PhysPort Implementation Guide:
Minnesota Assessment of Problem Solving (MAPS)
Version 4.4

PhysPort
Supporting physics teaching with research-based resources

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Implementation

Purpose of the MAPS

To assess written solutions to problems given in undergraduate introductory physics courses.

Course Level: What kinds of courses is it appropriate for?

Intro college and High school

Content: What does it assess?

Problem solving (Useful problem description, physics approach, specific application of physics, mathematical procedures, logical progression)

Timing: How long should I give students to take it?

N/A minutes

Example Questions

The full Minnesota Assessment of Problem Solving (MAPS) rubric from Docktor et al. 2016.

TABLE I.

	5	4	3	2	1	0	NA(problem)	NA(solver)
USEFUL DESCRIPTION	The description is useful, appropriate, and complete.	The description is useful but contains minor omissions or errors.	Parts of the description are not useful, missing, and/or contain errors.	Most of the description is not useful, missing, and/or contains errors.	The entire description is not useful and/or contains errors.	The solution does not include a description and it is necessary for this problem /solver.	A description is not necessary for this *problem*. (i.e., it is given in the problem statement)	A description is not necessary for this *solver*.
PHYSICS APPROACH	The physics approach is appropriate and complete.	The physics approach contains minor omissions or errors.	Some concepts and principles of the physics approach are missing and/or inappropriate.	Most of the physics approach is missing and/or inappropriate.	All of the chosen concepts and principles are inappropriate.	The solution does not indicate an approach, and it is necessary for this problem/ solver.	An explicit physics approach is not necessary for this *problem*. (i.e., it is given in the problem)	An explicit physics approach is not necessary for this *solver*.
SPECIFIC APPLICATION OF PHYSICS	The specific application of physics is appropriate and complete.	The specific application of physics contains minor omissions or errors.	Parts of the specific application of physics are missing and/or contain errors.	Most of the specific application of physics is missing and/or contains errors.	The entire specific application is inappropriate and/or contains errors.	The solution does not indicate an application of physics and it is necessary.	Specific application of physics is not necessary for this *problem*.	Specific application of physics is not necessary for this *solver*.
MATHEMATICAL PROCEDURES	The mathematical procedures are appropriate and complete.	Appropriate mathematical procedures are used with minor omissions or errors.	Parts of the mathematical procedures are missing and/or contain errors.	Most of the mathematical procedures are missing and/or contain errors.	All mathematical procedures are inappropriate and/or contain errors.	There is no evidence of mathematical procedures, and they are necessary.	Mathematical procedures are not necessary for this *problem* or are very simple.	Mathematical procedures are not necessary for this *solver*.
LOGICAL PROGRESSION	The entire problem solution is clear, focused, and logically connected.	The solution is clear and focused with minor inconsistencies	Parts of the solution are unclear, unfocused, and/ or inconsistent.	Most of the solution parts are unclear, unfocused, and/ or inconsistent.	The entire solution is unclear, unfocused, and/ or inconsistent.	There is no evidence of logical progression, and it is necessary.	Logical progression is not necessary for this *problem*. (i.e., one-step)	Logical progression is not necessary for this *solver*.

Access: Where do I get the assessment?

Download the assessment from physport at www.physport.org/assessments/MAPS.

Versions and Variations: Which version of the assessment should I use?

The latest version of the MAPS, version 4.4, was released in 2008.

Administering: How do I give the assessment?

- The MAPS is not a test that is given to students. It is a rubric used to assess physics problem solutions.
- Read the "Problem Solving Rubric Category Descriptions" (on page 2 of problem-solving rubric) and familiarize yourself with the rubric descriptions.
- Determine the score (0 to 5 points or NA (problem) or NA (solver)) for each individual category using the rubric descriptions, for each problem you are assessing. Use NA (problem) when a given rubric category is not applicable to a given problem. Use NA (solver) when a given rubric category is not applicable for that specific solver (student).
- More training materials, including sample student solutions and a description of scores using the rubric are available here.

Scoring: How do I calculate my students' scores?

- The developers of the MAPS do not combine the individual scores into a single score, but instead looking at the frequency of rubric scores for each rubric category across all of your students to get a sense of their strengths and weaknesses around problem solving.

- If you want an overall score, you could combine the scores for each category into an overall score by determining the appropriate weighting based on the categories you consider most important for a particular problem. There is no consensus on how to weight the categories to create an overall score. For example, in one study, the developers weighted the total score as: Description (10%), Approach (30%), Application (30%), Math (10%), Logic (20%). For a different problem where the description was more important, the developers weighted the total score as: Description (20%), Approach (20%), Application (30%), Math (10%), Logic (20%).
- Once someone is familiar with the categories of the rubric, it takes approximately the same amount of time to score a written solution as it would take to use standard grading procedures.

Clusters: Does this assessment include clusters of questions by topic?

The rubric assesses the categories of Useful Description, Physics Approach, Specific Application of Physics, Mathematical Procedures, and an overall Logical Progression for a written problem solution.

Typical Results: What scores are usually achieved?

Because the MAPS is a rubric used to score physics problem solutions, there are no typical scores for this assessment. Here is an example of what the scores on this assessment look like (Table 24) for a specific physics problem (Test 1 Problem 2) for a specific group of students as reported in Docktor 2009.

Table 24: Average Rubric Scores and Problem Grades for Test 1 Problem 2

	Averages Section 1 (N=48)	**Averages Section 2 (N=110)**
Useful Description	49±4%	54±3%
Physics Approach	64±5%	73±3%
Specific Application	58±4%	62±3%
Math Procedures	78±4%	80±3%
Logical Progression	61±4%	71±3%
Rubric Score	65±4%	70±2%
Problem Grade	54±4%	67±3%

Test 1 Problem 2:

A punter kicks a football during a critical football game. The ball leaves his foot at ground level with velocity 20.0 m/s at an angle 40^{o} to the horizontal. At the very top of its flight, the ball hits a pigeon. The ball and the pigeon each stop immediately and both fall vertically straight to the ground from the point of collision.

(a) With what speed is the ball moving when it hits the pigeon? [10 points]
(b) How high was the ball when it hit the pigeon? [10 points]
(c) What is the speed of the ball when it hits the ground? [5 points]

Interpretation: How do I interpret my students' scores in light of typical results?

The MAPS rubric is different than traditional grading in that an overall score is not usually calculated. Instead, you can look at the frequency of rubric scores for each category across the students in your class to get a sense of their problem-solving strengths and weaknesses. For example, if many students in your class received a 1 or 2 in the Specific Application of Physics category, but received relatively high scores of 4 and 5 for the Physics Approach and Mathematical Procedures category, you could conclude although those students could recognize the physics principles needed to solve a problem and had the mathematical skill to do so, they were unable to apply those principles correctly to the specific situation.

You can use the MAPS rubric to look at the progression of your students' skills over time (either in a pre/post format or at multiple timepoints throughout a course). We do not recommend comparing student populations from different instructors unless several raters are used and inter-rater reliability has been established.

Resources

Where can I learn more about this assessment?

J. Docktor, J. Dornfeld, E. Frodermann, K. Heller, L. Hsu, K. Jackson, A. Mason, Q. Ryan, and J. Yang, Assessing student written problem solutions: A problem-solving rubric with application to introductory physics, Phys. Rev. Phys. Educ. Res. **12** (1), 010130 (2016).

The developers' website contains more information about the MAPS rubric and training materials to help you learn how to use the rubric for general purposes or research purposes. The rubric training materials give examples of how to apply the rubric to student solutions to problems.

Translations: Where can I find translations of this assessment in other languages?

You can download translations of this assessment in the following languages from PhysPort:

- **English**
- **Spanish** translated by Nicolás Budini

If you know of a translation that we don't have yet, or if you would like to translate this assessment, please contact us!

Background

Similar Assessments

This rubric is based on research on student problem solving at the University of Minnesota over many years - see Heller, Keith, & Anderson (1992), and the dissertations of Jennifer Blue (1997) and Tom Foster (2000). Although there are many similarities in the problem-solving processes assessed by those studies, this rubric differs in that it was extensively studied for evidence for validity, reliability, and utility. It was developed to be applicable to a broad range of problem types and topics in physics. Hull et. al (2013) found that MAPS and earlier versions of rubrics it was based on (described above) are the only "whole solution" rubrics for physics problems (where the rubric looked at the whole problem solution instead of just one or a few aspects of it).

Research: What research has been done to create and validate the assessment?

Research Validation: Bronze

This is the third highest level of research validation, corresponding to at least 3 of the validation categories below.

- [x] Based on research into **relevant theory and/or data**
- [x] Studied using **iterative use of rubric**
- [x] Studied using **inter-rater reliability**
- [ ] Studied using **expert review**
- [ ] Research conducted **at multiple institutions**
- [ ] Research conducted **by multiple research groups**
- [x] **Peer-reviewed publication**

Research Overview

The MAPS rubric is based on research on student problem solving at the University of Minnesota over many years. The MAPS rubric builds on previous work by attempting to simplify the rubric and adding more extensive tests of validity, reliability, and utility. The five problem-solving processes covered in the rubric are consistent with prior research on problem solving in physics (Docktor 2009). The validity, reliability, and utility of the rubric scores were studied in a number of different ways. Expert reviewers used the rubric to understand how rubric scores reflect the solvers process, the generalizability of the rubric as well as inter-rater agreement. Subsequent studies looked at the content relevance and representativeness, how the training materials influenced the inter-rater agreement and the reliability and utility of the rubric. Based on these studies, both the rubric and training materials were modified. The rubric was also studied using student interviews. Overall, the validity, reliability, and utility of the MAPS rubric were demonstrated with these studies. Research on the MAPS rubric is published in one dissertation, and one peer-reviewed publication.

Developer: Who developed this assessment?

Jennifer Docktor and Ken Heller

References

- J. Docktor, Development and Validation of a Physics Problem-Solving Assessment Rubric, Dissertation, University of Minnesota, 2009.
- J. Docktor, J. Dornfeld, E. Frodermann, K. Heller, L. Hsu, K. Jackson, A. Mason, Q. Ryan, and J. Yang, Assessing student written problem solutions: A problem-solving rubric with application to introductory physics, Phys. Rev. Phys. Educ. Res. **12** (1), 010130 (2016).
- J. Docktor and K. Heller, Assessment of Student Problem Solving Processes, presented at the Physics Education Research Conference 2009, Ann Arbor, Michigan, 2009.