> During the Middle Ages there were all kinds of crazy ideas, such as that a piece of rhinoceros horn would increase potency… Then a method was discovered for separating the ideas—which was to try one to see if it worked, and if it didn't work, to eliminate it. This method became organized, of course, into science.
>
> -- Richard Feynman, *The Pleasure of Finding Things Out*.

Instructor: Dr. Martin John Madsen
Office: Goodrich 309
Email: madsenm@wabash.edu

Discussion: *Goodrich 104:* MWF 10:20–11:10 am *AND* Lab: *Goodrich 205:* Thursday 8:10–11 am

Introduction

I welcome you to this lab science distribution course, one which is centered on the lab experience. In this course you should learn the core principles of science as described by Feynman in the quote above: 1) try ideas out to see if they work and 2) organize and communicate those ideas. This course is loosely based on methods popularized by the TV show "Mythbusters". Their model encourages critical thinking about the physical world and can be summarized by the following steps:

1. You will be presented a variety of "myths" or stories about some physical situation.
2. You will do background research into the physics models that apply to the situation.
3. You will work in teams to design, build, run, and analyze experiments that will test the physical ideas central to the myths and compare them to known models.
4. Your team will then present your findings to the class (and to the world!) and make conclusions as to whether the situation described by the myth is physically plausible or even possible.

The course will teach you the skills needed to carry out these experiments. At the end of the semester, you will be asked to implement this experimental methodology in a unique team project.

Learning Objectives

After completing this course, you should be able to:

- Research physics models and design experiments based on those models that test ideas about the physical world,
- Build and safely execute a variety of experiments that carefully and controllably test the physics models relevant to the ideas,
- Analyze the results of your experiments both qualitatively and quantitatively, and,
- Clearly communicate the results of your experiments in video format to a general audience.

Discussion Periods

The structure of the course will be centered on the weekly lab experience. Our discussion periods will be spent 1) preparing for lab activities and 2) practicing communicating the results of your experiments. I will periodically take some time during the discussion to explain new concepts, skills, and tools as needed during the semester.

Course Materials

There will be no official textbook for the course. Instead, you will be required to bring a video camera for use during the semester. By having each student bring a video camera, we will be able to film our experiments from many angles and perspectives simultaneously, providing a richer data set for analysis and presentation. I will not require a particular make or model of camera, though the camera must have the minimum requirements listed below:

Video: 720p, 60 frames per second (not FIELDS per second)

Storage: 8 GB Format: H.264 video encoding

Several cameras that match these minimum requirements are listed below. If you have another camera that meets these requirements, please contact me with the make and model number so I can verify the specifications and add it to the list of possible cameras.

Kodak: Zi6 ($150)

Kodak: Zx1 ($150)

Myth Structure

During the course of this semester you will be presented a series of "Myths"- activities described below that you will work through with your team. Each Myth will follow this pattern:

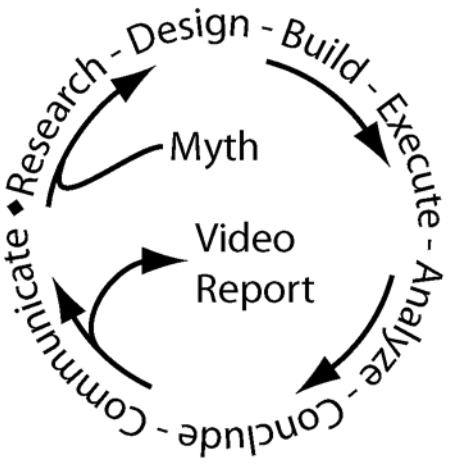
1. I will introduce you to the Myth.
2. Your team will work through the stages in the Methods section described below, repeating and iterating the experiments as needed to understand and test the Myth. Typically each myth will have a number of "Preliminary Experiments" (PEs) plus "Full-Scale Experiments" (FSEs).
3. At the end of each Myth, your team will assemble a video report that clearly communicates the results of your experiments and reaches a conclusion about the Myth.
4. There will be weekly "Challenges" associated with each myth, typically done on Friday in class or due on Monday. These challenges may include a variety of written or quantitative questions.
5. We will wrap up the myth and your video reports will be posted for a general audience to view.

Learning Areas

There are two major "learning areas", **Methods (M)**, **Concepts (C)**. You will be evaluated in your proficiency in each of these areas over the course of the semester, particularly in the Challenges.

Methods (M):

1. Research
    a. Begins with an initial brainstorming session talking through what you think is happening with the myth.
    b. Next, connect these ideas with models from physics: A model is a physics approximation that provides a simple picture about how one piece of the universe works.
    c. What math relationships describe those models?
    d. From those models, determine the kinds of things you will need to measure.
    e. Finally, determine how you are going to approach measuring them.



2. Design
    a. Design preliminary experiments that test the key ideas associated with the physics models.
    b. Incorporate experimental controls and clearly test the important variables.
    c. Design experiments that will test your methods and analysis.
3. Build
    a. Every experiment will require some building. This may be as simple as setting up a measuring scale, or as complex as building a custom machine to make a measurement.
    b. Follow your design plans in building your experiment.
    c. Safely use power tools as necessary when building your experiments.
4. Execute
    a. Safely executing an experiment includes thinking through how the experiment is going to work and move, as well as how to keep all the experimenters safe.
    b. Use appropriate safety equipment such as pads, helmets, and goggles as needed.
    c. Run your experiments multiple times to either
    d. Gather statistics by running the same experiment multiple times OR
    e. Change one variable by some increment and measure the change in the outcome
5. Analyze
    a. All experiment results require analysis. Measurement is the language of science and you will use that language to understand your results.
    b. Extract quantitative results from your experiments through a variety of analytical tools including:
        i. rulers
        ii. scales
        iii. video analysis (Logger Pro)

iv. other measurement tools

c. Compare your results against the relevant physics models:
   i. Did you find results that agree with your models?
   ii. What can your experiments tell you about making modifications to the model?

6. Conclude
   a. Following your analysis, reach a conclusion about both the relevance of the physics models and the validity of the myth.
7. Communicate
   a. You will present your experiment in video form to a general audience, teaching the audience about your physics models, your experiment design, what you built, how you executed the experiments, your quantitative results, and finally, your conclusions.

Concepts (C):

- Mass
- Velocity
- Acceleration
- Force
- Friction
- Drag
- Work
- Energy
- Entropy

Myths

The following is a tentative schedule of Myths for the semester. This list is subject to change and modification based on how the course flows and what we are able to accomplish.

Training Myth 1: Flintstone brakes

Training Myth 2: Push in the trench

Myth 3: Ping-pong cannonball

Build-off: Rolling Challenge

Myth 5: Stuck Wheels

Myth 6: Revisit a previous myth

Myth 7: Independent team myths.

Video Editing

Although we will be covering the basics of video editing in class and lab, you are encouraged to visit the Media Center for more specialized training in how to produce a quality video report.

Homework

There will be frequent homework assignments designed to help you work through different steps and stages of the myth busting work. Homework will be due at the START of class. The homework late policy is as follows:

1) Late homework will be marked off 50% (including work not turned in at the START of class).

2) Late homework may be turned in at most 1 class period late (i.e. homework due on Wednesday may be turned in late on Friday). After that point, the exercises are not as useful and it becomes pointless to do them.

Challenges

The weekly challenges will typically be done either in class on Friday or as a take-home assignment due Monday at the start of class. The same late policy as the homework applies to the Challenges. Unexcused absences from class on Friday will lead to a zero for that Challenge grade.

Attendance

Your ability to design and execute experiments is dependent on attending class and lab periods. Your team depends on you to come to class and lab and participate in the work. Unexcused absences will lead to failing a portion of the work (missed homework, Challenges, or experiments). Work missed because of excused absences (with a note from the Dean) may be made up. Excused absences from Lab must be made up by turning in a short summary of **ALL** the video clips recorded by your group during the missed lab period (minimum of 5 pages). This video summary is due no later than the following Monday.

Grading

I will maintain a running evaluation of your performance in the class based on the following criteria:

1. Participation – as defined by your engagement in the class, your wiliness to work, and your ability to work well with your team. **(20% of final grade)**
2. Homework and Challenges – each assignment will be evaluated on a point scale and assigned individually. **(40% of final grade)**
3. Video Reports – Each video will be evaluated and a general score will be assigned to all team members. Individual team members will also be evaluated based on their individual roles during the experiments and in post-production. Failure to complete a task during the process of producing a video report will be reflected on the responsible individual's grade. **(40% of final grade)**

Grades will be assigned on the following scale: 75% = C, 85% = B, 95% = A

Academic Support Services

Students with disabilities, whether physical, learning, or psychological, who believe they may need accommodations in this class, are encouraged to contact Academic Support Services as soon as possible to ensure that such accommodations are implemented in a timely fashion. Please meet with Julia Rosenberg (ext. 6024) to verify your eligibility for any classroom accommodations and for academic assistance related to your disability. You may also discuss your disability with the professor if you wish. All discussions will remain confidential. If you have a hidden or visible disability which may require classroom or test accommodations, please see me as soon as possible during a scheduled office hour. If you have not already done so, please visit Academic Support Services (Armory 101) which is responsible for coordinating accommodations and services for students with disabilities.

Emergency Procedures

In case of a fire, we are to proceed from the classroom out the nearest exit and toward the Chapel. This holds for both class discussion and lab. You should join the instructor and the class at the Chapel to make sure that everyone got out of the building ok. In the event of a severe weather storm, we are to proceed to the basement and shelter in the basement hallway.

Acknowledgements

I thank Adam Bowen from the Media Center for all his help in assembling the materials for this course.