Aiming for the Outer Planets

Key Learning Content

This film describes the mission of the Voyager 2 space probe in 1977, which was to explore the outer planets of our Solar System and beyond. The craft travelled by using the 'slingshot effect' (the gravitational pull of planets) to send it deep into space.

The formula for Newton's universal law of gravitation is given, and its variables and constants described. Proportion notation is used, for both direct and inverse proportion, and discussed in the context of Newton's formula. The film can be used either as an introduction to algebraic formulas, or to illustrate proportionality, in which case familiarity with proportion would be necessary before watching.

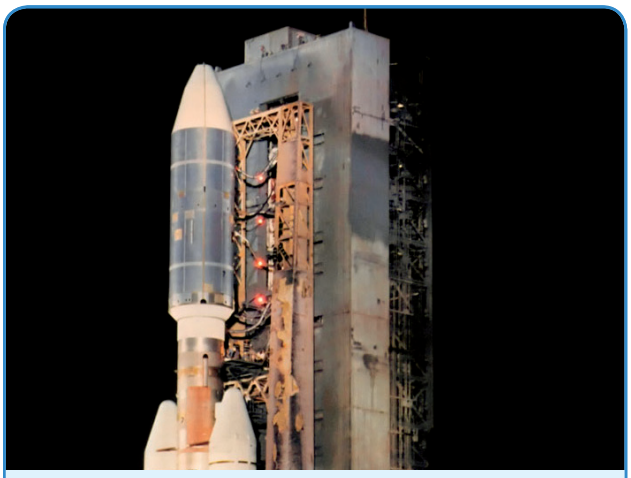
Core Outcomes

Learning Points

- Be able to understand that symbols may be used to represent numbers in equations or variables in expressions and formulae.
- Be able to understand that a letter may represent an unknown number or a variable.

Suggested Activities

- Assign values to the variables in Newton's formula and calculate the value of the gravitational force in different situations.
- Use values specific to a body on Earth and derive the acceleration due to gravity at the Earth's surface of 9.8m/s^2.



Scientists' understanding of physics and mathematics enabled the Voyager spacecraft to journey deeper into space than ever before.

Extension Outcomes

Learning Points

- Be able to set up problems involving direct and inverse proportion, to include: $y \propto x$, $y \propto 1/x$, $y \propto 1/x^2$.
- Be able to use the process of proportionality to evaluate unknown quantities.
- Be able to calculate an unknown quantity from quantities that vary in direct and inverse proportion.

Suggested Activities

- Set problems involving finding the value of one variable in Newton's formula as the value of other variables change.
- Classify everyday phenomena in terms of direct and inverse proportion, and find examples of more complex examples of proportion, such as $y \propto \sqrt{x}$.

Related Films

To use before the lesson plan:

European Mathematical Symbols	This film describes how and when algebraic symbols were first used in mathematics.
Proportion: The Vitruvian Man	This film provides an introduction to the idea of proportion in the human body using Leonardo da Vinci's famous drawing.

To use after the lesson plan:

Fractions: Slow Motion	This film shows how inverse proportion can be applied to explain the way time-lapse and slow-motion photography works.
Calculus: Newton	This film examines Newton's discovery of gravity and how he used it to explain the motion of planets.
Cylinders: Fuelling Saturn V	This film shows how much fuel was needed to send a huge rocketship into space.
Binary: The Alien Language	This film describes a space probe that was sent into deepest space and contained a message for alien civilisations.

Guide Lesson Plan

Introduction

Drop a book on the floor and tell the students you are going to write up a formula explaining what has just happened. Put Newton's formula for gravity on the board and ask students to guess what they think the symbols stand for.

Show Film

Aiming for the Outer Planets

Main Activity

Foundation

Recap what is meant in algebra by variables and constants. Go through each term in Newton's formula and define what it stands for and what units it is measured in. Give different values for masses and distance and calculate what happens to F as these variables change.

Main Activity cont ...

Advanced

Using proportion notation, set problems involving finding the value of one variable in Newton's formula, given the values of other variables. Ask how much further an object of twice the mass would have to be away from a planet so that the gravitational force on it remained the same.

Extension Activity

Foundation

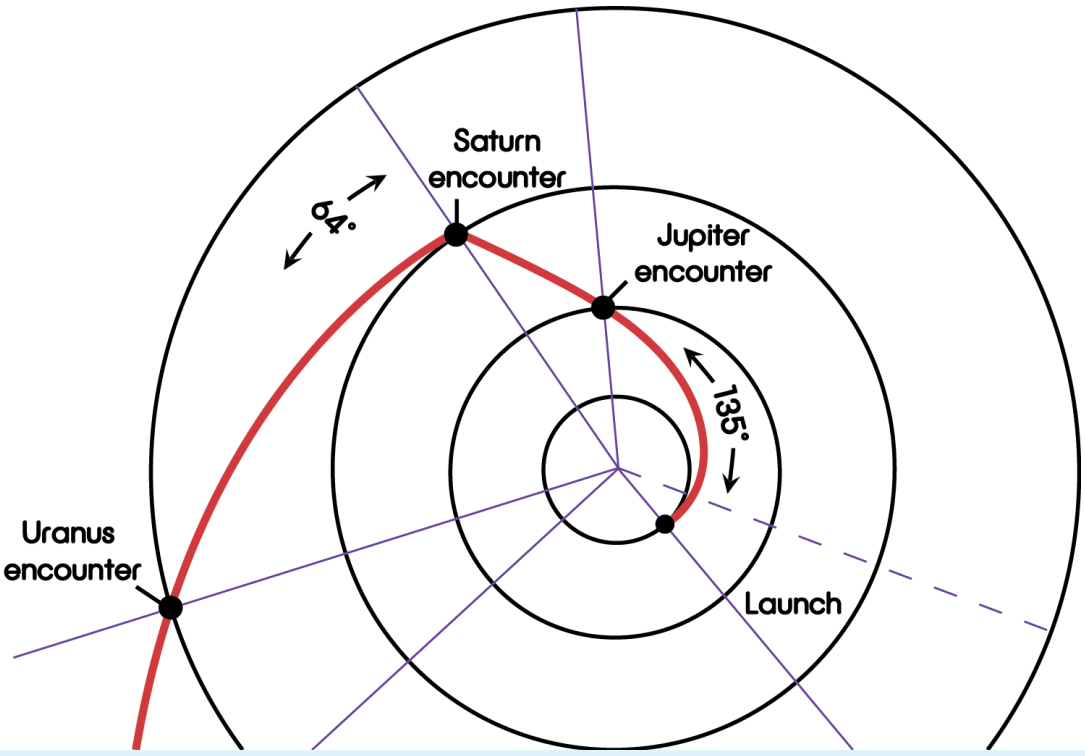
Explain that force is mass multiplied by acceleration, and that acceleration is measured in m/s^2 (i.e. metres per second per second, or metres per second squared). Give values for the mass and radius of the Earth and work out the value of acceleration due to gravity at the Earth's surface.

Advanced

Ask students to research what is meant by the 'three body problem' in mechanics, and describe it in simple language.

Optional Extra

Newton's formula is the classic example of one quantity being inversely proportional to the square of another. Can the students find other examples?



As the distance between Voyager and the planet decreased, the force of gravity increased, resulting in an increase in the craft's momentum.