Lesson Plan: Teaching Integration using World Petroleum Consumption Data

As a **high school** or **undergraduate Mathematics** teacher, you can use this set of computer-based tools to help you in teaching introductory **calculus (integration)** and specifically how to **solve integration equations**.

This lesson plan will allow you to teach **integration** using **a hands-on computer-based classroom activity** that includes **world petroleum consumption data from 1980 to 2016**. This activity includes **a set of inquiry-based questions** that will enable your students to apply their understanding of the **relationship between a function and its integral** and to **set up and solve equations with an integral** to describe the trend of world petroleum consumption over time. Carbon emissions from fossil fuels such as petroleum have contributed towards global warming since the beginning of the industrial age. This lesson plan also includes a classroom resource to enable your students to understand about oil production projections such as the **Hubbert's Peak Theory** and the **global Carbon Budget** to stay within a 2-degree Celsius warming scenario, as per the UN's Paris Agreement.

Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in **Mathematics**.

Use this lesson plan to help your students find answers to:

- What is the relationship between a function and its integral?
- How has the world petroleum consumption changed since 1980?
- How does the Hubbert's peak prediction and actual oil production in the US since 1980 differ?

About the Lesson Plan

Grade Level: High School, Undergraduate

Discipline: Mathematics, Earth Sciences

Topic(s) in Discipline: Setting up and solving integration equations, Relation between a function and its integral

Climate Topic: Energy, Economics and Climate Change, Climate Mitigation and Adaptation

Location: Global, USA

Access: Online, Offline

Language(s): English

Approximate Time Required: 50-60 min

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4. Suggested questions/assignments for learning evaluation

- What is the relationship between a function and its integral?
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2 Step-by-step User Guide

Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

1. Topic introduction and discussion

Use the teaching module, 'Integration- Introduction' by OpenStax, Rice University, to teach about integration and its applications. Navigate to the sub-sections within the module to explain the relation between a function and its integral. Use the in-built practice exercises and quizzes to evaluate your students' understanding of the topics.

This can be accessed at:

https://openstax.org/books/calculus-volume-1/pages/5-introduction

2. Extend understanding

Use the classroom activity, 'World Petroleum Consumption' from Sustainability Math by Thomas J. Pfaff, Professor of Mathematics, Ithaca College, USA, to enable your students to apply their understanding of integration using a dataset from the US Energy Information Administration (EIA). This classroom activity includes a dataset of the World's Petroleum Consumption from 1980 to 2016. This data is provided in an Excel

spreadsheet. The classroom activity also includes a Word document that contains directions on how to use different mathematical methods on the data provided. It further includes questions that you may wish to use in your classroom to explain integration to initiate a discussion on the global oil consumption in recent times. Direct your students to download the Excel file (with datasets) and the Word document (with directions to use the dataset and a set of questions to analyze the dataset). Proceed with the classroom activity and encourage your students to answer the questions by applying their understanding of integration and setting up and solving equations with integrals. Discuss how this global petroleum consumption is responsible for carbon emissions that have contributed towards post-industrial age global warming.

This can be accessed at:

http://sustainabilitymath.org/calculus-materials/

3. Discuss further

Use the visualizations and associated reading, 'How long before we run out of fossil fuels' by Hannah Ritchie, Our World in Data, to discuss the global fossil fuel reserves and the carbon budget for a 2-degree world. Begin by discussing the Hubbert's Peak Theory that predicts that the United States will run out of its oil reserves in the decades following year 2000. Then use the chart of actual US oil production over time (1910-2016) and discuss why it deviates from the Hubbert's Peak prediction. Discuss why this is significant in the context of carbon emissions and their effect on global warming. The data for the chart is available to download as a CSV file, if you wish to perform further mathematical problems based on it. Finally, use the other visualizations to discuss the global fossil fuel reserves and the target carbon budget to ensure that global warming is kept within the 2-degree warming scenario (by reducing fossil fuel based carbon emissions), as per the UN's Paris Agreement.

This can be accessed at:

https://ourworldindata.org/how-long-before-we-run-out-of-fossil-fuels

4. Questions/Assignments

Use the tools and the concepts learned so far to discuss and determine answers to the following questions:

- What is the relationship between a function and its integral?

- How has the world petroleum consumption changed since 1980?
- How does the Hubbert's peak prediction and actual oil production in the US since 1980 differ?

3 Learning Outcomes

The tools in this lesson plan will enable students to:

- learn about integration and the relation between a function and its integral.
- set up and solve integration equations to describe the trend of global oil consumption since 1980.
- know the significance of the difference between the Hubbert's peak prediction and actual US Oil production.
- discuss the importance of the carbon budget to reduce global warming.

4 Credits/Copyrights

All the teaching tools in our collated list are owned by the corresponding creators/authors/organizations as listed on their websites. Please view the individual copyright and
ownership details for each tool by following the individual links provided.
We have selected and analyzed the tools that align with the overall objective of our project and have provided the corresponding links. We do not claim ownership of or responsibility/liability for any of the listed tools.

1. Teaching Module; 'Introduction-Integration'

OpenStax by Rice University.

2. Classroom Activity; ‘World Oil Consumption’

Provided by Sustainability Math by Thomas J. Pfaff, Professor of Mathematics, Ithaca College, USA.

3. Teaching Module; ‘How long before we run out of fossil fuels’

By Hannah Ritchie, Our World in Data