

## Coordinator Notes:

### Module 1.3 Air & Flight - Fluid Dynamics and Vortex Rings

This Module explores Fluid Dynamics and Vortex Rings!

- Students will build their understanding of how fluids (liquids and gases) move.
- Students will learn about fluid dynamics, in particular, turbulent and laminar flow.
- Students will learn about how vortex rings form, and where they can be seen in nature.
- Students will utilise this knowledge in experiments and a Vortex Cannon Challenge.

#### Session Length:

This Module can be presented in different session durations per your needs.

Lesson plans are provided for:

- A 120 minute session, or, 2 x 60 minute sessions
- 45 minute, 75 minute, and 90 minute sessions

#### Technology:

**PowerPoint:** If you do not have access to a data projector and cannot display the PowerPoint presentation, we recommend that you print the most important slides before the session, and either enlarge them onto cardboard to use in place of slides, or create a booklet that students can share in small groups. The most important slides have been included as a 'Reduced Slides' PowerPoint file, and an easily printable pdf version of these slides is also provided. If you choose this option, we recommend that you still read and use the slide notes included in the full PowerPoint for the session.

The session can be conducted without slides all together, but they offer visual aid in explanation of scientific concepts. We recommend at the very least that instructions for each experiment are printed for the students.

**Videos links:** The suggested links to online videos within the session can be helpful with explanation. Notes have been included in the slides if there is an essential component to a video which the facilitator should discuss or demonstrate, if the video cannot be played.

**Video files:** A video file for each Module has been provided to aid explanation and instruction for some experiments and challenges. It is recommended coordinators view video files prior to delivering sessions, if the experiments and challenge activities are unfamiliar.

**\*Please read the Module 1 Risk Assessment before proceeding with the session\***

***Module 1.3 can be delivered before session 1.2 if needed.***

| <b>Contents</b>   | <b>Page</b> |
|---|-------------|
| Module 1.3 Overview   | 3           |
| Lesson Plan for Module 1.3 - 120 minute session, or, 2 x 60 minute sessions | 5           |
| Experiment E1.3.1: Laminar Flow   | 7           |
| Experiment E1.3.2: Water Drop   | 9           |
|   |             |
| Challenge M1.3 – Vortex Cannon – Coordinator Notes                          | 10          |
| Challenge M1.3 – Vortex Cannon – Planning Sheet                             | 12          |
| Challenge M1.3 – Vortex Cannon – Score Sheet                                | 13          |
|   |             |
| Lesson Plan for Module 1.3 - 90 minute session                              | 15          |
| Lesson Plan for Module 1.3 - 75 minute session                              | 17          |
| Lesson Plan for Module 1.3 - 45 minute session                              | 19          |
|   |             |
| References  | 20          |
| Materials Required for Module 1.3 sessions                                  | 21          |

## Module 1.3 Air & Flight – Fluid Dynamics and Vortex Cannons: Overview

Welcome back participants and welcome new participants!

Begin the session by recapping Modules 1.1 and 1.2. In Module 1.1, we started to explore the science around air, aerodynamics, and the forces of flight. In Module 1.2, we looked at the science around rockets and the laws of motion. Our experiments looked at how objects move in air.

In this module, we'll explore the movement of air itself!

Encourage students to use the scientific method and form hypotheses for their experiments.

### Content overview:

| Concept / Activity   | Session Duration (minutes) |    |    |    |
|--|----------------------------|----|----|----|
|  | 120                        | 90 | 75 | 45 |
| <b>Underwater Bubble Ring Video</b><br>Share the ABC Surfing Scientist video clip showing underwater bubble rings, a type of vortex ring.  | *                          | *  | *  |    |
| <b>Fluid Dynamics</b><br>Introduce Fluid Dynamics, the science describing the flow of fluids (fluids are liquids and gases). Discuss different types of fluids with students, and explore ideas on how different liquids flow.   | *                          | *  | *  |    |
| <b>Laminar and Turbulent Flow</b><br>Introduce two different types of flow, smooth and rough. Discuss when we might see different flow types in nature, and when different types of flow might be useful.  | *                          | *  | *  |    |
| <b>Experiment E1.3.1 Laminar Flow</b><br>This experiment is an engaging way to observe laminar (smooth) flow. It is also known as the 'un-mixing' experiment.  | *                          |    |    |    |
| <b>Vortex Rings</b><br>Discuss with students how turbulent flow can cause vortices to form in both liquids and gases. Encourage students to think about where they may see vortexes occur in nature, or at home. For example, a tornado, or, water swirling into a circular sink drain. The proper name for a bubble ring, smoke ring or steam ring, is a <b>toroidal vortex</b> . They are circulating rings of fluid. 'Torus' is the name for the shape of a doughnut or a ring. 'Toroid' is the mathematical name for a doughnut shape. | *                          | *  | *  | *  |
| <b>Experiment E1.3.2 Water Drop</b><br>This experiment is an engaging way to create and observe a toroidal vortex in liquid.   | *                          | *  | *  |    |
| <b>Vortex Cannon Challenge</b><br>Explore vortex cannons using cardboard boxes and air pressure. Which designs create the furthest travelling toroidal vortex?   | *                          | *  | *  | *  |

**Slides:**

PowerPoint Slides are available to support the delivery of this module. Slides explain concepts visually, and include short, engaging videos relevant to the topic.

A full list of slides and recommended inclusions for each session duration are provided in the table below. Appropriate slides are also noted in lesson plans for each duration.

| <b>PowerPoint Presentation:<br/>'M 1.3 - Master Slides 120 minute Session Duration'</b> |   | <b>Session Duration<br/>(minutes)</b> |           |           |           |
|---|---|---------------------------------------|-----------|-----------|-----------|
| <b>Slide</b>  | <b>Content</b>  | <b>120</b>                            | <b>90</b> | <b>75</b> | <b>45</b> |
| <b>1</b>  | Introductory title page for Module 1.3                      | *                                     | *         | *         | *         |
| <b>2</b>  | Video link to underwater bubbles                            | *                                     | *         | *         | *         |
| <b>3</b>  | Prompt for discussion about Fluid Dynamics                  | *                                     | *         | *         | -         |
| <b>4</b>  | Outline of flow types, Laminar and Turbulent flow           | *                                     | *         | *         | -         |
| <b>5</b>  | Prompt for discussion about fluid flow                      | *                                     | *         | *         | -         |
| <b>6</b>  | Outline of Experiment 1.3.1 'Laminar Flow'                  | *                                     | -         | -         | -         |
| <b>7</b>  | Procedure for Experiment 1.3.1 'Laminar Flow'               | *                                     | -         | -         | -         |
| <b>8</b>  | Prompt for discussion about Vortex Rings                    | *                                     | *         | *         | *         |
| <b>9</b>  | Outline of how Toroidal Vortexes work                       | *                                     | *         | *         | *         |
| <b>10</b>   | Outline of Experiment 1.3.2 'Water Drop'                    | *                                     | *         | *         | -         |
| <b>11</b>   | Prompt for discussion about weird / wacky vortex uses       | *                                     | *         | *         | *         |
| <b>12</b>   | Introduces Challenge 1.3: 'Vortex Cannon Challenge'         | *                                     | *         | *         | *         |
| <b>13</b>   | Video link to toroidal vortexes created with vortex cannons | *                                     | *         | *         | *         |
| <b>14</b>   | Rules for Challenge 1.3: 'Vortex Cannon Challenge'          | *                                     | *         | *         | *         |
| <b>15</b>   | Extra Rules for Challenge 1.3: 'Vortex Cannon Challenge'    | *                                     | *         | *         | *         |
| <b>16</b>   | Session references, online links                            | *                                     | *         | *         | *         |

## Module 1.3 AIR & FLIGHT – Fluid Dynamics and Vortex Cannons Lesson Plan

**120 minute session or 2 x 60 minute sessions**

**High Tech:** Use PowerPoint Presentation ‘M1.3 - Master Slides 120 minute Session Duration’

**Low Tech:** Print PowerPoint ‘M 1.3 - Reduced Slides for Printing’. Use side notes from the ENTIRE 120 minute presentation, adapting discussion to cover omitted slides.

### Key Learning Area

Physics

### Topic

Fluid Dynamics, Vortex Rings

| Timing        | Running Time (hh:mm) | Procedure  | Materials  |
|---------------|----------------------|--|--|
| <b>5 min</b>  | 00:05                | <b>Lesson Introduction</b><br>Briefly recap previous sessions.<br>Welcome new participants.<br>Watch Underwater Bubble Video | PowerPoint M1.3 (Slides 1-2)   |
| <b>10 min</b> | 00:15                | <b>Body of Lesson<br/>(Lesson 1, 2 x 60 minute sessions)</b><br>Introduce fluid dynamics, and laminar and turbulent flow     | PowerPoint M1.3 (slides 3-5)   |
| <b>15 min</b> | 00:30                | Discuss hypothesis and conduct Experiment 1.3.1 Laminar Flow, discuss results.   | PowerPoint M1.3 (slide 6-7),<br>Liquid soap, narrow & wide clear cups, water, food colouring, bulldog clips, droppers or straws, small containers, paper towel . |
| <b>5 min</b>  | 00:35                | Vortex rings and how they work   | PowerPoint M1.3 (slides 8-9)   |
| <b>15 min</b> | 00:50                | Discuss hypothesis and conduct experiment 1.3.2 Water Drop, discuss results.   | PowerPoint M1.3 (slide 10),<br>Food colouring, water, clear cups, paper towel, droppers / straws.  |
| <b>5 min</b>  | 00:55                | Weird and wacky Vortex Cannons   | PowerPoint M1.3 (slide 11)   |
| <b>5 min</b>  | 01:00                | <b>(Break for 2 x 60 minute sessions)</b>  | 5 min break for 120 min session  |

|               |                        |  |  |
|---------------|------------------------|--|--|
|               |                        | <b>Body of Lesson<br/>(Lesson 2, 2 x 60 minute sessions)</b>   |  |
| <b>10 min</b> | 0:10/<br>01:10         | Introduce challenge and watch cannon video<br>(If video is unable to be played, the coordinator should discuss with students how a vortex cannon works. Coordinator should watch the video prior to the session) | PowerPoint M1.3 (slides 12-15)   |
| <b>15 min</b> | 00:25/<br>01:25        | Design and build vortex cannons  | Cardboard boxes, plastic bags, tape, scissors, rulers, markers, drawing compass. |
| <b>10 min</b> | 00:35/<br>01:35        | Trial tests  | Smoke machine (if available), plastic cups, measuring tape.                      |
| <b>15 min</b> | 00:50/<br>01:50        | Final Testing  | As above.  |
|               |                        | <b>Lesson Conclusion</b>   |  |
| <b>10 min</b> | 00:60/<br>2:00<br>END. | Clean up. Discussion about the session and which cannons were most accurate, which cannons created the most forceful toroidal vortices.  |  |

## Module 1.3 – Fluid Dynamics and Vortex Cannons: Experiments

### Experiment E1.3.1: Laminar Flow

**Aim:** To observe how laminar flow affects the mixing of fluids

**Equipment:** (per group)

- 1 x wide, clear short cup
- 1 x narrow, clear tall cup
- Food colouring (3 colours)
- 3 x droppers, or straws
- 3 x small cups or containers
- 4 x bulldog clips
- Liquid hand soap (or dishwashing liquid)
- Paper towel

**Procedure:**

1. Form into groups of 2 to 4 students.

In groups:

2. Fill the wide, short cup 1/3 full with liquid soap. Minimise air bubbles.
3. Fill the narrow, tall cup with water and place it inside the wide cup.
4. Ensure the tall cup sinks to the bottom. Clip the bulldog clips, evenly spaced, around the rim of the wide cup, resting against the inner narrow cup.
5. Dispense a small droplet of liquid soap into each of the three small containers.
6. Add a drop of a food colouring to each container (a different colour in each).
7. Slowly mix the colours into the soap (minimise air bubbles).

When the coloured soap and clear soap are free of air bubbles:

8. Use a dropper / straw to suck up a droplet of liquid from one container of coloured soap.
9. Place the tip of the dropper / straw into the clear liquid soap inside the wide cup (about halfway down the cup), then squirt the coloured soap out of the dropper and into the clear liquid soap.
10. Repeat this with the remaining two coloured soaps, squirting the droplets next to each other. There should now be three blobs of colour in the liquid soap inside the wide cup.
11. Spin the narrow cup slowly inside the wide cup, in a clockwise direction. Make sure you hold onto the wide cup so it is stabilised. The colours should begin to mix.
12. After rotating in a clockwise direction for 3 rotations, stop, and turn the narrow cup back the other way for 3 rotations (anticlockwise).
13. Observe the effect on the coloured soap. Document your observations!

**Expected result:**

The blobs of coloured soap smeared together as the cup was rotated. When the cup was spun in the reverse direction, the colours 'unmixed' and eventually formed into 3 separate blobs.

If you look down into the space between the outer and inner cups after the "mixing" rotation, you will notice that the blobs are not really "mixing" together. Each one is actually dragged out to form a spiral.

**Explanation:**

The liquid soap is very viscous (thick) so it usually undergoes laminar flow. As the inside, narrow cup was slowly rotated, it caused the liquid soap to move or flow in a laminar way. The coloured blobs were spread in parallel sheets, or 'streamlines' as the cup spun. When the cup rotation was reversed, the parallel sheets of colour which had been formed were also reversed.

This would not occur if the flow was turbulent, the colours would mix up and you would not be able to separate them again.

**Notes:**

- *The students need to keep their inner, narrow cup in the centre of the wide glass, and keep it as stable as possible.*
- *The inner, water filled cup should be filled so that it sinks to the bottom of the outer, soap filled cup.*
- *Encourage the students to spin their inner cup very gently and slowly, especially when it comes to reversing the direction of spin.*
- *This experiment should be performed on a surface which can get wet.*
- *Ensure paper towel / towels are available to clean up spills.*
- *Be aware of potential sensitivities to soap.*
- *Coloured soap can be used if clear liquid soap is not available. Ensure food colouring chosen for experiment is contrasting to the colour of soap used.*
- *Dishwashing liquid can be used instead of liquid hand washing soap.*

**\*\*Note:** This experiment is included in the Module 1.1 Video\*\*

## **Experiment 1.3.2 – Water Drop**

**Aim:** To observe how toroidal vortices form.

**Equipment:** (per student)

- 1 x tall clear cup
- Food colouring
- Dropper (or straw)
- Water
- Paper towel

**Procedure:**

1. Fill a cup to the brim with water.
2. Let the cup stand for at least 1 minute so the water is completely still.
3. Draw up a single drop of food colouring, and dangle it just above the surface of the water.
4. Touch the water surface with the drop of food colouring.
5. Observe closely, looking down on the water surface. Document results!

**Expected result:**

The food dye should form a ring as it drops into the water. As the food colouring moves quickly, it will remain stable and retain its ring shape. As it slows down, it will form different patterns. If the water is completely still, the ring may form an upside down crown shape with new, smaller rings at each crown tip.

**Explanation:**

The food colouring droplet is travelling quickly as it hits the still water. The sides of the droplet experience different amounts of friction to the bottom of the droplet as it passes through the still water. The bottom of the droplet experiences more friction than the sides. The droplet leaves a wake of low pressure behind it as it travels through the still water.

The unequal friction, and the change in pressure in the still water behind the droplet, cause the sides of the droplet to be dragged up and then back down through the middle of the droplet, causing a toroidal vortex to form.

## Challenge M1.3 – Vortex Cannon Challenge

### Coordinator Notes

#### Scoring:

A scoring mechanism is included, so the element of ‘competition’ may challenge all students to participate to their fullest. You may remove the scoring system all together if it does not work with your group of students.

When scoring it is important to only announce the furthest successful distance for a cannon to knock over cups, and the most cups to be knocked over - so there will be no ‘losers’ or last place. It is important to highlight the good strategies of each cannon so all feel like they have done a good job.

Consider asking students how they might approach the task differently if asked to do it again, or how they might teach the same things they learned during the club to a younger student.

**\*\* If you choose not to use a scoring system modify the slides that reference a ‘score’\*\***

#### Activity Notes:

- If you do not have the technology available to show the video about vortex cannons to students, we recommend that you watch the video before the session so you have some idea of what the participants will be building and can give students help if required.
- The students should either draw, make notes or think of a plan for their cannon design before starting construction.
- This activity is best done inside. Air-conditioning and fans should be minimised during testing to reduce air turbulence.
- If you have access to a smoke machine, ensure the venue has good ventilation and minimise the amount of smoke used. The smoke is not necessary, it just helps to visualise what is happening.
- Supervise students and demonstrate safe use of scissors. Pay particular attention when students are cutting out their circular holes and provide assistance as needed.
- Students may like to work individually, or in groups of 2 to 4.
- During testing, encourage students to watch, support and cheer for each cannon.
- Support students to perform the official measuring and cup counting, and to help record results.

**Suggested rules / guidelines:**

- Vortex cannons should be build out of a cardboard box and a few other small items.
- Plastic bags could be used to form one side of the cannon, or cannons may be entirely made of cardboard.
- The cannon should have a round opening for the vortex ring to come out of. When you hit the sides of the box, air will be pushed out of the opening, forming a toroidal vortex.
- The cannon will be 'fired' from on top of a table, and aimed at a stack of plastic cups on another table.
- The plastic cup stack must be a pyramid shape, with a base of 5 cups in a single line on a table.
- The further away your cannon is from the cups and the more cups you knock down – the higher your score!
- You will have 3 official attempts at each distance. The best one is scored.
- Testing will begin at a 1 metre distance between tables, and will increase in distance by 1 metre each round. If you do not successfully knock down any cups, you cannot progress to the next distance.
- The final score will be the distance, times the number of cups from each round added together.

**Notes:**

- ***The cannons may be filled with smoke using a smoke machine (if available) prior to firing. This makes the toroidal vortices visible, and can assist with aiming during testing.***
- ***Plastic Vortex Cannons are available online. You may wish to purchase one for the group, however this is not essential.***

**45 minute session adjustment:**

- Encourage all students to form into small groups to reduce the number of vortex cannons to be tested (and increase time available for testing).
- Offer each group only two official distances for testing / scoring. Once all groups have completed their official attempts, offer additional distances if time permits.

**\*\*Note: This challenge is included in the Module 1.1 Video\*\***

## Planning Sheet M1.3: Vortex Cannon Challenge

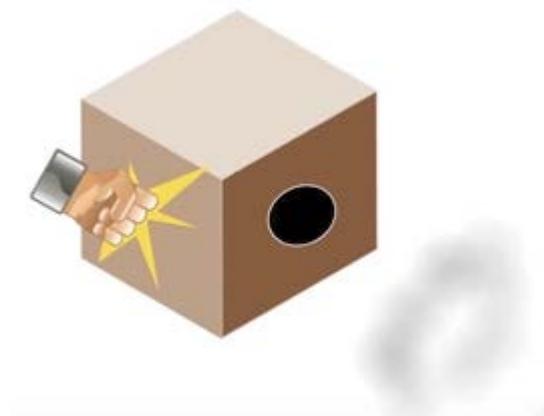
To design your vortex cannon, keep in mind:

**ACCURACY** – how accurate would you like your cannon to be able to aim?

**FORCE** – how far would you like your toroidal vortexes to travel through air?

**SIZE & SHAPE** – does the diameter of the cannon change accuracy and / or force? Does the size and / or shape of the box make a difference?

Thinking about these concepts, sketch ideas for your cannon design below!



## Score Sheet: M 1.3 – Vortex Cannon Challenge

### Notes:

- Points are calculated for each test round, by multiplying the number of cups knocked over, by the distance between tables.
- To determine final score, add together the points from each round.
- Only progress to the next distance if cups are knocked down at the previous distance. I.e. don't progress to testing at 2 metres, if no cups are knocked down at 1 metre.

| Team, Individual or Cannon Name | Distance between tables (metres) | Number of cups knocked over | Points per Round (distance x number cups knocked over) |
|---------------------------------|----------------------------------|-----------------------------|--|
|                                 | 1 m                              |                             |  |
|                                 | 2 m                              |                             |  |
|                                 | 3 m                              |                             |  |
|                                 | 4 m                              |                             |  |
|                                 | 5 m                              |                             |  |
|                                 | 6 m                              |                             |  |
| <b>Final Score</b>              |                                  |                             |  |
|                                 | 1 m                              |                             |  |
|                                 | 2 m                              |                             |  |
|                                 | 3 m                              |                             |  |
|                                 | 4 m                              |                             |  |
|                                 | 5 m                              |                             |  |
|                                 | 6 m                              |                             |  |
| <b>Final Score</b>              |                                  |                             |  |
|                                 | 1 m                              |                             |  |
|                                 | 2 m                              |                             |  |
|                                 | 3 m                              |                             |  |
|                                 | 4 m                              |                             |  |
|                                 | 5 m                              |                             |  |
|                                 | 6 m                              |                             |  |
| <b>Final Score</b>              |                                  |                             |  |
|                                 | 1 m                              |                             |  |
|                                 | 2 m                              |                             |  |
|                                 | 3 m                              |                             |  |
|                                 | 4 m                              |                             |  |
|                                 | 5 m                              |                             |  |
|                                 | 6 m                              |                             |  |
| <b>Final Score</b>              |                                  |                             |  |

| Team, Individual or Cannon Name | Distance between tables (metres) | Number of cups knocked over | Points per Round (distance x number cups knocked over) |
|---------------------------------|----------------------------------|-----------------------------|--|
|                                 | 1 m                              |                             |  |
|                                 | 2 m                              |                             |  |
|                                 | 3 m                              |                             |  |
|                                 | 4 m                              |                             |  |
|                                 | 5 m                              |                             |  |
|                                 | 6 m                              |                             |  |
| <b>Final Score</b>              |                                  |                             |  |
|                                 | 1 m                              |                             |  |
|                                 | 2 m                              |                             |  |
|                                 | 3 m                              |                             |  |
|                                 | 4 m                              |                             |  |
|                                 | 5 m                              |                             |  |
|                                 | 6 m                              |                             |  |
| <b>Final Score</b>              |                                  |                             |  |
|                                 | 1 m                              |                             |  |
|                                 | 2 m                              |                             |  |
|                                 | 3 m                              |                             |  |
|                                 | 4 m                              |                             |  |
|                                 | 5 m                              |                             |  |
|                                 | 6 m                              |                             |  |
| <b>Final Score</b>              |                                  |                             |  |
|                                 | 1 m                              |                             |  |
|                                 | 2 m                              |                             |  |
|                                 | 3 m                              |                             |  |
|                                 | 4 m                              |                             |  |
|                                 | 5 m                              |                             |  |
|                                 | 6 m                              |                             |  |
| <b>Final Score</b>              |                                  |                             |  |
|                                 | 1 m                              |                             |  |
|                                 | 2 m                              |                             |  |
|                                 | 3 m                              |                             |  |
|                                 | 4 m                              |                             |  |
|                                 | 5 m                              |                             |  |
|                                 | 6 m                              |                             |  |
| <b>Final Score</b>              |                                  |                             |  |

## Module 1.3 AIR & FLIGHT – Fluid Dynamics and Vortex Cannons Lesson Plan

### 90 minute session

**High Tech:** Adapt 'M 1.1 - Master Slides 120 minute Session Duration'. Hide slides 6 and 7. Alternately, this option has been provided for you as PowerPoint 'M1.3b - 90 minute session Full Slides'

**Low Tech:** Print PowerPoint 'M 1.3b – 90 minute session Reduced Slides'. Use slide notes from the ENTIRE 90 minute presentation, adapting discussion to cover omitted slides.

| Key Learning Area |                      | Topic  |   |
|-------------------|----------------------|--|---|
| Physics           |                      | Fluid Dynamics, Vortex Rings   |   |
| Timing            | Running Time (hh:mm) | Procedure  | Materials   |
| 5 min             | 00:05                | <b>Lesson Introduction</b><br>Briefly recap previous sessions.<br>Welcome new participants.<br>Watch Underwater Bubble Video   | PowerPoint M1.3b (Slides 1-2)   |
| 10 min            | 00:15                | <b>Body of Lesson</b><br>Introduce fluid dynamics, and laminar and turbulent flow  | PowerPoint M1.3b (slides 3-5)   |
| 5 min             | 00:20                | Vortex rings and how they work   | PowerPoint M1.3b (slides 6-7)   |
| 10 min            | 00:30                | Discuss hypothesis and conduct experiment 1.3.2 Water Drop, discuss results.   | PowerPoint M1.3b (slide 8), Food colouring, water, clear cups, paper towel, droppers / straws |
| 2 min             | 00:32                | Wacky uses of Vortex Cannons   | PowerPoint M1.3b (slide 9)  |
| 8 min             | 00:40                | Introduce challenge and watch cannon video. (If video is unable to be played, the coordinator should discuss with students how a vortex cannon works. Coordinator should watch the video prior to the session) | PowerPoint M1.3b (slides 10-14)   |

|               |               |   |  |
|---------------|---------------|---|--|
| <b>15 min</b> | 0:55          | Design and build vortex cannons   | Cardboard boxes, plastic bags, tape, scissors, rulers, markers, drawing compass. |
| <b>10 min</b> | 01:05         | Trial tests   | Smoke machine (if available), plastic cups, measuring tape.                      |
| <b>15 min</b> | 01:20         | Final Testing   | As above.  |
| <b>10 min</b> | 01:30<br>END. | <b>Lesson Conclusion</b><br><br>Clean up. Discussion about the session and which cannons were most accurate, which cannons created the most forceful toroidal vortexes. |  |

## Module 1.3 AIR & FLIGHT – Fluid Dynamics and Vortex Cannons Lesson Plan

### 75 minute session

**High Tech:** Adapt 'M 1.1 - Master Slides 120 minute Session Duration'. Hide slides 6 and 7. Alternately, this option has been provided for you as PowerPoint 'M1.3c - 75 minute session Full Slides'

**Low Tech:** Print PowerPoint 'M 1.3c – 75 minute session Reduced Slides'. Use slide notes from the ENTIRE 75 minute presentation, adapting discussion to cover omitted slides.

| Key Learning Area |                      | Topic  |   |
|-------------------|----------------------|--|---|
| Physics           |                      | Fluid Dynamics, Vortex Rings   |   |
| Timing            | Running Time (hh:mm) | Procedure  | Materials   |
| 5 min             | 00:05                | <b>Lesson Introduction</b><br>Briefly recap previous sessions.<br>Welcome new participants.<br>Watch Underwater Bubble Video   | PowerPoint M1.3c (Slides 1-2)   |
| 5 min             | 00:10                | <b>Body of Lesson</b><br>Introduce fluid dynamics, and laminar and turbulent flow  | PowerPoint M1.3c (slides 3-5)   |
| 5 min             | 00:15                | Vortex rings and how they work   | PowerPoint M1.3c (slides 6-7)   |
| 10 min            | 00:25                | Discuss hypothesis and conduct experiment 1.3.2 Water Drop, discuss results.   | PowerPoint M1.3c (slide 8), Food colouring, water, clear cups, paper towel, droppers / straws |
| 2 min             | 00:27                | Wacky uses of Vortex Cannons   | PowerPoint M1.3c (slide 9)  |
| 8 min             | 00:35                | Introduce challenge and watch cannon video<br>(If video is unable to be played, the coordinator should discuss with students how a vortex cannon works. Coordinator should watch the video prior to the session) | PowerPoint M1.3c (slides 10-13)   |

|               |               |  |  |
|---------------|---------------|--|--|
| <b>15 min</b> | 0:50          | Design and build vortex cannons  | Cardboard boxes, plastic bags, tape, scissors, rulers, markers, drawing compass. |
| <b>10 min</b> | 01:00         | Trial tests  | Smoke machine (if available), plastic cups, measuring tape.                      |
| <b>10 min</b> | 01:10         | Final Testing  | As above.  |
| <b>5 min</b>  | 01:15<br>END. | <p><b>Lesson Conclusion</b></p> <p>Clean up. Discussion about the session and which cannons were most accurate, which cannons created the most forceful toroidal vortexes.</p> |  |

## Module 1.3 AIR & FLIGHT – Fluid Dynamics and Vortex Cannons Lesson Plan

### 45 minute session

**High Tech:** Adapt 'M 1.1 - Master Slides 120 minute Session Duration'. Hide slides 3, 4, 5, 6, 7 and 10. Alternately, this option has been provided for you as PowerPoint 'M1.3d - 45 minute session Full Slides'

**Low Tech:** Print PowerPoint 'M 1.3d – 45 minute session Reduced Slides'. Use slide notes from the ENTIRE 45 minute presentation, adapting discussion to cover omitted slides.

| Key Learning Area |                      | Topic  |  |
|-------------------|----------------------|--|--|
| Physics           |                      | Fluid Dynamics, Vortex Rings   |  |
| Timing            | Running Time (hh:mm) | Procedure  | Materials  |
| 2 min             | 00:02                | <b>Lesson Introduction</b><br>Briefly recap previous sessions.<br>Welcome new participants.  | PowerPoint M1.3d (Slides 1-2)  |
| 8 min             | 00:10                | <b>Body of Lesson</b><br>Vortex rings and how they work,<br>wacky uses   | PowerPoint M1.3d (Slide 3-5)   |
| 5 min             | 00:15                | Introduce challenge, watch cannon video. (If video is unable to be played, the coordinator should discuss with students how a vortex cannon works. Coordinator should watch video before the session.) | PowerPoint M1.3d (Slides 6-9)  |
| 15 min            | 00:30                | Design and build vortex cannons  | Cardboard boxes, plastic bags, tape, scissors, rulers, markers, drawing compass. |
| 10 min            | 00:40                | Test cannons   | Smoke machine (if available), plastic cups, measuring tape.                      |
| 5 min             | 00:45<br>END.        | <b>Lesson Conclusion</b><br>Clean up. Discussion about the session and which cannons were most accurate, which cannons created the most forceful toroidal vortices.                                    |  |

## Module 1.3 - References:

### Vortex Cannons:

<http://www.abc.net.au/science/articles/2012/07/17/3546850.htm>

<http://skullsinthestars.com/2012/08/28/physics-demonstrations-vortex-cannon/>

### Vortex Rings:

<http://www.abc.net.au/science/articles/2008/02/11/2959944.htm>

### Toroidal Vortex Videos:

<http://www.abc.net.au/catalyst/stories/2266199.htm>

<http://www.abc.net.au/science/articles/2014/04/11/3978532.htm>

### Fluid Dynamics, Flow:

<https://www.livescience.com/47446-fluid-dynamics.html>

<http://www.education.com/science-fair/article/thick-liquids-faster-slower-thin/>

<http://www.abc.net.au/science/articles/2013/01/30/3679522.htm>

<http://www.abc.net.au/catalyst/stories/3285559.htm>

## Module 1.3 - Required Materials

- Pens, pencils and writing paper are generally required every session.
- Students may like to bring a note pad to record their observations and ideas.
- A group usually refers to 2 - 4 students.

| Activity   | Material   | Amount  | Where can I find it?                    |
|--|--|---|---|
| All sessions   | PowerPoint Slides*<br>(digital, or printed)                          | 1 per coordinator                                 | Coordinator Package                     |
| All sessions   | Printed PowerPoint* Slide<br>Notes                                   | 1 per coordinator                                 | Coordinator Package                     |
| All sessions   | Printed Lesson<br>Plan   | 1 per coordinator                                 | Coordinator Package                     |
| All sessions   | Printed Module 1 Risk<br>Assessment                                  | 1   | Coordinator Package                     |
| All sessions   | Computer, Data Projector,<br>Screen                                  | 1   | Venue                                   |
| 120 minute or<br>2 x 60 minute<br>sessions<br><br>Experiment<br>E1.3.1 | Wide, short clear cups<br>(glass or thick plastic)                   | 1 per group                                       | Supermarket /<br>Homewares Shop         |
|  | Narrow, tall clear cups<br>(glass or thick plastic)                  | 1 per group                                       | Supermarket /<br>Homewares Shop         |
|  | Liquid Soap or<br>Dishwashing Liquid                                 | 2 x 500ml bottles<br>(Approx. 100ml<br>per group) | Supermarket /<br>Pharmacy               |
|  | Food colouring   | 3 different colours,<br>50ml bottles              | Supermarket                             |
|  | Droppers / straws  | 3 per group                                       | Supermarket /<br>Pharmacy               |
|  | Bulldog Clips<br>(3-4cm in size)                                     | 4 per group                                       | Supermarket /<br>Stationary Shop        |
|  | 3 small plastic<br>containers / cups<br>(e.g. plastic medicine cups) | 3 per group                                       | Supermarket /<br>Pharmacy, or recycled. |
|  | Paper Towel  | 2 rolls   | Supermarket                             |

Required materials list continues next page

\*Slide sets:

- 120 minute session or 2x60 minute sessions: Slides 1.3a (M 1.3 Master Slides)
- 90 minute session: Slides 1.3b
- 75 minutes session: Slides 1.3c
- 45 minutes session: Slides 1.3d

| Activity   | Material                                    | Amount  | Where can I find it?                                 |
|--|---|---|--|
| 120 minute,<br>2 x 60 minute, 75<br>minute, and 90<br>minute sessions,<br>Experiment 1.3.2 | Water                                       | 250ml per student                                 | Supermarket / tap                                    |
|  | Clear cups                                  | 1 per student                                     | Supermarket /<br>Homewares Shop                      |
|  | Food colouring                              | 1 to 3 x 50ml bottles                             | Supermarket  |
|  | Droppers / straws                           | 3 per group                                       | Supermarket /<br>Pharmacy                            |
| Vortex Cannon<br>Challenge   | Pre-made Vortex<br>Cannon (optional)        | 1   | <b>See link list below</b>                           |
|  | Smoke / Fog<br>Machine (optional)           | 1   | <b>See link list below</b>                           |
| All sessions   | Cardboard boxes                             | 1 per student<br>(minimum)                        | Recycled from local<br>supermarkets / shops          |
|  | Scissors                                    | 1 pair per 2 students                             | Supermarket /<br>Stationary Shop                     |
|  | Tape<br>(masking, sticky or<br>gaffer tape) | 2 large rolls<br>(approx. 1 metre<br>per student) | Supermarket /<br>Stationary Shop /<br>Hardware Store |
|  | Plastic cups                                | Minimum 15 cups                                   | Supermarket  |

## Online shopping links:

### Smoke / Fog Machines (From \$35):

<https://dycity.com.au/product/ave-vaperiza-500-smoke-machine/>

<https://www.storedj.com.au/dl-z400-smoke-machine-400w>

<https://www.jaycar.com.au/400w-mini-fog-machine/p/AF1220>

### Plastic, pre-made Vortex Cannons (from \$30):

<https://www.questacon.edu.au/qshop/Airzooka>

<https://www.madaboutscience.com.au/shop/airzooka-air-cannon.html>