Challenges of Space Travel

Space travel is not like it is portrayed in science fiction movies. The sheer scale and size of the distances between stars is very difficult to comprehend.

Travel to a nearby planet such as Mars would take a couple of years and even then only when the planets’ orbits are in alignment. If we take the distance between the sun and Earth as one unit (AU), then the most distant man-made object, the Voyager 1 satellite, is now about 140 AU away. Voyager 1 was launched in 1977, showing the massive scale involved when it comes to space, with the distance and the time involved making the idea of distant, manned space travel almost impossible.

Space travel also requires large amounts of energy for the devices involved in space travel to reach the necessary high velocities.

Much of the fuel we use during launch is essentially to put the devices into space. As a result we need to develop engines which will be able to increase the velocity of a device whilst using small amounts of fuel. Ion drive engines are designed to do this. These engines accelerate ions of Xenon between two electric plates. The ions are ejected from the satellite at a very high velocity and this provides a small but constant thrust to the satellite, increasing its speed.

We can also manoeuvre the object that is travelling in space close to a planet or large asteroid so that it accelerates towards them but ultimately misses it.

As it heads towards the planet or large asteroid, the object that is travelling accelerates and increases its velocity, meaning that it flies past at a greater velocity than before. This is referred as a gravitational slingshot or catapult.

Manoeuvring in space

With much less gravity and no air friction, objects move in a different way in space. When a thruster is fired the ship will accelerate forward. When the thruster stops firing it will continue to move at a constant speed. In order to stop the vehicle we would have to fire a thruster in the opposite direction.

We cannot brake or turn a wheel.

All change in movement has to be caused by applying a force in a certain direction.

Benefits of space exploration

Many areas of science and technology have made advances due to technological breakthroughs resulting from the manned exploration of space.

To get into orbit, powerful engines are required to provide thrust and hence velocity. Survival in space requires excellent environment control systems.

NASA has had to patent many applications to accomplish their tasks. Some examples include: water filters, ear thermometers, scratch resistant lenses, memory foam, shoe insoles, long distance communication, smoke detectors, enriched baby food and cordless tools.

Other benefits have included the development of satellites and associated technologies. With satellites we can communicate with anyone at almost any point on Earth. We can monitor weather systems to help predict the weather and we can monitor environmental conditions such as temperature and water content as well as gravitational field strength and the Earth's magnetic field.

We can also navigate ourselves with GPS (global positioning system). This system uses 3 satellites at any single time to pinpoint your location but there is a system of about 35 satellites that help us do this.

Risks of space exploration

Space exploration is a risky business. Space is a vacuum and humans cannot exist in a vacuum. This means that we have to create crafts and suits which provide an environment where humans can survive.

The risks involved with space exploration include:

* micrometeorites – danger from impact damage (to spacecraft and to astronauts during spacewalks)
* solar flares and radiation – danger from ionising radiations
* no atmosphere – we need air to breathe
* space debris – danger from impact damage
* Debris falling from space

The main danger in space comes from temperature. It can vary from being extremely cold (in shadow, not in line of sight of the sun -150 °C) to very hot (in line of sight of the sun +120°C). The suits and craft are designed to keep the environment at the temperature that we can live in – about 20°C; so excellent cooling and heating systems are required in space.

If astronauts are in orbit then they are usually travelling very fast. The International Space Station orbits the Earth about 12-15 times a day. In space, with no air, this is not a major problem in terms of air friction.

However, on returning to Earth, the spacecraft will re-enter the atmosphere. While the air itself may not seem dense, travelling very fast through air creates very high frictional forces generating extremely high temperatures.

To protect astronauts from these high temperatures, the spacecraft must be able to:

* absorb a certain amount of heat energy.
* radiate heat energy back into the atmosphere.

Spacecraft have heatproof tiles on the underside. These protect the occupants from the high temperatures and prevent the spacecraft from being destroyed on re-entry. Re-entry temperatures can reach as high as 1,650°C.

# Questions

1. Explain why travelling between different solar systems is difficult in current space ships
2. How far is one astronomical unit?
3. What symbol is used for the quantity astronomical unit?
4. What is the furthest distance a man-made object has travelled?
5. Why does space travel require large amounts of energy?
6. What is most of the fuel on board a space craft used for?
7. List three other uses of energy on a human space craft.
8. What solution has NASA come up with to overcome the problems of large fuel consumption?
9. What gas is used in an ion drive engine?
10. Which of Newton’s 3 Laws shows that ion drive would work?
11. Explain why the high speed gas ejected moves the spaceship.
12. Explain what occurs in a gravitation catapult or sling shot.

**I have a basic awareness of how astronauts manoeuvre a spacecraft in a zero friction environment, possibly to dock with the ISS**

1. Why does a space ship not require to leave its thrusters on during its journey in deep space?
2. How does a spaceship slow down in space?
3. Suggest what could happen during docking of a spaceship to the ISS if the spaceship arrived at the ISS at an angle and not directly on.
4. Which of Newton’s three Laws of Motion accounts for a space ship changing direction?

Benefits of Space Travel

1. List some of the unexpected benefits of space travel.
2. What is the minimum number of satellites required to determine your position on the Earth?

Risk of Space Travel

1. Suggest the consequences of an astronaut being hit by a micrometeorite when out on a spacewalk (try to include as much Physics as possible)
2. What are the dangers of lack air in space for astronauts and cosmonauts?
3. What is the main danger to astronauts of being in space?
4. What is likely range of temperatures for astronauts on a spacewalk?
5. The radius of the Earth is 6.4 x 106m and the ISS is about 400 km up. Find the
   1. Height of the ISS above the centre of the Earth.
   2. distance the ISS travels around the Earth using the formula for the circumference of a circle.
6. If the ISS travels 14times around the Earth in one day at a height of 400 km above the Earth’s surface, calculate the average speed of the ISS around the Earth.
7. Does air resistance have much effect on the ISS? You must explain your answer.
8. What protects astronauts from the high temperatures?
9. State the temperature the outside of a spaceship can reach during re-entry.

**I have a basic awareness of maintaining sufficient energy to operate life support systems in a spacecraft, with the possible solution of using solar cells with area that varies with distance from the Sun**

1. List uses of energy needed on the ISS during a human mission.
2. Why are solar cells useful on space stations?
3. What problems could arise from the use of solar cells on space stations?

# Space exploration Quiz

1. Which of these objects orbit a star?
2. A natural satellite
3. A planet
4. A galaxy
5. Which of these objects radiate energy?
6. A meteor
7. A planet
8. A star
9. Which of the following best describes the universe?
10. The name we give to all the stars, planets and energy ever created
11. The name we give to a group of stars
12. The name we give to our solar system
13. What is an advantage of a geostationary orbit?
14. It means a satellite is in the same position above the Earth
15. It means the satellite doesn’t orbit and is easier to communicate with
16. It can be seen from Earth
17. Why is manned travel to nearby stars unlikely?
18. It is too dangerous
19. The distances are so vast
20. There is no gravity in space
21. The gravitational field strength on the moon is 1.6 Nkg-1. What would the weight of a 24 kg mass on the moon be?
22. 9.8 N
23. 38 N
24. 240 N
25. During re-entry, a great amount of heat energy is generated by the spaceship interacting with the air. One of the key properties of a heat shield tile is to be able to...?
26. Cut through the air smoothly
27. Withstand high wind speeds
28. Radiate much of the heat energy away
29. How could a spacecraft slow down when in orbit?
30. By releasing a parachute and it increases air drag
31. By firing a thruster in the opposite direction
32. By reducing its orbital height
33. What is the main reason that Ion drive engines are being developed for space travel?
34. They are safer
35. They are easy to operate
36. They generate acceleration but use the least amount of fuel

10. The Milky Way is an example of a

1. solar system
2. galaxy
3. red giant