Jockey Club STEAM Education Resources Sharing Scheme

UV, You and We

Teachers' Guides

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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 for 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: UV, You and We

Ultra-Violet, also known as UV, is one of the radiations in the electromagnetic spectrum. Every day, our bodies continuously receive different electromagnetic radiations such as visible light and infrared from the sun in the daytime, and also UV, even though it is a cloudy day. Although UV is invisible to us, it has tremendous effects and applications in our daily life.

UV, a high-energy electromagnetic wave, is very important in our daily lives. For example, the human body can only produce Vitamin D when UV is absorbed through the skin. Nowadays, UV as a disinfectant is popularized due to the pandemic situation. Objects that cannot be disinfected by using alcohol easily, such as cell phones, remote controls, glasses or microphones, can be disinfected by UV exposure. It can also be used to drive many chemical reactions called photochemical reactions. In the laboratory, UV is commonly used for many purposes, such as visualization, detection and molecule activation.

In this module, the science of UV will be introduced. Different biological, chemical and physical applications of UV and their working mechanism will also be illustrated with examples. In the middle part, students will be guided to design and make a UV box which will be used for the later biological and chemical experiments in this module.

1.2 Participants Recommended for this Module

☐ Junior Secondary School Students (please specify: S3)
☑ Senior Secondary School Students (please specify: S4-S6)
☐ Others (please specify: _____)

1.3 Module Aims

The module "UV, You and We" aims to:

- Introduce the knowledge of physics, chemistry and biology related to UV and its applications;
- Raise students' awareness of the scientific knowledge and working principles of tools using UV in daily life;
- Provide a chance for students to make use of technology and engineering knowledge to facilitate the later biological and chemical experiments in this module;
- Advance students' application of subject knowledge and skills learned in the school curriculum of SS Biology, Chemistry and Physics.

1.4 Module Learning Outcomes

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

- Understand the nature of UV as a kind of electromagnetic radiation ;
- List out different applications of UV in daily life;
- Explain the working principles of UV in some applications by applying the physical, chemical, and biological knowledge learnt;
- Make a UV box ;
- Use the UV box in the later biological and chemical experiments.

1.5 Learning & Teaching Approach / Practice

The primary UV source of the earth is the sun. Besides emitting visible light to light up our world, invisible radiations such as infrared and UV are also released from it. Although it is invisible, humans can still use UV for many applications such as disinfection, water purification and fluorescence and lightning. In this module, the nature of UV and its science will be introduced and illustrated with real-life examples. Students will need to make their UV box which will be used for later biological and chemical experiments. This module will adopt both problem-based learning and experimental approaches to explain different observations.

After introducing all the necessary knowledge in Units 1 to 2, students would have a chance to design their UV box by using a UV lamp in Unit 3. After that, the box will be used to facilitate their experiments in Unit 4.

At the end of the module, students will increase their understanding of the STEAM-related subject matter investigated. In addition, transferrable skills such as problem-solving, creativity and critical thinking will also be enhanced.

1.6 Nature of STEAM Activity

Element	Description	Composition
Science	The nature of UV, electromagnetic radiation, wavelength, UV used by nature, fluorescence	✪✪✪✪✪
Technology	Disinfectant UV tools and UV apparatus used in the laboratory	✪✪✪✪
Engineering	DIY UV-box	✪✪✪✪
Arts	Design of the UV-box	✪✪✪
Mathematics	The wavelength, frequency, energy, calculation of reagents used in the experiment	✪✪

1.7 Mapping of Key Learning Areas (KLAs)

Unit	Science Education	Technology Education	Mathematics Education	Arts Education
1	◆ Wave motion (SP3.1.1) ◆ Wave motion (SP3.1.2) ◆ Wave nature of light (SP3.2.6) ◆ Fluorescence ◆ Electromagnetic spectrum (SJ14.7) ◆ EM radiation as a carrier of energy (SS7.2.1)	◆ Radio ◆ Microwave oven ◆ IR thermometer ◆ Calibration method		
2	◆ Contribution of analytical chemistry to our society (SC15.5) ◆ Diseases (SB4.2) ◆ Microbiology (SB7.1) ◆ Harmful effects of microorganisms (SB7.4) ◆ Water purification (SJ2.3) ◆ Further treatment of drinking water (SJ2.4) ◆ UV used by nature ◆ Nutrition in humans (SB3.2) ◆ Fluorescence	◆ UV disinfection ◆ UV used in forensic science		

Unit	Science Education	Technology Education	Mathematics Education	Arts Education
3	◆ Circuits and domestic electricity (SP4.2.4) ◆ Circuits and domestic electricity (SP4.2.5)	◆ Production Process (TK6.2)		◆ Design of the UV-box
4	◆ Separation and purification methods (SC15.2) ◆ Instrumental analytical methods (SC15.4) ◆ Techniques in modern biotechnology (SB8.1) ◆ Laboratory equipment and basic practical skills (SJ1.4) ◆ Dissolving (SJ2.2)	◆ Tools and Equipment (TK5.2) ◆ UV apparatus in Laboratory	◆ Using percentages (MJ5.1, 5.2) ◆ Rates, ratios and proportions (MJ6.1, 6.2)	

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	The Nature of EM Radiation	120 mins
2	UV, You and We	120 mins
3	DIY UV-box	120 mins
4	UV in Laboratory	120 mins
	Total	**8 hours 00 mins**

*Remark: A total of **1.5** non-contact hours of the module is recommended.*

2 Module Design

Electromagnetic radiations such as radio waves, microwaves, infrared, and visible light, are well-known and commonly used in our daily life. We listen to the radio, heat food using a microwave oven and check our temperatures using an infrared sensor. However, we seldom hear tools that make use of ultraviolet (UV) light. Is it not useful at all or do we just miss it?

In this module, the science of UV will be introduced. Different biological, chemical and physical applications of UV, such as disinfection, water purification and fluorescence and lightning, and their working mechanism will also be explained. In the middle part of it, students will be guided to design and make a UV-box which will be used for the later biological and chemical experiments in this module.

Students are expected to learn basic knowledge of the nature of electromagnetic radiation and its applications. Unit 1 will familiarise students with the nature of electromagnetic radiation, such as the wavelength, frequency and energy of a wave. Different types of EM radiation and their applications will be mentioned and explained.

In Unit 2, the unique features of UV radiation and its applications, such as UV disinfection tools, water purification, fluorescence and lightning, will be introduced together with their design and working mechanisms.

In Unit 3, students will be guided to make and design a DIY UV-box. The box can be used for object disinfection, and its effectiveness could be tested using a convenient bacteria-checking method called ATP-bacteria test. The box will also be used for the later biological and chemical experiments in Unit 4 for viewing some UV-active molecules.

In Unit 4, one biological experiment related to DNA and gel electrophoresis will be introduced. Students are expected to prepare an agarose gel and add the DNA molecules into it by using an auto-pipette. Finally, the DNA molecules in the gel will be visualized by using the DIY UV-box. Another chemical experiment related to thin-layer chromatography will also be demonstrated. Students are expected to use a piece of thin-layer chromatography to check the completeness of a chemical reaction which is a very common but useful technique for performing chemistry research. Finally, the UV-active molecules on the thin layer chromatography will be visualized by using the DIY UV-box.

2.1 Unit 1: The Nature of EM Radiation

In Unit 1, the nature and different features such as wavelength, frequency and energy of electromagnetic (EM) radiation will be introduced and illustrated with real-life examples and applications. This unit would familiarise students with the physics of EM radiation which is necessary for them to understand the next unit.

2.1.1 Objectives

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

- Understand the concepts of electromagnetic radiation
- Identify corresponding wavelengths and frequencies of different electromagnetic radiations
- List out the applications of different electromagnetic radiations
- Briefly explain the working mechanisms of the applications

2.1.2 Pre-requisite (if appropriate)

Nil.

2.1.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction: ◆ Arouse students' interest in relevant real-life issues. ◆ To explain the learning objectives of this unit.	10 mins	◆ PowerPoint slides
(2) The nature of electromagnetic radiation: ◆ To introduce the definition of electromagnetic radiation ◆ To introduce different features of EM radiation	15 mins	◆ PowerPoint slides
(3) The applications of EM radiation ◆ Radio ◆ Microwave oven ◆ Temperature sensor	40 mins	◆ PowerPoint slides
(4) The details of the applications: ◆ To briefly mention the working mechanisms of them ◆ To explain why a specific EM radiation is used for each application	45 mins	◆ PowerPoint slides
(5) Debriefing: ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	10 mins	◆ PowerPoint slides ◆ Notes
Total	**120 mins**	

2.1.4 Assessment (if appropriate)

- Student's knowledge of the nature of EM radiation will be assessed through polling and multiple-choice questions
- Student's knowledge of the science behind each application of EM radiation will be assessed through multiple-choice and short questions
- Overall students' participation would be reviewed

2.2 Unit 2: UV, You and We

After acquiring some basic knowledge of EM radiation, students would start to learn the applications of EM radiation, especially UV, in daily life. Electromagnetic radiation, such as radio waves, microwaves, infrared, and visible light, are well-known and commonly used around us. We listen to the radio, heat food by using the microwave oven and check our temperatures by using an infrared sensor. How about UV radiation?

In Unit 2, the unique features of UV and its applications, such as fluorescence, production of vitamin D, UV disinfection tools, and water purification, will be introduced together with their working mechanisms. How the unique features of UV radiation are utilized for different purposes will be shown so that students will be further familiarized with the nature of UV radiation.

2.2.1 Objectives

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

- Understand the unique features of UV radiation
- List out different applications of UV radiation
- Describe briefly the working mechanisms of each application introduced
- Explain why UV is used for the corresponding applications

2.2.2 Pre-requisite (if appropriate)

Nil.

2.2.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction: ◆ To recap major ideas from the previous lesson ◆ To assess students' prior knowledge ◆ To explain the learning objectives of this lesson	10 mins	◆ PowerPoint slides

Description	Duration (hr/min)	Resources
(2) Different applications of UV radiation: ◆ Working mechanisms and usages of each of them ◆ Fluorescence ◆ Production of vitamin D ◆ UV disinfection tools ◆ Water purification ◆ UV disinfection box	80 mins	◆ PowerPoint slides
(3) The unique features of Ultra-violet radiation: ◆ Frequency ◆ Energy ◆ Penetration power	20 mins	◆ PowerPoint slides
(4) Debriefing: ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	10 mins	◆ PowerPoint slides ◆ Notes
Total	**120 mins**	

2.2.4 Assessment (if appropriate)

- Student's knowledge and understanding of the working principles, scientific explanations and the corresponding features of UV radiation will be assessed through polling and multiple-choice questions
- Overall students' participation would be reviewed

2.3 Unit 3: DIY UV-box

In Units 1 and 2, students have been familiarised with the nature and some unique properties of EM radiation. Real-life examples such as radio, infrared temperature sensors and UV disinfection tools have also been introduced together with working mechanisms and scientific knowledge. In this unit, students are provided with a chance to make their own EM radiation application called UV-box. This box is simply made of a UV lamp and an A4 paper box. However, students are required to design the structure of the box so that it would be convenient to use. The box can be used as a disinfection tool for objects such as cell phones, keys and wallets and also be used in the later biological and chemical experiments in Unit 4.

2.3.1 Objectives

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

- List out the unique properties and types of UV
- Make a DIY UV-box
- Design the DIY UV-box
- Pay attention to the safety issues of using UV radiation

2.3.2 Pre-requisite (if appropriate)

Nil.

2.3.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction: ◆ To recap knowledge of the previous lessons ◆ To explain the learning objectives of this lesson	5 mins	◆ PowerPoint slides
(2) The unique features of UV: ◆ To list out the unique features of UV ◆ To explain how its unique features can be utilized for disinfection and fluorescence purposes	10 mins	◆ PowerPoint slides
(3) DIY UV-box: ◆ To brief students on the safety issues of using a UV lamp ◆ To guide the students in making the box ◆ To encourage students to create and design the structure of their own UV-box	105 mins	◆ PowerPoint slides
(4) Debriefing: ◆ To review the knowledge covered in this lesson ◆ To briefly introduce the next lesson	10 mins	◆ PowerPoint slides ◆ Notes
Total	**130 mins**	

2.3.4 Assessment (if appropriate)

- Student's performance will be assessed through the session
- Overall students' participation would be reviewed

2.4 Unit 4: UV in Laboratory

In order to have a comprehensive understanding of the science of EM radiation, especially UV, students will complete three different biological and chemical experiments in this unit with the aid of their DIY UV box. Students equipped with scientific knowledge introduced in Units 1, 2 and 3 should be able to handle and finish the experiments.

In Unit 4, students will use their UV box to disinfect objects such as cell phones, keys or glasses. After that, a biological test called the ATP-bacterial test will be used to check the disinfection effectiveness of the UV box. Since the UV apparatus is usually used as a viewing device to visualize any UV-active molecules, one biological experiment about

gel electrophoresis and one chemical experiment about thin-layer chromatography will be introduced to the students in this unit. The box will be used to visualize UV-active molecules on the agarose gel and the thin-layer chromatography.

2.4.1 Objectives

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

- Use the DIY UV box for disinfection and visualization purposes
- Conduct the ATP-bacteria test
- Conduct gel electrophoresis
- Use thin-layer chromatography

2.4.2 Pre-requisite (if appropriate)

Nil.

2.4.3 Description of Activity

Description	Duration (hr/min)	Resources
(1) Introduction: ◆ To recap knowledge of the previous lessons ◆ To explain the learning objectives of this lesson	10 min	◆ PowerPoint slides
(2) Safety instruction: ◆ To brief students on the safety issues of using different chemical reagents	10 min	◆ PowerPoint slides
(3) Experiment section 1: ◆ Experiment 1) ATP-bacterial test ◆ To brief students on the procedures of the experiment ◆ To guide students to finish the experiment	30 min	◆ PowerPoint slides ◆ Activity 1
(4) Experiment section 2 or 3: ◆ Experiment 2) Gel electrophoresis ◆ Experiment 3) Thin layer chromatography ◆ To brief students on the procedures of the experiment ◆ To guide students to finish the experiment	60 min	◆ PowerPoint slides ◆ Activity 2 or 3
(5) Debriefing: ◆ To review the knowledge covered in all units	20 min	◆ PowerPoint slides ◆ Notes
Total	**130 min**	

2.4.4 Assessment (if appropriate)

- Student's scientific knowledge and understanding of the experiment will be assessed through polling and multiple-choice questions
- Student's laboratory performance will be assessed through the laboratory session
- Overall students' participation would be reviewed

3 Resources

3.1 Resources for Unit 1

- Teachers' Guide
- PowerPoint slides
- Notes

3.2 Resources for Unit 2

- Teachers' Guide
- PowerPoint slides
- Activity book
- Notes

3.3 Resources for Unit 3

- Teachers' Guide
- PowerPoint slides
- Online videos
- Activity book
- Notes

3.4 Resources for Unit 4

- Teachers' Guide
- PowerPoint slides
- Activity book
- Notes

4 References

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5 Project Team

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