Jockey Club STEAM Education Resources Sharing Scheme

Hello ‘Holo’

Teachers’ Guide

First Edition December 2020

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Contents

Jockey Club STEAM Education Resources Sharing Scheme is a 4-year project (2019-2023) funded by The Hong Kong Jockey Club Charities Trust and operated by the School of Science and Technology, Hong Kong Metropolitan University.

Traditionally, knowledge is transferred to students through a teacher-centred approach. Teachers teach students based on a subject-based curriculum that aims at content acquisition. However, little attention is given to how students learn and apply the knowledge to tackle matters in and beyond classrooms. Moreover, the knowledge domains are covered in terms of individual subjects, such as Physics, Biology, Chemistry, and Mathematics. Students learn individual subjects separately without holistic integration. As a result, students may not be sufficiently equipped to solve authentic problems in the real world.

"While Hong Kong students perform well in science, technology and mathematics, they may focus on disciplinary studies and may not evenly participate in hands-on activities in schools. Therefore, it is necessary to strengthen the ability of students to integrate and apply their knowledge and skills across different subject disciplines through solving daily life problems with practical solutions and innovative designs." (Curriculum Development Council, 2015).

Under this Scheme, the operational team will create a set of STEAM modules for secondary schools to strengthen students' ability to integrate and apply their knowledge and skills across different subject disciplines with a special focus on the use of innovative teaching pedagogies for STEAM education, i.e.

Science
Technology
Engineering
Arts
Mathematics

At least 20 modules would be developed to target students of average ability in solving authentic problems in daily life. Each module would provide 4 to 40 contact hours of student activities. In addition, students would do preparation or follow-up activities during non-contact hours. The ratio between contact hours and non-contact hours is approximately 1:1.

This document provides a detailed module plan for learning, teaching and assessment activities. The module will provide an opportunity for students to learn STEAM through hands-on and minds-on activities that integrates knowledge and skills across Science, Technology, Engineering, Arts and Mathematics under real-world contexts.

1. Module Outline

1.1 Module Title: Hello 'Holo'

Holographic projection applies the concept of reflection of light to form a special visual effect. Audiences can view the projection (hologram) clearly from different sides of a holographic projector. Sometimes floating "objects" are seen, some people even call holographic projection an optical illusion.

Although hologram formation is not explicitly explained in the secondary syllabi, the relevant scientific principle: the reflection of light is taught in the Senior Secondary Physics syllabus. It is worth putting forth as this principle can illustrate many other optical illusions. It is hoped that students may discover the knowledge they learned from school can be so close to their daily lives. Let's say hello to 'holo' (holograms) in this module.

1.2 Participants Recommended for this Module

- ☑ Junior Secondary School Students (S3 is preferred)
- ☐ Senior Secondary School Students
- ☑ Others (Students who are interested in computer graphic design and video editing)

1.3 Module Aims

The module "*Hello 'Holo'* " aims to:

- *Introduce* students to the principles and relevant scientific information about the holographic projection
- *Utilise* graphic design and video-editing software to create holographic videos
- *Provide* students with practical experience in producing their own projection pyramids

1.4 Module Learning Outcomes

Upon the completion of the module, students should be able to:

- *Understand* the physical principles of reflection of light
- *Draw* professionally simple graphics (e.g. the prototype of projection pyramids) using *Adobe Illustrator*
- *Create* holographic videos using graphic and video design software: *Blender* and video-editing software: *PowerDirector*
- *Produce* their own projection pyramids for experiencing their holographic videos

1.5 Learning & Teaching Approach / Practice

Knowledge gained in STEAM education helps students analyse and interpret real-life phenomena, for instance, when students encounter mysterious holograms in *Unit 1* which may trigger their curiosity. Several disciplines of scientific and technological knowledge are brought together to explain the formation of holograms.

In this module, three investigations take place: 1) students try to recognise and differentiate real and virtual images by a series of observations, 2) students strive to find out "the best angle" of the projection pyramid by repeated modification and 3) students compare the visual effect of holograms if the projection pyramids are modified, and the ambient environment is changed respectively. Skills in evidence-based thinking and logical deduction of students are thus enhanced.

Furthermore, lessons in *Units 2-3* on technological tools (*Adobe Illustrator*, *Blender* and *PowerDirector*) are offered to students. The skills learnt and experience gained make students confident in designing and making the authentic set of products in *Unit 4*, i.e. their own unique holograms which can be viewed when using their custom-made projection pyramids.

At the end of the module, the understanding of STEAM-related subject matter increases and students' skills in scientific investigation, design-thinking, communication, computer application, and information technology are nurtured.

1.6 Nature of STEAM Activity

Element	Description	Composition
Science	Observe the phenomena caused by the reflection of light and drawing respective ray diagrams	✪✪✪✪
Technology	Utilise graphic design and video-editing software to create own holographic videos	✪✪✪
Engineering	Custom-make projection pyramids for mobile devices, starting from making the prototypes	✪✪
Arts	Appreciate the beauty of holograms	✪✪
Mathematics	Handle calculation concerning the ratio of similar shapes	✪✪

1.7 Mapping of Key Learning Area (KLA)

Unit	Science Education	Technology Education	Arts Education	Mathematics Education
1	◆ Introduction of reflection of light (SP3.2.2) ◆ Drawing of light rays to explain how virtual image is formed (SJ14.1)			
2		◆ Drawing of the prototype of projection pyramids using *Adobe Illustrator*		
3		◆ Own holographic videos design using *Blender* and *PowerDirector*	◆ Video and graphic design of holograms	◆ The three orthographic views of 3-D figures (MJ17.4)
4			◆ Appreciation of the beauty of holograms	◆ The relations among lengths, areas and volumes of similar pyramids (MJ18.3)

Remark: Mapping the skill sets in this module with the respective KLAs in the school curriculum that would be covered.

1.8 Module Structure

Units		Contact Hours
1	Knowing about Reflection of Light	100 min.
2	Drawing Prototype of Projection Pyramids	100 min.
3	Designing Own Holograms	160 min.
4	Production of Projection Pyramids	105 min.
	Total	**7 hr. 45 min.**

*Remark: A total of **1** non-contact hour of the module is recommended.*

1.9 Thematic Area

- ☐ Environment and Health
- ☐ Food and Biotechnology
- ☐ Biochemistry
- ☑ Digital Transformation
- ☐ S.M.A.R.T.

2. Module Design

In order to understand how holograms are formed, students are first equipped with the relevant knowledge: the reflection of light in *Unit 1*, By drawing ray diagrams, a clear picture of the formation of the virtual image is shown.

In *Unit 2*, students will start using graphic design software- *Adobe Illustrator* to draw the prototype of projection pyramids according to their mobile devices' size, preparing for making projection pyramids using appropriate materials in *Unit 4*.

Furthermore, students will learn two software- *Blender* and *PowerDirector* in *Unit 3*. They are free to create 3-D graphics and videos, as well as holographic videos then. Sharing of holographic videos is enabled when students upload theirs to the internet.

When it comes to *Unit 4*, to put together the fruits from previous units, the projection pyramids constructed using the prototype will be deployed to form holograms from the holographic videos.

2.1 Unit 1: Knowing about Reflection of Light

Reflection of light is defined as light bouncing off an object when it hits its surface. A spectacular example of nature is the lake reflection, which displays an inverted picturesque scenery near a still lake. Even if there are ripples in the lake, a different phenomenon called diffuse reflection is caused.

In this unit, holograms are showcased, and their formation can be explained by the physical principle: the reflection of light. Students will also learn how to draw the corresponding ray diagrams. These allow students to recognise the essential role of projection pyramids, which they are going to draw in Unit 2, in holographic projection.

2.1.1 Objectives

Upon completion of *Unit 1*, students should be able to:

- *Identify* examples/phenomena caused by the reflection of light
- *Distinguish* and *compare* real and virtual images
- *Understand* the laws of reflection of light
- *Draw* ray diagrams regarding the reflection of light from plane mirrors
- *Outline* the principle of holographic projection

2.1.2 Pre-requisite (if appropriate)

Nil.

2.1.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction • Assess students' prior knowledge • Explain the learning objectives of this lesson	5 min.	
(2) Understanding the reflection of light • The teacher introduces examples/phenomena related to the reflection of light ***(Activity 1.1)*** • The teacher produces real images and virtual images for student's observation ***(Activity 1.2)*** • Students learn the definitions of the angle of incidence, angle of reflection and normal • The teacher explains the laws of reflection of light	55 min.	• PowerPoint slides • Worksheet
(3) Drawing of ray diagrams • The teacher demonstrates how ray diagrams regarding the reflection of light from plane surfaces are drawn • Students practise drawing several ray diagrams • The teacher explains the principle of optical illusion	30 min.	• PowerPoint slides • Worksheet
(4) Debriefing • The teacher reviews the knowledge covered in this lesson • The teacher briefly introduces the next lesson	10 min.	• Worksheet • Video
Total	**100 min.**	

2.1.4 Assessment

- Student's knowledge of the nature of images and laws of reflection of light will be assessed through the student worksheet with short questions
- Student's skills in drawing ray diagrams will be assessed through the student worksheet with boxes for drawing

2.2 Unit 2: Drawing Prototype of Projection Pyramids

Projection pyramids are one of the key tools to produce holograms. A projection pyramid is made of four transparent sheets placed symmetrically and fixed at an angle of around 45 degrees to the illuminating mobile device. Part of the light gets reflected by the sheet, and an image of the reflection (hologram) is produced and seen from all four sides of the pyramid.

Knowing that there are specific ratios of the lengths of projection pyramids that offer the best display of holograms, students are advised to custom-make their own pyramids according to the dimensions of their mobile devices. In this unit, prototypes

of pyramids are drawn with graphic design software: *Adobe Illustrator* in a precise and professional way.

2.2.1 Objectives

Upon completion of *Unit 2*, students should be able to:

- *Discover* the best angle of inclined planes of projection pyramids
- *Calculate* with ratio the appropriate dimensions for the projection pyramids when considering the sizes of their mobile devices
- *Apply* the drawing technique in *Adobe Illustrator* and *draw* the prototype of projection pyramids

2.2.2 Pre-requisite (if appropriate)

Nil.

2.2.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction • The teacher recaps major ideas from the previous lessons • The teacher assesses students' prior knowledge • The teacher explains the learning objectives of this lesson	10 min.	
(2) Discovering "the best angle" ***(Activity 2.1)*** • Students are asked to manipulate the angle between the screen of mobile devices and the inclined plane(s) of the projection pyramid and observe the effect on the image formed	30 min.	• PowerPoint slides • Worksheet
(3) Drawing using *Adobe Illustrator* ***(Activity 2.2)*** • Students calculate the dimensions of projection pyramids using ratios • The teacher demonstrates how to draw shapes in specified dimensions in the software • The teacher demonstrates how to align shapes in order to draw out the prototypes of projection pyramids Time is allowed for students' trials and the teacher assists students when needed.	50 min.	• PowerPoint slides • Worksheet • Video with manual
(4) Debriefing: • The teacher reviews the knowledge covered in this lesson • The teacher briefly introduces the next lesson	10 min.	• Worksheet
Total	**100 min.**	

2.2.4 Assessment

- Student's records of the observation in *Activity 2.1*.
- Student's ability to calculate ratios will be assessed through the student worksheet with short questions
- Whether students are successful in drawing prototypes of projection pyramids using the software will be monitored during the lesson

2.3 Unit 3: Designing Own Holograms

Nowadays, drawing is no longer restricted on paper or in 2-dimensions (2D), what makes drawings more vivid is that they are in 3-dimensional (3D) graphics and systematically presented with orthographic views in computer software.

In this unit, students are guided to use graphic and video design software- *Blender* to draw 3D graphics and then turn them into short videos. Accompanied by manipulating these videos in another video-editing software- *PowerDirector*, students can create their videos for holographic projection. With the soft skills of software equipped, the unlimited artistic ability and creativity of students would be unleashed.

2.3.1 Objectives

Upon completion of *Unit 3*, students should be able to:

- *Manage* the orthographic views of 3D figures
- *Draw* 3D graphics and then turn them into short videos by *Blender*
- *Create* holographic videos by *PowerDirector*

2.3.2 Pre-requisite (if appropriate)

Nil.

2.3.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction • The teacher recaps major ideas from the previous lessons • The teacher explains the learning objectives of this lesson	10 min.	

Description	Duration (hr/min)	Resources
(2) Graphics and video making using *Blender* ***(Activity 3.1)*** • The teacher introduces orthographic views of 3D figures • The teacher demonstrates how to draw simple shapes in the software • The teacher demonstrates how to render videos of moving graphics • Time is allowed for students' trial and the teacher provides assistance if needed	90 min.	• PowerPoint slides • Video with manual • Worksheet
(3) Holographic video making using *PowerDirector* ***(Activity 3.2)*** • The teacher demonstrates how to align several sub-videos to make holographic videos • Time is allowed for students' trials and the teacher assists students when needed • The teacher demonstrates how to upload the videos to YouTube	50 min.	• PowerPoint slides • Videos with manuals • Worksheet
(4) Uploading holographic videos to YouTube • Students are required to upload the videos before the next lesson	(*)	
(5) Debriefing • The teacher reviews the knowledge covered in this lesson • The teacher briefly introduces the next lesson	10 min.	• Worksheet
Total	160 min.	

*Remark: (*) Around **1** non-contact hour is expected.*

2.3.4 Assessment

- Student's ability to manage orthographic views of 3D figures in software and render videos will be assessed through their products
- Whether students are successful in producing holographic videos using the software will be monitored during the lesson

2.4 Unit 4: Production of Own Projection Pyramids

The previous units serve to prepare for this unit. Students produce their own projection pyramids from the prototype (drawn in Unit 2) and observe their own holograms (created in Unit 3) using the newly-produced pyramids. They experience what they have learnt about the reflection of light in Unit 1. The successful holographic projection would be inevitably fruitful and memorable to students.

Last but not least, to take advantage of the pyramids of different sizes already produced, mensuration is introduced to students to further explore the relations among lengths, areas and volumes of similar pyramids.

2.4.1 Objectives

Upon completion of *Unit 4*, students should be able to:

- *Produce* their own projection pyramids
- *Experience* their holographic videos using their own projection pyramids
- *Handle* calculations concerning the volume of the frustum and the relations between similar shapes

2.4.2 Pre-requisite (if appropriate)

Nil.

2.4.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction • The teacher recaps major ideas from the previous lessons • The teacher explains the learning objectives of this lesson	10 min.	
(2) Producing projection pyramids ***(Activity 4)*** • Students construct pyramids using transparent sheets • Resin is filled into pyramids (optional) • Students perform a product test • Students investigate the factors affecting the visual effects of holographic projection	50 min.	• Worksheet • Video
(3) Learning about mensuration ***(Activity 4)*** • The teacher puts forward the relations among lengths, areas and volumes of similar shapes • Students calculate the volumes and areas of different similar projection pyramids	30 min.	• Worksheet
(4) Debriefing • The teacher reviews the knowledge covered in all units	15 min.	• Worksheet
Total	**105 min.**	

2.4.4 Assessment

- Students' ability to produce functional projection pyramids
- Students' understanding of mensuration will be assessed through the student worksheet with short questions and calculations.
- Student's knowledge covered in *Units 1-4* will be assessed by checking answers in the student workbook

3. Workshop (Activity)

3.1 Activity 1.1 – Understand the types of reflection of light

3.1.1 Introduction

This activity demonstrates mirror reflection, internal reflection, and diffuse reflection using a plane mirror, aluminium foils, and a transparent sheet. A holographic projection pyramid makes use of the reflection of light as well and it is used to form holograms.

3.1.2 Duration

About 20 minutes.

3.1.3 Objective

- To present the three types of reflection and explain the differences between the images formed in the three cases.
- To anticipate the working principle of holographic projection pyramids

3.1.4 Equipment

- Mobile device (iPad or mobile phone)

3.1.5 Materials

- Plane mirror
- Aluminium foil
- Transparent sheet
- Holographic projection pyramid

3.1.6 Procedures

1. The demonstrator asks students to look at different surfaces and note down what the images look like, respectively. The surfaces are
    i) plane mirror;
    ii) smooth aluminium foil;
    iii) rough aluminium foil;
    iv) transparent sheet

2. The demonstrator introduces the three types of reflection (mirror reflection, specular reflection and diffuse reflection). Students are required to match the cases in 1 with these types.

3. Students are provided with answers after trying to explain the differences in images formed using laws of reflection of light.

4. A holographic projection pyramid is used to show holograms. Students try to identify the type of reflection involved.

3.1.7 Result and Discussion

- Discussion on the differences of images formed from 3 types of reflection of light

3.2 Activity 1.2 – Identify real and virtual images

3.2.1 Introduction

In this activity, real images are produced using the convex lens, and virtual images are produced by the plane mirror and holographic projection pyramid.

3.2.2 Duration

About 20 minutes.

3.2.3 Objective

To examine real and virtual images and make a summary of the properties of real and virtual images.

3.2.4 Equipment

- Light bulb / lightbox
- Plane mirror
- Convex lens
- Mobile device (iPad or mobile phone)

3.2.5 Materials

- A piece of paper- as a screen
- Holographic projection pyramid

3.2.6 Procedures

1. Place the illuminating light bulb/lightbox in front of a convex lens at a distance (as long as the lens is placed between F and 2F, where F is the focus of the lens), then place the paper screen behind the convex lens at a certain corresponding distance to capture the real image.

2. Place the illuminating light bulb/lightbox in front of a plane mirror at a certain distance, then place the paper screen behind the plane mirror at the same distance and capture the image (nothing can be captured as the image is virtual).

3. Using the holographic projection set up in Activity 1.1, place the paper screen at positions A and B and look for the image captured (if any) (see diagram 1).

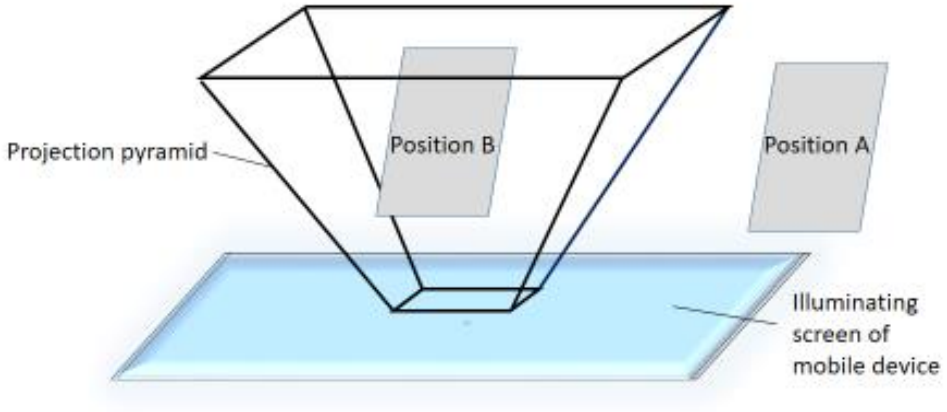


Diagram 1: The positions of the paper screen

4. Students are guided to draw ray diagrams to explain why the images are real or virtual for the cases in 1-3.

5. Make a summary of the properties of real and virtual images.

3.2.7 Result and Discussion

- Discussion on the similarities and differences between real and virtual images
- Worksheet for drawing ray diagrams of reflection of light in the convex lens, plane mirror and projection pyramids, and summary of real and virtual images

3.3 Activity 2.1 – Discover “the best angle”

3.3.1 Introduction

In this activity, by simple manipulation, different combinations of angles of inclination of the planes of projection pyramids result. This allows students to observe and compare the visual effects of holograms so projected.

3.3.2 Duration

About 30 minutes.

3.3.3 Objective

- To observe the clarity and position of holograms when changing the angles of inclination of the planes of projection pyramids.
- To find out “the best angle”.

3.3.4 Equipment

- Protractor
- Mobile device (iPad or mobile phone)

3.3.5 Materials

- Holographic projection pyramid (with the 4 inclined planes detached)
- Adhesive tape

3.3.6 Procedures

1. Change the angle of all inclined planes of projection pyramids θ (see diagram 2) to 30^o using the protractor and fixed them temporarily with adhesive tapes.

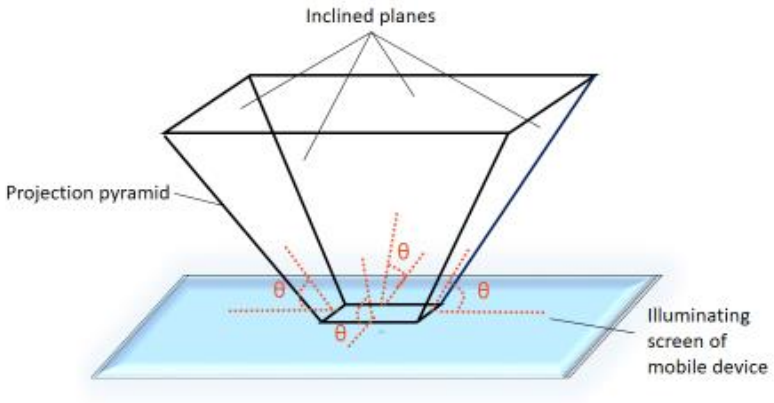


Diagram 2: θ, the angle between the screen of a mobile device and the inclined planes of the pyramid

2. Note down the clarity and position of holograms formed (if any).

3. Repeat 1 and 2 by changing θ to 45^o and 60^o.

4. Try to repeat 1 by adjusting θ from 0^o to 90^o in a continuous manner and observe the instant change in the image.

5. The best angle of inclined planes θ' is found when the hologram is most clearly seen.

6. Change θ of one of the planes only (i.e. θs of the other 3 planes remain unchanged) (see diagram 3), and observe the visual effects of the hologram.

7. Repeat 6 by changing θs of 2 or 3 more planes at arbitrary degrees, observe and compare the visual effects of the hologram.

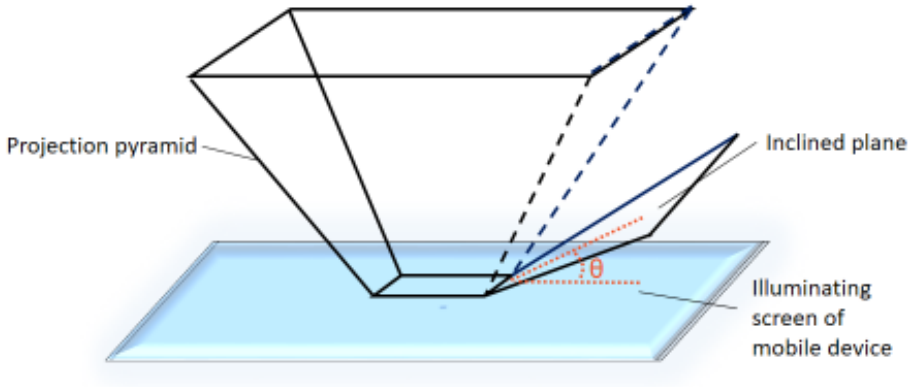


Diagram 3: Change the angle θ of one of the inclined planes of the pyramid

3.3.7 Result and Discussion

- Discussion on "best angle" θ'
- Worksheet for recording observations on the visual effects when changing θ
- Discussion using ray diagram on the visual effects of hologram if is θ <45° or >45°

3.4 Activity 2.2 – Using Adobe Illustrator

3.4.1 Introduction

In this activity, students learn the basics of drawing in *Adobe Illustrator* and draw the prototypes of projection pyramids in specified dimensions.

3.4.2 Duration

About 40 minutes.

3.4.3 Objective

- To measure the sizes of own mobile devices to obtain data for calculating the dimensions of own projection pyramids.
- To gain hands-on experience in drawing using *Adobe Illustrator*.
- To align shapes in order to draw out the prototypes of projection pyramids.

3.4.4 Equipment

- Computers with *Adobe Illustrator* installed

3.4.5 Materials

N/A

3.4.6 Procedures

1. Measure for the side (d) of the maximum square that can fit the screen of a mobile device (see diagram 5 or 6).

2. For all inclined planes of the pyramid, the ratio of the length of the bottom side (f): the height (e): the length of the top side (d) = 1: 3.5: 6 (see diagram 4). Calculate the dimensions of the pyramid using the specified ratio.

3. Draw the prototypes of pyramids using *Adobe Illustrator*, after watching the demonstration video and the steps for drawing design 1 and design 2.

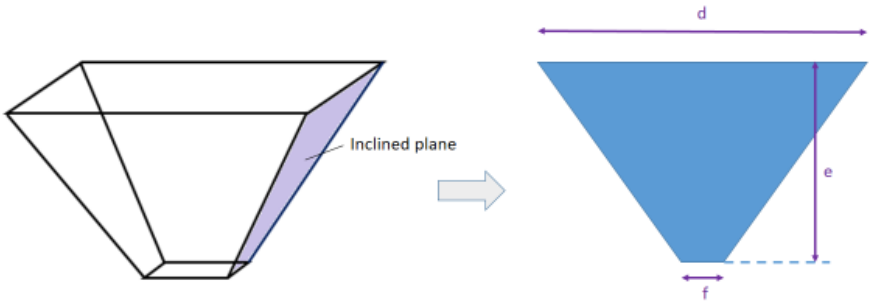


Diagram 4: The dimensions of an inclined plane of the pyramid

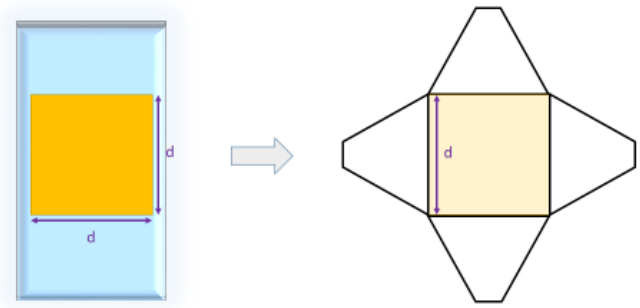


Diagram 5: Design 1 of the prototype of the projection pyramid

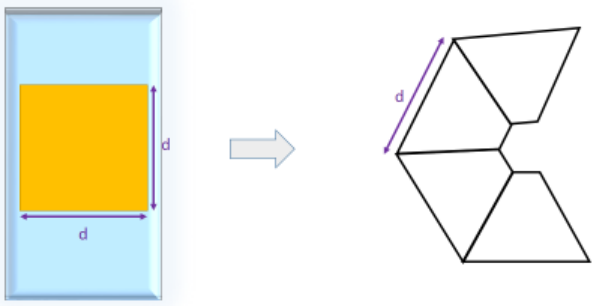


Diagram 6: Design 2 of the prototype of the projection pyramid

3.4.7 Result and Discussion

- Worksheet for the calculation of the dimensions of own pyramids
- The manipulation of functions in *Adobe Illustrator*

3.5 Activity 3.1 – Using Blender

3.5.1 Introduction

In this activity, students learn the basics of drawing graphics and making videos in *Blender*, in which students can look at graphics in 3 orthographic views of 3D figures as well.

3.5.2 Duration

About 80 minutes.

3.5.3 Objective

- To comprehend graphics in 3 orthographic views.
- To gain hands-on experience in drawing 3D graphics and making videos using *Blender*.

3.5.4 Equipment

- Computers with *Blender* installed

3.5.5 Materials

N/A

3.5.6 Procedures

1. In *Blender*, students try to look at the 3 orthographic views (i.e. front view, top view and side view) of figures.

2. Students are taught to draw simple shapes (e.g. spheres) in *Blender*.

3. Students are asked to design their own graphics by combining different shapes and objects.

4. Students are taught to make videos of moving, rotating graphics and/or graphics with their physics (e.g. bouncing balls)

5. Short videos are rendered and output for use in the next step (i.e. producing holographic videos).

3.5.7 Result and Discussion

- Manipulation of basic functions in *Blender*
- Discussion on various advanced functions in *Blender* for further refinement

3.6 Activity 3.2 – Using PowerDirector

3.6.1 Introduction

In this activity, students learn how to align short videos (created in Activity 3.1) in *PowerDirector*. Videos compatible with holographic projection are then created.

3.6.2 Duration

About 50 minutes.

3.6.3 Objective

- To gain hands-on experience in aligning short videos to make holographic videos.
- To upload and share the holographic videos to YouTube.

3.6.4 Equipment

- Computers with *PowerDirector* installed, with internet access

3.6.5 Materials

N/A

3.6.6 Procedures

1. Input the short videos (created in *Activity 3.1*) into *PowerDirector*.

2. Set the background of the video to black.

3. Align 4 identical short videos concentrically of the same distance z from the center.

4. The holographic videos are rendered.

5. The holographic videos are uploaded to YouTube for sharing and use in the next activity.

3.6.7 Result and Discussion

- Manipulation of basic functions in *PowerDirector* to produce holographic videos
- Appreciation of other's works

3.7 Activity 4 – Production of projection pyramids

3.7.1 Introduction

In Units 2 and 3, prototypes of projection pyramids and holographic videos are prepared respectively. In this activity, students are going to make the projection pyramids using a transparent sheet and experience the works along the way.

3.7.2 Duration

About 70 minutes.

3.7.3 Objective

- To construct projection pyramids.
- To observe the holograms.
- To handle calculations concerning the volumes of similar pyramids.

3.7.4 Equipment

- Cutting mats
- Cutters
- Scissors
- Adhesive tapes
- Long rulers
- Marker pens
- Mobile device (iPad or mobile phone) with internet access
- Calculators

3.7.5 Materials

- Transparent sheets and/or semi-transparent sheets
- Small suckers (optional)
- Resin (optional)

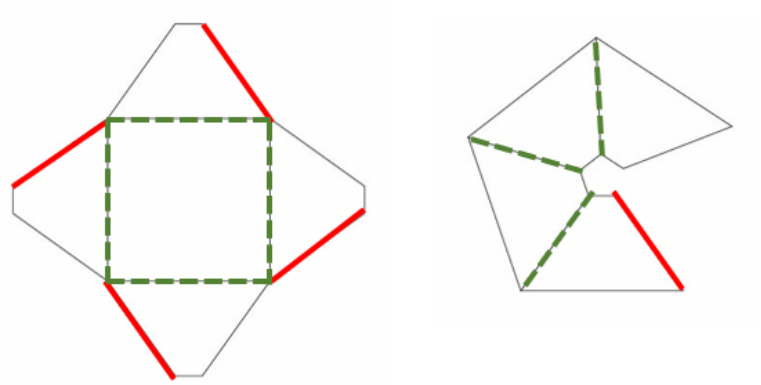
3.7.6 Procedures

1. Place the prototype of projection pyramid on top of a transparent or semi-transparent sheet, trace the shape using a marker pen and cut the sheet out. (Or student can use laser cutter to trim the outer shape of the pyramids precisely).

2. Fold the sheet according to the lines on the prototype.

3. Use adhesive tape to attach the side(s) of the inclined plane(s) together and make a pyramid.

4. If needed, trim the narrow (bottom) end of your pyramid so it sits upright on a flat surface. OR Fit a small sucker at the bottom end of the pyramid.



Dotted green lines: to fold and shape the pyramid;
Solid red lines: adhesive tapes to be used to connect adjacent inclined planes.

5. Use a mobile device to open the holographic video on YouTube.

6. Place the pyramid in the middle of the screen with the narrow (bottom) end facing down.

7. Dim the lights in the room (or place the set-up into a black box) and look through any one of the inclined planes of the pyramid in order to observe the hologram. Perform the product test.

8. See the holographic videos produced by other classmates on YouTube.

9. For similar shapes (e.g. projection pyramids of different sizes) (see diagram 9), the relations among the lengths, areas and volumes are as follows:

$$\frac{V_O}{V_P} = \left(\frac{L_O}{L_P}\right)^3$$

$$\frac{A_O}{A_P} = \left(\frac{L_O}{L_P}\right)^2$$

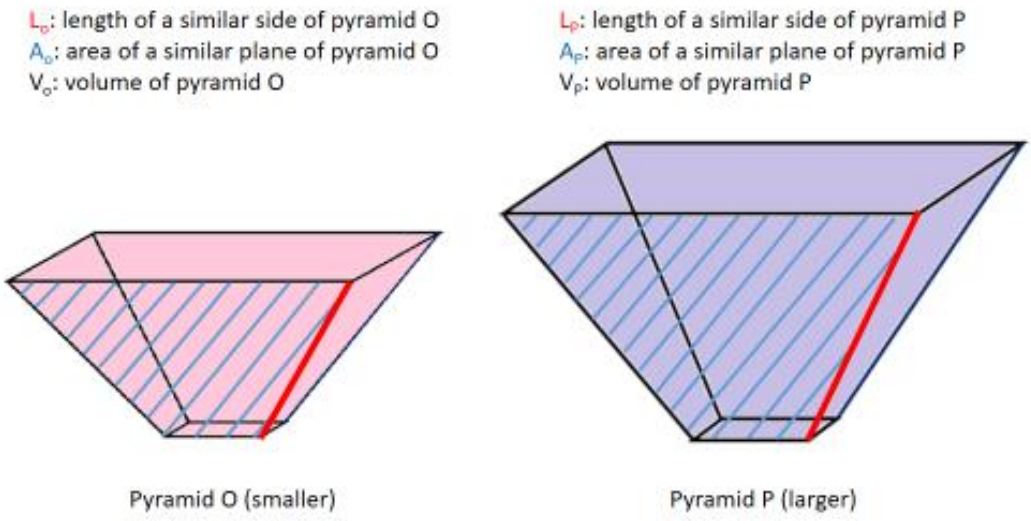


Diagram 9: Dimensions of similar pyramids

10. Calculate the volumes and areas (and similar areas) of pyramids of different sizes after measuring the lengths of their similar sides.

3.7.7 Result and Discussion

- Appreciation of other's works
- Discussion on the way of improvement of the visual effect of holographic projection
- Use of ratios to handle the relations among the lengths, areas and volumes of similar shapes

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5. Acknowledgement:

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