

Lesson Plan: Teaching Differential Calculus (Polynomial Differentiation) using Global Average Temperature Data

As a **high school** or **undergraduate Mathematics** teacher, you can use this set of computer-based tools to help you in teaching introductory **differential calculus** and specifically **polynomial differentiation**.

This lesson plan will allow you to teach introductory **derivatives** and **differentiation**. The lesson plan includes a **hands-on computer-based classroom activity** to be conducted on a **dataset of global annual mean surface air temperatures from 1880 to 2018**. This activity includes a **set of inquiry-based questions** that will enable your students to apply their understanding of **function composition** and **polynomial differentiation** and to solve **tangent line problems**.

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 are derivatives and tangent line equations?
- Using an example, describe polynomial differentiation.
- Is the global annual mean surface temperature increasing since 1950? Since 1880?
- What is the rate of change of global average temperatures?
- Predict the global average temperatures for 2030, 2050, and 2100.
- What is the latest rate of change of global average temperatures according to the last recorded data point (2018)?

[About the Lesson Plan](#)

Grade Level: High School, Undergraduate

Discipline: Mathematics

Topic(s) in Discipline: Derivatives, Tangent Lines, Differentiation, Differentiation Rules, Function Composition, Polynomial Differentiation

Climate Topic: Climate and the Atmosphere, Climate Variability Record

Location: Global

Access: Online, Offline

Language(s): English

Approximate Time Required: 50-60 min

1 Contents

1. Teaching Module (30 min)

A teaching module to explain the basics of derivatives, derivative rules, and differentiation.

This can be accessed at:

<https://www.khanacademy.org/math/ap-calculus-bc/bc-differentiation-1-new>

2. Classroom Activity (20 min)

A classroom activity to apply understanding of derivatives and polynomial differentiation using a dataset of Global Average Temperatures.

This can be accessed at:

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

3. Visualizations (10 min)

A set of visualizations using similar datasets to better understand the changes in global surface temperatures in recent times.

These can be accessed at:

<https://climate.nasa.gov/vital-signs/global-temperature/>

<https://www.flickr.com/photos/150411108@N06/49414879103/in/photostream/>

<https://www.usgs.gov/media/images/simulated-global-temperature-change-0>

4. Suggested questions/assignments for learning evaluation

- What are derivatives and tangent line equations?
- Using an example, describe polynomial differentiation.
- Is the global annual mean surface temperature increasing since 1950? Since 1880?
- What is the rate of change of global average temperatures?
- Predict the global average temperatures for 2030, 2050, and 2100.
- What is the latest rate of change of global average temperatures according to the last recorded data point (2018)?

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, '[Differentiation: definition and basic derivative rules](#)' by Khan Academy, to introduce the concept of derivatives and differentiation. Navigate to the sub-sections within the module to explain derivative rules, the power rule, and how to differentiate polynomials. Use the in-built practice exercises and quizzes to evaluate your students' understanding of the topics.

This can be accessed at:

<https://www.khanacademy.org/math/ap-calculus-bc/bc-differentiation-1-new>

2. Extend understanding

Use the classroom activity, '[Global Average Temperature](#)' from Sustainability Math by Thomas J. Pfaff, Professor of Mathematics, Ithaca College, USA, to enable your students to apply their understanding of derivatives and polynomial differentiation using a dataset from NASA Goddard Institute for Space Studies (GISS). This classroom activity includes a dataset of the global annual mean surface air temperature linked from NASA's observations from 1950 to 2018. It also includes data from 1880 to 2018. 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 mathematical functions and methods and to initiate a discussion on the increase in global annual mean surface temperature due to anthropogenically forced global warming. Direct your students to download the Excel file (with dataset) 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 function composition, tangent line equation, and polynomial differentiation.

This can be accessed at:

<http://sustainabilitymath.org/calculus-materials/#>

3. Discuss further

Use the visualizations, '[Global Temperature](#)' by NASA/GISS, '[Temperature Change; 1880-2019](#)' by Antti Lipponen using NASA GISTEMP data, and '[Simulated global temperature change](#)' by US Geological Survey (USGS) to encourage discussion amongst your students about the real and simulated increase of global surface air temperatures from the years 1880-2020 and 1850-2100 respectively. Discuss how these changes could be affecting Earth's climate in recent times.

These can be accessed at:

<https://climate.nasa.gov/vital-signs/global-temperature/>

<https://www.flickr.com/photos/150411108@N06/49414879103/in/photostream/>

<https://www.usgs.gov/media/images/simulated-global-temperature-change-0>

4. Questions/Assignments

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

- What are derivatives and tangent line equations?
- Using an example, describe polynomial differentiation.
- Is the global annual mean surface temperature increasing since 1950? Since 1880?
- What is the rate of change of global average temperatures?
- Predict the global average temperatures for 2030, 2050, and 2100.
- What is the latest rate of change of global average temperatures according to the last recorded data point (2018)?

3 Learning Outcomes

The tools in this lesson plan will enable students to:

- learn about derivatives and differentiation
- understand function composition and tangent line problems
- apply polynomial differentiation to predict changes in global average temperatures from a given dataset

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; 'Differentiation: definition and basic derivative rules'

Developed by [Khan Academy](#)

2. Classroom Activity; 'Global Average Temperature'

Provided by [Sustainability Math](#) by Thomas J. Pfaff, Professor of Mathematics, Ithaca College, USA.

3. Visualizations

'Global Temperature' by [NASA: Climate Change and Global Warming](#)

'Temperature Change; 1880-2019' by [Antti Lipponen](#) using NASA GISTEMP data

'Simulated global temperature change' by [US Geological Survey \(USGS\)](#)