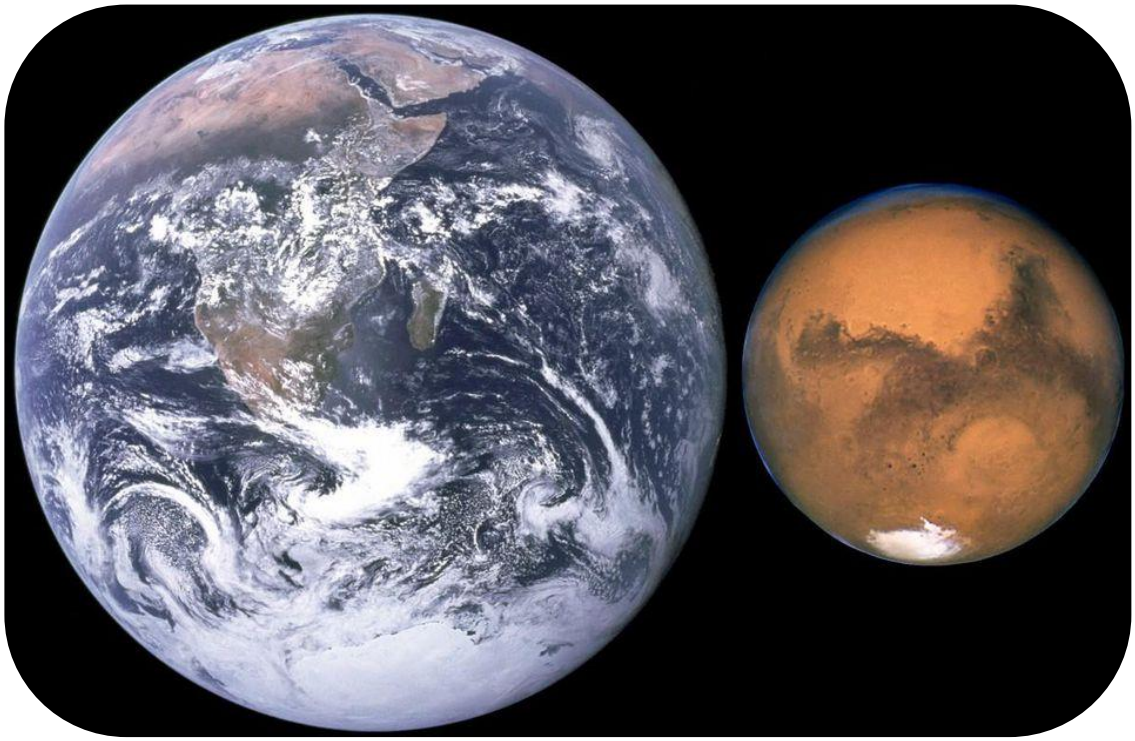
CESAR Science Case

Seasons on Mars

Following the Martian seasons with *Mars Express*

Student Guide



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Background

The Red planet

Mars is one of the planets of the Solar System that is visible to the naked eye and therefore it has been known since humans first started to watch the sky. The first observations of Mars using a telescope were made by Galileo Galilei in 1610.

In the 19th century some astronomers suggested that it might be home to intelligent life. This idea was popularly accepted until the 1970s when the first space missions travelled to Mars and returned high resolution images from its surface showing no evidence of life as it was known on Earth.

Thanks to numerous space missions, the Mars surface has been mapped and its composition is better understood. The Martian atmosphere has been found to contain similar gases (in different quantities) to the Earth's atmosphere, such as carbon dioxide, nitrogen, water vapour and more.

It is also thought that in the past Mars might have been partially covered by a sea of water, similar to the Earth. But, the reasons why Mars evolved from a watery world to a dry one are not yet well understood. We must take care of the Earth to prevent it becoming an uninhabitable planet.

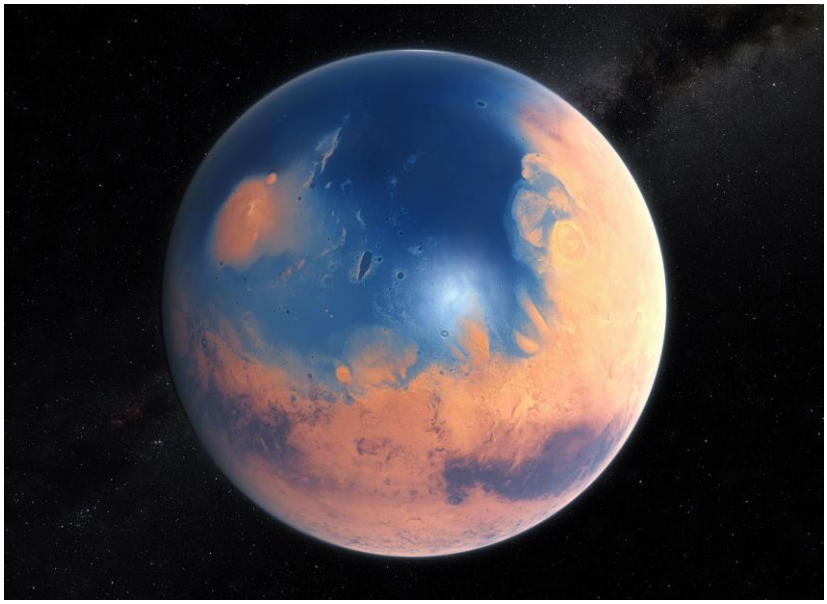


Figure 1: *Artist's impression of how Mars may have looked four billion years ago. Credit: ESO/M. Kornmesser/N. Risinger (skysurvey.org).*

Mars is an interesting world whose exploration can help us to understand the rocky planets of the Solar System, their habitability, and also the important processes that take place on Earth.

In the coming decades ESA plans to explore Mars further with more robotic missions, and perhaps one day humans will set foot on Mars. For that reason we need to know more about what they will find there.

The Mars Express Mission

One of the many spacecraft currently orbiting the Red Planet (as of 2019) is the European Space Agency's Mars Express mission. Onboard this spacecraft there are different instruments capable of measuring the composition of the planet and its thin atmosphere.

For these activities, you are going to use data acquired by the Visual Monitoring Camera (VMC), which has been taking thousands of images of Mars since 2008. The VMC is a standard camera in an extraordinary place.

Did you know?

Mars Express was the first European Space Agency mission to Mars. It was launched on 2 June 2003, and entered into orbit around Mars on 25 December. The "Express" part of the mission's name refers to the speed and efficiency with which the spacecraft was designed and built. In July 2018 Mars Express detected a lake of liquid water hidden under the planet's south pole.

Figura 2: *Artist's impression of Mars Express at Mars. Credit: ESA/ATG medialab*

Investigating Mars

Activity 1: Compare Mars and Earth

In this activity you will investigate the differences and similarities between the Earth and Mars.

Use the Mars facts cards (provided by your teachers) to complete the following table with the information you find out.

Property	Tierra	Marte
Radius	6378 km	
Colour	Mainly blue	
Tilt in axis	23.5 degrees	
Atmosphere		Yes, Very thin
Polar ice caps	Yes	
Average temperature		- 63ºC

***Table 1**: Comparing some properties of Mars and Earth.*

Activity 2: The seasons of Earth and Mars

In this activity, you are going to investigate the seasons of both Earth and Mars.

But, do you know what causes the seasons?

Activity 2.1:

Complete the following diagram, labelling the seasons for Earth's Northern and Southern Hemispheres over the course of a year. Also, write the inclination of the rotational axis of the Earth.

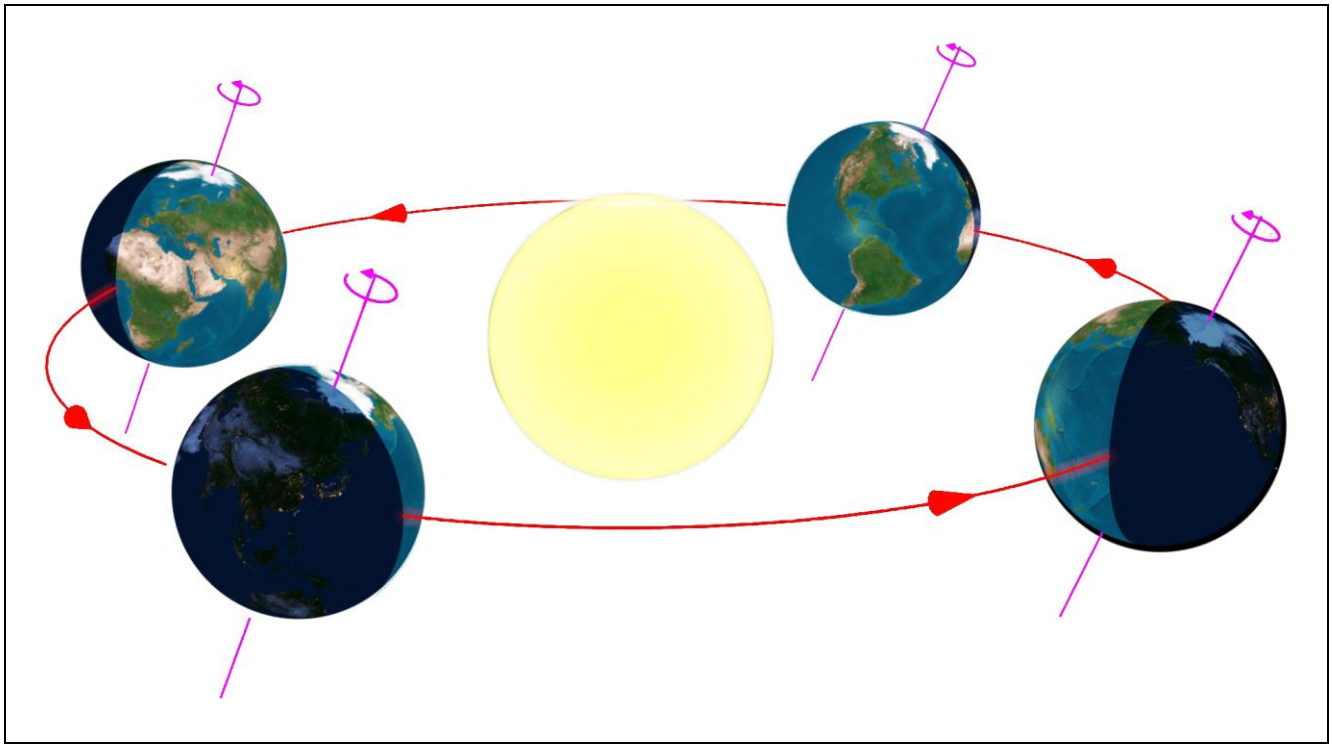


Figure 5: *Earth's orbit around the Sun.*

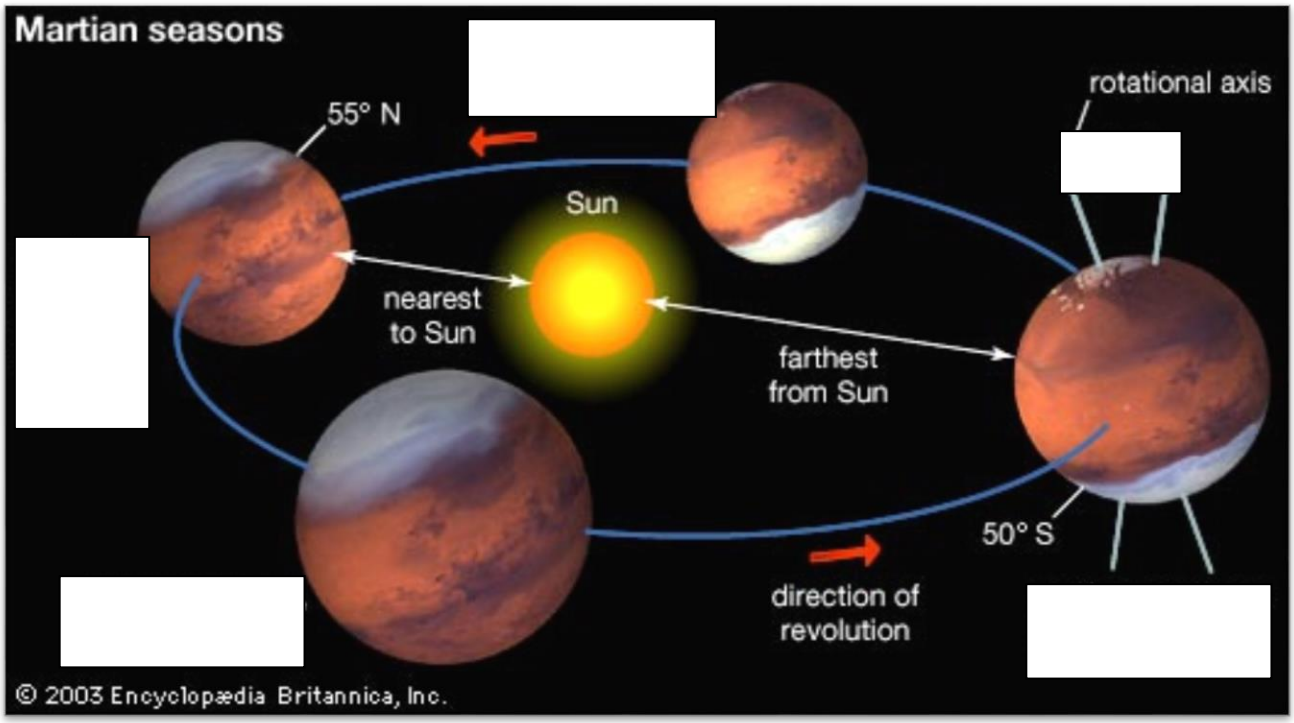
Now, think about Mars and answer the following questions. Explain your answers.

- Do you think that Mars has seasons?

- What do you think the main similarities are between the seasons on Earth and Mars?

- What do you think the main differences are between the seasons on Earth and Mars?

Complete the following diagram, labelling the seasons for Mars' Northern and Southern Hemispheres over the course of a year. Also, write the inclination of the rotational axis of Mars.



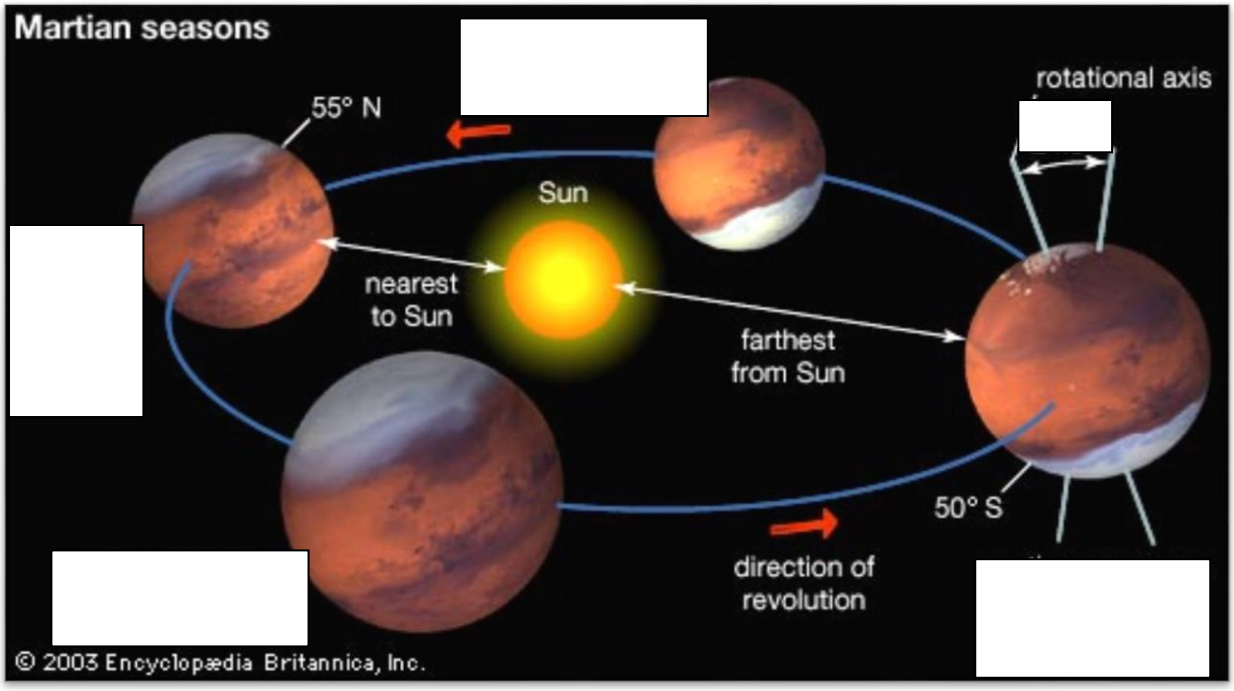


Figura 4: *Mars orbit round the Sun.*

Activity 2.2:

The formation and evolution of polar ice caps is one of the processes that tells us more information about the seasons of a planet.

For this study you are going to use the web tool, developed by the CESAR Team, that will allow to analyse data collected by the VMC camera (on board the Mars Express mission) and explore the Mars Seasons. Once you will get familiar with the Mars seasons you will select six of the VMC images that you consider cover a wide range of seasons within a single Martian year. This should allow you to derive (in terrestrial days) a reasonable estimation of the duration of a Martian year.

The CESAR Team will be guiding you in the various steps of the process.

- Here it is the web tool to be used: http://cesar.esa.int/tools/18.martian_year/

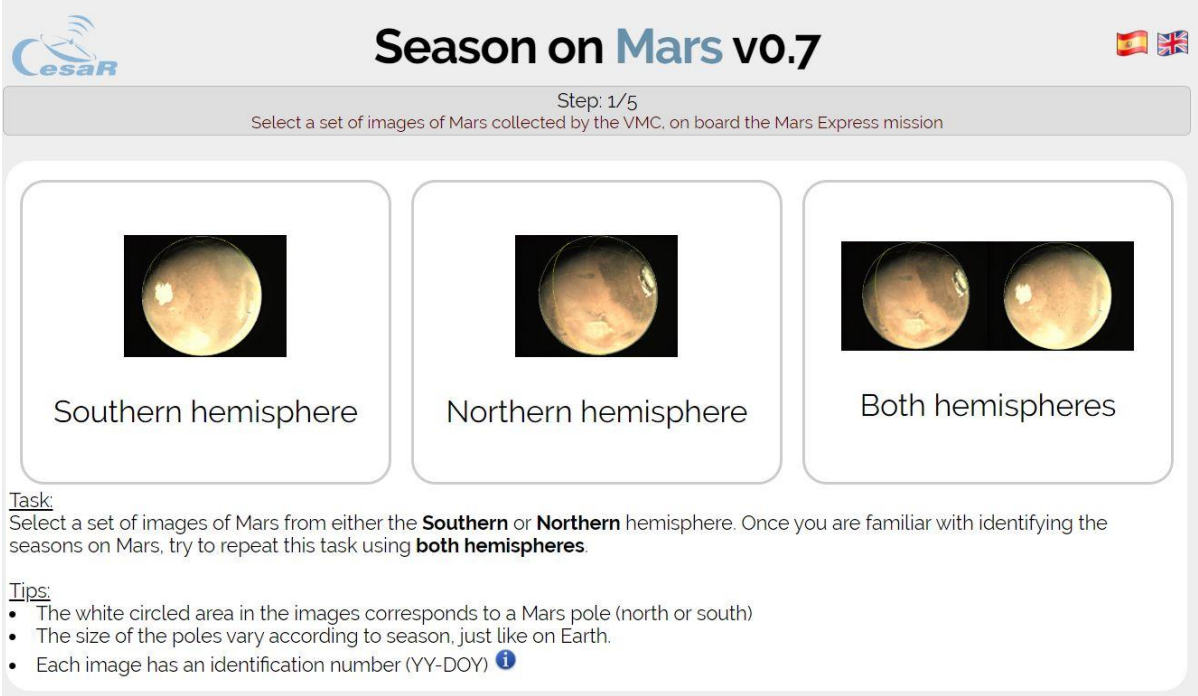


Figure 5: *Opening page and Step 1 of the Mars Seasons webtool.*

- **Step 1/5:** Select a set of images of Mars using the webtool, either for the northern or the southern hemisphere, which will help you to recognise the different seasons on Mars.
- **Step 2/5:** Identify the Mars season for each image. Remember that the size of the polar caps is closely related to the season!

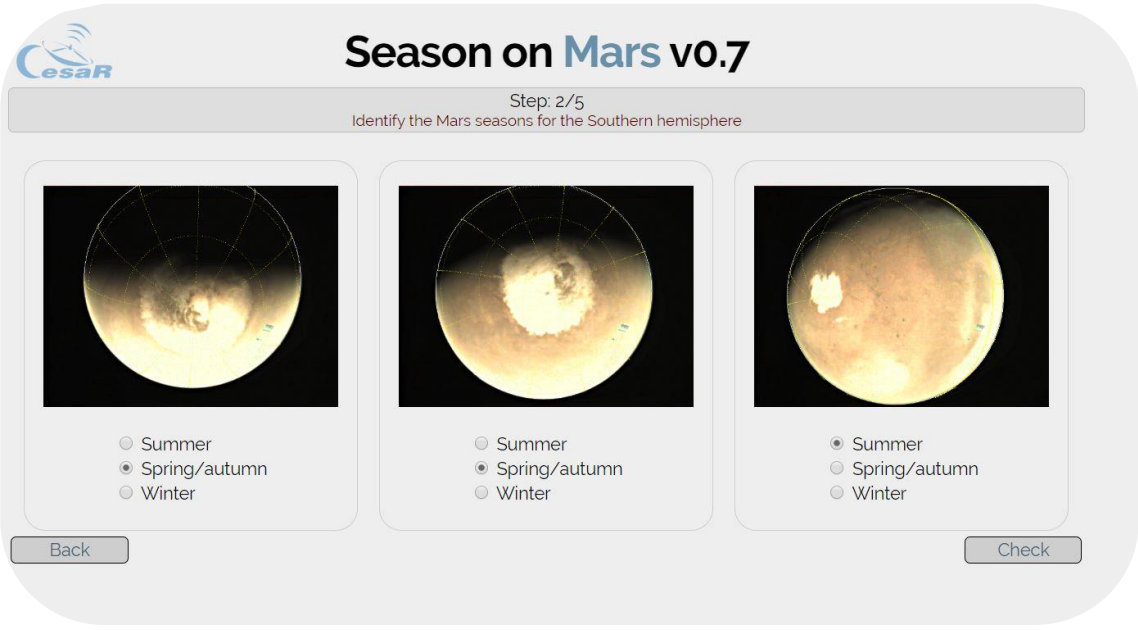


Figure 6: *Second step of the Martian Year Exploration webtool.*

Once you have selected your preferred option for each image, click “Check” and you will get a pop-up message, which will confirm if your answers are correct. If they are correct the webtool will lead you to the next step, which will be done in the next activity. Leave the webtool open.

Before moving to the next step, explain why you made your choices in Table 2.

	Primavera	***Verano***	***Otoño***	***Invierno***
Explain how you selected the images for each season.	Image X because …	Image X because …		

***Table 2**: Reasons for choice of images for each season.*

On Mars, just like on Earth, the north or south pole doesn't receive any light during winter. In the cold of the winter, carbon dioxide (CO_2) from the atmosphere freezes – changes from gas to ice - and forms part of the polar caps. In summer the opposite takes place. When winter ends and light from the Sun starts to heat the poles, the CO_2 from the caps doesn’t melt into liquid as water does, instead it changes from solid ice straight into gas state. As time passes and temperatures increase, the polar caps melt and the CO_2 returns to the atmosphere. The polar cap then significantly reduces in size.

Activity 3: How long is a Martian year?

Hypothesis: How long do you think a Martian year lasts? How old would you be in Martian years?

On Mars the easiest way to know when a year has passed is by looking at the poles which you know evolve with the seasons.

In this activity, you are going to calculate the duration of a Martian year by looking at different images taken with the VMC where you can see how the poles change.

- Step **3/5 :**
  - Select a set of at least 6 images covering a whole Martian year from the database. **All images must belong to the same hemisphere**. Write in Table 3 the date (year, DOY) of the selected images.

__Figura 7:__ Paso 3 de la herramienta CESAR. Con lupa rosa se identifican las imágenes del hemisferio norte de Marte y con lupa azul las del hemisferio sur. (Créditos: ESA/Mars Express/VMC – CC BY-SA IGO 3.0)

Note 1: Note that in the lower right corner, the colour of the magnifying glass icon tells you the hemisphere of the image: a **blue icon** means **southern hemisphere** and a **pink icon** means **northern hemisphere.**

Note 2: Each image has an identification number which is actually the date it was taken. They are labelled as **YY-DOY,** where:

- **YY:** corresponds to the last two numbers of the year when the image was collected, i.e. 16 refers to the year 2016.

- **DOY**: corresponds to the day of the year which goes in value from 1 to 365 (or 366 in a leap year), i.e. 32 corresponds to the 2 February.

Año	DOY

__Table 3__: Year and day images selected were taken to calculate a Martian year.

- **Step 4/5:** Take a look at the images and work out the duration of Mars year. Use the image identification to count the days between your first selected image and your last one.

  Remember what you learned about the seasons in the background information section, and complete the table below. The relationship between the illumination of the planet during its orbit and the amount of ice present at the poles is the key for you to understand the seasons on Mars.

- **Step 5/5:** Now it is time to check in the tool whether you were able to correctly calculate the duration of a Martian year, with a low error.

Conclusions: Compare your results with your hypothesis

From your calculations, how long does a Martian year last?

How old are you in Martian years?

Did you know?

In space missions, some Martian “slang” may be used. As an example, for the Mars Exploration Rover of NASA:

- yesterday is called “yestersol”, today is called “tosol”, tomorrow is called “morrowsol”

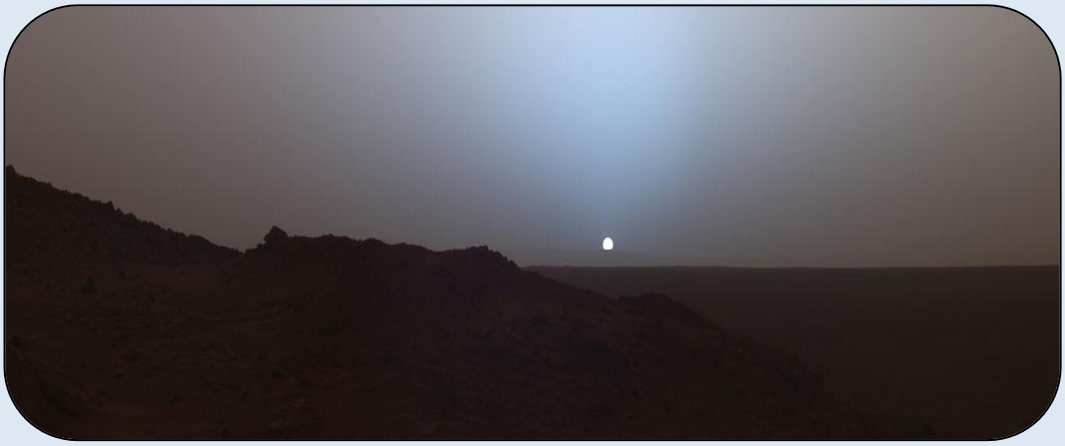


Figura 10: *Sunset on Mars as seen by the Spirit rover (Credit: NASA)*

Links … to know more…

ESA Mars Express mission

- ESA: Mars Express overview: http://www.esa.int/Our_Activities/Space_Science/Mars_Express
- ESA: Mars Express in depth: http://sci.esa.int/mars-express/
- Achievements: http://blogs.esa.int/mex/files/2013/06/Mars-Express-10-year-highlights.png

Mars

- ESA: The Red Planet: http://exploration.esa.int/mars/44997-the-red-planet/
- CESAR Booklet: Mars: http://cesar.esa.int/upload/202004/bookletmars_v4_english.pdf
- ESA: Life on Mars: http://exploration.esa.int/mars/43608-life-on-mars/
- ESA: Mars infographics: http://www.esa.int/Our_Activities/Human_and_Robotic_Exploration/Exploration/ExoMars/Highlights/Ten_things_about_Mars

Seasons

- Simulation: Seasons and ecliptic simulator: http://astro.unl.edu/classaction/animations/coordsmotion/eclipticsimulator.html
- Simulation: Time-Lapse Seasons Demonstrator: http://astro.unl.edu/classaction/animations/coordsmotion/transitmovie.html

Interesting features in the Mars surface

- ESA: *Olympus Mons* https://www.esa.int/Our_Activities/Space_Science/Mars_Express/Olympus_Mons_-_the_caldera_in_close-up
- ESA: *Valles Marineris* http://www.esa.int/Our_Activities/Space_Science/Fly_through_a_canyon_on_Mars

ESA Education Teach with Space classroom resources

- Could like survive in alien environments?: https://www.esa.int/Education/Teachers_Corner/Could_life_survive_in_alien_environments_-_Defining_environments_suitable_for_life_Teach_with_space_B09

- Astrofarmer: www.esa.int/Education/Teachers_Corner/Astrofarmer_-_Learning_about_conditions_for_plant_growth_Teach_with_space_PR42

- Astrofood: https://www.esa.int/Education/Teachers_Corner/Astrofood_-_Learning_about_edible_plants_in_Space_Teach_with_space_PR41

- Plants on Mars: https://www.esa.int/Education/Teachers_Corner/Plants_on_Mars_-_Build_an_automatic_plant_watering_system_Teach_with_space_T09