

Intelligent coaches for problem-solving in physics

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Motivation

- Problem-solving is important and computers can help students to develop such skills
- Increasing prevalence of online learning emphasizes need for practical and effective online learning tools.
- Computers could provide more effective instruction to a more diverse student audience.

C₃PO: Customizable Computer Coaches for Physics Online

- Coaches students in the use of an expert-like decision-making framework for solving problems
 - Highly interactive
 - Emphasizes the explicit use of a general decision-making framework for all problems
 - Gives students guidance and feedback with flexible grain-sizing according to student preferences
 - Fully customizable by instructors according to their instructional environment and preferences

C₃PO Development process: Stage 1

- Version 1.0 (Proof of principle with students)
 - Highly interactive
 - Emphasizes the explicit use of a general decision-making framework for all problems
 - Gives students guidance and feedback with flexible grain-sizing according to student preferences
 - Fully customizable by instructors according to their instructional environment and preferences
- Completed
 - Tested usability and educational impact with students in real classes
 - Achieved positive results (improvement in problem solving skills equivalent to one full letter grade on final exam)

Section One: Focus the Problem

Focus the Problem

Picture

Important Objects

Kinematic Quantities

Position

Velocity

Acceleration

Time

Dynamic Quantities

Forces

Other Quantities

Questions

Approach

Physics Principle

System

Relevant Times

Relevant Info

Describe the Physics

Plan the Solution

Execute the Plan

Evaluate the Solution

Summary

Important Objects

What objects should be included in a picture of the solution?

Choose the answer from the list below. Use the scroll bar if necessary.

- Puck only.
- Ramp only.
- Both puck and ramp.

From which point of view do you want to draw the picture?

Choose the answer from the list below.

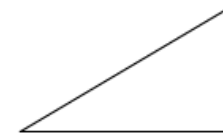
- Top view.
- Side view.

Make Decisions
about Drawing A
Picture

Problem

At the State Fair you see people trying to win a prize at a game booth. They are sliding a metal disk shaped like a puck up a wooden ramp so that it gets near the top of the ramp before sliding back down. You estimate that you can slide the 'puck' at 8.0 ft/sec, but would that win the game? The two boundaries of the zone appear to be at 10 and 10.5 feet from the bottom of the ramp where you release the 'puck.' The ramp appears to be inclined at 37° from the horizontal. You happen to remember that between steel and wood, the coefficients of static and kinetic friction are 0.1 and 0.08,

Picture



Okay.

Problem

Continue

Type 1: Computer (C) guides, student (S) decides, C assesses
Modeling, coaching

Section One: Focus the Problem

Focus The Problem

I am having trouble deciding how to get started. What should I do first?

Choose the answer from the list below.

- Choose an approach to use
- Decide on the question to be answered
- Draw a physics diagram
- Draw a picture of the situation
- Write down quantitative relationships

Student guides solution process

Problem

Your company is designing an apparatus for an ice skating show. An ice skater will start from rest and slide down an ice-covered ramp. At the bottom of the ramp, the skater will glide around an ice-covered loop which is the inside of a vertical circle before emerging out onto the skating rink floor. 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 for the skater to make it around the loop. When barely making it around, the skater briefly loses contact with the ice at the top of the loop and at that point the skater is in free fall.



Type 2: S guides, C:student decides, S assesses, C:overseer assesses
(Reciprocal teaching, coaching)

Section One: Enter the Answer

Enter & Evaluate the Answer

Enter & Evaluate the Answer

Enter your expression for the unstretched length of the bungee cord L in terms of the mass m of the jumper and the height h of the jump. Click Done when finished.

Use the interface to build an expression that yields the correct answer.

Solve it on your own

m	4	+)	
g	5	-		
h	6	*		
1	7	/		+/-
2	8	^	C	CA
3	9	(Done	

I got stuck and couldn't get an answer.

Problem

Because of your knowledge of physics, you have a summer job working for a company that arranges bungee jumps. The cords used in the jump are sorted by their unstretched length and their spring constant (when the cords stretch, they exert a force that has the same properties as the force exerted by a spring). Your first task is to develop equations for the company employees to use when picking out a cord for a jump. Given the mass of the jumper and the height of the jump, your equations should allow an employee to calculate the correct unstretched length and spring constant for the bungee cord to be used and you decide to first develop an equation for the correct unstretched length. For the most exciting jump, the person should stop just short of the ground. In order to keep the jumper safe, the company doctor recommends that the maximum acceleration

Answer



Type 3: S works independently, C assesses and provides help as necessary (Fading, coaching as necessary)

C₃PO Development process: Stage 2

- Version 2.0 (Proof of principle with instructors)
 - Highly interactive
 - Emphasizes the explicit use of a general decision-making framework for all problems
 - Gives students guidance and feedback with flexible grain-sizing according to student preferences
 - Fully customizable by instructors according to their instructional environment and preferences (**using a GUI**)
- Currently in alpha version
- Details in next talk

Comparisons

- Web-based homework systems (WHS):
 - WebAssign (www.webassign.com)
 - Mastering Physics (www.masteringphysics.com; Pritchard and Morote, 2002)
 - Interactive Examples (www.smartPhysics.com)
- Strengths of WHS:
 - Large database of problems
 - Well-integrated with course management systems
- Shortcomings of WHS:
 - Do not include detailed coaching on the use of a generalizable decision-making framework
 - Assume that students are competent at creating and translating between various representations (pictures, diagrams, equations)

Comparisons

- Intelligent tutoring systems (ITS):
 - Andes (VanLehn et al., 2005)
 - ViPS (Virtual Physics System) (Myneni et al., 2013)
 - MATHEMA (Papadimitriou et al., 2009)
- Strengths of ITS:
 - Can interpret a wide variety of student responses
 - Use student responses to provide individualized guidance and feedback
- Shortcomings of ITS:
 - Do not include detailed coaching on the use of a general decision-making framework.
 - Difficult/impossible for an instructor to customize.

Summary

- The University of Minnesota Physics Education Research Group has been developing the C₃PO system (Customizable Computer Coaches for Physics Online)
 - Critical features are (1) coaching the use of a generalizable, expert-like, decision-making framework and (2) customizability by typical instructors.
 - The system aims to achieve effectiveness through careful instructional design, rather than sophisticated AI.
- Version 1.0 completed and tested
 - groups.physics.umn.edu/phyped/prototypes.html
- Version 2.0 in development
 - Details in the next talk