Module 5: Gravitational Fields

This section provides knowledge and understanding of Newton’s law of gravitation, planetary motion and gravitational potential and energy. Newton’s law of gravitation can be used to predict the motion of orbiting satellites, planets and even why some objects in our Solar system have very little atmosphere with the opportunity to analyse evidence and look at causal relationships (HSW1, 2, 5, 7). Geostationary satellites have done much to improve telecommunications around the world. They are expensive; governments and industry have to make difficult decisions when building new ones. Learners have the opportunity to discuss the societal benefits of satellites and the risks they pose when accidents do occur.

| Specification reference | Checklist  questions | |
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| 5.4.1 a | Can you understand gravitational fields being due to mass? |  |
| 5.4.1 b | Can you state the mass of a spherical object modelled as a point mass at its centre? |  |
| 5.4.1 c | Can you describe gravitational field lines to map gravitational fields? |  |
| 5.4.1 d | Can you calculate gravitational field strength; g = ? |  |
| 5.4.1 e | Can you explain the concept of gravitational fields as one of a number of forms of field giving rise to a force? |  |
| 5.4.2 a | Can you state Newton’s law of gravitation? |  |
| 5.4.2 a | Can you calculate the equation F = − ? |  |
| 5.4.2 b | Can you calculate gravitational field strength g = −  for a point mass? |  |
| 5.4.2 c | Can you understand the uniformity of gravitational field strength close to the surface of the Earth and its numerical equivalence to the acceleration of free fall? |  |
| 5.4.3 a | Can you explain Kepler’s three laws of planetary motion? |  |
| 5.4.3 b | Can you calculate the centripetal force on a planet from the gravitational force between it and the Sun? |  |
| 5.4.3 c | Can you calculate the equation *T*2 = *r*2? |  |
| 5.4.3 d | Can you describe the relationship for Kepler’s third law *T*2 ∝ *r*3 applied to systems other than our Solar System? |  |
| 5.4.3 e | Can you explain geostationary orbit and the uses of geostationary satellites? |  |
| 5.4.4 a | Can you describe gravitational potential at a point as the work done in bringing unit mass from infinity to the point? |  |
| 5.4.4 b | Can you calculate the expression for gravitational potential at a distance *r* from a point mass *M*? |  |
| 5.4.4 c | Can you describe a force–distance graph for a point or spherical mass; work done as area under graph? |  |
| 5.4.4 d | Can you describe changes in gravitational potential? |  |
| 5.4.4 e | Can you explain escape velocity? |  |

**Homework and Independent Study**

HW: Assessed past-paper questions.

Kerboodle online task(s)

Revision: As part of second half-term test (Module 5.5)

IS: Textbook summary questions on each sub-topic, to self-assess.

Zig-zag booklets for revision and IS. *Answers distributed at end of topic.*

Use of online resources including physicandmathstutor.com, Seneca Learning and Kerboodle textbook, Chapter 18.

Practise past-paper questions at the end of topic (textbook pages 357-9).

**Key Terms**

**Escape Velocity:** The minimum velocity required by an object to be able to

escape a gravitational field of a mass when projected vertically from its surface.

**Field Lines:** A line representing the path that a mass would take when placed

within the field.

**Geostationary Satellite:** A satellite that orbits above the equator with a 24 hour

period, so it will always remain above the same position on the Earth. They orbit

approximately 36,000km above the surface of the Earth.

**Gravitational Field Strength:** The force per unit mass exerted on a small test

mass placed within the field.

**Gravitational Field:** A region surrounding a mass in which any other object with

mass will experience an attractive force.

**Gravitational Potential Energy:** The component of an object’s energy due to its

position in a gravitational field.

**Gravitational Potential:** The work done per unit mass required to move a small

test mass from infinity to that point.

**Kepler’s First Law:** All planets travel in elliptical orbits, centred around the sun.

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**Kepler’s Second Law:** All planets sweep out the same area in a given period of

time.

**Kepler’s Third Law:** The square of a planet's period is directly proportional to the

cube of its mean distance to the sun.

**Newton’s Law of Gravitation:** The force between two masses is proportional to

the product of the masses involved and inversely proportional to the square of the

separation of the masses.