Written by: Students from Course Teaching Secondary School Mathematics

Lesson Topic: Understanding the importance of time and consistency

Lesson Overview:

This lesson engages students in a real-world financial literacy investigation, exploring the time value of money and the importance of investing. Students assume the role of financial analysts, using mathematical models to evaluate investment opportunities and examine how interest rates, initial investments, and time influence long-term financial growth.

The lesson incorporates **vertical alignment**, connecting prerequisite concepts from Math 1, Math 2, and Mathematical and Statistical Modeling to the advanced mathematical reasoning required in AP Precalculus. Students apply foundational algebraic skills, exponential functions, statistical reasoning, and regression analysis to investigate investment scenarios. Using technology such as Desmos, students develop exponential regression and piecewise models to represent investment growth under different financial conditions.

Students analyze model parameters, interpret rates of change, compare investment strategies, and make predictions about accumulated wealth. The lesson culminates in AP Precalculus-style Free Response Questions (FRQs), requiring students to interpret functions, justify mathematical conclusions, compare models, and communicate their reasoning using graphical, numerical, and algebraic representations.

Ultimately, this lesson demonstrates how vertically aligned mathematical concepts prepare students to tackle complex modeling problems while developing practical financial literacy and informed investment decision-making skills. The number of class periods required will depend on the level of student agency provided during the investigation and FRQ activities.

AP Precalculus Standards

- Exponential Functions and Models (2.5A & 2.5B)

Students use exponential functions and regression models to represent investment growth over time. They examine how initial investments, interest rates, and compounding periods affect accumulated wealth.

Students apply exponential models to answer questions about data sets and real-world situations, including predicting future investment values.

Students interpret the parameters of exponential models, explain growth rates, and use models to make financial predictions.

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- Polynomial and Rational Functions (1.14)

Topic 1.14 – Function Modeling: Students construct and interpret piecewise-defined functions to represent financial situations with changing conditions, such as different interest rates, investment periods, or financial contributions.

Students evaluate models, interpret their limitations, and use graphical, numerical, and algebraic representations to justify conclusions.

Essential Question

How can we use exponential and piecewise functions to model investment growth, predict future financial outcomes, and make informed financial decisions?

Instructional Delivery Plan

Phase one: Savings & Investment (Understanding Time Value of Money)

The students will be given the following question to ponder:
Is saving money the same as investing money?



The teacher will give students an opportunity to engage in group discussions about the importance of saving and investing. Students will share their personal perspectives on saving, discuss what they currently invest in or would like to invest in, and respond to guiding questions designed to encourage critical thinking and meaningful conversations about financial decision-making.

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Guiding Questions: Saving and Investing

1. Why is it important to save money, even when you have a small income?
2. If you received $1,000 today, how much would you save, spend, or invest? Explain your reasoning.
3. What is the difference between saving and investing? And why might someone choose to invest rather than simply save?
4. What are some things people can invest in besides stocks? And what risks are associated with those investments?
5. Why might someone who starts investing at age 18 have an advantage over someone who starts investing at age 35?
6. How does compound interest help money grow over time?
7. Would you rather have $5,000 today or invest $2,500 and allow it to grow over 15 years? Defend your decision.
8. Does an investment with the highest potential return always represent the best financial decision? Why or why not?

The teacher will then pose the discussion question for the students:

“Imagine you are saving money at home to buy your dream car, which currently costs $10,000. You finally save enough money, but by the time you are ready to buy it, the price has increased to $12,000. Why do you think the price increased? What does this tell you about the importance of saving and investing your money over time?"

The following questions will be used to guide the conversation:

- What happened to the price of the car?
- Do you still have enough money to purchase it?
- Why might the same $10,000 buy less in the future?
- **"If the money you saved at home did not grow, but the price of the car increased, did your savings really maintain their value?"**

This will then be used to understand the big concept called: Time **Value of Money**



Students will see that saving is overall a good thing; however, investing your money is better and gaining interest is one way of ensuring your money keeps value over time.

Phase 2: Understanding the financial situation

After students understand the concept of the time value of money, the class will be given the following scenario:



Imagine that you are a high school student who recently won $500 in an art competition. You are excited about receiving the money, but you are not quite sure what to do with it. You decide to keep the money safely in a drawer at home while considering your options.

For the first 10 months, the money remains in your drawer. Eventually, you decide to visit a bank and deposit the entire $500 into a savings account that earns interest.



After depositing the money:

- Six months later, your account balance is $508.67.
- Twelve months later, your account balance is $517.50.

You begin to wonder how much your investment could be worth if you allow the money to remain in the account for some time.

Phase 3: Constructing the investment model

The teacher will give the students the table, and allow them to fill in the table after reading the scenario:

Time (months)	**Account balance**
Before deposit	$500
0	
6	
12	

The teacher will then ask**: "If we wanted to represent the amount of money before it was deposited, what type of function could we use?"** After the students answer the teacher will then ask: **"What type of function could represent the money after it is deposited if it earns interest?"** As a class the students will then come up with a model that could be used to look at the entire situation from the time they put the money into the drawer to 12 months of the investment as shown:

$$M(t) = \begin{cases} 500 & -10 \leq t < 0 \\ ab^{t/12} & t \geq 0 \end{cases}$$

Phase 4: Analyzing investment growth

The class will then be asked to use Desmos to answer the following questions.

Part A

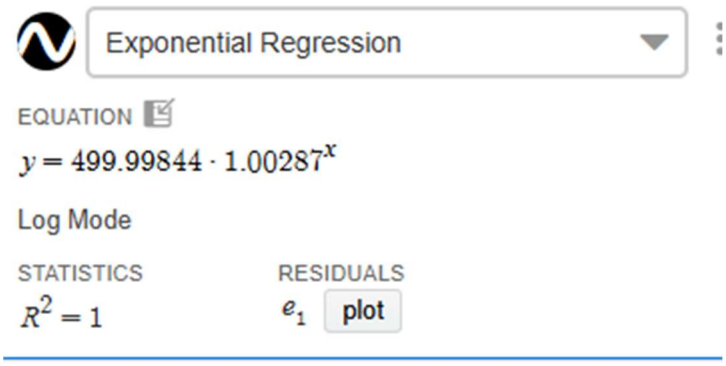
i. Use the given data to write two equations that can be used to determine the values of the constants (a) and (b\) in the expression for M(t).

Answer: $ab^{6/12} = 508.67$ and $ab^{12/12} = 517.50$

ii. Solve the equations from Part A(i) to find the values of (a) and (b). Express your answers as decimal approximations.

Answer:

x_1	y_1
0	500
6	508.67
12	517.50



Part B: Analyzing Investment Growth

Use the given data to calculate the average rate of change of the investment from (t= -2) to (t=12).

$$\frac{517.5 - 500}{12 - (-2)} = 1.25$$

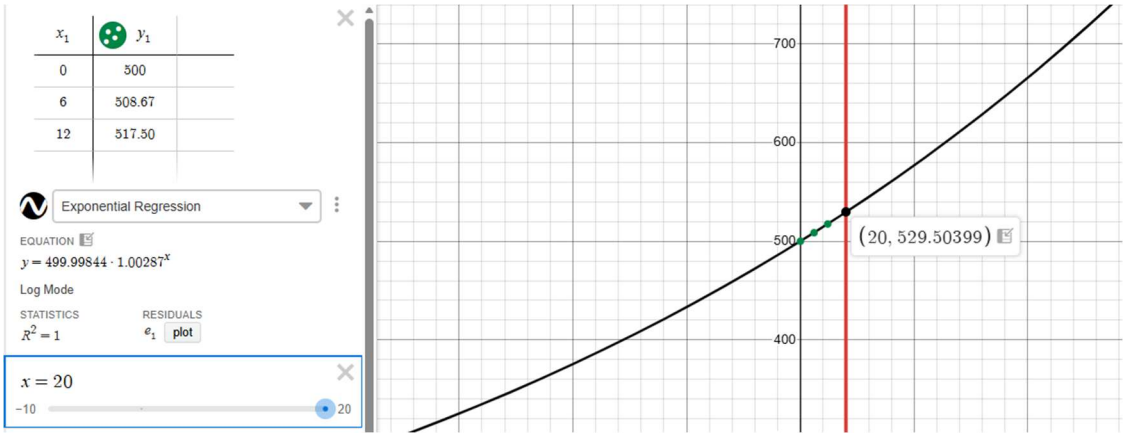
ii. Using the average rate of change, estimate the amount of money the student will have after 20 months.

Answer: The average rate of change tells you how much the amount in the bank will grow each month. Therefore each month the money in the bank will gain $1.25.

Since at month 12 the amount in the bank is $517.50, and 20 months would be 8 months more than 12, then after 20 months:

$$517.5 + 8(1.25) = 527.5$$

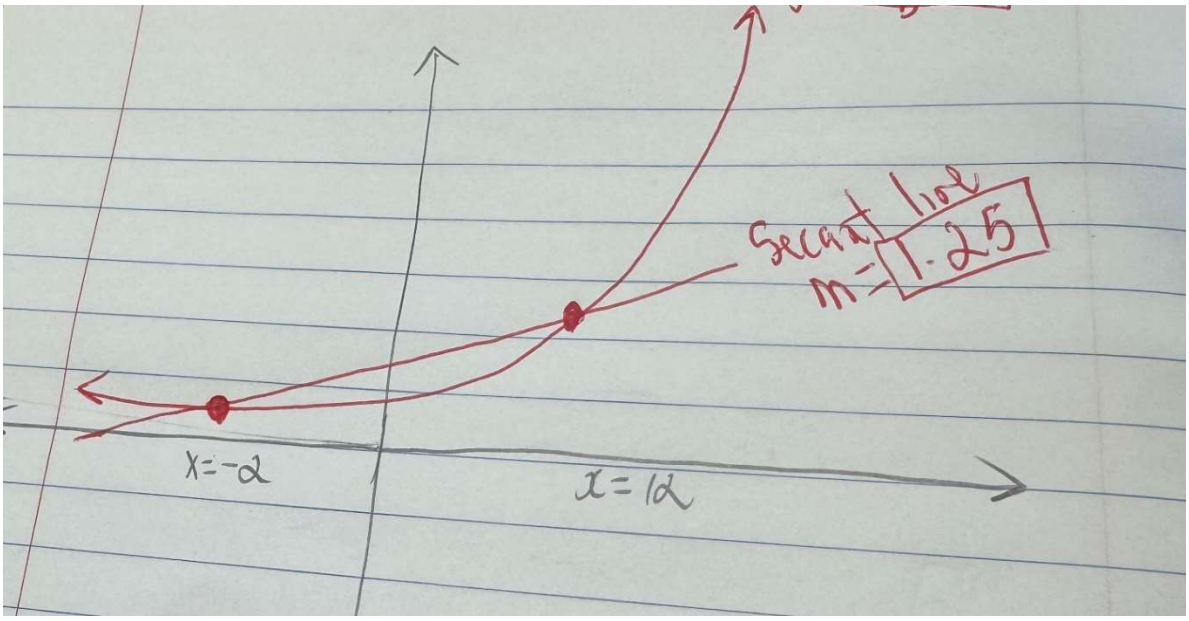
iii. Calculate M (20) using the exponential model.



Answer: $529.50

iv. Explain the difference between the estimate obtained using the average rate of change and the value calculated using M (20).

Answer: When you use the average rate of change (ROC) to estimate the amount in the account after 20 months, you are doing so using the Secant line that passes through x= -2 and x = 20. Since M(t) concaves up after t = 12 the secant line below the actual model (which means any estimate made using the ROC) will be less than when the actual model is used after 12 months as shown in the diagram below:



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The class will be given time to complete the task in groups, after which each group will be asked to answer each question by explaining what they did and why. After that discussion the students will ask:

1. What model was used to explore how the investment grew: Exponential

$$M(t) = 500(1.035)^{t/12}$$

2. Looking at our model, what does the $500 represent? The initial Investment
3. What does the 1.035 represent? The annual growth factor of investment.
4. If we started with $1,000 instead of $500, how would that affect the future account balance?
   Answer: If we started with $1,000, we would have more money in the account at the end because we started with twice as much money.
5. If we kept the initial investment at $500 but increased the growth factor, what would happen to the future balance?
   Answer: The future balance would be higher because the money would grow faster and earn more interest over time.

The students will examine the constant predicted increase assumption given by the average rate of change vs the exponential.

- Average rate of change estimate: $527.50
- Exponential model prediction: approximately $529.50

Through discussion the teacher will help the students understand why a constant dollar increase does not accurately represent compound investment growth because the amount of interest earned can increase as the account balance grows

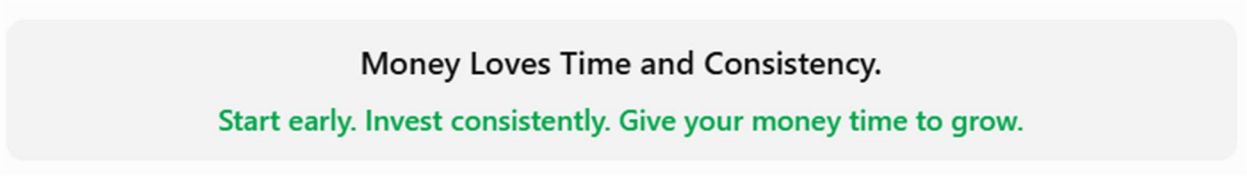
What determines how an investment grows?

Conclusion

The teacher will then ask the question:

“After everything we’ve explored today, why might someone who starts investing $500 today be better positioned than someone who waits five years to invest the same amount?”

The students will discover that money has the potential to grow when we give it time and allow interest to accumulate. The initial investment matters, but so does the interest rate, the length of time the money remains invested, and the consistency of our contributions. You do not necessarily have to start with a large amount of money to begin building wealth. What matters is developing good financial habits and allowing time and consistency to work together."



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Acknowledgements

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