



3D printing technology aims students understanding maths and recycling procedure

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Erasmus+ Call: 2019 - KA2 - Cooperation for Innovation and the Exchange of Good Practices - Strategic Partnerships for school education



Intellectual Output 3: Mathematics' Curricula

Deliverable Code: Stereometry



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1. Introduction

This is a class for students from 6 to 14 years old, which aims to help students develop spatial visualization by using 3D printing, since it is highlighted in the literature that measures of mathematical ability are strongly correlated with students' spatial ability.

Topic

This scenario is an alternative way to teach stereometry to students, using the **technology of 3D Printing**. The approach of the subject is done according to the methodology of the guided explanatory learning.

Exploration is an approach to learning that is related to general types of thinking mechanisms and high-level cognitive skills.

Tools Used:

- Two **questionnaires** of ten items were developed in order to define the topics of mathematics in which students face difficulties. The first questionnaire was addressed at students aged between 6 and 14. Each question focused directly on a specific mathematical topic. All questions had multiple answers but only one was correct. The sample size was 930 students from the three countries: Greece, Italy and Portugal. The sample size was estimated through normal distribution and it was representative for each school. Answers were collected and analyzed using SPSS Package 21.00.
- **3D Printing** technology was also used, as an innovative methodology to aim students at understanding fractions. Students will learn to use 3D Printers. Students will use **Tinker Cad** or **Sketch Up Software** in order to design 3D schemes, like circles and quarters and then they use 3D printers to print "pizzas" and parts of pizzas, in order to understand the concept of fractions.
- **Worksheets** will be given to students during the course
- **Power Point Presentations**

2. Goals, Learning Outcomes, Requirements

Main idea:

The main purpose of the curriculum is **the examination/ exploration of 3D shapes**. Although students learn and visualize 2D shapes at mathematics courses, 3D shapes remain a difficult subject. It is very difficult to convert a shape from the two dimensions to three dimensions. Students who lack of spatial ability, have difficulties to understand the concept of stereometry.

Value added:

In this process of exploratory learning the use of 3D printing technology can be of great value. 3D printing technology improves students' spatial ability (Huang and Lin, 2017). Spatial cognition is the underlying mental process that allows an individual to develop spatial abilities. (Miller and Bertoline, 1991). Spatial ability refers to spatial visualisation, orientation, and spatial relations (Miller and Bertoline, 1991). Katsioloudis and Jovanovic (2014) claimed that 3D models help students enhance their modelling tasks, and it enables them to comprehend visual data better than using 2D drawings

Required helping material and tools:

- A **3D Printer** per four students.
- A **school textbook** that provides theory and exercises
- **Worksheets** both for the course delivery and for homework.

Learning Outcomes

- Develop spatial visualization
- Distinguish among different criteria
- Realize and apply mathematical formulas
- Perform simple calculations

Expected results:

In terms of **mathematical achievement**, Students will be able:

- to **understand** the difference between 2 dimensions and 3 dimensions
- to **distinguish** 2D and 3D shapes
- to **calculate** perimeter and area of 2D shapes
- to **calculate** surface area and volume of 3D shapes

In terms of **teaching process** the students will:

- **Follow** the teacher's **instructions**.
- **Ask questions** and **give answers** to them.
- **Complete** the worksheet.

In terms of **3D Printing**, students will be able

- to **use** a 3D Printer
- to **search** and find 3D models at .stl files
- to **import** a file at a 3D printer
- to **slice** a model
- to **print** a model to play with solid object

3. Course Outline

Duration

The duration of the proposed course is 8-10 hours, depends on students' educational level, age of students, number of students at class

Material

Teachers could use the following educational material

- PowerPoint Presentations
- Videos
- Worksheets
- 3D Printers

Syllabus of courses

Course 1-2: 2D Shapes

- ✓ **Mathematical Concepts**
 - Two-dimensional shapes
 - Differences between regular polygons (equilateral triangle, square, regular pentagon, etc.) and not-regular ones (rectangle, quadrilateral, etc.).
 - Differences between polygons and curved shapes (circle, eclipse etc.).
 - Realize the importance of different criteria regarding naming the shapes

Definition

Two dimensional shapes are shapes that are flat. 2D shapes have no thickness and only two dimensions like height and width.

- ✓ **Videos**

<https://www.youtube.com/watch?v=4tISK2a05EQ>

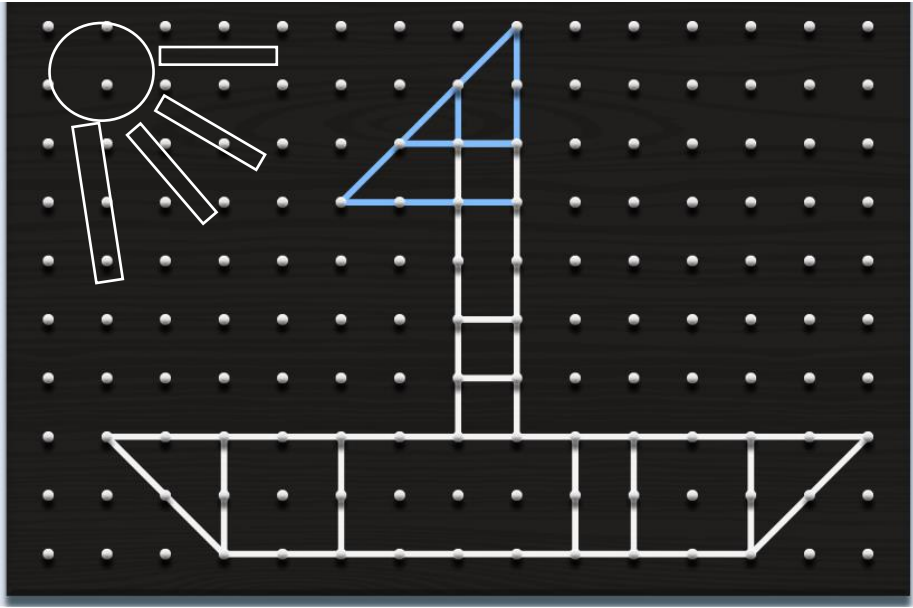
- ✓ **Power Point Presentation**
“Introduction to 2D shapes”






- ✓ **Software for use at the classroom**
 - <https://apps.mathlearningcenter.org/pattern-shapes/>
 - <https://www.abcya.com/games/tangrams>
 - <https://apps.mathlearningcenter.org/geoboard/>
 - <https://toytheater.com/geoboard/>

- ✓ **Activity**

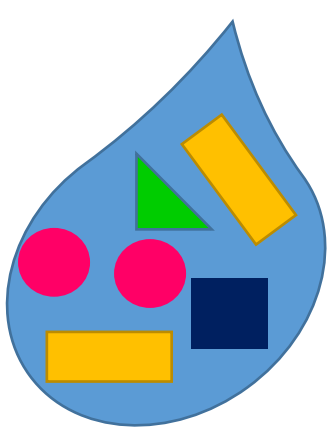
Pupils 6-9

Exercise 1: Define the shapes and count them

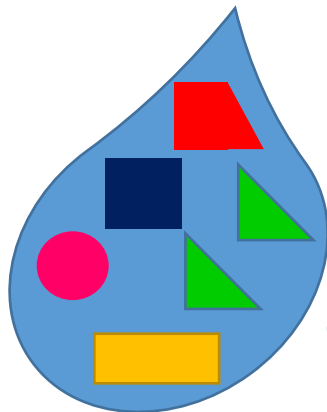


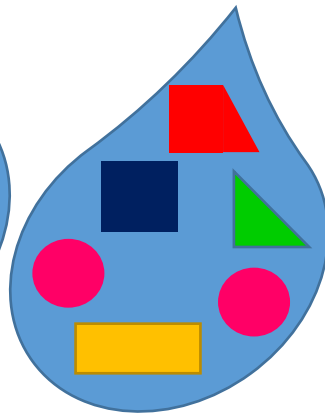
Exercise 2: Find the content of Smurf's present



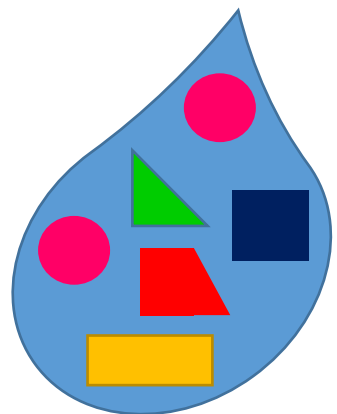
A



B



C



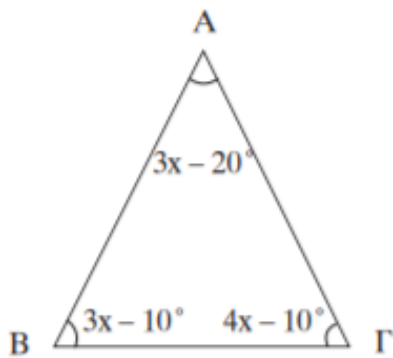
D



The present contains
 1 orthogonal
 2 circles
 1 square
 1 trapezium
 1 triangle

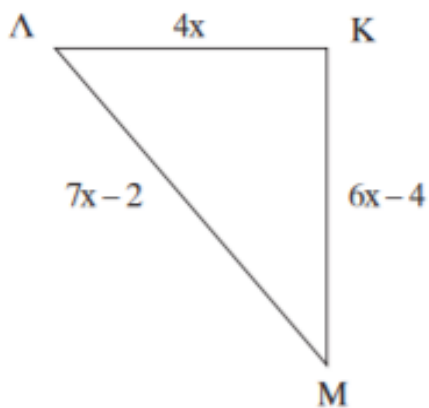
Pupils 10-14

Exercise 1: $\triangle AB\Gamma$ is an equilateral triangle. Base of the $\triangle AB\Gamma$ is $B\Gamma$. Define x

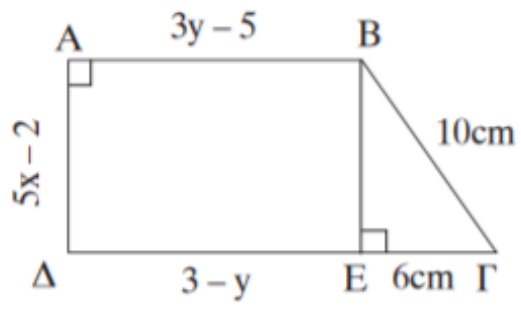


Exercise 2: The perimeter of $\triangle K\Lambda M$ is 96m

- Define x
- Examine if $\triangle K\Lambda M$ is a right triangle. Justify your answer



Exercise 3: $AB\Gamma\Delta$ is trapezoid. $AB \parallel \Delta\Gamma$. Angles A and Δ are 90. Define x, y



Course 3-4: Perimeter and Area of 2D shapes

✓ **Mathematical Concepts**

- Perimeter and Area of 2D shapes
- Intuitive reasoning and formulas in different shapes and combinations of shapes

Students should calculate the perimeter and area of the shapes. They should also combine the shapes and calculate the perimeter and area of the non-typical 2D shapes that they have constructed.

✓ **Videos**

- <https://www.youtube.com/watch?v=P7S0-E39kV8>
- <https://www.youtube.com/watch?v=4kMfh9s9NiE>

✓ **Power Point Presentation**

“Perimeter and area of 2D shapes”

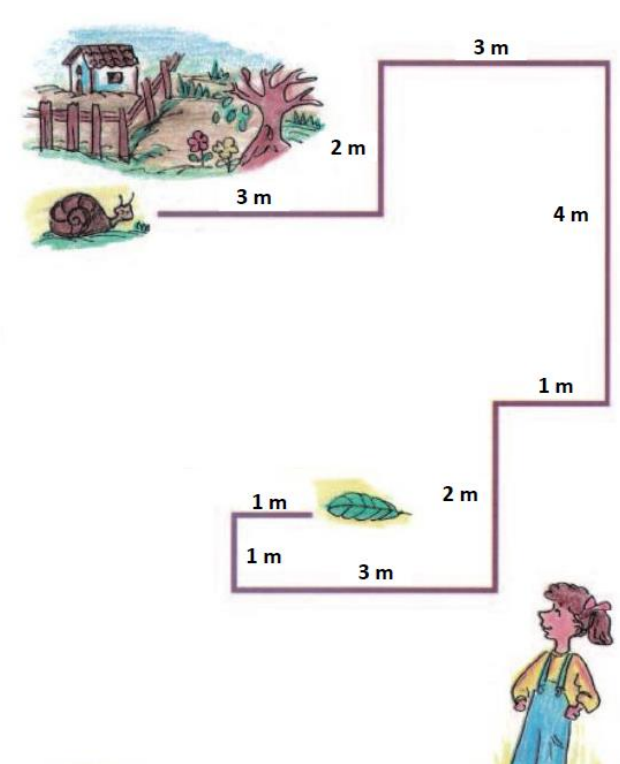
✓ **Software for use at the classroom**

- https://www.abcya.com/games/shapes_geometry_game
- <https://www.calculator.net/>
- <https://toytheater.com/shape-fall/>

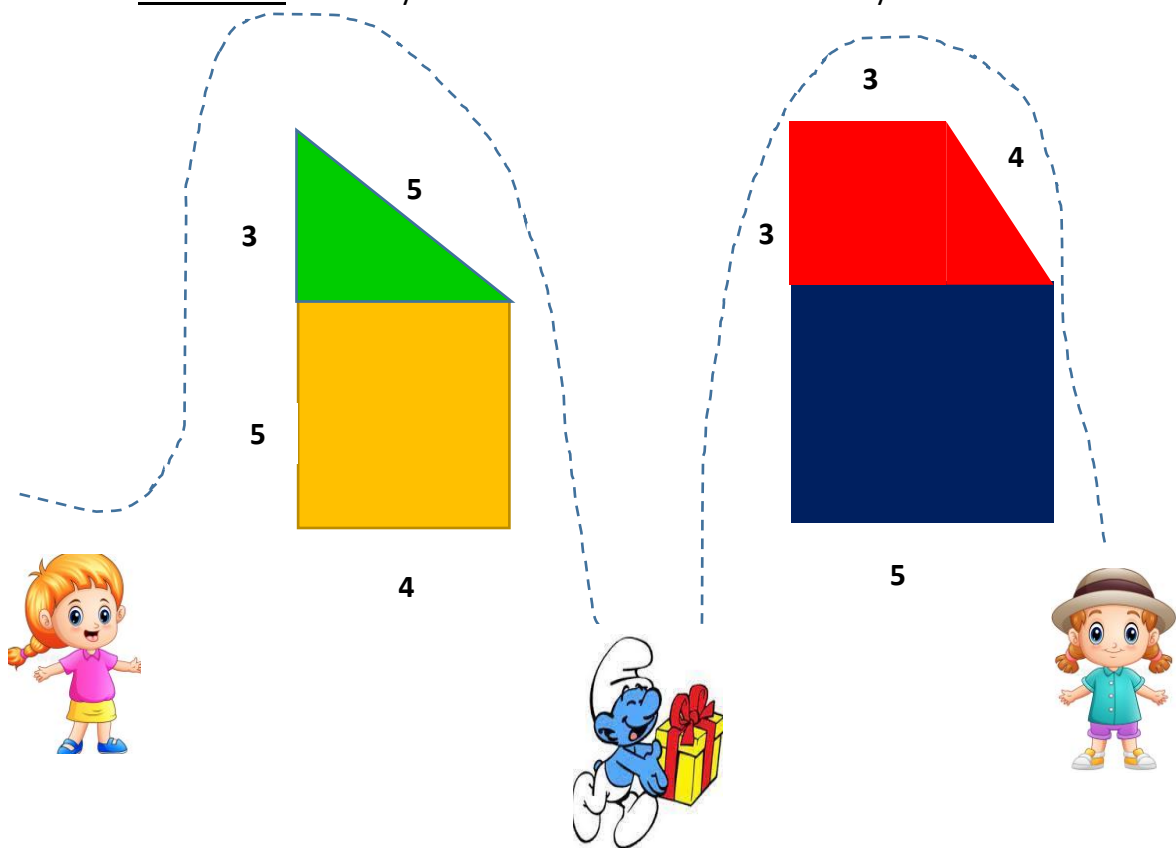
✓ **Activity**

[Pupils 6-9](#)

Exercise 1: Snail wants to go to Sally. Define the distance in meters

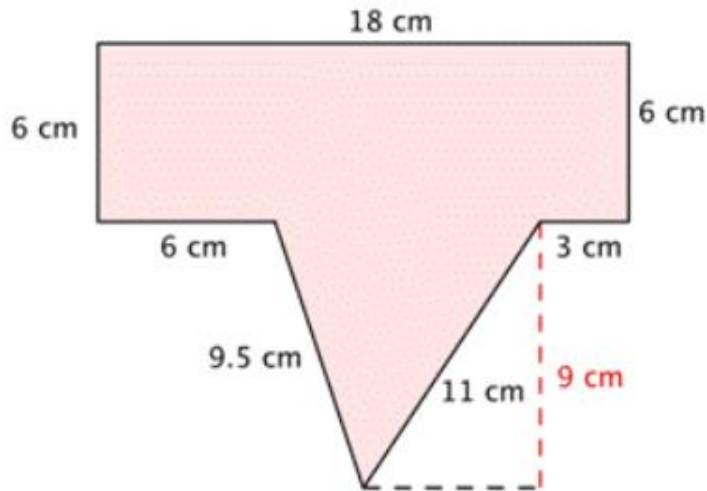


Exercise 2: Both Sally and Anna want to meet Smurf. Sally or Anna is closer to smurf?

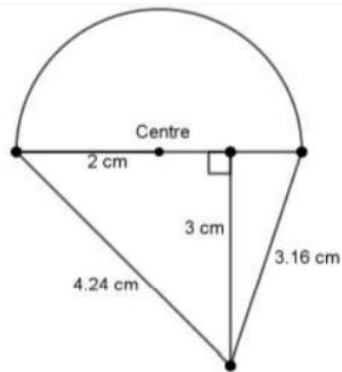


Pupils 10-14

Exercise 1: Find the area and the parameter of the pollygon

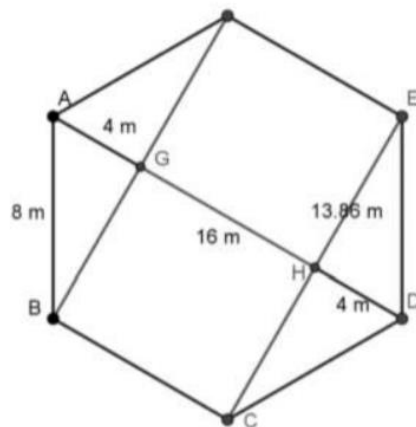


Exercise 2: Find the area and the parameter of the following shapes



a)

b)



AB = 8m

(Regular hexagon, all sides 8m)

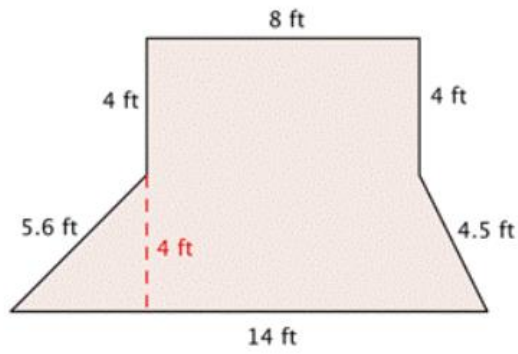
AG = 4m

HD = 4m

AD = 16m

CE = 13.86m

Exercise 3: Rosie is planting a garden with the dimensions shown below. She wants to put a thin, even layer of mulch over the entire surface of the garden. The mulch costs \$3 a square foot. How much money will she have to spend on mulch?



Course 5: From 2D to 3D (Two dimensions to Three dimensions)

✓ **Mathematical Concepts**

- Manual construction of solids gives to the student and intuitive conception of the 3D nature of the solid.

During this lesson kids use 3D printer in order to understand differences among 2D to 3D objects

✓ **Power Point Presentation**

“From 2D to 3D”

✓ **Software for use at the classroom**

- <https://kidspiration.software.informer.com/%CE%9B%CE%AE%CF%88%CE%B7/>
- [google Earth](#)
- <https://imagetostl.com>

✓ **Activity at 3D printer**

Students use photos, convert them to .stl files and then use slicer and print!!!!

Course 6: 3D shapes_edges_faces_vertices

- ✓ **Mathematical Concepts**
 - Introduction to 3D objects
 - Names and Properties
 - Number of faces, edges and Vertices of each shape

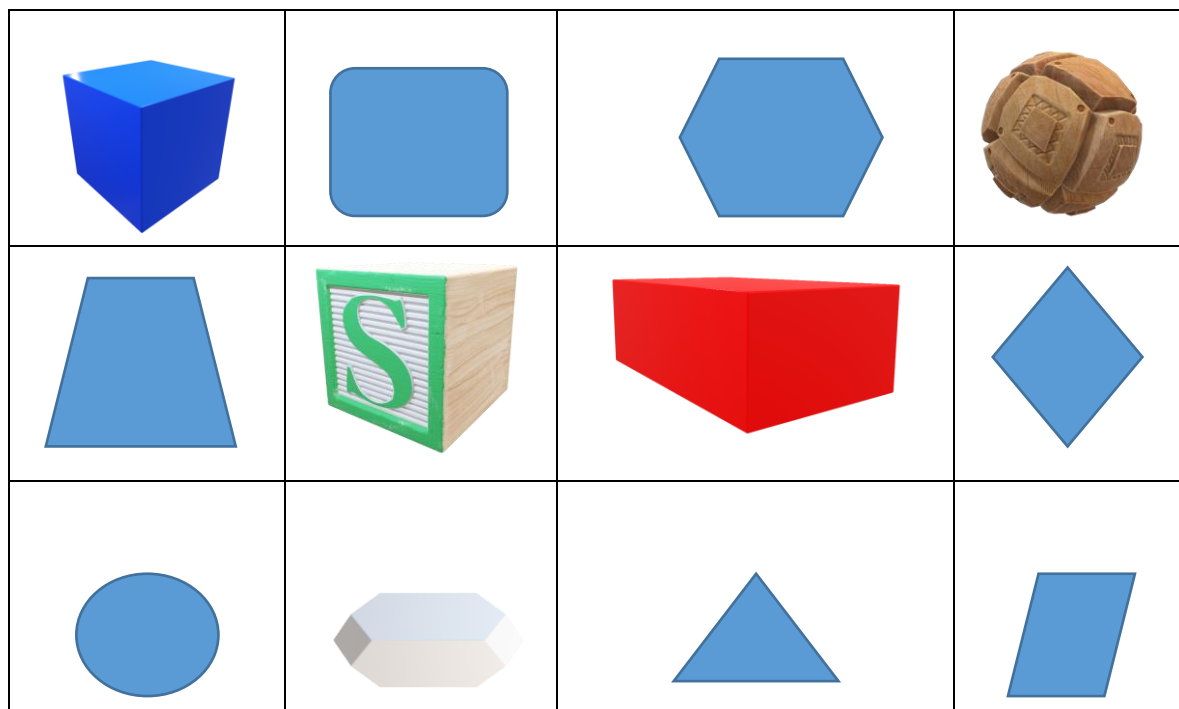
Find all necessary knowledge at pptx

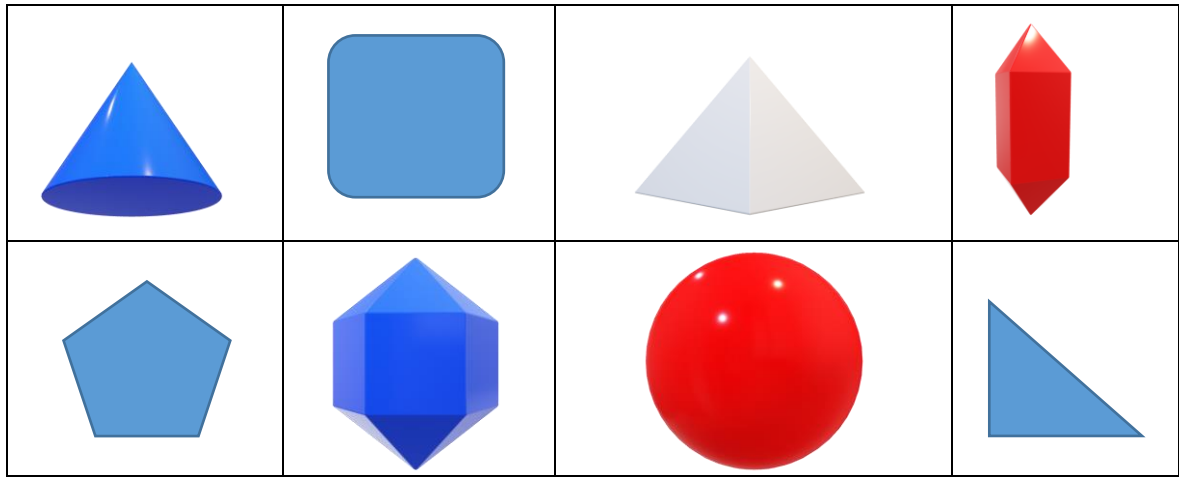
Pupils have to recognize the shapes and count the faces, the vertices and the edges

- ✓ **Video**
 - <https://www.youtube.com/watch?v=IWff44Jm1z0>
 - <https://www.youtube.com/watch?v=DnliMHblOR0>
- ✓ **Power Point Presentation**
"3D shapes_edges_faces_vertices "
- ✓ **Activity**
Find objects of 3D shapes at the classroom and recognize shapes and their characteristics.

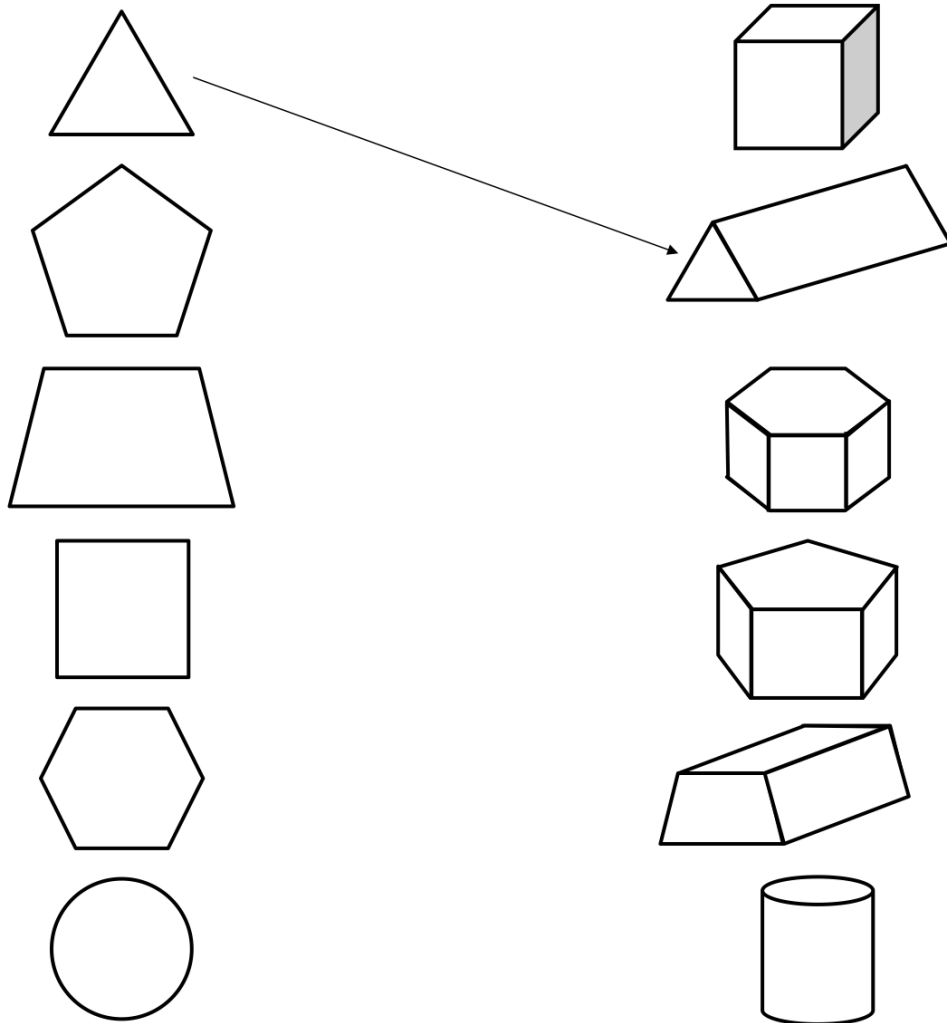
Pupils 6-9

Exercise 1: Circle the 3D shapes below



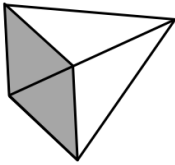
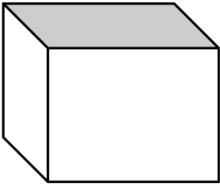
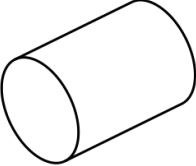
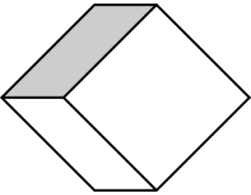
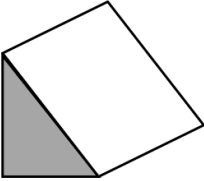
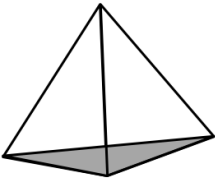


Exercise 2. Find and match the 2d shape in the correct 3d shape.

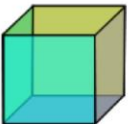

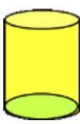

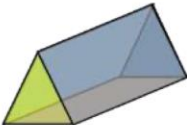

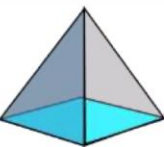
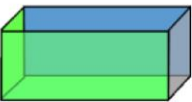

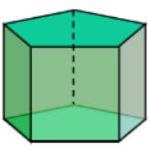

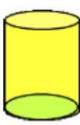
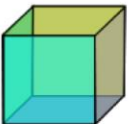

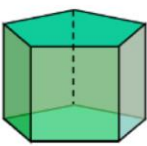


Pupils 10-14

Exercise 1: Write down the name of the shapes and the number of faces

		
Name of shape	Name of shape	Name of shape
Faces:	Faces:	Faces:
		
Name of shape	Name of shape	Name of shape
Faces:	Faces:	Faces:

Exercise 2: At each row find the correct shape based on the info at the first column

Faces: 6 Edges: 12 Vertices: 8			
Faces: 5 Edges: 9 Vertices: 6			
Faces: 5 Edges: 8 Vertices: 5			
Faces: 4 Edges: 6 Vertices: 4			
Faces: 7 Edges: 15 Vertices: 10			

Course 7: 3D Shapes, Surface Area, Volume

✓ **Mathematical Concepts**

- Formulas of Surface Area of 3D Shapes
- Formulas of Volume of 3D Shapes

Find all necessary knowledge at pptx

✓ **Video**

- <https://www.youtube.com/watch?v=9q43OxCKaXs>
- <https://www.youtube.com/watch?v=CYVmmTaqIPU>
- <https://www.youtube.com/watch?v=3-QwWFkz5hw>
- <https://www.youtube.com/watch?v=XJ1A5io8vc>
- <https://www.youtube.com/watch?v=LEuFeXsqXXA>
- <https://www.youtube.com/watch?v=ZJ-VMcbLTaU>

✓ **Power Point Presentation**

“3D Shapes_Surface Area and Volume”

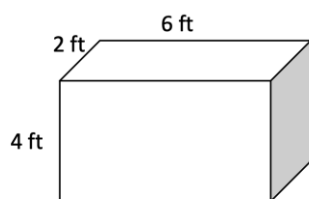
✓ **Activities**

Pupils 10-14

Exercises

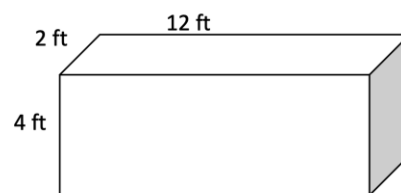
1. Surface Area: _____

Volume: _____



2. Surface Area: _____

Volume: _____

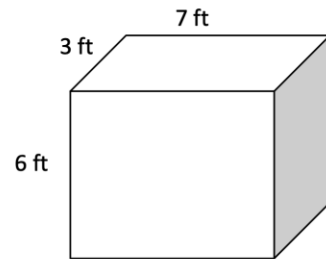
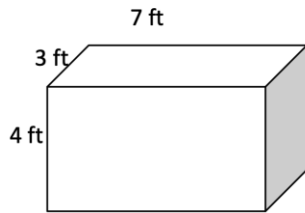


3. Surface Area: _____

4. Surface Area: _____

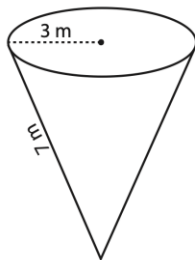
Volume: _____

Volume: _____

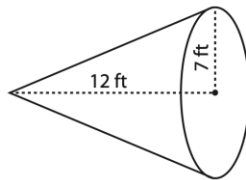


Find the surface area of each cone. Round the answer to nearest tenth. (use $\pi = 3.14$)

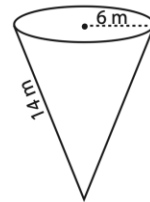
1)



2)



3)



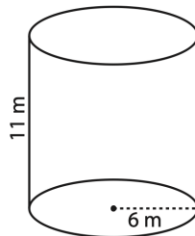
Surface Area = _____

Surface Area = _____

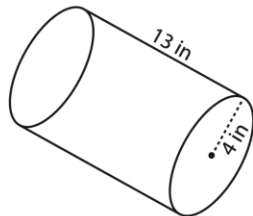
Surface Area = _____

Find the volume

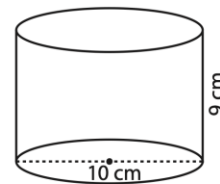
1)



2)



3)



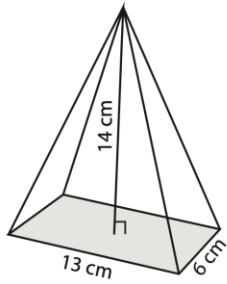
Volume = _____

Volume = _____

Volume = _____

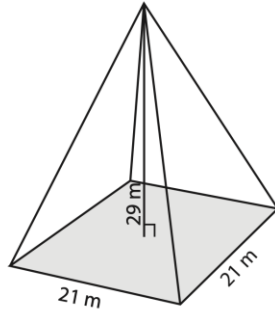
Find the volume of each rectangular pyramid. Round the answer to two decimal places.

1)



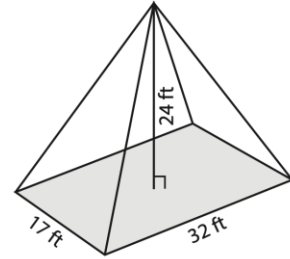
Volume = _____

2)



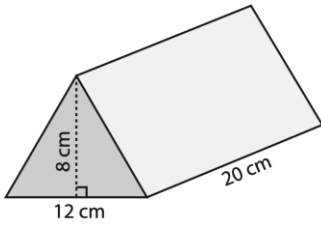
Volume = _____

3)



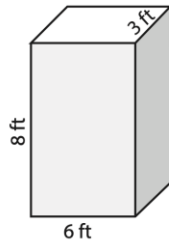
Volume = _____

4)



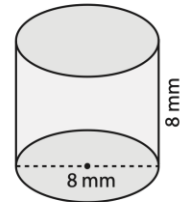
Volume = _____

5)



Volume = _____

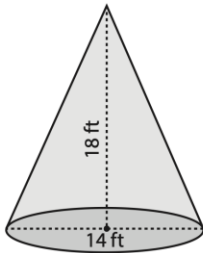
6)



Volume = _____

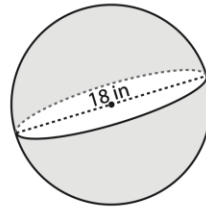
Find the exact volume of each shape.

1)



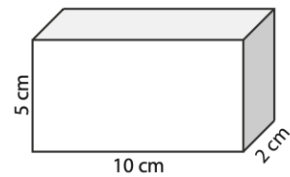
Volume = _____

2)



Volume = _____

3)



Volume = _____

Course 8: Print 3D Shapes

- ✓ **Site to use at Classroom**
 - www.designmaketeach.com
- ✓ **Power Point Presentation**
"3D Shapes_3D Printer"
- ✓ **Activity at 3D Printer**
Print solid shapes
Print
 - a sphere
 - a cylinder
 - a cube
 - a square based pyramid
 - a cone
 - a hexagon prism



