ASELL for Schools Workshop

Laboratory Learning Activity Manual

Hosted by Balwyn High School

26 March 2018

CONTENTS

ACKNOWLEDGEMENTS

We would like to thank:

WELCOME

Welcome to an ASELL for Schools Workshop!

ASELL (Advancing Science and Engineering through Laboratory Learning) has developed over the last 10 years. This project developed from its physical chemistry APCELL predecessor and then expanded to incorporate all of chemistry (ACELL). After successful trials of using ASELL principles at workshops in physics and biology, the project has now expanded to include biology and physics, and more recently engineering, hence the name change.

The ASELL project has been designed to help address challenges in student learning which arise in science laboratories. By bringing together diverse expertise and resources, it is possible to develop a collection of experiments, which can facilitate student learning, whilst also taking into account variations in student differences. In 2010, the first national ASELL Science Workshop was held at the University of Adelaide.

This ASELL for Schools workshop is the second Victorian workshop to be run under the Australian Mathematics and Science Partnership Funding Grant, which was awarded to ASELL in 2014. This phase of the project has been initiated by Deakin University in conjunction with the University of Sydney with support from ReMSTEP and the Australian Council of Deans of Science. With the introduction of the new Australian and Victorian Curricula now in place, an opportunity exists to address current school-based experimentation and incorporate science inquiry. ASELL for Schools will provide the following three outcomes:

- A repository of experiments with all associated documentation necessary to run them, ranging from health and safety notes, necessary equipment and resources, notes for technical staff to the science learning objectives and how the experiment achieves them.
- Authentic professional learning workshops on experimentation in schools.
- An interface and interaction between school and university staff.

Today, you will be participating in laboratory activities and discussion sessions to expand your understanding of issues surrounding learning in the laboratory environment. In particular, it is important to be able to experience the experiments as learners.

In addition to the formal program, please take the opportunity to exchange ideas about science and education and get to know each other, as an additional aim of the ASELL for Schools project is to build a community of educators interested in laboratory-based education and other aspects of science education.

We would like to gratefully acknowledge the efforts of the submitters in presenting their experiments, as well as the assistance of technical staff and others in making this workshop possible. A very big thank you to Katie Jones and the team at Balwyn High School, for hosting this Workshop. Each person has put in a lot of hard work to get this workshop set up and running. I want to thank everyone!

If you have any questions about the project, please speak with me or one of the Victorian ASELL for Schools team, who are present.

Sincerely,

Kieran Lim

Kieran Lim
ASELL for Schools Victorian Leader, on behalf of the ASELL for Schools Team

ASELL FOR SCHOOLS WORKSHOP SCHEDULE

ASELL for Schools **Hosted by Balwyn High School** ***Monday 26 March 2018*** **All sessions in the Xplore Centre**		
8:45–9:00	**Arrival/Registration**	
9:00–9:15	**Welcome and Introduction** with *Kieran Lim* and *Katie Jones* • Introductions (of ASELL for School team and Students and Teachers) • Outline ASELL for Schools • Outcomes for the day • How to use the booklet	
9:15–9:25	Introduction to Laboratory Learning Activity	
9.25 –10:25	***Laboratory Learning Activity 1 – "Corrosion: All at Sea"*** *John Long* and *Ian Bentley*	
10:25–10:45	Discussion and feedback on Laboratory Learning Activity	
10:45–11:20	**Teachers: Inquiry Skills in Science** with *Peta White* • How can we incorporate more science inquiry and inquiry skills into science? • Introduction to the inquiry scaffold tool	**Students:** Discussion about forensic science with *Kieran Lim*
11:20–11:50	**Morning Tea**	
11.50–12.15	**Teachers: Inquiry Skills in Science** (continued)	**Students:** Forensic science activity
12:15–12:25	Introduction to Laboratory Learning Activity	
12.25 –1:05	***Laboratory Learning Activity 2 – "Bullet-proof vests"*** *Katie Jones, John Long* and *Kieran Lim*	
1:05–2:05	**Lunch**	
2.05 –2:25	***Laboratory Learning Activity 2 – "Bullet-proof vests"*** *(continued)*	
2:25–2:45	Discussion and feedback on Laboratory Learning Activity	
2:45–3:15	Overall debrief and Evaluation for the day	

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LABORATORY LEARNING ACTIVITY 1
CORROSION: ALL AT SEA

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Corrosion: All at Sea

Introduction

The ocean is one of the most natural corrosive environments, made up of dissolved minerals (mainly sodium chloride) and carbon dioxide from the atmosphere.

Residents living near coastal areas may need to replace metal objects regularly if left outside for prolonged periods due to corrosion (e.g. cars, bikes, garden tools, BBQ's, golf clubs). Families or businesses that rely on boats and/or other leisure watercraft (e.g. jet skis, yachts, ships) with metallic parts, must deter or protect against the effects of corrosion

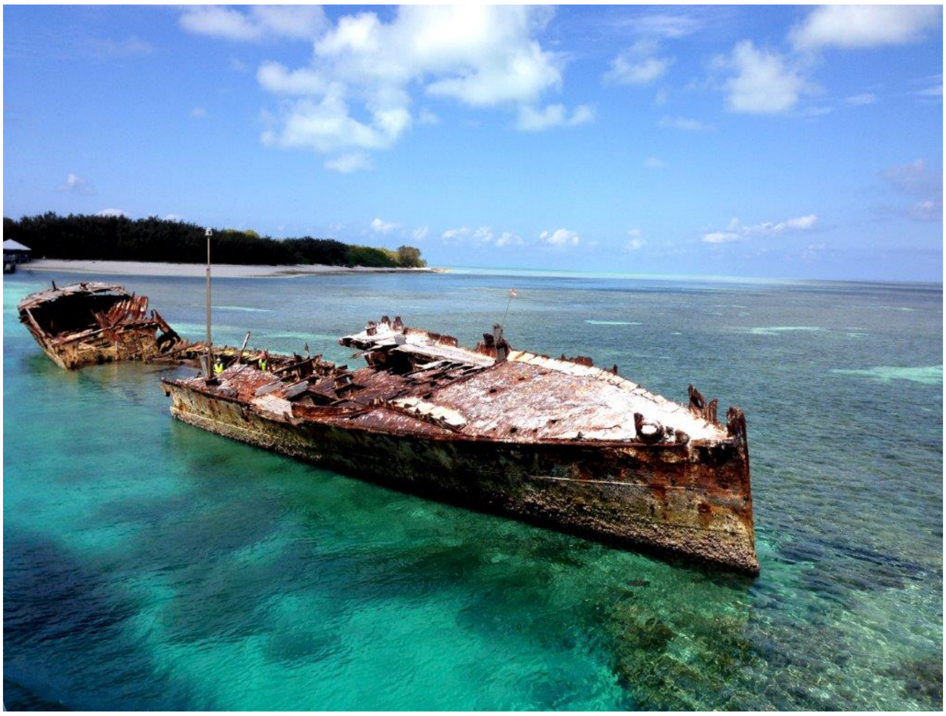

Photo: Dr Ian MacLeod, Heritage Conservation Solutions. Photograph used with permission

At some locations, marine archaeologists find metal artefacts and shipwrecks with severe corrosion due to the prolonged time spent submerged in the ocean, while at other sites there are artefacts and shipwrecks with almost no corrosion. Why is there a difference in the extent of corrosion?

In this activity, you will simulate and test which environmental conditions influence the rate corrosion of different metals and describe the observed changes.

Key ideas

Corrosion – The process of destruction or deterioration of a metallic material as a result of chemical reactions with the surrounding environment.

Metal - A substance that usually (1) can conduct electricity, (2) can conduct heat, (2) has shininess (lustre), and can be deformed when struck with a hammer or other hard object (malleability). When metals react, they tend to lose electrons to form positive ions (cations).

Chemical composition – The relative amounts of different elements or substances that are present in a sample.

Alloy - A solid mixture of two or more metals. Some alloys can include non-metal components. Steel is an alloy that consists of iron with small amounts of carbon. Stainless steel is an alloy that consists of iron with small amounts of carbon and about 18% chromium. 18-carat gold in jewellery is an alloy of 75% gold, 7.5% silver and 7.5% copper. Bronze and pewter are other common alloys.

Reactivity series – A ranking of listing of metals from the most reactive to the least reactive.

Solution - A mixture of two or more substances that is homogeneous. Homogeneous means that the solution is evenly mixed and has the same appearance and composition everywhere in the mixture. It is possible to have gas solutions, liquid solutions, and solid solutions. In this laboratory learning activity, **solution** will refer to water-based liquid solutions.

Concentration - The ratio of the amount of a solute in a solvent or total solution. There are many ways of measuring and expressing concentration. In this laboratory learning activity, the concentration will be expressed as the percentage mass per unit volume.

% (m/v) - Percentage mass per volume (%m/v) is one method of measuring concentration, defined as the mass of the solute per 100 mL of solution

$$\text{concentration (\%m/v)} = \frac{\text{mass of dissolved substance (g)}}{\text{volume of solution (mL)}} \times 100\%$$

Dissolve - The process in which the solute interacts with the solvent to form a solution. This only applies to mixtures in which the solute was originally in a different gas/liquid/solid states from the solvent.

Solute – A substance which is dissolved in a solvent to form a solution.

Solvent – The largest component of a liquid or a gas, in which another substance (the solute) is dissolved to form a solution.

Investigation - A scientific process of answering a question, exploring an idea or solving a problem that requires activities such as planning a course of action, collecting data, interpreting data, reaching a conclusion and communicating these activities

Variable - Something that can change.

Dependent variable - Variable that changes in response to changes in the independent variable and that is observed or measured.

Independent variable - Variable that is deliberately changed.

Controlled variables - Variables that are kept constant.

Fair test - When testing different materials all the variables except the one being tested need to be kept the same.

Equipment and materials

- Plastic or glass beakers
- Cooking salt
- Plastic spoons or glass stirring rods
- Demineralised water
- Paper clips, hair pins (or 'bobby pins'), metal washers, aluminium foil (1 cm strips), iron nails, galvanised nails, etc.
- Plastic tweezers or tongs
- 100 mL measuring cylinder
- Sticky labels or marker pens
- Safety glasses/goggles and gloves

Optional

- Metal coins
- Stainless steel cutlery
- Additional metal samples
- Carbonated mineral water or soda water
- Soft drink
- Hot water bath
- Thermometer
- Scissors
- Steel wool
- Emery paper or sandpaper
- Electronic balance or scales
- Timer or stopwatch

Hazards

- Nails, aluminium foil pieces, emery paper and steel wool may cause cuts and/or lacerations to skin if not handled correctly.
- Water that is used in corrosion experiments may contained dissolved ions, and should not be consumed.
- Use of a kettle to boil water must be situated away from wet areas and must be in good condition (i.e. no frayed chords or exposed wires). There is danger of burns from a hot appliance and/or hot water or steam.

Lesson plan organisation

Lessons 1 and 2: Recall of concepts learned from Years 7 and 8 on solutions, solvents, solutes, concentration, reactivity series of metals and chemical reactions involving formation of rust/corrosion.

% (m/v) - Percentage mass per volume (%m/v) is one method of measuring concentration, defined as the mass of the solute per 100 mL of solution

$$\text{concentration (\%m/v)} = \frac{\text{mass of dissolved substance (g)}}{\text{volume of solution (mL)}} \times 100\%$$

Lesson 3: Plan the inquiry and set up the investigation.

Lesson 4: Check the results of the investigation and analyse the results.

Lessons 5 and 6: Complete presentation of the investigation as a laboratory report, scientific poster, multimedia, or other format.

Part A1: Investigation Instructions

You will work in groups of approximately four students. Each group is assigned two metals each, so that each pair of students works with the same metal.

In your groups, design an experiment, using the provided equipment, that will determine if a metal undergoes corrosion.

Suggested procedure for preparation of solutions:

- To prepare a solution of concentration of 5%(m/v) of salt in demineralised water, weigh 5 g of salt into a dry beaker and add approximately 80-90 mL demineralised water. Dissolve the salt before topping up with demineralised water to the 100-mL mark.
- This procedure can be adapted to make solutions with other concentrations of salt in demineralised water.
- This procedure can be adapted to make solutions with other concentrations of salt in other types of water.

Part A2: Scientific questions

Suggest one or two scientific questions that you could ask using your experimental equipment and materials:

Some scientific questions will be more suitable for investigation in a classroom setting. Your teacher will lead a discussion to decide which scientific questions will be investigated. Your group will then decide how to investigate that question.

The scientific question that my group will investigate is:

Our hypothesis is:

Our **independent variable** is:

Our **dependent variable** is:

Our **controlled variables** are:

We will use the following **experimental procedure**. (If appropriate, make a drawing of your proposal.)

Are there any **safety** issues to consider?

Part A3: Testing our scientific question

Get approval from your teacher of your plans (Part A2) before starting Part A3.

Remember to take photos throughout your experiment to add to your laboratory report, scientific poster, or other presentation.

What happened? Record your observations or measurements:

Once all the groups have summarised their observations or measurements, a 'scribe' to collect all the results from each of the groups so that you can collate a summary of the entire class's results.

Part B: Analysis of results

Part C: Drawing conclusions (discussion prompts)

What was the purpose of using demineralised water instead of tap water in this experiment?

Looking at your results, which metals were the most reactive to the corrosive environment(s) simulated in this activity?

Looking at your results, which metals were the least reactive to the corrosive environment(s) simulated in this activity?

Was this a **fair test**? Are there variables that you have not controlled in your experiment? How might these variables affect your conclusions?

Using the internet, learn about the chemical composition (makeup) of some of the metals that you have used in this activity.

Using internet or textbook resources, write a **word equation** for the reaction of one of the metals that you tested from this activity.

Using internet or textbook resources, write a **chemical equation**, described by the above word equation.

Part D: Extension 1

The ocean is not the only corrosive environment. Use the internet or a library to research other types of corrosive environments and the types of corrosion that can occur within them.

Use the internet or a library to research materials or methods used to prevent corrosion and suggest which one(s) are suitable for the environment(s) that you have described above.

In January 2003, the famous chairlift at Arthur's Seat, on the Mornington Peninsula (south of Melbourne) collapsed, injuring passengers and leaving some stranded for several hours (see footnote 1).

Use the internet or a library to research the answers to the following questions:

- What type of corrosion was blamed for this near-disaster?
- How does this type of corrosion occur?
- What types of personnel were involved in the investigation and management of this accident?
- What human factors were involved in the incident?
- How could these factors have been managed?
- What economic costs occurred as a result of the accident?

Part E1: Extension 2 - Instructions

Consult with your teacher if you should do this second extension.

Based on your results and the class results, can you propose some additional tests relating to the corrosion of metals? To better compare your results from this Part with your earlier investigations, it is suggested that you have similar hypotheses and experimental procedures.

[1] The Age (2003). 'Chairlift Collapse 18 Hurt' Retrieved 16th July 2017 from <http://www.theage.com.au/articles/2003/01/03/1041566225573.html>.

Part E2: Extension 2 - Scientific questions

Our hypothesis is:

Our **independent variable** is:

Our **dependent variable** is:

Our **controlled variables** are:

We will use the following **experimental procedure**. (If appropriate, make a drawing of your proposal.)

Are there any **safety** issues to consider?

Part E3: Extension 2 - Testing our scientific question

Remember to take photos throughout your experiment to add to your scientific poster.

What happened? Record your observations or measurements:

Once all the groups have summarised their observations or measurements, a 'scribe' to collect all the results from each of the groups so that you can collate a summary of the entire class's results.

Part E4: Extension 2 - Analysis of results

Part F: Scientific poster

1. Complete introduction:
   - One- to two-paragraph overview of the reason for completing the investigation, the scientific context and an explanation of the relevant scientific theory.
   - All sources need to be acknowledged.
2. Complete the discussion section:
   - Discuss your scientific question in this section. **POE** is often a useful guide is to help what you put in this section:
     a. Predict. Your scientific question, hypothesis and prediction of what will happen.
     b. Observe. What you observed or measured.
     c. Explain. Did your observations or measurements agree with your expectations and prediction? Can you explain why?
   - Discuss the implications of your results.

- Were there any limitations to your investigation?

3. Complete the conclusion section:
   - State your main result from your investigation.
   - State whether this supports or refutes your hypothesis.
4. Complete References and Acknowledgements.

Acknowledgements

The contributions of Linda Lawrie, Jessica Saw and Ian Bentley, to the refinement of this laboratory learning activity are gratefully acknowledged.

- Photograph of shipwreck has been used and redistributed by permission of Dr Ian MacLeod, Heritage Conservation Solutions.

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LABORATORY SESSION 2
BULLETPROOF VESTS

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Bulletproof vest

Introduction

Law-enforcement officers and members of the armed forces are often in danger of death or serious injury from knifes, firearm-fired projectiles (bullets) or shrapnel from explosions. Personal armour, called “bulletproof vests” are worn to protect such people.

Not only does a bulletproof vest need to remain intact from a bullet impact, but it also needs to absorb the energy or momentum from the bullet as well. This can be done by using a combination of various materials.

In the first parts of this activity, you will investigate the properties of materials in order to design a combination of materials that will make a good bulletproof vest.

In the later parts of this activity, you will investigate quantities association with the motion of the bullet that is most associated with injury to people or damage to the bulletproof vest.

Key ideas

Force – a push or a pull

Compression force – a push that squeezes an object to try to make it smaller or shorter.

Tension force – a pull stretches an object to try to make it bigger or longer.

Newton – SI unit used to measure force. The symbol for newton is N, and it is spelt in lower-case letters (except at the start of a sentence).

Newton’s First Law – Objects at rest stay at rest. Objects in motion stay in a straight-line motion unless subjected to an unbalanced force.

Newton's Second Law – The net force acting on an object is equal to the mass of the object multiplied by its acceleration:
$F=ma$

Newton's Third Law – When one object exerts a force on a second object, the second object exerts an equal and opposite force back on the first object.

Kinetic energy – Energy that an object has by virtue of its motion.
$KE = \frac{1}{2} m v^2$, where m is the mass in kilograms, and v is the velocity in ms^{-1}.

Potential energy – Energy that is stored in an object has by virtue of its position.

Gravitational potential energy – Energy that is stored in an object has by virtue of its height.
$PE = m g h$, where m is the mass in kilograms, g is the acceleration due to gravity (9.8 ms^{-2} on earth), and h is the height in metres.

Energy loss – When energy is transformed from one form to another, there is some energy loss.

Momentum – This is the quantity associated with an object's resistance to a change in its motion, or its state of rest.
$p = m v$, where m is the mass in kilograms, and v is the velocity in ms^{-1}.

Impulse – The change of momentum of an object when the object is acted upon by a force for an interval of time.
$J = m \Delta v, = F_{average} \Delta t$, where m is the mass in kilograms, Δv is the change in velocity in ms^{-1}, $F_{average}$ is the average force in newtons acting on the object, and Δt is the length of time in seconds that the force is acting on the object.

Strength – The ability of an object or material to withstand forces without permanent change. There are many ways of measuring "strength". Not all types of strength are appropriate for a bulletproof vest.

Elasticity – The ability of an object or material to resume its normal shape after being stretched or compressed.

Stiffness – The ability of an object to maintain its overall shape. Stiffness is sometimes referred to as **rigidity**. Stiffness does not include the ability to resist scratching.

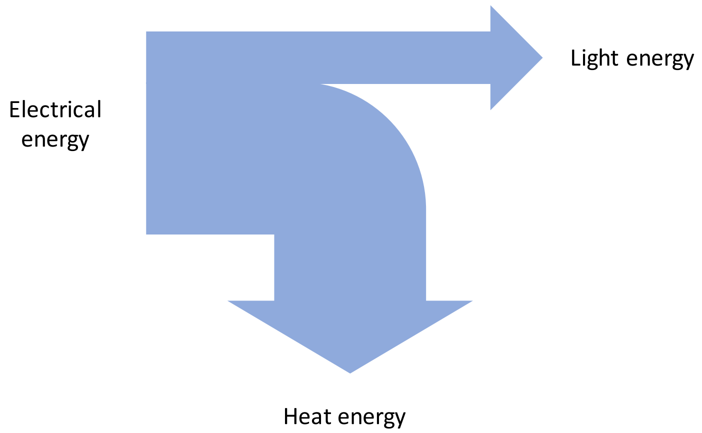
Hardness – The ability of an object to maintain its shape, especially when forces are exerted by a sharp object. Hardness includes the ability to resist scratching by sharp objects and/or abrasion.

Toughness – The ability of an object to absorb energy (from mechanical impact) without breaking.

Pressure – The force per unit area. Pressure is measured in pascal (Pa). $P = F / A$, where F is the force in newtons, and A is the area in square metres.

Density – The mass per unit volume. Density is normally measured in g mL^{-1}, which is the same as kg L^{-1}.
$d = m / V$, where m is the mass in grams and V is the volume in millilitres.

Sankey diagram – A picture summarising all the energy transfers taking place in a process. The thicker the line or arrow, the greater the amount of energy involved.



Sankey diagram for an electric lamp showing that most of the electrical energy is transferred as heat rather than light.

Equipment and materials

You will have access to a variety of materials for the bulletproof vest. Typical materials are:

- Paper
- Cardboard
- Plastic wrap
- Felt
- Foam sheets
- Duct tape

- Plastic bags
- Aluminium foil
- Fabrics
- Metal and/or nylon scourers (cleaning pads)
- Cork

Other ideas you can come up with are welcome!

You can use a combination of the following to prepare and test the strength of your bulletproof vest material:

- Scissors
- Balance
- Plumb bob (pointed weight)
- Metal washers
- String
- Tape measure or metre ruler
- I-pad or Go-Pro camera or other means of recording video
- Towel or other padding

Part 1: Designing a bulletproof vest

Discuss design specifications for the material for a bulletproof vest in your group and list the most desirable features. Give details – for example, what do you mean by "strong"?

You need to develop a small portion of a bulletproof vest. Your design must protect the area of an A5-sized piece of paper (half an A4 sheet), but must have mass less than 50 g. (You don't want the full bulletproof vest to be too heavy, do you?)

Inspect and investigate the materials that are available. Do you think a single layer of just one material will be suitable to make a bulletproof vest? Or will you make a composite material of more than one layer? Draw a picture representing your proposed bulletproof-vest material, showing the layering. Label your diagram, with the properties of the various layers, and explain why you have chosen to arrange the layers in a particular order.

Now, pick out your materials and build your design.

Part 2: Testing your bulletproof vest material

Place an A5-sheet of paper on top of a folded towel, which is on the floor. Place your bulletproof vest material on top of the A5-sheet of paper.

What is the purpose of the A5-sheet of paper?

You will use a plumb bob (pointed weight) as your "bullet". Hold the "bullet" 50 cm above your design.

Drop the "bullet".

You should repeat this test a few times, carefully observe what happens when the "bullet" hits your bulletproof vest design. If you have access to a video camera, viewing the impact in slow motion might help clarify your observations. Inspect the A5-sheet of paper. Did your design successfully stop the "bullet"? Record your observations.

Share your design and results with the rest of the class. What worked well? What could have worked better?

How would you improve your design?

Part 3: Improving your bulletproof vest material

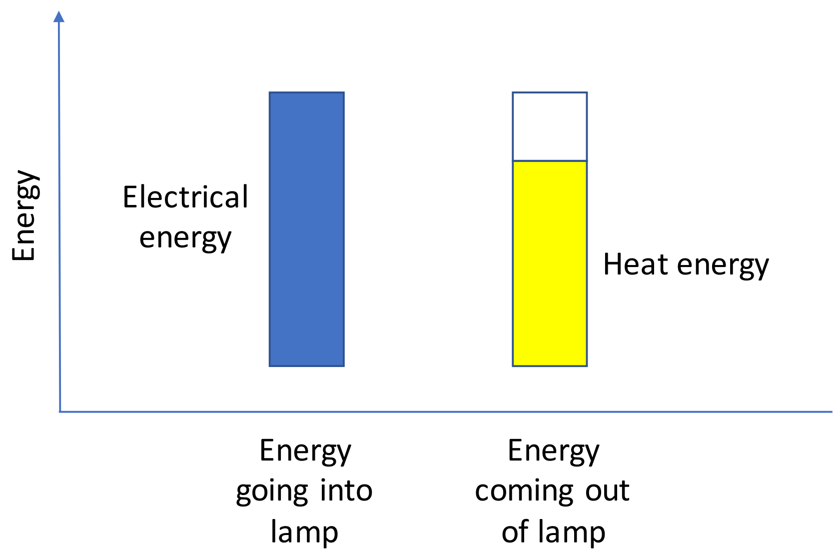
Pick out your materials and build your improved design, incorporating the ideas from Part 2.

Test your improved design, and record your observations. If there is sufficient time, you might try a few design-test-reflect-improve cycles.

Part 4: Analysing the impact of the "bullet"

Represent the energy transformations using a Sankey diagram.

There are many alternative ways of representing the energy transformations of an electric lamp. The diagram below is a different representation.



Can you design one other representation on the energy transformations involved in the impact of the “bullet” on the bulletproof vest?

Part 5: Analysing the impact of the “bullet”

Calculate the gravitational potential energy of the “bullet” when it is held 50 cm above your design.

Calculate the kinetic energy of the "bullet" when it hits your bulletproof vest. State any assumptions involved in the calculation.

Calculate the velocity of the "bullet" when it hits your bulletproof vest.

Calculate the momentum of the "bullet" when it hits your bulletproof vest.

Discuss whether the kinetic energy or the momentum of the "bullet" is more important in causing damage to the bulletproof vest.

Design a test to determine whether the kinetic energy or the momentum of the “bullet” is more important in causing damage to the bulletproof vest.

Conduct your test and record your observations.

Share your results with the rest of the class. What do you conclude from the combined class results?

Part 6: Summary

Reflect on and summarise your main discussion points, observations and conclusions from Parts 1-5.

Acknowledgement:

The first parts of this laboratory learning activity have been adapted and extended from an activity developed at the Ohio State University as part of the Translating Engineering Research K-8 (TEK8) project. <https://u.osu.edu/tek8/2016designchallenges/bulletproof-vests/>.

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