

# 6.6 Motion of Orbiting Satellites

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 9 marks

KEY WORDS satellite 卫星 • orbital speed 轨道速度

## Objective

Build the skills to answer exam questions on **the motion of orbiting satellites**.

**You must be able to:**

- explain how **gravity** provides the centripetal force that keeps a satellite in orbit
- relate the **orbital speed** 轨道速度 to the radius with  $\frac{GMm}{r^2} = \frac{mv^2}{r}$
- describe the energy of a satellite as kinetic plus gravitational potential energy

## 1 Worked examples

Study these first. Each one shows the method for a question type used later.

### ■ Gravity is the centripetal force

Setting the gravitational force equal to the required centripetal force:

$$\frac{GMm}{r^2} = \frac{mv^2}{r} \Rightarrow v = \sqrt{\frac{GM}{r}}.$$

### ■ Closer orbits are faster

Because  $v \propto 1/\sqrt{r}$ , a satellite in a **lower** orbit moves **faster**.

### ■ Energy

A satellite has kinetic energy  $\frac{1}{2}mv^2$  and (negative) gravitational potential energy; the two together give its total orbital energy.

## 2 Practice

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**2.1** State what provides the centripetal force on an orbiting satellite. [1]

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**2.2** State how the orbital speed changes if the orbital radius increases. [1]

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**2.3** Write the equation obtained by setting the gravitational force equal to the centripetal force. [1]

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## 3 Exam-style questions

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**3.1** The centripetal force on a satellite in orbit is provided by [1]

- **A** its engine
  - **B** gravity
  - **C** air resistance
  - **D** the normal force
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**3.2** As the orbital radius increases, the orbital speed [1]

- **A** increases
  - **B** decreases
  - **C** stays constant
  - **D** becomes zero
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**3.3** A satellite orbits Earth ( $M = 6.0 \times 10^{24}$  kg,  $G = 6.67 \times 10^{-11}$  N m<sup>2</sup> kg<sup>-2</sup>) at radius  $r = 7.0 \times 10^6$  m.

(a) Write the expression  $v = \sqrt{GM/r}$ . [1]

(b) Find the orbital speed.

[3]

## Solutions

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**2.1** the gravitational pull of the planet on the satellite.

**2.2** it decreases ( $v \propto 1/\sqrt{r}$ ).

**2.3**  $\frac{GMm}{r^2} = \frac{mv^2}{r}.$

**3.1** B.

**3.2** B.

**3.3** (a)  $v = \sqrt{\frac{GM}{r}}.$  (b)  $v = \sqrt{\frac{(6.67 \times 10^{-11})(6.0 \times 10^{24})}{7.0 \times 10^6}} = \sqrt{5.7 \times 10^7} = 7.6 \times 10^3 \text{ m s}^{-1}.$