

## Jumping on Another Planet!

### General Information

- ★ Level: grades 5 and 6 and high school.
- ★ Students per group: three.
- ★ How long: a 60-minute period.
- ★ Where: classroom.
- ★ Type of activity: discovery, problem solving.
- ★ Key words: gravity — mass — weight — gravitational acceleration.
- ★ Subjects covered: science and technology, math.

### Summary

Students are given measurement factors related to the surface gravity of the Sun and planets. Using this information, they measure and compare the height of their jumps and their weight on these different worlds.

### Starting Point

If you were standing on the surface of another planet, how high could you jump?

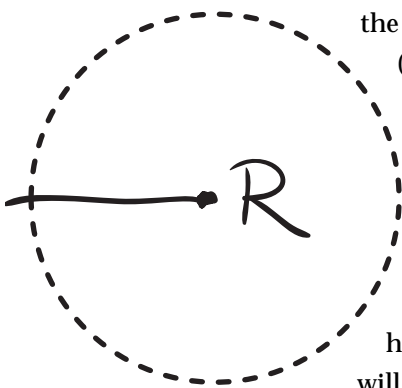
### Preconceptions

Students mightn't realize that their weight can differ from planet to planet and that they can jump different heights depending on the surface gravity of these worlds. Students often assume that gravity is the same everywhere. Some may believe the Earth is the only planet that exerts gravitational force. Others may think of gravity as a kind of magnetic force or as air pressure bearing down on our bodies and the objects around us.



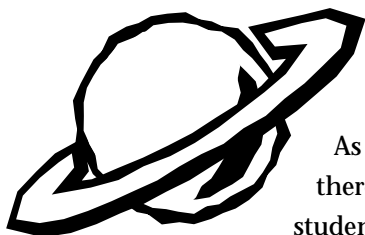
## Basic Concepts

We've all seen images of astronauts from the Apollo missions hopping on the surface of the Moon like kangaroos. Moving around in a zero-gravity or low-gravity environment fascinates students. After studying gravity in class, students can apply their knowledge to the other planets. This activity serves as an introduction to the notions of surface gravity and mass to help students calculate how much they'd weigh and how high they could jump on different planets.



The surface gravity of a star, planet, moon or any other object depends on the object's mass (the amount of matter it contains) and on its radius (the distance between its surface and its centre). Radius is a key factor for two reasons. First, an object's gravity acts as if its entire mass were concentrated in its centre. Second, the "force" of an object's gravity decreases with the square of the distance from the object's centre. If this distance is doubled, the force exerted will be four times less. If the distance is tripled, the force will be nine times less, and so on. Let's look at an example. Suppose two planets have the same mass but one has a radius twice as great as the other. The planet with the smaller radius will have a surface gravity four times stronger since an object on its surface will be twice as close to the centre of mass.

You should stress the difference between mass and weight. Mass measures the amount of matter that a body contains. It never varies despite the gravitational field in which it's found. Even in zero gravity, mass is always present and is felt as inertia (resistance to change). Weight, on the other hand, measures the force exerted on a body placed within a given gravitational field. Hence, the students' weight, and not their mass, would change if they suddenly found themselves on the surface of another planet. Mass and weight are often confused because we use the same unit (the kilogram) to express both. Mass is correctly measured in kilograms, whereas we should use the newton (a unit of force) to express weight. Mass and weight have the same value only on the Earth's surface (where gravitational acceleration equals  $9.81 \text{ m/s}^2$ ).



It's important to mention to students that the notion of surface is relevant only for solid bodies in the solar system (the planets Mercury to Mars, Pluto, planetary satellites, asteroids and comets). As for the Sun and the gas planets (Jupiter, Saturn, Uranus and Neptune), there's simply no solid surface on which to walk or jump. For these worlds, students will simply have to pretend there's a surface.

## Goals

By the end of this activity, students should be able to:

- Calculate how high they'd jump in an environment where the gravity is different from on Earth.
- Calculate how much they'd weigh in an environment where the gravity is different from on Earth.

## Steps in the Activity

### Preparations

The day before the activity, ask students to weigh themselves on a scale at home and to write down the results.

Make enough copies of the student handout *Jumping on Another Planet* for each team.

### Supplies

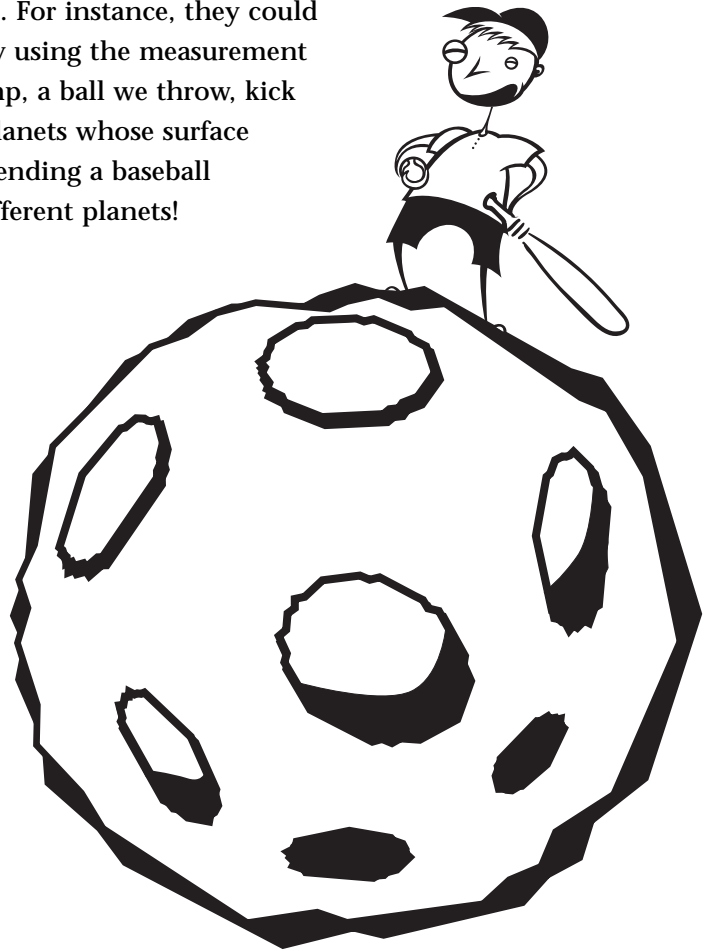
- A copy of the enclosed student handout *Jumping on Another Planet*.
- Metre sticks, measuring tape (one per team).
- Pencils, paper.
- Calculator (optional).

### Assignment

- ❶ Invite a team of three students to the front of the class to demonstrate the procedures.
- ❷ Ask Student 1 to do a standing jump (feet together, knees bent). This is an example of how high a person can jump on a planet (in this case, Earth).
- ❸ Give Student 2 a metre stick to hold vertically with one end touching the floor. Student 3 will kneel down to see the metre stick clearly and measure how high Student 1 can jump. Have Student 1 jump again and Student 3 record the height.
- ❹ Ask students to speculate on the factors that may influence the height of a jump (gravity, force).
- ❺ Send the teams to their work areas. Students must write down the height of their jumps. Using the table in the student handout, they'll calculate how high they could jump on the Sun and on the other planets. They'll also calculate their weight on these worlds..

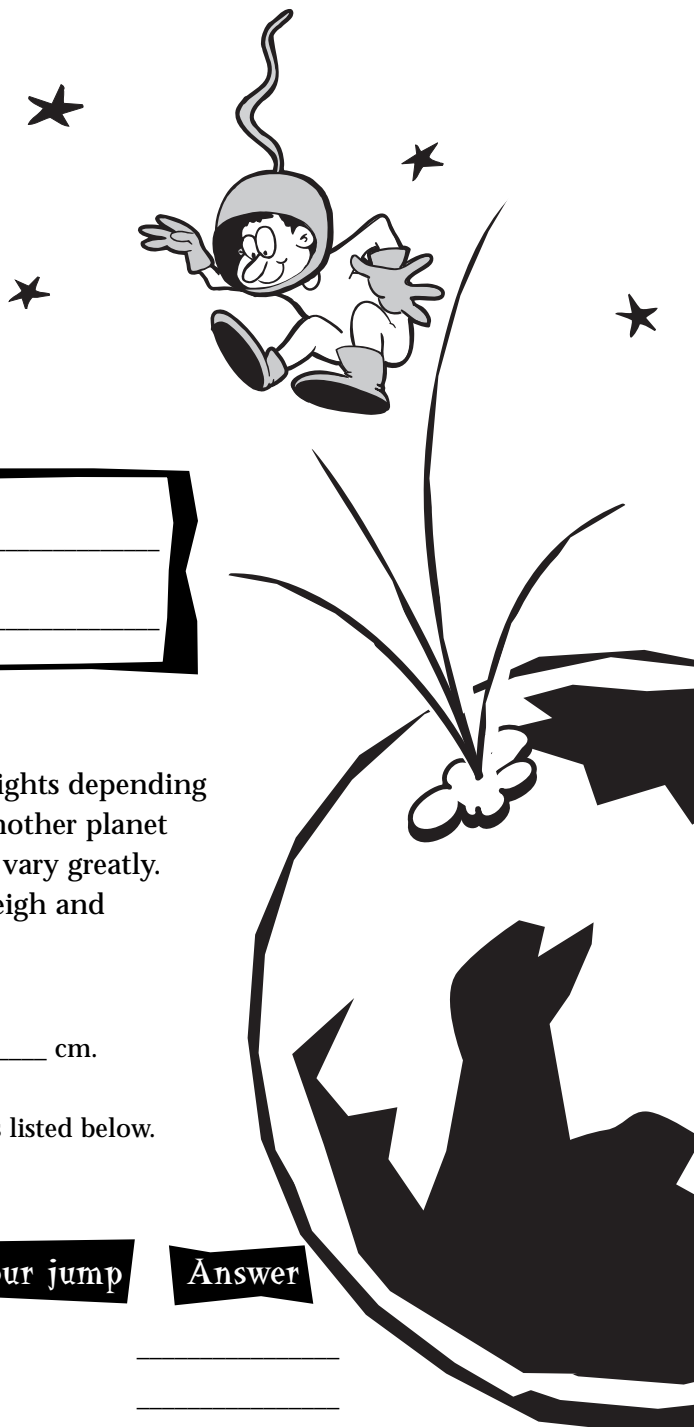
### Wrap-up

- ❶ Point out to students that gravitational force depends not only on the planet's mass but also on the distance separating us from its centre of gravity.
- ❷ Students may be surprised to learn that gravity on the Sun's surface doesn't seem very strong, even though the Sun is able to "hold" all the planets within the solar system. Remind students that the Sun's "surface" referred to in this exercise (the visible layer called the photosphere) is very far from the star's centre (about 700,000 km away).
- ❸ Have students evaluate how well they could play baseball or soccer or perform gymnastics on the other planets or on the Sun. For instance, they could estimate the distance a baseball could travel by using the measurement factors for surface gravity. Just as when we jump, a ball we throw, kick or hit will rise higher (and travel farther) on planets whose surface gravity is weaker. Students can even imagine sending a baseball into orbit around the smaller moons of the different planets!



*Adapted from How High Can You Jump on Another Planet? Reproduced with the permission of Project Pulsar, St. Louis Science Center, 5050 Oakland Avenue, St. Louis, MO 63110.*

# Jumping on Another Planet!



Name : \_\_\_\_\_

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

Did you realize you could jump different heights depending on whether you're on Earth, the Moon or another planet in the solar system? Your weight would also vary greatly. This exercise will reveal how much you'd weigh and how high you'd jump.

1. Record how high you jumped in class: \_\_\_\_\_ cm.
2. Calculate how high you'd jump on the worlds listed below. Don't forget to specify the units.

Object	Calculate the height of your jump	Answer
Sun	Divide by 30	_____
Mercury	Multiply by 5 and divide by 2	_____
Venus	Multiply by 10 and divide by 9	_____
Moon	Multiply by 6	_____
Mars	Multiply by 5 and divide by 2	_____
Jupiter	Multiply by 2 and divide by 5	_____
Saturn	Multiply by 7 and divide by 8	_____
Uranus	Multiply by 11 and divide by 12	_____
Neptune	Multiply by 5 and divide by 7	_____
Pluto	Multiply by 30	_____



3. Specify your weight in kilograms on Earth: \_\_\_\_\_ kg

4. Calculate how much you'd weigh on the worlds listed below.  
Don't forget to specify the units.

**Object**

**Calculate your weight**

**Answer**

Sun

Divide by 30

\_\_\_\_\_

Mercury

Multiply by 5 and divide by 2

\_\_\_\_\_

Venus

Multiply by 10 and divide by 9

\_\_\_\_\_

Moon

Multiply by 6

\_\_\_\_\_

Mars

Multiply by 5 and divide by 2

\_\_\_\_\_

Jupiter

Multiply by 2 and divide by 5

\_\_\_\_\_

Saturn

Multiply by 7 and divide by 8

\_\_\_\_\_

Uranus

Multiply by 11 and divide by 12

\_\_\_\_\_

Neptune

Multiply by 5 and divide by 7

\_\_\_\_\_

Pluto

Multiply by 30

\_\_\_\_\_

