AP PHYSICS 1 • EXERCISE SHEET

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

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

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

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

3 Exam-style questions

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

A B
C D

A its engine
B gravity
C air resistance
D the normal force

3.2 As the orbital radius increases, the orbital speed [1]

A B
C D

A increases
B decreases
C stays constant
D becomes zero

3.3 A satellite orbits Earth ($M = 6.0 \times 10^{24}$ kg, $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}) at radius $r = 7.0 \times 10^6$ m.

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

(b) Find the orbital speed. [3]