times a = 0$.

But this disproves Statement 1, which states that no whole number is equal to its successor.

The contradiction arose because of the false axiom, that a whole number divided by zero is a whole number.

So, the statements we choose as axioms require a lot of thought and insight. We must make sure they do not lead to inconsistencies or logical contradictions. Moreover, the choice of axioms themselves, sometimes leads us to new discoveries.

Time to teach	Asset type	Theme	Sub Theme
20 minutes	Main Script	Introduction to Euclid's Geometry	Theorems and consistents

QA_Axioms and postulates

Objective: Students will be able to apply appropriate axioms to answer the questions.

Teaching Aids: PPT, Worksheet

Notes to the teacher: The teacher may use the questions given below for classroom assessment and the questions in the worksheet can be given for additional practice or home assignment.

I. Fill in the blanks:

1. Concurrent lines intersect at a _____.
2. Intersection of two non-parallel planes is a _____.
3. If two lines intersect at 90° , then the lines are _____ to each other.
4. If a transversal cuts two lines, then the lines will meet in that direction where the sum of interior angles on the same side of the transversal is _____.
5. A system of axioms is called _____, if it is impossible to deduce from these axioms a statement that contradicts any axiom or previously proved statement.

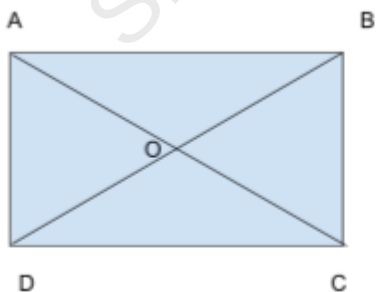
Answer for fill in the blanks

1. point
2. line
3. perpendicular
4. $< 180^\circ$
5. consistent

II. Answer the following:

1. If O is the intersection point of diagonals AC and BD of rectangle ABCD, show $AO + OC = AC$.

Answer :



AO + OC is a line passing through A, C.

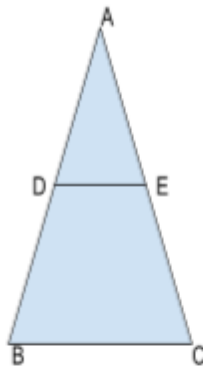
AC also passes through A, C.

Given two distinct points, there is a unique line that passes through them.

Thus, AO + OC coincides with AC.

Euclid's axiom 4, states that things which coincide with one another are equal to one another.
Hence, $AO + OC = AC$

2. In the figure given below, $AB = AC$. D and E are midpoints of AB and AC. Is $AD = AE$?
Justify your answer.



Answer:

$AB = AC$

$\frac{1}{2} AB = \frac{1}{2} AC$. (Using the axiom - Things which are halves of the same things are equal to one another).

Hence $AD = AE$.

Time to teach	Asset type	Theme	Sub Theme
15 minutes	Questions to Assess	Introduction to Euclid's Geometry	Euclid's axioms Euclid's five postulates

DD_Euclidean geometry

Objective: Students will be able to recognise the application of Euclidean geometry in day-to-day life activities.

Teaching Aids: PPT

Notes to the teacher: The teacher may recall Euclid's axioms and postulates and ask the children if they are able to relate any of the concepts of Euclidean geometry to their daily life. Expected answers: Vendors using physical balance, division and distribution of cakes or fruits.. After receiving a couple of answers she could proceed with the content given below.

Euclid's axioms and postulates speak about the basic geometric concepts such as point, line, parallel lines, angles, etc. It is with the help of these concepts that geometry has been evolving and has a direct connection to many activities in our day-to-day life and in the world around us.

1. A surveyor helps in making maps and in planning of construction projects. He uses various tools such as 3D scanners, measuring tape, level and rod, theodolite, etc. to measure distances, angles, etc. To measure the distance between two ends of a site, he would need to mark one point and extend the tape to the opposite point on the other end. If the starting or the end point changes, the measure of the distance will also change. So we see how indirectly we are applying Euclid's postulate to even do a simple task like measuring distance accurately.



On Site Surveyor: pixabay.com/photos/surveyor-geodesy-total-station-585462/ - Attribution: SmartGeoPL

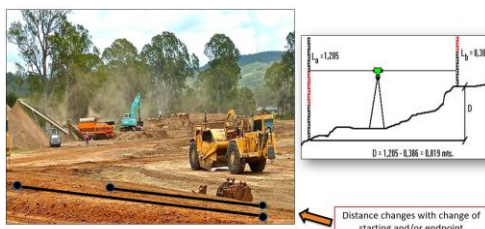
Surveying Equipment: pixabay.com/photos/surveying-equipment-surveyor-2871079/ - Attribution: paulbr75



Maps: flickr.com/photos/internetarchivebookimages/14764200182/ - Attribution: Internet Archive Book Images

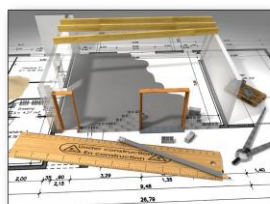
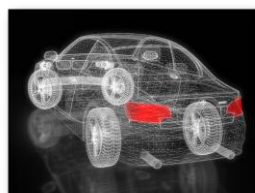
Tapes: pixabay.com/photos/measuring-tape-measurement-tools-926716/ - Attribution: StockSnap

Theodolite: pixabay.com/photos/tacheometer-topography-relief-4373171/ - Attribution: federicomaderno



Bulldozer: pixabay.com/photos/bulldozer-crawler-earth-moving-410119/ - Attribution: MemoryCatcher
Measurement: commons.wikimedia.org/wiki/File:Unidad_06_imagen_002.jpg - Attribution: Fjcaldera

2. The concepts of Euclidean geometry are also extended to Computer aided design. In computer aided drawings, we draw 2D drawings and 3D models. These drawings are essential to design any object like a car, smartphone, aeroplane, building, etc.



Car: pixabay.com/illustrations/car-three-dimensional-vehicle-shape-3075471/ Attribution: TayebMEZAHADIA
Building: pixabay.com/illustrations/works-plan-construction-site-3480187/ - Attribution: Amigos3D

Time to teach	Asset type	Theme	Sub Theme
4 minutes	Day-to-day Relevance	Introduction to Euclid's Geometry	Euclid's axioms Euclid's five postulates

IA_Non Euclidean Geometry

Objective: Students will be able to appreciate the interesting part of non-Euclidean geometry.

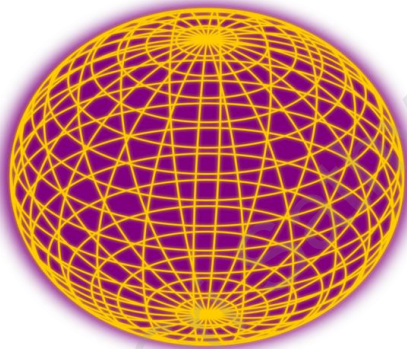
Teaching Aids: PPT

Notes to the teacher: The teacher may start by reminding the students about the nature of Euclidean geometry and its relationship with basic geometrical concepts such as point, line, plane surface, etc. However, not everything around is based on plane geometry.

We have been talking about Euclidean geometry. But there is also a type of geometry that's not Euclidean, i.e. that doesn't exist in a flat world. Non-Euclidean geometry is a rethinking and redescription of the properties of things like points, lines and other shapes in a non-flat world.

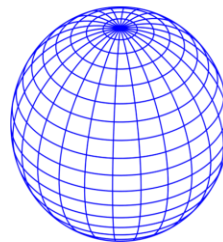
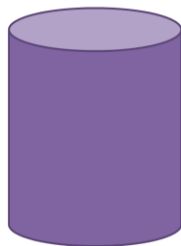
One of the examples of non-Euclidean geometry is spherical geometry.

In spherical geometry, lines are not straight. They are parts of great circles. (i.e. circles obtained by the intersection of a sphere and planes, passing through the centre of the sphere).



Globe: pixabay.com/vectors/globe-framework-red-round-150845/ - Attribution: OpenClipart-Vectors

Cone, sphere, cylinder, etc. are some examples of non-Euclidean surfaces.

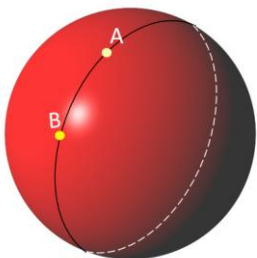


Cone: pixabay.com/illustrations/cone-cone-shaped-shape-3d-black-250097/ - Attribution: pixabay

There are many differences between Euclidean and non-Euclidean geometry.

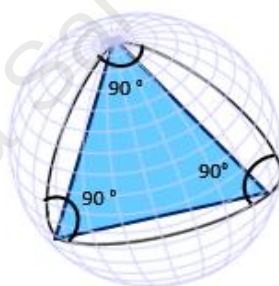
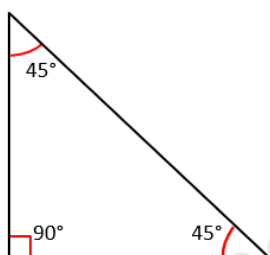
Let us see two interesting differences between Euclidean and non-Euclidean geometry.

- A straight line drawn in a plane can be extended indefinitely in both directions, whereas on a sphere if you connect two points and join them, and extend in both directions, they are bound to meet.



Sphere: pixabay.com/illustrations/sphere-ball-plastic-round-3d-953962/ - Attribution: TheDigitalArtist

- In Euclidean geometry, the sum of angles of a triangle is 180° , whereas in non-Euclidean geometry, the sum of angles of a triangle is more than two right angles.



Globe: pixabay.com/vectors/globe-geometric-grid-earth-35588/ - Attribution: Clker-Free-Vector-Images

Curved Triangle : OC

[Notes to the teacher: Teacher may carry a ball to show how Euclidean geometry does not work for spherical surfaces]

Time to teach	Asset type	Theme	Sub Theme
5 minutes	Interesting Asides	Introduction to Euclid's Geometry	Discovery of Non-Euclidean geometries



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Annexure to Master Lesson Plan

What is the purpose of this Master lesson Plan?	This Master Lesson Plan (MLP) prepared by Sri Sathya Sai Vidya Vahini (SSSVV), covers the entire chapter for the given board. The MLP for the chapter given in the textbook is broken down into smaller modules known as assets. Any chapter can be taught using the 7 asset types in SSSVV methodology. Several different assets together complete the entire chapter. Depending on the requirement, each asset is supported by teaching aids such as animated presentation, audio, video, and learning aids such as worksheets. The MLP is for the teacher's preparation and the teaching aids are for use in the classroom.
How to use it?	You can prepare for your class with this MLP by following 3 simple steps: 1. Read your textbook; 2. Go through the information given in the assets (document & multimedia); 3. Prepare your teaching notes. Great! Now you are ready to transact the chapter.
Duration	Kindly note the duration given for each asset. Due care has been taken in planning the assets, to ensure the chapter is completed within the time specified by the Board. Note: Preparation time is not included in the asset duration. The teaching time depends on the duration of the teaching aids and is not impacted by the length of the MLP.
What is a 'Main Script' (MS) Asset?	The Main Script asset is there for explaining the main concepts of the chapter clearly. The information given in the textbook is simplified, organised and structured to give more clarity. Additionally, you may find a video or mnemonics or a graphic organiser to deepen the understanding of the concept.
How to teach using the MS asset?	Please use the blackboard, slides and interaction to develop the concept.
What is an 'Inquisitive Questions' (IQ) asset?	The Inquisitive Questions asset uses questions to promote higher order thinking like the n th why, what-if, new perspectives, cause-effect, and others, creating curiosity.
How to teach using the IQ asset?	You may use the questions to connect with the students, encourage exploration to engage them in the learning process. You may allow multiple responses and instead of rejecting any of the responses, ask why, before revealing the suggested answer or hints.
What is a 'Day to day Relevance' (DD) Asset?	The Day to Day Relevance asset helps students understand the practical relevance of every topic, making them eager participants in the classroom. If students connect the concepts to their environment, they would learn meaningfully without dislike or simply memorizing for exams.
How to teach using the DD	You may use the asset by asking questions about their experience and use it to establish why they are learning the topic. If necessary you may substitute with a

asset?	recent or local example.
What is an 'Interesting Aside' (IA) asset?	The Interesting Aside asset uses attention grabbing titbits or anecdotes to bring joy and satisfy the child's hunger to know more. This is a quick/short asset intended to bring attention back to the main concept being taught.
How to teach using the IA asset?	You may use this asset to give a piece of interesting information relevant to the topic, without prolonged explanation/discussion. You may suggest appropriate books for further reading.
What is a 'Suggested Activity' (SA) Asset?	The Suggested Activity asset provides a detailed step by step procedure for the teacher to conduct a hands-on activity. This promotes Activity Based Learning.
How to teach using the SA asset?	You may use this asset to energise your students to learn by doing simple, fun-filled activities based on the topic. The asset includes - preparation, activity, and follow-up. You may engage the students in the preparation and follow-up stages to develop collaboration and responsibility. You could try it once, yourself, before the actual delivery to be more comfortable with it. Note: The duration mentioned in the asset is usually for the activity part only.
What is a 'Value Content' (VC) Asset?	The Value Content asset integrates Universal Human Values (such as empathy, inclusivity, respect for nature that translates into responsible behaviour) seamlessly into the curriculum, as the "End of education is character".
How to teach using the VC asset?	You may use this asset to engage with the students to bring out their innate values and connect with the intrinsic values in the topic/concept. The asset includes pointers on the specific pedagogical technique followed.
What is a 'Questions to Assess' (QA) asset?	The Questions to Assess asset uses an interactive approach to check learning of different types of learners, and provides feedback to the teacher for appropriate action. The questions cater to all the levels of Bloom's Taxonomy. Questions from 'Apply' level and above enable students to reflect on their learning.
How to teach using the QA asset?	You may go through the slides to understand its flow and know when to click for the answer (slides include suggested answers). While presenting in the class, you may display the question and encourage multiple responses, before revealing the answer. In some cases, this asset may include extra questions/worksheet that can be given as homework.