Coding Integration into High School Physics & Physical Science using STEMcoding Project Resources
Two week absolute beginner coding course (option: 1.0 grad credits)

Instructor:
Prof. Chris Orban
e-mail: chris.m.orban@gmail.com

Course Meetings:
Videoconferences on zoom (typically at 1pm EST unless otherwise noted)

Dates: June 26 - July 7, 2023

Final exam: No final exam
Course web page: `http://stemcoding.herokuapp.com`

Specific Goals/Rationale

The goal of this particular course is to show teachers how computer programming exercises can be integrated into high school physics (AP or non-AP) and high school physical science in a simple, fun and engaging way.

The basis of this course is a set of computer programming exercises that Prof. Orban developed (at least initially) for freshman physics courses on OSU's Marion campus. A few thousand college and high school students, many of whom have never written a computer program before, have successfully completed these exercises. As discussed in Orban et al. 2018 (`https://aapt.scitation.org/doi/10.1119/1.5058449`) surveys of students at OSU Marion seem to indicate that the content is at an appropriate difficulty level, even for absolute beginner programmers.

There is no specific requirement that you will use these activities in your courses in the coming academic year. Ultimately it is up to you to decide how pervasive you want to make computer programming activities in your own course. There are no "strings attached" to your participation in this course.

Videoconferencing

We will regularly use videoconferencing on Zoom as part of the course. Please download zoom from `https://zoom.us` If you cannot get zoom working on a computer or laptop, you can use teams on a smartphone or tablet instead. **You should not have to pay anything to use Zoom to participate in this course!** Zoom sessions **will** be recorded so that people traveling (for example around July 4) can catch up later.

Relevancy to Science, Computer Science and Math Standards

The Next Generation Science Standards (NGSS), which is the basis of most state science standards in the US, includes "computational thinking" as one of its core practices. For an in-depth discussion of how activities like these align with computational thinking please consult this paper: Orban & Teeling-Smith 2020 `https://doi.org/10.1119/1.5145470` which is published in The Physics Teacher. A free version of this paper is available at this link: `https://arxiv.org/abs/1907.08079`

Regarding the specific statements in the NGSS that outline important science learning objectives, the activities that will be discussed in this course do align with many of these statements. A google document that summarizes the alignment between NGSS and the STEMcoding activities in this course is accessible from this link: `http://go.osu.edu/ngss`

Increasingly, states are adopting or creating K12 computer science (CS) standards. Typically these standards are derived from a national set of standards approved by CSTA. For the most part, these state CS standards can be interpreted as a blanket permission to include computer science and computational thinking oriented activities in K12 science and math classes. We believe our activities line up well against state and national CS standards to the point where one could use these activities as the basis for a computer science course.

Some of the content in this course – particularly the STEMcoding Object Tracker – is described as a "data science" activity because it involves analyzing video data from a simple experiment in Excel or Google Sheets. From a standards point of view, this activity can be said to align with certain high school math standards for analyzing and visualizing data *and* it aligns with computer science standards that relate to using data to inform models. So although "data science" is a relatively new trend in education, it involves concepts that have been part of the school system for quite some time.

The activities in this course involve algebra 1 and algebra 2 level concepts including working with 2D plots with x and y axes. The activities for this course do NOT involve any trigonometry or pre-calculus math concepts. There does exist a number of STEMcoding activities that do involve trigonometry that will be covered in the intermediate level course which follows this one.

Expected Learning Outcomes

1. Teachers will learn how to use a computer code to solve physics problems in an iterative way
2. Teachers will learn about potential pitfalls and common mistakes that students make in completing physics-focused computer programming exercises
3. Teachers will learn some of the limitations of using a computer code to iteratively solve physics problems (e.g. energy conservation, lack of perfect agreement with analytic expectations)
4. Teachers will become familiar with assessment questions designed to probe student conceptual knowledge gains from completing physics-focused computer programming exercises
5. Teachers will become familiar with the `http://stemcoding.herokuapp.com` learning management system

How the Learning Objectives will be met

1. Teachers will complete a set of physics-focused computer programming exercises that solve physics problems in an interative way, and often in an interactive way
2. After completing each exercise, teachers will read through a set of detailed instructor notes outlining potential pitfalls and common mistakes
3. Many of the exercises include comparisons to analytic expectations. Teachers will learn the limitations of the codes by completing the exercises and in discussions with Prof. Orban
4. Teachers will complete pre and post assessments for each exercise. These assessments are the same that students would complete.
5. After completing the exercises teachers will learn to set up a course in the `http://stemcoding.herokuapp.com` learning management system

Texts and Required Material

There is no required text for this course. All of the exercises are available at `http://stemcoding.herokuapp.com`

STEMcoding Learning Management System (stemcoding.herokuapp.com)

Ohio State University created a custom-built learning management system for Prof. Orban's coding activities. A mirror site that uses the same source code is available at `http://stemcoding.herokuapp.com`. This site is run by a non-profit called "STEMcoding Education Ohio" which is led by Prof. Chris Orban and Dr. Richelle Teeling-Smith.

Please register an e-mail address on `http://stemcoding.herokuapp.com` and use the course join key AAPTSummer2023Intermediate You can register any e-mail you want with the system. It does not have to be your school e-mail. At the end of the course you will be given "teacher" status on the learning management system so you can set up your own courses and grade student submissions. The fees you pay for this course provide you with unlimited use of `http://stemcoding.herokuapp.com` for one year. Following that, the rate will be $20 per teacher per year. Student use of the site is free and teachers can enroll an unlimited number of students on the system.

This learning managment system has been used successfully on various operating systems, including chromebooks and iPads. The main limitation is that the activities do require a physical keyboard. Tablets and iPads without a physical keyboard will not work.

What programming language is involved?

The activities in this course involve modifying and running javascript programs. For people with experience working with C, C++ or Java code, this language will seem very familiar. We do not currently use python or vpython in our activities. Python uses indentation instead of curly brackets to define the logic of the program, which means that just adding a space to the code in the wrong place could change the behavior of the program and lead to confusion. (However, many people argue

that the role of indentation in python helps students avoid writing sloppy looking code.) We may set up a python version of our activities in the future if there is interest.

Participants with Disabilities

Any teacher who feels that they may need an accommodation based on the impact of a disability should contact Dr. Orban to discuss their specific needs.

Grading:

Teachers who complete required exercises will earn an A in the course. The exercises are available on `http://stemcoding.herokuapp.com`

Required exercises:

1. Move the blob
2. Accelerate the blob
3. Apollo Moon Landing
4. Bird Launcher
5. Pong (elastic collisions)
6. STEMcoding Object Tracker

Optional: STEMcoding Slack Channel

In the previous summers that this course has been offered, teachers have often wanted to talk to each other during the course. To facilitate this we have a "slack channel" at `http://stemcoding.slack.com` You can add yourself to this slack channel by clicking this link

Tentative Course Schedule

(all times are Eastern Standard Time)

	Dates	Topic / Item	Assignments due
Week 1	June 26	video chat at 1pm	Hello world / troubleshooting
	June 27	video chat at 1pm	Move the blob
	June 28	video chat at 1pm	Accelerate the blob
	June 29	video chat at 1pm	Apollo moon landing
	June 30	Optional chat at 1pm	Catch up / office hours
Week 2	July 3	video chat at 1pm	Bird launcher
	July 4	no meeting	
	July 5	video chat at 1pm	Pong
	July 6	video chat at 1pm	STEMcoding Object Tracker
	July 7	Optional chat at 1pm	Catch up / office hours

Additional Training: July 10 - July 21, 2023

Prof. Orban will be teaching an "intermediate" course for two weeks in July that is a continuation of the activities that you will complete in this course. If interested, you should be able to add this course after you begin the introductory course. Here are some of the ways the intermediate course will be different from the introductory course:

1. The course will be more intense, meeting every day, covering more activities. Participants signed up for grad credit will earn 2.0 grad credits instead of 1.0 grad credits
2. Many of the activities will involve trigonometry. The STEMcoding asteroids game for example uses sines and cosines to calculate the x and y component acceleration. Likewise, there is a STEMcoding projectile motion activity that involves sines and cosines to calculate the x and y components of the initial velocity.
3. The STEMcoding activities will cover a wider range of topics, including torque, momentum, harmonic motion and electromagnetism

4. We will spend less time introducing the coding environment and the syntax of the language

In summary, the June 26 - July 7 course is designed for high school physical science and non-AP physics while the July 10 - July 21 course is designed for non-AP or honors physics and AP physics. The July 10 - July 21 course is also designed to build from the June 26 - July 7 course.