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 $\omega = \dfrac{v}{r} = \dfrac{6.0}{0.30} = 20$ rad/s.

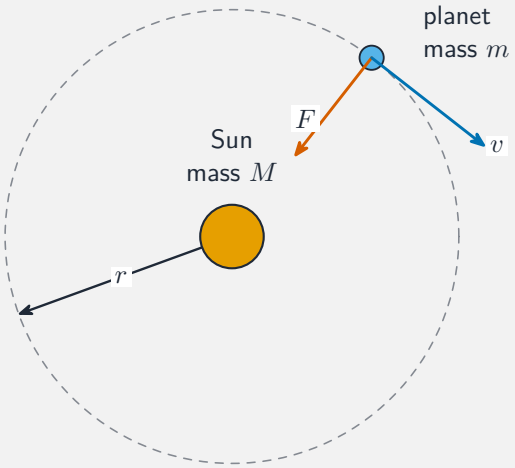
2 Rolling shares the energy

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: $v = \sqrt{\dfrac{4.0 \times 10^{14}}{6.4 \times 10^6}} \approx 7.9 \times 10^3$ 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]