PHYS101E

"Movie Physics"

Summer 2024

Course Description

In this online summer course, students learn how to critically evaluate Hollywood action movies using the laws of physics and Fermi type estimation techniques. After being given the background physics and quantitative training required to understand a particular topic, students will typically be shown a movie clip and asked to quantitatively judge the veracity of the physics in the scene. Is it a good or bad representation of what actually happens in the real world? Assignments will involve both solving physics word problems and evaluating movie clips such as an action scene or a 'doomsday scenario' (e.g. abrupt onset of an ice age triggered by changes in the ocean currents).

For example: which requires the most force: *stopping a runaway subway train* or *catapulting a large farm animal onto a bunch of English knights*?

By the end of the semester, the student who takes this course will be able make quick back of the envelope estimates to determine whether a particular 'movie action scene' is feasible or not. Emphasis will be on problem solving on the fly, in class and/or while watching a movie.

If you claim a scene violates the laws of physics, you need to be able to back up that claim with a sound quantitative argument. This is what students learn to do in Movie Physics.

Instructor and Teaching Fellow

Instructor: Frank Robinson

- Office Hours: Schedule via email
- Email: frank.robinson@yale.edu

Teaching Fellow: Iver Warburton

- Office Hours: Schedule via email
- Email: iver.warburton@yale.edu

General Course Information

Online Virtual Classroom Meeting: Monday & Wednesday 10:00am-11:30am (EST)

Students are required to participate in two online section meetings per week in our "virtual classroom". During these virtual classroom sections, students will participate in open discussions with Professor Robinson and the TF. It is expected that you will have already watched and made your own notes from the lectures before each online classroom meeting begins.

Lectures: Before each "Virtual Classroom Meeting" you will be required to watch a set of online lecture videos (each 5-20 minutes long) on your own. You are expected to **watch and take notes** from the lectures needed for each online discussion before the online meeting time. Note that some weeks, you will be expected to watch 2 hours of lecture videos before a meeting, so do plan your schedule so that you can keep up with lecture viewing. Much of the information on the exams will come directly from what is presented in the lectures. *It is your responsibility to put together a set of detailed notes based on the lectures*.

Grading Breakdown

Your final grade in the course will be based on:

- 30% Final Exam composed of a written test (20%) and an oral test (10%)
- 30% Midterm Exam composed of a written test (20%) and an oral test (10%)
- 15% Homework assignments
- 25% Participation in online section discussion (15%) and lecture mini-quiz participation (10%)

Final Exam: Scheduled to be taken at 10 am on Wednesday June 26th**.** The final exam is cumulative and will cover all material discussed in the lectures and readings. You must take the final exam during this timeslot (we will not be using Examity). After finishing the exam, students will have a 5-10 minute one on one oral test with one of the instructors (typically they will be asked to either one of their answers in the exam or describe how they would solve a similar problem).

Midterm Exam: Scheduled to be taken during the online class meeting at 10am on Monday June 10th**.** The midterm will cover readings and lectures up to and including class before midterm (we will not be using Examity). You must be available to take the midterm during this time slot. After finishing the exam, students will have a 5-10 minute one on one oral test with one of the instructors (typically they will be asked to explain one of their answers in the exam or describe how they would solve a similar problem.)

Online Discussion Section Participation: You will also receive a grade based on your online section participation. The goal of these discussions is to develop good problem-solving skills required to solve homework problems, answer exam questions and understand lecture material.

Homework: During the course students will receive homework problems twice a week. Typically, one homework will be assigned on Monday (due the following Friday at 12 pm EST (noon)) and one will be assigned on Wednesday (due the following Monday at 9pm EST). We will provide hints on how to do these types of problems during discussion section, but it's ideal if you try do these problems on your own (or in groups) before class. Late homeworks will be given a maximum of 50 % for one day late and 25 % for 2 days late. You will scan your written homework and upload it to Canvas. You will be responsible for the legibility of your work, which includes handwriting *and* scanning. You may also typeset your homework (using LaTex, etc.), in which case you are only responsible for typos.

Academic Honesty: Both the midterm and the final exam are closed book, which means the use of any written material or any form of collaboration is forbidden. For a short but useful discussion, see: http://yalecollege.yale.edu/faculty-staff/faculty/handbook-instructors-undergraduates-yale-college/teaching/academic-dishonesty. All suspected cases of cheating will make be reported to the Yale College Executive Committee.

Dates, Topics, and Lectures

Class 1: Math review. How to make a good guess. Extracting useful data from a movie clip. (Chapter 1)

Monday, May 27: Open Questions & Discussion of Chapter 1

Introduction and orientation, class overview

Accuracy, sig figs

The geometric mean, guesstimation sample problems.

Class 2: Kinematics (Chapter 2)

Wednesday, May 29: Discussion of Problem Set #1 and Chapter 2

Scalars and vectors, velocity and acceleration

Getting kinematic data from clips

Equations of motion in a straight line, applications to uniform acceleration.

Class 3: Two-dimensional motion. Newton's laws of motion. The physics of jumping (Chapters 3, 4, 5)

Monday, June 3: Open Questions & Discussion of Problem Set #2 & Chapters 3, 4 & 5

Projectile motion

Newton's laws of motion

The physics of jumping

Jump contact time/distance. Movie example.

Class 4: Damping forces. Air resistance (drag). Friction (Chapters 6, 7)

Wednesday, June 5: Discussion of Problem Set #3 & Chapters 6 & 7

Air resistance. Terminal velocity

Indiana Jones falling to the ground in a dingy

How to drive a car on the ceiling (lift).

Friction and 007.

Class 5: Midterm (Chapters 1-7)

Monday, June 10: Midterm Exam (written and oral tests)

Class 6: Circular motion (Chapter 8)

Wednesday, June 12: Discussion of Chapter 8

Introduction to circular motion.

Example "Tray and cup demo".

Artificial gravity

Class 7: Gravitation and Energy (Chapters 9 & 10)

Monday, June 17: General Q&A. Discussion of Problem Set & Chapters 9 & 10

(note: Chapter 11 is optional)

Weightlessness

Orbits

Newton's law of gravitation

Estimating g and other quantities on the asteroid in Armageddon

What is energy?

Forms of energy.

Work and energy

Disorder and the arrow of time.

Class 8: Waves (Chapter 12)

Wednesday, June 19: Discussion of Problem Set and Chapter 12

Intro. to waves.

Properties of waves.

Combining waves.

Sound.

Electromagnetic spectrum.

Class 9: Quantum Mechanics & Anthropogenic Climate Change (Chapters 13 &14)

Monday, June 24: Discussion of Problem Set & Chapters 13 &14)

Waves and particles

The photoelectric effect

Double slit experiment (Dr. Quantum video)

Heisenberg's uncertainty principle

Radiation and steady state

Global energy budget

Radiative forcing

Climate sensitivity

Forcing and feedback

<u>Class 10</u>: <u>Final Exam</u>: Wednesday June 26 (Chapters 1-14, excluding 11)