November 5, 2022

NASA’s DART Mission Is a Success
Did you hear about the spacecraft that crashed into an asteroid — on purpose?! In this Guide, students will learn about NASA's DART mission and discuss the core physics principles behind it.

**This Guide includes:**

**Article-based Comprehension Q&A** — Students will answer questions about a NASA mission to smash a spacecraft into an asteroid after reading a *Science News* article and watching a *Science News* TikTok video about the mission. A version of the article, “NASA's DART mission is a success,” appears in the November 5, 2022 issue of *Science News*. Related standards include NGSS-DCI: MS-ESS1; HS-ESS1; MS-PS2 and HS-PS2.

  **Student Comprehension Worksheet** — These questions are formatted so it’s easy to print them out as a worksheet.

**Cross-curricular Discussion Q&A** — NASA's DART mission knocked an asteroid off course. Use the mission to teach core physics principles — including force and Newton's laws of motion. Learning outcomes: Application of forces and Newton's laws of motion. Related standards include NGSS-DCI: MS-PS2 and HS-PS2.

  **Student Discussion Worksheet** — These questions are formatted so it’s easy to print them out as a worksheet.
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Article-based Comprehension, Q&A

Directions for teachers: Project and play the Science News TikTok “Crashing into an asteroid on purpose?!” for your class. Then ask students to read the online Science News article “NASA’s DART mission successfully shoved an asteroid” and answer the following questions. A version of the article, "NASA’s DART mission is a success," appears in the November 5, 2022 issue of Science News.

1. In your own words, describe the goal of NASA’s DART mission. What does DART stand for?

The goal of NASA's Double Asteroid Redirection Test, or DART, mission was to knock an asteroid off course by smashing a spacecraft into it. If successful, the tactic could be used to divert a potentially dangerous asteroid from colliding with Earth.

2. What was the DART spacecraft’s target? Is the target a threat to Earth? Explain.

DART's target was the asteroid Dimorphos, which orbits a slightly larger asteroid called Didymos. Dimorphos and Didymos are approximately 11 million kilometers from Earth and are not threats to us.

3. How fast was DART traveling through space when it hit its target? Don't forget to include appropriate units of measure.

DART was traveling about 22,500 kilometers per hour when it smashed into Dimorphos.

4. What was the result of the impact on the asteroid’s orbit? How did the result compare with scientists’ expectations?

DART shortened the orbit of Dimorphos by 32 minutes, which is more than 30 minutes longer than the minimum 73-second shift that scientists had anticipated. Before the impact, Dimorphos orbited Didymos every 11 hours and 55 minutes. After the impact, the small asteroid completed an orbit every 11 hours and 23 minutes.

5. What do scientists think contributed to the difference between their expectations and the results?

The impact itself moved the asteroid a little bit, but the debris that the spacecraft kicked up when it crashed acted like a rocket engine and gave the asteroid an additional boost.

6. How did scientists figure out that the DART mission was successful?

Four telescopes in Chile and South Africa that watched the asteroids after the impact detected periodic changes in brightness as the asteroids eclipsed each other. The observations were confirmed by direct radar measurements of the asteroids’ orbits.
7. What do the results suggest about the success of a future planetary defense program? If a large asteroid were headed toward Earth, how far in advance would a spacecraft need to crash into it to avert disaster?

The results suggest that crashing a spacecraft into a potentially hazardous asteroid could nudge it out of the way before it hits Earth. For such a mission to be successful, scientists would want to know that the space rock is coming years before it gets close to our planet.
Student Comprehension Worksheet

**Directions**: Watch the *Science News* TikTok “Crashing into an asteroid on purpose?!?” and read the online *Science News* article “NASA’s DART mission successfully shoved an asteroid.” Then answer the following questions as directed by your teacher. A version of the article, “NASA’s DART mission is a success,” appears in the November 5, 2022 issue of *Science News*.

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7. What do the results suggest about the success of a future planetary defense program? If a large asteroid were headed toward Earth, how far in advance would a spacecraft need to crash into it to avert disaster?
Cross-curricular Discussion, Q&A

Directions for teachers:
Ask students to read the Science News article “NASA’s DART mission successfully shoved an asteroid” and answer the following questions. Encourage students to work together in groups to answer the questions or use the questions to lead a class discussion. A version of the article appears in the November 5, 2022 issue of Science News.

Want to make it a virtual lesson? Post the online Science News article to your virtual classroom. Discuss the article and questions with your class on your virtual platform.

Understanding force
1. Imagine a stationary object. What is it? How can it be set in motion? List every way you can think of. (Hint: Don’t forget to consider how objects can attract one another.)

Student answers will vary. Depending on the object, it could move if it is pushed, dragged, dropped or bumped by the student or another object. It could fall if another object supporting it is moved. If the object is magnetic or charged, it can also be attracted to (or repelled by) another magnetic or charged object.

2. What is force? What forces are involved in the scenarios you listed above? Are those forces considered contact or non-contact?

(Note for teachers: You may want to review the definitions of contact and non-contact forces with your class. Contact forces result from the interaction of two objects in contact with each other, and non-contact forces result from an object’s location or proximity to another object or the physical makeup of two objects in proximity to one another.)

Force is a push or pull on an object with mass resulting from its interaction with another object. Student answers will vary. Applied force, frictional force, air resistance (a type of frictional force) and normal force are all examples of contact forces. Non-contact forces include gravity, electrical force, magnetic force and nuclear force.

3. What forces act on stationary objects on Earth? What needs to be true about those forces for the object to remain stationary? Why would a stationary object move?

Stationary objects generally have a gravitational force pulling down on the object and a normal force exerted by the ground or whatever the object is sitting on. A stationary object has a net force of zero, meaning the forces acting on it are equal in magnitude and opposite in direction. If an additional force is applied to a stationary object and creates a net force, then the object will be set in motion.

4. Think about an object on Earth that is moving at a constant velocity, like a car on the highway. What forces act on the car? What needs to be true about the forces for the car to remain moving at a constant velocity?
The moving car has a gravitational force and a normal force (from the road and ground below). The car also has frictional forces from the road and air resistance in the direction opposite of the car’s movement. The car’s engine is providing the force to move it forward. For the car to move at a constant velocity, the net of all the forces on the car is zero.

5. What would happen if an additional force is applied to the car?

If an additional force is applied to the car, its motion could stop, it could change velocity (accelerate or decelerate) or it could change direction.

6. What scientific law relates to your answers for questions No. 3 through 5? Define it.

Newton’s first law of motion about inertia states that “an object in motion will remain in motion, and an object at rest will remain at rest, unless acted upon by an outside force.”

**Diversion tactics**

1. Think of a time when you’ve diverted the path of a moving object. Explain what happened and what force you used to divert the object.

*Student answers will vary but they may describe an object falling on them, moving a ball or a defender in a sports game, etc. Most examples will likely involve an applied force by the student.*

2. What conditions did you consider (either consciously or not) when you estimated the amount of force needed to divert the object? What scientific laws applied? Define the laws.

*Students probably had an idea of the object’s mass, velocity and path to create a plan to divert the object. Students applied Newton’s second and third laws of motion. Newton’s second law of motion states that “net force is equal to mass times acceleration,” and Newton’s third law states that “for every action, there’s an equal but opposite reaction.”*

3. Are you familiar with any movies or sci-fi stories about trying to interrupt an asteroid’s path? How did the characters plan to stop the asteroid from hitting Earth? Were they successful?

*Student answer will vary but may include storylines from movies such as Armageddon, Deep Impact and Don’t Look Up.*

4. Do scientific laws apply the same way to Earth and to the asteroid? How would the influence of Earth’s gravity on the asteroid change over time?

*Yes, scientific laws apply the same way to both Earth and the asteroid. The influence of Earth’s gravity on the asteroid depends on how far the space rock is from Earth. Generally, the influence of Earth’s gravity on the asteroid will grow stronger as the space rock gets closer to our planet.*
(Note for teachers: If you teach high school students, you might have students consider that the force of gravity follows an inverse square law. The force of gravity between Earth and the asteroid is inversely proportional to the square of the distance between the center of the asteroid and the center of Earth.)

5. Imagine that you are a NASA scientist trying to protect Earth from a large asteroid. Based on your answers to the previous questions, how would you form a plan for stopping the asteroid from hitting Earth? What information about the asteroid and the forces acting on it would you need to know? What types of strategies might you consider?

Student answers will vary but students should highlight information that would help them calculate the forces acting on the asteroid and the amount of force required to divert the asteroid. Such information includes the asteroid’s mass, velocity, distance from the Earth and direction of travel. Students might also want to know what the asteroid is made of, its shape and other characteristics. Possible strategies include hitting something into the asteroid to knock it off its path, trying to blow up the asteroid, trying to lasso the asteroid (either with a physical rope or through the attraction of gravitational or magnetic forces).
Student Discussion Worksheet

Directions: Have you ever wished you could move a heavy object using a magic wand like Harry Potter’s? Sadly, magic exists only in fictional stories. But physics is very real, and scientists recently used it to move an asteroid in outer space! Read about this cool achievement in the Science News article “NASA’s DART mission successfully shoved an asteroid” and answer the following questions as instructed by your teacher. A version of the article appears in the November 5, 2022 issue of Science News.

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