Physics Education Laboratory
Lecture 09
Content Knowledge for Teaching Dynamics

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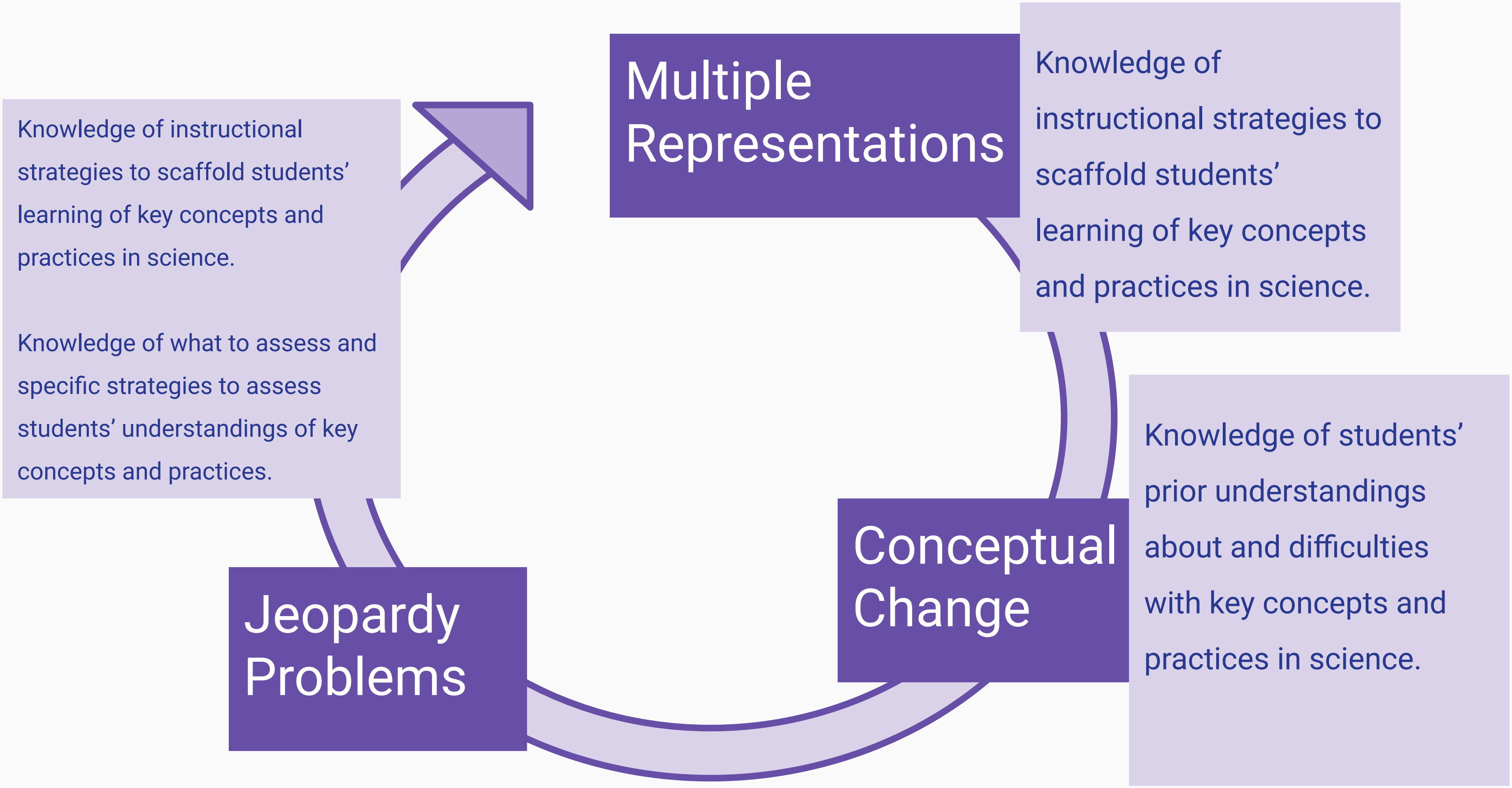


HOW TO DEVELOP DIFFERENT PCK'S ASPECTS and CONTENT KNOWLEDGE FOR TEACHING

Jeopardy problems

Physics Jeopardy problems require students to work backwards. Instead of constructing and solving equations pertaining to a given physical situation, students are asked to construct a proper physical situation from a given equation or graph.

(Cui et al., 2006)

EXAMPLES:

Jeopardy problems ensure that "students cannot use formula-centered, plug-and-chug problem solving methods, rather they must give meaning to symbols in the equation" and "help students to learn to translate between representations in a more robust manner."

(Van Heuvelen et al., 1999)

Jeopardy Equations:

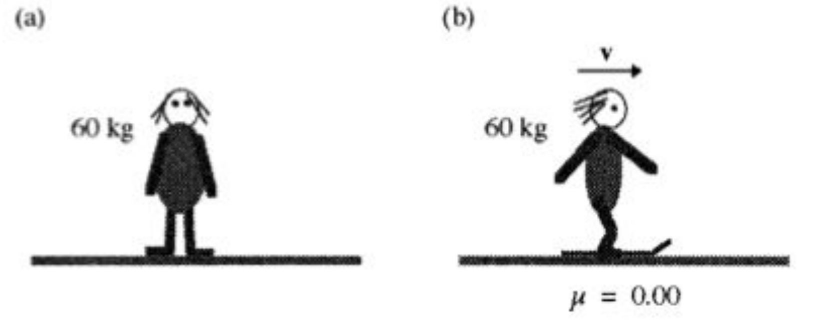


Fig. 1. The equation $N-(60\text{ kg})(9.8\text{ m/s}^2)=0$ describes the situations shown in (a) and (b).

In Equation Jeopardy, you reverse the normal process by providing a mathematical equation as the given information and asking the student to construct an appropriate physical situation that is consistent with the equation.

Consider a Jeopardy Problem involving the component form of Newton's second law applied to an object on an incline,

$$150\ \text{N} - (14.5\ \text{kg})(9.8\ \text{m/s}^2)\sin 34° - (0.32)(14.5\ \text{kg}) \times (9.8\ \text{m/s}^2)\cos 34° = (14.5\ \text{kg})a_x .$$

With a little work, a physicist will recognize that something exerts a 150-N force parallel to a 34° incline while pulling (or pushing) a 14.5-kg object up the incline. There is friction with a 0.32 kinetic friction coefficient between the object and the inclined surface. This Jeopardy Problem is somewhat more challenging.

We can ask the students to translate from the mathematical representation to a physics sketch, a free-body diagram in this case, and then from the diagram to a picture-like sketch of an appropriate physical situation.

Finally, students could be asked to invent a word problem that is consistent with the equation.

Diagram and Graph Jeopardy problems:

In Diagrammatic and Graphical Jeopardy Problems, students are first given a diagram or graph.

They then invent a word or picture description and a math description for a process that is consistent with the diagram or graph. Consider the force diagram in Fig. 2(a). Tell as much about the situation as you can.

The force diagram could describe a box or block moving downward at constant velocity along a vertical wall (Fig. 2(b)).

The normal force indicates that the object is pressed against a vertical wall. The kinetic friction force indicates that the object is moving down.

Notice that the y components of the forces parallel to the wall's surface add to zero.

This provides a nice opportunity to confront the common belief "misconception" that there must be a net force in the direction of motion in order for that motion to continue.

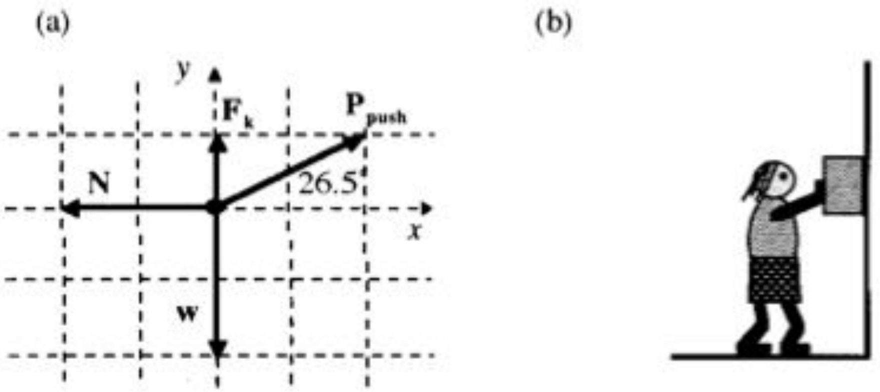


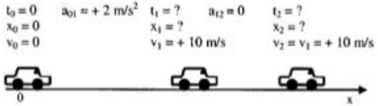
Fig. 2. The free-body diagram shown in (a) represents the process shown in (b).

Multiple Representations in Kinematics

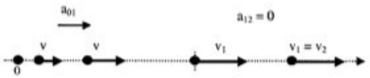
Verbal Representation

A car at a stop sign initially at rest starts to move forward with an acceleration of 2 m/s^2. After the car reaches a speed of 10 m/s, it continues to move with constant velocity.

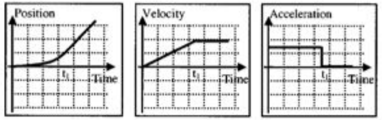
Pictorial Representation



Physical Representation (Motion Diagram)



Physical Representation (Kinematic Graphs)



Mathematical Representation

For $0 < x < x_1$ and $0 < t < t_1$	For $x_1 < x$ and $t_1 < t$
$x = 0 + 0 \bullet t + (1/2)(2\ \text{m/s}^2)\, t^2$	$x = x_1 + (10\ \text{m/s})\, t$
$v = 0 + (2\ \text{m/s}^2)\, t$	$v = +10$ m/s

Fig. 1. The kinematics process described in the problem can be represented by qualitative sketches and diagrams that contribute to understanding. The sketches and diagrams can then be used to help construct with understanding the mathematical representation.

A crate moves along a vertical wall. The application of Newton's second law in component form to that crate is shown below (the y-axis points up). Assume that g = 10 m/s^2.

$$F \cos 60^0 + \quad 0 \quad - N + \quad 0 \quad = 0$$

$$F \sin 60^0 + 0.40\, N + 0 - 200\ \text{N} = (20\ \text{kg})(-0.50\ \text{m/s}^2)$$

What is the object's mass? 20 kg

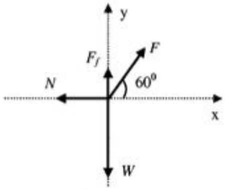
What is the object's weight? 200 N

How many forces act on the object? 4

Solve the equations for the unknowns.

$F = 178$ N, $N = 89$ N

Draw below a set of coordinate axes, one horizontal and the other vertically up. Then, examine the components of each force one at a time and draw arrows representing each force, thus constructing a free-body diagram.



Describe in words and/or in a drawing some real situation that might result in the diagram above.

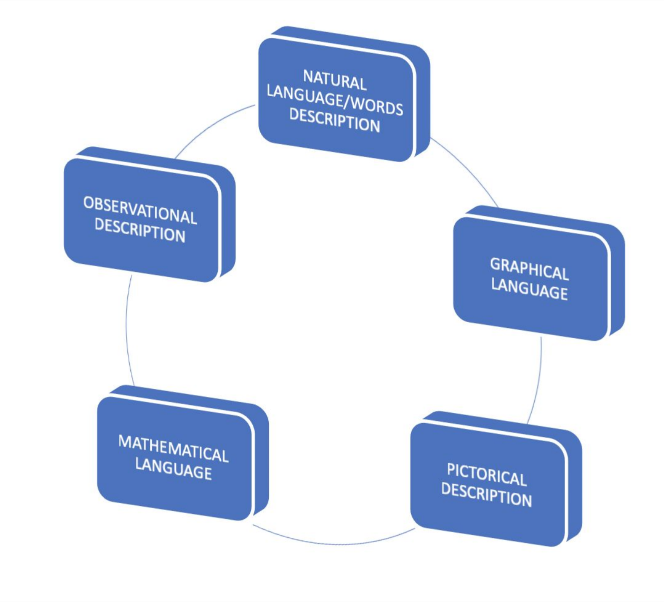
Fig. 2. The physical process described in the mathematical equations can be represented by diagrams, sketches, and words. The diagrams and sketches aid in understanding the symbolic notations, and help give meaning to the abstract mathematical symbols. (There could be more than one diagram and sketch consistent with the mathematical equations.)

Multiple Representations in Kinematics and Dynamics mean a wide usage and application of Jeopardy problems

11. • **Jeopardy!** Contestants on the game show *Jeopardy!* depress spring-loaded buttons to "buzz in" and provide the question corresponding to the revealed answer. The force constant on these buttons is about 130 N/m. Estimate the amount of energy it takes—at a minimum—to buzz in.

Kinematics and dynamics concept integration

Rotational Motion DESMOS EDUCATIONAL LABORATORY



ACTIVITY 1: Observe the phenomena

https://teacher.desmos.com/activitybuilder/custom/61827677ea59770a1ada8332

ACTIVITY 2: Represent the phenomena

https://teacher.desmos.com/activitybuilder/custom/6182738298fcb5dbfae73882

ACTIVITY 3: Integrate languages/descriptions

https://teacher.desmos.com/activitybuilder/custom/618277f16591badbf9ee0fbe

Genuine understanding is most likely to emerge...if people possess a number of ways of representing knowledge of a concept or skill and can move readily back and forth among these forms of knowing.

(Gardner, 1991)