TSTS 2019: STEM Challenges

Celebrating the 1969 moon landing

This unit is:

a. Designed to use balloons to be amazed at the achievement of landing people on the moon;
b. The substance of the 2019 Tasmanian Science Talent Search STEM challenge, the full details of which are included at the end of the document;
c. Is larger in scope than the TSTS STEM challenge; and
d. Contains exercises, challenges and investigations which may be adapted to individual teaching styles and desired outcomes.

It is based on:

a. Constructivism,
b. Hands-on activity,
c. Teaching and learning outcomes, and
d. Starting points for an in-class theme to be fitted to your teaching style.

The 5 STEM challenges, in brief, are:

a. **Challenge 1: for children up to Grade 2**
   Make a balloon rocket which will fly along a taut fishing line, in a large room like a gymnasium or multi-purpose room, with the starting point 1m above the ground and the potential finishing point being 2.5m above the ground.
b. **Challenge 2: for children in grades 3 and 4**
   Make a balloon-powered paper-rocket which will make a vertical take-off along a launch stick of up to 1.5m length (or longer if necessary).
c. **Challenge 3: for children in Grades 5 and 6**
   Make a balloon retro-rocket "capsule", which when released from a height of 3metres, descends slowly to the floor.
d. **Challenge 4: for students in Grades 7 and 8**
   Make a solar-powered lunar buggy which will travel across a lunar terrain of crushed concrete (or sand, gravel, rocks of different dimensions) spread over a tarpaulin.
e. **Challenge 5: STEM open investigation: Hero's Engine**
   Make a balloon-powered Hero's engine (design below) and improve on it.
   Make a balloon-powered Catherine wheel operating in a horizontal plane and improve on it.
   Make a simple and safe steam-powered Hero engine on an established design as shown on-line - search engine - "Steam -powered Hero's Engine" or try, as a start,

http://www.foresightguide.com/50CE-a-steam-engine-in-ancient-rome/

   Apply the design to a working model
   In a report, describe the science of Hero's engine and relate that to the creation of factories, motor cars and rockets.

Balloon rockets in the classroom

1. What is to be learnt/taught?

Concept:

- an enormous amount of energy is required to launch a rocket.
    - 2 million litres of liquid hydrogen and kerosene in the first 165 seconds
- An enormous amount of energy is required to have a capsule make a soft landing.
- An amount of energy may be expressed informally
- Energy may be stored
- Newton's first law – body at rest or uniform motion in a straight line – the rocket on the launch pad or travelling through space
- Newton's third law – for every action (force) there is an equal and opposite reaction - the thrust of the rocket motors against hard surface and atmosphere at the take-off

Note: Hands-on activity is not necessarily in-depth learning. Students need to be asked what they think they have learned.

Skills:

- The activities are mostly measurement driven but other skills could be developed;
    - Measurement: How big was Apollo 11 in all dimensions?
    - Interpreting data if working from the picture/photograph/diagram starter
    - Problem solving
    - Using space/time relationships
    - Hypothesising

2. Constructivism

- What do they know? oral or written responses - whole class, small group, individual. The question should be given pre-teaching and post-teaching:
    - What happens to a balloon when I blow it up and let it go and why does it behave like this? or
    - How might I make a balloon fly in a straight line? (Note: this is the preferred question and assumes that all children will have had some experience with balloons.)
    - Create a diagram (or diagrams) with explanatory notes to show how a space ship can travel from the earth to the moon.
    - How is it that a man in a spaceship could land on the moon and still be able to get back to earth?
    - As a space rocket scientist, what questions would you need to ask yourself to overcome problems for a trip to the moon and return?

- **Typical Structure of the Observed Learning Outcomes for Q1 - SOLO**
    - Pre-structural – blow it up and let it go (merely repeating the question)
    - Uni-structural - tie a string to it after it has been blown up; do something to it so that it won't fly just anywhere; put something on the front so that it looks like a rocket;

    - Multi-structural – tie it to a fixed line after it has been blown up; stick a straw on it, blow it up, thread a line through the straw and it will fly along it.
    - Relational: because the end of the balloon is not fixed, the air coming out goes in any direction and so it will not fly straight it needs to be tied to a line.
    - Extended abstract: the air in the balloon is recognized as a general fuel/energy source and the action of the balloon is seen as an energy source in rockets and other moving vehicles; explanations of Newton's first (inertia) and third (action & reaction) laws;

3. STEM starting points with hands-on activities

- <u>Science:</u>
    - Whole class discussion leading to the construction of a child-initiated activity.
      Concept understanding: How is it that we inflate (blow up) a balloon?
      Problem: How might we make a balloon rocket? Or
      Problem: How do we make a balloon rocket travel in a straight line?
      Exercise: How far might a balloon rocket travel?
      Exercise: What type of balloon makes for the best balloon rocket?
      Exercise: How long does it take a balloon rocket to travel from A to B?

    - Explorations and challenges based on blowing hard
      Problem: How much is a lungful of air?
      Problem: How might you discover the amount of energy in a lungful of air?
      Exercise: How far can you blow a ping-pong ball with one breath on a carpet/lino surface?
      Exercise: How might you improve on the performance?
      Exercise: What difference would blowing through a drinking straw make to performance?
      Exercise: How might I make sure that the ping-pong ball travels in a straight line?
      Exercise: How many lungsful of air does it take to make a balloon rocket fly?
      Problem/exercise: Is there a better way of measuring input to a balloon than lungsful of air?

- <u>Technology: working from a demonstration</u>
    - Release an untethered balloon; observe, formalise observations from several attempts then challenge;
        - What must I do to make this balloon fly in the direction I want it to fly?
    - Demonstrate a purchased/constructed device - balloon rocket, balloon car, balloon helicopter, balloon boat – then make your own
    - Demonstration of balloon on a string followed by formalised skills-development such as observations, measurements, inferences and probable explorations (maybe hypotheses). Note - no use of the word prediction because of specific meaning
        - Going further
            - What alterations might be made to have the balloon fly further, faster in a straight line? Set up ways of testing the idea.

        - What might happen when the balloon rocket flies at (angle 1, 2, 3) and vertical? Set up ways of testing the new conditions.
        - What way might be constructed to have the balloon reach its maximum size without exploding?
    - Further still:
        - How can the energy in an inflated balloon be controlled to make a rocket vertical take-off rocket or retro-rocket?

- English 1: the story's the thing (the play, the lexicon)
    - The story precedes the video because of the emotion.
      Three men were awoken at 4am to eat bacon and eggs, put on their space suits and 5 hours later be on their way to the moon.
      The walk to the lift, the rise of over 100m -36 storeys- to the space module, lying on your back strapped into the capsule seats, the nervous tensions when the rocket fired; the apprehension of the lift-off, are all better said before the video
      Search engine: "moon landing 1969" 3 videos; 2 mins, 4 mins, 10 mins; in the 10-minute version, the control centre in Houston and the capsule pilot are calling the descent – it's magic.

      The other parts of the story are:
        - The voyage; how long did it take and how did they go to the toilet?
        - Entering the lunar module, firing the retro rocket and the descent
        - Michael Collins left alone – his thoughts
        - The ladder descent, the moon-walk (hop or jump), the specimen collection
        - Re-entering the lunar module and return to the command module
        - The re-entry – how hot is hot?

  English 2: from a picture: Why do people wear space suits on the moon, or in space etc?

  English 3: reading for a purpose: make the NASA paper rocket or demonstrate its capabilities.

    - Manipulate the paper rocket to make it perform better.
        - Note: Science reading is a distinct genre.
    - Discussion/writing: What does it mean; "One small step for (a) man, one giant leap for mankind."
        - Social science: In what other human endeavour might this apply?

- Mathematics
  Research and measure: How big is a Saturn V rocket? – (111m or 36 storeys) mock it up on the oval
  Research and measure: How big were the modules on top of the rocket? – mock them up in the classroom
  Command module: 3.2m tall, 3.9m diameter
  Lunar module: 7m tall, 9.4m diameter; 3 stages- cabin, ascent, descent
  Mass 3920 kg; African elephant 6000kg

Research and make table of comparisons: How hot is hot?

Re-entry temperature on the command module was 2760^{o}C

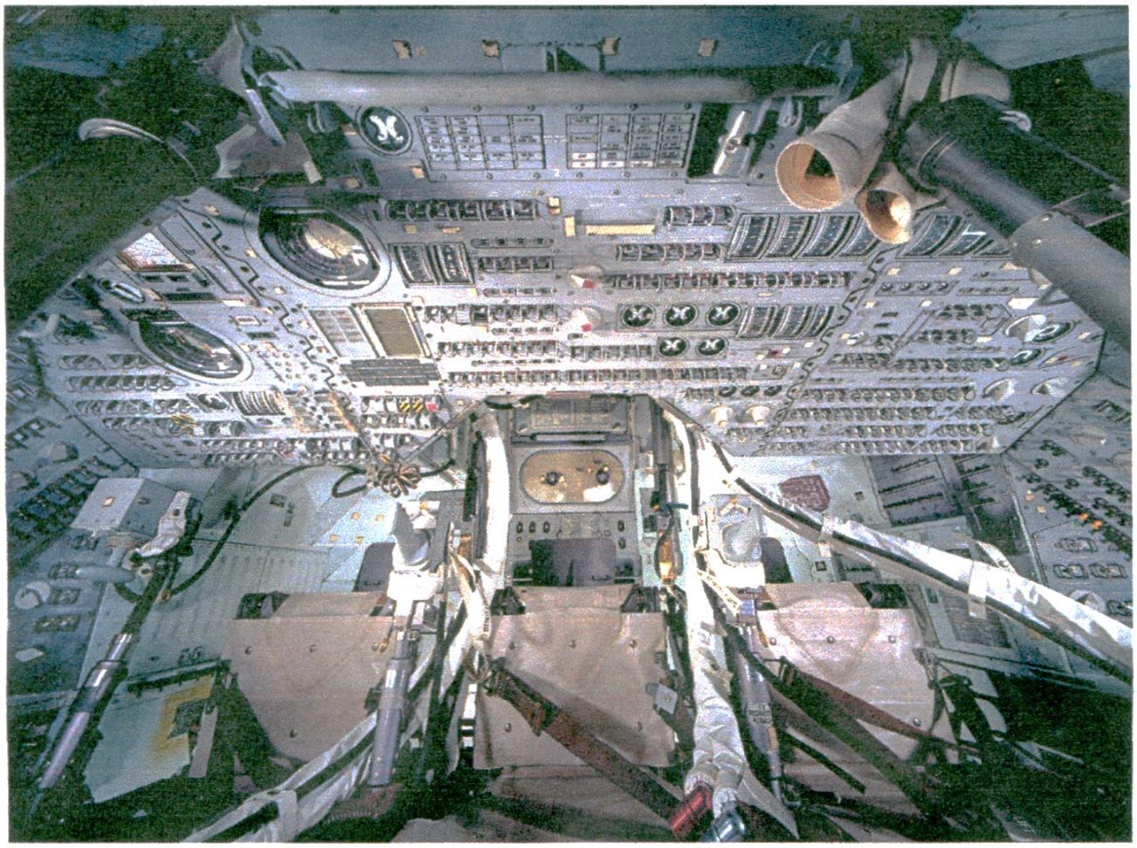
What is a hot day?

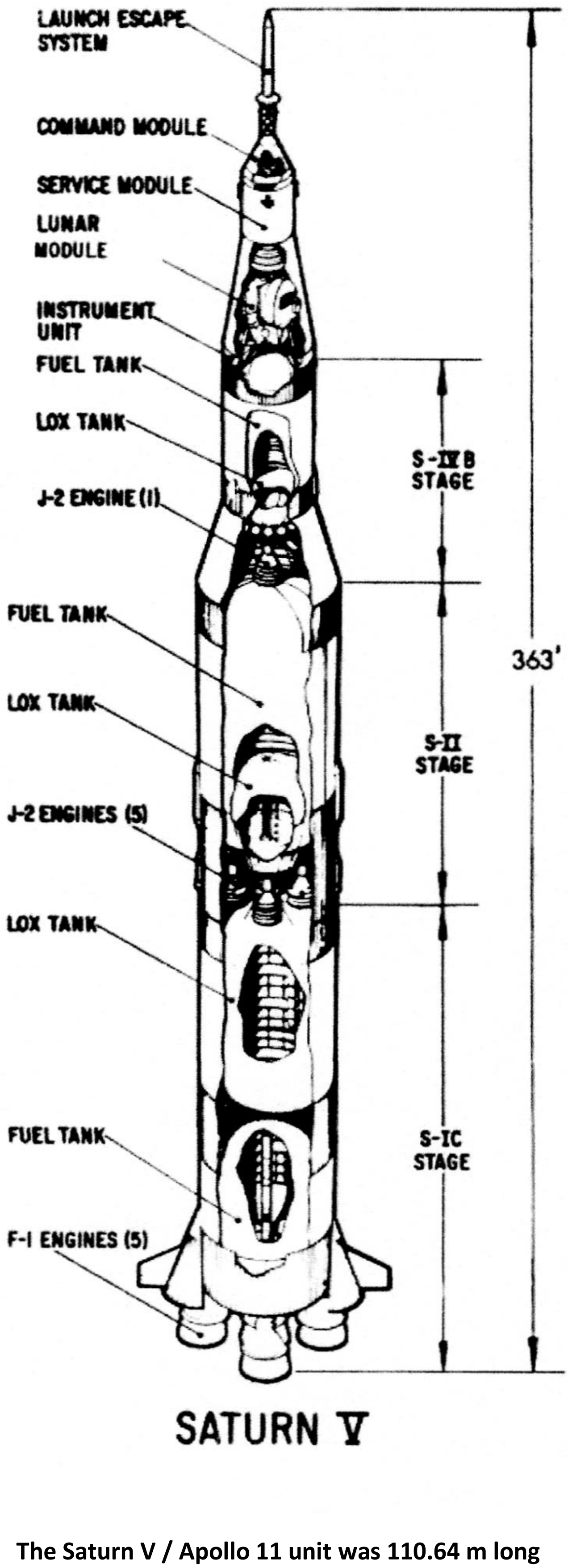
The boiling point of water? (The temperature of water from a hot tap?)

The melting points of aluminium, molten glass, molten steel

Problem: How do I discover the maximum size of a balloon before it bursts?
Problem: What must be done to get a balloon to inflate to the same dimension each time it is blown up?
Exercise: How far does a balloon vehicle (rocket, boat, car) travel at optimum inflation?
Exercise: What happens when I change on a commercial balloon-powered vehicle?
Exercise: What happens when I change the conditions of a commercial balloon-powered vehicle?
Problem or exercise: Make your own balloon-powered vehicle and record what happens.

Command Module Columbia





The Saturn V / Apollo 11 unit was 110.64 m long

Paper rockets in the classroom

3...2...1...PUFF!

Materials

Sheet of A4 paper

Adhesive tape

Scissors

Ruler

Metre stick or tape measure

Fat, round pencil or dowel

Eye protection

Drinking straws

Copy of paper rocket plans

Procedure

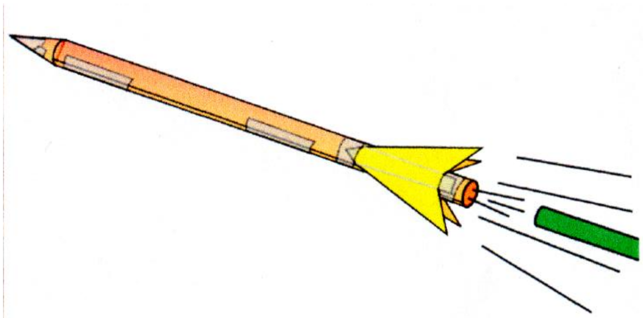
- Cut a strip of paper for the rocket body (about 4 cm wide by 28 cm long).
- Use a round pencil as a form and roll the strip around the pencil.
- Tape the long seam.
- Close off one end to make a nose cone.
- Cut out three or four fins.
- Tape the fins to the open (lower) end of the rocket. Bend them outward to space them equally.

After students have constructed their rockets, show them how to perform drop tests to check for stability.

- Hold the rocket horizontally at eye level and drop it to the floor. If the nose of the rocket hits the floor first, the rocket is stable and ready for flight.
- If the rocket falls horizontally or the fin end hits first, the rocket is unstable. Larger fins may be needed to stabilize the rocket.
- Have students perform their own stability tests and adjust rockets if needed.

Demonstrate the launch procedure for the rocket.

- Stand at one end of your launch range.
- Insert a straw into the rocket body.
- Aim the rocket down range and puff strongly into the straw.
- Lift off!

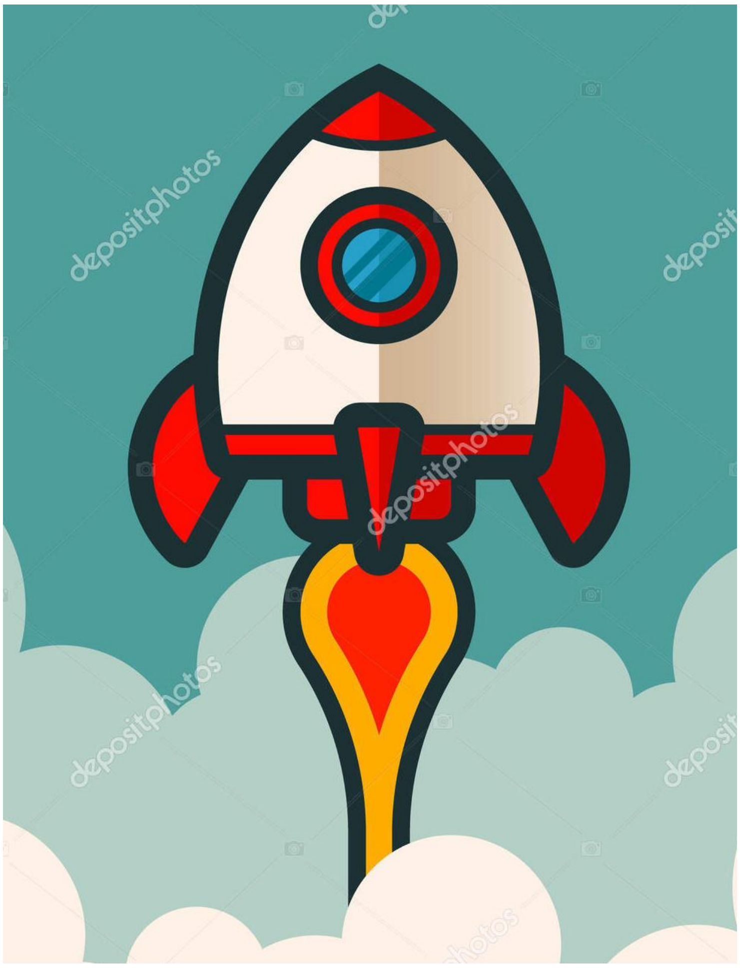


Soft landing in the classroom

The retro-rocket landing was a major problem for NASA and therefore an achievement for the Apollo 11 expedition.

NASA's objective was to achieve a soft landing at a designated site. In one sense it failed, but only because the earth-bound scientists could not get a close enough look at the Sea of Tranquility.

The students' objective is to soft land a capsule on a designated spot and determine how much energy was needed to achieve the result.



Travelling in a lunar buggy

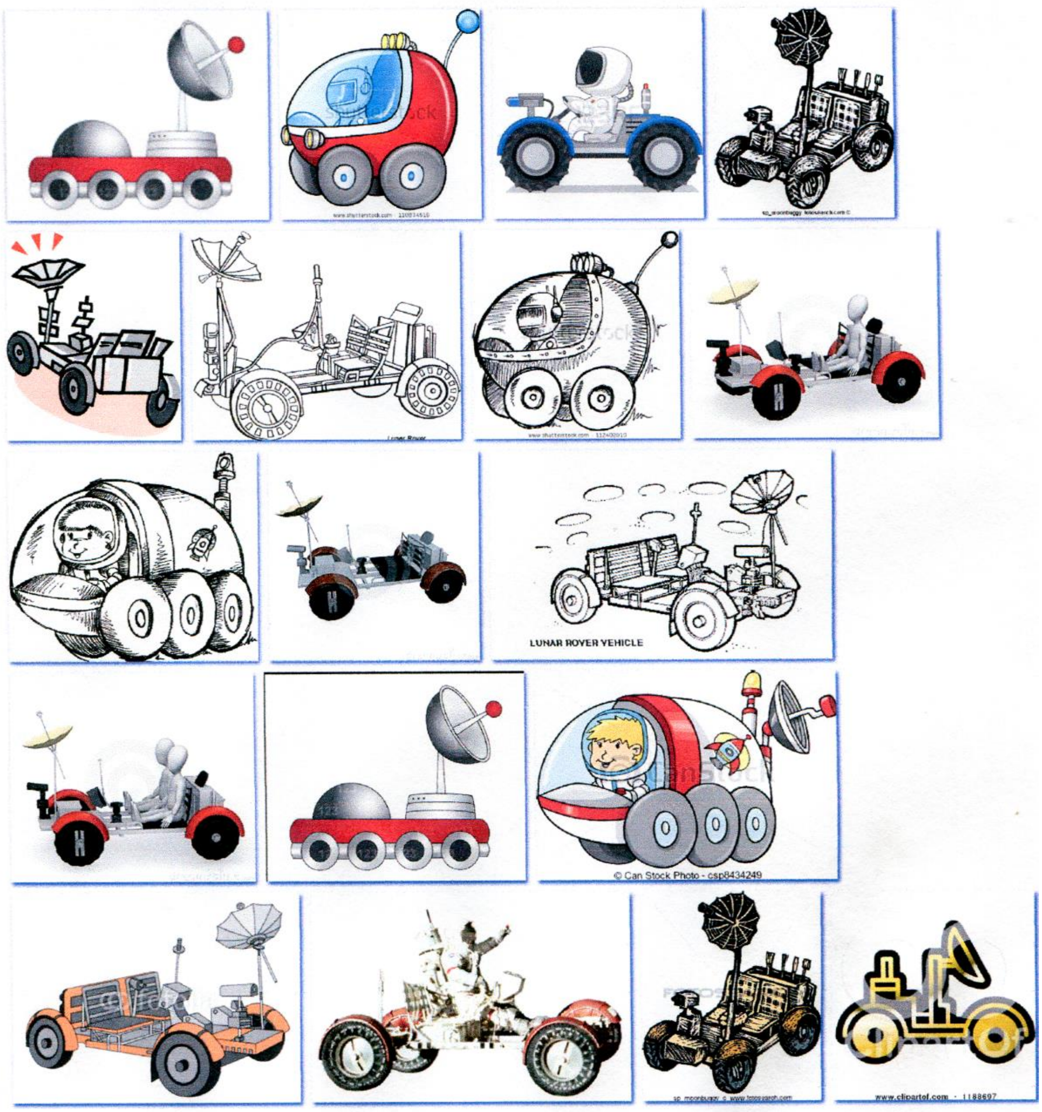
Make a solar-powered lunar buggy which will travel across a lunar terrain of crushed concrete (or sand, gravel, rocks of different dimensions) spread over a tarpaulin.

Strictly speaking, the lunar buggy was not part of the Apollo 11 mission.

After the Eagle had landed, Aldrin and Armstrong could be seen sort of kangaroo hopping in the reduced gravity of the moon. Kit appears that walking was not as straight forward as imagined.

The lunar buggy appeared in later moon missions but for those students who like to work with mechanics and electronics, a lunar buggy challenge is provided.

Moon vehicle clipart

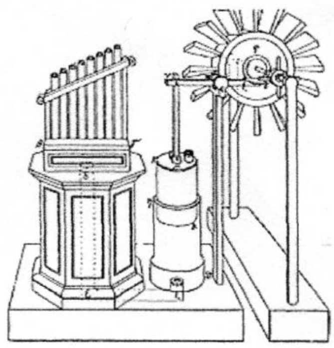


A HERO in the classroom

- Hero of Alexandria lived in Roman Egypt and invented a device which operated because of the potential energy within water. When water was converted to steam things happened.
- Hero's importance to this 50th anniversary of the Apollo 11 Moon Launch celebration is because of his "engine".
    - o STEM debate – E section: Was Hero's engine a machine?
- He lived at the time of Jesus of Nazareth -10 AD to 70 AD – and was an inventor
    - o Students studying energy from first principles (grade 6, grade 8) might well start with replicating Hero's devices and understanding the science and technology behind them.
        - ▪ A coin in the slot Holy Water vending machine;
        - ▪ Wind-powered organ;
        - ▪ Wind-wheel for harnessing wind energy on land;
        - ▪ A force pump as in a fire engine;
        - ▪ An air-pressure fountain
- Inside Hero's engine was the potential for energy from steam, not utilized until:
    - o 1698 by Thomas Savery – primitive;
    - o 1712-ish Thomas Newcomen – advancement;
    - o 1763 James Watt's application and the birth of the industrial revolution
- **Hero's engine encapsulates the principles that reached from the industrial revolution to space exploration**

Hero of Alexandria

17th-century German depiction of Hero



Hero's wind-powered organ (reconstruction)

Hero's aeolipile

TSTS 2019 STEM Challenge

50 Years from the first moon landing

Challenge 1: for children up to Grade 2

Make a balloon rocket which will fly along a taut fishing line, in a large room like a gymnasium or multi-purpose room, with the starting point 1m above the ground and the potential finishing point being 2.5m above the ground.

Measure the distance the balloon rocket travels.

Present the project computer-ready (thumb drive or disc) and include photographs. Video elements may be included.

Winners could be asked to demonstrate their projects at the TSTS award presentation.

Limitations:

1. Entries may be individuals, small groups or whole class.
2. The minimum mass of the balloon and any attachments, when dry and before being filled with air is 5 grams.
3. There must be three (3) attempts per entrant with redesigning time allowed between each run.

Report: Students will present a written report in two sections:

1. A log showing the stages of development of the project.
2. A description of reasons that the rocket works as well as it does.

Challenge 2: for children in grades 3 and 4

Make a balloon-powered paper-rocket which will make a vertical take-off along a launch stick of up to 1.5m length (or longer if necessary).

Measure the height the rocket ascends, taken from the top of the rocket.

Present the project computer-ready (thumb drive or disc) and include photographs. Video elements may also be included.

Winners could be asked to demonstrate their projects at the TSTS award presentation.

Limitations:

1. Entries will be individuals, small groups or whole class.
2. The paper rocket must be the NASA small paper rockets design found in Rockets Educator Guide – NASA; then 3…2…1…Puff! The first activity only (not the second which is a rocket with a steerable engine).

   https://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/3_2_1_Puff.html

3. Entrants should design their own secure launch stick which may be made of wood, plastic or metal and may be polished or treated in some other way to reduce friction.

4. There will be three (3) attempts per entrant and redesign time allowed between launch attempts.

Note:

1. The NASA paper rockets are launched by blowing through a drinking straw and this technique should be investigated as the results will vary greatly.
2. For the competition, however, entrants will be required to attach one or more balloons to the prescribed rocket to achieve lift-off.
3. Be aware that there is no such thing as a failure. Not meeting the challenge as anticipated is still part of a valid scientific process and log books and reports should still be entered recognizing this fact and what might be done in further rounds of experimentation

Report: Students will present a written report in two sections:

1. A log showing the stages of development of the project.
2. A description of reasons that the rocket works as well as it does and recognition of the problems and limitations of the launch technique.

Challenge 3: for children in Grades 5 and 6

Make a balloon retro-rocket “capsule”, which when released from a height of 3metres, descends slowly to the floor.

Time the capsules’ descents and calculate the speeds. (S = d/t). The slowest speed will be the best.

Present the project computer-ready (thumb drive or disc) and include a table of information and photographs. Video elements may also be included.

Winners could be asked to demonstrate their projects at the TSTS award presentation.

Limitations:

1. Entries will be individual or small groups only.
2. The minimum mass of the balloon and attachments will be 5 grams.
3. On the floor below the launching point design a target and demonstrate the descent accuracy. Control of the “capsule” is important.
4. An entrant will climb onto a launch platform and, prior to the capsule’s release, the length of the drop will be measured.
5. There will be three (3) attempts per entrant and redesign time will be allowed between drops.
6. All attempts will be recorded on a table of information.

Challenge 4: for students in Grades 7 and 8

Make a solar-powered lunar buggy which will travel across a lunar terrain of crushed concrete (or sand, gravel, rocks of different dimensions) spread over a tarpaulin.

Measure the time taken to manoeuvre the course.

Present the project computer-ready (thumb drive or disc) and include photographs. Video elements may also be included.

Winners could be asked to demonstrate their projects at the TSTS award presentation.

<u>Limitations:</u>

1. Entries will be from individuals and small groups only.
2. The terrain will be set on a picnic blanket tarpaulin or similar surface.
3. Run the event indoors with room lighting and some auxiliary lighting.
4. The buggy may be steered by being wired or wirelessly.
5. Entrants must build the buggy, not use a ready-made buggy, but commercial materials may be used in the construction.
6. The buggy should have a maximum wheel base of 200mm and a maximum wheel diameter (including tyre if any) of 25mm.
7. There will be no restrictions on the number of wheels or the style of wheel/traction.
8. There will be starting and finishing gates and the buggies will have to negotiate through three other gates on the track. The finish gate should be a minimum 5m from the starting gate.

STEM open investigation: Hero's Engine

This investigation is open to all students K-12 and may be completed as an individual or in small groups.

The project should be presented computer-ready (thumb drive or disc) and should include photographs. It may include video elements.

Winners could be asked to demonstrate parts of their projects at the TSTS award presentation.

The purpose of the research is to discover how the application of the ancient Hero's engine related to the industrial revolution and machine power beyond that.

<u>Challenge:</u>

a. Make a balloon-powered Hero's engine (design below) and improve on it.
b. Make a balloon-powered Catherine wheel operating in a horizontal plane and improve on it.
c. Make a simple and safe steam-powered Hero engine on an established design as shown on-line - search engine - "Steam -powered Hero's Engine" or try, as a start,

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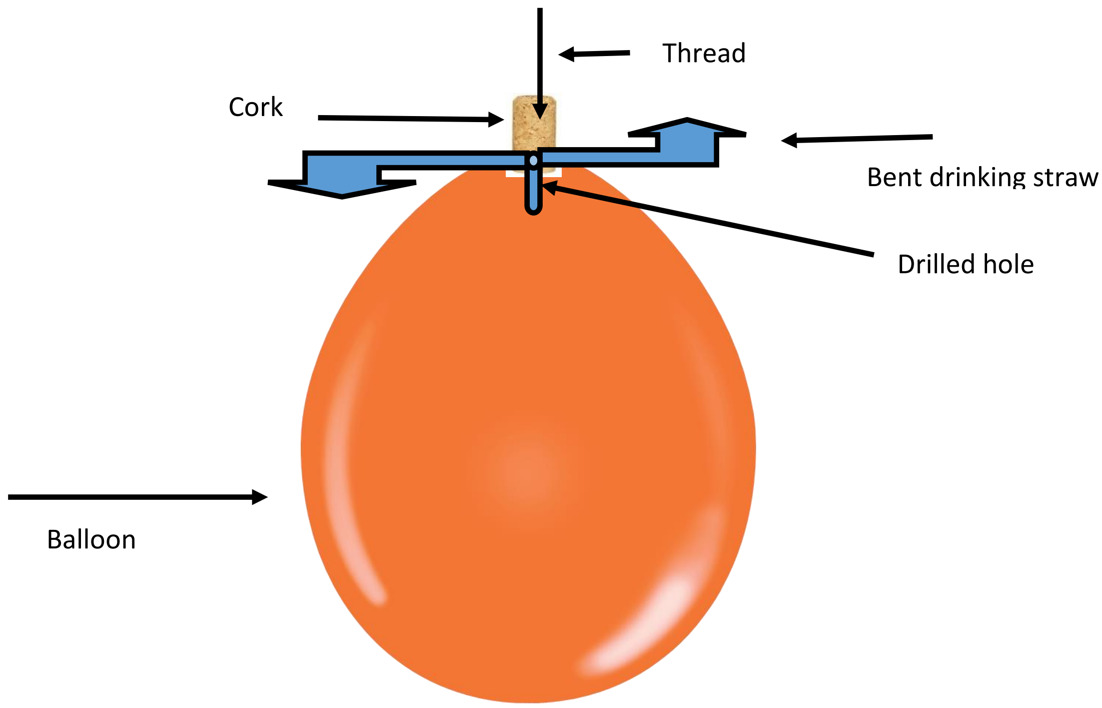
e. In a report, describe the science of Hero's engine and relate that to the creation of factories, motor cars and rockets.


Thread
Cork
Bent drinking straw
Drilled hole
Balloon