

# Remote Summative Assessment in Equation-based Courses



## Assessment Resources

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# Spot the Error



To a novice problem-solver, incorrect solutions that reach a numerical answer may be just as convincing as correct solutions. As students become more practiced at problem-solving, they should also become better at articulating *why* certain steps were taken in the solution rather than others. **Consider providing an incorrect solution to a problem that features a common conceptual or computational mistake.**

## Examples from mathematics:

**Ex1.** Learning Goal: Students should be able to apply l' Hopital's Rule to evaluate indeterminate limits of the appropriate form.

In your own words, explain what is wrong with the following calculation.

$$\lim_{x \rightarrow 3} \frac{x^2 - 9}{x^3 - 8} \stackrel{\text{L'Hopital's}}{=} \lim_{x \rightarrow 3} \frac{2x}{3x^2} = \lim_{x \rightarrow 3} \frac{2}{3x} = \frac{2}{9}$$

**Ex2.** Learning Goal: Students should be able to identify when an integral is improper.

In your own words, explain what is wrong with the following calculation.

$$\int_1^4 \frac{1}{x-2} dx = \ln|x-2| \Big|_1^4 = \ln|4-2| - \ln|1-2| = \ln 2 - \ln 1 = \ln 2$$

## Example from economics:

**Ex.** Learning Goal: There is no error in calculation here. The student must know that to get the price for the Monopolist, they need to plug the quantity  $Q$  into the demand equation.

A profit maximizing Monopoly has the following demand, Marginal Revenue, and Marginal cost Equations, where  $P$  is Price and  $Q$  is quantity.

$$\text{Demand: } P = 2000 - 2Q$$

$$\text{Marginal Revenue: } P = 2000 - 4Q$$

$$\text{Marginal Cost: } P = 6Q$$

Find the  $P$  and  $Q$  that maximize profit for this Monopolist.

$$P = 2000 - 4Q = 6Q$$

$$Q = 200$$

$$P = 2000 - 4(200) = 1200$$

# Explain the Solution



A traditional equation-based course places heavy emphasis on the final answer, and not how one gets there. **These questions shift the emphasis from the algorithmic problem-solving to the reasoning behind it.**

An instructor could evaluate a student's reasoning by asking the student to explain an approach without solving the problem. Alternatively, an instructor might use a rubric to evaluate how well a student explains their solution.

Examples from mathematics:

**Ex.** Learning Goal: Students should understand that integration and differentiation are inverse processes.

Please explain in words how you would verify the following equality, using **two different methods**.

$$\int x \cos x \, dx = x \sin x + \cos x + C$$

Example from economics:

**Ex.** A firm is trying to make choices to minimize cost in the long run when choosing appropriate levels of labor and capital. Their production function is given by

$$Q = K^{\frac{1}{2}} L^{\frac{1}{2}}, \quad MPL = \frac{1}{2} K^{\frac{1}{2}} L^{-\frac{1}{2}}, \quad MPK = \frac{1}{2} K^{-\frac{1}{2}} L^{\frac{1}{2}}, \quad PL = 15, \quad PK = 20$$

Explain the steps that you would take to solve this problem (do not actually solve the problem). For each step, explain why the step is done and/or how this step represents actual firm behavior (i.e., if you set two equations equal to each other, WHY did you take that step?).

Rubrics for physics and other equation-based disciplines:

[AAC&U VALUE Problem Solving Rubric](#)

[AAC&U VALUE Quantitative Literacy Rubric](#)

[Jennifer Docktor, "Problem-Solving Rubric," University of Minnesota Physics Education Research and Development Group \(2008\).](#)

[Todd Tinsley, "DISCoVer Strategy Rubric"](#)

# Student-Developed Exam Questions



Instructors of equation-based courses know that it takes a sophisticated understanding of the course material to write an exam to assess whether students can *recall* information, *identify* concepts, and *solve* problems. Why not let students prepare for such an exam by asking them to design their own exam questions? In doing so, **the instructor encourages students to move further up [Bloom's taxonomy of learning](#) to better *differentiate* between concepts in the course, *critique* possible solutions, and *design* problems of their own.**

Models for encouraging higher-order thinking:

[Berrett, D. \(2019\). "A Professor Asked His Students to Write Their Own Exam Questions. Here's What He Found." \*The Chronicle of Higher Education\*, March 28.](#)

[Jones, J. \(2016\). "The Student-Developed Quiz \(or Exam\): Scaffolding Higher-Order Thinking." \*NACTA Journal Teaching Tips/Notes\*, June.](#)

Examples:

**Ex1.** Choose one interesting problem from the text of medium difficulty that was not assigned. Describe why you find it interesting. Then either solve it, or find a solution online and work through it, using your own understanding to critique that solution and improve it.

[Su, F. \(2020\). "7 Exam Questions for a Pandemic \(or any other time\)." \*Francis Su's Blog\*, April 26.](#)

**Ex2.** For each of the Chapters assigned to you, please do the following:

1. Create an exam question and assign a point value. Think of this question, being part of an hour-long exam, which is worth 100 points total.
2. Write down the solution of the question you posed.
3. In a few sentences, explain your choice of the topic for question, the question, and the assigned point value. In your justification, be sure to include how your choice of question addresses what important ideas you learned in the course.

# Open-Ended Questions



Equation-based courses can leave students with the impression that real problems have unique and fixed solutions. Such a view hardly seems to describe the work we do in our disciplines. **Shouldn't our courses capture the open-ended nature of questions in our fields and the many complementary approaches we have to answering those questions?** Classroom teachers might consider writing exam questions that ask students to connect their learning to their experiences, encourage multiple approaches to a question, or ask students to apply course knowledge to material in the literature for the discipline.

A classic illustration: The Barometer Question

[Calendra, A. \(1968\). "Angels on a Pin." \*The Saturday Review\* Education in America, December 21.](#)

Example from mathematics:

**Ex.** Give one example of a mathematical idea from this class that you found creative, and explain what you find creative about it. For example, you can choose an instance of creativity you experienced in your own problem-solving, or something you witnessed in another person's definition or reasoning.

[Su, F. \(2020\). "7 Exam Questions for a Pandemic \(or any other time\)." \*Francis Su's Blog\*, April 26.](#)

Example from physics:

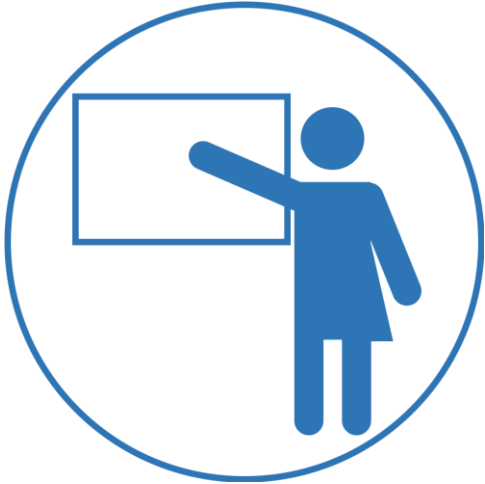
**Ex.** You find yourself in the International Space Station, orbiting the earth, and needing to determine the mass of lemon-sized, solid object.

- Come up with three ways you could determine the mass of the object using concepts you have learned in this course.
- Describe the direct measurements you would make and how you would use physics concepts to determine the mass.
- Critique the pros and cons of each method.

MCAT-style examples:

["Chemical and physical sciences practice passage questions." Khan Academy. <https://www.khanacademy.org/test-prep/mcat/physical-sciences-practice>](https://www.khanacademy.org/test-prep/mcat/physical-sciences-practice)

# Oral Assessment



Have you ever had that moment where you ask a student to solve a problem for you on your office board and you begin to see how disorganized the material is inside the student's mind? Or, alternatively, have you listened to a student explain a solution to a peer and within seconds it's clear how well the student understands the material? **Oral assessment can be a terribly efficient method to assess whether significant learning has happened or not, but it might prove more difficult to assess the *degree* to which learning has happened without introducing bias.**

## Using videos to assess learning:

Dr. Rhett Allain of Southeastern Louisiana University asks students to submit videos of themselves working problems. In a 2017 *Wired* article he describes how this low-stakes version of oral assessment works in his course:

*I give my students the chance to create a short video—less than five minutes—in which they solve a problem. They post it, send me a link, and I assign a grade. Students who don't like their grade can keep sending me videos.*

You will be surprised how quickly a short video conveys just what students know—or don't know—about the subject. I can tell how well they understand a concept simply by looking at the problem they choose to solve. When students approach a new idea, they tend to pick trivial problems that require little more than plugging data into an equation. As their understanding of the material deepens, they tackle more complicated questions, or even make up problems on their own.

[Allain, R. \(2017\). "The Best Way to Test Students? Make Them Explain It On Video." \*Wired Science\*, August 16.](#)

## Guides on the Use of Oral Assessment:

[Joughin, G \(2010\). "A short guide to oral assessment." Leeds Met Press in association with University of Wollongong.](#)

An outstanding guide on oral assessment complete with pros, cons, bias, and rubrics.

[Chan, C. \(2009\). "Assessment: Oral Assessment." Assessment Resources@HKU, University of Hong Kong.](#)

An even shorter guide to oral assessment with helpful information on rubrics.

# General Assessment Resources

## General Assessment Information:

- [Fisher, M.R., Jr. and Bandy, J. \(2019\). "Assessing Student Learning. Vanderbilt University Center for Teaching." Center for Teaching, Vanderbilt University.](#)
- ["Course-Level Assessment Resources." Institutional Research, Analysis, & Planning, Bates College.](#)

## General Assignment Information:

- ["Creating Assignments." Eberly Center, Carnegie Mellon University.](#)

## Assessment in Online Courses:

- [Harris, K. and Kim, H. \(2020\). "10 Alternatives to Traditional Exams: Remote Assessment Options That Support Student Learning." Teaching and Learning with Technology, Rutgers University.](#)
- [Davis, G. \(2016\). "The Benefits of Rubrics in Online Classes." Wiley Education Services.](#)
- [Orlando, J. \(2017\). "What Research Tells Us about Online Discussion." Faculty Focus, Magna Publications. March 17.](#)