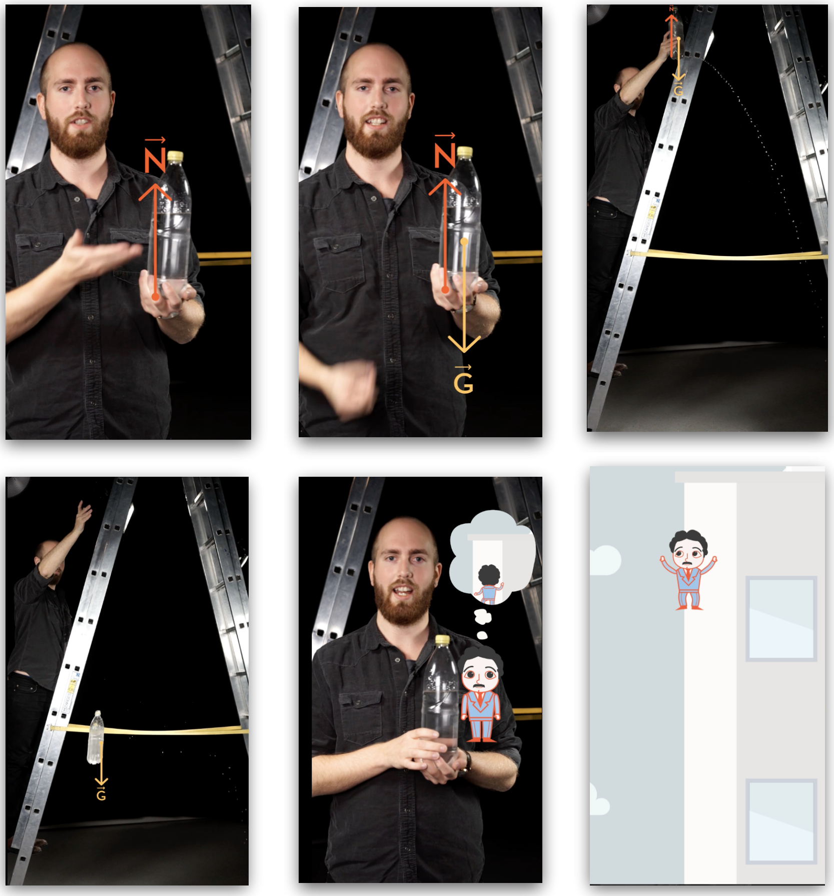

A Relatively Modern Physics Lesson

IN THIS PROJECT, WE HAVE DEVELOPED A COLLABORATIVE ONLINE LEARNING RESOURCE THAT PROMOTES TEACHING AND LEARNING OF EINSTEIN'S GENERAL THEORY OF RELATIVITY. A SIMPLE VIDEO DEMONSTRATION WITH A FALLING BOTTLE OF WATER HELPS STUDENTS TO UNDERSTAND THE PRINCIPLE OF EQUIVALENCE WHICH IS A KEY CONCEPT IN GENERAL RELATIVITY. BY WORKING WITH THE VIDEO DEMONSTRATION THAT WE SUPPLEMENT WITH INTERACTIVE ANIMATIONS AND ILLUSTRATIONS BASED ON A HISTORIC APPROACH, STUDENTS ARE ASKED TO DISCUSS THE PHYSICS OF GRAVITY FROM EINSTEIN'S POINT OF VIEW. THIS WAY, THEY ARE ABLE TO UNDERSTAND SEVERAL NEW PHENOMENA SUCH AS GRAVITATIONAL REDSHIFT AND TIME DILATION IN A QUALITATIVE MANNER.

SUMMARY

The physics curricula for middle and high schools around the world are strongly dominated by classical mechanics. To date, only few countries, like Norway, have incorporated modern subject matter that arose from the discoveries of twentieth century physics into their national curriculum. One out of five main topics in the Norwegian physics curriculum is ‘Modern Physics’. One learning goal asks students to give a qualitative description of Einstein’s general theory of relativity. However, this and several other learning goals have proved to be challenging for both students and teachers. In order to support teaching and learning quantum physics and general relativity, the research project ReleQuant was founded. In collaboration between science educators and teachers, the project aims to develop online learning resources in modern physics and to investigate students’ understanding thereof.

“A Relatively Modern Physics Lesson” is a teaching unit from the ReleQuant resource on general relativity at its core. The purpose of this lesson is to give an introduction to general relativity by explaining the principle of equivalence and two relativistic phenomena related to this principle. The intended learning outcomes are for the students to understand that:

- acceleration and gravity are two equivalent phenomena
- a homogeneous gravitational field and constant acceleration are locally indistinguishable
- there are physics phenomena that can be observed, but cannot be described by Newton’s classical theory of gravity
- time is influenced by gravity
- light gets red shifted when moving upwards in a gravitational field

The online learning resource contains an interactive video in three parts. Part one of this video introduces a simple demonstration consisting of a bottle filled with water that has a hole at its base. Before the actual demonstration, the video raises the question “What will happen to the jet of water when the bottle is dropped from this height?” Part two shows that the jet of water stops immediately as soon as the bottle is dropped and uses slow-motion effects to emphasize the principle. Part three explains why this happens and relates the demonstration to the principle of equivalence and to what is often referred to as Einstein’s “happiest thought”. Following the video, the resource takes a historic approach and makes use of illustrations to promote students’ understanding of some abstract thought experiments. Also included in the resource is an interactive animation where students learn about gravitational redshift and time dilation. During all these activities, students are challenged to talk physics while learning new concepts with the online resource. They discuss in pairs or in small groups as well as in plenum discussions in the class.

A short time after working with the learning resource on general relativity, students were interviewed. In the interviews, they were able to explain the concepts mentioned above, and they appreciated the mixture of activities. Many students mentioned that the simplicity of the water bottle demonstration was helpful in order to understand principle of equivalence properly, because they were able to connect Einstein’s abstract thought experiments to their everyday experience of gravity. They also highlighted that being challenged to “think

aloud" and discuss the subject matter throughout the lesson was a meaningful approach to learn the new concepts, and motivated them to stay focussed.

After conducting and analysing interviews and classroom observations, it seems evident that our lesson and learning resource successfully support student learning and that our approaches with varied activities such as demonstrations, interactive animations, historic perspectives, illustrations and student discussions promote student engagement in the physics classroom.

ReleKvant

ASKER videregående skole

UiO : Universitetet i Oslo