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STEM Project

Chapter 9: Earth, Sun and Moon

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Planning a mission: Is it worth it? Cost vs benefit vs risk

Is it worth it? Engineering projects constantly consider this question by weighing up the benefits of each decision in the engineering process against the costs and the risks involved.

The **benefit** of an engineering decision refers to the positive outcomes the decision will produce. For example, choosing a high-quality material for a moving part can increase the lifetime of a machine.

The **cost** of an engineering decision refers to the resources that are consumed due to the decision. This could be money or it could be other things that are sacrificed, such as time or space. For example, adding several mechanical arms on a robot could limit the space available for other instrumentation. This lack of space is a cost.

The **risk** involved in an engineering decision refers to the likelihood that things will turn out as expected. Risks could be related to safety or to the likelihood of a successful result. For example, using a low-quality lubricant in a machine may involve the risk of moving parts getting damaged and stopping your machine from working.

Space exploration is a field of science and engineering where these issues of benefit, cost and risk are really important. In this activity, you will explore these concepts in relation to a mission to space.

Let's start by considering benefits, costs and risks of space exploration in general. As a class or in small groups, brainstorm some ideas below.



Benefits	Costs	Risks



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With these benefits, costs and risks in mind, let's go on a mission into space.

Step 1: Create your destination planet

The first step is to figure out which planet your mission will explore. In small groups, decide on the characteristics of a distant planet that may be useful for humans to explore. To do this, choose an option for each planet characteristic below.

For each option, ask yourself what the benefits, costs and risks of studying this planet could be. For example, to explore a planet with violent windy weather will be very risky, but might bring lots of benefit through finding out about the effect of major weather events.

Circle your chosen planet characteristics:

Planet characteristics	Option 1	Option 2	Option 3
State of surface	Solid	Liquid and solid	Gas
Distance from Earth	Near	Medium	Far
Likelihood of water	Small	Medium	High
Surface texture	Flat	Cratered	Mountainous
Temperature	Freezing	Mild	Extremely hot
Atmosphere	Negligible	Thin and acidic	Extremely heavy
Weather	Stable	Gasoline rain	Violently windy

Give your planet a name, note down the choices you have made above and give some reasons for them.

Planet name:

Chosen characteristic	Reason for your choice
Surface	
Distance from Earth	
Likelihood of water	
Surface texture	
Temperature	
Atmosphere	
Weather	



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Step 2: Decide on a mission type

There are many types of missions possible for space exploration. Choose a mission type from the table below by circling your chosen option. Discuss in your group which option best suits the exploration of your particular planet.

Mission type	Mission characteristics
Flyby	This mission type involves a spacecraft flying past the planet to observe it for only a short period of time. A flyby mission has limited observations it can make, but it is cheaper and less risky than some other mission types. Often one spacecraft can make multiple flyby missions past different planets on the same journey.
Surface lander	This mission type involves sending a module to the surface of a planet to explore the planet from the ground. It has significant cost and risk involved, but the possibilities for collecting information are many. Note that surface lander would be extremely difficult for a gas planet.
Orbiter	This mission type involves sending a spacecraft designed to orbit a planet, while making observations and studying the planet from above. It has lower risk than some other mission types, but it also has restrictions on the variety of observations it can make.
Underground miner	This mission type combines a surface lander with a type of digging module that can explore under the surface of a planet. There are high risks associated with this mission type, but also high levels of observations possible. This is also an expensive mission option.
Something else?	Can you think of another type of mission that might be suitable for your planet?

Which mission type did you choose? Explain the thinking behind your decision in terms of the benefits, costs and risks involved for your particular planet.

Step 3: Choose your equipment

Space missions use a wide array of equipment to explore space. Missions beyond Earth without people on-board must employ machines to navigate to a location, take observations and send data back to Earth for us to analyse.



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Choose three to five pieces of equipment from the table below for your mission. Think about the benefits, costs and risks involved with each. Discuss your selection with your group and agree together on what to take.

Equipment category	Option 1	Option 2
Power supplies	Solar panels – This option is moderately expensive and slightly risky, but will provide an endless supply of energy if the panels can be exposed to sunlight.	Chemical batteries – This option is reliable, low risk and cheap. However, the energy will run out over time and can't be replenished.
Image detectors	Light imager – These instruments can detect light to provide information about the surface of a planet, such as land features, colour and heat. For this activity, they are considered to be moderately expensive and low risk.	Imaging radar – These instruments measure radio waves bounced off a planet's surface to provide 3D images of the surface. For this activity, they are considered to be moderately expensive and low risk.
Element detectors	Gas spectrometer – These instruments can tell us which gases occur in the atmosphere of a planet by detecting how light interacts with the atmosphere. For this activity, they are considered to be moderately expensive and low risk.	X-ray spectrometer – These instruments can tell us what types of rocks exist on a planet by observing how X-rays interact with the surface. For this activity, they are considered to be moderately expensive and high risk.
Mechanical equipment	Crusher – These devices measure how hard a rock sample is by crushing it. They are only useful if a surface rock sample can be collected. For this activity, they are considered to be cheap but high risk.	Dust detector – These devices can detect when charged particles strike them. They are useful for finding out what particles exist on a planet's surface. For this activity, they are considered to be expensive but low risk.

Note down the choices of equipment you have made and the reasons for them.

Chosen equipment	Reason for your choice – benefits vs costs vs risks

Discussion and reflection

Given the nature of your planet and the decisions you have made regarding the mission type and equipment on-board, is your mission worthwhile? Why/why not? Explain your answer in terms of the benefits expected from the mission and the costs and risks involved.



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How could you change your mission to make it more worthwhile? What increased benefits or decreased costs and risks would make the mission more worthwhile?

What decision have you had to make in your own life where you had to weigh up the benefits, costs and risks? How did you compare these things in order to make your decision?
