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The Use of Asynchronous Web Modules for Review and Just-in-time Learning of Mechanics

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Introduction

This paper presents the concepts and plans for developing a set of asynchronous web modules that are designed to provide an effective way for a student to review, discover misconceptions, and extends his/her understanding of mechanics to a more realistic level. The process was developed using examples from an Interactive Learning Systems Institute by Pacific Crest[1]. The modules will cover special topics in:

- Statics
- Particle Dynamics
- Rigid Body Dynamics
- Strength of Materials

Each module will contain a set of learning objects (LO), based of a survey of the departmental faculty. Although the opportunity exists for the student to directly use the module for review, a set of problems will be provided that will direct the student to a particular section of a module if an error is detected. The students will not be provided with a specific answer, but they must discover their problem from the material presented. It has been shown that the process of just-in-time self-discovery maximizes retention of information[3].

The combination of learning styles and maturity results in a wide diversity of fundamental understanding in upper division students[3]. Although review lectures are often given at the start of the new course, the group diversity prevents many students from benefiting from this class time. The instructor presents from the perspective of an expert, however the students can easily miss significant points because of both the context of their understanding and the pace of material presentation. Because they are not immediately using the information, they frequently do not realize that they do not fully understand the concepts presented.

The effectiveness of the modules will be assessed during the spring of 2003 and the information used to improve and extend the future efforts in this area. The materials will be used initially in a junior level biomechanics course. The class will be randomly separated into two groups for each module. Both groups will be given a pre-test. One group will be told to review material for a second test, while the other group will be given access to the review modules. The ratio of the post-test to pretest performance will be used to assess the benefits of a particular set of LOs. After the post-test, the students will be surveyed on their perceptions of strengths and areas for improvement of the LOs and then all students will be provided access to the LOs.

Background

The movement from tutoring to large classes greatly reduces the level of learning[2]. Bloom demonstrated a move from 50% comprehension in large classes to 90% comprehension if pathways to mastery were developed[2]. The difficulty in achieving mastery relates to both faculty and student time.

We believe that technology may provide a solution to these problems when a combination of educational planning and web development are joined. The questions used to direct students to the just-in-time learning objects should provide individualized guidance for the students to prepare them for new material to be presented.

The problems presented in engineering are reality that has already been modeled. Once the initial LOs are developed, a new set of problems will be developed for the students to develop their own models of reality. The students will be given access to the advanced modules when they have successfully completed the review modules. The completion of the modules will automatically provide them with a password and also send the faculty member an email about the student completion.

This project has been initially funded by the University of Tennessee College of Engineering and the Innovative Technology Center. Each participating faculty member received a day of training for the developments and funding for an assisting graduate student.

Plan

The following survey was sent all departmental faculty. Individual faculty that responded were also interviewed to maximize the understanding of needs.

SURVEY OF MECHANICS FACULTY

Name of Faculty Member Date:

Courses Commonly Taught:

Topics for Development of Instructional Modules

Statics
Mass, Gravity, Weight, Inertia
Free-Body Diagrams
Equilibrium
Friction

Particle Dynamics
Laws of Motion (kinematics)
Curved Path Motion
Newton's Laws (kinetics)
Conservation of Energy
Conservation of Momentum

Rigid Body Dynamics
Center of Mass
Relative Velocity
Relative Acceleration
Transition from Particles to Rigid Body
Conservation of Rotational Energy

Solid Mechanics
Statically Indeterminate Members
Shear Force and Bending Moment Diagrams
Mohr's Circle
Combined Loading
Theories of Failure

Of the topics listed above, which concepts do you find students have difficulty grasping?

List any other topics or concepts in fundamental mechanics (Statics, Dynamics, Mechanics of Materials) where students consistently have difficulty.

List any topics of concepts that you find students have difficulty integrating or transferring into other contexts (i.e. when they do not have a "textbook" problem or when they have to use the concept in a different course).

Could you suggest some specific problems that include these concepts?

Any other comments?

The results of the survey have been used to establish a priority for the continuing project. Our initial efforts have been to design the structure for all of the modules and their individual learning objects. After completion of the initial objects, problems will be presented.

A student will be given a multiple-choice question. If the answer is incorrect, the same problem will be given in multiple-choice stages. When an error is discovered, the student will be taken to one of the LOs to detect the error. If the student feels that they can see the error immediately, they can select a new problem. If the same mistake is made, they will be sent to the LO and they must complete it to be able to return to the question set.

The following are potential areas for development of LOs.

Development of Learning Objects for the various Modules

1. **Statics**
    a. **Mass-Weight-Gravity**
    b. **Applied Trig**
    c. **Free body Diagrams**
    d. **Equilibrium**
    e. **Friction**
2. **Dynamics**
    a. **Moment of Inertia**
    b. **Newton's Laws**
    c. **Energy**
    d. **Conservation**

3. **Strength of Materials**
    a. **Mohr's Circle**
    b. **Concepts of Failure**
    c. **Beam Bending**
    d. **Axial Load**
    e. **Torsion**

The process for development of each LO requires a planning process.

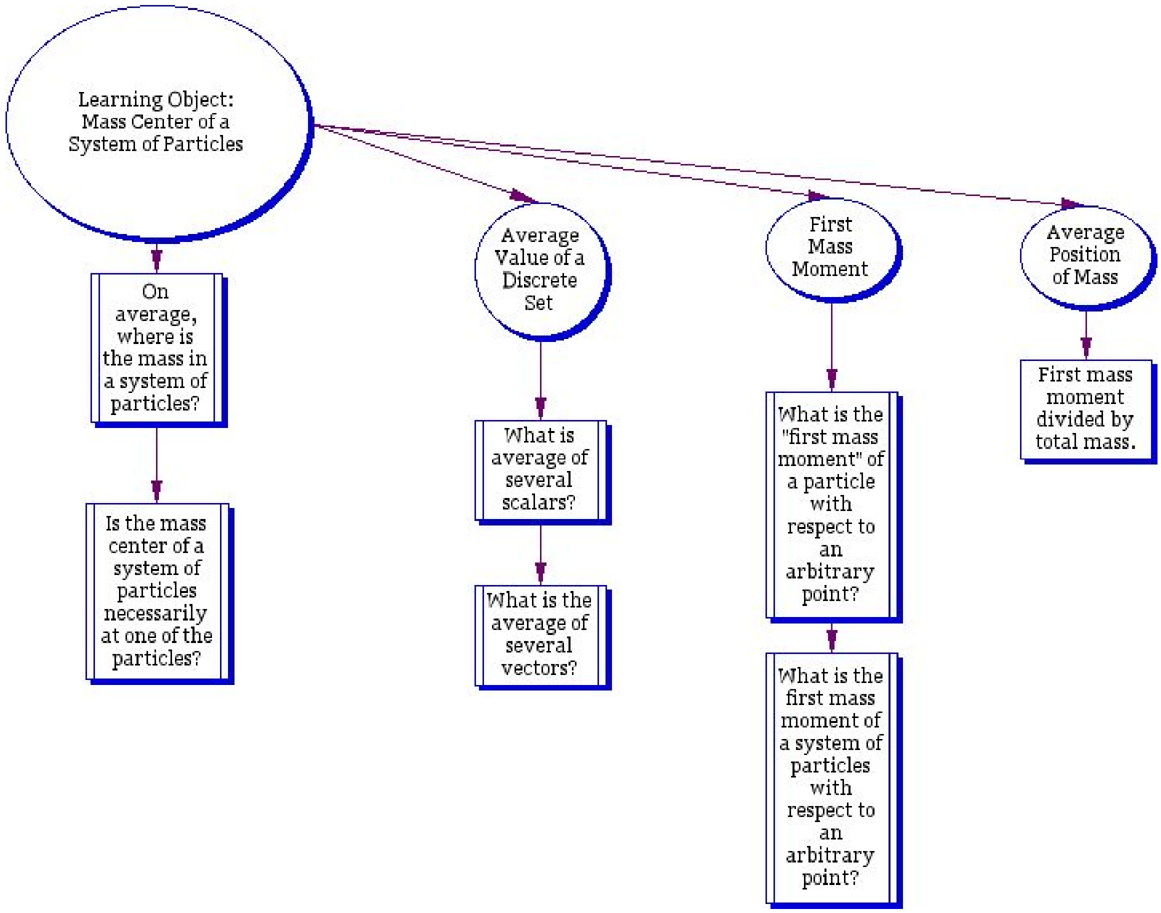
Learning Object: Mass Center of a System of Particles
On average, where is the mass in a system of particles?
Is the mass center of a system of particles necessarily at one of the particles?
Average Value of a Discrete Set
What is average of several scalars?
What is the average of several vectors?
First Mass Moment
What is the "first mass moment" of a particle with respect to an arbitrary point?
What is the first mass moment of a system of particles with respect to an arbitrary point?
Average Position of Mass
First mass moment divided by total mass.

Figure 1. Pedagogical framework for the concept of mass center

As an example of the way in which a module's structure evolves, consider the diagram in Figure 1, which shows a pedagogical model of the concept of mass center The overall concept is based on several smaller ideas, each of which plays a part in establishing the meaning of the mass center of a system of particles. Each smaller idea is represented by a question. The primary question, whose answer is "the mass center," cannot be understood without first understanding the answers to the subsidiary questions.

In constructing a learning module on the subject of mass center, we will associate each smaller idea in Figure 1 with a web page of information and exercises whose mastery implies understanding of the corresponding idea. As for all other modules in this project, wrong answers will lead the student back to topics that should equip the student to answer correctly the next time he or she attempts the exercises.

Results

The Mechanics Website allows the students to select the area that they are working to review. When selected, each module provide an estimated time for completion

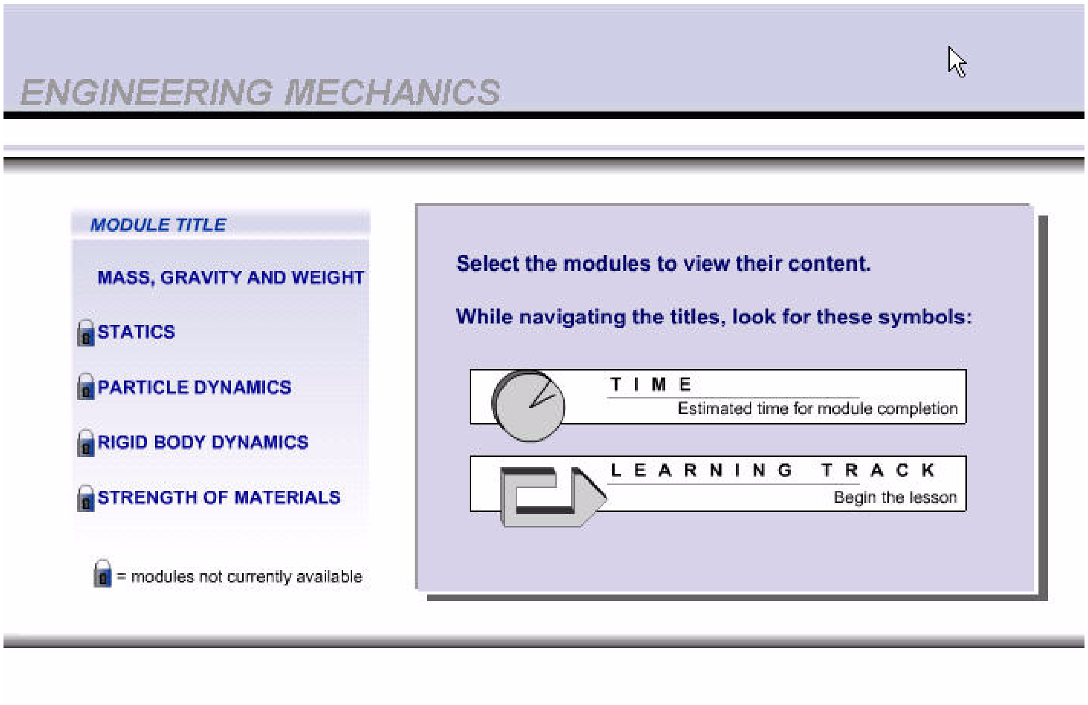

Figure 2 – Module Introduction to Learning Object areas

As part of the introduction, each module provides a "Why" as well as the time.

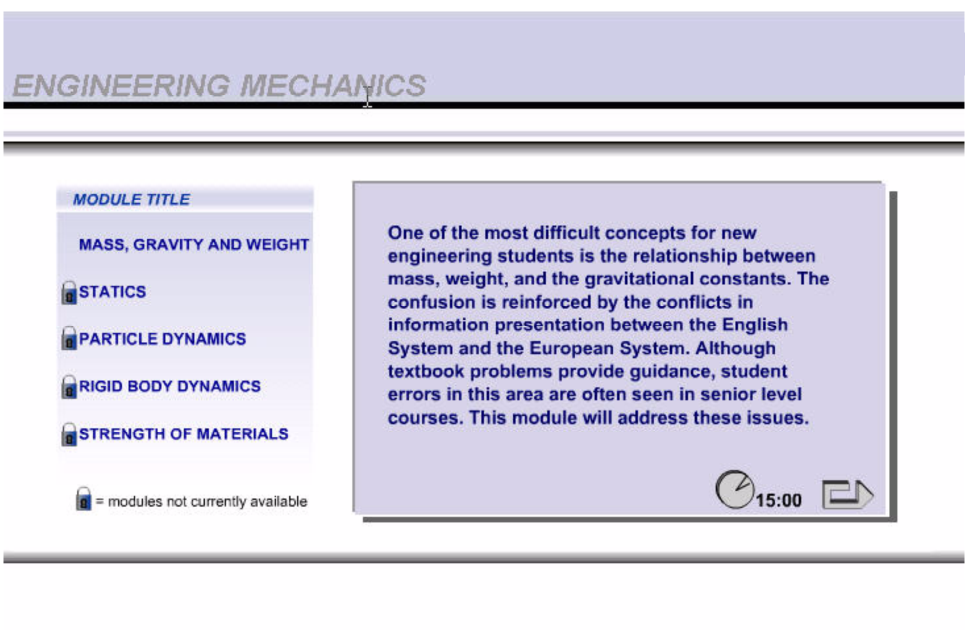

Figure 3 – Introduction to Mass, Gravity, Weight

The structure of the LOs includes a top menu enabling a student to jump from one area to another and a learning pathway. The learning pathway provides a sequence of ideas with a video/audio link for explanation. Camtasia software has been used to generate the videos, because of the ease of use.

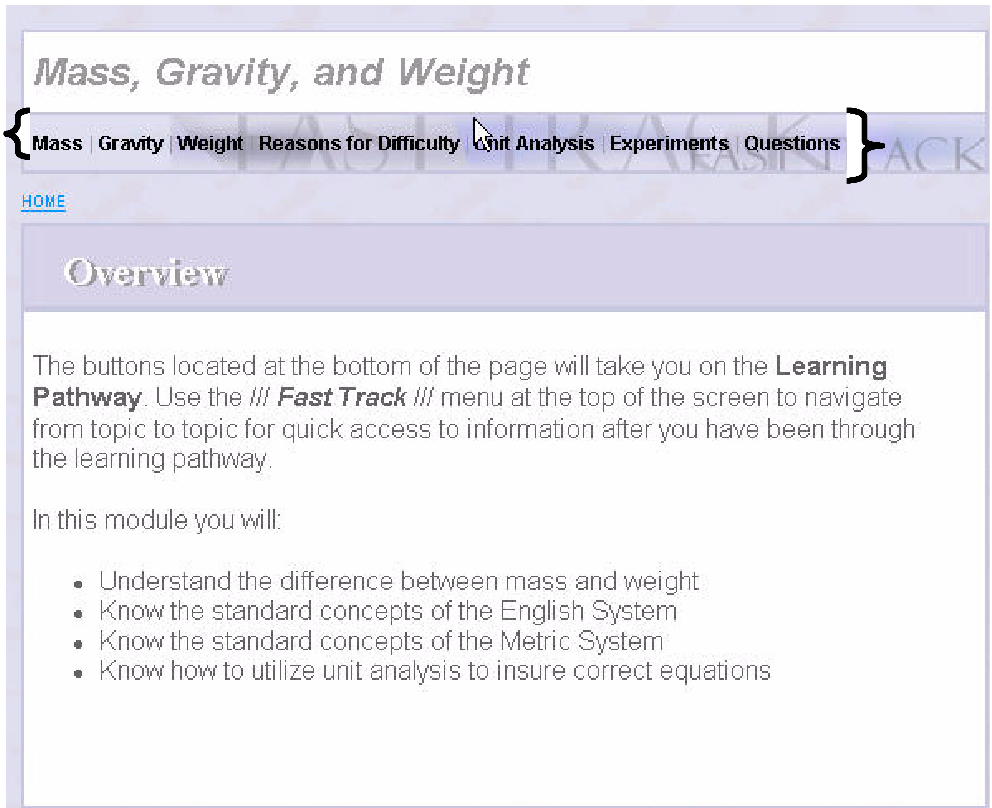

Figure 4 – LO Information on Learning versus Reference Use

As they progress through the material, they have the option of back to refresh.

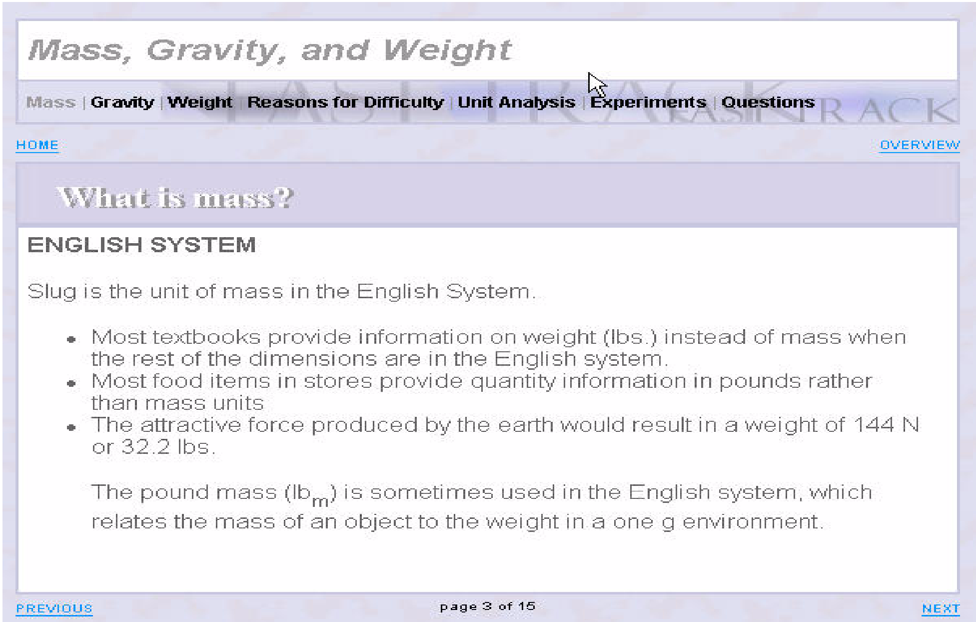

Figure 5 – Example of Text Page

The next material includes concepts and equations with access to overview videos.

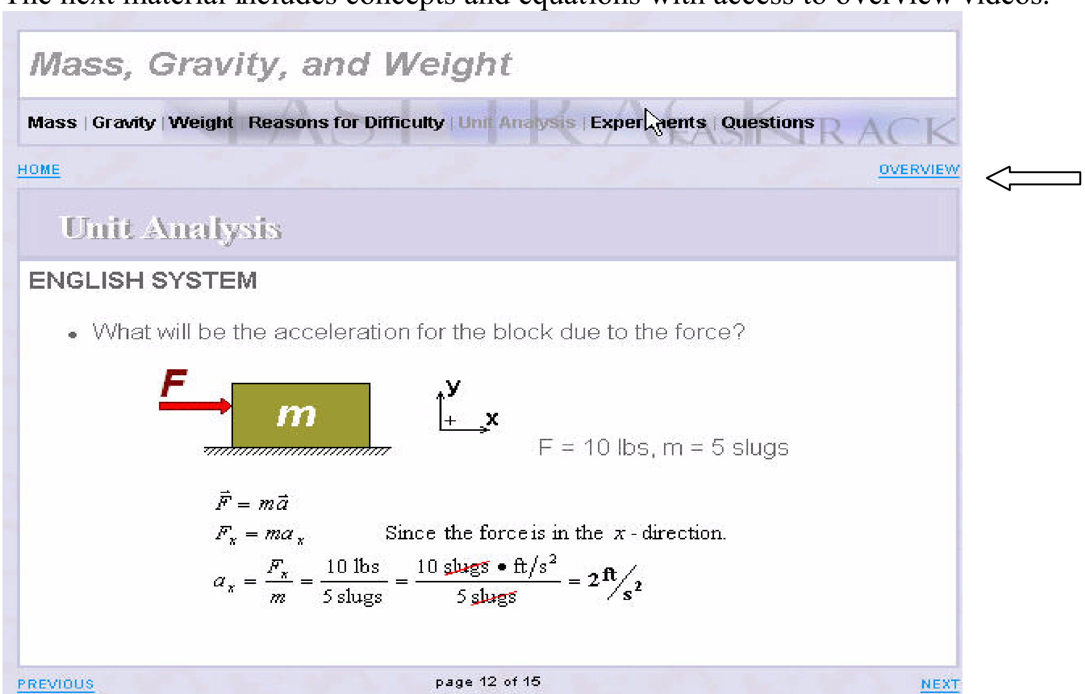

Figure 6 – Example of Units Page

The experiments require the student to first provide an answer and then they can run the experiment to see if they were correct. Some experiments include humor to add interest.

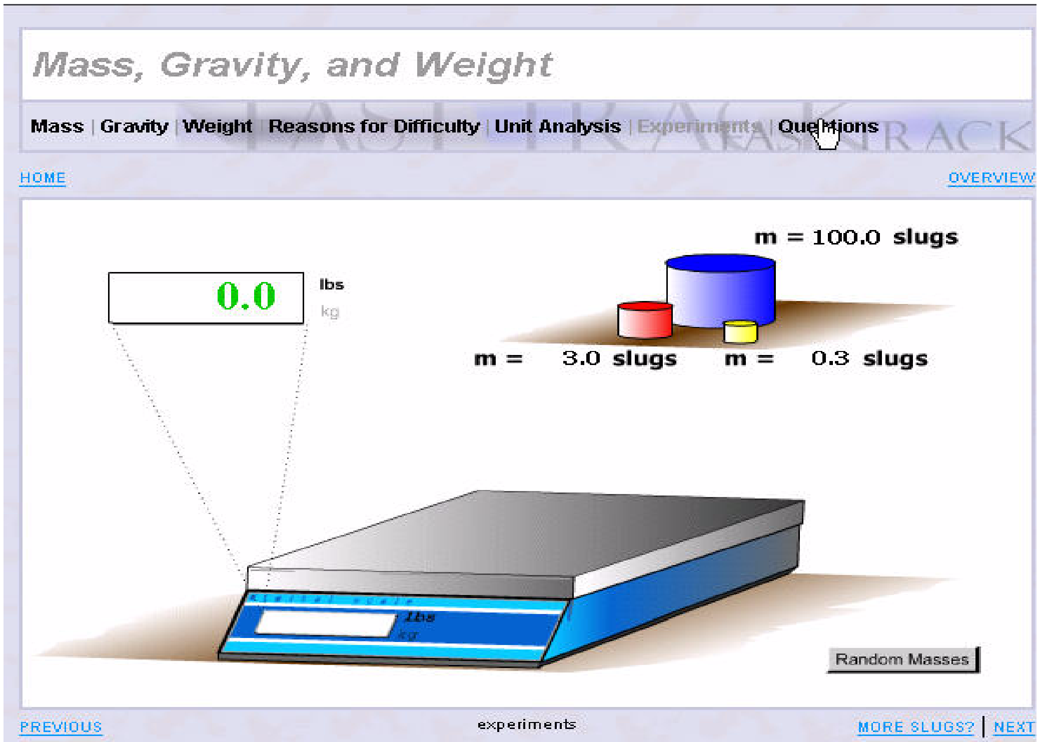

Figure 7 – Example of Experiment Page

The Quizzes provide a series of questions that must be answered correctly before they get the password needed to return to the next LO.

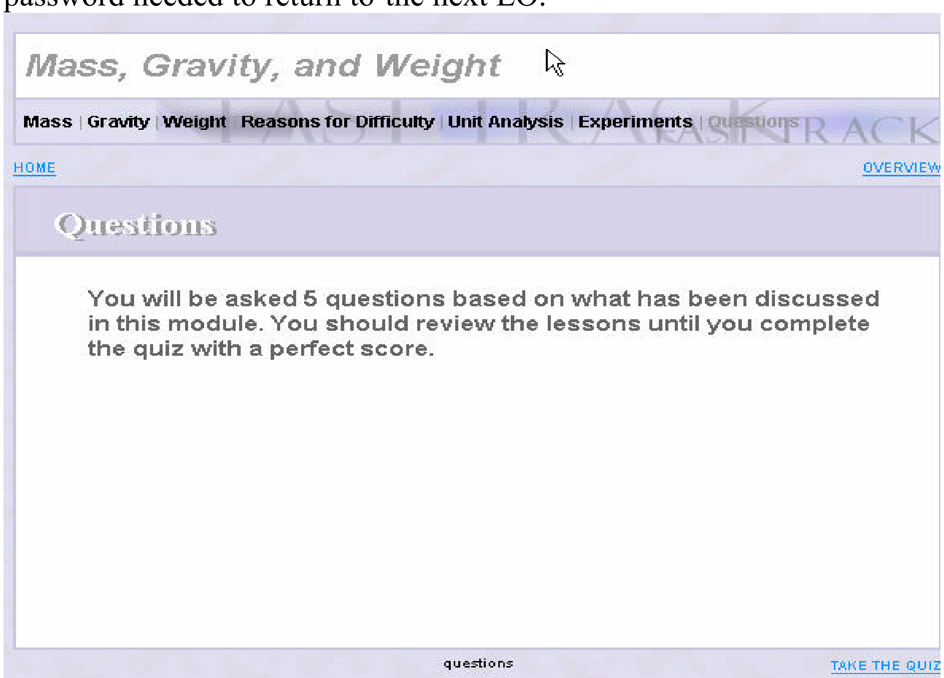

Figure 8 – Introduction to Quiz

The actual questions increase in complexity to check understanding.

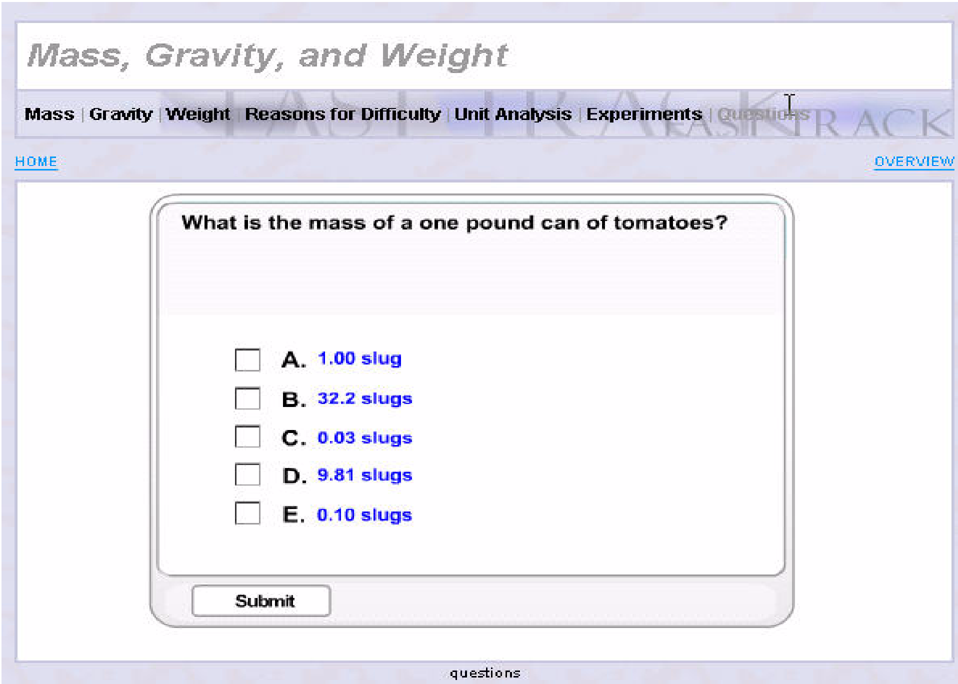

Figure 9 – Example of Quiz Page

An initial assessment of the Mass – Gravity – Weight module was performed in BME 310 –Biomechanics. The class had 35 students. An unannounced quiz on this topic was given on a Friday. The following week it was announced that a more detailed quiz would be given on the next Monday. The class was divided randomly into two groups. One group was given access to the online module 3 days before the quiz. The group that had access to the module scored 7 points higher on the 100 point quiz than the other group. The students that had access to the module were surveyed anonymously and the responses we very positive including a desire for additional modules for both the course and the freshman year.

Conclusion and Recommendations

The initial faculty response to the described program has been positive, but the student response will be measured in the spring. Many of the initial LOs have been constructed in PowerPoint and then converted into HTML files. The PowerPoint LO has taken about three days to prepare after which it's conversion to HTML by a graduate student takes an additional 2 hours. We will be measuring time for development.

Based on the initial trial, the use of animation to reinforce the concepts that were being presented was especially well received. The students also felt the availability of the module at their convenience was a positive benefit.

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