AP Physics 1 and 2 Problem scenario maker

Box 1. Select knowledge to test for

1. Copy some items from cribsheet(s) for current unit below.

Box 2. List related objects and processes

2. List some objects.
3. List some actions/processes.

Box 3. Brainstorm combinations

4. Brainstorm some ways to combine items (not necessarily all of them) from Box 2.

Box 4. Choose number of time points

5. Copy one of the brainstormed arrangements from Box 3 into one of the comic strip panels below. Decide whether to describe additional time points. Fill in as many additional panels as needed. *Timelines are good for testing whether students can recognize that some principles (e.g. conservation laws) sometimes apply to two, but not to three, time points.*

$t = t_i$	$t_i < t < t_f$	$t = t_f$

6. List some quantities/variable names.

7. In the lists of above, circle some quantities/variables that might be interesting to calculate.

8. **Derive expressions** (**general** and **limiting-case**) for some of the quantities brainstormed in the preceding step. (Use a separate page for each calculation).

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A. Level 1 reasoning: Retrieve and apply one single cribsheet principle; monocausality and multicausality				
A1. Test for knowledge of (name principle)				
A2. Quantitative relationship				
A3. Pick a variable appearing in A2				
A4. Pick other variable(s) appearing in A2				
A5. Other formula(s) involving variable(s) appearing in A4				
A6. Way(s) to change scenario so as to affect the variable(s) in A4 directly and/or by way of A5				

Kind: “Suppose that the situation is now changed as described in A6. How is the variable in A3 affected?”
Fun: “Suppose that the situation is now changed (insert phrases that might be misread as phrases describing the change in A6, but which, thanks to subtle changes in wording, are actually irrelevant to the problem). How is the variable in A3 affected?”

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B. Level 2a reasoning: Retrieve and apply multiple cribsheet principles; monocausality and multicausality				
B1. Test for knowledge of (name 1st main principle)				
B2. Quantitative relationship				
B3. Test for knowledge of (name of 2nd main principle)				
B4. Quantitative relationship				
B5. Pick a variable appearing in B2/B4				
B6. Pick other variable(s) in B2/B4				
B7. Other formula(s) involving variable(s) appearing in B6				
B8. Way(s) to change scenario so as to affect the variable(s) in B6 directly and/or by way of B7				

Kind: “Suppose that the situation is now changed as described in B8. How is the variable in B5 affected?”
Fun: “Suppose that the situation is now changed (insert phrases that might be misread as phrases describing the change in B8, but which, thanks to subtle changes in wording, are actually irrelevant to the problem). How is the variable in B5 affected?”

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C. Level 2b reasoning: Retrieve and apply multiple cribsheet principles; assess implication(s) of invalidating a principle				
C1. Test for knowledge of (name 1st main principle)				
C2. Quantitative relationship				
C3. Test for knowledge of (name of 2nd main principle)				
C4. Quantitative relationship				
C5. Principle to toggle on/off				
C6. Reason(s) that principle in C5 held				
C7. Change(s) that can negate reason(s) from C6				
C8. Quantitative consequences (e.g. $=$ replaced by $<$) that can occur when changes in C7 toggle principle in C5				
C9. Changes in variable(s) that can be deduced from C8				

Kind: “Suppose that the situation is now changed as described in C7. How is the variable in C9 affected?”
Fun: “Suppose that the situation is now changed (insert phrases that might be misread as phrases describing the change in C7, but which, thanks to subtle changes in wording, are actually irrelevant to the problem). How is the variable in C9 affected?”

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D. Theory of mind: Critique reasoning

D1. Correct reasoning	**D2. Incorrect reasoning**
Write out a correct solution to a question based on the worksheets for Level 1, 2a, or 2b reasoning. Work vertically down this column, splitting this column into the "statement-reason" two-column proof format if helpful.	Circle ~2 of the more subtle points in the correct reasoning written out in column D1. In this column, write out incorrect versions of the circled equations, illustrations, and sentences. Avoid creating superficial errors that result from weaknesses in arithmetic. Try, instead, to come up with examples of errors that result from serious errors in knowledge and logic, including 1. Misapplication of equations and laws resulting from (a) Failure to recognize cases of linguistic function overloading and homonyms. (b) Failure to parse prepositional phrases. 2. Sloppy learning of "the gist" of relationships in English without carefully reading the exact details of equations (see example below). 3. Relying on intuition to generate reasons not found in the canon of permitted conditional statements in AP Physics (guessing by feeling).

Example

D3. Example of a correct statement	**D6.** Example of a way to obtain an incorrect statement based on a correct statement
D4. "Inward acceleration quadruples as the tangential speed doubles because inward acceleration is proportional to the square of the tangential speed."	**D7.** Re-express the justification in D5 less precisely, for example, by writing "because inward acceleration increases with increasing tangential speed."
D5. Example of correct and precise justification "because inward acceleration is proportional to the square of the tangential speed."	**D8.** Develop a claim that is consistent with the less precise statement in D7, but which is distinct from the claim in D4 and which contradicts the precise statement of the justification in D5. For example, write, "Inward acceleration doubles as the tangential speed doubles because inward acceleration increases with increasing tangential speed." The incorrect statement creates an incorrect assumption that inward acceleration is proportional to tangential speed.

In the template of AP Physics 1 & 2 problem types (separate handout), refer to problem type TOM-CR for an example of how the contents of columns D1 and D2 can be organized into parts of a problem.

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E. Experimental design: Use relationships to plan appropriate procedures; identify what to measure for a “single point” trial				
E1. Setup, preparation, and initialization corresponding to calculation				
E2. Copy derived relationship and circle variable to be determined				
E3. Isolate circled variable				
E4. Other variable(s) needing to be measured and how they can be measured (instruments and techniques)	Var, Instr. Tech.	Var, Instr. Tech.	Var, Instr. Tech.	Var, Instr. Tech.

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F. Experimental design: Use relationships to plan appropriate procedures; investigate trend				
F1. Independent variable x				
F2. Dependent variable y				
F3. Setup, preparation, and initialization (e.g. “launch”)				
F4. Procedure (instruments and techniques) for changing the value of x (without changing values of control variables)				
F5. Procedure (instruments and techniques) for measuring the resulting value of y				

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G. Experimental design: Use relationships to plan appropriate analyses				
G1. Annotate an equation that has $y = mx + b$ form, indicating x, y, m, and b				
G2. Cartoon of scatterplot with a line of best fit				
G3. Quantity to be determined from expression for m and/or expression for b				
G4. Other quantities that need to be measured and how they are to be measured (instruments and techniques)	Var, Instr. Tech.	Var, Instr. Tech.	Var, Instr. Tech.	Var, Instr. Tech.

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Example problem parts
Render problem parts using the examples below. Combine problem parts using the handout outlining AP Physics 1 & 2 problem types. Increase cognitive load for all problem types by writing extensive and dense situation descriptions.

Level 1 and 2a reasoning

FRQ-Predict effect of change. "Describe a situation. Suppose that ___ is (adjusted). How will ___ be affected? Indicate increase, decrease, or stay the same.
Justify your answer."

FRQ-Compare situations. "Describe situations A and B side by side. Compared to situation B, how is the _____ of situation A? Indicate greater than, less than, or equal.
Justify your answer."

MC-Predict effect of change. "Describe a situation. Suppose that ___ is (adjusted). How will ___ be affected? Choose the correct response.
(A) Right conclusion because right reason.
(B) Right conclusion because true, but irrelevant, reason
(C) Wrong conclusion because right reason.
(D) Wrong conclusion because true, but irrelevant, reason"

MC-Compare situations. "Describe situations A and B side by side. Compared to situation B, how is the _____ of situation A? Choose the correct response.
(A) Right conclusion because right reason.
(B) Right conclusion because true, but irrelevant, reason
(C) Wrong conclusion because right reason.
(D) Wrong conclusion because true, but irrelevant, reason"

RT/MC-Rank situations. (Make trap answers that penalize students who forget that a change in a situation can affect multiple variables, not just the one variable that most readily comes to mind). "The panels below illustrate scenarios in which ____ (describe adjustment(s)). Rank the panels according to _____ (affected quantity) from greatest to least."

Level 2b reasoning

FRQ-Compare-without given result. "In situation A _____, but in situation B _____ (describe change that toggles applicability of a principle, but do not actually mention the principle). In a coherent paragraph-length . . . , explain how is ____ affected."

FRQ-Compare-with given result. In situation A ____, but in situation B ____ (change that toggles applicability of a principle—do not actually mention the principle). In a coherent paragraph-length . . . , explain why ___ is ___ (describe effect)."

Critique reasoning

In inventory of AP Physics 1 & 2 problem types, see TOM-CR.

Experimental design

FRQ/MC-Linear analysis. "Based on (given) plot, what is ____ (calculated value using slope and/or intercept)."

FRQ/MC-Linear analysis. "What is the significance of the fact that the (slope | intercept) is (positive, negative, zero)?"

MC-Design. "Someone wants to test (relationship). How can this be achieved?
(A) Correctly adjust something that directly adjusts independent variable *with all else controlled*, and correctly observe possible resulting changes in dependent variable
(B) Correct adjustment (all else controlled), incorrect observation
(C) Incorrect adjustment/control, correct observation
(D) Incorrect adjustment/control, unhelpful observation"

MC-Design. "Which of the following options lists a set of instruments that can be used to measure (variable)?"

In the inventory of AP Physics 1 & 2 problem types, see PEA-VAL and PEA-BOOLEAN.