Make It Fit

Calculus Optimization

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Grade Level	12th Grade	**Time Frame**	3-4 class period(s)
Subject	Mathematics	**Duration**	180 minutes
Course	AP Calculus		

Essential Question

Why do we need optimization? What is it used for?

Summary

In this lesson, students will explore the calculus concepts of optimization and learn to increase their ability to identify, to model, and to set up functions to solve calculus word problems, focusing on the conceptual understanding over calculations. This is done through a mix of activities and by playing through Mission Prime, a digital game-based learning (DGBL) module. The DGBL module gives students the opportunity to explore and apply the concepts within an interactive world that provides them with three-dimensional visualizations of the word problems they are attempting to solve.

Snapshot

Engage

Students use the Two-Minute Paper strategy to begin thinking about optimization and to refresh what they learned in the previous lesson.

Explore

Students play the first two missions of Mission Prime to explore the concepts of calculus optimization.

Explain

Students use the Example and Non-Examples strategy to learn how they would use optimization in their daily lives.

Extend

Students extend their understanding of the concepts by playing the third mission of the Mission Prime DGBL module.

Evaluate

Students apply the concepts they've learned to a physical optimization problem to show their understanding of the concepts.

Standards

AP Calculus AB and BC Course and Exam Description (AP Calculus AB & BC (2020))

FUN-4: A function's derivative can be used to understand some behaviors of the function.
FUN-4.C: Interpret minimum and maximum values calculated in applied contexts
FUN-4.C.1: Minimum and maximum values of a function take on specific meanings in applied contexts

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Attachments

- Box Optimization Worksheet—Make It Fit - Spanish.docx
- Box Optimization Worksheet—Make It Fit - Spanish.pdf
- Box Optimization Worksheet—Make It Fit.docx
- Box Optimization Worksheet—Make It Fit.pdf
- Game Portal Guide_v1.2.pdf
- Mission Prime Instructors Guide 2017-08.pdf
- Mission Prime Mission Solutions.docx
- Mission Prime Mission Solutions.pdf

Materials

- Student devices with internet access
- K20 Game Portal accounts or iPad apps of Mission Prime for each student
- Whiteboard
- Writing utensils
- Paper
- Graph paper
- Scissors
- Tape
- Box Optimization Worksheet (attached)
- Mission Prime Solutions (attached)

Engage

Teacher's Note: Spanish Handouts

The learner handout is available in English and Spanish to meet your students' needs. Keep in mind that the AP exam is only administered in English.

Teacher's Note: Prerequisite Knowledge

It is important that students have certain prerequisite knowledge before attempting this lesson. This includes a solid understanding of algebra related to expressions and functions, geometry knowledge related to the shape and volume of simple and 3D shapes, and differential and integral calculus.

At the start of class, hold up a can of soup and ask students what they know about optimization and how that relates to the can you are holding.

Have each student take out a piece of paper and, using the Two-Minute Paper strategy, have them write everything they know or think they know related to the concept and how it might apply. Once students have finished writing, have some students share out what they have written.

Explore

Once students have finished sharing from their papers, introduce them to the Mission Prime DGBL module. Click here to learn more about the game. Play through the game at least once before teaching it so that you have a general understanding of the story and the characters that students will encounter as they play.

Teacher's Note: Accessing the Game

For your students to play Mission Prime, you'll need to set up a class in the K20 Center Game Portal ahead of time. Go to games.k20center.ou.edu and create an account. After you log in, you'll be able to create a class and invite students. For more information, refer to the Game Portal Guide in the Attachments section. If you experience any issues, go to games.k20center.ou.edu/support to contact user support.

Prepare students to play the game on their computers or tablets and have them play through the first two missions, which should take roughly 30-45 minutes. You do not need to give them further instructions here. The game will introduce them to its mechanics, concepts, and story. At this point, take time to walk around the room, helping students who are confused or stuck and observing their progress. A handout with the proper order of operations for each mission is in the Attachments section should you need it.

Optional Alternative for Technology Limitations

If it is not possible to supply each student with access to the game, having students play the game in small groups will also work. You may even find this preferable to individual play. It is, however, recommended that these groups have no more than four students apiece.

Teacher's Note: Gameplay Overview

If students rush through the directions or return to the game having forgotten how the mechanics of the game work, consider the following explanation:

Use the Tools tab to find the tools (equations) needed for the problem. Drag the tools and given numerical values to the Workbench tab to use them. The Workbench does algebraic manipulations, such as isolating variables, for the user. Individually drag the items from the Workbench or drag Tools to the Solution tab to perform actions such as solving a system of equations using substitution, taking a derivative, or finding critical values (zeros of the first derivative). Click the green check mark to submit the final answer.

This game helps students see the **process** of solving optimization problems and saves time by removing calculations.

Use the attached **Mission Prime Mission Solutions** and **Mission Prime Instructors Guide** documents for more specific guidance.

Teacher's Note

Mission Prime consists of four missions, and each one becomes progressively more challenging. Because of the length of the game, this lesson breaks up gameplay into two sections. The first section covers the first two missions, and the second section covers the third mission. Because of the time required to play it, the fourth mission is not required for this lesson. However, you may have students play this if you wish.

Explain

Having played some of the game and seen how optimization is applied within its virtual world, use the Example and Non-Examples strategy to help students think about how they would use optimization in their daily lives.

Form students into groups or continue using the groups they played the game in. Have them come up with four examples and four non-examples with explanations. Then, have each group share out one of each with the class and discuss them.

If students' examples don't already show it, you might remind them that optimization does not only pertain to physical items. It can also be used to maximize the crop yield of a field or the return on investment of a business venture. Optimization means finding the maximum or minimum values of a quantity or finding when these maximums or minimums occur.

Extend

Now, have students to go back and play mission three. This should take around another 30-45 minutes to complete. As mentioned previously, it is not required that players complete mission four, but if you have students who complete mission three very quickly, you can have them continue on to the final mission. The final mission will take another 30-45 minutes to complete.

Teacher's Note

Again, having students play the game in small groups will work if it is not possible to provide each student with individual access. It is recommended that these groups have no more than four students apiece.

Evaluate

Now that students have played the game and applied their optimization knowledge in a virtual world, it's time to have them translate that to the physical world. Have students form groups of four or five. If they were in groups to play the game, you can continue using those same groups.

Give each group some graph paper and the attached **Box Optimization Worksheet**. Give students 15-20 minutes to discuss the problem, create their paper boxes, and complete the worksheets. Then, have groups share out the volumes they ended up with. Record these numbers on the board.

Find whose box had the highest volume and have them share the processes they used to determine the size of the squares they were going to cut out of the graph paper. Make sure to clear up any misconceptions that students might have related to the concepts here as well.

Resources

- K20 Center. (n.d.). Two-Minute paper. Strategies. https://learn.k20center.ou.edu/strategy/152
- K20 Center. (n.d.). Example and non-example. Strategies. https://learn.k20center.ou.edu/strategy/163
- K20 Center. (n.d.). Mission Prime. Games. https://learn.k20center.ou.edu/game/1039