AP PHYSICS 1 • HOLIDAY HOMEWORK 假期作业

6 Rolling and orbiting satellites – Part 2

Name: ______ Class: ______ Date: ______

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
rolls without slipping	纯滚动			
satellite	卫星			

Recall

In Part A you met rotational energy and angular momentum. Two everyday examples bring them together:

- A wheel that **rolls** is moving and spinning at the same time.
- A **satellite** stays in orbit because gravity keeps pulling it toward the planet.

Each idea has a worked example before the Practice.

New ideas

1 Rolling without slipping

When a wheel **rolls without slipping** 纯滚动, the point touching the ground is momentarily still, and the speed of the centre links to the spin:

$$v = r\omega.$$

Worked example. A wheel of radius 0.30 m rolls so its centre moves at 6.0 m/s. Its spin rate is $\omega = \frac{v}{r} = \frac{6.0}{0.30} = 20$ rad/s.

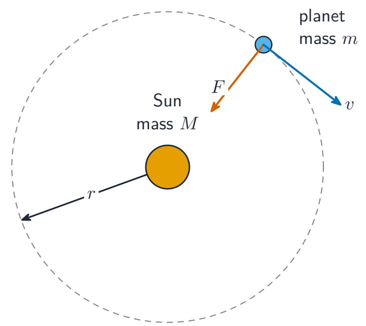
2 Rolling shares the energy

A rolling object splits its kinetic energy between **moving** ($\frac{1}{2}mv^2$) and **spinning** ($\frac{1}{2}I\omega^2$). Because some energy goes into spin, a ball rolling down a ramp speeds up **more slowly** than a block that slides down without friction.

3 Satellites and orbits

A **satellite** 卫星 in orbit is really in free fall: gravity provides exactly the **centripetal force** needed to bend its path into a circle. Setting gravity equal to the centripetal requirement gives the orbit speed

$$v = \sqrt{\frac{GM}{r}}.$$



Worked example. For a low orbit, $r = 6.4 \times 10^6$ m and $GM = 4.0 \times 10^{14}$ m^3/s^2: $v = \sqrt{\frac{4.0 \times 10^{14}}{6.4 \times 10^6}} \approx 7.9 \times 10^3$ m/s, about 7.9 km/s.

4 Bigger orbit, slower speed

Because $v = \sqrt{GM/r}$, a satellite farther out (*larger* r) moves **slower**. The satellite's own mass cancels, so all satellites in the same orbit move at the same speed.

Watch out: a satellite is not "beyond gravity." Gravity is exactly what holds it in orbit – it is falling toward the planet all the time, but moving sideways fast enough to keep missing it.

Practice

Try these in order. The methods are all above.

2.1 A wheel of radius 0.25 m rolls without slipping; its centre moves at 5.0 m/s. Find its angular velocity. [2]

2.2 Explain why a ball rolling down a slope accelerates more slowly than a block sliding down the same frictionless slope. [2]

2.3 What force provides the centripetal force that keeps a satellite in orbit? [1]

2.4 Two satellites orbit the same planet, one close and one far. State which moves faster, and why. [2]

2.5 A wheel of radius 0.40 m spins at $\omega = 15$ rad/s while rolling. Find the speed of its centre. [2]