Need to Know

Higher Physics

Quick and easy revision

Key content at your fingertips

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Contents

Getting the most from this book

This *Need to Know* guide is designed to help you throughout your course as a companion to your learning and a revision aid in the months or weeks leading up to the final exams.

The following features in each section will help you get the most from the book.

You need to know

Each topic begins with a list summarising what you 'need to know' in this topic for the exam.

Exam tips

Key knowledge you need to demonstrate in the exam, tips on exam technique, common misconceptions to avoid and important things to remember.

Key terms

Definitions of **highlighted** terms in the text to make sure you know the essential terminology for your subject.

Do you know?

Questions at the end of each topic to test you on some of its key points. Check your answers here: **hoddereducation.co.uk/needtoknow/answers**

Synoptic links

Reminders of how knowledge and skills from different topics in your Higher course relate to one another.

End of section questions

Questions at the end of each main section of the book to test your knowledge of the specification area covered. Check your answers here: **hoddereducation.co.uk/needtoknow/answers**

1.4 Gravitation

You need to know

- the horizontal and vertical motions of a projectile are independent of each other
- satellites are bodies that are in free fall around a planet or star
- how to resolve the initial velocity of a projectile into horizontal and vertical components
- how to use the horizontal and vertical components as vectors and use appropriate relationships to solve projectile problems
- how to use Newton's law of universal gravitation to solve problems involving force, masses and their separation

All bodies (objects) are under the influence of the gravitational field of a large mass. Bodies may be stationary (at rest) or have an initial velocity when they are released and be allowed to move in the gravitational field.

Gravitation

- An object that is released above the surface of the Earth, for example, will experience a force that causes it to be accelerated towards the centre of the Earth. It will accelerate (vertically downwards) at $9.8\,\mathrm{m\,s^{-2}}$ if it is relatively close to the Earth's surface.
- We can assign the acceleration to be negative because it acts in a downwards direction.
- An object launched vertically upwards will still experience an acceleration of $-9.8\,\mathrm{m\,s^{-2}}$ because it is in the Earth's gravitational field.

Key term

Projectile An object that is launched or released and is then acted on by only gravity and air friction.

Projectiles

- A **projectile** is an object that is usually launched at an angle to the horizontal and is then acted on by only gravity and air friction.
- Projectiles have no internal means of maintaining their motion (such as a rocket or jet engine) – for example, a struck golf ball.
- In the example of a projectile shown in Figure 1.21, you can resolve the initial velocity into its horizontal and vertical components using:

$$V_h = 55 \times \cos\theta$$

$$V_v = 55 \times \sin\theta$$

Exam tip

Make sure you can describe the motion of a projectile both if you ignore air friction and if you take air friction into account.

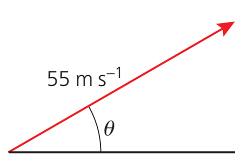

Figure 1.21

- The horizontal component of the projectile's velocity is not affected by gravitational attraction and, therefore, you can solve most problems relating to horizontal motion using:

  $s = vt$

- Problems involving the vertical component of the velocity are more complex because they are under the influence of gravity and the velocity continually changes. You may need to use:

  $v = u + at$

  $s = ut + \frac{1}{2}at^2$

  $v^2 = u^2 + 2as$

  $s = \frac{1}{2}(u + v)t$

Synoptic link

The equations of motion are discussed on pages 5 and 6.

Satellites

- An object projected horizontally will follow a curved path until it hits the ground. If it projected more quickly, it will travel further before it reaches the ground.
- The time taken for an object projected horizontally to hit the ground is determined by the height from which the object is projected, not its speed.
- Any object projected horizontally, such as a bullet, will hit the ground at the same time as an object dropped vertically from the same height.
- As the horizontal velocity of a projectile is increased, it travels further before it hits the surface, as shown in Figure 1.22. There will come a point when the velocity is so high that the curve of the projectile's path will match the curve of the planet. At this point, the projectile will be in orbit around the planet.

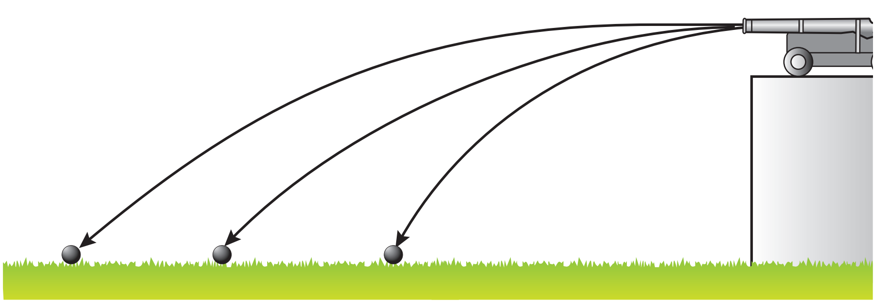

Figure 1.22

- The velocity required to maintain orbit depends on the mass of the planet and the altitude of the **satellite** above the centre of the planet.

Key term

Satellite An object that orbits a relatively large gravitational mass, such as a planet.

- The higher the altitude, the longer it takes for the satellite to orbit the planet.
- Satellites are placed in position at the correct height and velocity for them to remain in a constant orbit. If a satellite travels too quickly, it will gradually increase its height above the planet and ultimately leave orbit. If it travels too slowly, it will gradually fall into the atmosphere and be destroyed.
- When probes are sent into deep space, it is difficult for them to reach the high velocity needed for them to travel through space relatively quickly. Fuel is heavy and difficult to transport into orbit. A probe's velocity can be increased by directing it towards planets or moons where it is 'caught' by the gravitational field of the planet and accelerates towards the planet. It then leaves the gravitational pull at a greater velocity. This is called a 'slingshot'.

Newton's law of universal gravitation

The force of attraction, F, between any two objects that have mass m_1 and m_2 and distance r between them is calculated by:

$$F = G\frac{m_1\, m_2}{r}$$

where ***G*** is the gravitational constant with a value of $6.67 \times 10^{-11}\ \text{m}^3\,\text{kg}^{-1}\,\text{s}^{-2}$.

This equation describes the gravitational forces between Earth and the Sun, and Jupiter and its moons for example.

Exam tip

Make sure you do not mix up g with G. G is the universal gravitational constant and g is the gravitational field strength, which is equal to the weight of an object divided by its mass. G is constant everywhere in the universe, whereas values of g vary with location.

Do you know?

1 An object is dropped from a height of 22 m.
  a Calculate how long it takes to hit the ground.
  b Calculate the velocity with which it strikes the ground.
2 A ball is launched with a velocity of $28\ \text{m}\,\text{s}^{-1}$ at an angle of 65° above the horizontal. Calculate the maximum height it could reach.
3 Calculate the gravitational attraction between a mass of 125 kg and a mass of 145 kg at a distance of 3.5 m between their centres.
4 Calculate the force of attraction between the Earth and an 85 kg person. The distance to the Earth's centre can be taken as 6370 km.
5 Describe how a satellite remains in orbit around a planet.

Key term

G The universal gravitational constant. It relates the force of attraction between masses and their separation.