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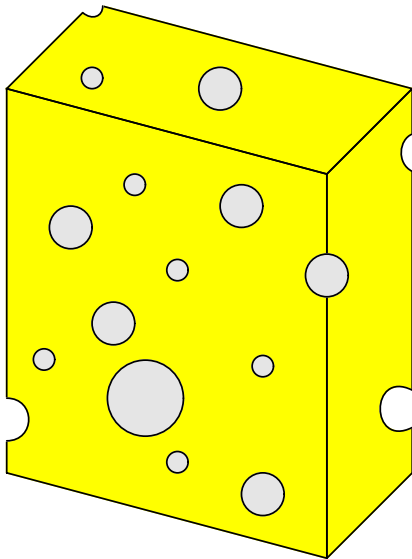
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- 1 Today's presentation begins with a critique of a common problem within academic courses

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- 1 Today's presentation begins with a critique of a common problem within academic courses
- 2 Next, we will explore a strategy to address this problem

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- 1 Today's presentation begins with a critique of a common problem within academic courses
- 2 Next, we will explore a strategy to address this problem
- 3 Finally, we will look at examples of how this solution finds application at BTC

Meet David

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One of my second-year Instrumentation students, David, was unable to manipulate algebraic expressions as simple as this:

$$2x - 5 = 13 \quad (\text{solve for } x)$$

Meet David

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Stress

One of my second-year Instrumentation students, David, was unable to manipulate algebraic expressions as simple as this:

$$2x - 5 = 13 \quad (\text{solve for } x)$$

This was despite having passed MATH 98, MATH 99, and MATH& 141, as well as the entire first-year sequence of Instrumentation courses.

Deja-vu

Have you ever seen this before, where a student comes to your class with major “holes” in their competence?

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Stress

Have you ever seen this before, where a student comes to your class with major “holes” in their competence?

Have you ever contributed to this before, where a student passed your class with major “holes” in their competence?

Deja-vu

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Have you ever seen this before, where a student comes to your class with major “holes” in their competence?

Have you ever contributed to this before, where a student passed your class with major “holes” in their competence?

I certainly have!

How does this happen?

Conceptual crutches

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Students are very good at finding “crutches” for their conceptual weaknesses. Typically this takes the form of memorization in lieu of reasoning.

How does this happen?

Conceptual crutches

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Stress

Students are very good at finding “crutches” for their conceptual weaknesses. Typically this takes the form of memorization in lieu of reasoning.

Does this sound familiar to anyone?

How does this happen?

Conceptual crutches

Students are very good at finding “crutches” for their conceptual weaknesses. Typically this takes the form of memorization in lieu of reasoning.

Does this sound familiar to anyone?

This is how David survived his first year of Instrumentation: he would memorize every form of every algebraic formula used in order to avoid having to solve for variables.

How does this happen?

The Points Game

Students “play the points game” to pass courses. Most courses spread enough points over a range of measures to allow students to pass even if they fail to grasp one or more major concepts.

How does this happen?

The Points Game

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How does this happen?

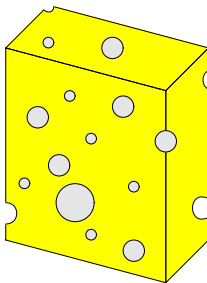
The Points Game

Students “play the points game” to pass courses. Most courses spread enough points over a range of measures to allow students to pass even if they fail to grasp one or more major concepts.

Does this sound familiar to anyone?

This is how David survived his math courses: the grading structure left enough room for him to earn a passing grade despite never learning how to solve for variables.

Swiss-cheese competence



Any course where a passing grade is based on achieving a minimum *average* score guarantees *swiss-cheese competence* where some students exit with “holes” in their knowledge and abilities.

Swiss-cheese competence

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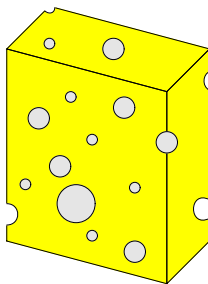
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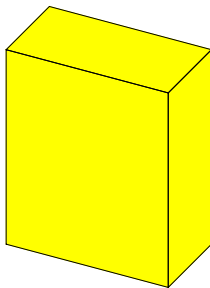
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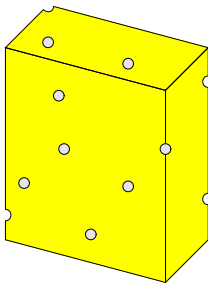
Maybe this won't matter much, if the “holes” lie in areas of knowledge and skill that aren't essential. But what if some of those holes happen to fall on one or more *really important* areas?

Perfection is unrealistic



Expecting every single student to master every single concept in any complex course of study is simply not realistic. Students are human beings, after all!

Raise the cut score?



Raising the minimum passing score helps, but at the risk of unnecessarily failing students who could succeed given the right circumstances. Students are human beings, after all!

PE licensure exam

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Some years ago, I read an online post on an engineering discussion website where a professional engineer described his experience taking the exam for his engineering license. He said this exam came in two parts:

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Stress

Some years ago, I read an online post on an engineering discussion website where a professional engineer described his experience taking the exam for his engineering license. He said this exam came in two parts:

- 1 The first part of the exam had to be passed with 100% competence – failing any part of this meant failing the entire examination!

PE licensure exam

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Stress

Some years ago, I read an online post on an engineering discussion website where a professional engineer described his experience taking the exam for his engineering license. He said this exam came in two parts:

- 1 The first part of the exam had to be passed with 100% competence – failing any part of this meant failing the entire examination!
- 2 The second part of the exam had a regular “cut score” of 70% correct to pass

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The technical term for the first kind of assessment is a *mastery exam*. The student cannot pass unless and until they demonstrate *mastery* of all concepts represented on that exam. Some common traits of mastery exams include:

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Stress

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- Exclusive focus on only the most important concepts

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The technical term for the first kind of assessment is a *mastery exam*. The student cannot pass unless and until they demonstrate *mastery* of all concepts represented on that exam. Some common traits of mastery exams include:

- Exclusive focus on only the most important concepts
- A very high minimum score to pass (generally 80% or higher)

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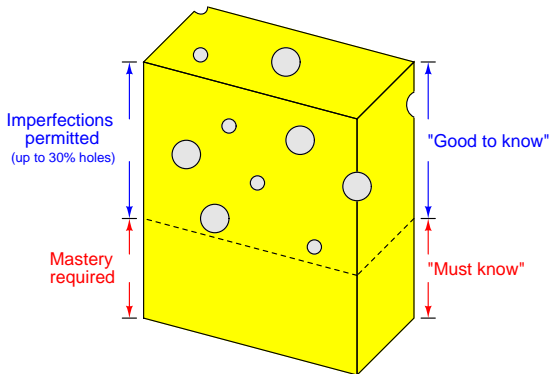
Fail rate
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Stress

The technical term for the first kind of assessment is a *mastery exam*. The student cannot pass unless and until they demonstrate *mastery* of all concepts represented on that exam. Some common traits of mastery exams include:

- Exclusive focus on only the most important concepts
- A very high minimum score to pass (generally 80% or higher)
- Multiple opportunities to re-try

PE licensure exam

The PE exam set limits where “holes” are allowed:



In other words, a Professional Engineer had to score 100% on the “must know” areas. The rest could be imperfect.

Mastery in the lab

Safety first!

Mastery assessments are commonly found in clinical and lab teaching environments where students practice safety-related skills. The reasoning here is self-evident:

Mastery in the lab

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Mastery in the lab

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- What would less than 100% competence mean for a mechanic replacing brakes on a vehicle?

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- What would less than 100% competence mean for a nurse administering a dose of medicine?
- What would less than 100% competence mean for a mechanic replacing brakes on a vehicle?
- What would less than 100% competence mean for an electrician wiring lights in a new home?

Mastery in the lab

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Mastery is the standard here because the stakes are so high

Mastery in the classroom

Ensuring a solid foundation!

Why not apply a standard of mastery to all concepts we know to be *absolutely fundamental* to the students' future success, not just those related to safety?

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Ensuring a solid foundation!

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Why not apply a standard of mastery to all concepts we know to be *absolutely fundamental* to the students' future success, not just those related to safety?

This is what helped David fill the holes in his algebra competence: being faced with mastery exams in second-year Instrumentation courses where he *had* to manipulate equations.

Mastery in the classroom

Ensuring a solid foundation!

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Why not apply a standard of mastery to all concepts we know to be *absolutely fundamental* to the students' future success, not just those related to safety?

This is what helped David fill the holes in his algebra competence: being faced with mastery exams in second-year Instrumentation courses where he *had* to manipulate equations.

David mastered this skill after just one week of remediation, knowing this was necessary for him to pass.

Good mastery objectives

Objectives represented on a mastery assessment must share these three traits:

Good mastery objectives

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Objectives represented on a mastery assessment must share these three traits:

- 1 They must be *critically* important

Good mastery objectives

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Stress

Objectives represented on a mastery assessment must share these three traits:

- 1 They must be *critically* important
- 2 They must be within all students' reach

Good mastery objectives

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Objectives represented on a mastery assessment must share these three traits:

- ① They must be *critically* important
- ② They must be within all students' reach
- ③ They must be clearly stated and thoroughly covered

Example #1

(sampled from BTC course syllabus)

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GRADING CRITERIA FOR CLASS: 4 module exams and one math exam will be given; these will count for 80% of the course grade. To receive a passing grade, exam scores must have a combined average of 80% or greater, 100% is a passing score for math exams. Students who do not maintain this average will not receive a passing grade in the course and will not be able to progress in this program. The math exams may be retaken two times. If not passed on the third time, this is unsatisfactory progress and the student will not be allowed to progress in the program. Scoring below 80% on an individual theory exam requires content remediation. The student is responsible for meeting with the instructor to create a remediation plan.

Example #2

(sampled from BTC course syllabus)

Assessment	Percentage weight
Tests, Labs, Presentations	80%
Attendance	20%
TOTAL	100%

Exams and Quizzes: All exams and quizzes must be completed with 80% correct to pass the course. Scores less than 80% correct will require a retake of the exam or quiz. The retake must be passed at 80% correct or above. The recorded score on the grade sheet will be the first attempt.

Example #3

(sampled from INST230 course syllabus)

Assessment	Percentage weight
Completing <i>all</i> mastery exams and mastery lab objectives	50%
Proportional exam	40%
Lab questions	10%

Mastery exam re-takes carry no penalty. Failure to successfully pass a mastery exam by the deadline will result in an F grade. Failure to complete any “mastery” lab objective by the deadline will result in a C- grade cap, with a one-day extension to complete. Failure to complete those mastery objectives by the end of that extra day will result in an F grade.

INST230: Motor Controls course

Objectives covered on first mastery exam:

- ① Sketch proper wire connections for a relay control circuit
- ② Determine status of a relay logic circuit given a schematic diagram and switch stimulus conditions
- ③ Calculate either the full-load current or the horsepower of an electric motor (single-phase) given the other relevant parameters
- ④ Solve for a specified variable in an algebraic formula
- ⑤ Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms

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INST230: Motor Controls course

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- ④ Solve for a specified variable in an algebraic formula
- ⑤ Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms

This list appears on every assignment given to students during the INST230 course

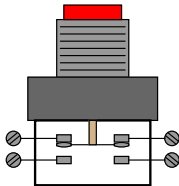
INST230_x1 mastery exam

Typical circuit-sketching question

Sketch a circuit *de-energizing* the lamp when the switch is pressed and *energizing* the lamp when the switch is released. The switch contacts must not experience more than 24 volts:



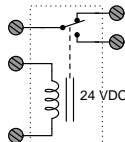
Pushbutton switch



24 VDC supply



Relay



INST230_x1 mastery exam

Typical relay circuit status question

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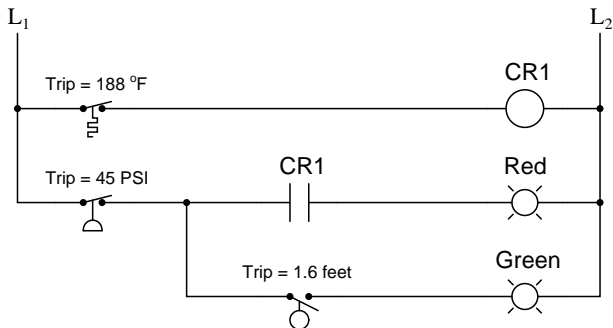
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Determine the statuses of the red and green lamps:



Pressure = 40 PSI ; Level = 2.2 feet ; Temp = 232 °F

INST230_x1 mastery exam

Typical motor current/power question

A 2.5 horsepower, single-phase electric motor runs on a line voltage of 117 volts. Calculate the line current for this motor while operating at its rated power, assuming 94% efficiency and a perfect power factor (1.0).

INST230_x1 mastery exam

Typical algebra question

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This formula describes the amount of *reactance* (X_C) exhibited by a capacitor (C) at different frequencies (f):

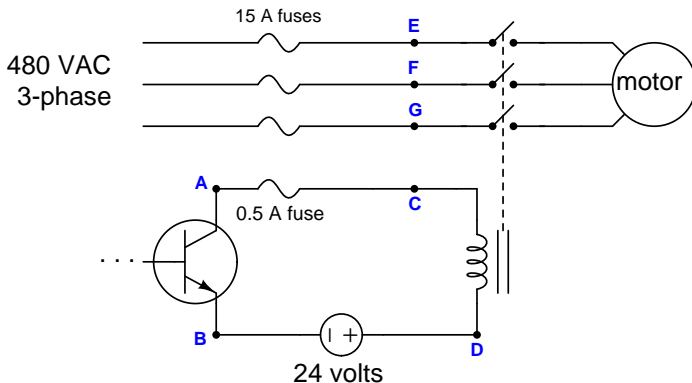
$$X_C = \frac{1}{2\pi fC}$$

Algebraically manipulate this formula to solve for f

INST230_x1 mastery exam

Typical circuit fault question

This electric motor won't start. A voltmeter reads 0 volts between **C** and **D** when the motor should be running:



INST230_x1 mastery exam

Typical circuit fault question (continued)

Identify the likelihood of each specified fault for this circuit, considering each fault one at a time (i.e. no coincidental faults):

Fault	Possible	Impossible
Transistor failed open		
Transistor failed shorted		
Motor winding(s) failed open		
0.5 amp fuse blown		
15 amp fuse blown		
Relay coil failed open		

INST230_x1 mastery exam

Re-take policy

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If *any* question is incorrectly answered on this exam, the student must re-take a new version of the same mastery exam in its entirety.

No penalty for failed mastery exams, except that it must be passed by a specified deadline in order to pass the course.
Limit of one re-take per day.

Student confers with instructor following a failed attempt.
Problem(s) identified and remediation recommended.

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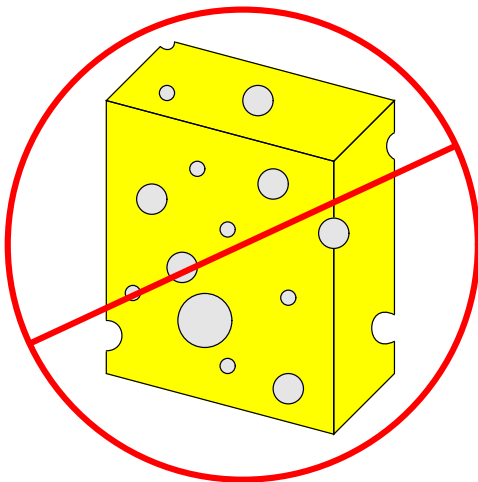
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Frequently Asked Question

Won't this fail a lot of students?

Frequently Asked Question

Won't this fail a lot of students?

No, because:

- Students know what's expected of them well in advance
- The concepts are covered thoroughly
- Multiple re-tries are allowed

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Frequently Asked Question

Won't this take a lot of time?

Frequently Asked Question

Won't this take a lot of time?

Not really. Time spent ensuring a solid foundation saves time later in the course (and in the program, if you teach a sequence of courses) because students progress with a stronger grasp of foundational concepts.

Frequently Asked Question

What about the time required for re-takes?

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Frequently Asked Question

What about the time required for re-takes?

Encourage students to get it right the first time, to reduce re-takes. Options include:

- First-attempt score recorded toward the grade
- Bonus for passing on the very first attempt

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Frequently Asked Question

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Encourage students to get it right the first time, to reduce re-takes. Options include:

- First-attempt score recorded toward the grade
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Schedule re-takes so as to not disrupt your teaching:

- Exam re-takes administered during office hours
- Exam re-takes scheduled after hours, outside of class time (e.g. ExamView)

Frequently Asked Question

Won't such high standards over-stress students?

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Frequently Asked Question

Won't such high standards over-stress students?

No, because they know the opportunity to try again gives them room to make honest mistakes.

Frequently Asked Question

Won't such high standards over-stress students?

No, because they know the opportunity to try again gives them room to make honest mistakes.

Also, mastery standards communicate a very important message to students: *you can do this!* This is encouraging, not discouraging.