Teaching Physics Modules

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What is the purpose of the modules?

• To provide materials for those programs that prepare physics teachers (or do professional development) to make the work of this programs more efficient,

• To use results of PER in practice,

• To “take advantage” of teacher educators who combine knowledge of physics, knowledge of PER and real high school teaching experience,

• To help teachers motivate high school students and ensure that they are successful.
What should a physics teacher know?

**PHYSICS**
Subject matter (concepts, rules, problem solving).
Methods of acquiring knowledge: How do we know what we know? What are accepted rules of the game?

**EDUCATION**
How human brain works.
How people learn.
How people work in groups.
How motivation is related to learning.

**WHAT IS MISSING?**

What should students learn in a physics course?
What difficulties do they have?
How can we help them best?
How can we assess them?
What resources are available?
How to structure the curriculum?
Elements of Teacher Knowledge

- Content knowledge (CK)
- Physics department
- Pedagogical content knowledge (PCK)
- School of education

Pedagogical knowledge (PK)
The need for modules

• There is a lot of research on how to help students learn physics, be successful, stay motivated, etc. Learning and teaching physics is different from learning and teaching biology.

• The preparation for the challenges of every day instruction is what helps teachers be successful.

• We should be able to help our students who plan to teach physics – HOW TO TEACH PHYSICS.
Modules address most common aspects of teaching physics

A sequence of Multiple representations modules (Kinematics, Dynamics, Momentum and Energy).

Module on planning instructional elements

Module on experimentation (physics experiments)
How to use the modules

• As materials for existing science methods courses
• As materials for a stand alone course/courses just for future physics teachers
• As materials used in independent study courses
• As materials supplementing physics courses for future physics teachers so they have a taste of pedagogy while learning physics
Examples
Introduction to MR series

Purpose: the purpose of this module is to help pre-service physics teachers learn how to integrate science practices into the learning of physics. Specifically the module focuses on multiple representations that are used in the practice of science (see Next Generation Science Standards) when scientists analyze and interpret data, construct models and explanations, evaluate claims, and communicate. Pre-service teachers will learn about most commonly used representations in a physics course, devise activities that help high school students “read and write” with those representations and interpret student work.
Introduction

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Module work structure

Four types of activities in the module

• reading the informational text,
• working through multiple representation activities (using PUM curriculum modules),
• designing your own activities;
• responding to assessment questions.
Assessment Questions for the Introduction

*Why do we need to use multiple representations when helping students learn physics?*

1. For every paper that you read answer the following questions: Why was the paper assigned? How is the paper related to the multiple-representation ideas? How can this paper contribute to my future teaching of physics?

2. Why is using words and mathematics insufficient to think like a physicist?

3. How do experts and novices categorize problems? Why is it important for a teacher to know the difference?

4. What is a “representational competence” and why is it important when learning physics?
Kinematics Module

Designing your own activities

1. Give student a motion diagram for a complicated motion and ask them to devise a story about this motion;

2. Give a list of short descriptions of different motions and a list of motion diagrams and ask students to match them;

3. Ask students to draw a motion diagram for an object moving to the left and slowing down and then moving to the right and speeding up and ask whether the direction of the arrows on the diagram is indicative of whether an object is speeding up or slowing down.

4. Finally, design activities when students have to move from one representation to another, especially from velocity-versus-time graphs to motion diagrams and back.
Kinematics Module

Assessment questions (examples)

1. Why do students need to learn motion diagrams? Why are dot diagrams not enough?
2. What difficulties students might have with motion diagrams and what activities might help them?
3. How can you help students see the relationship between kinematics graphs and motion diagrams?
4. What are the difficulties that students experience with the kinematics graphs?
Dynamics Module

Examples for Designing your own activities

1. You wish that your students use force diagrams to understand, solve and evaluate problems not as an add-on after a problem has been solved just to please you. What strategy/ies will you use? Outline the strategy and give specific examples.

2. Design an activity that will help students learn how to self-assess force diagrams.

3. Examine the following Equation Jeopardy activities and using them as an example design similar activities for your students

Several mathematical statements are listed below. For each statement, describe a problem for which this statement could be a solution. Then represent the statement using a force diagram and a motion diagram. For one of the forces involved in the situation find Newton’s third law pair.

a) \((9.8 \text{ N/kg}) \times (3 \text{ kg}) = \Sigma F_{\text{on object}}\)
b) \((3 \text{ s}) \times (a) = (-7 \text{ m/s}) + (2 \text{ m/s})\)
c) \((1 \text{ kg}) \times (a) = (-35 \text{ N}) + (9.8 \text{ N})\)
d) \(F_{\text{rope on sled}} + (-F_{\text{Jake on sled}}) = (35 \text{ kg}) \times (0 \text{ m/s}^2)\)
e) \((5 \text{ kg}) \times (a) = (70 \text{ N}) \cos 30^\circ +(-0.4 F_{\text{floor on crate}})\)
Dynamics Module

Assessment questions

1. Examine PUM activity 3.10. First answer the questions as if you are a student. Then approach the same activity as a teacher: what is the learning purpose? What student difficulties did the authors of the activity try to address? What are possible answers that the students might provide and why?

2. Why do we suggest labeling force with two subscripts? Why do we suggest drawing the length of the forces to scale?

3. Explain how student difficulties with force resemble the struggles of physicists and how the language “object A exerts a force on object B” addresses these difficulties.

4. Discuss how different authors in the Physics Teacher articles approach force diagrams.

5. Give an example of a problem where having to search for consistency between a motion diagram and a force diagram is helpful for a student.
Planning Instructional Elements

Module

The module consists of several small parts. Each part has two or more of the following components: brainstorming, information and activities. Assessment for the module will consist of you writing a unit plan and a lesson plan.

- What is an instructional element? 3 steps in planning any element
- Setting goals
- Matching assessment to the goals - formative and summative
- Planning instructional sequence. Writing a lesson plan
- Writing a unit plan
- Evaluation of teacher unit and lesson planning and assessment
Activities in the part “Setting goals”

1. Examine NGSS for a core idea of Energy for High School. Use materials in the standards to identify 3 goals of instruction that your students can achieve studying energy in mechanics (a unit) and describe the evidence that will show whether the goals are achieved.

2. Choose one hypothetical 45-min lesson from the energy unit in mechanics and list the goals that address the disciplinary core ideas, science practices and crosscutting concepts.

3. Find curriculum for a school district and familiarize yourself with it.

4. Can you identify goals of instruction in the curriculum? Make a list.
Activities in “Planning instructional sequence”

Activities based on the lesson plan provided as an example

1. List numbered elements of the lesson plan and explain the purpose of each.

2. Does the lesson plan indicate that students are engaged in the construction of their own knowledge or that they are passive listeners? Provide arguments.

3. Does the plan indicate knowledge of students’ strengths and weaknesses? Provide arguments.
Questions?

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