Jockey Club STEAM Education Resources Sharing Scheme

Wind Powered Car

Teachers' Guide

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School of Science and Technology
Hong Kong Metropolitan University

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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 aimed 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 integrate knowledge and skills across Science, Technology, Engineering, Arts and Mathematics under real-world contexts.

1. Module Outline

1.1 Module Title: Wind Powered Car

There is an interesting science question that has been debated over a decade: Can any wind powered car can go faster than the wind itself that is pushing the car? The answer was eventually unveiled in 2021.

Throughout this module, students will not only understand the working principles but also learn how to evaluate the performance of the wind powered car.

The module is compiled with the following 2 units,

- Unit 1 - Design and build a wind powered car
- Unit 2 - Investigate the different designs on the performance of the wind powered car

1.2 Participants Recommended for this Module

☑ Junior Secondary School Students
☐ Senior Secondary School Students
☐ Others (please specify:_____)

1.3 Module Aims

The module "*Wind Powered Car*" aims to:

- Design and build a wind powered car
- Study the working principles of wind powered cars
- Evaluate the design on the performance of a wind powered car

1.4 Module Learning Outcomes

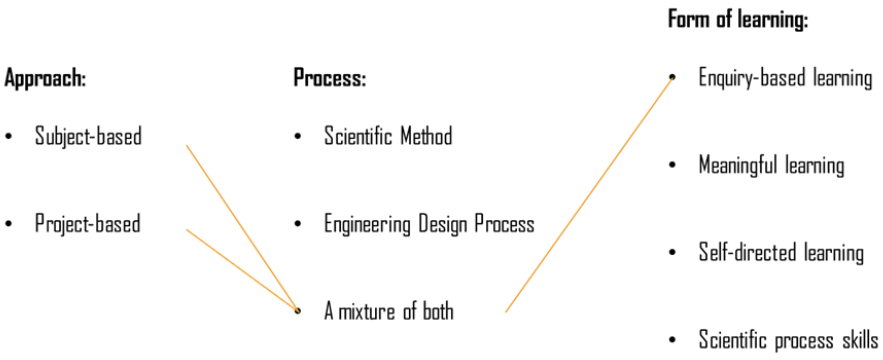
Upon the completion of the module, students should be able to:

- *Describe* Newton's 3rd law
- *Demonstrate* how to evaluate the performance of the wind powered car
- *Identify* the factors affecting the performance of the wind powered car

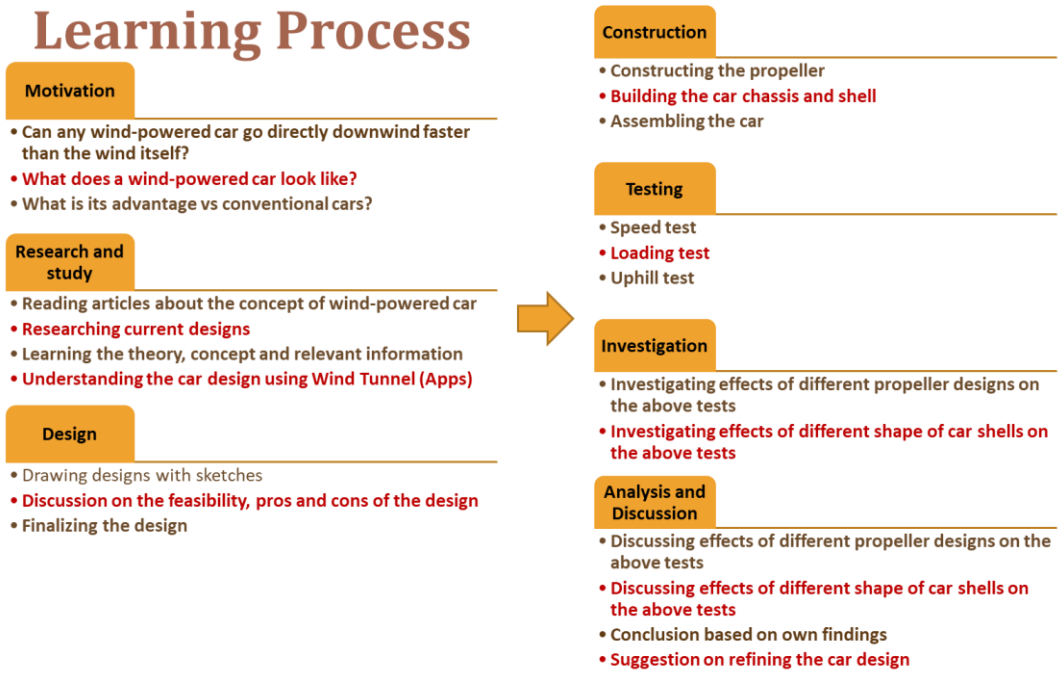
1.5 Learning & Teaching Approach / Practice

This module can be implemented using either a subject-base or project-based approach. The learning process combines both the scientific method and the engineering design process. Students will acquire knowledge through the form of enquiry learning.

The class design flowchart is illustrated below:



The learning process is described below.



The elements for enquiry learning are listed below:

Process	Element	
Ask	Motivation	Can any wind-powered car go directly downwind faster than the wind itself? What does a wind-powered car look like? What is its advantage vs conventional cars?
Investigation	Research and study	Understanding the car design using Wind Tunnel
	Investigation	Investigating effects of different propeller designs on the above tests Investigating effects of different shape of car shells on the above tests
Discuss	Design	Discussion on the feasibility, pros and cons of the design
	Analysis and Discussion	Discussing effects of different propeller designs on the above tests Discussing effects of different shape of car shells on the above tests
Conclude	Analysis and Discussion	Conclusion based on own findings
Reflect	Design	Finalizing the design
	Analysis and Discussion	Suggestion on refining the car design

1.6 Nature of STEAM Activity

Element	Description	Composition
Science	● Apply the concepts of energy transfer, force and motion ● Outline some basic circuit design ● Identify the four forces (Thrust, Drag, Lift and Weight)	✪✪✪
Technology	● Use digital technology for the design process ● Choose suitable materials and resources and apply common tools and equipment for the production process	✪✪✪
Engineering	● Build electronic circuits ● Apply the engineering design process to build the model	✪✪
Arts	● Use sketching, drawing, information technology or other appropriate tools and resources to stimulate and develop ideas	✪
Mathematics	● Organise and present data	✪

1.7 Mapping of Key Learning Areas (KLAs)

Unit	Science Education	Technology Education	Mathematics Education	Arts Education	Others
Units 1	SJ5.1-5.3 Energy SJ8.1-8.4 Making use of electricity SP2.1.1-2.1.6 Position and movement SP2.2.1-2.2.4 Force and motion SP4.2.4-4.2.6 Circuits and domestic electricity	TK3.1-3.3 Materials and Resources TK5.5-5.8 Tools and equipment TK6.1-6.5 Production Process Wind tunnel apps	MJ28.1-28.3 Organisation of data MJ29.1-29.7 Presentation of data	Developing Creativity and Imagination	

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	Design and build a wind powered car	2.5
2	Investigate the different designs on the performance of the wind powered car	1.5
	Total	**4 hours**

Remark: A total of 4 non-contact hours of the module are recommended.

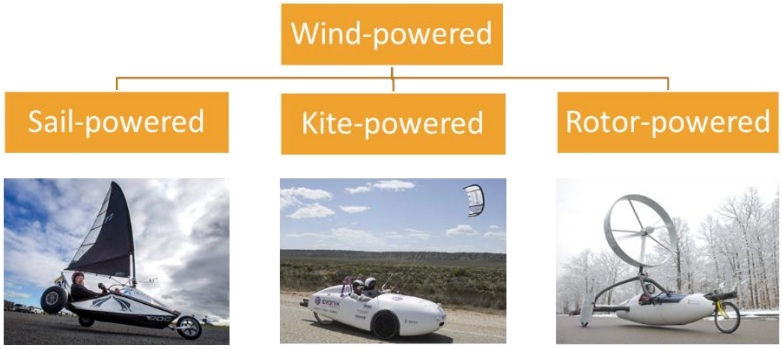
1.9 Thematic Area

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

2. Module Design

2.1 Unit 1: Design and build a wind powered car

Wind powered cars can be mainly classified into 3 types based on their wind harvesting methods. They are sail powered, kite powered and rotor powered respectively.



Instead of using nature wind, here we demonstrate the use of an electrically powered motor to generate wind and drive the car. Students will have to use Wind Tunnel app to design the car shell and understand its effects on drag and lift. Students will also need to design their own propeller and evaluate how it affects the performance of the car.

2.1.1 Objectives

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

- *Identify the four forces (thrust, drag, lift, and weight)*
- *Illustrate how the shape of the car will affect the drag and lift using Wind Tunnel app*
- *Describe Newton's 3rd law*

2.1.2 Pre-requisite (if appropriate)

Nil

2.1.3 Description of Activity

Description	Duration (hr/min)	Resources
Introduction • Initiating motivation by raising a question: Can any wind-powered car can go faster than the wind itself that is pushing the car?	15 min	PPT(1) Video
Research and study	30 min	PPT(1)

• Reading and finding information about wind powered cars (home task) • Introducing the four forces and the criteria to design a car • Explain the working principles for a rotor powered car and Newton's 3rd law		Wind Tunnel app
Build a wind powered car • Draw the car design • Build the chassis, circuit, car shell, propeller and assembly • Testing	1 hr 30 min	PPT(1)
Summary	15 min	PPT (1)
Total	2.5 hours	

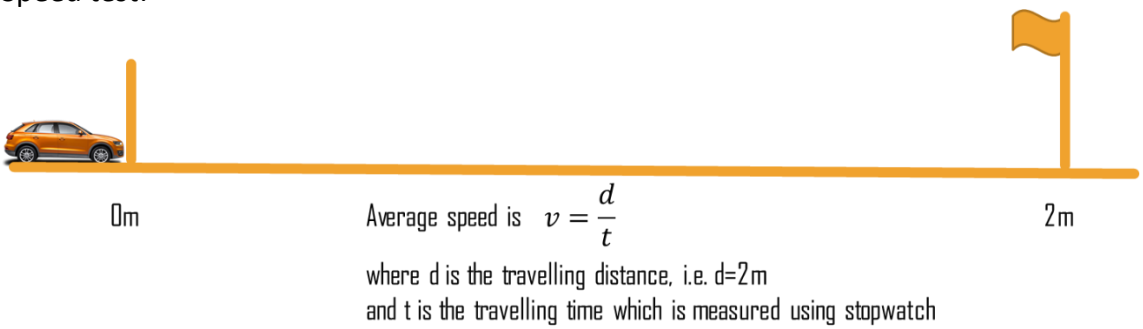
2.1.4 Assessment (if appropriate)

A worksheet for understanding Newton's 3rd law
A worksheet for designing the car shell using the Wind Tunnel app

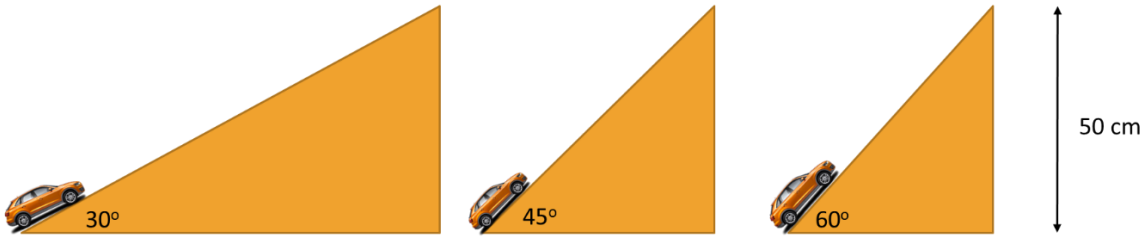
2.2 Unit 2: Investigate the different designs on the performance of the wind powered car

After building a wind powered car, the performance can be evaluated using a speed test and an uphill test. The teacher can decide to choose either one or both tests for their needs. A speed test can be used to evaluate the effect of both car shelsl on the drag and propeller on the thrust. An uphill test can be used to evaluate the effect of a propeller on the thrust.

Speed test:



Uphill test:



For the speed test, we measure the time for a car to pass the destination. For the uphill test, we can place the car on an uphill road with a different tilt angle respectively. If the car can reach the top then it passes the test.

2.2.1 Objectives

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

- Describe how the car shell affects the drag and hence the speed of a car
- Recognize the propeller can affect the thrust and hence the speed and uphill ability

2.2.2 Pre-requisite (if appropriate)

Nil

2.2.3 Description of Activity

Description	Duration (hr/min)	Resources
Introduction • Present the methodology to investigate the car performance	15 min	PPT (1)
Perform the speed test	30 min	PPT (1)
Perform the uphill test	30 min	PPT (1)
Summary	15 min	PPT (1)
Total	1.5 hours	

2.2.4 Assessment (if appropriate)

- A worksheet for investigating car performance

3. Resources

3.1 Resources for Unit 1 – Design and build a wind powered car

- PPT (Unit 1);

3.2 Resources for Unit 2 – Investigate the different designs on the performance of the wind powered car

- PPT (Unit 2);

4. References

Curriculum Development Council & Hong Kong Examinations and Assessment Authority (2007). *Mathematics Education Key Learning Area:* Mathematics - *Curriculum and Assessment Guide (Secondary 4 - 6)*. Hong Kong: Government Logistics Department. Retrieved November 8, 2013, from http://334.edb.hkedcity.net/doc/eng/math_final_e.pdf

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5. Acknowledgement

6. Project Team

Jockey Club STEAM Education Resources Sharing Scheme, Hong Kong Metropolitan University