

Computer Problem-Solving Coaches

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Theoretical framework

- Cognitive apprenticeship
 - Curricular efforts to improve students' problem-solving skills are all based (explicitly or implicitly) on this.
 - Components: Modeling, Coaching, Fading
 - Examples: craft apprentices, athletes, graduate students

Computers as coaches

- In an introductory physics class, the time available for students to practice solving problems in an environment where they can receive guidance and feedback is severely limited!
- Well-constructed computer programs can provide students with 24/7 coaching.

Functions of the computer

- Make explicit the expert's tacit knowledge, break down the expert's compiled knowledge
- Model expert-like problem-solving behavior, provide students with coaching, withdraw assistance as student learns

Making thinking visible

Minnesota problem solving framework

1. Focus the problem
 - Draw a picture incl. given information
 - Determine question to be answered
 - Determine approach to use
2. Describe the physics
 - Draw diagrams and define physical quantities
 - Determine target quantities
 - Write down quantitative relationships
3. Plan the solution
 - Select an equation containing the target quantity
 - Identify other unknowns in equation
 - Solve a sub-problem to find each unknown
 - Check units of result
4. Execute the plan
 - Calculate value of target quantity
5. Evaluate the answer
 - Check if answer is properly stated
 - Check if answer is unreasonable
 - Check if answer is complete

Draw a picture

- important objects
 - perspective
- kinematics quantities
- position
 - velocity
 - acceleration
 - time
- dynamics quantities
- force
 - other parameters

Computer coaching

- Help students use expert-like framework to solve problems, providing individualized guidance and feedback
- Model and coach cognitive functions: deciding, implementing, assessing
- Vary assistance according to students' skill level

Instructional strategies

- Reciprocal teaching
 - Implementation mode:
Computer decides, student implements, computer assesses
 - Coaching mode:
Student decides, computer implements, student assesses
- Learning from well-studied examples
 - Performance mode:
Student solves problem with minimal assistance

Implementation mode

Presentation Window File Reference Review

Section 1 FOCUS THE PROBLEM

1. FOCUS THE PROBLEM

Picture & given info

- ✓ Important Objects

Kinematics Quantities

- ✓ Position
- 1 Velocity
- ✓ Acceleration
- ✓ Time

Dynamics Quantities

- 1 Forces
- Other Parameters

Question(s)

Approach

- Physics Principle
- System
- Relevant Times
- Relevant Info.

2. DESCRIBE THE PHYSICS

3. PLAN THE SOLUTION

4. EXECUTE THE PLAN

5. EVALUATE THE ANSWER

Forces

What are the forces acting on the train?

Click on all correct answers, then click "Done".

- Gravitational force
- Normal force
- Spring force
- Frictional force
- Force of motion (inertial force)

Done

Problem

At the train station, you notice a large horizontal spring at the end of the track where the train comes in. This is a safety device to stop the train so that it will not plow through the station if the engineer misjudges the stopping distance. While waiting, you wonder what would be the fastest train that the spring could stop at its full compression, 3.0 ft. To keep the passengers safe when the spring stops, the maximum acceleration of the train, caused by the spring, is $g/2$. You make a guess that a train might have a mass of 0.5 million kilograms. For purposes of getting an estimate, you assume that all frictional forces are negligible.

Picture

$t_i = 0$ \vec{v}_i $\vec{a}_i = 0$ $d = 3.0\text{ft}$ $a_f = g/2$ $t_f = ?$ $\vec{v}_f = 0$ \vec{a}_f \vec{F}_N \vec{W} \vec{F}_s

No. A force is an interaction between two objects. There is no such thing as a "force of motion."

PAL

Coaching mode

Skating around a vertical loop File Reference Review

Section 1 FOCUS THE PROBLEM

1. Focus the Problem

- 2 ● Draw a picture
- 1 ● Decide on the question

What do I do now?

Choose from menu

- Choose an approach to use
- Draw a physics diagram
- Decide on a target quantity
- ✓ ● Write down quantitative relationships

Problem

You have a job at a company that designs equipment for sports exhibitions. The company has a contract to design an apparatus for an ice skating show. An ice skater will start from rest and glide down an ice-covered ramp. At the bottom of the ramp, the skater will then glide around an ice-covered loop which is inside a vertical circle. After going around the vertical circle, the skater emerges at the bottom to glide out onto the skating rink floor to the wild applause of the audience. For a spectacular effect, the circular loop will have a diameter of 30 feet. Your task is to determine the minimum height from the rink floor to the top of the ramp so the skater will make it around the loop. If the skater is going just fast enough for this stunt to work, her skates just barely lose contact with the ice when she is upside down at the top. At that point, she is in free fall, so her acceleration is g .

Picture

h_i $\vec{v}_i = 0$ $a_i = ?$ $t_i = 0$ \vec{a}_i \vec{v}_f $t_f = ?$ $v_f = ?$ $\vec{a}_f = g$ W $h_f = 30 \text{ ft.}$

Question

How high should the skater's starting point be so as not to fall off the loop at the top?

PAL No. Before you can write down any equations, you need to decide which approach(es) are appropriate for solving the problem.

Performance mode

Presentation Window File Reference Review

Independent performance (Attempt # 1)

Enter Answer

1. Enter Answer
2. Evaluate Answer

Enter your answer for the spring constant k in terms of the distance d the jet is pushed by the spring, the length L of the runway, the force F supplied by the jet's engines, the mass m of the plane, and the minimum velocity v needed for take-off.

Problem
The Navy wants a new jetplane launcher for their aircraft carriers and you are on the design team. The launcher is effectively a large spring that pushes the jet for the first few meters of the runway. During that same time, the jet's engines supply a constant thrust force for the entire length of the runway. The planes need to have a certain minimum velocity by the end of the runway in order to achieve a successful take-off. What should be the spring constant for the launcher in terms of quantities such as the distance the jet is pushed by the spring, the total length of the runway, the thrust force supplied by the jet's engines, the mass of the jet, and the minimum velocity necessary for take-off?


Answer

$k =$

L	d	v	2
m	g	F	3
²	$\sqrt{\quad}$	()
+	-	/	*
Delete last	Delete all	Enter	

Press Enter when equation is completed.

I got stuck and couldn't get an answer.


PAL

Assessing the coaches

- Prototype usability
 - Test coaches with a small number of student volunteers
- Educational efficacy
 - Small-scale pilot study
 - Quasi-experimental study for educational impact

Pilot Study

- Two groups of student volunteers
 - Groups matched according to previous exam scores
 - Group 1: Computer coaches
 - Group 2: No computer coaches
- Compare performance on subsequent exam
 - Problem-solving success
 - Use of expert-like framework
 - Assessment behaviors
- Interview students and examine log files for ideas on possible improvements

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