

# Collaborative learning in Physics

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# Why collaborative learning?

- In meta-analyses, students in cooperative learning had higher achievement, higher-level reasoning, more frequent generation of new ideas and solutions, and greater transfer of knowledge than competitive or individualistic structures (Barkley, et al, 2005: p.17-18)



# Why collaborative learning?

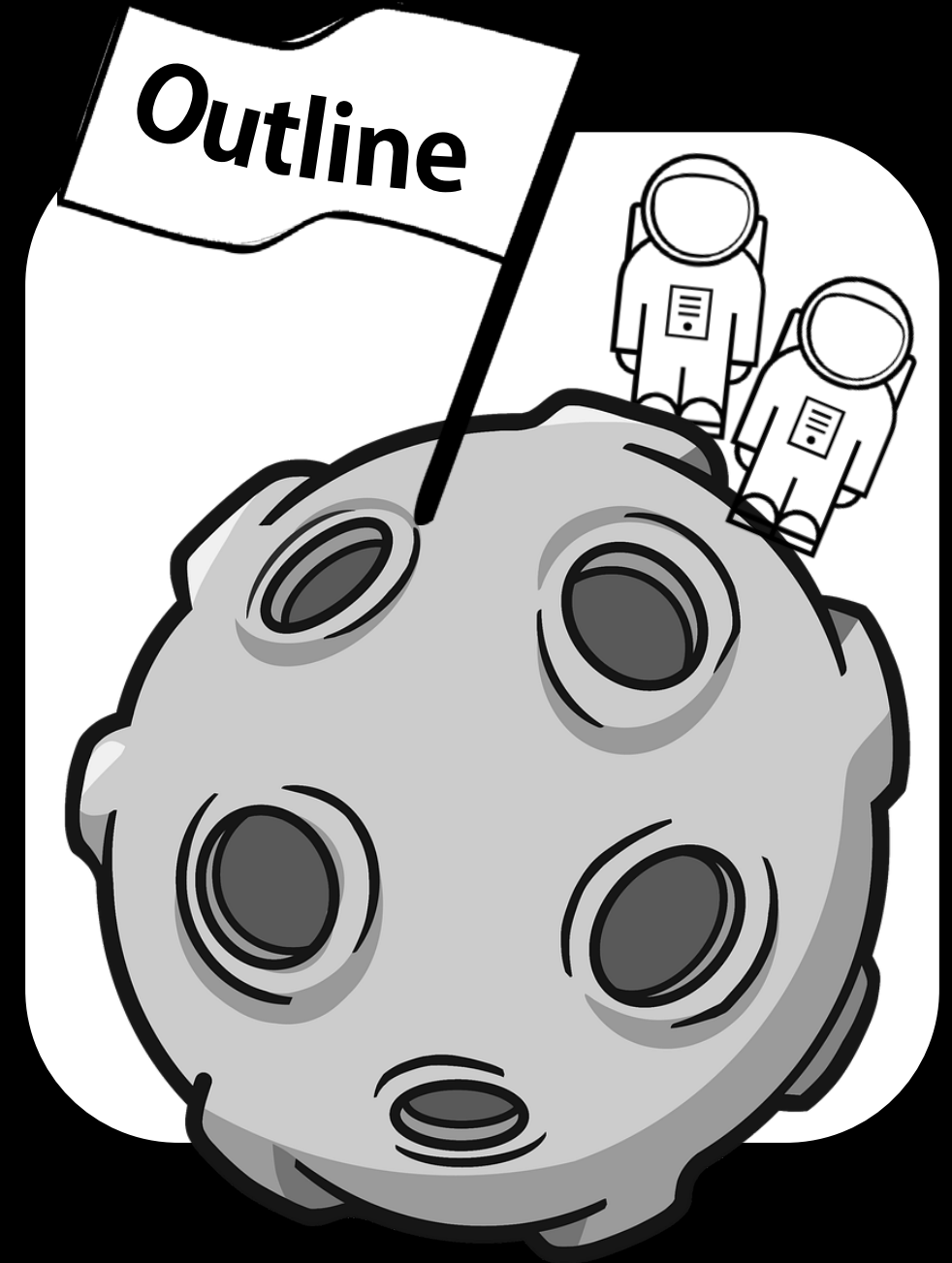
- cooperative learning has also been observed to enhance achievement of female students and other groups often unrepresented in a number of disciplines (Herreid, 1998 ).



# Why collaborative learning?

- 61% of the cooperative-learning classes achieved significantly higher test scores than traditional classes
- effective classes stressed group goals and individual accountability. (Slaven, 1991)

- **our aims**
- **benefits**
- **essential elements**
- **sample projects**

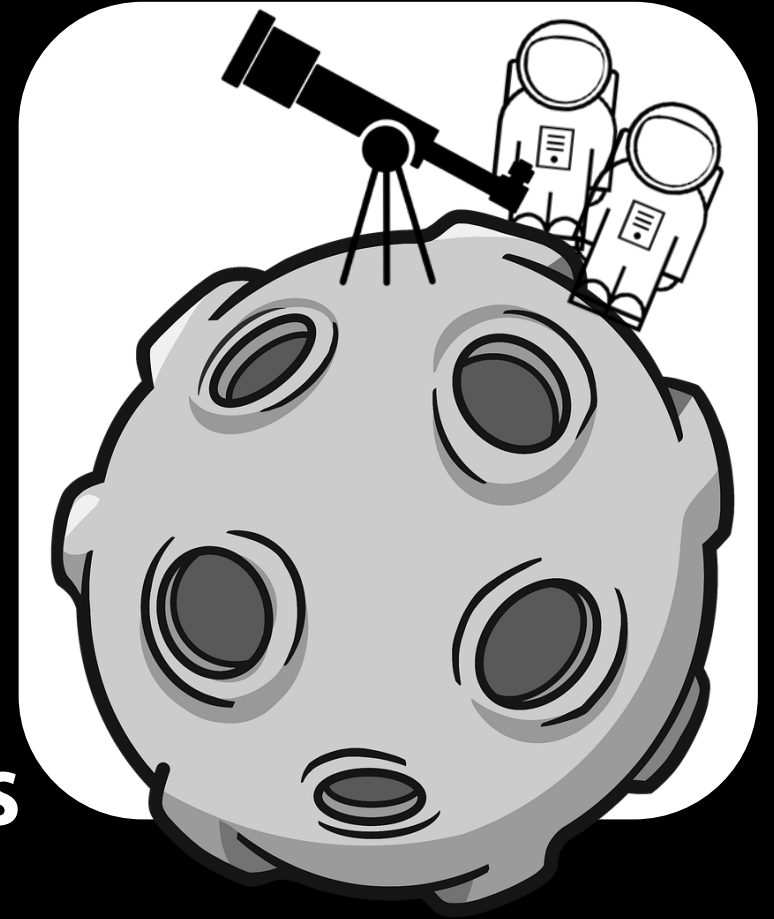


# what are we about?

- embed collaborative learning
- physics is accessible

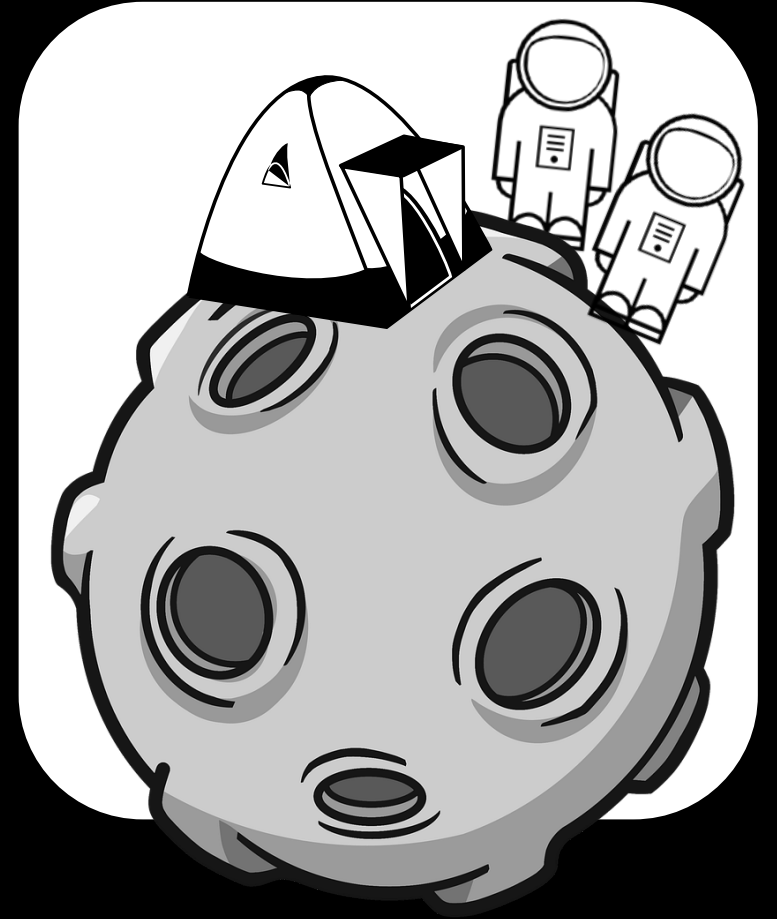
## benefits

- increased numbers in VCE Physics
- greater participation of girls
- students transition from 11 to 12



# essential elements

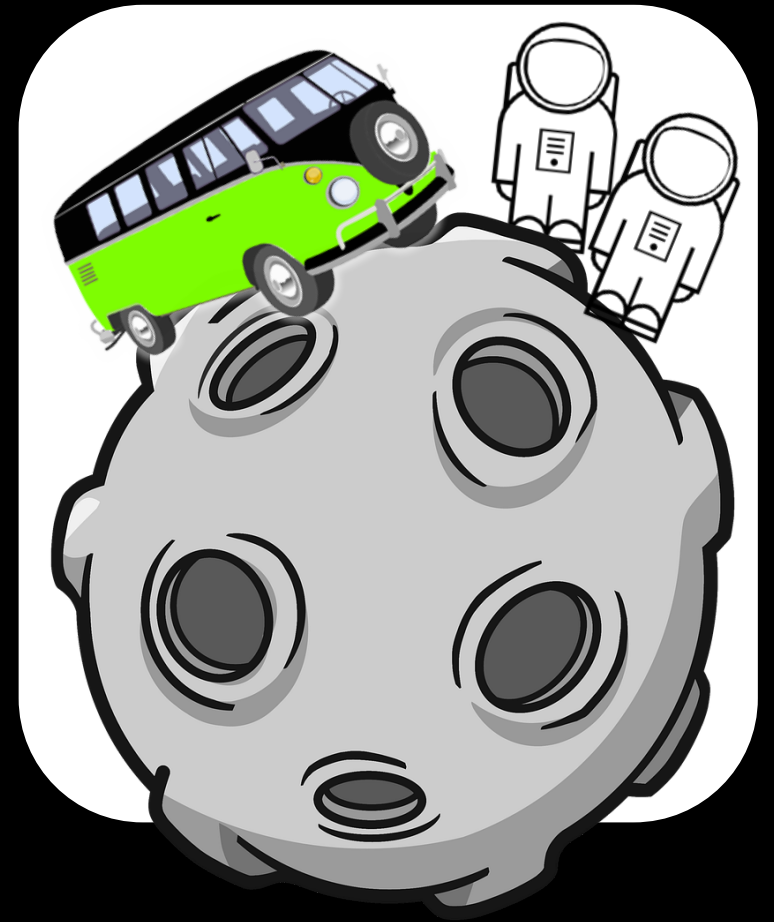
- **student choice**
- **purposeful**
- **individual accountability**
- **connection with other students**
- **provide milestones**
- **provide regular feedback**



# U1AOS2 Transducer Investigation

**Task Outline:** To investigate how transducers work and explain how it is used in a household appliance.

You will choose to investigate either a thermistor, a light dependent resistor or a potentiometer.





# U1AOS2 Transducer Investigation

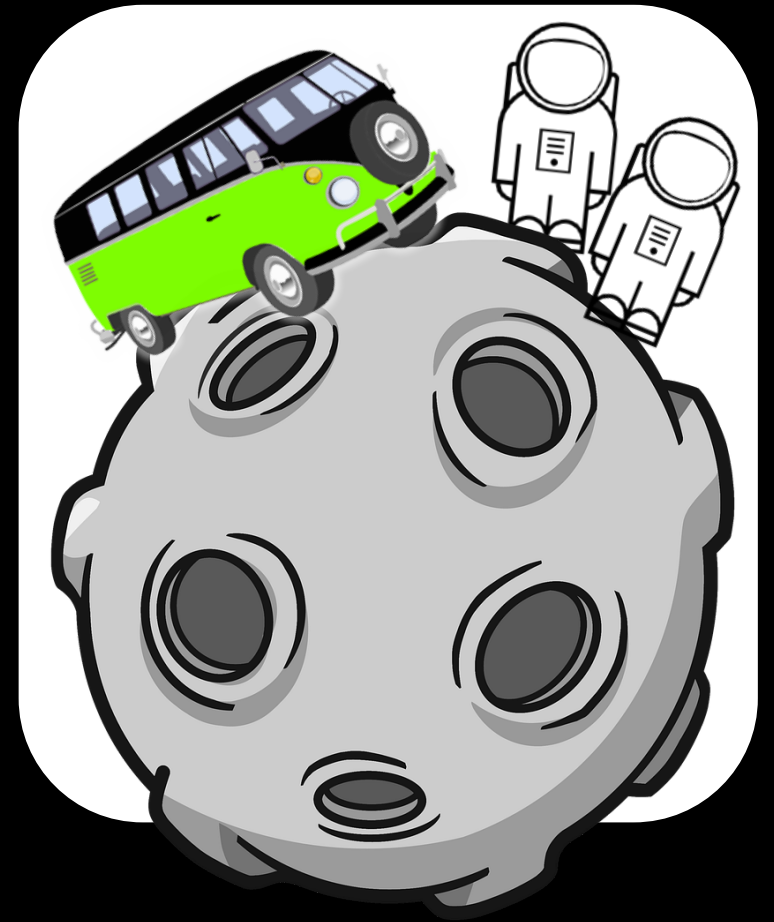
## Task Timeline

Lesson 1: Section A Voltage divider experiment

Lesson 2: Section B Transducer experiment

Lesson 3: Section C Transducers in home appliances; complete on A3 sheet

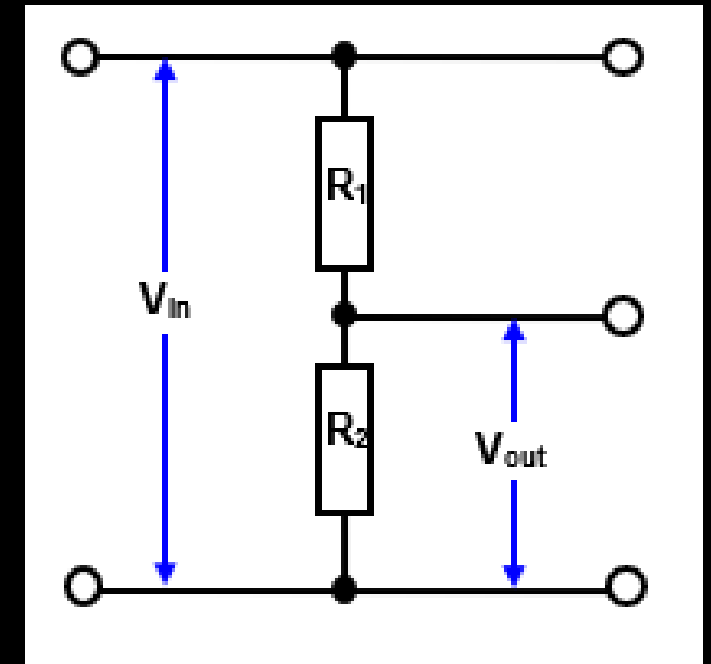
Lesson 4: Section C Transducers in home appliances; complete on A3 template.



# U1AOS2 Transducer Investigation

## SECTION A: Voltage divider experiment

In this experiment, you will make a voltage divider. A voltage divider is used to reduce a voltage to a value needed for a part of the circuit. Voltage dividers are used to control many appliances, such as turning on heating in a home when the temperature drops.

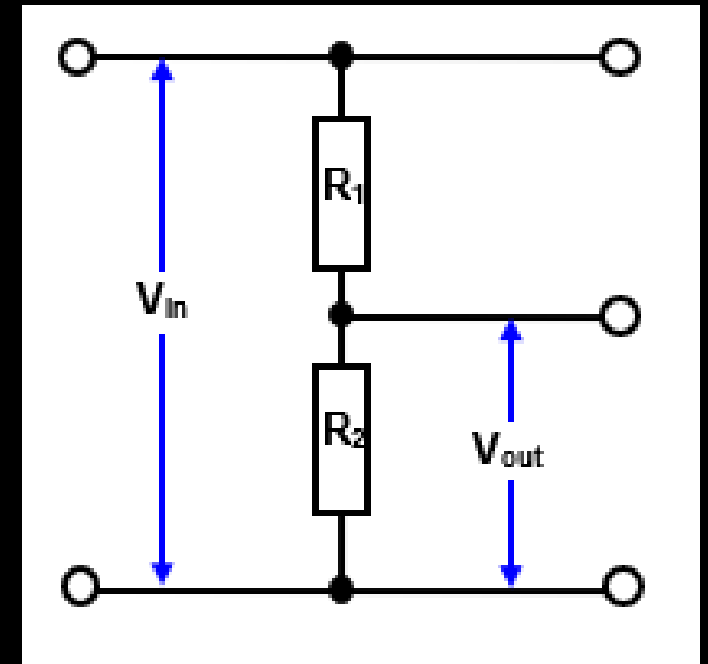


# U1AOS2 Transducer Investigation

## SECTION B: Transducer experiments

Select a transducer to investigate and complete the relevant experiment.

- Thermistor Experiment
- Light Dependent Resistor
- Potentiometer



# U1AOS2 Transducer Investigation

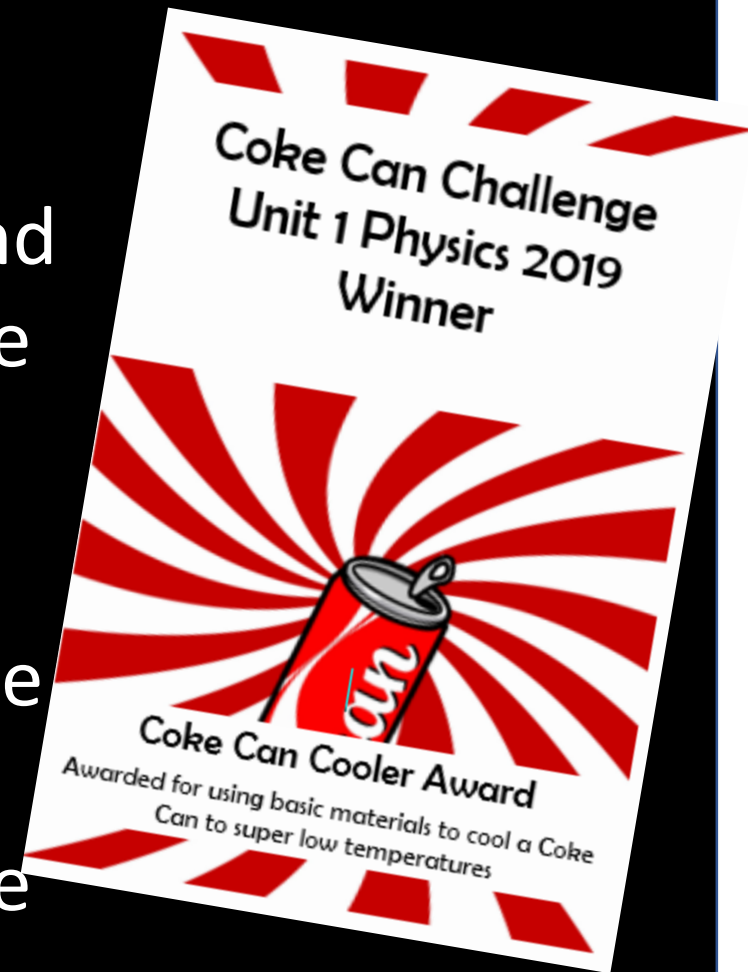
**SECTION C:** Investigate how the transducer that you have selected is used in a home appliance. Insert your answers into the A3 grid.

Section C: A3 grid Transducers in home appliances		Name: _____	Partners Name: _____	Type of transducer: _____
<p>a) Select an application of where the transducer is used and explain how it is important in its operation.</p>	<p>applies understanding of how transducer functions in appliance</p> <p>describes how transducer functions</p> <p>identifies purpose of transducer in appliance</p> <p>gives definition of transducer</p> <p>Transducer in appliance</p>			
	<p>b) <u>Model</u></p> <p>(Identify the power rating of the appliance and explain what the 'power rating' means.)</p>	<p>explains 'power rating'</p> <p>states power rating</p> <p>identifies model</p> <p><u>Power</u> rating</p>		
		<p>bi) Calculate how much energy the appliance would use during one year of operation in the home.</p> <ul style="list-style-type: none"><li>How many hours per week does the appliance operate?</li><li>How many hours per year?</li><li>Now calculate energy in kWh per annum.</li><li>Explain energy used in kWh per annum.</li><li>Is this appliance a high energy device compared to other appliances in the home? Explain your answer.</li></ul>	<p>Compares appliances in the home</p> <p>Explains energy kWh per annum</p> <p>Calculates answer with units</p> <p>Energy use</p>	
		<p>iii) Calculate the running cost of the appliance per year if the consumer is charged at a rate of 16.381 cents per kilowatt – hour.</p> <ul style="list-style-type: none"><li>Explain what running cost per annum means.</li><li>Describe how families could reduce the running costs of using this appliance.</li></ul>	<p>Devises energy saving strategies</p> <p>Explains running cost per annum</p> <p>calculates answer and units</p> <p>Running cost</p>	
		<p>iv) Explain how the safety devices used in the home reduce the risk of electrocution or household fires (p94-97 textbook)</p> <ul style="list-style-type: none"><li>Define Fuse</li><li>Describe how fuse works</li><li>Define Circuit breaker</li><li>Describe how circuit breaker works</li><li>Define Earthing</li><li>Describe how earthing works</li><li>Define Residual current device</li><li>Describe how a residual current device works</li></ul> <p>Evaluate which safety device is most effective at saving lives. Explain your answer in terms of effects of electric shock.</p>		
		<p>links findings to electric shocks in homes and danger thresholds for current and duration</p> <p>evaluates which safety devices most effective at saving lives</p> <p>describes how safety devices operate</p> <p>gives definition of devices</p> <p>Safety devices</p>		

# U1AOS1 Coke Can Challenge

**Scenario:** Today is the hottest day of the year and its  $44^{\circ}\text{C}$ . You would love a can of coke, BUT there is no electricity for your fridge.

But you have been learning about Thermodynamics so you can use your knowledge of conduction, convection and radiation to cool the coke can. The challenge is that you only have limited materials.





# U1AOS1 Coke Can Challenge

There are two awards

**Coke Can Cooler Award** – Cool car to lowest temperature.

**Thermodynamics Genius Award** Embeds most thermochemical principals into design



# U1AOS1 Coke Can Challenge

## Materials

Choose 6 items

- 200 g Ice (150 g)
- 10 g Salt (5 g)
- 2 L water
- 30 cm plastic wrap
- small plastic container
- 20 cm aluminium foil
- 1 x zip lock bag
- packing peanuts
- 20 cm foam insulation
- 20 cm bubble wrap

## Procedure

There are three phases; design, build and test.

### Design

You have **20 minutes** to design your fridge. During this time you select your materials and draw a design. You need to explain where you have used thermodynamic principles in your design.

### Build

You have **10 minutes** to construct your fridge. Do not put your Coke can in your fridge yet.

### Test

You have **10 minutes** to test your fridge. Place the Coke can into the fridge along with a temperature probe and monitor the change in temperature.

# U1AOS1 Coke Can Challenge

## Unit 1 AOS1 Physics: Coke Can Challenge

Applying principles of Conduction, Convection and Radiation

**Scenario:** Today is the hottest day of the year – its 42°C. You're thirsty and would love a can of coke, BUT there is no electricity and your fridge and freezer aren't working.

The only chance you have of obtaining your delicious beverage is if you cool it yourself. But no need to worry because you have been learning about Thermodynamics in Physics so you can use your knowledge of conduction, convection radiation to cool the coke can.

You will need to select from a limited range of materials to make a fridge.

There are two awards;

**Coke Can Cooler Award** - The group who can get the cool can to the lowest temperature will be the winner and will gain one can of coke per group member.

**Thermodynamics Genius Award** - The group who can embed the most thermochemical principals into their design. Each thermochemical idea is awarded one point.

### Materials

You can choose 6 out of these 11 materials:

- 100g ice (150g)
- 5g salt (5g)
- 10L bucket
- 2L water
- 30 cm plastic wrap
- small plastic container
- 10 cm aluminium foil
- 1 cm bubble wrap
- 20 x foam peanuts
- 20 cm foam insulation
- 20 cm bubble wrap

### Materials required by each group

- temperature probe
- timer
- can of drink

### Procedure

The challenge is divided into three phases; design, build and test.

### Design

You have 20 minutes to design your fridge. During this time, you will select your materials and draw a diagram to show your design. You will need to explain where you have used the ideas of conduction, convection and radiation in your design.

### Build

You will have 10 minutes to construct your fridge. During this part of the challenge you will use all the materials except the Coke can in the construction of your fridge.

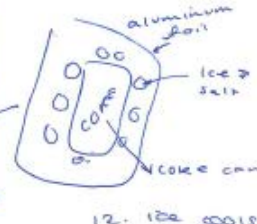
### Test

You will have 10 minutes to test your fridge. You will put the can into the fridge along with a temperature probe and monitor the change in temperature.

### Design

#### Thermodynamics

1. APPLY WORK
2. BUBBLE WRAP IS A GOOD INSULATOR
3. BUBBLE WRAP MAKES WATER IN LESS SURFACE AREA SO IT'S EASIER TO COOL.
3. ALUMINIUM FOIL REFLECTS LIGHT AND HEAT, KEEPING IT COOL.
4. Aluminium is good at conducting heat keeping things cold because it cuts down on the passage of heat.
5. Convection occurs therefore heat rises however coke can at the bottom of bucket surrounded by cool slow moving particles.
6. Surface area increases ~~rate of convection~~ ~~rate of cooling~~ this is increased by crushing the ice between coke can and aluminium.
7. Crushed ice because there is less surface area.
8. Salt added to ice makes you end up with a ice cube above melting point.
9. Placing the heat element (the can of coke) ~~inside~~ at the bottom of the bucket decreased its overall thermal energy.
10. BUBBLE WRAP IS A GOOD INSULATOR OF HEAT AND KEEPS AIR IN.
11. WATER WITH FOAM WITH ICE.
12. ICE COOLS.



Coke Can Challenge  
Unit 1 Physics 2019  
Winner  
Josie Smith

Thermodynamics Genius Award  
Awarded for including thermochemical principles  
into the design of a Coke Can Cooler



# U2AOS1 Mousetrap car investigation

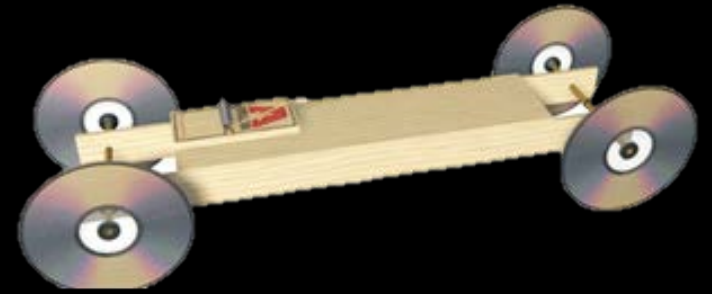
## Task Outline

Your aim is to improve the design of a mouse trap car.

Awards will be presented for the car that covers the greatest distance and the car with most improved base line data.

Each team of three will be allocated a basic mousetrap car and will determine the baseline data.

You team will then improve the design and you will write an individual report on your investigation under test conditions.





# U2AOS1 Mousetrap car investigation

## Instructions

1. Collect baseline data for the mousetrap car during experiments 1 – 3.
2. Design three improvements for the car. Predict and justify the effect of these improvements on data.
3. Collect data for modified car. Explain the changes that were observed. Justify with theory.
4. Complete the discussion grid. Submit the summary table and discussion grid for assessment.



# U2AOS1 Mousetrap car investigation

## Task Timeline

Lesson 1: Collect data on pulling distance and mechanical advantage

Lesson 2: Calculate the static and kinetic friction force

Lesson 3: Determine the torque and PE of the spring

Lesson 4: Design three improvements and justify with theory

Lesson 5: Modification Day – make improvements to car.

Competition day - Both classes will be competing together at lunch time for the awards.

Measurements will be taken for assessment task.

Lesson 6: Collect data on modified car.

Lesson 7: Complete summary table and discussion grid.

# U2AOS1 Mousetrap car investigation

## Calculate Maximum Pulling Distance of Mousetrap Car

Reference: Balmer, A.J (2012) Calculate maximum pulling distance, [www.docfizzix.com](http://www.docfizzix.com), date accessed 23<sup>rd</sup> July 2018.

### Purpose

To determine the pulling distance, mechanical advantage and distance travelled by mousetrap car.

### Equipment

- Ruler or digital callipers
- Measuring tape or meter ruler

### BACKGROUND THEORY

The pulling distance of a mousetrap car is a measurement of how far the car will be under the pulling force of the mouse trap. In this activity, you will calculate how far your mousetrap car should be pulled (theoretical pulling distance) and then compare this to the actual pulling distance.

The pulling distance is not the total distance that a mousetrap car will travel, but rather how far the vehicle will be under the force of the mouse trap's spring.

### IMPORTANT FACTS

- The distance that a mousetrap car is being pulled under the force of the mouse trap's spring is directly proportional to the size of the drive wheels, the drive axle, and the length of the lever arm.
- The travel distance is inversely proportional to the size of the drive axle.

### Mathematical Equations for calculating the pulling distance

The pulling distance is calculated from the number of turns that the drive wheel(s) make times the circumference of the drive wheel. The number of turns that a drive wheel makes depends on the length of string that can be pulled from the drive axle divided by the circumference of the drive axle. By putting the first two formulas together you can predict the pulling distance.

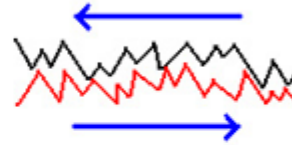
# U2AOS1 Mousetrap car investigation

## Measuring static friction and kinetic friction

### Background

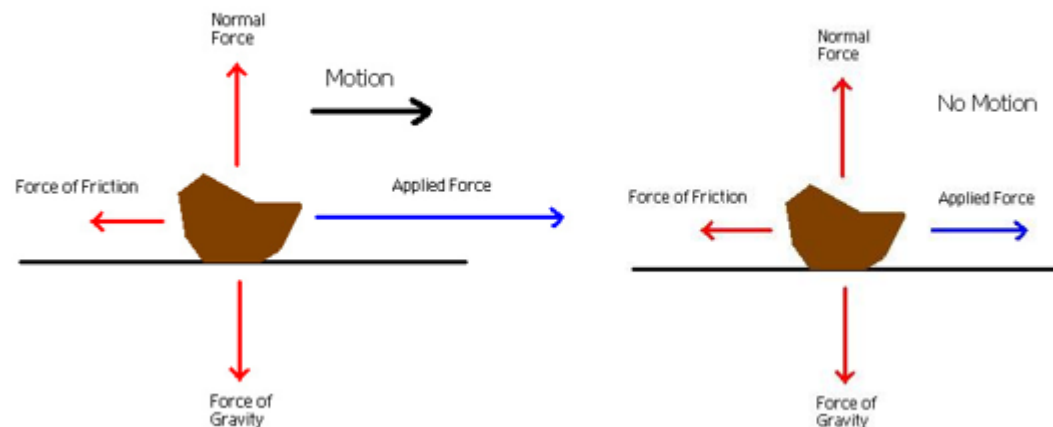
Reference: [http://ffden-2.phys.uaf.edu/211\\_fall2002.web.dir/ben\\_townsend/staticandkineticfriction.htm](http://ffden-2.phys.uaf.edu/211_fall2002.web.dir/ben_townsend/staticandkineticfriction.htm)

The force of friction is a force that resists motion when two objects are in contact. If you look at the surfaces of all objects, there are tiny bumps and ridges. Those microscopic peaks and valleys catch on one another when two objects are moving past each other.



This explanation is a little simplified. There are other processes at work, including chemical bonding and electrical interactions.

The level of friction that different materials exhibit is measured by the coefficient of friction. The formula is  $\mu = f / N$ , where  $\mu$  is the coefficient of friction,  $f$  is the amount of force that resists motion, and  $N$  is the normal force. Normal force is the force at which one surface is being pushed into another. If a rock that weighs 50 Newtons is lying on the ground, then the normal force is that 50 Newtons of force. The higher  $\mu$  is, the more force resists motion if two objects are sliding past each other.



# U2AOS1 Mousetrap car investigation

## Lesson 3: Measuring the Torque and the Spring constant of the Mousetrap Spring

A mousetrap car is a vehicle that is powered by the energy stored in the spring of a mousetrap. One of the basic ways in which most mousetrap vehicles are set into motion is by connecting the lever of the mousetrap bar through a string to the axle of the car. As the mousetrap lever is released, the tension that was built up in the spring is released, and the car sets into motion.

To get the car to go the farthest, you need to store the maximum amount of potential energy in the mousetrap spring. A car which has a higher spring constant will be able to store more potential energy.

You will use the torque formula to calculate the torque from the measured force at different angles.

### Torque formula

$$\tau = r_{\perp} F_{\perp} \quad (\text{To use this simple formula you need to ensure that the angle between the lever and the force sensor is at } 90^{\circ})$$

The spring constant ( $k_1$ ) can be determined from the equation that connects torque ( $\tau$ ) and the angle of rotation ( $\theta$ ).

$$\tau = k_0 + k_1 \theta$$

As it is a linear equation, the spring constant can be determined from the slope of the line.

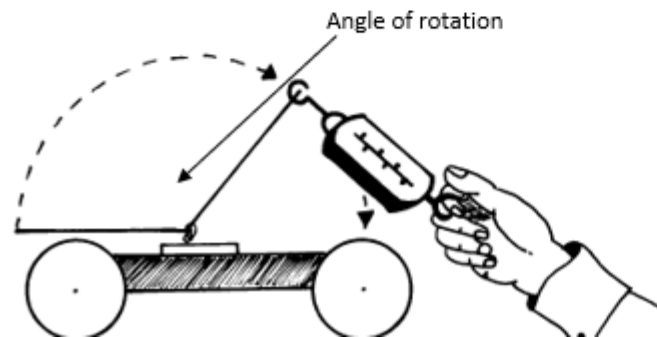


Table 1

Angle of rotation	Torque (Nm)
0	
45	
90	
135	
180	

# U2AOS1 Mousetrap car investigation

	Base Car	Reports results	Predicted effect of modifications on car Justify with theory (in text citations)	Modified car	Observations <u>Summarise</u> the effect of changes
Mechanical Advantage		Identify links between mechanical advantage, pulling distance and total distance			
Pulling Distance					
Total distance travelled by car					
Static friction		<u>Summarise</u> static and kinetic friction and spring constant data			
Kinetic friction					
Spring Constant					
Makes conclusions: <u>Summarise</u> key findings, identifies limitations, makes recommendations and discussions implications					

# U2AOS1 Mousetrap car investigation

		explains how modifications improve quality of results	discusses implications of key findings
uses observations that summarises investigation	summarises results and identifies trends	justifies effect of modifications using theory <u>with in</u> text citations	makes recommendations
identifies observations that influence results	summarises results	explains how modifications improve design	identifies limitations of key findings
records observations	lists results	identifies modifications	summarises key findings
<b>makes observations</b>	<b>reports results</b>	<b>modifies method</b>	<b>makes conclusions</b>
<b>Links to VCAA VCE Physics Key Science Skills</b>			
systematically generate, collect, record and summarise quantitative data		analysis and evaluation of primary data	draw conclusions consistent with evidence and relevant to the aim
process quantitative data using appropriate mathematical relationships, units and number of significant figures		linking of results to relevant physics concepts	identify, describe and explain the limitations of conclusions, including identification of further evidence required
		Identification of limitations in data and methods, and suggested improvements	determine to what extent evidence from an investigation supports the purpose of the investigation, and make recommendations, as appropriate, for modifying or extending the investigation
		take a qualitative approach when identifying and analysing experimental data with reference to accuracy, precision, reliability, validity, uncertainty and errors (random and systematic)	discuss the implications of research findings and proposals





# U2AOS3 Practical investigation

## Task Outline

You will complete an individual research task within a research group. In your research group you will be able to support each other by collaborating on the background theory and even measurement techniques. However, you will need individual research questions.

There are four research groups to choose from:

- Ski Jump Safety
- Design a safety harness
- Safety Barriers



# U2AOS3 Practical investigation

## Task Timeline

Lesson 1&2: Plan the investigation - design research question, establish variables, write hypothesis & aim.

Lesson 3: Write materials lists, method, table of results. Submit materials order.

Lesson 4: Submit logbook requirements and introduction for assessment rubric 1.

Lesson 5: Conduct experimental work.

Lesson 6: Conduct experimental work

Lesson 7: Draw graphs. Complete discussion template.

Lesson 8: Complete analysis on template

Lesson 9: Write up discussion under test conditions

Lesson 10: Complete poster and submit.

# U2AOS3 Practical investigation

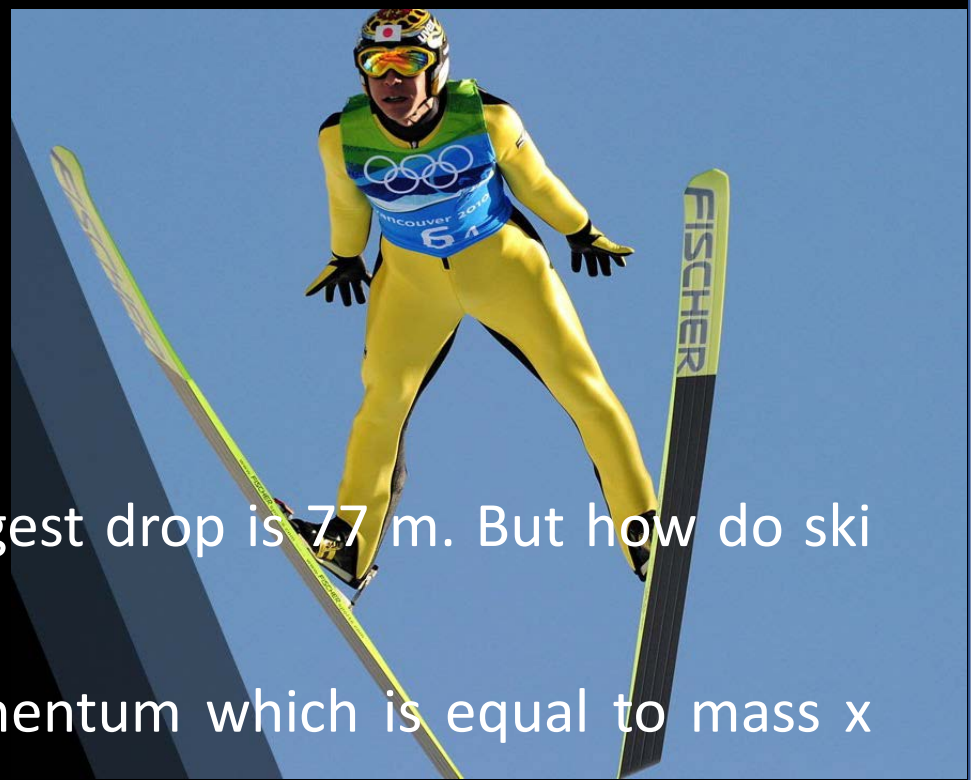
## Research groups; ski jump safety

The longest ski jump in world is 246 m while the longest drop is 77 m. But how do ski jumpers land in the snow without breaking their legs?

When the skier lands it causes a change in the momentum which is equal to mass  $\times$   $\Delta$ velocity.

The momentum is also equal to; Impulse = Force  $\times$   $\Delta$  time where F = impact force multiplied by the collision time.

You will investigate strategies that can be used to reduce the force of impact on the ski jumper when they land, by extending the time of the collision.



# U2A0S3 Practical investigation

## Research groups; safety barriers



Safety barriers reduce the severe injuries when cars run off the road.

When a moving car comes in contact with a stationary object, it causes a change in the car's momentum which is equal to mass  $\times$   $\Delta$ velocity.

Momentum is also equal to; Impulse = Force  $\times$   $\Delta$  time

The purpose of safety barriers is to extend the collision time in order to reduce the force of the impact on the car.

You will investigate different strategies that can be used to extend the time of the collision in order to reduce the force of impact on the car.

# U2AOS3 Practical investigation

## Research groups; safety harness

Falls are a significant danger to workers in a range of industries. From 2003 to 2011, 232 workers were killed following a fall from a height.

People first used ropes to stop falls, but this caused severe injuries to internal organs. This was because when a person falls, they experience a change in momentum. This change in momentum is equal to;  $\text{Impulse} = \text{Force} \times \Delta \text{time}$  which is the impact force multiplied by the collision time. So when a person comes to a sudden stop, this results in a huge impact force on the body.

Today, harness systems spread the impact force across the whole body. Shock absorbers are also used, which reduce the impact force on the body.

In this project, you will investigate the types of materials that can be used as shock absorbers to extend the time that it takes for the body to become stationary after a fall.

# U2AOS3 Practical investigation

see onenote

## Investigation Guide

Use this to guide your investigation. Include all information into your [log book](#). The checklists and assessment rubric [is](#) a useful tool to ensure that your investigation is of the required standard.

## Planning the Experiment

### Research Question

In your logbook, you need to include a research question that will be used to guide all parts of the investigation. It is important that your research question is not too broad or too generalised. The research question should also state what will be done in the investigation and should be able to be answered in a laboratory investigation.

### Research Question Checklist

	states what will be done
	can be answered experimentally

### Variables

In your logbook, you need to include the independent and dependent variables and summarise what factors you will control. A variable can exist in differing amounts or types and can be measured. Use the table below as a guide. Remember that you need to investigate two independent variables, one of which is a continuous variable.

Independent Variable (what will you be changing?)	Dependent variable (what change will you be measuring?)	Controlled variables (what will you keep constant in each trial?)

### Hypothesis

You need to include a hypothesis in your logbook. The hypothesis is

### Hypothesis Checklist

	States the predicted effect and
--	---------------------------------

## Assessment Rubric 1

justifies predictions using known theory		distinguishes between variables in prediction		applies ideas to new contexts	
questions that be tested		makes predictions based on theory		Identifies all variables	
that will be ne		guesses outcomes		distinguishes between factors to control, measure and change	
purpose		makes predictions		uses a risk assessment that follows requirements	
Planning the experiment		identifies factors		records risks and controls	
		identifies risks and controls		explains key physical concepts	
Correlation with Physic Study Design				uses physics terminology	
				forms ideas	
hypotheses, questions and that can be tested		identify independent, dependent and controlled variables		apply relevant occupational health and safety guidelines while undertaking practical investigations	
				clarity of explanation of physical concepts, ideas and models	
		follows		Introduction	



# U2AOS3 Practical investigation

## Safety barrier student investigation

### Introduction:



Safety Barriers are a means to reduce the impact of crashing high moving vehicles. The SAFER barrier is a newer design and has become the safest option primarily achieved through the Steel And Foam Energy Reducing (SAFER) barrier model. The foam can absorb large amounts of force and return back into its original shape which is essential for safety barriers on race courses that might need to be used frequently. In motion physics impulse-momentum is calculated by:  $P (\text{momentum}) = \text{Force} \times \Delta \text{time}$  and therefore safety barriers reduce momentum by either absorbing the force or by increasing the duration of the collision to give the object a slower deceleration rate.

This experiment aims to determine what angle and material of a safety barrier will reduce the overall momentum of the vehicle by increasing the collision time by increasing the total distance travelled. If the angle of the barrier is decreased and material with lower friction is used, the duration of the collision will be longer and therefore reduce the risk of a driver dying in a crash. This is because by increasing the friction the vehicle will come to a halt faster due to the fact that whilst the force remains constant the increase of friction increases resistance force therefore increasing the deceleration rate (Andrew Rader Studios, n.d.). Furthermore the decrease of the angle will increase the surface area of the safety barrier therefore increasing the distance and subsequently the duration of the collision as the driver has to go up and back down the barrier on an angle of  $30^\circ$  compared to a straight collision at  $90^\circ$ .

### Methodology:



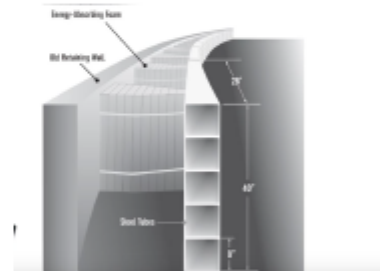
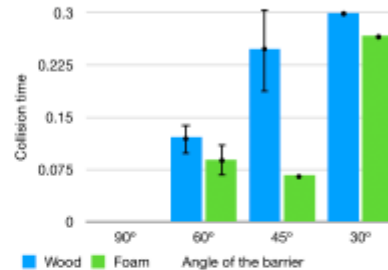
Initially, the time it took for a car to go up the barrier, (duration of the collision) was collected. The car was attached to a waited pulley system. The car was pulled back and let go and moved due to the weight in the pulley system. Videos of each trial was recording and through video physics the collision duration time was recorded.

To ensure safety, equipment was securely fastened and heavy objects was attached to other comments and placed in the middle of the table avoiding any falling objects from damaging feet.



### Results:

The collision time of a cart with varied materials and angle of the barrier



The SAFER barrier design displayed in "Know your NASCAR: SAFER barrier".

### References:



-Las Vegas Motor Speedway 2017, Know Your NASCAR: SAFER Barrier, 1 February, viewed 5 November 2019, <[https://www.youtube.com/watch?v=t\\_LoZtHwELc](https://www.youtube.com/watch?v=t_LoZtHwELc)>.  
-Friction Basics n.d., PHYSICS4KIDS, viewed 5 November 2019, <[http://www.physics4kids.com/files/motion\\_friction.html](http://www.physics4kids.com/files/motion_friction.html)>.  
-Professor Dave Explains 2017, Impulse and Momentum, 14 March, viewed 5 November 2019, <[https://www.youtube.com/watch?v=E13h1E\\_Pc00](https://www.youtube.com/watch?v=E13h1E_Pc00)>

### Discussion:



It was found that when the barrier was at  $90^\circ$  the collision duration time was 0 seconds for both wood and foam. When the barrier was at  $60^\circ$  the average collision duration time was 0.122 seconds for the wood board and 0.089 seconds for the foam board. When the barrier's angle decreased to  $45^\circ$  the average collision duration time was 0.248 seconds for the wood board and 0.067 seconds for the foam board. For the final result when the wood and foam boards were at  $30^\circ$  the collision duration time was 0.3 seconds on the wood board and 0.267 seconds for the foam board. The narrow 95% confidence intervals indicate that the data obtained is precise as 95% of trials will not differ more than 0.075 seconds from the mean. On 3 separate occasions the 3 trials had the same consistent result either suggesting the results were acutely recorded or the recording device was not specific enough and a trend is broken when the foam board at  $45^\circ$  has a shorter collision time despite the wooden counterpart increasing proving results to be inaccurate for the  $45^\circ$  data set.

This data suggests that lower angles for barriers increase the duration of the collision. This is potentially due to the increase in surface area lengthening the time it takes to go up the barrier. Additionally the friction of the barrier is inversely proportional to the duration of the collision. This is due to friction theory suggesting that the increase of friction 'slows objects down' faster as it takes a greater amount of force to travel the surface distance and if force is constant the object will travel to a halt faster (Andrew Rader Studios, n.d.).

The angle was not controlled since a protractor was manually used to measure the angle of barrier and the barrier shifted in-between trials. Consequently, collision times would have been impacted as a lower angle would have increased the collision time. Furthermore at  $30^\circ$  the car was going over the barrier which in a real life scenario would not be effective as the high speed vehicle could endanger civilians behind the barrier. The precision of the data may have been compromised as each trial would have different barrier angles which would lead to more variation in collision duration time. This could be rectified by inserting a block of wood carved to a specific angle which was fixed to the barrier to ensure consistency of angle readings and collect data on angles that could have practical use preventing the car to go over the edge. However the wood carved block could dislodge and alter the angle therefore there are limitations within the proposed solution to controlling this variable. The precision and reproducibility of results is increased by ensuring that further trials experience nearly identical conditions as one another.

When the foam board was trailed the original foam material was incapable of collecting results as the friction was so high causing the car to stop on impact of the foam. The thickness of the foam was reduced which decreased friction and increased



The car traveling off the edge of the barrier.



The car colliding with the foam barrier.

### Conclusion:



The decrease of the barrier's angle and the surface area with the least amount of friction tended to increase the duration of the collision, evident by the average collision time of wood and foam being significantly higher (Wood-0.3, Foam-0.267) at  $30^\circ$  compared to data at  $90^\circ$  (Wood-0 seconds, Foam- 0 seconds.) Lower angled barriers are potentially a viable option in race-car courses. However some of the angles tested caused the car to go over the barrier becoming a safety issue and thus it is unknown what specific angle is the most effective at increasing the collision duration without the car traveling over the barrier. Further testing should be conducted to determine which angle is most suitable to increase the collision time whilst reducing the risk of race cars travelling over the edge. Additionally other materials that vary in friction level should be tested to determine what material will increase the duration of a collision by the highest factor.



# Year 10 Biomechanics Investigation

## Task Outline

During this term, you will design a prototype assistive aid for a client. You will need to identify your client's needs, develop an understanding of the biomechanics of how people walk, identify suitable materials to use for your prototype and then design an assistive aid suitable for your client.

The final assessment task will be in Week 5 where you answer questions about your meeting with your client. In this meeting you will need to describe to them the main features of the assistive that you will have designed for them.





# Year 10 Biomechanics Investigation

## Timeline

Investigation Lesson 1: Identifying your clients' needs

Investigation Lesson 2: Forces and Balance – Centre of Gravity

Investigation Lesson 3: Newton's First Law of Motion

Investigation Lesson 4: Newton's 2nd Law

Investigation Lesson 5: Newton's 3rd Law

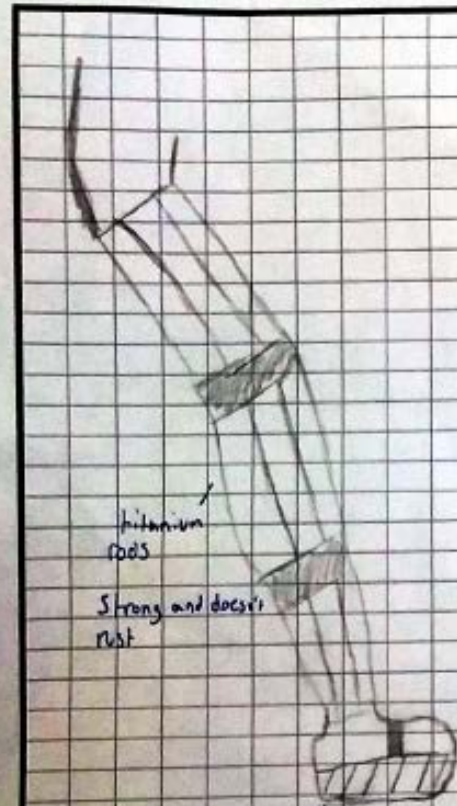
Investigation Lesson 6: Investigating properties

Investigation Lesson 7: Designing the prototype

Investigation Lesson 8: Designing the prototype

Investigation Lesson 9: Complete client interview under test conditions

# Year 10 Biomechanics Investigation



rubber sole  
So it has grip to the ground and so David doesn't slip and fall

titanium rods



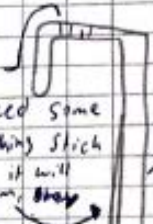
front view

Nylon straps

its firm and comfortable so David's feet stay in place and doesn't feel

David will need some grip on the walking stick because it will help him

rubber grip



keep his hands on the stick and it won't hurt his hands

walking stick

Drawn by



Title:

Material

Drawing no.

- explains how assistive aid functions
- design considers constraints
- design considers client needs
- lists reasoning behind the choice of materials
- includes a drawing with labels
- designs assistive aid

Drawn by

Title:

Material

Drawing no.

# Year 10 Biomechanics Investigation

## Assessment

	design considers all client needs	taylor's explanations to suit audience		
evaluates effect of science ideas on assistive aid design	design considers most of client needs	explains subject specific words		identifies limitations of key ideas
applies science ideas to assistive aid design	lists reasoning behind the choice of materials	defines subject specific words	explains links between science ideas and design	evaluates importance of key ideas
explains clients' needs	uses labels	uses subject specific words in correct context	identifies links between science ideas and design	explains key ideas
includes facts about client	includes a drawing	uses general words	discusses ideas	lists key ideas
<b>forms ideas</b>	<b>designs model</b>	<b>uses terms</b>	<b>evaluates ideas</b>	<b>makes conclusions</b>
<b>client profile</b>	<b>design assistive aid</b>	<b>client interview</b>		



# Year 10 Student design investigation

## Task Outline

In this task, you will design an investigation based on a research area. You will need to plan the experiment, collect data and communicate your findings as a poster.

The planning and design of your investigation will be submitted for assessment prior to conducting the experiment.

You will be writing the discussion under test conditions and then complete a digital poster of your research.

You will collect your own individual data and submit your own poster. Although you will be working individually on your own research question, you will be working in a research team.



# Year 10 student design investigation

## Timeline

Week 1: Plan the investigation - research question, introduction, aim, identify variables, set up poster template

Week 2: Plan the investigation - materials list, method, design the table of results, sign off experimental design

Week 3: Conduct experimental work

Week 4: Conduct experimental work

Week 5: Graph data and complete statistical analysis, work on poster

Week 6: Complete discussion planning document, write discussion under test conditions, complete poster

# Year 10 student design investigation

## Investigation guide

### Planning the Experiment

#### Research Question

A research question is used to guide all parts of the investigation. It is important that your research question is not too broad or too generalised. For example, "What type of starch can be used to make the best bioplastic?" is too broad as there are many different types of starch and how is it possible to measure 'best'?

A more specific research could be;

"What type of starch (potato, tapioca or cornflour) produces bioplastics with the greatest tensile strength?"

#### Research Question Checklist

	Includes the variable(s) that will be changed.
	states what will be effected

#### Variables

Identify the independent, dependent and controlled variables. Use the table below as a guide.

Independent Variable (what will you be changing?)	Dependent variable (what change will you be measuring? Include units)	Controlled variables (What will you keep constant? – You will need at least 5 controlled variables)



# Year 10 student design investigation

See MyAitken and OneNote

## How Does the Density of Soil Affect the Rate of Growth of a Plant?

### Introduction

As our earth's population grows at a rapid rate, the demand for housing increases as well, clashing with the demand for food and farming land. Having a limited amount of space, looking towards the planets remains the only option. However, the rocks and soil on mars are toxic and unsuitable for plant growth, and regular soil will be too heavy to transport. To combat this issue, lowering the density of soil will result in a lighter mass while taking up the same volume as regular soil would in the ship. But, how will lowering the density of soil affect the growth of the plants?

Bulk density is an indicator of soil compaction. It is found by dividing the soil's mass by its volume, and is expressed in g/cm<sup>3</sup>. Lowering the bulk density of the soil mix is predicted to increase the rate of growth of plants. This is because the biopores - voids in the soil - in high density soils are significantly smaller than those of low density soils, restricting root growth and resulting in poor movement of air and water through the soil, thereby decreasing growth and crop yield [soilquality.org, 2011]. Although roots grow most rapidly in low bulk densities, their intake of water and nutrient are limited, due to the minimal soil to root contact [Passioura, 1991]. This means that for the best plant growth, a medium bulk density would be prime. According to an experiment conducted in 1996 where barley plants were grown at different bulk densities in a growth chamber, the plants grew best in an intermediate bulk density. This presumably represented a "compromise between soil which was soft enough to allow good root development but sufficiently compact to give good root-soil contact" [Strzaker, R.J., Passioura, J.B. & Wilms, Y, 1996]. From this information, a hypothesis can be made that plants will grow bigger at an intermediate bulk density.

### Methodology

400g of potting mix was measured and split into 3 beakers; 225g in beaker 1, 100.5g in beaker 2, and 56.5g in beaker 3. 56.5g of vermiculite was then measured and mixed with potting mix in beaker 2. An additional 100.5g of vermiculite was also measured and mixed with potting mix in beaker 3. Contents in beaker 1 were evenly distributed between 3 pots containing 1 romaine lettuce plant each, and were labelled 'control'. Contents in beaker 2 were also evenly distributed between 3 pots containing 1 romaine lettuce plant each, and were labelled '75%'. Finally, contents in beaker 3 were evenly distributed between 3 pots containing 1 romaine lettuce plant each, and were labelled '25%'. Plants were then kept on a bench located in SE, and were measured and watered with a nutrient mix (0.4g calcium nitrate, 0.6 fertilizer with 500ml of water) everyday, for 3 days.

Risks in this experiment include breaking the beaker used and inhaling dry potting mix, which may lead to minor to major effects to the experimenter. Extra caution was taken around the use of beakers, and beakers were not left on the edge of benches. Use of potting mix was taken to a well-ventilated area and potting mix was kept moist at all times.

### Bibliography

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- Merrick, J 2013, Plants reveal their secrets: Scientists have worked out why some grow tall and some wide, viewed 30 October 2019, <<https://www.independent.co.uk/news/science/plants-reveal-their-secrets-scientists-have-worked-out-why-some-grow-tall-and-some-wide-8735105.html>>

### Discussion

Over the experimental period of 3 days, data was gathered of romaine lettuce's height in different densities of soil mix. In the pot(s) with 25% potting mix - the lowest density mix - 24% increase in the mean was seen. This was then followed by the control condition, being the most dense mix with a 23% increase in the mean, and lastly, the pot(s) with 75% potting mix - medium density - increasing by 20.26%. Although differences were shown in each independent variable, no data found was statistically significant. Shown on graph 1, error bars of the different conditions overlap, inferring that data across trials were similar, and that the data is not accurate nor precise.

As there was no statistical significant difference in results, the different densities of soil mix had no effect on the growth of the plants. This is because plants are robust, and are able to adapt to different soil conditions, which cannot be readily explained in terms of intake of water and nutrients [Passioura, 2002]. Roots of the romaine lettuce may have sensed difficult conditions in the most dense variable, as there was no adequate room for them to grow. The roots thereby send inhibitory signals to the shoot, which then adapt accordingly by hardening themselves to push further into the soil [Passioura, 2002]. Through this mechanism, results show that romaine lettuce will adapt to the soil mix and show similar results, regardless of soil bulk density.

There were also some outliers in results, whereby the first theory cannot be applied. In trial 1 of the control, there was a 21.3% increase when compared to its other trials. Additionally, trial 3 of the least dense soil mix showed a 30% increase when compared to the 'normal' trials. These outliers suggest that many errors in the method were present. The most influential error was the measuring of the plants themselves; height was the only growth factor considered. Over the course of the experimental period, leaves were observed to be visibly bigger when compared to their initial size. This is because some plants grow wider, rather than taller. The anti-gravitropic offset (AGO) mechanism is what causes this; it acts as a counterbalancing force in branches, and is crucially evident in vegetable plants. The hormone Auxin is present in all plants, and regulates the magnitude of AGO. When plants grow wider rather than taller, they have stronger AGO, and vice versa [Merrick, 2013]. From this, an inference can be made that the outliers in the experiment had a weaker AGO and that there were multiple growth factors that were not accounted for in the experiment, thereby producing certain outliers.

Using these key findings, a generalisation can be made that density of soil has no effect on the growth of romaine lettuce. This cannot be applied to plants further than what was tested as similar experiments show significant difference in other plants' growth in different densities of soil.

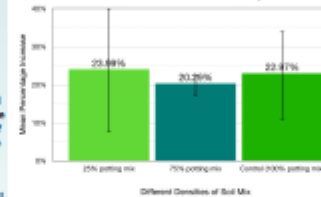
As shown in the results, many errors in the method were present. A definitive error was the measuring method. In some trials, there was some negative growth. This shows that the measuring method was not accurate, and may be subjective at times, thereby affecting the data's precision and accuracy. Additionally, mass of the plant before and after, root length, and leaf area are all growth factors that weren't accounted for, which may have greatly affected the result. Furthermore, intake of the nutrients in the soil and plants was also an error. It was observed that when nutrients were poured into the control condition pots, the nutrient mix would leak out, leaving less nutrients for the plant to intake, affecting its growth and the results that followed. This may have been what produced the outliers. The experimental period was also not long enough, which may have decreased the precision of data.

To further improve the results of the experiment, many measuring methods can be added and applied. To measure root growth, a clear pot can be used. However, this method may be subjective, and may produce results similar to the original method. The method that may produce the most precise and accurate results will be measuring the mass of the plant before and after the experimental period. This way, all growth factors are accounted for in a single unit; mass (grams). To further improve the method, the experimental period can be lengthened, which may produce more accurate results.

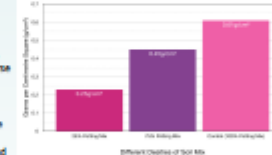
### Acknowledgements

Special thanks to Dr Hudson for her help in this experimental investigation. Big thanks to Sara as well for her help in during the experimental period.

Graph 1: Mean Percentage Increase of Romaine Lettuce in Different Densities of Soil Mix Over 3 Days



Graph 2: Mean Density of Earth Variable in g/cm³



### Conclusion

With these results a conclusion can be made that:

- No statistical significance between results.
- Different densities had no effect on the plant's growth because of their adaptive nature.
- Large variation (outliers) in trials due to many errors in method.
- Errors include:
  - Measurement methods not for accounting all growth factors.
  - Different nutrient intake.
  - Short experimental period.
- Can produce more accurate and precise results by:
  - Measuring plants' mass before and after experimental period.
  - Longer experimental period.



Plants in written conditions and trials at day 0 (above) and day 3 (below).



# Year 10 student design investigation

## Assessment

		distinguishes between variables in prediction	
applies ideas to new contexts	makes predictions based on further research	identifies all variables	identifies risk impact and likelihood
explains key science ideas	makes predictions based on theory	distinguishes between factors to control, measure and change	describes precautions
uses scientific terminology	makes predictions based on own ideas	identifies factors to change	Identifies risks
forms ideas	makes predictions	identifies factors	identifies risks and controls
Introduction		Planning	

uses graphs that include statistical analysis	evaluates quality of summarised data	uses theory to link or reconcile key findings including outliers	assesses effect of errors on quality of data	makes recommendations to overcome limitations	communicates ideas in concise and easy to read way
uses graphs that follows the set conventions	identifies trends and or patterns in data	explains key findings using theories	explains errors	identifies limitations of key findings	follows required poster conventions
uses graphs that follows some of the set conventions	summarises data	matches key findings with theory	identifies errors	summarises key findings	follows some of the poster conventions
includes graphs	includes data	includes findings	includes errors	includes findings	represents information on poster
represents data	evaluates data	analyses results	evaluates method	makes conclusions	designs poster
Reporting results		Discussion			Poster