Model of a Black Hole

Science Film Festival
Knowledge Through Entertainment

Science Film Festival Film

NOVA Wonders – What's the Universe Made of?

Introduction

In "classical" or "Newtonian" mechanics, gravity is described as a force that acts between two objects, pulling them together. Technically, any object with mass exerts a gravitational force on other objects. However, this force between objects is usually too small for us to feel. You don't feel a sideways gravitational pull from the person standing next to you, for example, or even from bigger objects like cars or buildings. We only feel the gravitational force from huge masses like the Earth.

Einstein's theory of general relativity describes gravity a little differently. First, it describes space and time as a "fabric" or "continuum" called space-time (if you think of space as three-dimensional, and you add time as another dimension, then you get something that has four dimensions). General relativity describes gravity as the curvature of this four-dimensional space-time, which is caused by mass. So, large masses like the Earth cause a large curvature in space-time, whereas smaller masses like our bodies barely cause any curvature. In this activity, your stretchy fabric represented space-time and the heavy ball in the middle was a large mass like the Earth – it caused space-time to curve. Smaller masses like the marbles were affected by this curvature in space-time, but were not heavy enough to cause much curvature on their own.

While the Earth's gravity is very strong, we can build rockets and spaceships that can escape it and fly off to the rest of the solar system. We can also send electromagnetic radiation, like light or radio waves, out into space. A black hole is an object in space with so much mass, and gravity so strong (it curves space-time so much), that nothing can escape it, not even light. Anything that passes too close to a black hole (inside a region called the event horizon) will be sucked in. You might wonder how astronomers know black holes exist. After all, if light cannot escape them (meaning they do not emit light or reflect light), how can we see them? Scientists know black holes exist because we can observe their effects on other celestial bodies like stars. For example, the orbit of a star may be affected by the gravity of a nearby black hole, and we can observe matter being sucked into black holes (before it disappears behind the event horizon). Imagine if your fabric curved so much that you could never roll the marble fast enough to get near the middle and still escape – that would be like a black hole!

Key Objectives

- To introduce what affect mass has on gravity.
- To introduce what affect gravity has on space-time.
- To introduce characteristics of a black hole.

Materials

- Stretchy fabric, like a polyester/lycra t-shirt (not cotton) or a large athletic bandage
- Round, heavy object like an apple, orange, or pool ball
- Two marbles or ping pong balls
- Two helpers
- Optional: marker and ruler

Beginner

Resource Type
Project

Topics
Universe | Big Bang | Cosmology

Subjects
Physics | Astronomy

Keywords
Mass | Gravity | Space | Time

Time For Activity
15 – 20 minutes

Guiding Questions

1. What happens if you roll the marble slowly? Faster?
2. How does the shape of its path change?
3. Is there a minimum speed you need to roll the marble to prevent it from getting sucked in towards the larger ball?
4. Is it possible to roll the marble in a perfectly straight line?

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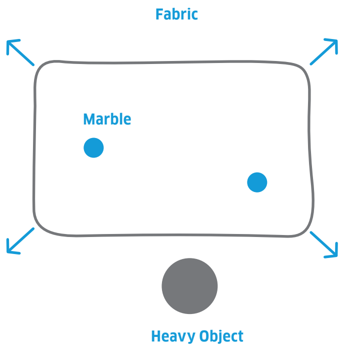
Tasks/Steps

1. Have your two volunteers hold your stretchy fabric by the corners, pull it taut, and hold it flat.
2. This might seem silly, but put a marble somewhere on the fabric and watch it. What happens?
3. Now roll a marble across the fabric and watch how it moves. What shape does its path take?
4. Place your heavy, round object in the middle of the fabric. Make sure your volunteers still pull the fabric tightly enough that it does not have any wrinkles or bumps in it – try to make sure it's as smooth as possible. What happens to the fabric?
5. With the heavy object still on the fabric, place the marble near the edge of the fabric and let it go. What happens now?
6. Now try to roll the marble from one side of the fabric to the other. Is it difficult? What shape does the marble's path form now?
7. Experiment with rolling the marble across the fabric at different speeds.
8. Try rolling two marbles on the fabric at once. Do the marbles appear to affect each other's motion (assuming they do not collide)?



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→ **https://www.sciencebuddies.org/stem-activities/black-hole-model**