Final Project

PHY494 Computational Methods in Physics (2019)

Requirements

- team (3 students; 2 for remaining teams)

- GitHub repository

- keep "lab notebook" on wiki page

- final poster presentation

  - abstract, poster as PDF

  - description of contributions (PDF)

  - individual Q&A

Grading

- **objectives**
- **teamwork**
- **wiki**
- **abstract**
- **poster**
- **Q&A**

- code, achieves objectives (30%)

- teamwork (contributions, commits, evidence of communication) (10%)

- keep "lab notebook" on wiki page (5%)

- final poster presentation

  - abstract (5%)

  - poster (20%)

  - individual Q&A (30%)

30% 30% 10% 5% 5% 20%
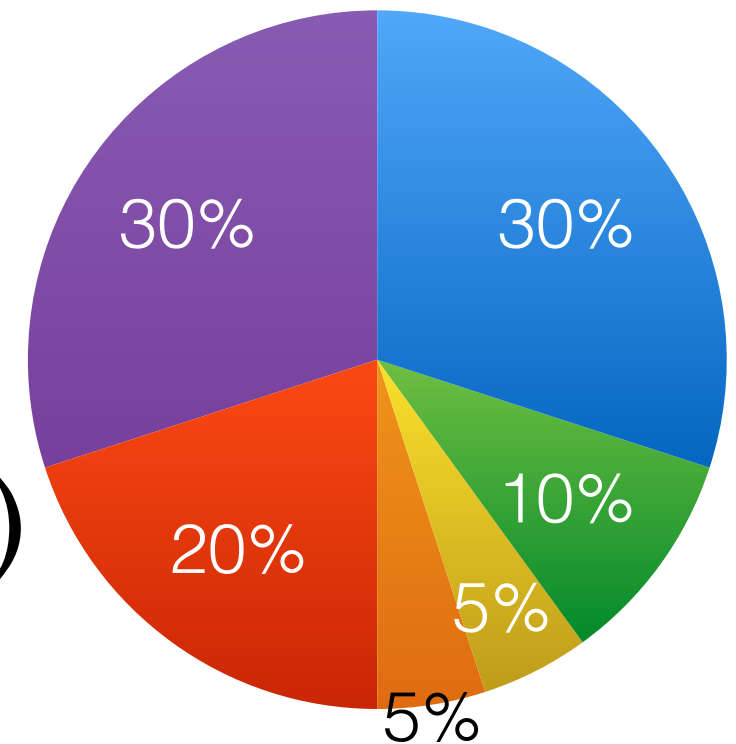
Projects

- Develop one from list (see Appendix A in HW10).

- Propose your own.

Projects need

- proposal

- pitch

Project Proposal

- 1 page

- title

- *Problem:* Describe the problem to be solved.

- *Approach:* Algorithms, outline of how you will solve the problem, requirements (e.g. what data needs to be collected?)

- *Objectives*: List 3–6 measurable non-trivial outcomes that you want to achieve; your grade will depend on achieving these objectives

Pitch project & build team

04/30
11:59pm

04/04

03/28

04/08

05/01

05/02

project pitch

- draft proposal (as HW)
- pitch & team up
- finalize proposal
- work on project
- abstract + contributions due
- poster PDF due
- poster symposium

Project Pitch

- ~5 min presentation (next Thursday)
  - ‣ email any slides as PDF in advance

- introduce project (*Problem*, *Approach*, *Objectives*)

- attract a team (3 students)!

- You can only *choose* a project that was pitched… so be prepared to pitch yourself!

Finalize proposal

04/30
11:59pm

04/04

03/28

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- draft proposal (as HW)
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Finalize proposal

1. work as a team to write the final proposal

2. submit to team repository

3. final proposals will be evaluated by instructor and requested changes will be posted as issues: need to be addressed
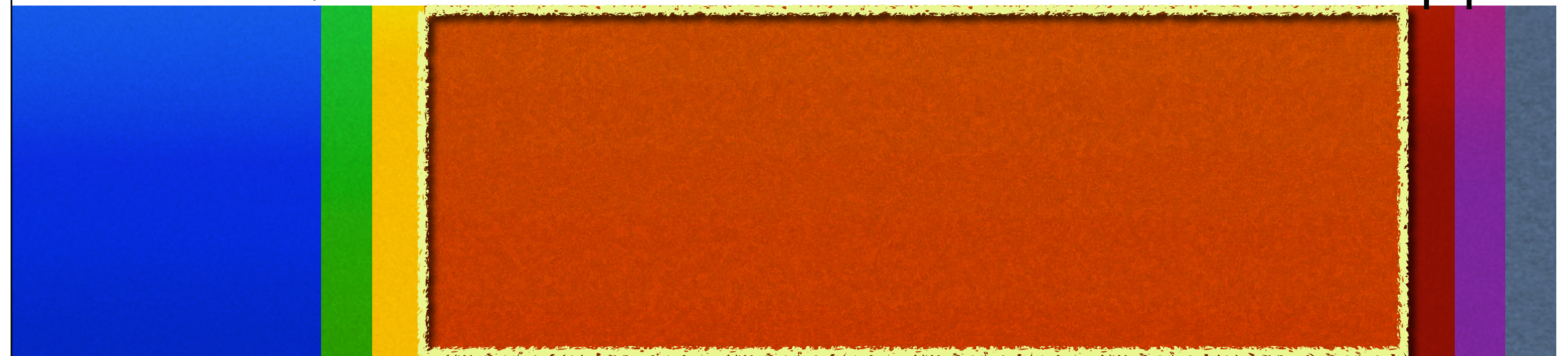
Work on project

04/30
11:59pm

04/04

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05/02

- 🟦 draft proposal (as HW)
- 🟩 pitch & team up
- 🟨 finalize proposal
- 🟧 **work on project**
- 🟥 abstract + contributions due
- 🟪 poster PDF due
- ⬜ poster symposium

Work on project

- use GitHub **repository** for code

- use GitHub **Wiki** for organization, notes on algorithms, preliminary results

- *optional*: use GitHub issue tracker for assigning tasks and keeping track of bugs and objectives

- Create **abstract** and **poster** together.

Start early!

Deliverables

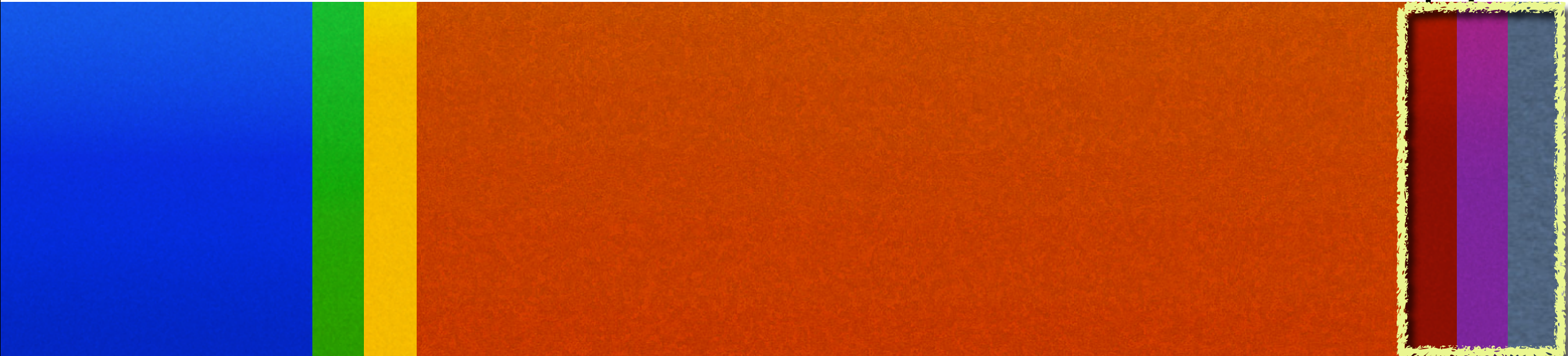1. submit abstract

2. create poster

3. present poster at Final Symposium (May 2, 11:15am – 2pm, PSH 356)

4. individual Q&A at poster

More details closer to the symposium…

Project ideas

- rough outline: expand in your proposal

- see also *Computational Physics* and *Computational modelling and visualisation of physical systems with Python*

1. Monte Carlo Simulation of liquid Argon

- difficulty: 1–2

- implement basic MC for liquid Argon in *NVT* (periodic boundaries, minimum image convention)

  - analyze at different temperatures (phase transition?)

  - calculate equation of state $P(T, \rho)$

- visualize

- extra: implement *NPT* (volume moves)

2. Monte Carlo simulation of the Ising magnet

- difficulty: 2–3

- implement MC for Ising spin system in 1D, 2D, possibly 3D

- compute magnetization as function of T (phase transition?)

- visualize

- compare to 2D exact result

3. Classical chaotic scattering

- difficulty: I

- Problem 9.4 in *Computational Physics*

- integrate equations of motions of particles scattering from "4-peak" potential (e.g. with RK4)

- vary parameters

- analyze cross section

- visualize

4. Quantum Mechanics: Wave packet propagation

- difficulty: 3

- See 22.2 and 22.3 in *Computational Physics*

- solve the time-dependent Schrödinger equation for a Gaussian wave packet in different potentials (Visscher or Maestri/Askar&Cakmak algorithm)

- 1D: step barrier, harmonic well, square well; 2D: slit

- calculate transmission/reflection, wave velocity, ...

- visualize

5. Fluid mechanics: 2D Navier-Stokes

- difficulty: 2 (3 without *CP…*)

- See Ch 25 in *Computational Physics*

- solve Navier-Stokes for incompressible 2D flow (finite difference with SOR algorithm)

- velocity (flow) field and vorticity for submerged beam, cylinder, drop shape

- visualize

- vary parameters (e.g. Reynolds number, velocities, boundary conditions)

6. Solar system

- difficulty: 1–2

- simulate the solar system (planets + sun + various comets such as Halley's comet) using classical Newtonian mechanics

- obtain realistic parameters from NASA

- stability over time?

- effect of planets on comets?

- Or simulate a fictional system such as "Tatooine" with two suns – do stable orbits exist where one would see a two-sun rise?

7. Stock market forecasting with wavelets

- difficulty: 4

- See e.g. Yousefi et al (2005), doi:10.1016/j.chaos. 2004.11.015

- implement a wavelet analysis (Daubechies wavelets) for stock market and commodity prices timeseries

- test how well you can forecast (correlation between "predicted" data and data not used for the wavelet analysis)

- vary forecast range

8. Agent based modelling of self-driving cars

- difficulty: 2 (?)

- "Once cars can talk to each other, we will not need any traffic lights or even restrictions on which side of the road they can drive, it will look very organic, e.g. like water flowing."

- Use agent-based modelling to simulate large numbers of cars on a small street network.

- Analyse traffic flow as function of car density (and rules)

9. Analysis of natural motion

- difficulty: 3 (?)

- motion (walking, swimming, flying) can be decomposed into very few components using SVD

- example:

  - Girdhar K, Gruebele M, Chemla YR (2015) The Behavioral Space of Zebrafish Locomotion and Its Neural Network Analog. PLoS ONE 10(7): e0128668. doi:10.1371/journal.pone.0128668

  - *Mission Impossible: Rogue Nation*: https://www.youtube.com/watch?v=0iZ-nQ4yFn4 starting at 0:51.

- use videos and image processing + SVD

- gait analysis: is how you walk like a finger print?

- What are the most complex motions?