Maths in Context: ‘Mission to Mars’

An AMSI Schools ChooseMATHS ‘Rich Task’

for Students in Years 5 & 6 (Challenging) or Years 7 & 8

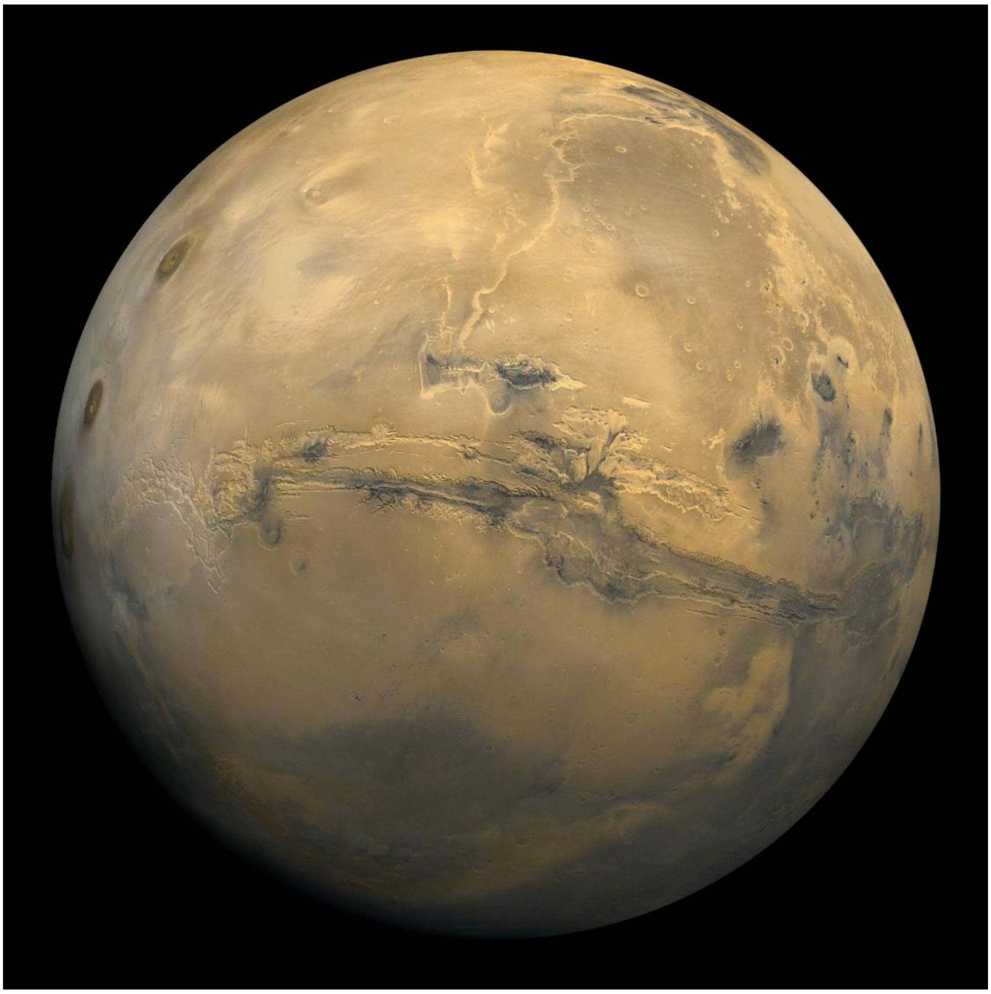

Image credit: Mars by Viking 1 (1980), from Wikipedia article, *‘Mars’*, URL https://simple.wikipedia.org/wiki/Mars. Image labelled for non-commercial reuse.

Teacher Booklet

This task was developed in consultation with Branxton Public School (NSW) and Scone Grammar School (NSW).

Aims and Objectives for this Task:

The aim of this task is to provide a rich, contextual activity through which students can gain an understanding of (a) the distances relevant to the size of our solar system, and (b) how an understanding of place value, metric measurement systems and time measurement can be used to represent these large distances and convert calculations to solve problems.

Warmup:

Watch the following You Tube clip, ‘Cosmic Voyage’ (section from 6:00 minutes to 10:40 minutes), narrated by actor Morgan Freeman.

https://www.youtube.com/watch?v=MjcT7acDzAo

This short excerpt will introduce the concept of moving away from the Earth in distances marked by powers of ten. Teachers may want to demonstrate on the board as the film progresses the ways by which the circumferences of the concentric circles grow, converting them into new units, eg. from 1 metre, to 10 metres, to 100 metres, to 1 kilometre, …

Remind students of indices as a ‘shorthand’ way of writing repeated multiplication, eg.

$10 \times 10 \times 10 \times 10 = 10^4$ … and so on.

Background:

It is the Year 2035. You are a member of the International Solar Exploration Federation (ISEF) team, charged with exploring and setting up a base on Mars to establish the potential for mining, eventual terraforming[1] and human settlement on the red rocky planet.

You are working for the Communications and Transport Division of the ISEF team, charged with calculating distances and travel times for both communications and physical travel between Earth Base and Mars Base. This will mean working with some pretty big numbers.

The new Mars Base settlement will be permanent and will establish docking facilities for Earth-to-Mars supply craft. The plan is that within 5 years' time (by 2040), Mars will have it's own craft launch facilities to enable crews to travel back from Mars to Earth as well. In the meantime, the first Mars settlers will be 'one way' passengers who can only be assisted, at least within the first five years, by radio and video communications and by the delivery of (unmanned) provisions craft every six months.

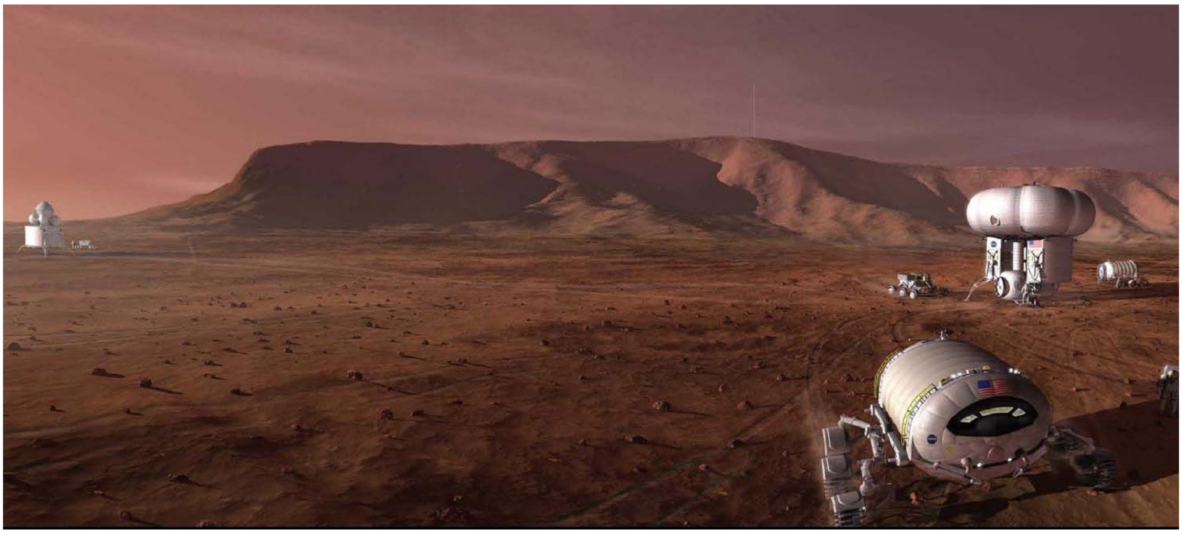

Image credit: Concept for 5.0 (2009), from Wikipedia article, *'Mars to Stay'*, URL https://en.wikipedia.org/wiki/Mars_to_Stay. Image labelled for non-commercial reuse.

Communicating between Earth and Mars, once a base has been established, will be extremely important. Earth Base and Mars Base will communicate between one another using radio telescopes. Communication therefore occurs via radio waves, which travel at the speed of light – that is:

299 792 458 *metres per second (mps)*

[1] Using technology to change a hostile (unliveable) planet's environment so that it can be liveable – that is, people and animals can walk freely on the surface, breathe the air and grow food.

Background Question 1 (Place Value):

How many **millions** of metres per second is this?

299.792458

Hint: *You will need to use decimal points in your answer!*

How many **kilometres** per second is this?

299 792.458

If we were to **round** this number (of metres per second) to the **nearest million**, what *approximate* speed would the speed of light be (in metres per second)?

300 000 000 (300 million)

Background Question 2 *(Place Value – Going Further)*:

To convert the above speed of 299 792 458 mps into **metres *per hour*** we need to **multiply** this already huge number by the number of seconds there are in one hour, which is (60 x 60) = 3 600.

So, the speed of light in metres per hour = 299 792 458 x 3 600

= **1 079 252 848 800** metres per hour

In words, that's ***one trillion, seventy-nine billion, two-hundred and fifty-two million, eight hundred and forty-eight thousand, eight hundred metres*** per hour!

Now **- how many kilometres per hour is this?**

(Hint: remember that there are 1 000 metres in 1 kilometre!)

1 079 252 848.8 **km / h**
(or 1 079 252 849 when rounded)

Remember this figure! You will need it when you get to Activity 3.

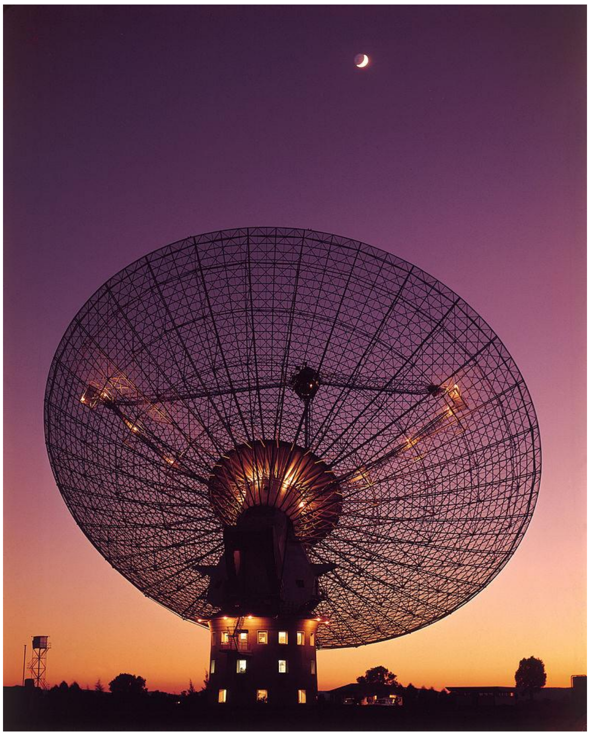

Image credit: CSIRO ScienceImage 4350 – CSIRO's Parkes Radio Telescope with moon in the background (1968), from Wikipedia article, *'Parkes Observatory*, URL: https://en.wikipedia.org/wiki/Parkes_Observatory. Image labelled for non-commercial reuse.

ACTIVITY ONE – Understanding Number Order, Place Value and Index Notation

Some background information:

One (1) 'Astronomical Unit' (AU) is the distance from the Sun to Earth, which is *approximately 150,000,000 (one hundred and fifty million) km*.

Planet	**Average Distance from Earth in AUs[2]**	**Average Distance from Earth in km[2]**
Jupiter	4.2	628 730 000
Mars	0.52	78 340 000
Mercury	0.61	91 691 000
Neptune	29.09	4 351 400 000
Saturn	8.52	1 275 000 000
Uranus	18.21	2 724 000 000
Venus	0.28	41 400 000

a) Use the distances in the table above to order the planets *according to their distance from Earth*, in ascending order.

Then, write the distance each planet is (in kms), in words.

The first one has been done for you.

[2] **This distance varies during the year.** It can vary by as much as 2 AU, because the distance between Mars and the Earth varies according to where each of the planets are in their respective solar orbits. We'll base our calculations on these figures as the shortest distance between the planet and earth – ie, assuming the planets were 'aligned' in their orbits around the Sun.

Planet	Distance from Earth in kms	Distance from Earth in Words
Venus	41 400 000	Forty-one million, four hundred thousand km.
Mars	78 340 000	Seventy-eight million, three-hundred and forty thousand km.
Mercury	91 691 000	Ninety-one million, six hundred and ninety-one thousand km.
Jupiter	628 730 000	Six hundred and twenty-eight million, seven-hundred and thirty thousand km.
Saturn	1 275 000 000	One billion, two-hundred and seventy-five million km.
Uranus	2 724 000 000	Two billion, seven-hundred and twenty-four million km.
Neptune	4 351 400 000	Four billion, three hundred and fifty-one million, four hundred thousand km.

b) A 'shorthand' way that scientists and astronomers often use to write large numbers is to use **index notation**. We can use powers of ten to help us do this.

For example, the number '100' can be represented as '10 x 10' – that is, $\mathbf{10^2}$.
'1000' is '10 x 10 x 10', or $\mathbf{10^3}$**.**

The following table summarises the index notation format for numbers from 100 to 1 000 000 000 (1 billion):

Number (Multiples of 10)	Number in words	Number in Index Notation
100	One hundred	10^2
1 000	One thousand	10^3
10 000	Ten thousand	10^4
100 000	One hundred thousand	10^5
1 000 000	One million	10^6
10 000 000	Ten million	10^7
100 000 000	One hundred million	10^8
1 000 000 000	One billion	10^9

Describe the **pattern** between the written number and its representation in index notation form:

The number of the index power (eg. '4') is the same number of zeros in the integer (eg. 10 000)

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Now it's your turn!

When using index notation in Science, we use only one decimal place to the left of the decimal and then 'raise' the remainder of the number to an appropriate power of ten, using index notation. Thus,

41 400 000 = 4.14×10^7

Convert the above large distances into their index notation form by expressing them as a multiple of a power of ten. *Round to only 3 decimal places in your answer.* The first two have been done for you:

Planet	Distance from Earth in kms	Distance from Earth in Index form
Venus	41 400 000	4.140×10^7 km.
Mars	78 340 000	7.834×10^7 km.
Mercury	91 691 000	9.169×10^7 km.
Jupiter	628 730 000	6.2873×10^8 km.
Saturn	1 275 000 000	1.275×10^9 km.
Uranus	2 724 000 000	2.724×10^9 km.
Neptune	4 351 400 000	4.3514×10^9 km.

ACTIVITY TWO: 'Orbital Variance' – Solving a Problem

Actually, because of the orbit of the planets around the sun, the distance between Earth and Mars (and between earth and all the planets) varies quite a lot! A simple diagram showing the orbits of the planets in the solar system quickly shows why this is the case.

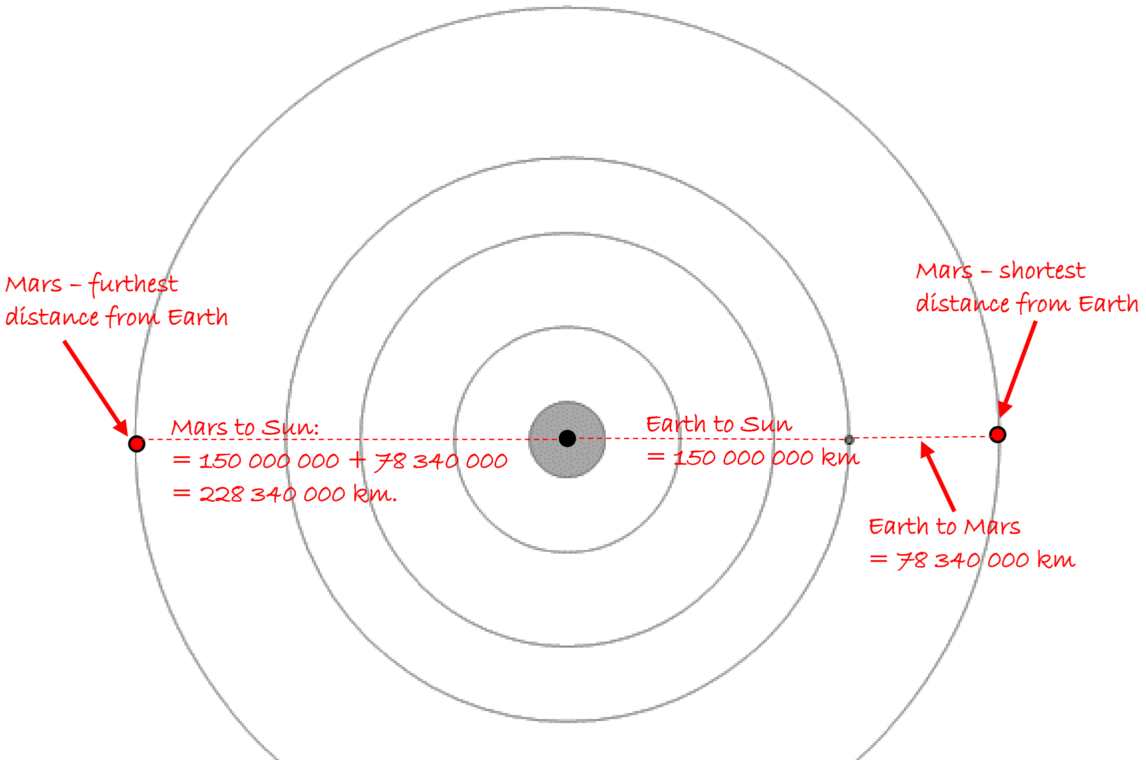
Here is a diagram of the sun and the orbits of the four inner planets of the solar system. Earth is shown as a dot.

1. Mark in where Mars would be so that the time for signals between Earth and Mars is:

a) Shortest
b) Longest.

2. In both cases, work out the distance between Earth and Mars and how long it would take for signals from the Mars base to reach Earth.

   Hint: Remember that the distance between Earth and the Sun is approximately 1 AU, or 150 000 000 km (150 x 10^6 km).



Mars' shortest distance from Earth = 78 340 000 km (from earlier)
Mars' longest distance from Earth = (150 000 000 + 78 340 000) + 150 000 000
= 228 340 000 + 150 000 000
= 378 340 000 km.

Calculation of Time Taken *(in hours)*: $\dfrac{\textbf{Distance in km}}{\textbf{Speed of Light in Km/h (1 079 252 849)}}$

a) Shortest distance between Earth and Mars: 78 340 000 km (0.52223 AU) AU / km *(circle one)*

Shortest time taken for a radio message between Earth and Mars: 0.0725872 *hours* (4 min., 21 sec.)

b) Longest distance between Earth and Mars: 378 340 000 km. (2.52223 AU) AU / km *(circle one)*

Longest time taken for a radio message between Earth and Mars: 0.350557 *hours* (21 min., 2 sec.)

Possible student working:

a) Radio message time between Earth & Mars at shortest distance
= 78 340 000 km ÷ 1 079 252 849 *(speed of light in km/h)*
= 0.0725872
60 minutes (ie, 1 hour) x 0.0725872 = 4.36 minutes (ie, 4 minutes 21 seconds)

Therefore a return radio message between Earth & Mars = 2 x 4 min. 21 sec.
= 8 minutes, 42 seconds.

b) Radio message time between Earth & Mars at shortest distance
= 378 340 000 km ÷ 1 079 252 849 *(speed of light in km/h)*
= 0.350557
60 minutes (ie, 1 hour)
x 0.350557 = 21.03 minutes
(ie, 21 minutes 2 seconds)

Therefore a return radio message between Earth & Mars
= 2 x 21 min. 2 sec.
= 42 minutes, 4 seconds

ACTIVITY THREE: Fluency with Operations

Part of the task of the Mars-based ISEF settlers will be to collect data on other planets and moons in our solar system. They will do this by sending small radio probes from Mars out to selected parts of the solar system[3]. Select 3 planets to visit from the above list.

Use the following website to look up distances between Mars and your selected planets or moons. You may record your answer in either kilometres or in AUs:

http://theplanets.org/distances-between-planets/

Using the table to record your results, calculate the return distance and then the time taken (in hours[4]) for a return radio message (ie, from Mars to the planet or a close moon, and then back again, at the speed of light) for your 3 selected planets.:

Planet (or moon)	Return distance from Mars (in kms or AUs)	Time taken for return message *(in hours)*
Earth	= 78 340 000 x 2 = 156 680 000 km	= 156 680 000 ÷ 1 079 252 850 = 0. 15 hours (8.7 minutes)
Eg. Saturn	= 1 196 660 000 km	= 1 296 660 000 ÷ 1 079 252 850 = 1.201 hours (1 hr. 12 min.)
Eg. Jupiter	= 550 390 000 km	= 550 390 000 ÷ 1 079 252 850 = 0.51 hours (30 min. 36 sec.)
Eg. Neptune	= 3 076 400 000 km	= 3 076 400 000 ÷ 1 079 252 850 = 2.85 hours (2 hr. 51 min.)

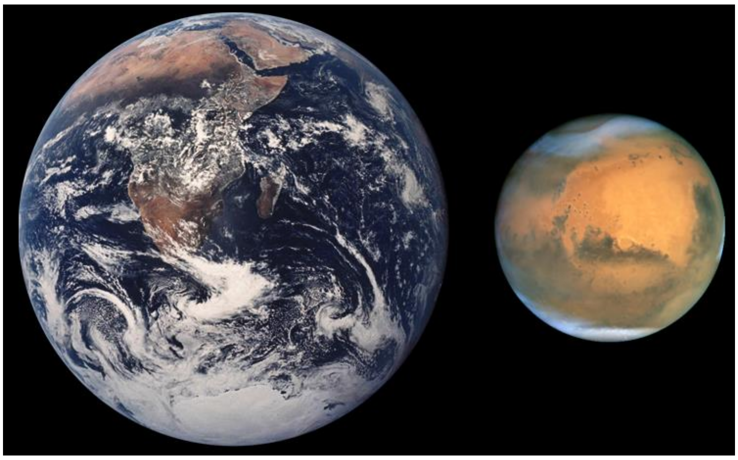


Image credit: Size comparison of Earth and Mars in true colour (2012), from Wikipedia article, *'Planet Mars*, URL https://bar.wikipedia.org/wiki/Mars_(Planet)#/media/File:Mars_Earth_Comparison.png. Image labelled for non-commercial reuse.

[3] It's comparatively easier to do this (as long as you have the equipment) compared with earth, as Mars has a much thinner atmosphere and its surface gravitational pull is only 37% that of Earth's!
[4] Can you also calculate the time taken in **minutes**? This is simply 60 (minutes) x the number of hours; so 0.15 hours = 0.15 x 60 = 8.7 minutes!

EXTENSION ACTIVITY: Calculating a Mars Year – Using Ratios and Proportions;
Solving an Open-ended problem.

Rotation of the Earth on its axis (ie, the Earth 'spinning') is what creates out 'day' and 'night'. As you know, Earth takes almost exactly 24 hours to complete a full rotation.

It takes Mars about 24 hours and 40 minutes to complete one full rotation, making the Martian day pretty close in length to an Earth day.

There are 60 x 24 = 1140 minutes in one Earth day, so this means this means that:

1 Mars day = 1440 + 40 minutes = 1480 minutes.

a) **How many Mars days are there in one Earth day?** (Hint: you will need to use a decimal!) You can use a calculator for this if you need to!

1 Mars day = 1.0278 Earth days

b) How many Mars days are there in one Earth week?

1 Earth Week = 6.81 Mars days

It takes Mars 687 Earth days to orbit the Sun with its orbit radius of 227,840,000 km.

c) How many Earth years is one Mars year?

1 Mars year = 1.88 Earth years

d) How many Mars days in one Mars year?

1 Mars year = 668.432 Mars days

= 668 Mars Days + 10.368 hours

e) The Mars ISEF residents have been asked to design an **annual Mars Calendar** for recording 'Mars dates'. ISEF headquarters back on Earth have asked you to maintain the measure of seconds, minutes and hours, so this means that Mars days will be measured as 24 hours and 40 minutes. However, the number of months in the year, and the number of days in the month, are up to you. They should of course reflect a full solar orbit

Important: You will need to work with the total number of Mars Days (from *(d)* above), and then *add the additional number of hours and minutes in (d) on to the end of the Calendar year* (as a kind of 'MarsWarp TimeSlip'!), to ensure that the length of your Mars calendar year accurately matches up with the full orbital path of Mars around the Sun.

When you're finished, publish your Mars Calendar on a poster and display it on the classroom wall!

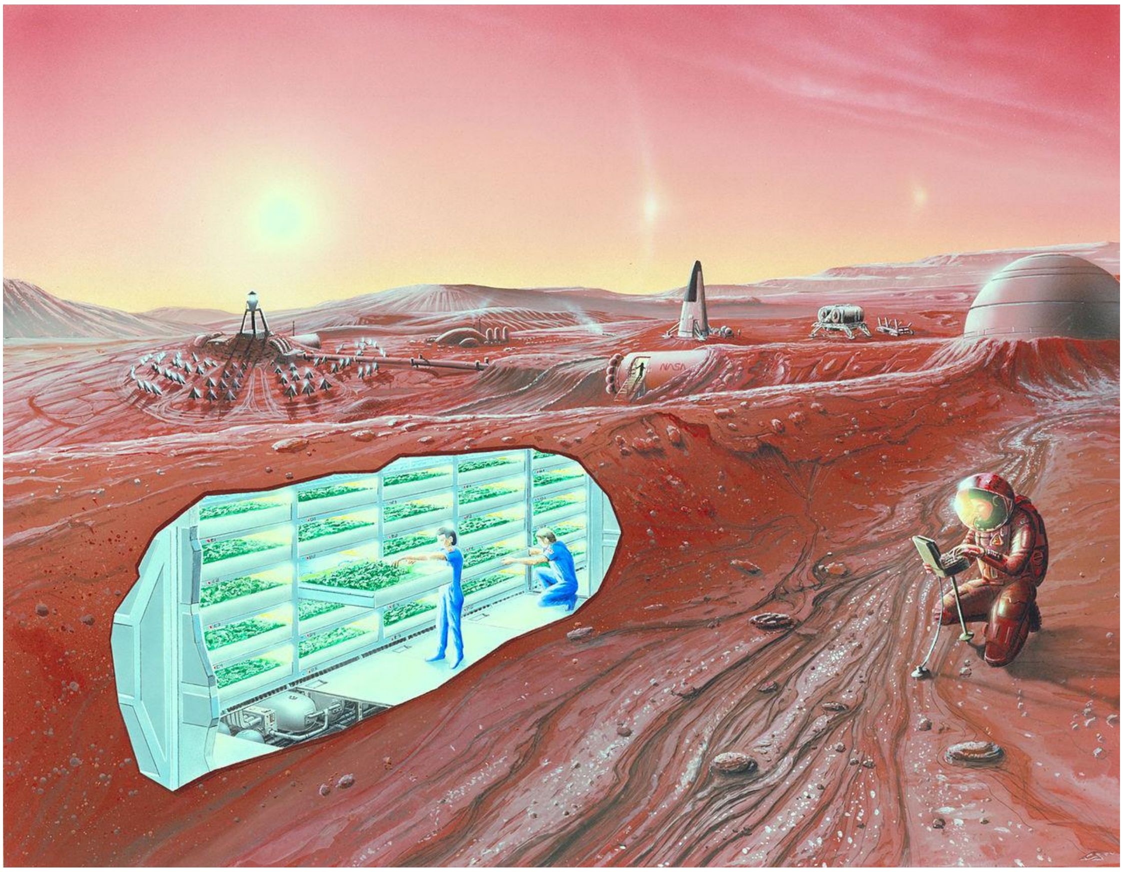


Image credit: NASA Ames Research Center (2005), Mars colonisation: Artistic Impression, from Wikipedia article, *'Colonisation of Mars*, URL https://de.wikipedia.org/wiki/Marskolonisation.
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Extension Activity Working and Response Page (section (e)):

NSW Syllabus and Australian Curriculum Outcomes

Whole Number and Place Value – Year 5/6 - (Mathematics);

'Space Maths' – Year 5/6 – The Physical World (Science).

Stage 3 NSW Science Curriculum:

- Describes how discoveries by people from different cultures and times have contributed to advancing scientific understanding of the solar system (ST3-8ES).

Australian Curriculum (Science) Outcome:

- The Earth is part of a system of planets orbiting around a star (the sun) (ACSSU078).
  Students:
  - Research the key features of the planets of the solar system and compare how long it takes to orbit the sun.

Stage 3 NSW Maths Syllabus (incorporating Australian Curriculum (Mathematics) Outcomes):

- Selects and applies appropriate problem-solving strategies, *including the use of digital technologies*, in undertaking investigations (MA3-2WM);
- Gives a valid reason for supporting one possible solution over another (MA3-3WM);
- Interpret information from the internet, the media, the environment and other sources that use large numbers (Communicating, Reasoning);

- Orders, reads and represents integers of any size and describes properties of whole numbers (MA3-4NA):
  Students:
  - Recognise, represent and order numbers to at least tens of millions;
  - Apply an understanding of place value and the role of zero to read and write numbers of any size;
  - Arrange numbers of any size in ascending and descending order;
  - Record numbers of any size using expanded notation, eg 163 480 = 100 000 + 60 000 + 3000 + 400 + 80;
  - Partition numbers of any size in non-standard forms to aid mental calculation, eg when adding 163 480 and 150 000, 163 480 could be partitioned as 150 000 + 13 480, so that 150 000 could then be doubled and added to 13 480; and
  - Use numbers of any size in real-life (or simulated) situations.

- Selects and applies appropriate strategies for addition and subtraction with counting numbers of any size (MA3-5NA):
  - Use efficient mental and written strategies and apply appropriate digital technologies to solve problems (ACMNA291); and
  - Use estimation and rounding to check the reasonableness of answers to calculations (ACMNA099).

- Selects and applies appropriate strategies for multiplication and division, and applies the order of operations to calculations involving more than one operation (MA3-6NA):
  - Select and apply efficient mental and written strategies, and appropriate digital technologies, to solve problems involving multiplication and division with whole numbers (ACMNA123).

- Selects and uses the appropriate unit and device to measure lengths and distances, calculates perimeters, and converts between units of length / distance (MA3-9MG):
  - Convert between common metric units of length / distance (ACMMG136); and
  - Solve problems involving the comparison of lengths / distances using appropriate units (ACMMG137).

Stage 3 Marking Rubric

Achievement Grade	Achievement Performance Description
A	• Demonstrates a strong understanding that the Earth is part of a system of planets orbiting around the sun by identifying key features of the planets of the solar system, accurately recording distances from Earth at various orbital points and comparing solar orbits of planets; • Selects and applies appropriate problem-solving strategies, including the use of digital technologies such as calculators and discerning use of websites, in undertaking their investigation on distances in the solar system; • Gives valid reasons (such as showing clear working) for supporting solutions to calculations; • Clarifies and correctly interprets information from the internet and other sources that use large numbers (to describe space distances and speeds); • Orders, reads and represents large integers and describes decimal properties of these large numbers using index notation; • Selects and applies appropriate strategies for addition and subtraction with large counting numbers, ensuring consistent accuracy with place value; • Selects and applies appropriate strategies for multiplication and division, and applies the order of operations to calculations involving more than one operation with large counting numbers, ensuring accuracy with place value; and • Selects and uses the appropriate unit and device to measure lengths and distances and converts accurately and efficiently between units of distance, speed and time.
B	• Demonstrates a sound understanding that the Earth is part of a system of planets orbiting around the sun by identifying the planets of the solar system and accurately recording distances from Earth; • Selects and applies appropriate problem-solving strategies, including the use of digital technologies such as calculators and websites, to undertake an investigation on distances in the solar system; • Shows some valid working for supporting solutions to calculations; • Correctly interprets information from the internet to describe space distances and speeds; • Orders, reads and represents large integers and converts some large numbers using index notation; • Applies appropriate strategies for addition and subtraction with large counting numbers, displaying reasonable accuracy with place value; • Selects and applies appropriate strategies for multiplication and division, and applies the order of operations to calculations involving more than one operation with large counting numbers displaying reasonable accuracy with place value; and • Selects and uses the appropriate unit and device to measure lengths and distances and converts with reasonable accuracy between units of distance and speed.
C	• Demonstrates a satisfactory understanding that the Earth is part of a system of planets orbiting around the sun and records distances from Earth; • Selects and applies problem-solving strategies including the use of digital technologies such as calculators, to undertake an investigation on distances in the solar system; • Shows limited working for supporting solutions to calculations; • Interprets information from the internet to describe space distances and speeds with a satisfactory degree of accuracy; • Orders and reads large integers and converts some large numbers using index notation; • Applies strategies for addition and subtraction with large counting numbers with limited efficiency, displaying variable accuracy with place value; • Applies strategies for multiplication and division with large counting numbers with limited efficiency, displaying variable accuracy with place value; and • Selects and uses some appropriate units to describe lengths and distances and converts with variable accuracy between units of distance and speed.
D	• Demonstrates a limited understanding that the Earth is part of a system of planets orbiting around the sun, transcribing some distances from Earth; • Applies problem-solving strategies and digital tools such as calculators with limited proficiency to undertake an investigation on distances in the solar system; • Shows limited or no working for supporting solutions to calculations; • Interprets limited information from the internet to describe space distances and speeds with a variable degree of accuracy; • Reads large integers and demonstrates the ability to order these given teacher or peer support; • Applies strategies for addition and subtraction with large counting numbers with limited efficiency and/or with teacher or peer support; • Applies strategies for multiplication and division with large counting numbers with limited efficiency and/or with teacher or peer support; and • Uses some appropriate units to describe distances and converts between units of distance and speed with variable accuracy and/or with teacher or peer support.
E	• Displays limited understanding regarding the Earth is part of a system of planets orbiting around the sun and/or fundamental misconceptions regarding distances from Earth; • Uses digital tools such as calculators with limited proficiency and/or only with teacher support to undertake an investigation on distances in the solar system; • Displays incomplete or inaccurate solutions to calculations; • Interprets limited information from the internet to describe space distances and speeds with a low degree of accuracy; • Reads large integers with support, however, experiences difficulty in ordering these with any degree of accuracy; • Applies inefficient strategies for addition and subtraction with large counting numbers and/or displays inaccurate or incomplete responses; • Applies inefficient strategies for multiplication and division with large counting numbers and/or displays inaccurate or incomplete responses; and • Demonstrates difficulty with describing distances and/or converting between units of distance and speed.

Whole Number and Place Value – Year 7/8 - (Mathematics); and

Year 7/8 – The Physical World (Science).

Stage 4 NSW Science Curriculum:

- Describes the dynamic nature of models, theories and laws in developing scientific understanding of the Earth and solar system (SC4-12ES);
- Processes and analyses data from a first-hand investigation and secondary sources to identify trends, patterns and relationships, and draw conclusions (SC4-7WS); and
- Selects and uses appropriate strategies, understanding and skills to produce creative and plausible solutions to identified problems (SC4-8WS).

Australian Curriculum (Science) Outcomes:

- Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124);
- Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126);
- Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence(ACSIS130);

Stage 4 NSW Maths Syllabus (incorporating Australian Curriculum (Mathematics) Outcomes):

- Operates with ratios and rates, and explores their graphical representation (MA4-7NA);
- Operates with positive-integer and zero indices of numerical bases (MA4-9NA);
- Performs calculations of time that involve mixed units, and interprets time zones (MA4-15MG);
- Communicates and connects mathematical ideas using appropriate terminology, diagrams and symbols (MA4-1WM);
- Applies appropriate mathematical techniques to solve problems (MA4-2WM);
- Recognises and explains mathematical relationships using reasoning (MA4-3WM);
- Compares, orders and calculates with integers, applying a range of strategies to aid computation (MA4-4NA).

Stage 4 Marking Rubric

Achievement Grade	Achievement Performance Description
A	• Demonstrates a strong understanding of the dynamic nature of the Earth, Mars and other planets in the solar system as they orbit the sun, our closest star; • Comprehensively and clearly summarises data regarding distances and planets within our solar system from their own investigations of secondary sources and uses a scientific understanding to draw conclusions to set problems based on this evidence; • Operates accurately and fluently with positive-integer and zero indices of decimal bases, ratios and rates as they relate to large numbers; • Connects mathematical ideas together and applies efficient mathematical techniques to solve problems using appropriate terminology and with reference to diagrams and mathematical notation; • Compares, orders and calculates with large integers, applying a range of strategies to aid computation and ensuring accuracy with place value; and • Accurately and efficiently performs calculations of time that involve mixed units, converts and interprets time zones based on given information regarding solar orbits.
B	• Demonstrates a sound understanding of the dynamic nature of the Earth, Mars and other planets in the solar system as they orbit the sun, our closest star; • Satisfactorily summarises data regarding distances and planets within our solar system from their own investigations of secondary sources and uses scientific references to draw conclusions to set problems; • Operates with a sound degree of accuracy and fluency with positive-integer and zero indices of decimal bases, and calculates some rates as they relate to large numbers; • Applies correct mathematical techniques and operations to solve problems using appropriate terminology and with reference to diagrams; • Compares and orders with large integers, and calculates by applying correct digital or written strategies ensuring accuracy with place value; and • Accurately performs calculations of time that involve mixed units, and converts and interprets time zones based on given information regarding solar orbits with direct teacher or peer support.
C	• Demonstrates a satisfactory although incomplete understanding of the dynamic nature of the Earth, Mars and other planets in the solar system as they orbit the sun, our closest star; • Records and refers to data regarding large distances in the solar system from their own investigations of secondary sources and draws some conclusions to set problems; • Operates with a variable degree of accuracy and fluency with positive-integer and zero indices of decimal bases, and calculates some rates as they relate to large numbers with direct teacher or peer support; • Applies some mathematical techniques and operations with limited efficiency to work on problems with reference to diagrams and / or their own working; • Compares and orders large integers, and calculates by using digital or written strategies, displaying variable accuracy with place value; and • Performs calculations of time that involve mixed units with direct teacher or peer support.
D	• Demonstrates a limited understanding of the dynamic nature of the Earth, Mars and other planets in the solar system as they orbit the sun, our closest star; • Records data regarding large distances in the solar system from given secondary sources and draws some conclusions to set problems; • Operates with limited accuracy and fluency with large positive-integers and calculates some rates as they relate to large numbers with direct teacher support; • Applies some mathematical operations with limited efficiency to work on problems with little reference to diagrams or own working; and • Compares and orders large integers and calculates by using digital or written strategies, displaying limited accuracy.
E	• Demonstrates a limited understanding of the dynamic nature of the Earth, Mars and other planets in the solar system as they orbit the sun, our closest star; • Incompletely records data regarding large distances in the solar system from given secondary sources; • Operates incompletely or with limited accuracy with large positive-integers; • Inaccurately applies some mathematical operations to work on problems with little or no reference to diagrams or own working; and • Compares but inaccurately orders large integers and displays limited accuracy and incomplete responses in calculations.