GRAVITY OF THE SITUATION

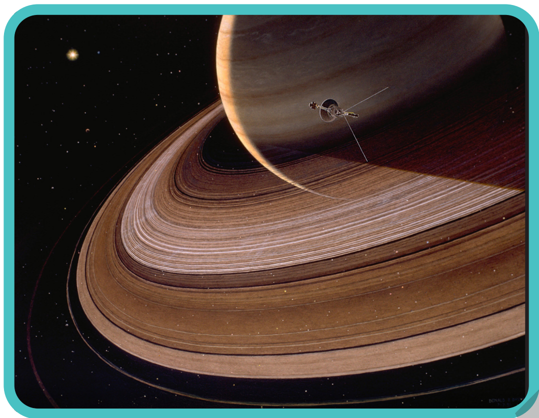
STUDENT WORKBOOK

ACTIVITY 1

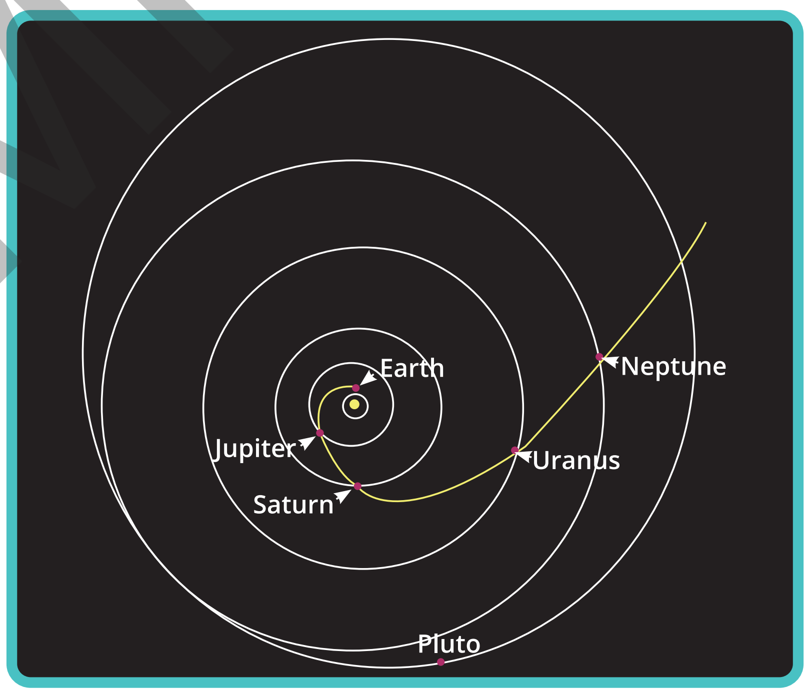
SPACE SLINGSHOT

Our Solar System includes planets, asteroids, and human-made objects, and much more. Space probes study moons, the Sun, and other objects. How do these probes maneuver out in space? Let's look at an example to find out.

I VOYAGER OUT



On August 20, 1977, Voyager 2 was launched from Earth by the National Aeronautics and Space Administration (NASA) with the goal of leaving the Solar System. The Solar System is a **planetary system**, or a set of planets and other objects bound in orbit around a star.



As you see in the image, the path out of the Solar System is not a straight shot away from the Sun. If the space probe was launched directly away from the Sun, it would have made it approximately to Jupiter before being pulled back toward the Sun. In fact, Voyager 2 cast off its thrusters after it passed Jupiter.

How did Voyager 2 continue to change velocity after it dropped its thrusters? As you can see from the graph and illustrated path through the Solar System, Voyager 2 experienced significant changes in velocity and direction on its flight. **Velocity** is the change in position over time. The graph shows large swings in velocity as the space probe traveled to the edge of the solar system.

MATTER REVIEW – MASS VS. WEIGHT

All matter has mass.
Mass is the amount of matter in an object.
Weight is the force of gravity acting on an object.
Weight can be calculated as the mass of an object times the acceleration due to gravity.

Mathematical Forces

We often think of objects traveling in terms of speed or velocity. As Newton defines motion, in his **Second Law of Motion**, the force of an object is equal to the product of its mass and acceleration. This can be further described using the equation:

$$F = m \times a$$

where F is the force, m is the object's mass, and a is the object's acceleration. **Acceleration** is the change in velocity over a period of time.

The motion of objects can be described in terms of its mass and acceleration. To understand the difference between velocity and acceleration, consider an example. A train parked at a station has no velocity and no acceleration. As the train leaves the station is gradually increases its velocity, from 0 meters per second (m/s), to 5 m/s, to 10 m/s. The change in velocity can be measure as acceleration or meters per second per second (m/s^2). When the train reaches 10 m/s, it stops accelerating and keeps a constant velocity.

All objects here on Earth are pulled toward the center of Earth at the same accelerating rate: 9.8 m/s^2. The force of gravity between different objects and Earth is not the same because the masses are different. Imagine your younger self at a playground, jumping off a play structure. Gravity accelerates at the same rate then as it does today, but you've grown and have more mass. So, if you jumped from the same play structure today, you would hit the ground with a greater force.

ACTIVITY 3

HANGING AROUND

Once Voyager 2 escapes Earth, it still experiences gravity from this planet and other bodies in space. How can the force of gravity between these objects be determined, and where does this force come from?

LEARNING GOALS:

- I can use a model to explain how the amount of potential energy in a system depends on the arrangement of interacting objects.
- I can use evidence to argue that gravitational forces are attractive and that they depend on the masses of objects and the distances between them.
- I can describe and predict gravitational forces and electrostatic forces between objects using Newton's Law of Gravitation and Coulomb's Law.

4 NEWTON'S RETURN

Gravity of the Universe

Gravity attracts all objects great and small in the universe. Gravity attracts some objects with such great force that they can't escape, like objects on Earth's surface. Try this experiment to find out how the masses of objects affect their motion and ability to "escape."

WHAT YOU NEED:

FROM THE KIT:

- 2 balls, steel, 1"
- 6 binder clips
- Ball, steel, 0.5"
- Ball, wood
- Masking tape
- Ping-pong ball
- Stretch fabric
- Box the kit comes in

SAFETY: **WARNING! CHOKING HAZARD - Small parts.** Not for children under 3 years.

WHAT TO DO:

1. Open the top of the box so that all 4 flaps stand straight up. Place a strip of tape along each of the 4 corners to keep the flaps in place.

2. Cover the top of the box with the stretch fabric. Use the 6 binder clips to secure the fabric to the top of the box. Make sure that the fabric is not pulled too tightly on any one side.

LAUNCH

SCIENCE UNLOCKED

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Kit	SU-GRAVST
Instructions	IN-GRAVSTS
Revision Date	3/2022