Maths in Context: ‘Mission to Mars’

An AMSI Schools ChooseMATHS ‘Rich Task’

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

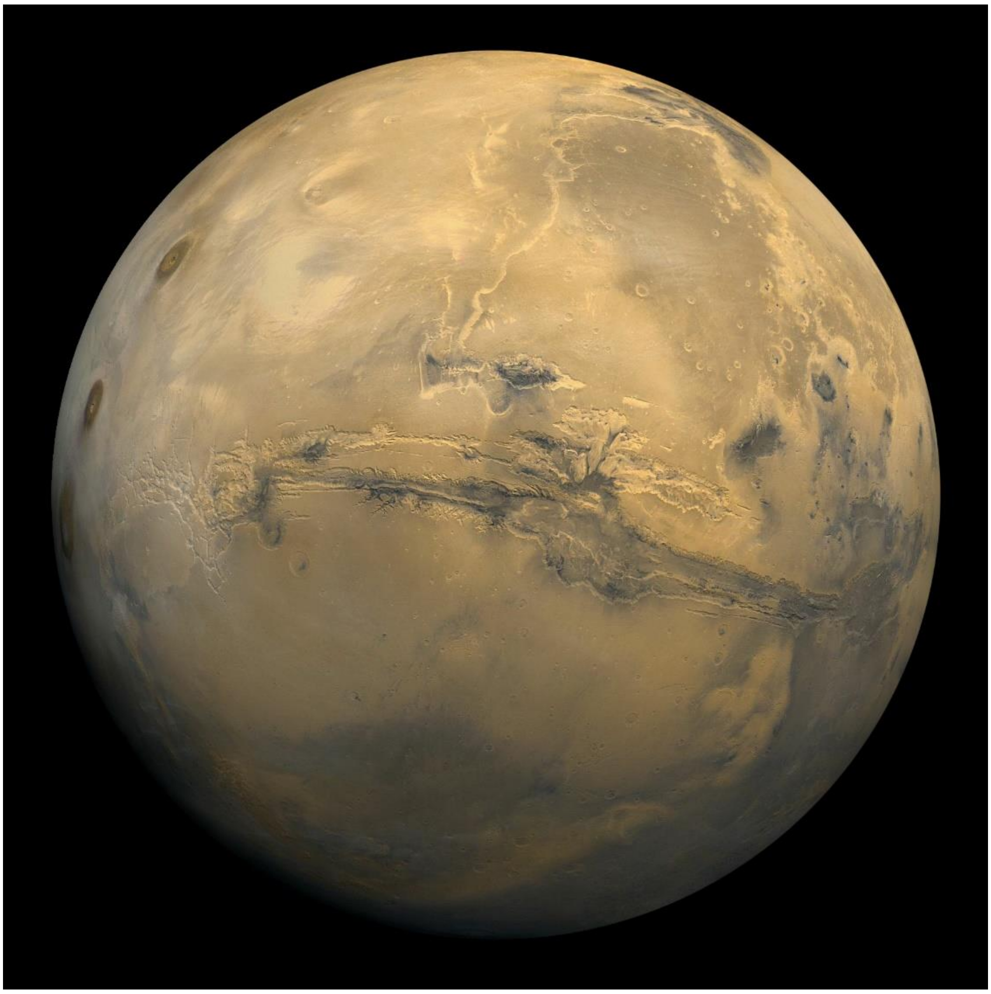


Image credit: Mars by Viking 1 (1980), from Wikipedia article, *‘Mars’*, URL https://simple.wikipedia.org/wiki/Mars. Image labelled for non-commercial reuse.

Student Booklet

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

Aims and Objectives for this Task:

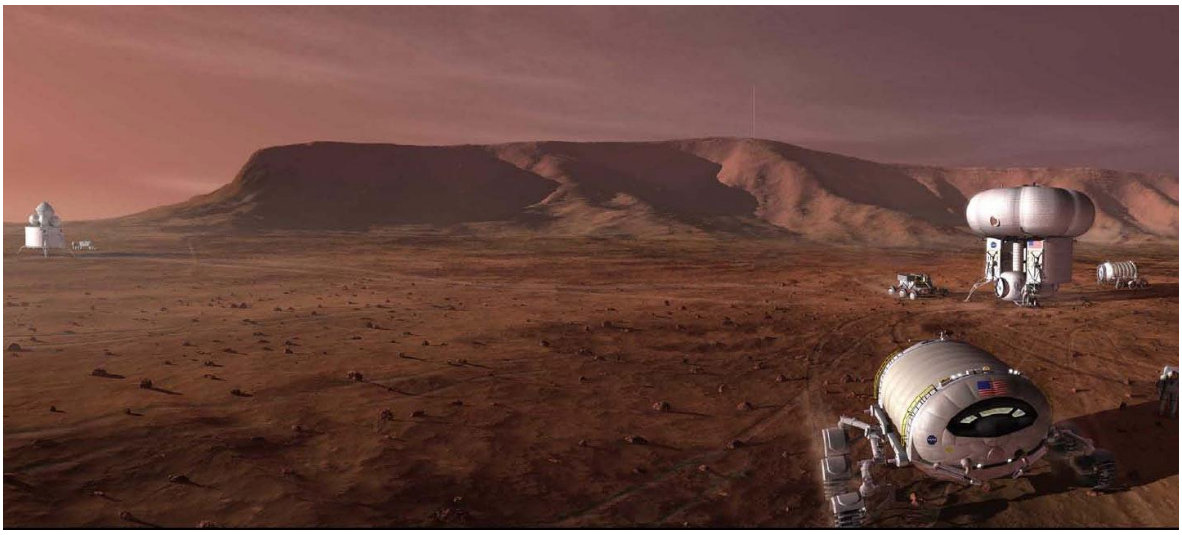
The aim of this task is to provide a rich, contextual activity through which students can gain an understanding of (a) the distances relevant to the size of our solar system, and (b) how an understanding of place value, metric measurement systems and time measurement can be used to represent these large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

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.



[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.

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)*

Background Question 1 (Place Value):

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

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

____

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

____

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)?

____

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!)

______________________________ **km / h**

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.

AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

CHOOSE MATHS

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 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.

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:

____

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,

$$41\,400\,000 = 4.14 \times 10^7$$

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.

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.

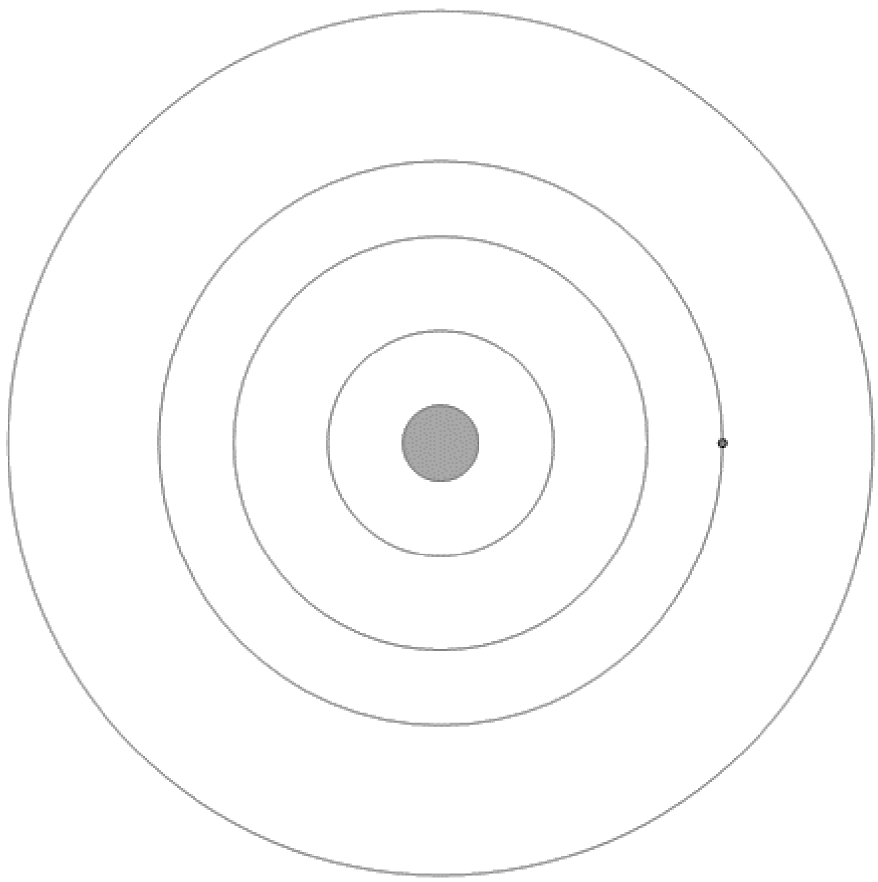
Here is a diagram of the sun and the orbits of the four inner planets of the solar system. Earth is shown as a dot.

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).



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: ____________________ AU / km *(circle one)*

Shortest time taken for a radio message between Earth and Mars: _____________ *hours*

b) Longest distance between Earth and Mars: ____________________ AU / km *(circle one)*

Longest time taken for a radio message between Earth and Mars: _____________ *hours*

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)

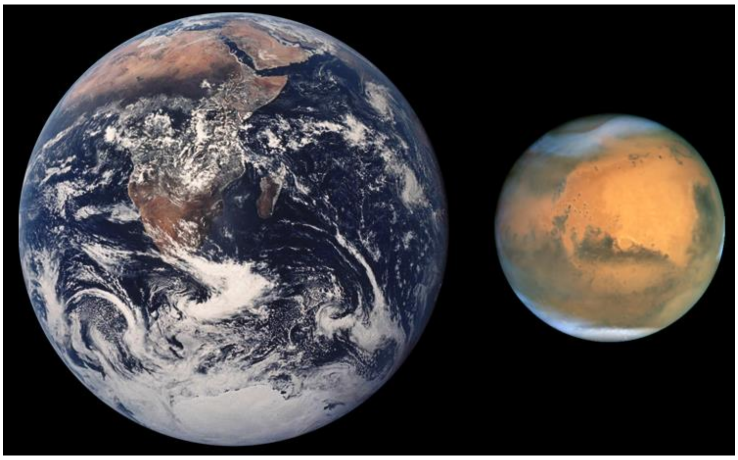


Image credit: Size comparison of Earth and Mars in true colour (2012), from Wikipedia article, *'Planet Mars*, URL https://bar.wikipedia.org/wiki/Mars_(Planet)#/media/File:Mars_Earth_Comparison.png. Image labelled for non-commercial reuse.

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[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 = _________ Earth days

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

1 Earth Week = _______ 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 = __________ Earth years

d) How many Mars days in one Mars year?

1 Mars year = ______._____ Mars days

= __________ Mars Days + ______ 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'!), 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!

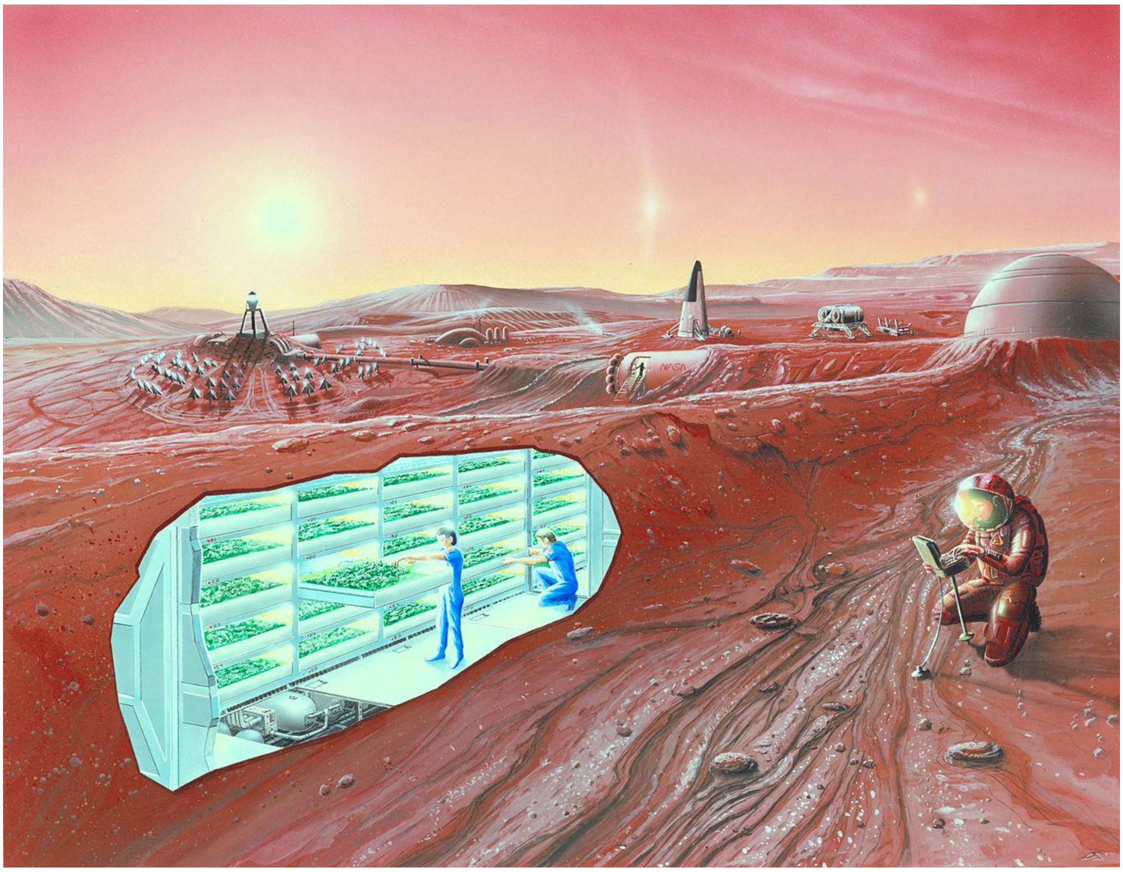

Image credit: NASA Ames Research Center (2005), Mars colonisation: Artistic Impression, from Wikipedia article, *'Colonisation of Mars*, URL https://de.wikipedia.org/wiki/Marskolonisation.
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Extension Activity Working and Response Page (section (e)):