Illustrative Mathematical Concepts with Practical Applications

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DISCOVERY PARK

Motivation

- Average drop, failure, and withdrawal (DFW) rates for Calculus I [1]
  - 22% among undergrad institutions
  - 38% among two-year institutions
- Math skills are directly correlated to student performance in engineering courses [2,3]

[1] Bressound, D. M. (2015). Insights from the MAA National Study of College Calculus, *Journal of Mathematics Teacher Education,* 109(3), 178.

[2] Imran, A., Nasor, M., & Hayati, F. (2012). Relating grades of maths and science courses with students' performance in a multi-disciplinary engineering program – a gender inclusive case study. *Procedia – Social and Behavioral Sciences*, *46,* 3989-3992.

[3] Bischof, G., Zwölfer, & A. Rubeša, D. (2015). *Correlation between engineering students' performance in mathematics and academic success,* Paper presented at 2015 ASEE Annual Conference & Exposition, Seattle, Washington. 10.18260/p.23749

Objectives

- Develop Jupyter Notebooks, publish on nanoHUB that will:

  1) graphically illustrate critical mathematical concepts
  2) bridge key concepts with practical applications
  3) engage students in interactive, multi-step activities

- Implement tools in Engineering courses offered at Ivy Tech Community College in Lafayette, IN.

1. Key Concept | 2. Application | 3. Activities | 4. Code

Approach

$$f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h} = \frac{dy}{dx}$$

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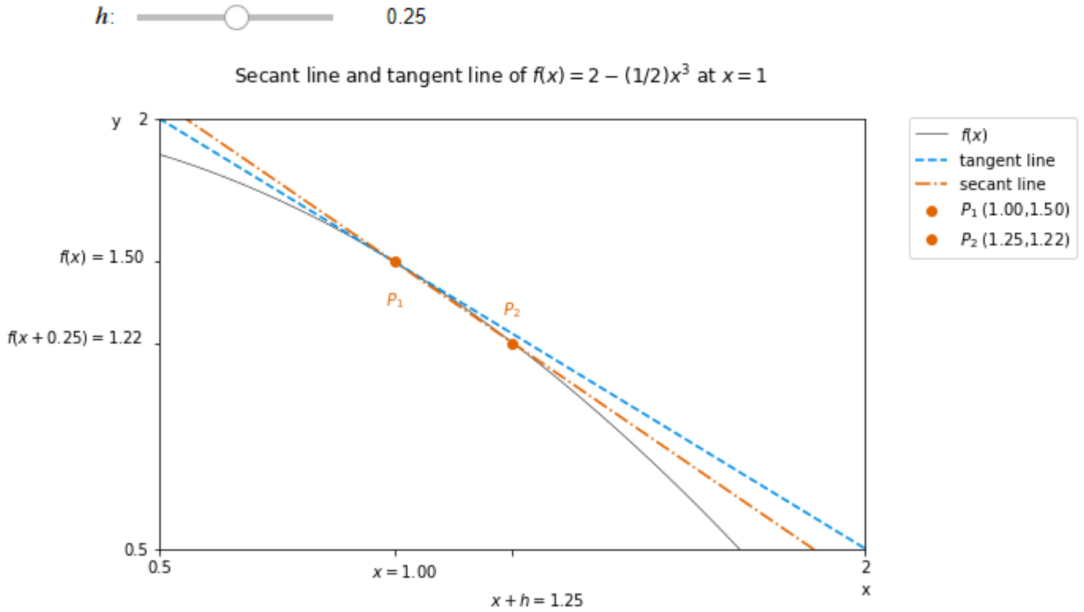
$$dy = \Delta y \to 0 = \lim_{h \to 0} f(x+h) - f(x)$$
$$dx = \Delta x \to 0 = \lim_{h \to 0} h$$

$$f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h} = \frac{dy}{dx}$$



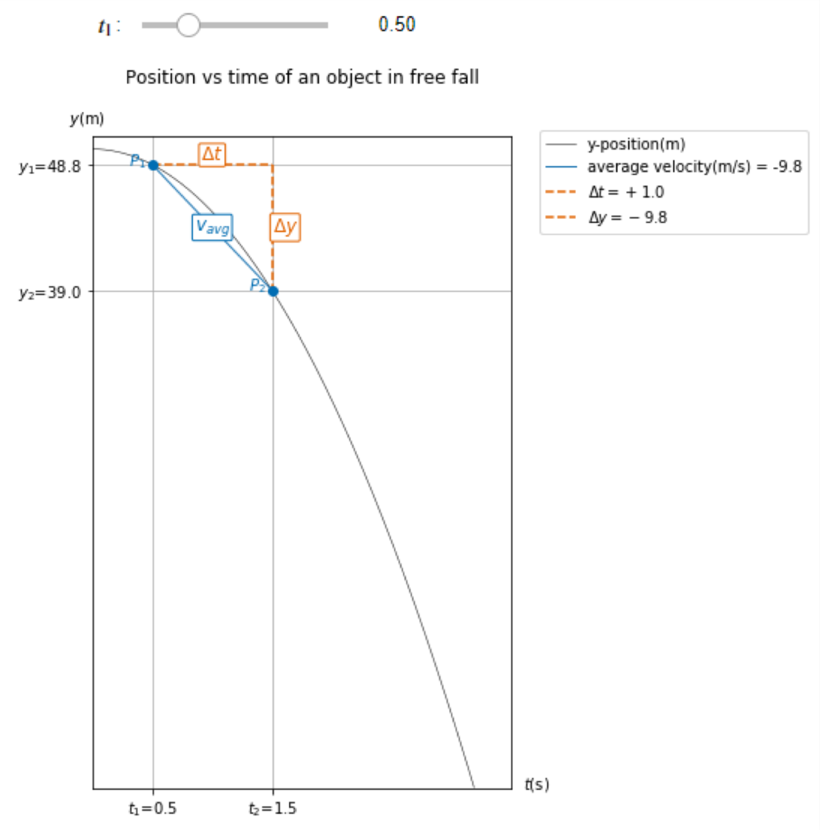
Approach

1. Key Concept
2. Application
3. Activities
4. Code

$$v_{avg} = \frac{\Delta\text{position (m)}}{\Delta\text{time (s)}}$$

$$v_x = \frac{dx}{dt}, \quad v_y = \frac{dy}{dt}, \quad v_z = \frac{dz}{dt}$$

$$a_x = \frac{dv_x}{dt}, \quad a_y = \frac{dv_y}{dt}, \quad a_z = \frac{da_z}{dt}$$



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Approach

1. The first derivative $f'(x)$ determines the concavity of the original function $f(x)$.

True	False
Wrong	False

```
The second derivative $f''(x)$ determines the concavity of $f(x)$
```

2. If $f''(x)$ is a zero function then there won't be an inflection point on f(x).

True	False
True	Wrong

```
Inflection point occurs on the point where the first derivative has a local min
```

3. Find the velocity v_t after time $t = 5.0$ s for the given function:
$f(t) = 3 + 2.5t + t^2$

7.5 m/s	40.5 m/s	10.5 m/s	12.5 m/s
7.5 m/s	40.5 m/s	10.5 m/s	Right

Approach

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4. Modify the given code to plot the derivative of $f(x) = 3\ln(x)$ and find the value of $f'(6)$.

```
# Sample code
import matplotlib.pyplot as plt
import numpy as np
from scipy.misc import derivative

# Define variables
# x = np.arange(start value, end value, steps)
x = np.arange(0, 10, 0.1)
# f = lambda x: function in terms of x

# Create a fig
fig, ax1 = plt.subplots(figsize=(8,5))
```