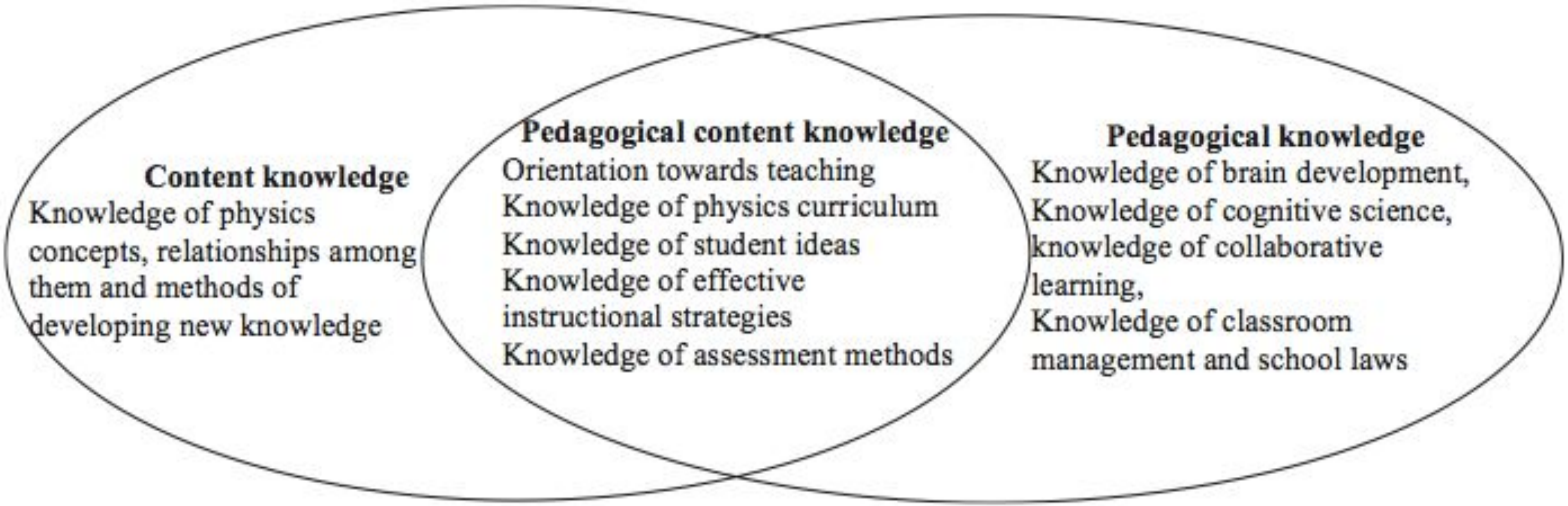
Laboratorio Didattico di Fisica - Modulo A Lezione 03

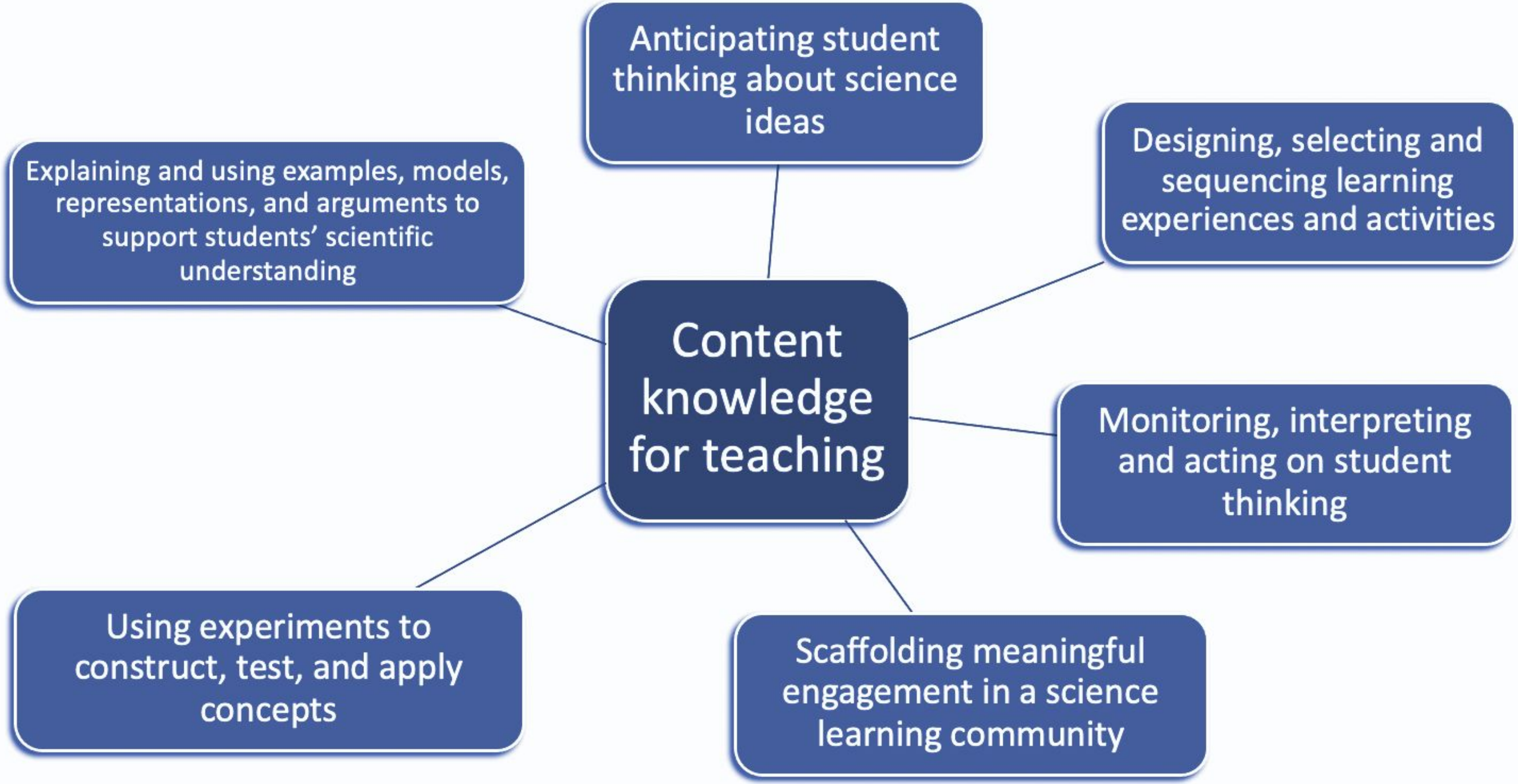
Francesco Longo • 17/10/2024

La struttura della “Teacher Knowledge”
(Fazio, 2010)



Teachers' content knowledge for teaching

E.Etkina et al. (2018)
PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH 14, 010127


Anticipating student thinking about science ideas
Explaining and using examples, models, representations, and arguments to support students' scientific understanding
Designing, selecting and sequencing learning experiences and activities
Content knowledge for teaching
Monitoring, interpreting and acting on student thinking
Using experiments to construct, test, and apply concepts
Scaffolding meaningful engagement in a science learning community

Etkina, 2018

Tasks of Teaching

APPENDIX A: TASKS OF TEACHING

This section provides a list of the tasks of teaching.

Task of teaching	Description	Specific tasks
I. Anticipating student thinking around science ideas	*While planning and implementing instruction teachers are able to anticipate particular patterns in student thinking. They understand and recognize challenges students are likely to confront in developing an understanding of key science concepts and mathematical models. Teachers are also familiar with student interests and background knowledge and enact instruction accordingly.*	*Teachers:* I. a) anticipate specific student challenges related to constructing scientific concepts, conceptual and quantitative reasoning, experimentation, and the application of science processes I. b) anticipate likely partial conceptions and alternate conceptions, including partial quantitative understanding about particular science content and processes I. c) recognize student interest and motivation around particular science content and practices I. d) understand how students' background knowledge both in physics and mathematics can interact with new science content

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II. Designing, selecting, and sequencing learning experiences and activities	*Classroom learning experiences and activities are designed around learning goals and involve key science ideas, key experiments, and mathematical models relevant to the development of ideas and practices. Learning experiences reflect an awareness of student learning trajectories and support both individual and collective knowledge generation on the part of students.*	*Teachers:* II. a) design or select and sequence learning experiences that focus on sense-making around important science concepts and practices, including productive representations, mathematical models, and experiments in science that are connected to students' initial and developing ideas II. b) include key practices of science including experimentation, reasoning based on collected evidence, experimental testing of hypotheses, mathematical modeling, representational consistency, and argumentation II. c) address projected learning trajectories that include both long-term and short-term goals and are based on evidence of actual student learning trajectories II. d) address learners' actual learning trajectories by building on productive elements and addressing problematic ones II. e) provide students with evidence to support their understanding of short- and long-term learning goals II. f) integrate, synthesize, and use multiple strategies and involve students in making decisions II. g) prompt students to collectively generate and validate knowledge with others II. h) help students draw on multiple types of knowledge, including declarative, procedural, schematic, and strategic II. i) elicit student understanding and help them express their thinking via multiple modes of representation II. j) help students consider multiple alternative approaches or solutions, including those that could be considered to be incorrect

Tasks of Teaching

III. Monitoring, interpreting, and acting on student thinking	*Teachers understand and recognize challenges and difficulties students experience in developing an understanding of key science concepts; understanding and applying mathematical models and manipulating equations; designing and conducting experiments, etc. This is evident in classroom work, talk, actions, and interactions throughout the course of instruction so that specific learning needs or patterns are revealed. Teachers also recognize productive developing ideas and problem solutions and know how to leverage these to advance learning.* *Teachers engage in an ongoing and multifaceted process of assessment, using a variety of tools and methods. Teachers draw on their understanding of learners and learning trajectories to accurately interpret and productively respond to their students' developing understanding.*	*Teachers:* III. a) employ multiple strategies and tools to make student thinking visible III. b) interpret productive and problematic aspects of student thinking and mathematical reasoning III. c) identify specific cognitive and experiential needs or patterns of needs and build upon them through instruction III. d) use interpretations of student thinking to support instructional choices both in lesson design and during the course of classroom instruction III. e) provide students with descriptive feedback III. f) engage students in metacognition and epistemic cognition III. g) devise assessment activities that match their goals of instruction

Tasks of Teaching

IV. Scaffolding meaningful engagement in a science learning community	*Productive classroom learning environments are community-centered. Teachers engage all students as full and active classroom participants. Knowledge is constructed both individually and collectively, with an emphasis on coming to know through the practices of science. The values of the classroom community include evidence-based reasoning, the pursuit of multiple or alternative approaches or solutions, and the respectful challenging of ideas.*	*Teachers:* IV. a) engage all students to express their thinking about key science ideas and encourage students to take responsibility for building their understanding, including knowing how they know IV. b) develop a climate of respect for scientific inquiry and encourage students' productive deep questions and rich student discourse IV. c) establish and maintain a "culture of physics learning" that scaffolds productive and supportive interactions between and among learners IV. d) encourage broad participation to ensure that no individual students or groups are marginalized in the classroom IV. e) promote negotiation of shared understanding of forms, concepts, mathematical models, experiments, etc., within the class IV. f) model and scaffold goal behaviors, values, and practices aligned with those of scientific communities IV. g) make explicit distinctions between science practices and those of everyday informal reasoning as well as between scientific expression and everyday language and terms IV. h) help students make connections between their collective thinking and that of scientists and science communities IV. i) scaffold learner flexibility and the development of independence IV. j) create opportunities for students to use science ideas and practices to engage real-world problems in their own contexts

Tasks of Teaching

V. Explaining and using examples, models, representations, and arguments to support students' scientific understanding	*Teachers explain and use representations, examples, and models to help students develop their own scientific understanding. Teachers also support and scaffold students' ability to use models, examples, and representations to develop explanations and arguments. Mathematical models are included as a key aspect of physics understanding and are assumed whenever the term* model *is used.*	*Teachers:* V. a) explain concepts clearly, using accurate and appropriate technical language, consistent multiple representations, and mathematical representations when necessary V. b) use representations, examples, and models that are consistent with each other and with the theoretical approach to the concept that they want students to learn V. c) help students understand the purpose of a particular representation, example, or model and how to integrate new representations, examples, or models with those they already know V. d) encourage students to invent and develop examples, models, and representations that support relevant learning goals V. e) encourage students to explain features of representations and models (their own and others') and to identify/evaluate both strengths and limitations V. f) encourage students to create, critique, and shift between representations and models with the goal of seeking consistency between and among different representations and models V. g) model scientific approaches to explanation, argument, and mathematical derivation and explain how they know what they know. They choose models and analogs that accurately depict and do not distort the true meaning of the physical law and use language that does not confound technical and everyday terms (e.g., heat and energy). V. h) provide examples that allow students to analyze situations from different frameworks such as energy, forces, momentum, and fields

Tasks of Teaching

VI. Using experiments to construct, test, and apply concepts	*Teachers provide timely and meaningful opportunities throughout instruction for students to design and analyze experiments to help students develop, test, and apply particular concepts. Experiments are an integral part of student construction of physics concepts and are used as part of scientific inquiry in contrast with simple verification.*	*Teachers:* VI. a) provide opportunities for students to analyze quantitative and qualitative experimental data to identify patterns and construct concepts VI. b) provide opportunities for students to design and analyze experiments using particular frameworks such as energy, forces, momentum, field, etc. VI. c) provide opportunities for students to test experimentally or apply particular ideas in multiple contexts VI. d) provide opportunities for students to pose their own questions and investigate them experimentally VI. e) use questioning, discussion, and other methods to draw student attention during experiments to key aspects needed for subsequent learning, including the limitations of the models used to explain a particular experiment VI. f) help students draw connections between classroom experiments, their own ideas, and key science ideas VI. g) encourage students to draw on experiments as evidence to support explanations and claims and to test explanations and claims by designing experiments to rule them out

Investigative Science Learning Environment

(ISLE approach)

As teachers, how do we create an environment in which students can discover and learn physics for themselves - to own it, so to speak?

ISLE approach involves students' development of their own ideas by

- Observing phenomena and looking for patterns,
- Developing explanations for these patterns,
- Using these explanations to make predictions about the outcomes of testing experiments,
- Deciding if the outcomes of the testing experiments are consistent with the predictions,
- Revising the explanations if necessary,
- Encouraging students to represent physical processes in multiple ways.

(Etkina et all, 2007-2010-2019)

The combination of these features is applied to every conceptual unit in the ISLE learning system, thus helping them develop productive representations for qualitative reasoning and for problem solving.

The ISLE Game

ISLE is a game that models the process by which physicists create their knowledge.

The key to what makes it non-threatening is that it is like a mystery investigation.

Students construct physics concepts and develop science process abilities emulating the processes that physicists use to construct knowledge.

The steps of the ISLE cycle proceed as follows:

1.Students come upon some interesting physical phenomenon that needs explaining.

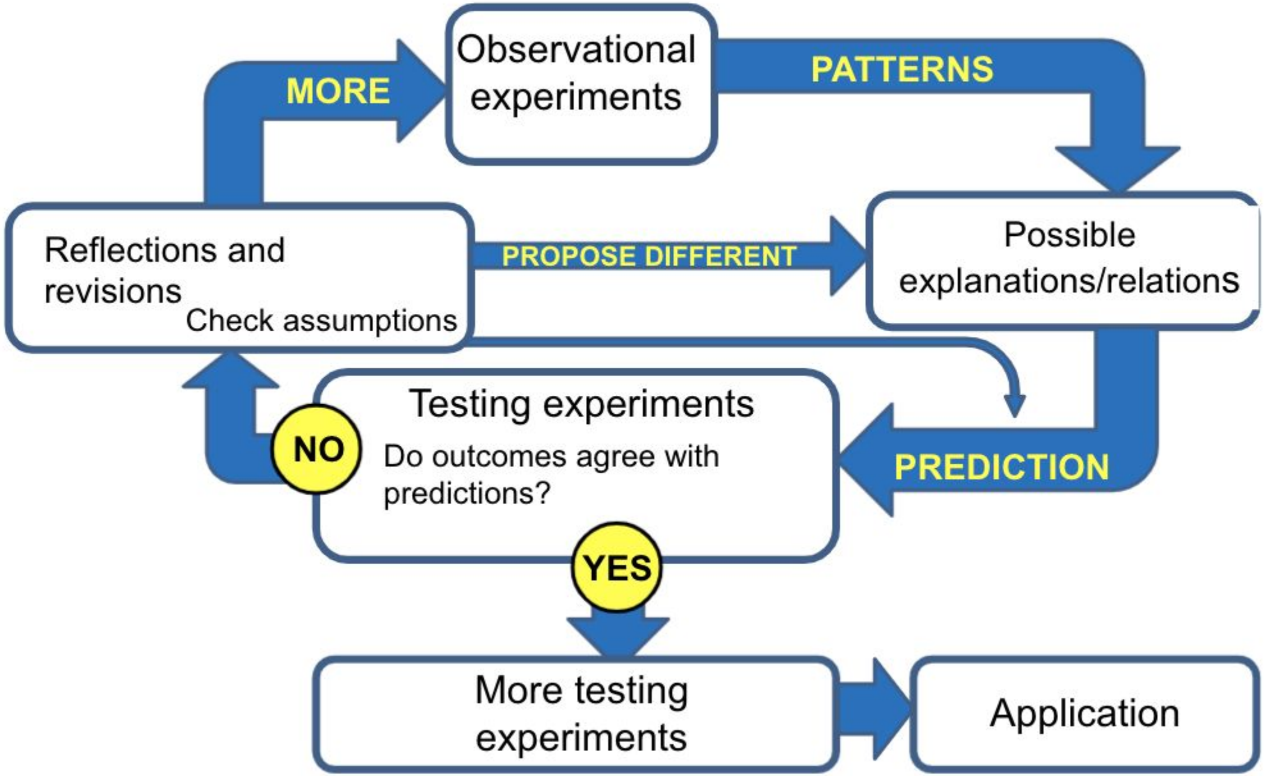
2. Students gather data about the phenomenon, identify interesting patterns and come up with multiple mechanistic explanations for why the phenomenon is happening.
We say “come up with any crazy idea that could explain this” because we DO NOT want students to feel deeply emotionally attached to their ideas.

3. They then test their explanations by conducting one or more testing experiments.

The primary goal is to eliminate explanations rather than “prove” them.
This is key to the non-threatening nature of the process. In ISLE, “predicting” means saying what would be the outcome of the testing experiment if a particular hypothesis were true. Ideas that are not eliminated are kept and re-tested with further experimentation.
Finally students apply the ideas they have established to solve real-world problems.

The cycle repeats twice, first qualitatively, then quantitatively.

Investigative Science Learning Environment - ISLE cycle



Etkina, 2015

The Three Components ISLE

The first component is a cycle of logical reasoning that repeats for every new topic that is learned. The reasoning logic is a marriage of inductive and hypothetico-deductive reasoning:

Inductive: Observational experiments provide students with interesting data (and patterns) that need to be explained. Students generate multiple explanations based on prior knowledge and analogical reasoning.

Hypothetico-deductive: If this explanation is correct, and I do such and such (perform a testing experiment), then so and so should happen (prediction based on explanation). But it did not happen, therefore my idea is not correct (judgment). Or and it did happen therefore my idea has not been disproved yet (judgment).

The Three Components ISLE

The second component of ISLE is an array of representational tools that students learn to use to travel around the ISLE cycle and solve real-world problems (applications).

pictures

motion diagrams

graphs

force diagrams

impulse-momentum bar charts

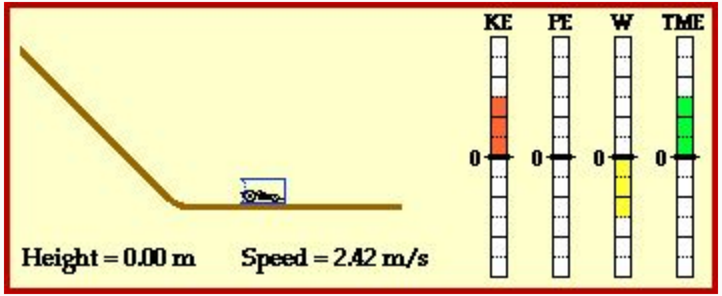
electric circuit diagrams

work-energy bar charts

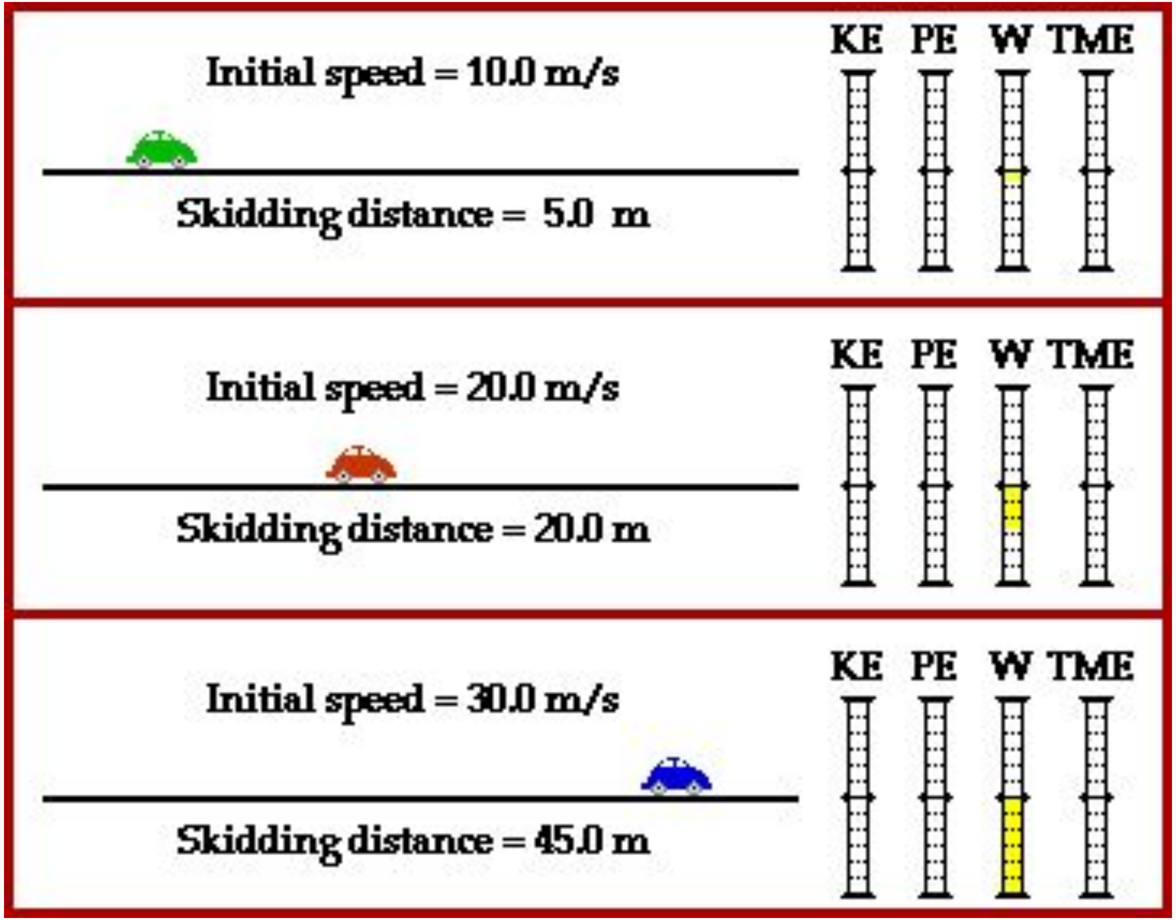
ray diagrams

Qualitative work – energy bar charts that serve the same role for analyzing work – energy processes as motion diagrams and force diagrams serve when analyzing kinematics and dynamics problems.

The use of these bar charts helps students think more about the physics of a work – energy process rather than relying on formula-centered techniques that lack qualitative understanding.



View animation: https://www.physicsclassroom.com/mmedia/energy/hw.cfm



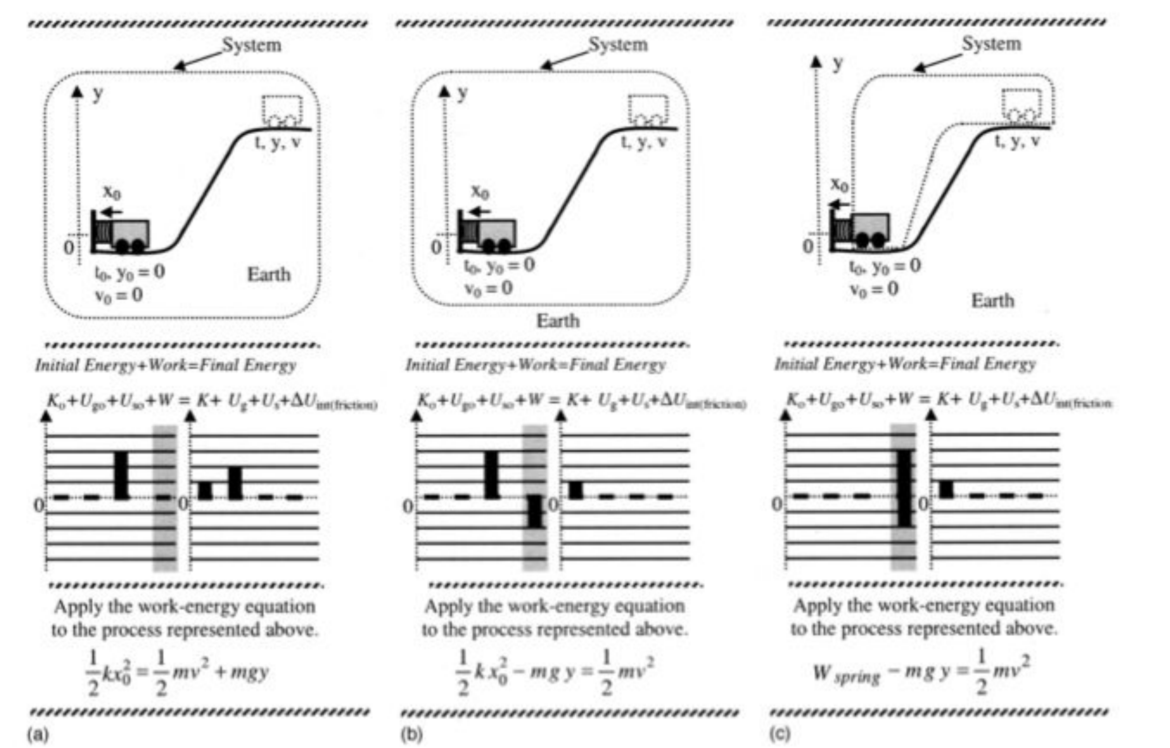
View animation: https://www.physicsclassroom.com/mmedia/energy/cs.cfm https://www.physicsclassroom.com/Physics-Interactives/Work-and-Energy/Work-Energy-Bar-Charts/Work-Energy-Bar-Charts-Interactive

TEST YOURSELF!

The different systems are chosen for the same physical process.

(a) The cart, the spring, and Earth are in the system.
(b) The cart and the spring are in the system, but not Earth.
(c) The system includes only the cart.
For each chosen system there is one work–energy bar chart and the corresponding generalized work–energy equation.

In practice, it would be easy for students to use a system that includes Earth and the spring, although the choice of the system does not affect the physical results.



The Three Components ISLE

The third component of ISLE is the development of a set of scientific abilities or scientific habits of mind that allow students to travel around the ISLE cycle and solve real-world problems (applications) by thinking like a physicist.

Students are able to identify assumptions they are making and how those assumptions affect a result. Notice that this ability applies in multiple contexts. Assumptions are made in designing a testing experiment and may affect the outcome of that experiment or the conclusions that are drawn from that experiment.

Assumptions are made when applying physics knowledge to solve a real-world problem (e.g., figure out how far a projectile will travel). The assumptions made will affect the result of the calculation when compared with the actual outcome (i.e., firing the projectile and seeing how far it actually went). The full set of scientific abilities and the multiple contexts in which they occur are codified in the scientific abilities rubrics.

Observational experiments: energy conversions - part 1

Goals: Explain a series of experiments using the knowledge of energy
Equipment: none

1. Watch the video [https://youtu.be/u3Y4npFvlO4] Answer the following questions:
    A. Construct a microscopic explanation for how the hot gas pushes out the stopper. Remember what you learned about molecules of gas, their motion, and the pressure that they exert.
    A. Choose the gas inside the test tube, the stopper, and Earth (not the flame) as the system, and use the concepts of work and energy to explain the experiment. If you need a new physical quantity or quantities for your explanation, define them qualitatively.
    B. Draw an energy bar chart to explain the experiment using this new physical quantity. The system is the gas and the cork. The initial state is before we started warming up the gas and the final state is when the cork is flying out.

Rubrics for assessment

The Rutgers Physics and Astronomy Education (PAER) group has developed rubrics for assessment of scientific abilities. The rubrics contain descriptors for individual scientific sub-abilities. One can use the descriptors to assign either a numerical score or a descriptive score for a portion of student writing related to a certain sub-ability. The relationship between the scores is shown in the table below. We prefer to give students rubric description with a descriptive score as numerical scores were found to have a negative effect on student learning. A score of 0 describes a write-up in which the sub-ability is ‘Missing’, 1 stands for a write-up where the sub-ability is ‘Not adequate’, 2 describes a write-up with the sub-ability that ‘Needs some improvement’ and 3 describes a write-up in which is ‘Adequate’.

- Ability to represent information in multiple ways
- Ability to design and conduct an observational experiment
- Ability to design & conduct an experiment to test an idea/hypothesis/explanation or mathematical relation
- Ability to design & conduct an application experiment
- Ability to communicate scientific ideas
- Ability to collect and analyze experimental data
- Ability to evaluate models, equations, solutions, and claims

DA ISLIZZARE

- Sistema in equilibrio - Statica (del punto e del corpo rigido)
- Moto uniformemente accelerato
- Moti in 2D
- Moto rotatorio
- Circuiti in serie e in parallelo
- Galleggiamento
- Bernoulli