SPACE WEEK

Our Planet • Our Space • Our Time

Resource Book for Teachers

TOPIC: Heavy Lifting Rockets

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Theme	Heavy Lifting Rockets
Curriculum	Strand: Energy & Forces Strand Unit: Forces Curriculum Objectives: • investigate how forces act on objects (26, 45) • explore how objects may be moved (65) • explore how some moving objects may be slowed down (65) • identify and explore how objects and materials may be moved (87) • explore the effect of friction on movement and how it may be used to slow or stop moving objects air resistance, streamlining (87) • come to appreciate that gravity is a force Skills Development: Designing and Making: Exploring; Planning; Making; Evaluating.

Engage

The Prompt	Wondering	Exploring	Considerations for inclusion
Starship launch video Artemis Mission images of heavy lift rockets Saturn V image	Why do we need rockets? Why do rockets go up? What forces make a rocket speed up, what forces make the rocket slow down? Teach the concepts: weight, thrust, drag and lift.	Make a balloon rocket (English or Irish) and explore how they work. Discover how it is launched and how it moves. Learners could carry out a full investigation into factors that affect this type of rocket, then apply that learning to the designing and making of a heavy lifter.	

Investigate: Balloon Rockets

Starter Question	Predicting	Conducting the Investigation	Sharing: Interpreting the Data/Results
What affects how well the balloon rocket flies? Learners should investigate only one factor at time, possibly by: • Inflating two identical balloons to different sizes • Using different size balloons inflated to the same size • Using different shape balloons • Using different types of string • Using different lengths of string	Leaners should refer to prior experience and their understanding of forces as they give a reason for their prediction. Note: increasing the size of the balloon will increase the drag on it as it flies, so "the larger balloon will be faster because the air is pushing it more" may not be the case.	Learners should design a fair test to see how their starter question affects the flight of the balloon. Two strings can be set up, with the two balloons ‘racing’ each other. Note: since the balloons only feel a thrust when the air is rushing out of them, a smaller balloon may accelerate faster, but then slow down or stop before the end of a long course.	Learners might measure the distance the various balloon rockets travelled or attempt to measure the time they took to travel a certain distance. What features did the fastest balloon have? Did the balloon that was fastest at the start keep going the furthest?

Investigate: Design & Make Heavy Lifters

Explore	Plan	Make	Evaluate
How can we design a rocket to carry the most weight?	Plan how three long balloons can be connected to make a 'heavy lifter.' Use only the materials given, although not all must be used.	Learners should make their heavy lifter balloon rockets and test them on vertical strings to see which can carry the most paper clips all the way to the ceiling.	Compare the best rocket to the others, how was it different?

Investigate: Design & Make Two-Stage Rockets

Explore	Plan	Make	Evaluate
How can we design a two-stage rocket? View this video.	Plan how two long balloons can be connected to fire one after the other.	Learners can make their two-stage balloons and test them on horizontal or vertical strings.	How well did the stages separate? Did a two-stage balloon go further than a single balloon rocket?

Take The Next Step

Applying Learning	Making Connections	Thoughtful Actions

Investigate the mathematics of launch costs.

If you could launch a small satellite, what would you study? Find out more about satellites with this resource from SpaceWeek.ie http://www.spaceweek.ie/wp-content/uploads/2020/09/SpaceWeekSatellites.pdf

Follow Ariane 6, a new heavy lifter being built for the European Space Agency. Ariane 6 Assembly Timelapse

Follow the Artemis Mission

Reflection

Did I meet my learning objectives?
What went well, what would I change?
Are the learners moving on with their science skills?
What questions worked very well? What questions didn't work well?
Ask the learners would they change anything or do anything differently.
Are there cross curriculum opportunities here?
What further questions did students have?

Background Information

Saturn V credit NASA

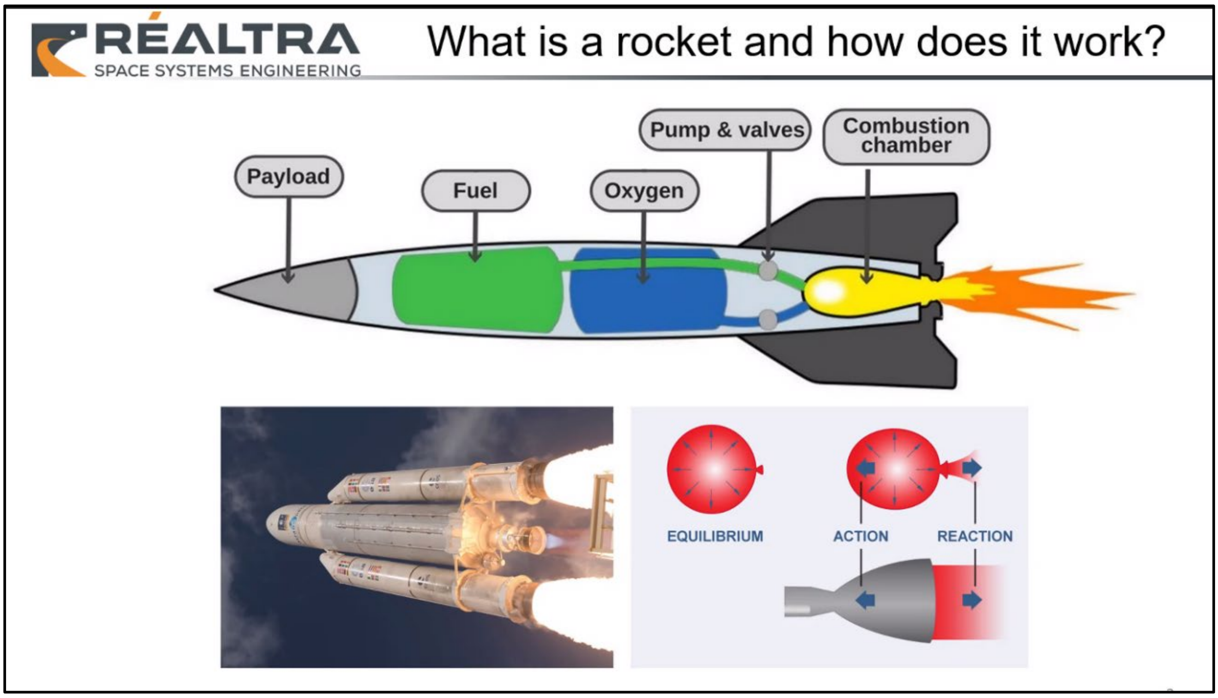
The American Moon missions in the 1960s and 1970s used a large rocket called the Saturn V. This **Heavy Lift Vehicle** was very powerful. It used three stages to launch from Earth and send astronauts to the Moon.

Heavy lifters are now being used again, as humans are planning to return to the Moon with the Artemis mission. The SLS (space launch system) is being built and will carry an ESA module connected to the Orion spacecraft that the astronauts will use. SLS uses a central rocket with two outer boosters. This design is derived from the Space Shuttle launch system.

Crew of Artemis II credit NASA

The Artemis I mission launched in 2022, and Artemis II is scheduled for late 2024. Artemis III is planned to take humans to the Moon, possibly in 2026! Artemis III will use Starship HLS to land on the Moon, and that spacecraft is still being developed.

SpaceX's Starship super-heavy rocket was launched in April 2023, but not all rockets worked properly, and it was destroyed after 4 minutes.



View this video to explore how balloon rockets model real rockets.

Rockets can be modelled in the primary classroom with balloons. See Curious Minds resources “[Rocket Launch]” or “[Roicéad a theilgeadh].” Learners can make the standard balloon rocket as shown and then can be challenged to adapt this balloon rocket design to lift vertically and to carry as much weight as possible.

Explore: How can we design a rocket to carry the most weight?

Plan how three long balloons can be connected to make a ‘heavy lifter.’ Use only the materials given, although not all must be used.

Materials:

- 3 long balloons per group
- length of fishing line or smooth string, fixed to the ceiling per group
- drinking straws
- masses (paper clips are ideal)
- Tape, scissors, rubber bands, clothes pegs

Learners should outline their design and then make their heavy lifter and test how many paper clips it can carry all the way to the ceiling.

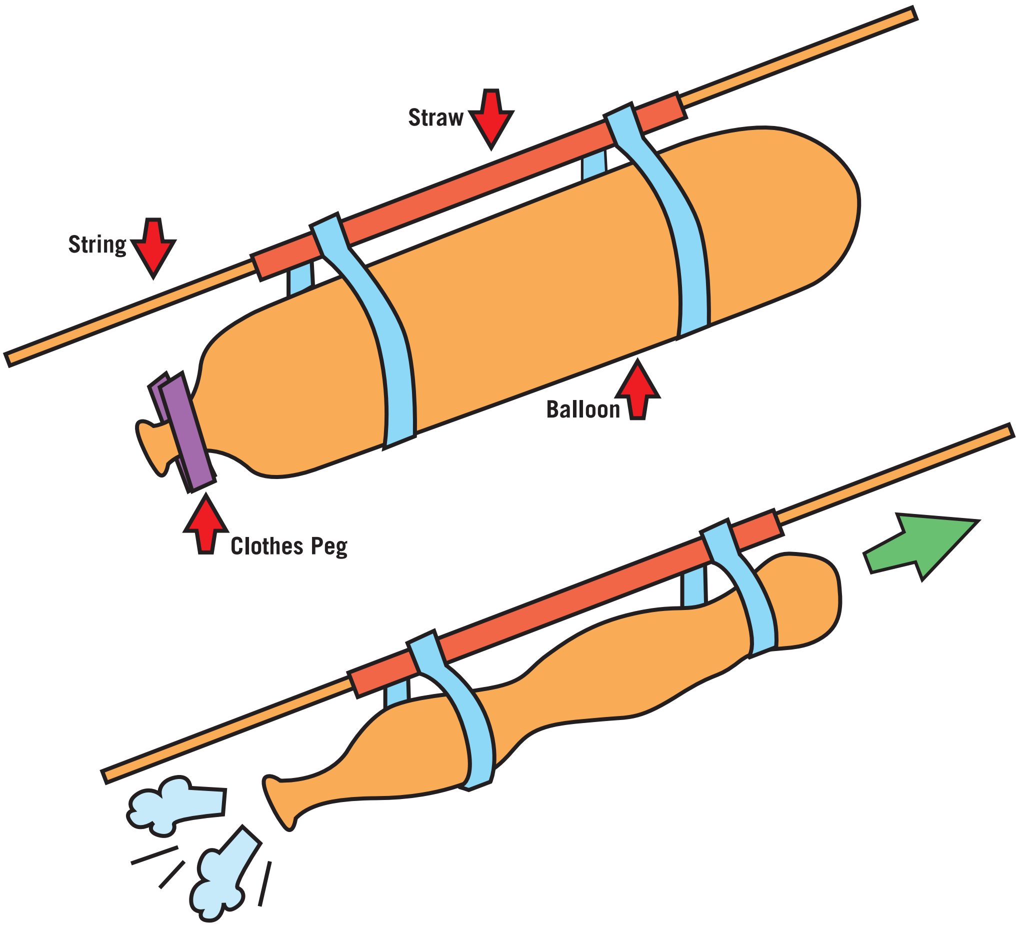
Rocket Launch

SILVER

EQUIPMENT	Large balloons (long shaped) (Round ones will work but the long balloons look more like a rocket.), Balloon pump, String OR cotton thread OR fishing line 3-4 m long, Drinking straw, Clothes-peg, Sellotape, Two chairs
PREPARATION	Collection of materials
BACKGROUND INFORMATION	The air coming out of the back of the balloon pushes the balloon forward. This is how rockets work – the hot burning gases rushing out the back of the rockets push them forwards.
SKILLS	Investigating and experimenting
ACTIVITY	Blow up a long shaped balloon and let it go. Notice what happens. *(The balloon will travel off in random fashion as the air rushes out the back of it.)* Now control the path of the balloon by connecting it to a piece of string. *(The balloon will whiz along the string).*
SAFETY	**Care with the string.**

Rocket Launch continued

1. Blow up a long-shaped balloon and let it go.
2. Notice what happens.
3. Pull string through a drinking straw.
4. Tie the string to two chairs and pull it tight.
5. Blow up a long-shaped balloon and keep the air in it using a clothes peg.
6. Using sellotape attach the balloon to the side of the straw.
7. Pull the whole thing back to the beginning of the string and take off the clothes peg and … launch your rocket!



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Launch Costs

The cost to launch something into orbit is usually given as a cost in $ per kilogram launched. This cost allows for how much it cost to develop the rocket and the cost to actually carry out a single launch, including making all the rocket parts and the fuel. The cost of development can be split amongst all the launches, so a rocket design that launches many times will cost less in the long run.

Some rockets launch systems have reusable components, such as the Space Shuttle (1981-2011) and the newer designs from SpaceX. This tends to keep costs down. New rocket designs that are lighter and use more efficient fuels will also cost less to launch.

Launch costs to Low Earth Orbit (LEO) in 2021 equivalent US$. [Source of launch costs: https://ourworldindata.org/grapher/cost-space-launches-low-earth-orbit]

Ariane 5G	$10,200 per kilogram
Falcon Heavy	$1,500 per kilogram
Long March 5	$7,900 per kilogram
Saturn X	$5,400 per kilogram
Space Shuttle	$65,000 per kilogram
Soyuz	$17,500 per kilogram
Starship*	Possible $100 per kilogram

Space Launch System (SLS) is under development and will launch Artemis to the Moon. This is much more expensive than to a low Earth orbit, and development of this system has cost $27.5 billion between 2011 and 2022.

*SpaceX plan to fly Starship every day, sending over 100 tons to orbit per launch. This could bring launch costs as low as $100 per kg to LEO.

You can explore this further in this interactive graph that shows number of launches and costs. https://aerospace.csis.org/data/space-launch-to-low-earth-orbit-how-much-does-it-cost/

Questions:

How much would it cost to launch a 1 litre bottle of water to the Moon? (1 litre of water weighs 1 kilogram). How much water does a person need each day? What would that cost?

If you wanted to launch a 2kg cubesat into orbit, which rocket would do that the cheapest?

Curious Minds ESERO

Framework for Inquiry - Promoting Inclusion

SPECIAL EDUCATION SUPPORT SERVICE
building on ability

When planning science activities for students with Special Educational Needs (SEN), a number of issues need to be considered. Careful planning for inclusion using the framework for inquiry should aim to engage students in science with real purpose. Potential areas of difficulty are identified below along with suggested strategies. This list is not exhaustive, further strategies are available in the Guidelines for Teachers of Students with General Learning Disabilities (NCCA, 2007).

ENGAGE

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Delayed language development/poor vocabulary/concepts	• Teach the language of science demonstrating meaning and/or using visual aids (material, property, strong, weak, textured, dimpled, absorbent, force, gravity). • Have the student demonstrate scientific phenomena, for example gravity —using 'give me, show me, make me,' as much as possible. • Assist the student in expressing ideas through scaffolding, verbalising a demonstration, modelling. • Use outdoor play to develop concepts.

INVESTIGATE

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Fear of failure/poor self-esteem/fear of taking risks	• Model the speculation of a range of answers/ideas. • Repeat and record suggestions from the students and refer back to them.
Understanding Time and Chronology	• Practice recording the passing of time, establish classroom routines that draw the students' attention to the measurement of time. • Teach and practice the language of time.
Fine/Gross Motor Difficulties	• Allow time to practice handling new equipment. • Allow additional time for drawing diagrams, making models etc. • Give students the option to explain work orally or in another format.
Short Term Memory	• Provide the student with visual clues/symbols which can be used to remind him/her of various stages of the investigation.

TAKE THE NEXT STEP

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Developing Ideas	• Keep ideas as simple as possible, use visuals as a reminder of earlier ideas. • Discuss ideas with the whole group. • Repeat and record suggestions from students and refer back to them. • Encourage work in small group and in pairs.
Communicating Ideas	• Ask students to describe observations verbally or nonverbally using an increasing vocabulary. • Display findings from investigations; sing, do drawings or take pictures. • Use ICT: simple written or word-processed accounts taking photographs, making video recordings of an investigation.

REFLECTION

- Did I take into account the individual learning needs of my students with SEN? What differentiation strategies worked well?
- Did I ensure that the lesson content was clear and that the materials used were appropriate?
- Was I aware of the pace at which students worked and the physical effort required?
- Are there cross curriculum opportunities here?
- Are the students moving on with their skills? Did the students enjoy the activity?

More strategies, resources and support available at **www.ncse.ie**

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