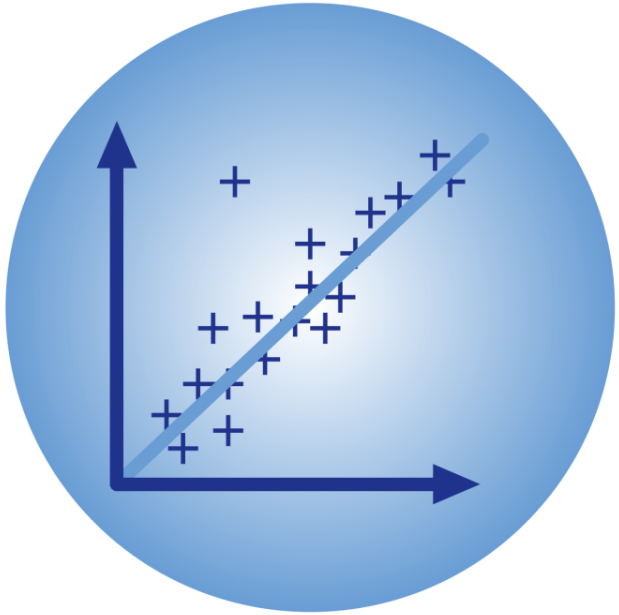


BPhO Computational Challenge

Introduction

Dr Andrew French.
December 2021.

BPhO
British Physics Olympiad

- Register via https://www.bpho.org.uk/

- **11 x 1 hour weekly seminars** Jan-April via Zoom, delivered live. Course content (slides, homework problems, code) available at the BPhO website and via Dr French's Eclecticon.

- Annual ***Challenge*** to be set after April-Sept. **Bronze**, **Silver** and **Gold** standard problems, so you can choose your level.

- The ***Challenge*** can be attempted individually or in pairs, and you are free to use any appropriate spreadsheets or programming languages. In the course, students will have direct experience of Microsoft Excel, MATLAB and Python.

- Submit your ***Challenge*** entry via a hyperlink to a ***two-minute unlisted YouTube video***, i.e. a 'screen-cast' which describes your solution(s) to the Challenge tasks. The Chrome browser add-on Screencastify is a recommended tool.

Screencastify

BPhO
British Physics Olympiad

BPhO
Computational Challenge

Why are we doing this?

Think of a modern profession that *does not* involve the use of computers to create, record and store information, control machinery .... I'm not sure I can.

Experience of **data flow, data processing** and **information presentation** is a particularly vital element of scientific craft. But at the moment your Science experience is probably mostly theoretical problem solving, taking notes and performing lab experiments.

Real Scientists will spend most of their time on data flow, data processing and information presentation. **So start learning these skills and you are more likely to get a job.** The likes of Amazon, Google, Uber, Facebook will continue to 'disrupt' traditional industries. **If you don't have these skills, you will not have much to offer to the higher paid sectors of the economies of the future.**

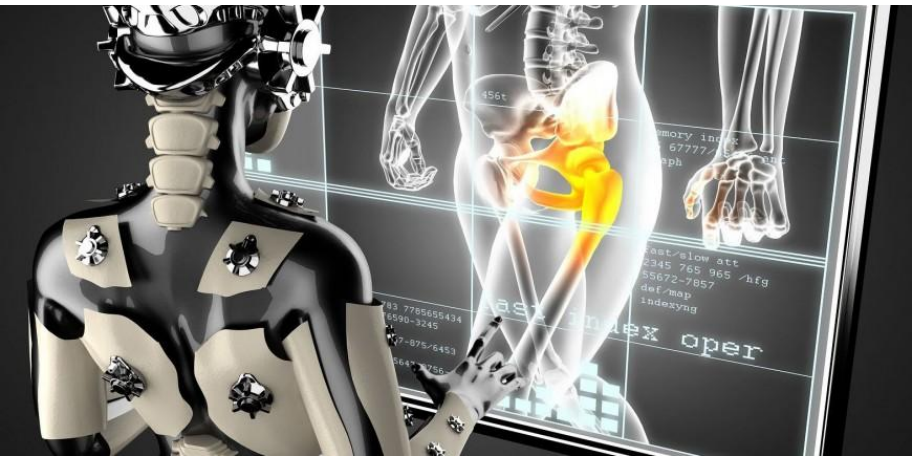
But even if your horizon is merely "how can a get a Distinction at A-Level and get into a top flight University?" skills in Scientific Computing are a great way to consolidate your subject, especially when you **begin to create projects and systems of your own design.**

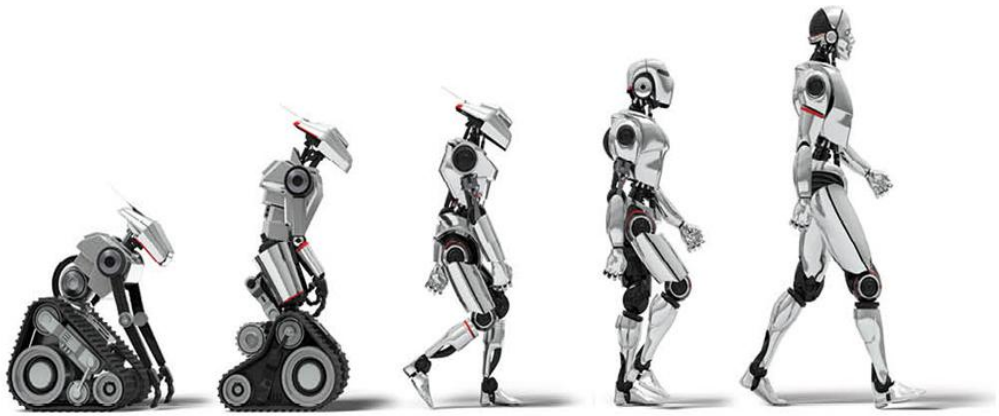
***Making things yourself* is the BEST motivator for learning**

BPhO Computational Challenge

If most future jobs currently performed by humans will be done much more efficiently and safely by robots / artificial intelligence...

*Wouldn't **you** want to be the person **programming** this technology?*





https://robohub.org/envisioning-the-future-of-robotics/

BPhO Computational Physics course content (weeks 1 – 5)

1. **ERRORS.** Incorporating experimental uncertainty in calculations. Presenting calculations clearly using spreadsheets and code scripts.

2. **DATA PROCESSING PIPELINE.** Pendulum period vs length data in Excel. Linearize and compare model to data via a line-of-best fit. Find g +/- error. Automation of the data processing pipeline in MATLAB.

3. **LINES OF BEST FIT.** Mathematics of linear regression i.e. recipe for finding m and c for an optimum $y = mx + c$ fit to a (linearized) data set, and errors in m and c. Also $y = mx$ fit

4. **CHERNOBYL.** Recap of a data analysis pipeline using a radioactive decay scenario. Scatter graphing in Excel. Determine background noise level. Linearization & line of best fit. Parameter estimation (i.e. half-life, initial activity) + errors. Automation in MATLAB.

5. **WEATHER.** Analysis of moderate to large amounts of data using the example of meteorological measurements recorded since 2018 via an automated system on the roof of Winchester College Science school.

BPhO Computational Challenge

BPhO Computational Physics course content (weeks 6 – 11)

6. **THE PLANETS.** *Kepler's Third law* for Solar System. Compare to *Exoplanets*

7. **NUMERIC CALCLUS.** Numeric methods to solve differential and integral Calculus problems.

8. **GRAVITY & VERLET.** Use of the *Verlet method* for: (1) 1D ball drop (and bounce), (2) Projectile motion with drag, (3) Orbital motion.

9. **RANDOM WALKS.** Idea of *mean free path*, *Knudsen number*, *diffusion*. 1D random walk displacement proportional = step size $\times$ $\sqrt{}$(# steps). Extension to 2D and 3D.

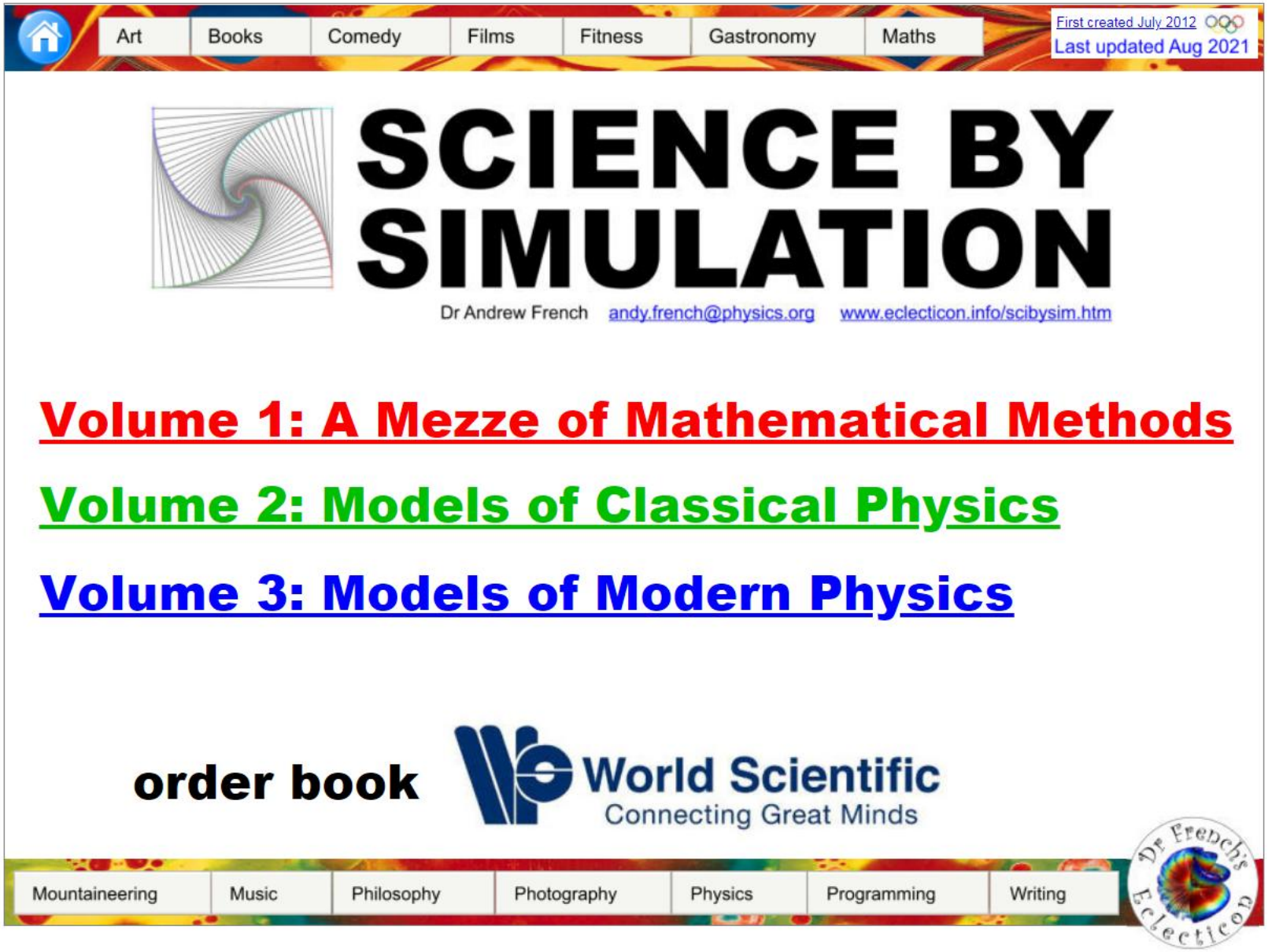
10. **CHAOS.** *May's population model*. r parameter results in extinction, stability, oscillations, and ultimately a progression to *chaos* via a cascade of *bifurcations*.

11. **EPIDEMIOLOGY.** Mompesson's S,I,R,D data for Eyam Plague in 1666. Estimate α, β, R_0 parameters that characterize the epidemic in this *closed system*. Can we apply the model to other diseases such as Ebola and Coronavirus?

then ***CHALLENGE***

BPhO Computational Challenge

Recommended text for the course:



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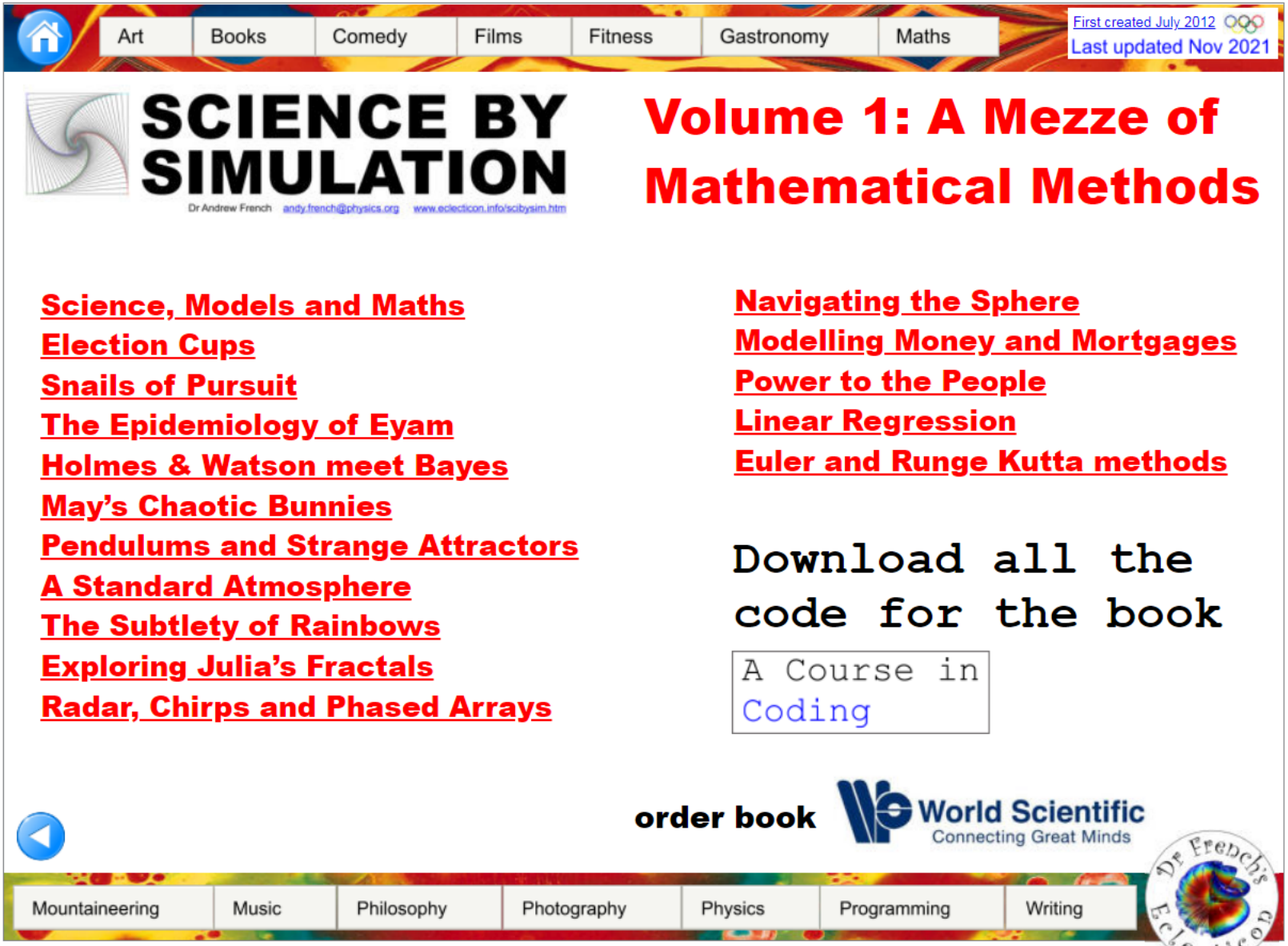

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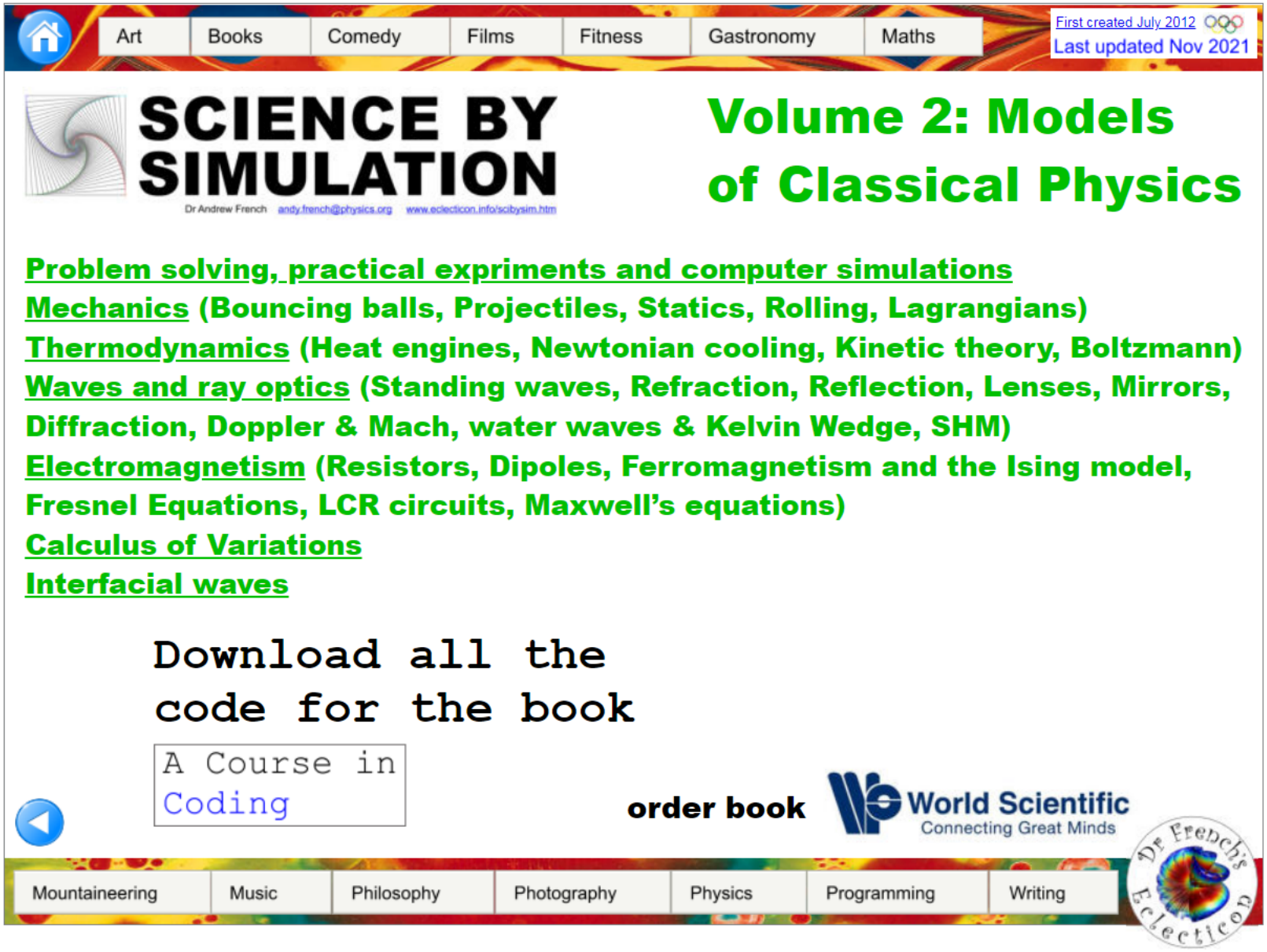

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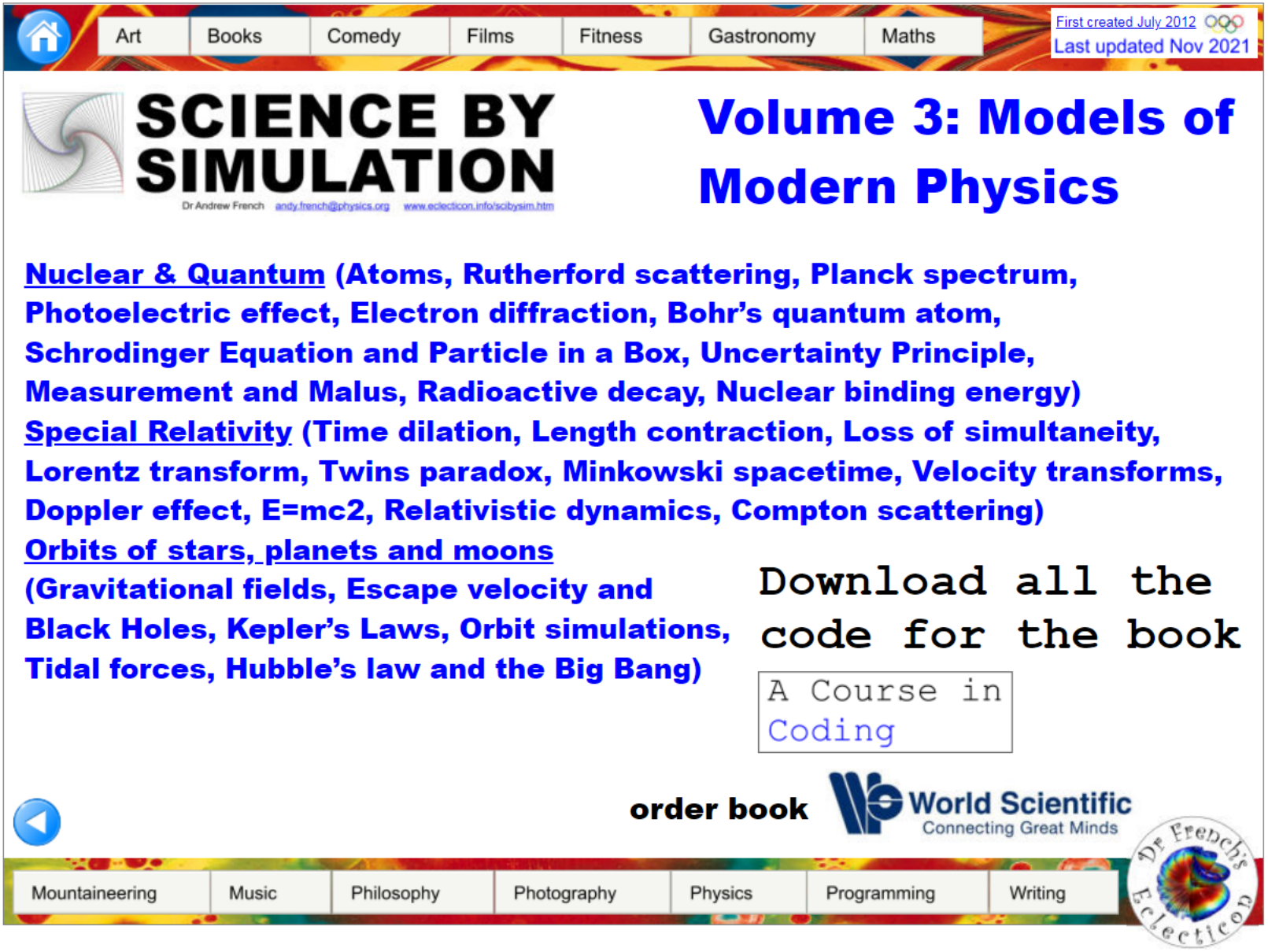
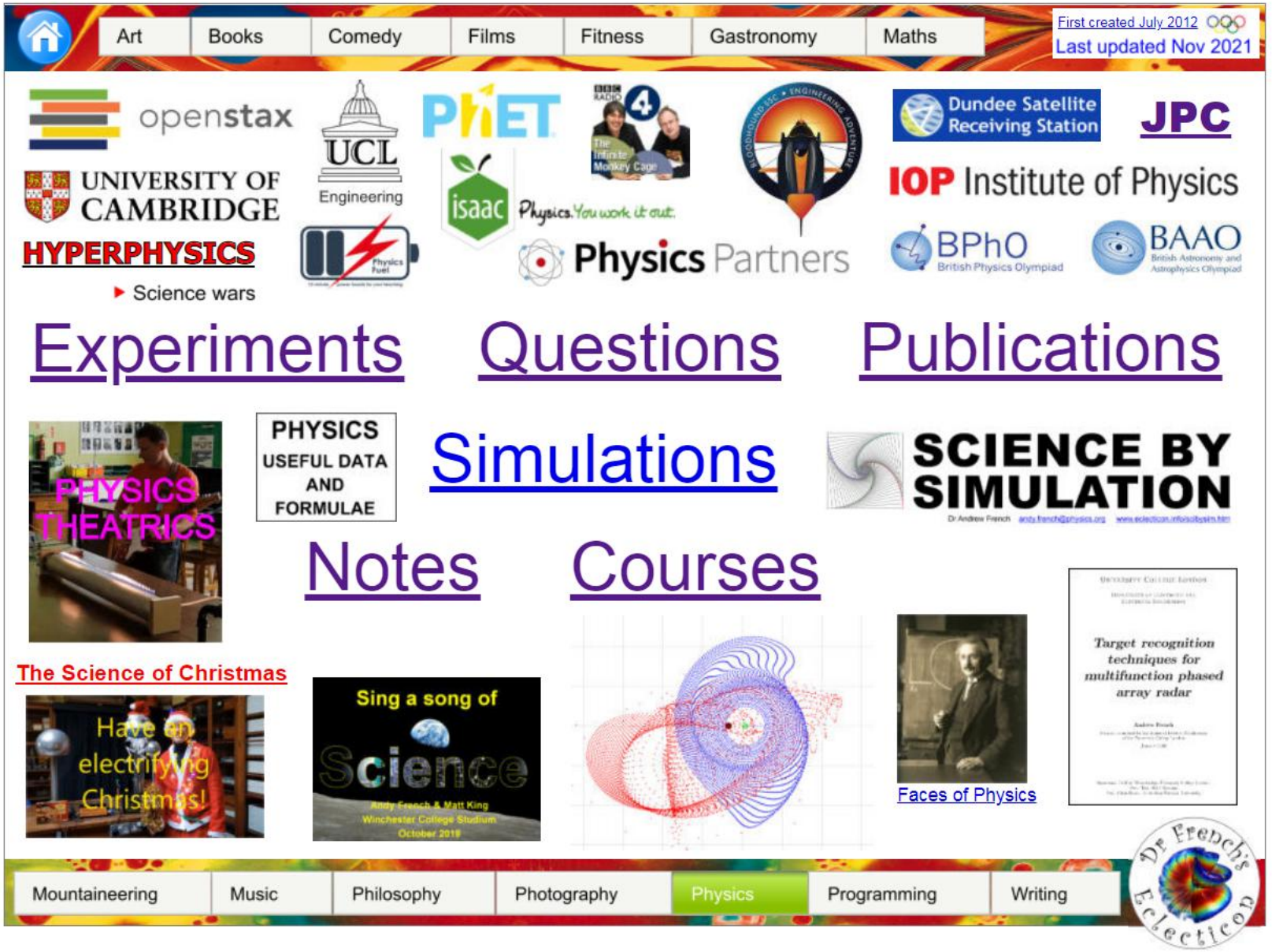


Additional online materials: http://www.eclecticon.info/physics.htm



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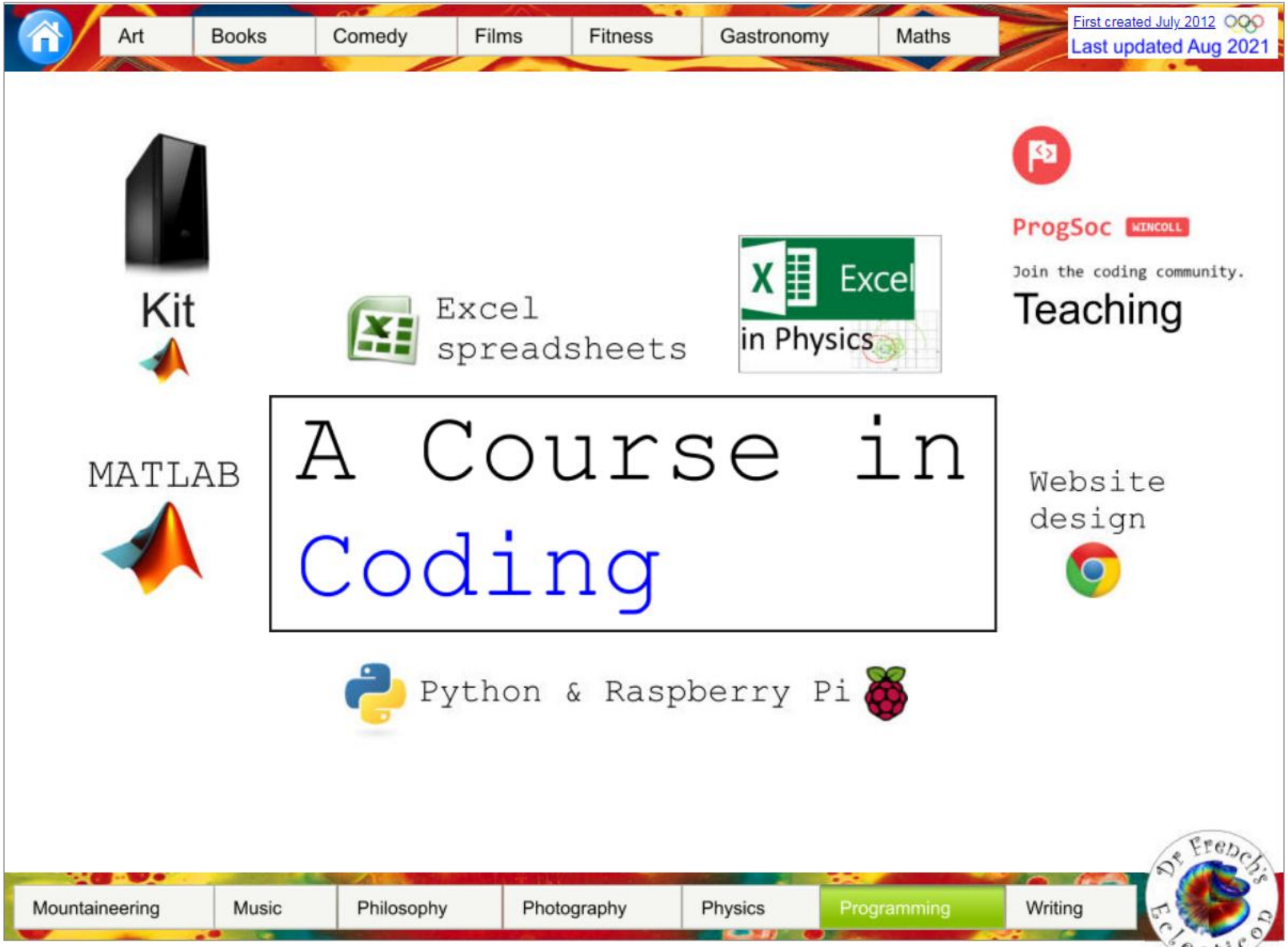

Additional online materials: **http://www.eclecticon.info/physics_excel.htm**