principia MISSION

Maths in Space Pack 1

How much do you eat? An exploration of how Tim Peake will get six months' worth of food to the International Space Station (ISS)

A mathematics resource for primary and secondary school teachers

9 - 14

UK SPACE AGENCY

esero

STEM LEARNING

UK Space Agency

The UK Space Agency is at the heart of UK efforts to explore and benefit from space. The UK's thriving space sector contributes £11.8 billion a year to the UK economy and directly employs over 34,000 people with an average growth rate of almost 8.5%.

The UK Space Agency is responsible for ensuring that the UK retains and grows a strategic capability in space-based systems, technologies, science and applications

STEM Learning Ltd

STEM Learning Ltd operates the National STEM Learning Centre and Network; providing support locally, through Science Learning Partnerships across England, and partners in Scotland, Wales and Northern Ireland; alongside a range of other projects supporting STEM education. STEM Learning is an initiative of the White Rose University Consortium (comprising the Universities of Leeds, Sheffield and York) and Sheffield Hallam University.

ESERO

ESERO-UK, also known as the UK Space Education and Resource Office, aims to promote the use of space to enhance and support the teaching and learning of science, technology, engineering and mathematics (STEM) in schools and colleges throughout the UK.

Principia

Tim's mission to the International Space Station, called 'Principia', will use the unique environment of space to run experiments as well as try out new technologies for future human exploration missions. Tim will be the first British ESA astronaut to visit the Space Station where he will spend six months as part of the international crew.

Introduction

On December 15th 2015 European Space Agency astronaut Tim Peake launched on the six month Principia mission to the International Space Station. Principia was named after Isaac Newton's *Naturalis Principia Mathematica*, describing the principal laws of motion and gravity.

The education and inspiration of young people is a core element of the Principia mission. Tim is determined to make Principia an exciting adventure for the younger generation. This resource is part of an extensive education programme to inspire children to pursue STEM subjects.

This collection of mathematics resources is aimed at teachers of key stage 2, 3 and 4 students (age 7 to 16), and is closely linked to elements of the mathematics national curriculums of England, Northern Ireland, Scotland and Wales which can be taught in new and stimulating ways. Children can explore familiar and unfamiliar mathematical ideas relating to Tim's Principia mission, including estimation, measures, combinations, permutations and probability.

This teacher guide, and the resources that accompany it,can be used in a number of different ways:

1. Following the activities in sequence will cover the curriculum links listed within. This might be done as part of a themed week, or over a series of sessions.

2. Teachers can pick and choose which activities, resources and links to use and when – they can be used independently of each other. This might enhance the ways in which space and mathematical topics are currently taught. If teachers have specific challenges in mind that align with their interests and those of the children, learning activities might be selectively chosen.

3. Teachers may wish to present children, in class or as part of an extra-curricular activity, with the activities only.

Click here for more teaching resources and ideas linked to Tim's mission.

Introductory videos

The National STEM Learning Centre online resource collection hosts a variety of Tim Peake related resources, from primary to secondary, covering science, technology and computing topics. As part of our collections the following videos may also form a good introduction to some, if not all, of the maths ideas in this resource:

- Tim Peake (http://stem.org.uk/rxce8)
  Tim talks about studying STEM subjects and how he became an astronaut.
- Tim Peake: Becoming an Astronaut (http://stem.org.uk/rxdex)
  Tim talks about the importance of science skills to be able to work on the International Space Station (ISS).
- Can You Get Fat in Space (http://stem.org.uk/rxcvn)
  As part of the Great British Space Dinner competition, celebrity chef, Heston Blumenthal, asks us the question, "Can you get fat in space?"
- Cooking with Astronauts (http://stem.org.uk/rxcz9)
  Heston Blumenthal describes how preparing food on the ISS is different from that on Earth. Water is used to rehydrate foods and the food cannot be heated with ovens or microwaves.
- Cows in Space (http://stem.org.uk/rxcvo)
  As part of the Great British Space Dinner competition, celebrity chef, Heston Blumenthal, asks the question, "Can you take cows into space?"
- Dinner Party in Space (http://stem.org.uk/rxcvr)
  Heston Blumenthal explains that, in the weightless environment on the International Space Station, you cannot have foods that can float around and get into people eyes and instruments, and you need to drink out of plastic bags, rather than cups.
- Food Texture (http://stem.org.uk/rxcvp)
  Heston Blumenthal asks children to think about textures of food for astronauts. He suggests mixing textures together to give the best experience for Tim when he eats his meal.
- Tim Peake's Food Likes (http://stem.org.uk/rxcvq)
  As part of the Great British Space Dinner competition, celebrity chef, Heston Blumenthal, asks astronaut Tim Peake about what foods he likes to eat.

Curriculum Links

Subject content:

- estimate and have an appreciation of the magnitude of volume
- calculation of the volume of a cuboid
- calculation of the volume of a cylinder
- convert between cm3 and m3
- calculation of percentage waste

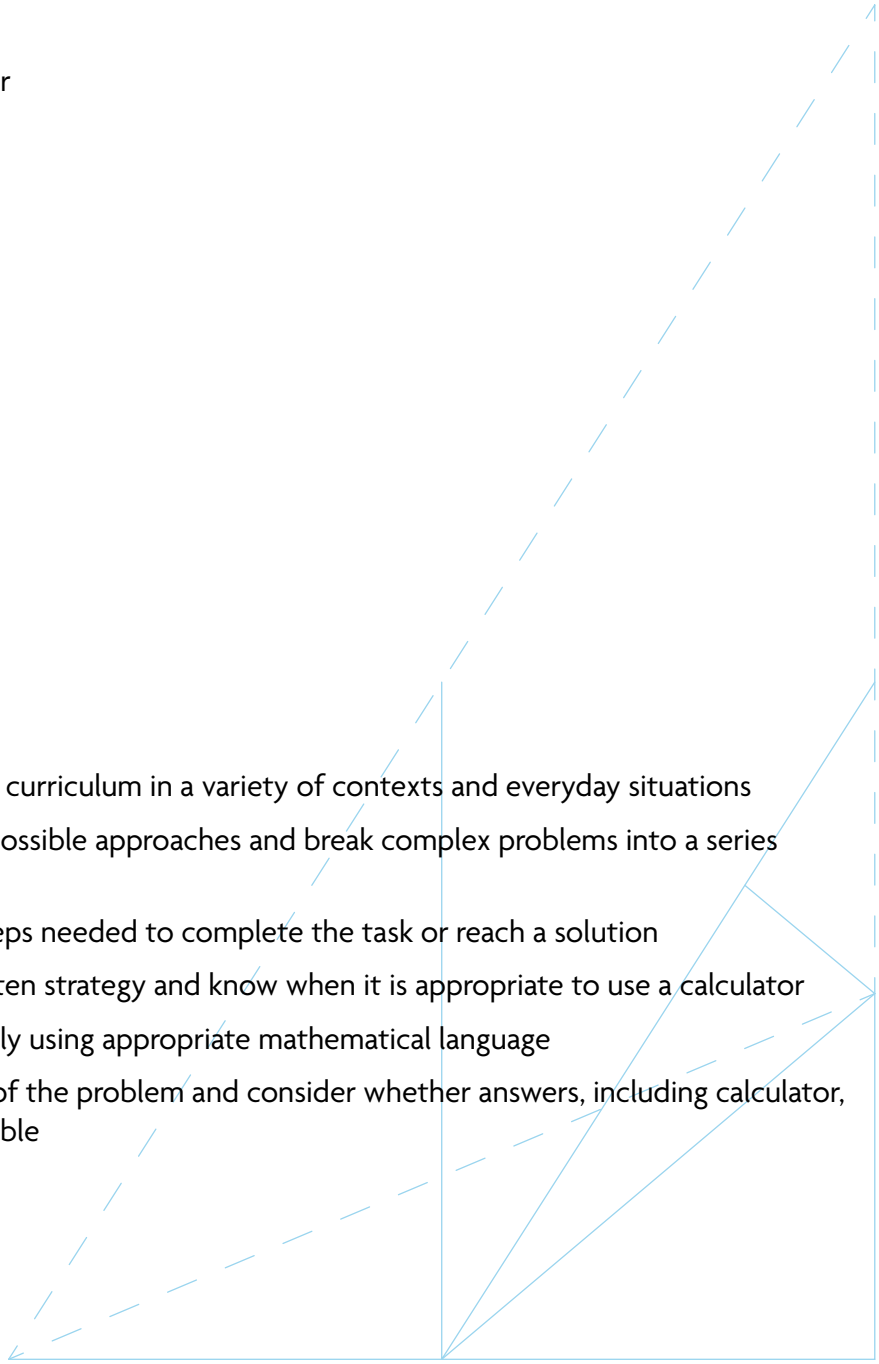
England:

Working Mathematically

- simplifying a problem
- making assumptions
- interpreting results

Wales:

- transfer mathematical skills across the curriculum in a variety of contexts and everyday situations
- select, trial and evaluate a variety of possible approaches and break complex problems into a series of tasks
- prioritise and organise the relevant steps needed to complete the task or reach a solution
- choose an appropriate mental or written strategy and know when it is appropriate to use a calculator
- explain results and procedures precisely using appropriate mathematical language
- interpret answers within the context of the problem and consider whether answers, including calculator, analogue and digital displays, are sensible



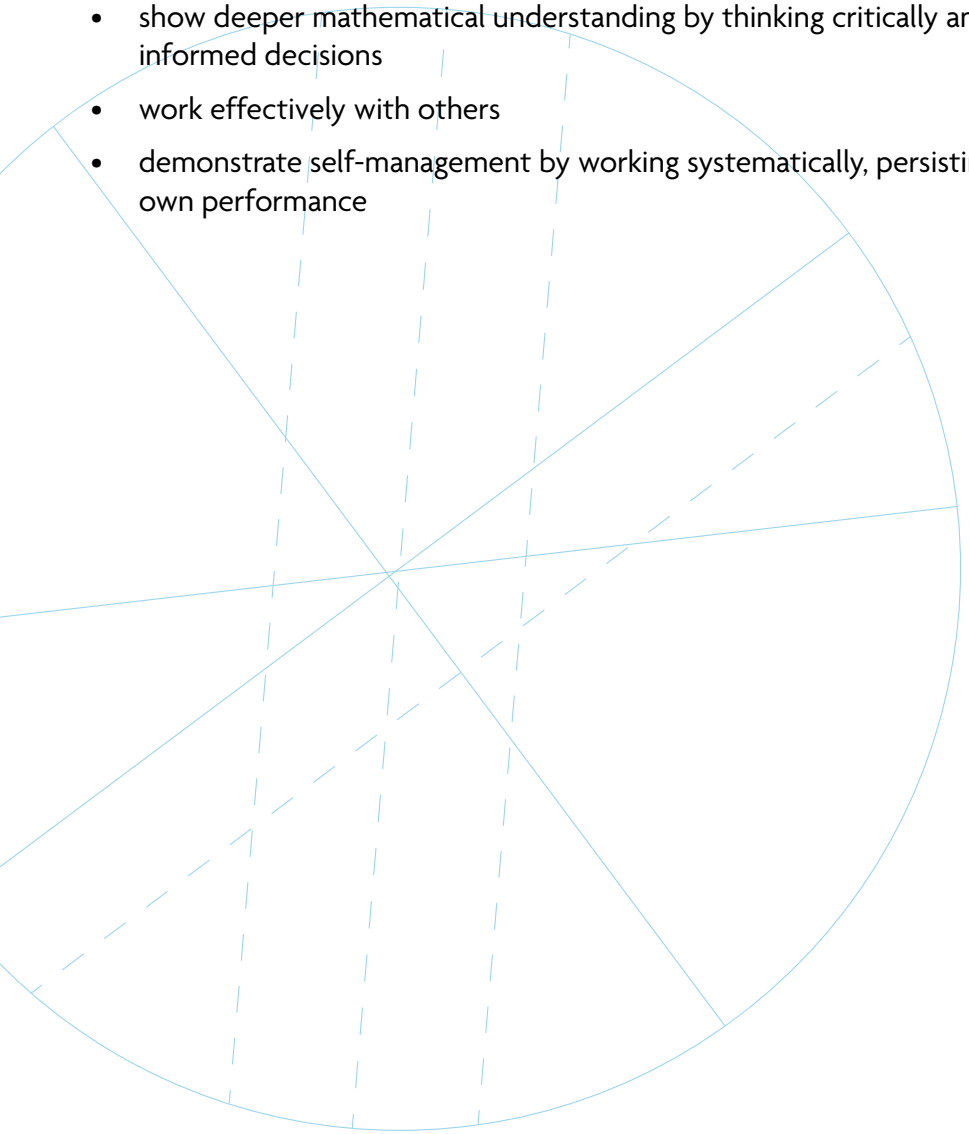
Scotland:

- I can use a variety of methods to solve number problems in familiar contexts, clearly communicating my processes and solutions
- I can solve problems by carrying out calculations with a wide range of fractions, decimal fractions and percentages, using my answers to make comparisons and informed choices for real-life situations.
- By applying my understanding of probability, I can determine how many times I expect an event to occur, and use this information to make predictions, risk assessment, informed choices and decisions.

Northern Ireland:

Examine the role of mathematics as a "key" to entry for future education, training and employment. Explore how the skills developed through mathematics will be useful to a range of careers

- decide on the appropriate method and equipment to solve problems–mental, written, calculator, mathematical instruments or a combination of these
- show deeper mathematical understanding by thinking critically and flexibly, solving problems and making informed decisions
- work effectively with others
- demonstrate self-management by working systematically, persisting with tasks, evaluating and improving own performance



Introduction

The purpose of this activity is for students to gain an appreciation of the magnitude of different volumes. It is intended that students will use approximate answers rather than attempt to calculate exact answers unnecessarily. The context of the activity is how much food Tim Peake requires for his six month stay on the International Space Station, and how best to get supplies to the ISS.

Introductory activity

Prior to the main activity, students could be asked to complete a food diary, detailing all they have eaten in the last day or, ideally, the last week. At the start of the activity, based upon their research, the following questions could be posed: • Could their food for a week fit into a one metre cube box? • How many boxes would be required to contain the food eaten in six months? Extension questions could be: Do all six month periods have the same amount of days? If not what is the maximum/minimum number of days in any six month period?	There is an opportunity for some estimation work here: six months is roughly 180 days. Students could calculate the exact number of days of Tim Peake's planned mission starting on 15 Dec 2015 and scheduled return on 5 June 2016.

Main activity

Suppose Tim Peake has to take all his food with him when he travels to the International Space Station. • Would he be able to take what you ate last week? • What information do you need to know to answer this question?	Tim Peake will travel to the ISS on the Soyuz TMA. Information about previous Soyuz TMA modules can be found at https://en.wikipedia.org/wiki/Soyuz_(spacecraft) This provides a good exercise in reading information from a table. The orbital module has a volume of 5m3. Although the orbital module has a volume of 5m3 it contains a lot of equipment such as communications equipment and even a toilet. Students should appreciate the magnitude of this space and that there would not be a lot of room left for cargo which can lead to a discussion, at the end of the task, of how food and other supplies are transported to the ISS

Making an assumption

Assume Tim takes all his food in cans the size of a standard soup tin can and he has three meals a day. How much space would these take up?	Students need to measure or estimate the size of a standard soup tin and calculate the volume of each tin. Then decide how many tins are required and calculate the total volume. Students will be required to convert between cm3 and m3.

Packing

The tins cannot be stored loose in the space craft. • How could the tins be best packed into boxes? • How do you know your solution is the best? • Consider percentage volume waste. Students may also be asked to consider the suitability of taking canned food to space. How realistic is this? Would the weight be an issue? Can students calculate the mass of a can using the thickness and density of the aluminium? Note tin cans might also be in danger of exploding if the cargo bay was depressurised!	Students can be creative looking at different sizes of rectangular box and comparing percentage waste. Students may be encouraged to investigate facts about cans https://en.wikipedia.org/wiki/Tin_can#Materials This work can lead to a discussion as to why cans are not used and that food is transported in shrink wrapped plastic pouches

Conclusion

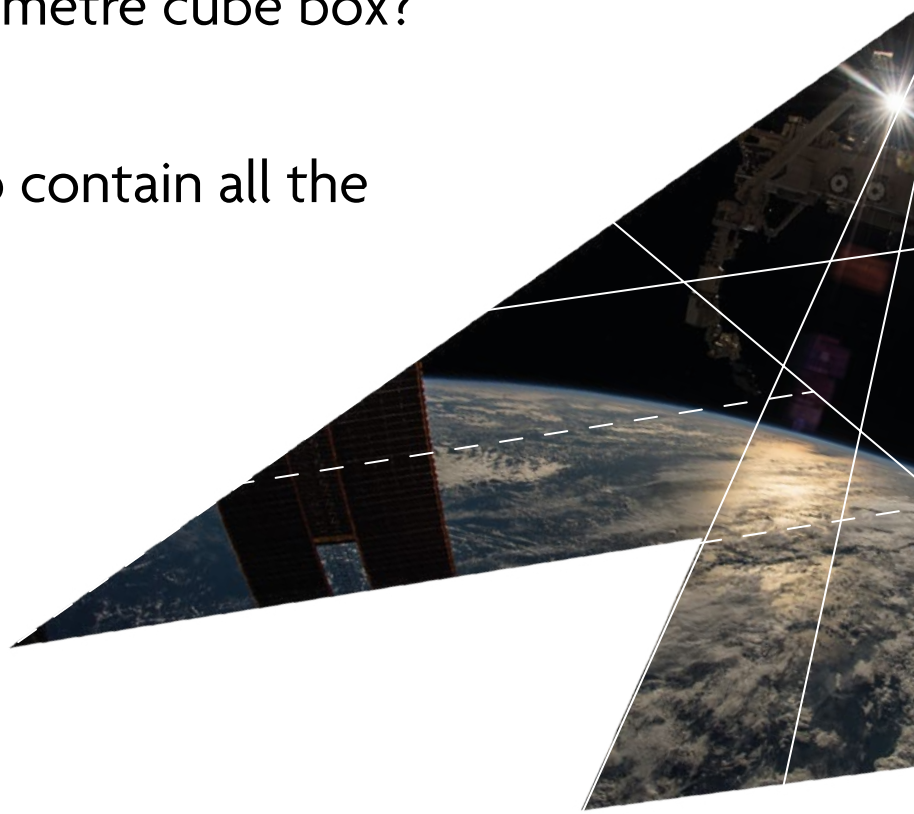
As Tim Peake will be travelling with two other astronauts it is not possible for all their food to be taken in tins as suggested. It is now appropriate to view the resource Great British Space Dinner Lesson 2: taking food into orbit http://stem.org.uk/rxedz	The Progress spacecraft is used to supply the space station see: https://en.wikipedia.org/wiki/Progress_(spacecraft)

How much do you eat?

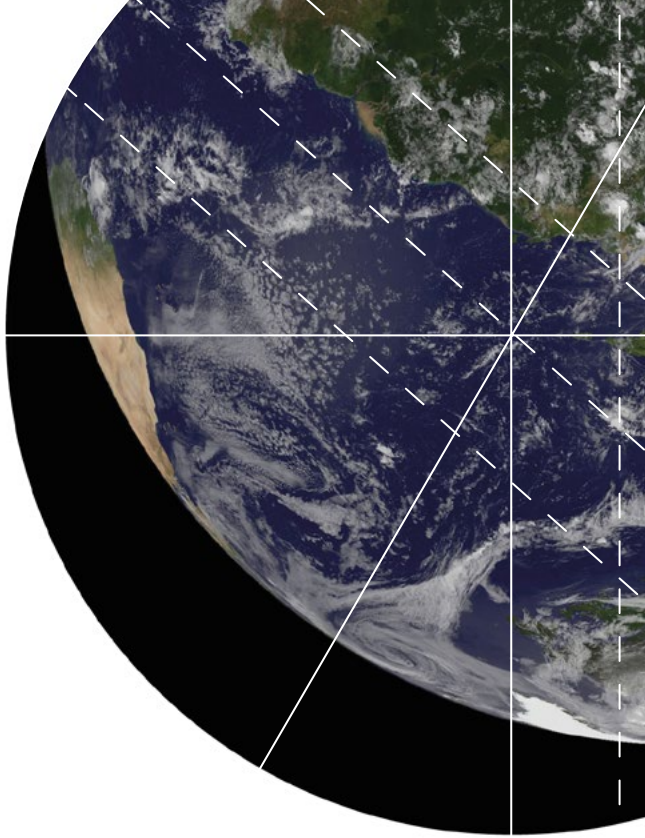
- Estimate how much food you eat in a week.
- Would the food you ate in one week fit in a one metre cube box?
- How many days are there in six months?
- How many metre cube boxes would you need to contain all the food you would eat in six months?

Things to consider:

- How much do you drink as well as eat?
- Do all six months contain the same number of days?
- How big is a metre cube? How many metre cubes can you fit into your classroom?



Getting food to ISS



Assume all Tim Peake's food is taken to the ISS in standard sized soup cans.

- How many cans would he need to last for six months if he has three meals a day
- How can the cans be best packed into rectangular boxes so as to minimise the percentage waste?
- Will all the food fit in the space craft?

Things to consider:

- You will need to find out, or estimate, the dimensions of a standard sized soup can.
- What different dimensions of box could be used? How many cans will be in each box?
- Tim Peake's mission is scheduled to last from 15 December 2015 to 5 June 2016. How many days is that?
- The rocket Tim Peake will travel in to the space station is the Soyuz TMA. You may need to find out the volume of the module Tim Peake will be travelling in.

Three astronauts

Tim Peake will travel to the ISS with two other astronauts.

- Will the food for all three astronauts, plus the astronauts themselves, fit into the space craft?
- What other supplies do you think you would need to take with you if you were going to the ISS for six months?
- How do you think supplies are taken to the ISS?

Things to consider:

- What is the volume of an astronaut?
- What food do you think Tim Peake will actually eat?
- How do you think the food is packaged to keep it fresh?
- You may like to investigate what the Progress spacecraft is used for and explain its relevance to this task.

Sample Solutions

Dimensions of a tin can approx. 11cm high and 7.5cm in diameter.
Volume of a standard can is approximately 500cm^3

Conversion to m^3

Method 1
Convert linear dimensions to metres so v=πx(0.0375)2x0.11 which is approximately 0.0005m^3

Method 2
1m^3 = 1000000cm^3
hence 500cm^3 = 500 ÷ 1000000 = 0.0005m^3

Number of days in six months

Approximately 30 days per month hence 180 days in six months.
The least number of days there can be in six complete months is 181 and the largest is 184
Number of tins required is about 180 x 3 = 540
Volume of 540 tins is about 540 x 0.0005m^3 = 0.27m^3
i.e. about a third of a cubic metre.

Box packing:

If we chose 12 tins in a box, 540 ÷ 12 = 45 hence 45 boxes each containing 12 tins are required
If two 3x2 layers of tins are used then the dimensions of the box is

Length 3 x 7.5 = 22.5cm
Width 2 x 7.5 = 15cm
Height 2 x 11 = 22 cm

Volume of box approximately 7500cm^3 or 0.0075m^3
So 45 boxes will have a volume of approximately 0.0075 x 45 = 0.33m^3

Interpretation

Seems about correct as we still get about a third of a metre cubed.
Percentage waste placing in rectangular boxes of these dimensions
Waste = 0.33-0.27 = 0.06m^3
Percentage waste = 0.06 ÷ 0.33 x 100 = 18.18% so about 20% wasted space.

Space Module

The module Tim Peake will travel in is 5m^3
It can be assumed that each astronaut will take up about 1m^3