

## STEM.ORG Certification

### Capstone Project

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## STYROFOAM BOAT RACE @ school's swimming pool

### Lesson Plan

Duration: **50 minutes**

#### Notes:

- This 50-minute lesson plan is part of a Project-Based Learning for Cambridge O Level Physics students where they are expected to apply knowledge and understanding of force, energy, work, and power while introducing the concept of efficiency. The STEM lesson aims to integrate Technology, Engineering, Art, and Mathematics.
- Prior to this lesson, a session has already been conducted where students [design and construct their boats](#) using only the materials provided.
- Also prior to this lesson, the boat race has already been held where students record data and observation.
  - video-captured boat lunch
  - total mass of boat
  - distance and time the boat traveled
- The class is divided into 3 groups corresponding to which house i.e. Red Lion, Green Rhino, and Blue Eagles. The distribution of members of houses done at the beginning of the school year is based on the equal share of members in each year level and students' talents and skills.
- The Physics class which this lesson plan is intended to has no record of autism and any other issues that could affect their participation.

Desired outcomes	<p><b>For the <a href="#">O Level Physics 5054 syllabus</a></b></p> <ul style="list-style-type: none"><li>• Calculate speed from the gradient of a distance–time graph</li><li>• Recall and use the equation<math display="block">\text{resultant force} = \text{mass} \times \text{acceleration}</math><math display="block">F = ma</math></li><li>• Recall and use the equation<math display="block">\text{work done} = \text{force} \times \text{distance moved in the direction of the force}</math><math display="block">W = Fd</math></li><li>• Recall and use power as work done per unit time and also as energy transferred per unit time.</li><li>• Define and use efficiency as:<ul style="list-style-type: none"><li>◦ (a) (%) efficiency = (useful energy output) / (total energy input) ( × 100%)</li><li>◦ (b) (%) efficiency = (useful power output) / (total power input) ( × 100%)</li></ul></li></ul> <p><b>For the <a href="#">O Level Mathematics 4024 syllabus</a></b></p> <ul style="list-style-type: none"><li>• Interpret and use graphs in practical situations including travel</li></ul>
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	<p>graphs and conversion graphs</p> <ul style="list-style-type: none"> <li>• Draw graphs from given data</li> <li>• Apply the idea of rate of change to easy kinematics involving distance–time and speed–time graphs, acceleration and deceleration</li> </ul> <p><b>For Engineering and Art Skills</b></p> <ul style="list-style-type: none"> <li>• Design and construct a boat using the only the materials provided</li> <li>• Decorate the constructed boat using their house emblem as the theme</li> </ul>
Related requirements	<p>As explained in <b>Notes</b> above, groups have already done the following:</p> <ul style="list-style-type: none"> <li>• design and construction of the boat, 50-minute session</li> <li>• testing their boats with other groups &amp; gathering data for this lesson, 50-minute session</li> </ul>
Lesson materials	<p>The materials for this lesson are the following:</p> <ul style="list-style-type: none"> <li>• laptop [can also be conducted in ICT laboratory] with installed spreadsheet app e.g. Microsoft Excel</li> <li>• data gathered from the boat race i.e. figures and video</li> <li>• all the boats built by the groups</li> </ul>
Lesson procedure	<p><b>Recap</b></p> <p>Teacher asks students to recap the previous activities. Each group/house will share all or any of the following:</p> <ul style="list-style-type: none"> <li>• What do they feel about the boat race?</li> <li>• What data they needed to obtain and how?</li> <li>• Who won the race and why do they think they did?</li> </ul> <p><b>Link/Connection and Objective of the Session</b></p> <p>Teacher tells students that their observation and the data gathered during the race will be used, by them, to determine the winner of the event i.e. the most efficient styrofoam boat.</p> <p><b>Lesson proper</b></p> <p><i>Group work with spreadsheets</i></p> <ul style="list-style-type: none"> <li>• Each group/house will be given data recorded by other groups.</li> <li>• Using a spreadsheet app, the group creates a table of measured quantities they got from the previous session. <ul style="list-style-type: none"> <li>○ Table columns are Force/newton, Distance/metre, Work/joule, Time/second, Output power/watt, Input power/watt</li> <li>○ They have done the video-capture and measurements 3 times and so must realize that they need to take the average. <ul style="list-style-type: none"> <li>■ 5-metre race</li> <li>■ 10-metre race</li> </ul> </li> </ul> </li> </ul>

	<ul style="list-style-type: none"> <li>■ 20-metre race <ul style="list-style-type: none"> <li>○ For the Force/newton, students will use the captured videos to determine the acceleration [may use graph or just mathematical equations] and multiply by the mass of the boat.</li> </ul> </li> <li>● Based on the tables/graphs, each group will tell which group is the most efficient. They need to explain why.</li> </ul> <p><b>Conclusion</b> Teacher discusses efficiency and relates the concept to groups' explanations on which boat they think was the most efficient.</p>
Assessment method	<ul style="list-style-type: none"> <li>● Group Reflection Each group will reflect on how they could improve their boat if they are to participate in the same race again.</li> <li>● Peer assessment of design Each group to give constructive criticism of the other groups' boats i.e. what could be done to increase the efficiency of a boat</li> </ul>
Homework	Think of a situation where efficiency is very important. Situations can be about an industry, a machine, etc. and suggest a way to increase its efficiency.
Lesson reflection	Teacher reflects or self-assesses the execution of the lesson plan using the STEM Checklist [see the next table].

#### STEM Lesson Checklist, Teacher's LP, and Reflection [after the activities]

STEM concepts	Inclusion in LP	Reflection
Aligned to Cambridge Syllabus 5054 Physics	The lesson is to be conducted within Physics class time and should be taught with learning objectives [LO] from the syllabus.	
Multidisciplinary	<p>The lesson integrates technology, engineering, and mathematics to the Physics activity. Arts integration is also expected in the completed project.</p> <ul style="list-style-type: none"> <li>● Technology <ul style="list-style-type: none"> <li>○ Spreadsheets e.g. Microsoft Excel or Google Sheets for analysis of data</li> <li>○ Deducing the time from video captured during the race</li> </ul> </li> <li>● Engineering <ul style="list-style-type: none"> <li>○ Groups will be constructing a</li> </ul> </li> </ul>	

	<p>styrofoam boat from limited materials.</p> <ul style="list-style-type: none"> <li>● Mathematics <ul style="list-style-type: none"> <li>○ Calculations relative to power, work, and energy are needed.</li> <li>○ Interpretations of graphs require mathematical skills.</li> </ul> </li> <li>● Arts <ul style="list-style-type: none"> <li>○ Groups are to decorate their boats to add excitement to the race. This is included in the grading rubric for the project.</li> </ul> </li> </ul>	
Addresses Authentic Challenges	The method for this STEM lesson is Project-Based Learning where students in groups will address a challenge expected to showcase their creativity, develop critical thinking, and apply knowledge learned in Physics class and other subjects.	
Integrates 21st Century Skills	The lesson encourages students to develop creativity, critical thinking, problem solving, and teamwork.	
More Than One Solution	Though student-groups are given the same materials, the project can be done in many different ways/designs..	
Uses the Engineering Design Process	Since the materials are limited, groups have to do brainstorming so as not to waste any material in implementing their designs of the project.	
Hands-On	The lesson requires groups to construct the project. Each member is expected to manipulate the materials to fit their design.	
Integrates Technology	<p>Microsoft Excel or Google Sheets can be used to speed up the analysis of data from the boat race.</p> <p>Accuracy in measurement is expected to be better when analyzing motion of objects captured via video as compared to having measurements in real time.</p>	