Name Period Date

**3rd Law of Motion in Space**

One of NASA's first attempts at a "space walk" turned into an exhausting failure for astronaut Gene Cernan. Unlike astronauts who had "walked" in space on previous missions, Cernan had several tasks to accomplish outside the spacecraft. However, every time he attempted to push or turn a valve, he was sent hurtling in the opposite direction, with little control over his trajectory. After many exhausting minutes, his mission outside the capsule was called off, and NASA scientists began trying to figure out what went wrong.

NASA scientists and engineers should probably have predicted that if an astronaut applied force to open or close a valve, the valve would apply the same amount of force to him, but in the opposite direction. After all, nearly 300 years ago, Isaac Newton presented what came to be known as his third law of motion, which says that for every action there is an equal and opposite reaction. We experience these conditions on Earth; if we lean heavily against a wall, the wall pushes back with a force equal and opposite to our lean. (To illustrate the wall's opposing force more vividly, imagine leaning against it while wearing roller skates.) On Earth, gravity and friction provide the stability we need to resist the forces exerted on us during everyday tasks. In contrast, orbiting astronauts must struggle against conditions of "weightlessness."

Orbiting astronauts never actually experience "zero gravity, " even though they commonly use this term to describe the sensation of "weightlessness." In fact, at an altitude of 320 kilometers (200 miles), Earth's gravitational pull is about 90 percent of what it is on the planet's surface, meaning that an orbiting spacecraft and its passengers weigh about 90 percent of their weight on the ground. The sensation of "weightlessness" is the result of the spacecraft's constant state of free-fall around Earth. The spacecraft travels at about 7.5 km (4.7 miles) per second. At this speed, gravity continues to pull the spacecraft toward Earth, but the surface of the Earth also curves away from the spacecraft. As a result, the spacecraft continuously falls at a rate that matches this curvature. The spacecraft is always falling, but from its perspective, so is the surface of the Earth. To the astronauts, it seems as though gravity has disappeared even though it is still very much present.

To combat "weightlessness," NASA engineers began to equip spacecraft with footholds and handholds to give space-walking astronauts the stability they need to perform work.

**Questions**

 What is Newton's third law of motion? How did it affect Gene Cernan?

 What solution helps astronauts work in space now? Why?

 What is meant by "zero gravity?" By "weightlessness?" Is there really no gravity in space?