

## PHY 11030 – Seven Ideas that Shook the Universe

### The Mission:

Make clear to general level freshmen the differences between Newton's and Einstein's theories of **gravity** – in three minutes!

### The Task:

Communicate a whole page of highlights (over) in an engaging way.

### The Method:

- Write a script for a fictional TV show where a neutral third party moderates a discussion (from Einstein's point of view) or an argument (from Newton's perspective) on the differences between their theories.
- Give some drama students from another course extra credit for playing the parts of Newton, Einstein, and the M.C.
- Have Teleproductions record the show in a studio on campus.
- Have the Office of Continuing and Distance Education pay for the Teleproductions service as part of a major course upgrade.

### The Context:

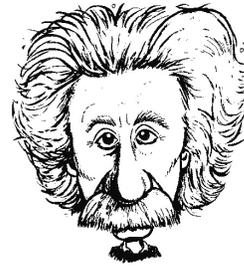
This little drama culminates a unit on Einstein's two Theories of Relativity, as a way to summarize and clarify the content.

### The Source of the Idea:

Galileo himself! Galileo wrote his books in lively Italian (rather than stuffy, academic Latin), and he wrote them as little plays or dialogues. I used that format twice before in the course, so this lesson is titled, "The Way We Were, Take Three."

I use the professional video in the distance learning sections of Seven Ideas that Shook the Universe. In the face-to-face sections, I use the same script but have volunteers from the class play the roles, to involve more students.

# Newton and Einstein on gravity



Question	Newton's explanation	Einstein's explanation
What <i>is</i> gravity?	A force, like any other, between two objects	An illusion, a misunderstanding because we didn't realize that space can curve or warp
Why does anything fall, at all?	A gravitational force between the earth and object pulls it down – 'planet pulling'	Space around the object pushes it down – 'space squirting'
Why does everything fall alike?	For all objects, the ratio of weight/mass is the same, with a value of $9.8 \text{ m/s}^2$	Objects in the same space are affected in the same way – "They get their moving orders from the same piece of space" – John Wheeler
What's the preferred or natural path of an object?	Uniform motion – a straight line at a constant speed	As straight a line as possible through curved space
Why do planets or satellites orbit?	They 'want' to go in a straight line, but the sideways force of gravitation from the central object bends the path into more or less a circle	They <i>do</i> go in a straight line – the straightest line possible, but space curves so much that the line bends back around on itself into more or less a circle
Why do astronauts float in their ships?	The ship is falling at the same rate as the astronaut, so they <i>feel</i> or <i>appear</i> to be weightless; apparent weight comes from the support force holding them up	They really <i>are</i> weightless when in free fall
Is light affected by gravitation?	No – only objects, things with mass, are affected	Yes – because space itself is warped, light is affected along with every object
What's the nature of space?	Pure emptiness, 'flat' space with high-school Euclidean geometry	No such thing as empty space – that is, space without <i>fields</i> ; geometry is non-Euclidean for curved spaces
Can black holes exist?	(Newton would have no idea what the question even means!) No, because light is not affected by gravity	Sure – in fact, scientists got to thinking about the idea of black holes <i>from</i> studying the implications of Einstein's work