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| **Flying high!** |
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| Calculating the amount of energy needed to launch a rocket into space |
| **Subject(s):** Design and Technology,Engineering, Mathematics, Science**Approx time:** 30-50 minutes |  | **Key words / Topics:** * energy
* escape velocity
* formulae
* future of flight
* gravity
* mass
* rocket
* satellite
* space
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| **Stay safe** Whether you are a scientist researching a new medicine or an engineer solving climate change, safety always comes first. An adult must always be around and supervising when doing this activity. You are responsible for:• ensuring that any equipment used for this activity is in good working condition• behaving sensibly and following any safety instructions so as not to hurt or injure yourself or others Please note that in the absence of any negligence or other breach of duty by us, this activity is carried out at your own risk. It is important to take extra care at the stages marked with this symbol: ⚠ |
| **Suggested Learning Outcomes**  |  |  |
| * To understand what is meant by escape velocity
* To be able to calculate the amount of energy needed to launch a rocket into space
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| **Introduction** |  |  |
| This is one of a series of resources designed to allow learners to use the theme of the future of flight to develop their knowledge and skills in Design and Technology, Science, Engineering and Mathematics. This resource focusses on calculating the amount of energy needed to launch a rocket into space.Rockets carry satellites, people, and supplies from the Earth into space. Can you calculate the amount of energy required to get a rocket from the ground and into space? |
| **Purpose of this activity**In this activity learners will make use of the theme of the future of flight to calculate the amount of energy needed to launch a space rocket. They will discuss the meaning of the term escape velocity and then perform calculations based on the Space X and Saturn V rockets.This activity could be used as a main lesson activity to teach about energy and related calculations within a space context. It could also be used as part of a wider scheme of learning to teach maths skills within Design and Technology and Engineering. |
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| **Activity** |  | **Teacher notes** |
| **Introduction and context (15-20 minutes)**Teacher to introduce the context shown in the presentation. Teacher to explain that rockets ae used to carry satellites, people, and supplies into space, but that this requires a lot of energy. Watch the video to see Tim Peake and Maggie Aderin-Pocock explain how satellites are launched into orbit:https://www.bbc.co.uk/teach/class-clips-video/physics-ks3-ks4-launching-satellites-into-orbit/zvfy8xs.Teacher to explain the term ‘escape velocity’.**Energy and mass (5-10 minutes)**Teacher to introduce and explain the formula for calculating the energy required to escape into orbit: E = ½ mv2.**Calculating the energy required to launch a rocket (10-20 minutes)**Teacher to demonstrate the calculation shown on slide 7 for the Space X Falcon rocket. Learners to perform their own calculation based on the information given for the Saturn V rocket.Learners could research the energy required to power different things and compare these values to the energy needed to launch the rockets.  |  | **Escape velocity**Note that the value used for escape velocity is greater than the value of 8 km/s presented in the video – that is the speed to maintain the position relative to the curvature of the earth, whereas escape velocity is to escape from earth.Learners could think of things that are really fast and investigate whether these are faster or slower than escape velocity.**Calculations**For reference:* E is for energy, measured in joules (J)
* m stands for mass, measured kilograms (kg)
* v stands for velocity, measured in metres per second (m/s)

The Saturn V rocket had a mass of 2.8 million kilograms and the newer Space X rockets have a mass of 1,420,788 kg.When looking at energy consumptions these are often given in kilowatt hours (kWh). 1 kWh = 3.6 x 106 j. The average UK home uses approximately 3100 kWh per year, or 1.12 x 1010 j. Hence the launch of 1 Space X rocket uses enough energy to power 7,946 homes for a year. |
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| **Differentiation** |  |  |
| **Basic** |  | **Extension** |
| * Provide partially completed calculations for weaker learners to complete.
 |  | * Perform calculations for a range of different spacecraft e.g., space shuttle, Soyuz rocket etc.
* Calculate the energy required by other activities, e.g., to run a car.
* Investigate possible sustainable fuels for spacecraft and how much energy these generate.
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| **Resources** |  | **Required files** icon-docicon-pdficon-ppt |
| * Paper/exercise books
* Calculators
* Pens/pencils
 |  |  Presentation – Flying high |
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| **Additional websites** |
| * **BBC Class clips – launching satellites:** Video that can be used when introducing the activity and context <https://www.bbc.co.uk/teach/class-clips-video/physics-ks3-ks4-launching-satellites-into-orbit/zvfy8xs>
* **Source of escape velocity value:** https://www.britannica.com/science/escape-velocity
* **Information sources for Saturn V and Space X rockets:** <https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-was-the-saturn-v-58.html>, https://www.spacex.com/vehicles/falcon-heavy/
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| **Related activities (to build a full lesson)** |  |  |
| **Starters** (Options) * Watch the video: https://www.bbc.co.uk/teach/class-clips-video/physics-ks3-ks4-launching-satellites-into-orbit/zvfy8xs.
* Discuss why space travel is needed and what learners know about it.
 | **Plenary*** Investigate the energy required to power different things and compare these values to the energy needed to launch the rockets.
* Discuss the importance of knowing how much energy is required to launch a rocket.
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| **The Engineering Context** film |
| * The future of flight is a great context to explore the opportunities that working in the aeronautical engineering industry presents! For example, designing, making, and maintaining aircraft and spacecraft, and all their different parts.
* Engineers must understand the mathematical concepts and their application relevant to their field of expertise. For example, calculating the energy needed to launch rockets or power spacecraft.
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| **Curriculum links** |
| **England: National Curriculum**Design & Technology * KS3 1b, 2b

Mathematics * KS3 use a calculator and other technologies to calculate results accurately and then interpret them appropriately.

Science * KS3 Motion and forces

**Scotland: Curriculum for Excellence**Science* SCN 4-07b

Mathematics* MTH 4-06b

Technologies* TCH 1-04b
* TCH 1-10a
 | **Northern Ireland Curriculum**Mathematics* Practical skills using technology

Science * Spiritual Awareness. Develop a sense of wonder about the universe- the vastness of outer space

Technology & Design* Manufacturing – selecting and using materials fit for purpose.

**Wales: National Curriculum** Mathematics* KS3 Using number skills

Science* Carry out fair tests

Design and Technology* KS3 skills: Designing 3
* KS3 skills: Making 1, 3
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| **Assessment opportunities** |
| * Informal and formal teacher assessment of calculations performed.
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