PHYSICS
AT WORK
for HKDSE

STEM WORKSHEETS

Sample

- **Teaching notes** and **worksheets** provided
- **Word files** available on OUP web:

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Contents (sample)

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Introduction (To teachers)

The worksheets are provided for STEM projects. There are Teacher's version and Student's version. The Teacher's version provides more details about the tasks and helps teacher to guide students through the working process. Teachers may score students' works to appreciate the effort they paid. The sample scoring rubrics specially designed for each worksheet are here to serve this purpose. The Student's version provides a clear workflow to assist them through the process step by step and help them to evaluate their performances.

Before start, teachers may brief students and hold a warm-up discussion on the task. The project guides below may be helpful in kicking off the briefing. Some suggested topics are provided in the worksheet to facilitate the discussion. After the task is done, teachers may hold a wrap-up discussion. Some suggested topics are also provided in the worksheet to facilitate the discussion.

Project guides

How to start: steps to complete the STEM project

STEM projects always involve designing, building, and testing something. The process in doing STEM projects is quite different from doing experiments. You may follow the steps below to complete the STEM project.

1 Define the problem

2 Do background research

3 Specify requirements

4 Brainstorm solutions

5 Choose the best solution

6 Draft a proposal and present it to your teacher and classmates for comments

7 Revise the solution according to comments received

8 Do development work

9 Build a prototype

10 Test and improve

11 Present your final product

The project worksheets are designed according to the above steps. Students may follow the instructions in the worksheets to complete the assigned tasks in a well-planned framework.

Student's version

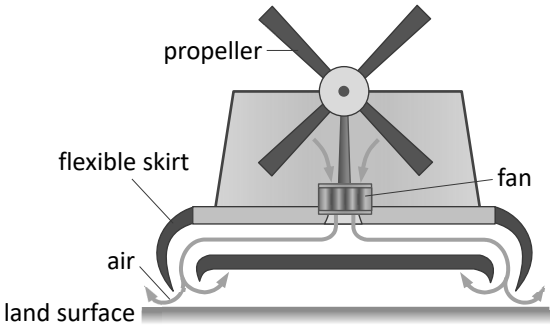
Book 2 Force and Motion

Project: Model hovercraft

Group: _____

Part 1: Introduction

A hovercraft is a vehicle that can travel on a surface of water or land. While moving, it blows air downwards to produce an air cushion. This greatly reduces the friction acting on it. It also blows air backwards to drive itself forwards.



♦ **Scenario**

Suppose you are a toy designer. You are asked to invent a toy hovercraft that can be made by using recycled materials. The toy should be able to travel on a flat surface and move straight.

♦ **Background knowledge**

Identify what physical concepts should be applied in designing the toy hovercraft.

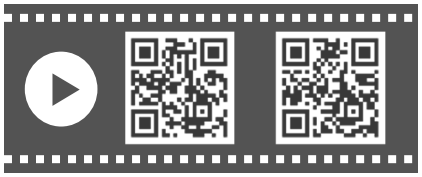
1 The air cushion reduces the friction between the hovercraft and the land surface. With the same propelling force, a (greater/smaller) acceleration and a (higher/lower) maximum speed can be reached.

2 The materials used should be (heavy/light) so that the hovercraft is able to be lifted up and can move forwards more easily. By Newton's second law, a (smaller/larger) mass has a greater acceleration when the pushing force is unchanged.

3 There should be a fan to drive the hovercraft forwards. By Newton's (second/third) law, when the hovercraft exerts a force to push air backwards, the air in turn exerts a force to push the hovercraft forwards.

Part 2: Design and make (I)

Write down your proposal below to show how your toy hovercraft is made and state its working principle. You may look at the following references to get some ideas before you start.



♦ **Material list**

♦ **Procedure**

When you think your proposal is fine enough, you may present it to the class and get comments. In the following space, write down the comments that are useful. Determine how your design should be revised accordingly.

♦ **Comment**

Part 3: Design and make (II)

Now, you may turn your idea into a product. Make your own hovercraft according to your finalized proposal. Take a photo of your product and attach it in the space provided.

♦ **My product**

Write down the working principle of your toy hovercraft. Draw a diagram if needed.

♦ **Working principle**

Part 4: Test and assessment

Test whether your toy hovercraft works normally. Design suitable methods to assess the performance of your toy hovercraft and record the results in the following table. Suggest what can be done to improve the performance. Some assessment areas are suggested for your reference.

Assessment area	Comment	Improvement
(a) Travelling speed		
(b) Travelling distance		
(c) Stability (how well the hovercraft can travel in a straight line when it is not disturbed)		
(d) Energy consumption		

Part 5: Improvement

Try to improve your design according to your assessment result.

Teacher's version

Book 2 Force and Motion

Project: Making a hovercraft

Difficulty	★★★ (hard)
Time required	3 weeks
Grouping	4 students

♦ **Suggested workflow**

Set a schedule to let students know what they should do at each stage.

	Attainment
Part 1	**Introduction** • Teacher facilitates a warm-up discussion and help students to do a revision on the related basic knowledge. • Each group does research and designs the prototype.
Part 2	**Design and make (I)** • Each group presents the design to the class and gets comments from teacher and other groups. • Each group modifies their design if necessary.
Part 3	**Design and make (II)** • Each group makes the prototype. Regular meetings with teachers for progress update and advice seeking are recommended.
Part 4	**Test and assessment** • Each group tests whether their prototype works normally and makes modification if necessary. • All groups gather and assess the performance of their own prototype as well as other groups' prototypes. • Teacher facilitates a wrap-up discussion.
Part 5	**Improvement** • Each group prepares an improved model. Test and assessment are done as in Part 4. • Teacher may facilitate another wrap-up discussion if necessary.

♦ **Warm-up discussion**

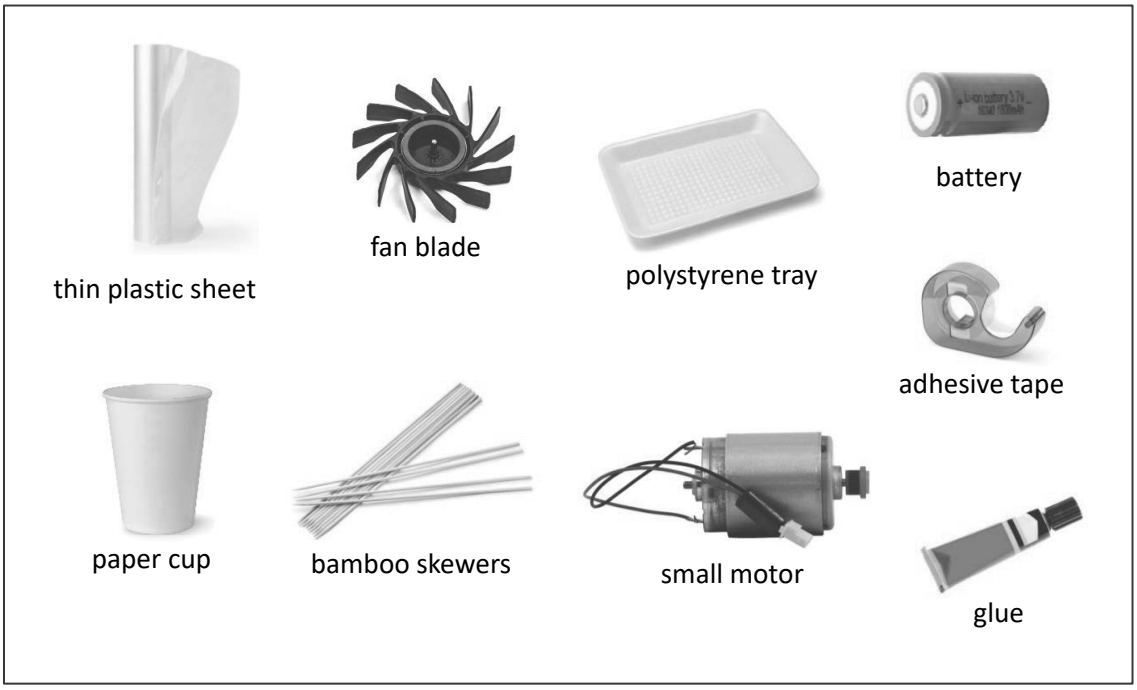
Teachers may hold a warm-up discussion before the project starts.

Suggested topics:

- How can an air cushion be produced under the toy hovercraft?
- How can the uplifting force be provided?
- How can the propelling force be provided?
- What are the factors affecting the uplifting force of the toy hovercraft?
- What are the factors affecting the speed of the toy hovercraft?
- What properties should the materials used to make the body of the toy hovercraft have?
- What materials should be used to make the body of the toy hovercraft?
- How can you keep the toy hovercraft balance while it is moving?
- How can the toy hovercraft be powered?
- How can the toy hovercraft keep moving forwards along a straight line?
- What criteria should be set to judge whether the toy hovercraft is built successfully?

♦ **Suggested design and procedure for a simple model**

A Material list



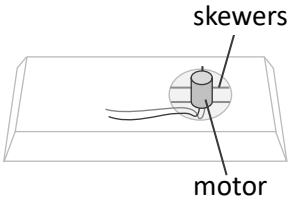
Note:

- Small motor can be obtained from handheld electric fan, electric toothbrush, etc. Motor with larger power rating is preferred.
- Fan blade can be obtained from computer fan, handheld fan, fly wheel toy, etc.

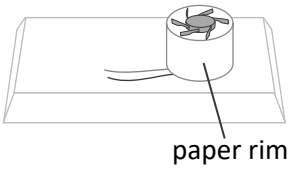
B Procedure

1 On the polystyrene tray, cut a hole with a size just bigger than the fan blade.

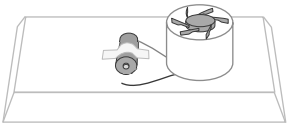
2 Fix the motor in the hole with skewers and glue.



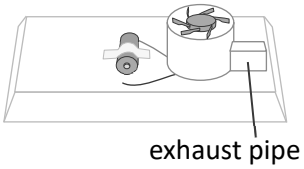
3 Attach the fan blade to the motor. Cut a rim from the paper cup and glue it on the tray to surround the fan blade. The rim serves as an intake and therefore it should be taller than the fan blade.



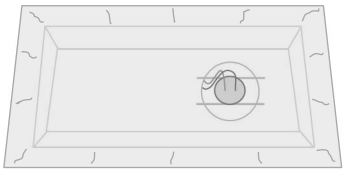
4 Fix the battery on the tray with tape.



5 Cut a small opening at the side of the paper rim. Make an exhaust pipe at the opening.

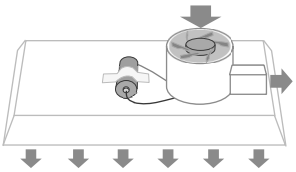


6 To make the skirt of the hovercraft, add glue to the edge of the tray and seal the tray with thin plastic sheet.



7 Cut away any extra sheet. Use a skewer to punch some tiny holes on the sheet.

8 Connect the wires of the motor to the battery. The fan should turn, and air should be drawn from the intake. A basic toy hovercraft is produced.



Safety precaution:
Prevent the conducting parts of the electrical circuits from getting wet.

Note:
Test the hovercraft on a flat smooth surface. Use a stronger fan or battery of higher voltage if the hovercraft cannot be lifted up. Adjust the exhaust pipe if the hovercraft cannot move forwards in a straight way.

♦ **Suggested testing method**

1 Set up lanes using tapes on a flat surface.

2 Measure the longest distance travelled *d* and the time taken *t*.

3 Calculate the speed of the hovercraft using the formula $\frac{d}{t}$.

♦ **Wrap-up discussion**

Teachers may hold a wrap-up discussion at the end of Part 4.

Suggested topics:

- Does the toy hovercraft move smoothly? Do you need to increase the force for lifting or propelling the hovercraft?
- Does the toy hovercraft move along the correct direction? How can you prevent it from turning uncontrollably?
- The mass of the toy hovercraft is a determining factor. How would you modify your toy hovercraft in order to produce larger forces without increasing the mass significantly?
- What was the greatest difficulty in designing/making the toy hovercraft? How did you solve it?
- Which part of the toy hovercraft is the best designed/made? Why?
- What are the shortages of your toy hovercraft? Why?
- Which part of the toy hovercraft can be better designed/made? Why?
- What factor is the most critical in making the toy hovercraft?
- What did you learn from this project?

♦ **Assessment checklist**

Score sheet for assessment of performance:

Assessment criteria	Score	Comments
Product design (25%)		
The design shows a good understanding of the physics involved.	/5	
The design fits the need.	/5	
The design is user friendly.	/5	
The design shows creativity.	/5	
The design shows significant improvement after adopting comments.	/5	
Materials selection (15%)		
The materials used are economical and chosen wisely.	/5	
The materials are easy to obtain.	/5	
There is little wastage and the materials used are environmentally friendly.	/5	
Product construction (20%)		
The structure of the hovercraft is stable.	/5	
The hovercraft is easy to build.	/5	
The power source and conducting parts of the hovercraft is safely insulated.	/5	
The hovercraft is durable, i.e. it can be used repeatedly.	/5	
Effectiveness (20%)		
The hovercraft can move straight forwards.	/5	
The hovercraft has steady performance.	/5	
The hovercraft is easy to turn on and off.	/5	
The hovercraft moves fast.	/5	
Scientific communication (10%)		
The written proposal is good.	/5	
The presentation is good.	/5	
Team collaboration (10%)		
Workloads are evenly shared among all team members.	/5	
All team members are actively involved in the design and construction of the hovercraft.	/5	
Final score	/100	

Student's version

Book 3B Wave Motion II

Project: Soundproof study room

Group: _____

Part 1: Introduction

Soundproofing is the act of preventing noises from entering or leaving a room. A movie theater or a music studio is often soundproofed for minimizing the disturbance. Acoustic foam, mineral wool and fiberglass are common examples of soundproofing materials.

Movie theater

Music studio

♦ **Scenario**

Hong Kong is a busy and noisy city. Noise often travels from the outside into a room. Suppose you are an interior designer. You are asked to design a soundproof study room for the children of your clients so that the children can have a quiet room for studying. The room should have at least one door and one window.

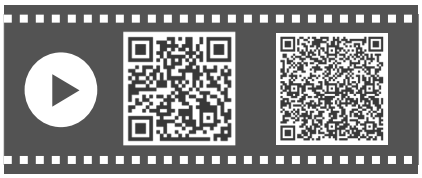
♦ **Background knowledge**

Identify what physical concepts should be applied in designing the soundproof study room.

1 When sound travels from one medium to another, it can be absorbed or reflected. The proportion depends on the properties of the medium's surface.
2 Sound carries energy. It loses some energy when travelling through a medium. The soundproofing materials should be (soft/hard) and porous so that they can absorb the sound.
3 A sound-reflecting material should be hard and smooth. It should be used on the (inner/outer) surface of the walls in a room.
4 The gaps between the wall and the door should be covered to prevent sound leakage. (Diffraction/interference) occurs when sound waves travel through a gap.

Part 2: Design and make (I)

Write down your proposal below to show how your soundproof study room model is made and state its working principle. Compare the effectiveness of materials of different types, shapes (smooth or rough) and at different positions (inner or outer surface). You may look at the following references to get some ideas before you start.



♦ **Material list**

♦ **Procedure**

When you think your proposal is fine enough, you may present it to the class and get comments. In the following space, write down the comments that are useful. Determine how your design should be revised accordingly.

♦ **Comment**

Part 3: Design and make (II)

Now, you may turn your idea into a product. Make your own soundproof study room model according to your finalized proposal. Take a photo of your product and attach it in the space provided.

♦ **My product**

Write down the working principle of your soundproof study room. Draw a diagram if needed.

♦ **Working principle**

Part 4: Test and assessment

Design suitable methods to assess the performance of your soundproof room and the effectiveness of different materials. Record the results in the following table. Suggest what can be done to improve the performance. Some assessment areas are suggested for your reference.

Assessment area	Comment	Improvement
(a) Effectiveness (how effective are the materials used for soundproofing)		
(b) Practicality (Will the design distract children from studying?)		
(c) Feasibility (Is the design applicable to a room of normal size?)		

Part 5: Improvement

Try to improve your design according to your assessment result.

Teacher's version

Book 3B Wave Motion II

Project: Soundproof study room

Difficulty	★ (easy)
Time required	2 weeks
Grouping	4 students

♦ **Suggested workflow**

Set a schedule to let students know what they should do at each stage.

	Attainment
Part 1	**Introduction** • Teacher facilitates a warm-up discussion and help students to do a revision on the related basic knowledge. • Each group does research and designs the prototype. • Teacher can assign each group with different types of material for comparison. • Teacher can set a limit on the thickness of wall.
Part 2	**Design and make (I)** • Each group presents the design to the class and gets comments from teacher and other groups. • Each group modifies their design if necessary.
Part 3	**Design and make (II)** • Each group makes the prototype. Regular meetings with teachers for progress update and advice seeking are recommended.
Part 4	**Test and assessment** • Each group tests whether their prototype works normally and makes modification if necessary. • All groups gather and assess the performance of their own prototype as well as other groups' prototypes. • Teacher facilitates a wrap-up discussion.
Part 5	**Improvement** • Each group prepares an improved model. Test and assessment are done as in Part 4. • Teacher may facilitate another wrap-up discussion if necessary.

♦ **Warm-up discussion**

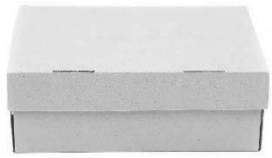
Teachers may hold a warm-up discussion before the project starts.

Suggested topics:

- How to measure the noise level?
- How to compare the effectiveness of different materials on soundproofing?
- Should the surface of the walls and the floor be smooth or rough?
- To increase the effect on soundproofing, should the layers of soundproofing materials be thicker or thinner?
- What will happen if the gaps between the wall and the door or the window are not filled?
- How can the gaps be filled without affecting the function of the door and the window?
- How to use minimum materials to build the model with the best soundproofing effect?
- What criteria should be set to judge whether the soundproof study room model is built successfully?

♦ **Suggested design and procedure for a simple model**

A Material list



cardboard box

thin plastic sheet

scouring pad

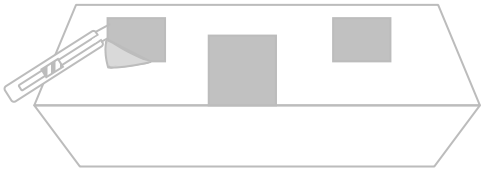
cutter

scissors

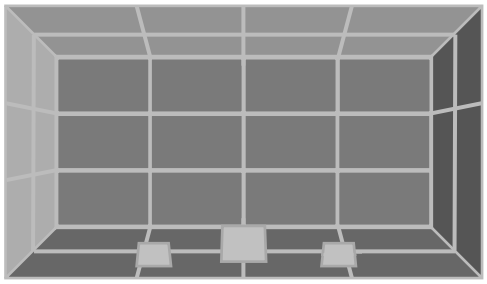
glue

B Procedure

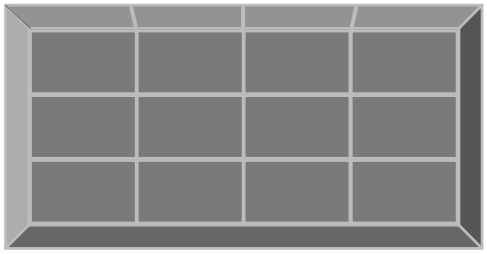
1 Cut holes on the cardboard box as the windows and the door.



2 Glue the scouring pads one by one onto all the inner surfaces of the box and the cover.



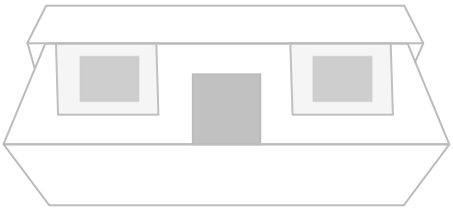
box



cover

3 Cut the thin plastic sheet into small rectangular shape and attach them to the holes on the walls as windows.

4 Put the cover back to the box.



5 After the test, glue one more layer of scouring pads onto all the inner surfaces of the box and the cover. Carry out the test again and compare the results.

6 If time is available, repeat the steps to make another model using different materials.

♦ **Suggested testing method**

1 Use a sound generator to produce noises outside of the room model at a fixed distance.
2 Put a sound intensity level meter inside the room model.
3 Measure and compare the sound intensity level with and without the soundproofing material.

* Smartphones can be used as sound generators and sound intensity level meters by downloading suitable apps.

♦ **Wrap-up discussion**

Teachers may hold a wrap-up discussion at the end of Part 4.

Suggested topics:

- What types of material absorb sound effectively?
- Is it possible to use fewer materials to get the same effect?
- Will it work better if the soundproofing materials have a smoother or rougher surface?
- What was the greatest difficulty in designing/making the soundproof study room model? How did you solve it?
- Which part of the soundproof study room model is the best designed/made? Why?
- What are the shortages of your soundproof study room model? Why?
- Which part of the soundproof study room model can be better designed/made? Why?
- What factor is the most critical in making the soundproof study room model?
- What did you learn from this project?

♦ **Assessment checklist**

Score sheet for assessment of performance:

Assessment criteria	Score	Comments
Product design (30%)		
The design shows a good understanding of the physics involved.	/10	
The design fits the need.	/5	
The design is user friendly.	/5	
The design shows creativity.	/5	
The design shows significant improvement after adopting comments.	/5	
Materials selection (15%)		
The materials used are economical and chosen wisely.	/5	
The materials are easy to obtain.	/5	
There is little wastage and the materials used are environmentally friendly.	/5	
Product construction (15%)		
The structure of the room model is stable.	/5	
The room model is easy to build.	/5	
The room model has a functioning window and door.	/5	
Effectiveness (20%)		
The room model can block noise from the outside.	/15	
The design is applicable to a room of normal size.	/5	
Scientific communication (10%)		
The written proposal is good.	/5	
The presentation is good.	/5	
Team collaboration (10%)		
Workloads are evenly shared among all team members.	/5	
All team members are actively involved in the design and construction of the room model.	/5	
Final score	/100	