

Rethinking Computing Education with Vocareum and Canvas



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University of Notre Dame

November 18, 2021

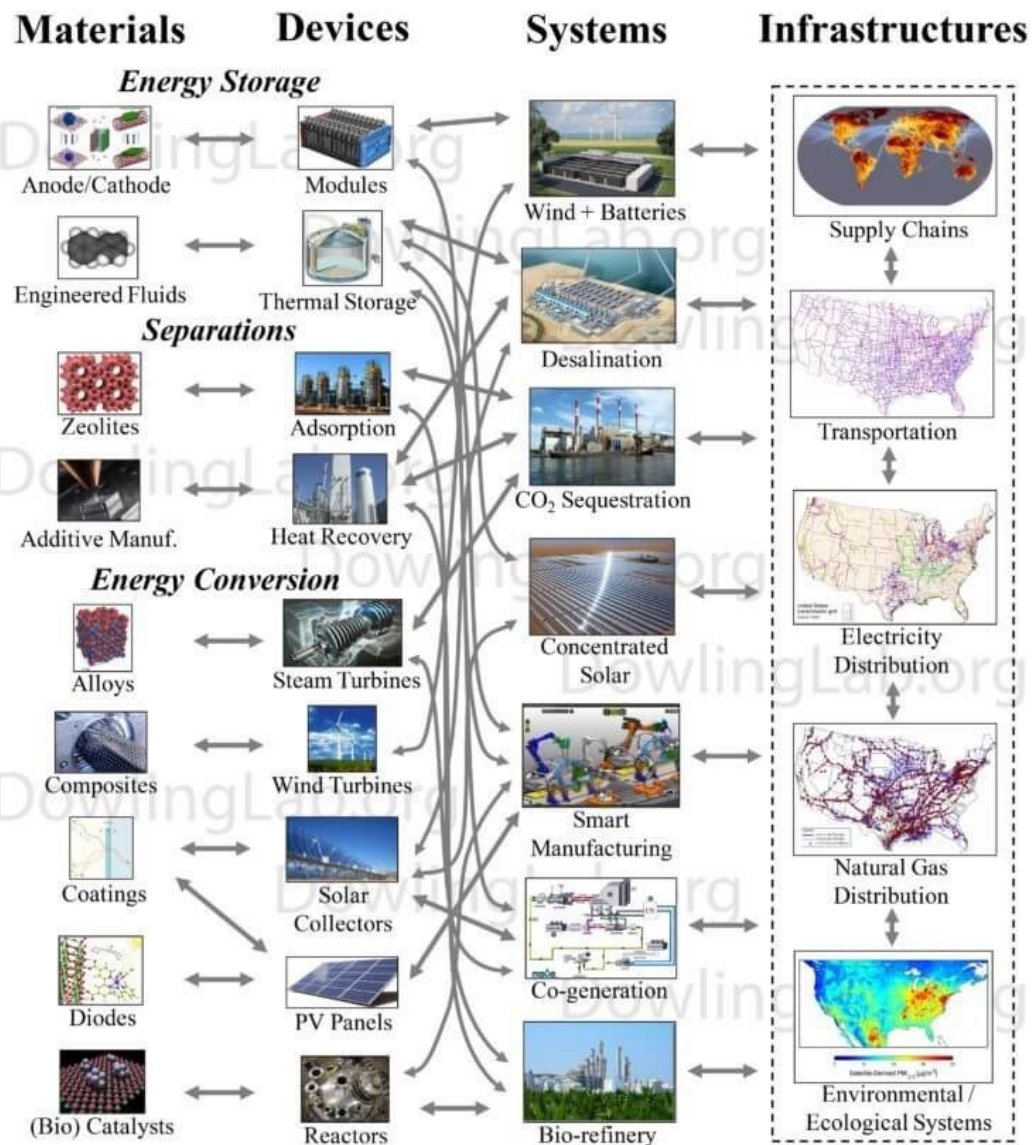
colab

vocareum



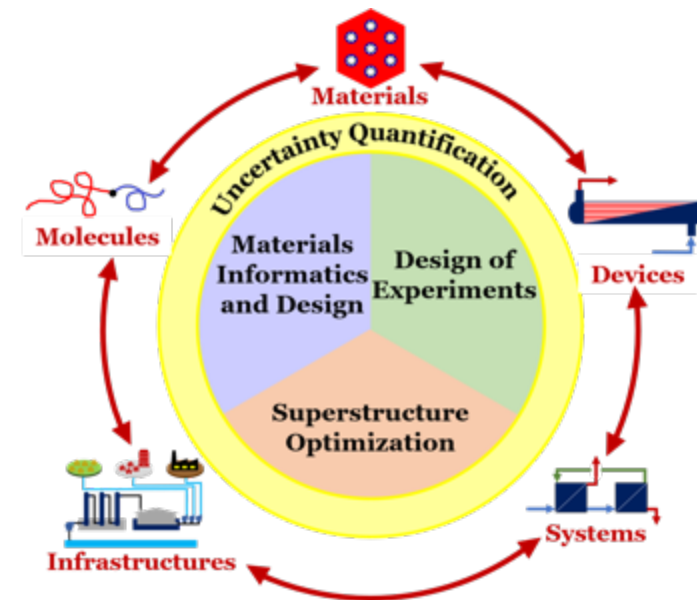
These slides are available at <http://psecommunity.org/LAPSE:2021.0803>

Research: Process Systems Engineering

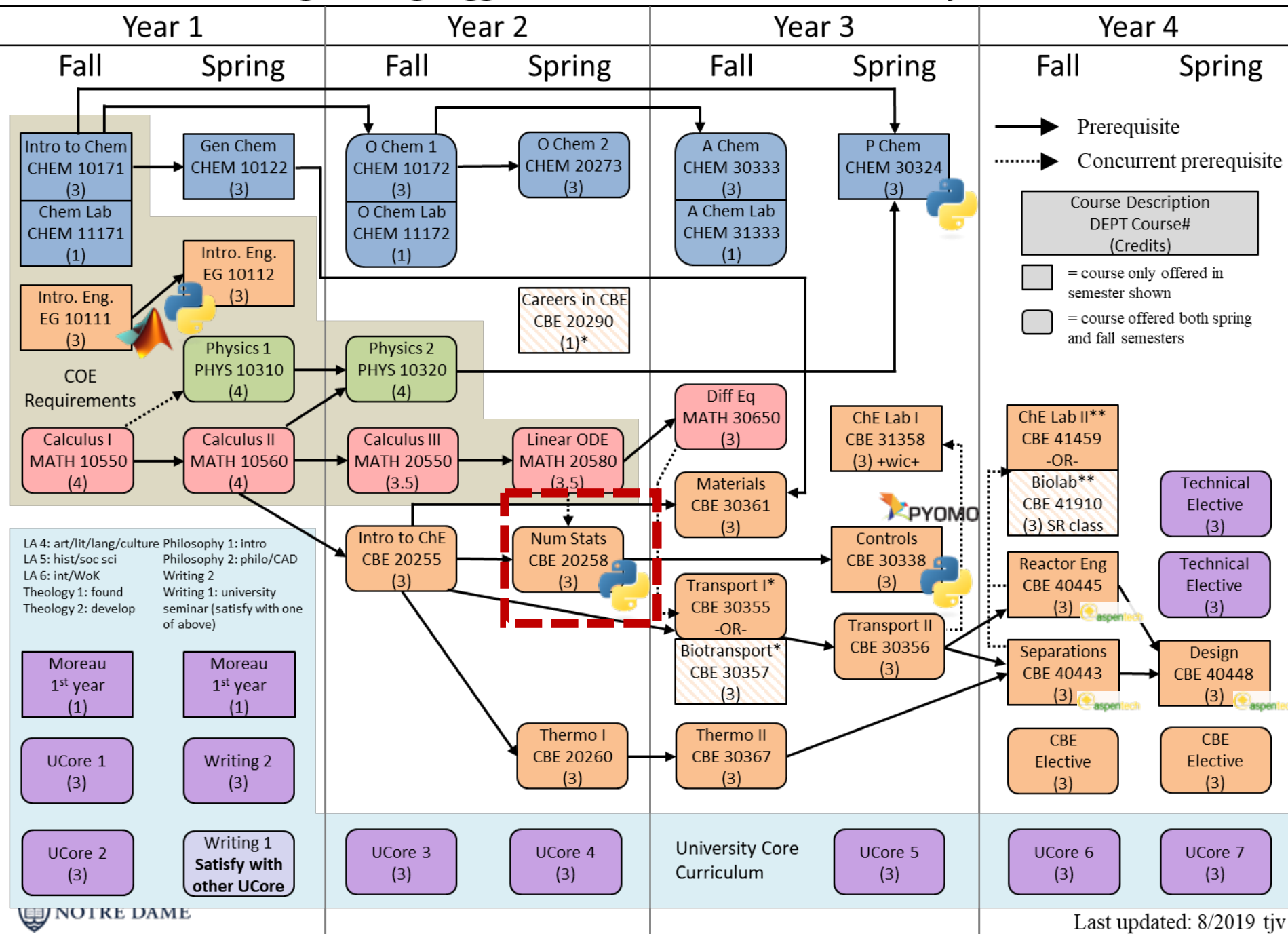


Themes

- Mathematical Modeling
- Computational Optimization
- Applied Statistics and Uncertainty Quantification
- Energy, Sustainability, & Systems Biology Applications



Chemical Engineering Suggested 4 Year Curriculum University of Notre Dame



Current Practice: Computing & Statistics

MATLAB in freshman engineering sequence

Sophomore-required
Numerical & Statistical Analysis (NSA)

Ad-hoc computing & statistics in upper-level classes:

"You learned this as sophomores... just figure it out" – Prof. Anonymous

Vision

Vertically integrate computing and statistics throughout the undergraduate curriculum

Modernizing Numerical and Statistical Analysis

Backward Course Design Set Clear Learning Objectives

At the end of the semester, you should be able to...

1. **Create mathematical models** and **apply computational methods** to analyze systems using basic principles of chemical engineering (e.g., mass and energy balances, thermodynamic equilibrium, etc.)
2. **Analyze data** and **quantify uncertainty** using standard statistical techniques and mathematical models grounded in engineering fundamentals
3. Independently plan, implement, and debug short (100 to 300 lines) **Python computer programs** to analyze data, solve engineering mathematical models, and visualize results

Major Changes

Reorganized class topics

- Removed advanced topics (QR factorization, compression with SVD, trust regions, BVPs, PDEs)
- Emphasized fundamentals, especially probability & statistics
- Added mass and energy balance examples

Switched to **Python**, with great student buy-in

Incorporated **active learning** into lectures

Shortened assignments

Active Learning is Essential for Computing and Statistics

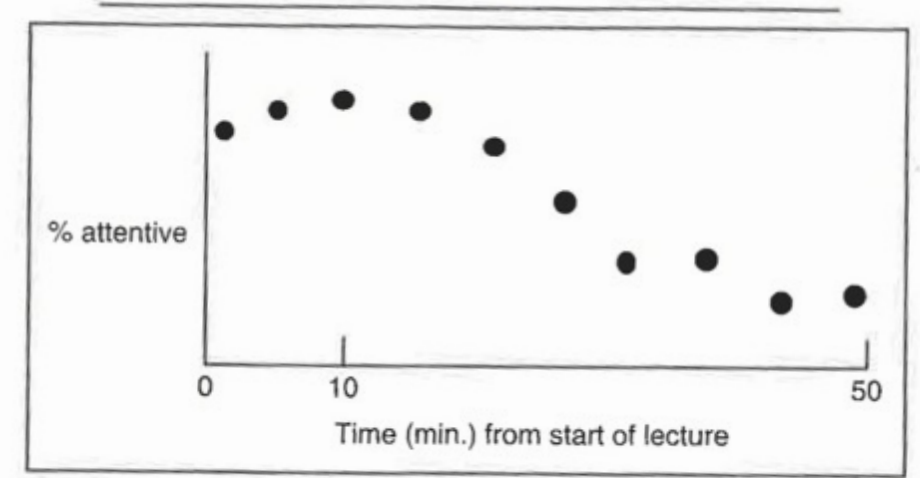


Figure 6.3-1: Attentiveness versus Time in Lecture—No Activities

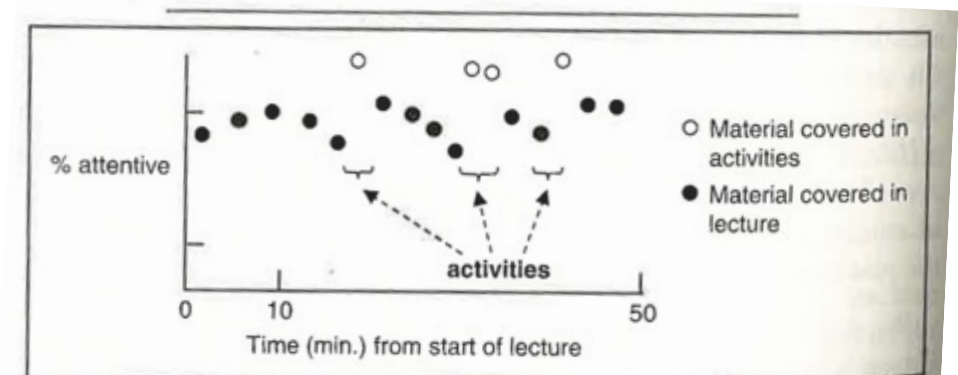


Figure 6.3-2: Attentiveness versus Time in Lecture—Activities Interspersed

Spring 2019: Cloud-based Google Colaboratory (Jupyter Notebooks)

`colab.research.google.com`

Benefits of Google Colaboratory:

Like Google Docs, but for code

Integrated with **Google Drive**:
automatic versioning, easy sharing

Removes barriers to access:
students can complete assignments
from **any internet connect computer**
– no need to support 80+ local Python
installations

Facilitates **active learning**

Free

The screenshot displays the Google Colaboratory web interface. At the top, the notebook title is 'L18-Error-Rates-Statistical-Power.ipynb'. Below the title bar, there are tabs for 'CODE', 'TEXT', and 'CELL'. The main content area shows a Jupyter notebook with a text cell containing the following text:

Based on this analysis, your team concludes that improving yield from 80 to 81 percent of theoretical maximum performance is not worth the capital investment. Upper management will only approve the new process if it has a **mean yield of at least 84 percent**.

With a partner, copy the code from above and repeat the analysis. Answer two questions:

1. What is the statistical power with $n = 50$ if we assume the mean yield of the new process is 84 and same standard deviation of the current process?
2. Using the same assumptions, what is the smallest sample size with a statistical power of at least 99.9%?

Record your answers here: <https://forms.gle/JodRxokLT4hpWGH8>

Below the text cell, there are two code cells. The first code cell contains the following text:

```
[ ] 1 ## Question 1
    2
    3 # Step 1
    4
    5
    6 # Step 2
    7
    8
    9 # Step 3
   10
   11
   12 # Step 4
   13
```

The second code cell contains the following text:

```
[ ] 1 ## Question 2
    2
    3 # Step 1
    4
    5
    6 # Step 2
    7
    8
```

On the right side of the interface, there is a sidebar with a 'COMMENT' button, a 'SHARE' button, and a user profile for 'Alexander Dowling'. A notification bubble indicates that students can add comments to their own local copy, just like Google Docs.

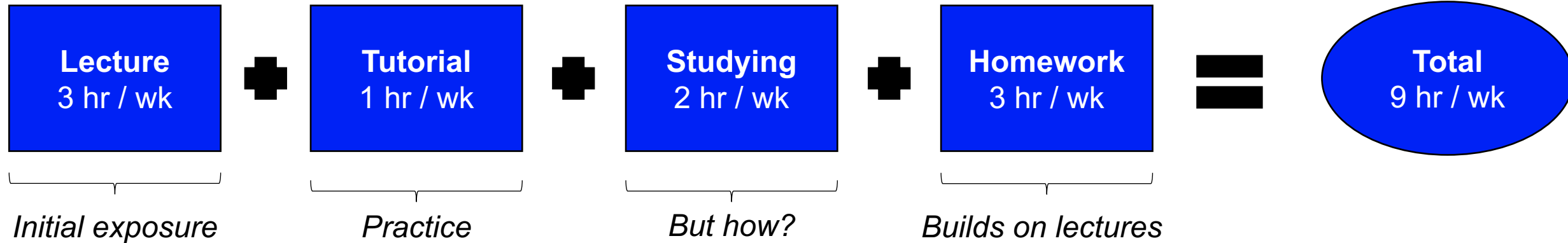
Making your time more effective

Easy

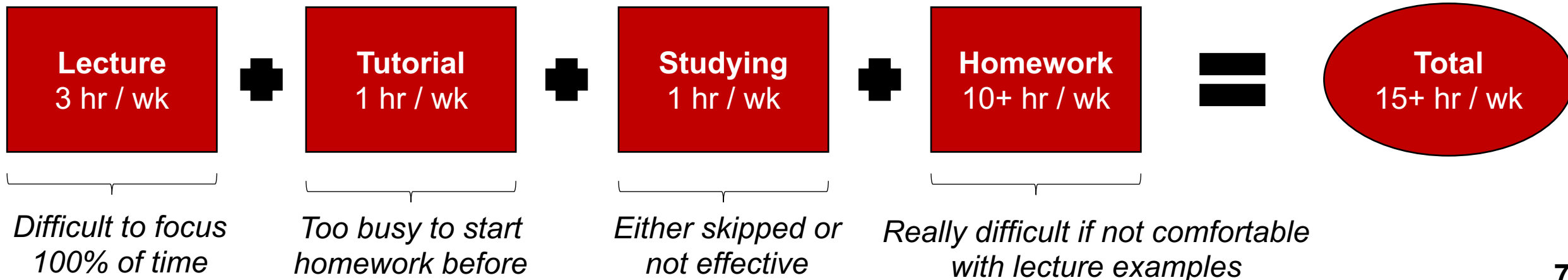
Complexity of Concepts and Applications

Difficult

Traditional Class (plan)



Traditional Class (reality for many)



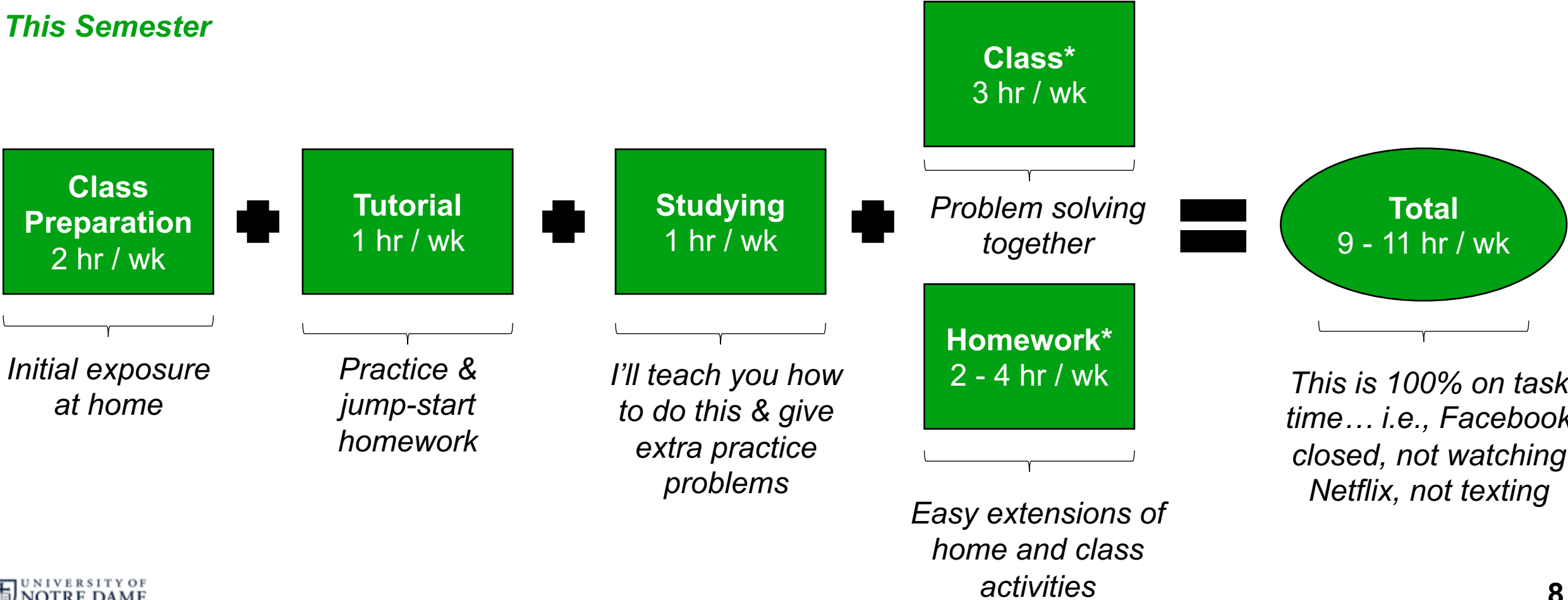
Making your time more effective

I show this slide on day 1.



**We'll start some homework problems during class.*

This Semester



Fall 2019 - today: Cloud-based Vocareum (Jupyter Notebooks)

www.vocareum.com

Benefits of Vocareum:

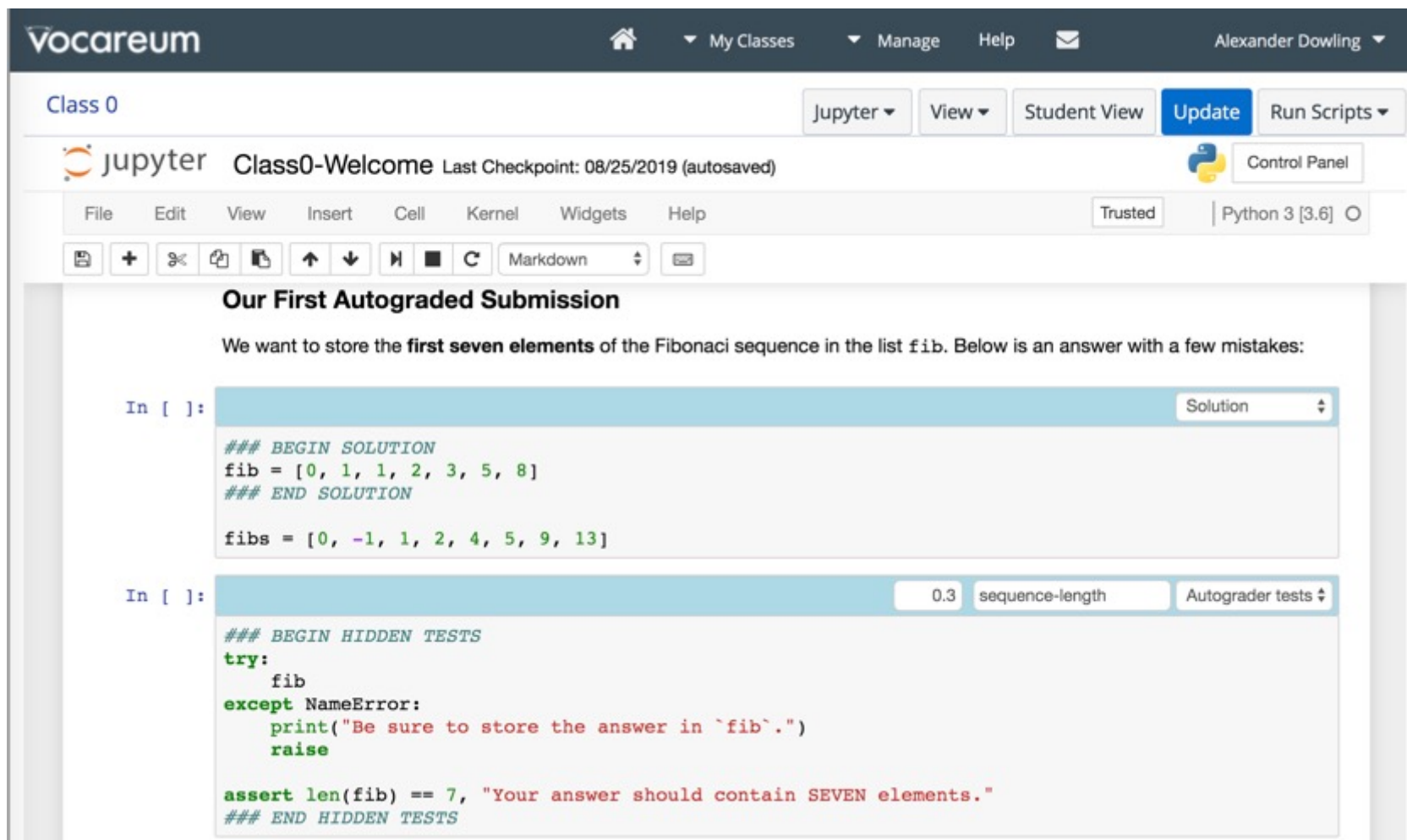
Many of the same cloud-based benefits as Colaboratory

Integrated with **Learning Management System** (e.g., Canvas) and gradebook

Supports **autograding** via nbgrader (with some enhancements)

Supports plagiarism detections (if you want it)

Paid service, but responsive technical support



The screenshot displays the Vocareum web interface for a Jupyter Notebook. The top navigation bar includes the Vocareum logo, a home icon, and links for 'My Classes', 'Manage', 'Help', and a user profile 'Alexander Dowling'. Below this, the notebook is titled 'Class 0' with buttons for 'Jupyter', 'View', 'Student View', 'Update', and 'Run Scripts'. The Jupyter interface shows a 'Class0-Welcome' message and a 'Last Checkpoint: 08/25/2019 (autosaved)' status. The notebook content is titled 'Our First Autograded Submission' and includes a text prompt: 'We want to store the **first seven elements** of the Fibonacci sequence in the list `fib`. Below is an answer with a few mistakes:'. The first code cell, labeled 'In []:', contains a solution attempt:

```
### BEGIN SOLUTION
fib = [0, 1, 1, 2, 3, 5, 8]
### END SOLUTION

fibs = [0, -1, 1, 2, 4, 5, 9, 13]
```

. The second code cell, also labeled 'In []:', shows hidden tests:

```
### BEGIN HIDDEN TESTS
try:
    fib
except NameError:
    print("Be sure to store the answer in `fib`.")
    raise

assert len(fib) == 7, "Your answer should contain SEVEN elements."
### END HIDDEN TESTS
```

. The autograder results for the second cell show a score of 0.3 for the 'sequence-length' test, with a dropdown for 'Autograder tests'.

Fall 2019 - today: Cloud-based Vocareum (Jupyter Notebooks)

www.vocareum.com

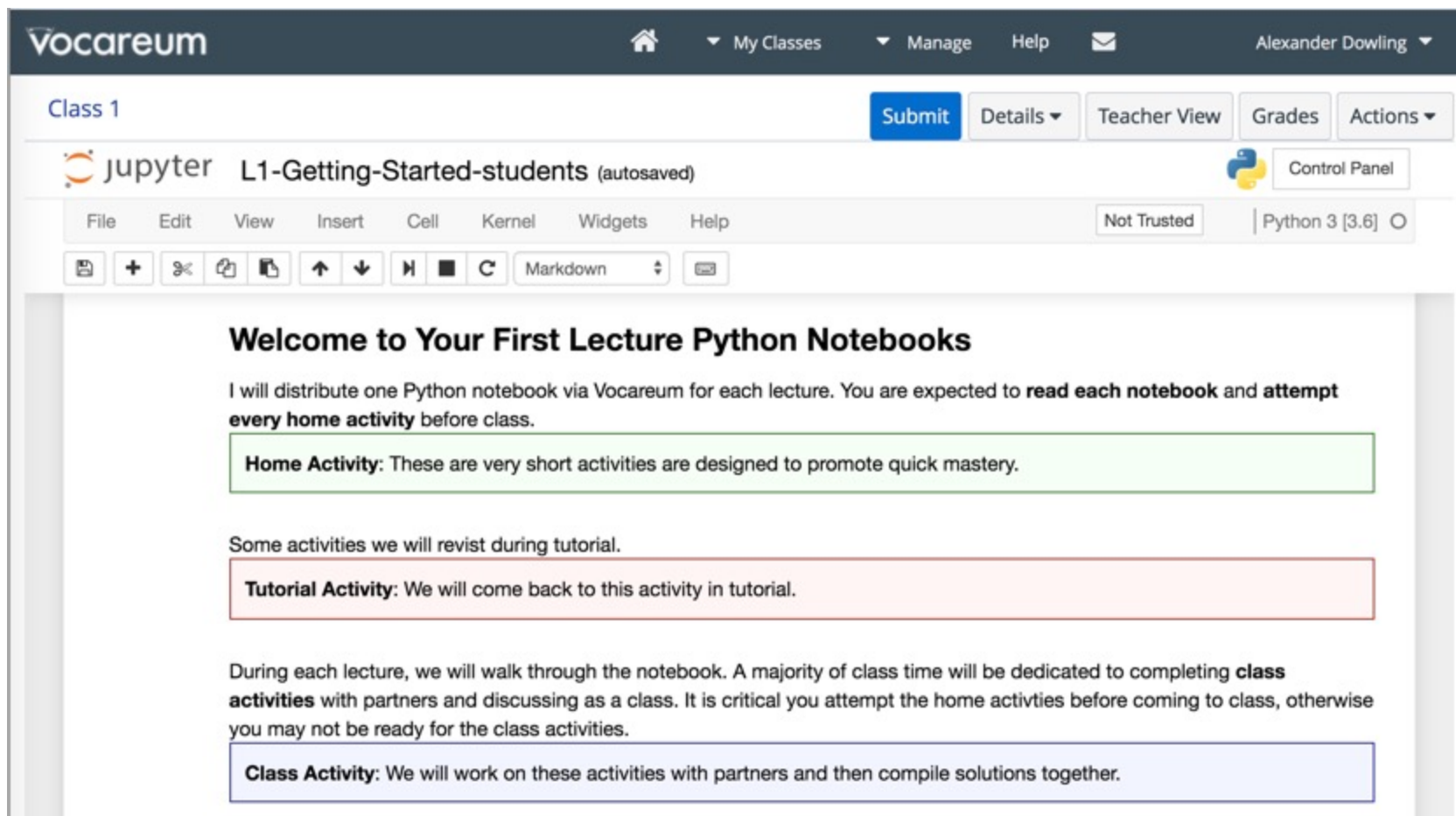
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Bottom Line: Autograder (Vocareum) enables accountability for meaningful home activities before class, which translates to more engaging class sessions.


Canvas *Assignments* give students landing page




Account




Dashboard




Courses




Calendar




Inbox



History



Commons



Help

FA21-CBE-20258-01 > Assignments

63 Student View

FA21

Search for Assignment

+ Group

+ Assignment

Home

Vocareum Content

Syllabus

Pages

Announcements

Assignments

Grades

People

Files

Gradescope

▼ Assignments

0% of Total

FA21 Vocareum Labs CBE-20258

▼ Class Participation

2% of Total

Tutorial 1 / Class 0: Welcome to Vocareum

Due Aug 23 at 6pm | 1 pts

Class 1: Getting Started in Python

Due Aug 26 at 9:25am | 1 pts

Class 2: Functions, Scoping, and Recursion

Due Aug 26 at 9:25am | 1 pts


Each Canvas *Assignment* includes a link to Vocareum



Account



Dashboard



Courses



≡

FA21-CBE-20258-01 > [Assignments](#) > Class 1: Getting Started in Python

👤 Student View

FA21

Class 1: Getting Started in Python

Submit completed notebook via Gradescope. There is no Vocareum autograder for this assignment.

This tool needs to be loaded in a new browser window

Load Class 1: Getting Started in Python in a new window


Home

Vocareum Content

Syllabus

Pages

Instructor Manually Creates Each *Assignment* in Canvas



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FA21

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Files

Gradescope

Panopto Video

New Analytics

Discussions

Outcomes

Rubrics

FA21-CBE-20258-01 > Assignments > Class 1: Getting Started in Python

Published

Details

Mastery Paths

Class 1: Getting Started in Python

Edit View Insert Format Tools Table

12pt Paragraph B I U A T²

Submit completed notebook via Gradescope. There is no Vocareum autograder for this assignment.

p

13 words

Points

1

Change title here

Write instructions here

Points in Canvas and Vocareum must match, otherwise grades will not transfer

Instructor Manually Creates Each *Assignment* in Canvas

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People

Files

Gradescope

Panopto Video

New Analytics

Discussions

Outcomes

Rubrics

Quizzes

Modules

Collaborations

Submission Type

External Tool

External Tool Options

Enter or find an External Tool URL

https://labs.vocareum.com/lti/vclab.php

Find

☒ Load This Tool In A New Tab

Submission Attempts

Allowed Attempts

Unlimited

Assign

Assign to

Everyone

Due

Aug 26, 2021, 9:25 AM

Select “External Tool”

Copy this URL from Vocareum (easy)

Check this box

Set due date here

Vocareum + Gradescope for Jupyter Notebooks

Typical assignments require three submissions:

1. Vocareum (autograder)
2. Gradescope Notebook
3. Gradescope Written

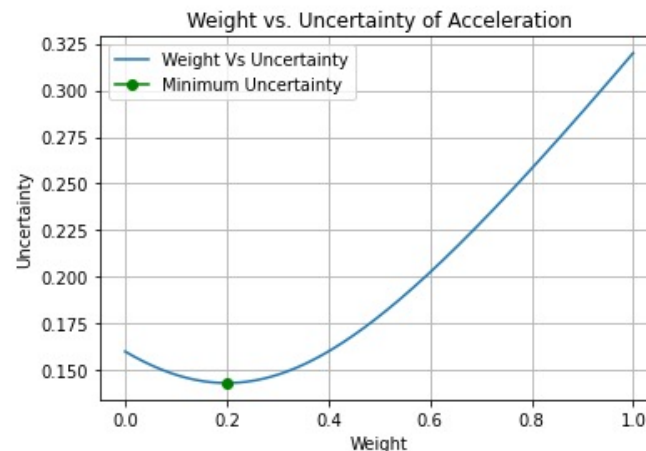
```
for i in range(len(w)):
    U[i] = math.sqrt((w[i]**2)*(U_A1**2) + ((1-
w[i])**2)*(U_A2**2))

#plot w vs uncertainty
plt.plot(w,U, label = 'Weight Vs Uncertainty')
plt.plot(w[np.argmin(U)],np.min(U), marker = 'o',
color = 'green', label = 'Minimum Uncertainty')
plt.xlabel('Weight')
plt.ylabel('Uncertainty')
plt.title('Weight vs. Uncertainty of Acceleration')
plt.legend()
plt.grid(True)
plt.show

# Find the minimum uncertainty
index = np.argmin(U)
weight = w[index]

#Calculate Acceleration
A3 = round(weight*A1 + (1-weight)*A2,2)

#Calculate Uncertainty
U_A3 = round(math.sqrt((weight**2)*(U_A1**2) + ((1-
weight)**2)*(U_A2**2)),2)
```



2:1c ▾

13 OF 13 GRADED

TOTAL POINTS

0.5 / 0.5 pts

[Rubric Settings](#)

[Collapse View](#)

1 **-0.0**

Correct

[+ Add Rubric Item](#)

[Create Group](#)

[Import...](#)

SUBMISSION SPECIFIC ADJUSTMENTS

Point Adjustment

APPLY PREVIOUSLY USED COMMENTS

nbpages + Google Colab

CBE60499

Nonlinear and Stochastic Optimization. <https://ndcbe.github.io/CBE60499/>

[View the Project on GitHub](#) ndcbe/CBE60499

CBE60499

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Chapter 1.0 Getting Started with Pyomo

- [1.1 60 Minutes to Pyomo: An Energy Storage Model Predictive Control Example](#)
- [1.2 Pyomo Mini-Project: Receding Horizon Stochastic Control](#)

Chapter 2.0 Optimization Modeling with Applications

This notebook contains material from [CBE60499](#); content is available [on Github](#).

[< 1.1 60 Minutes to Pyomo: An Energy Storage Model Predictive Control Example](#) | [Contents](#) | [Tag Index](#) | [2.0 Optimization Modeling with Applications](#) >

 [Open in Colab](#) [Github](#) [Download](#)

In []:

```
# IMPORT DATA FILES USED BY THIS NOTEBOOK
import os, requests

file_links = [("data/Prices_DAM_ALTA2G_7_B1.csv", "https://ndcbe.github.io/CBE60499/data/Prices_DAM_ALTA2G_7_B1.csv")]

# This cell has been added by nbpages. Run this cell to download data files re

for filepath, fileurl in file_links:
    stem, filename = os.path.split(filepath)
    if stem:
        if not os.path.exists(stem):
            os.mkdir(stem)
    if not os.path.isfile(filepath):
        with open(filepath, 'wb') as f:
            response = requests.get(fileurl)
            f.write(response.content)
```

1.2 Pyomo Mini-Project: Receding Horizon Stochastic Control

Deadline: Friday, March 5, 2021

1.2.1 Assignment Goals

Which platform?



Closed ecosystem, requires authentication (e.g., Canvas)

- More effort for students to access in future
- + Easy to control access

+ **Autograder** with Canvas integration

- More effort to setup/manage

+ Responsive tech support

Great for computing focused undergraduate classes



Sharing via Google Drive or website (nbpages)

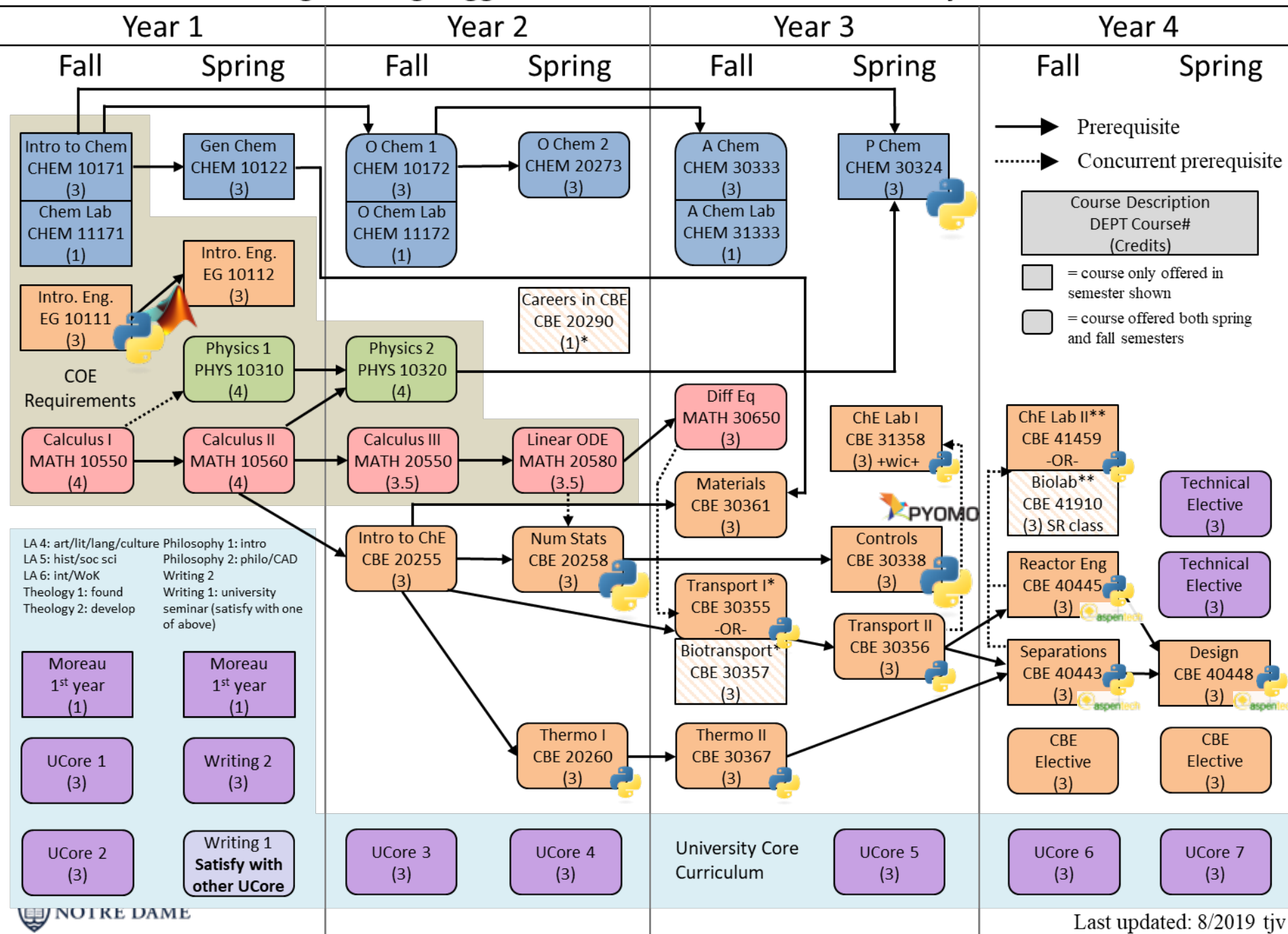
- + Easy to disseminate
- Limited control over access
- Only manual grading via Gradescope

+ Easier to setup

- On your own, fingers crossed Google does not end support for Colab ;)

Great for graduate classes and occasional class assignments/examples

Chemical Engineering Suggested 4 Year Curriculum University of Notre Dame



Vision

Vertically integrate computing and statistics throughout the undergraduate curriculum

Library of Cloud-based Jupyter Notebooks

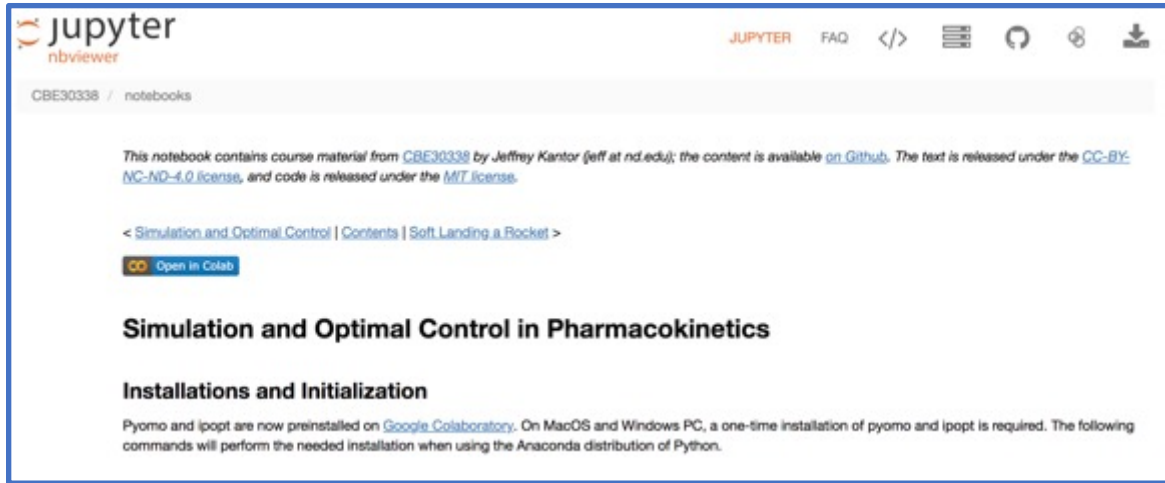
Complement existing core CBE classes with examples that use computing and statistics for problem solving

colab

vocareum

Last updated: 8/2019 tjv

Special Thanks



<https://github.com/jckantor>

Chemical Process Control

Introduction to Chemical Engineering Analysis

Introduction to Operations Research

Process Operations

Prof. Jeff Kantor



Prof. Yamil Colón



Vocareum Pilot

Pat Miller

Xiaoqing Duan

Kaneb Center

Kevin Barry

Dan Hubert

Kristi Rudenga

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