**Roller Coaster Polynomials**

(PART 1: Application problems – small group in class)

(PART 2: Individual roller coaster design)

**Purpose:**
In real life, polynomial functions are used to design roller coaster rides. In this project, you will apply skills acquired in Unit 2 to analyze roller coaster polynomial functions and to design your own roller coaster ride.

**Project Components:**
1. **Application Problems** – You will have to answer questions and solve problems involving polynomial functions presented in real life scenarios. Through your work, you are expected to gain an in depth understanding of real life application of concepts such as sketching and analyzing graphs of polynomial functions, dividing polynomials, determining zeros of a polynomial function, determining polynomial function behavior, etc.

2. **INDIVIDUAL Roller Coaster Design** – You will design your own roller coaster polynomial using the skills learned during the small group application problems.

**Project Evaluation Criteria:**
Your project will be assessed based on the following general criteria:

- **Application Problems** – will be graded on correctness and accuracy of the answers. **Provide all answers in a full sentence form.**
  Make sure you clearly justify your answers where required
  Possible points: 0-3 points per question based on accuracy 54 points
  Professional appearance of the work 10 points
  TOTAL POINTS = 64 points

- **Individual Roller Coaster Design Report** – will be graded as follows
  All 10 questions are labeled in the report and answered fully 10 points
  Roller Coaster design meets all minimum requirements 7 points
  Clear and accurate response for each part 0-3 points 30 points
  Professional appearance of your report 10 points
  Creativity 7 points
  TOTAL POINTS = 64 points

**Individual Roller Coaster Design REPORT CRITERIA:**
Report MUST be completed on a separate sheet of clean, neat, copy paper. All parts MUST be answered and final answers clearly labeled. The graph showing your polynomial function MUST be printed from the calculator - you can use TI Connect or Online Calculator
Graph print out MUST have
- the x-axes and the y-axes labeled with zeroes and the y-intercept clearly labeled
- you must show the window settings used to create the graph
ALL 10 parts of the report MUST be labeled!
APPLICATION PROBLEMS:

Fred, Elena, Michael, and Diane enjoy roller Coasters. Whenever a new roller Coaster opens near their town, they try to be among the first to ride. One Saturday, the four friends decide to ride a new coaster. While waiting in line, Fred notices that part of this coaster resembles the graph of a polynomial function that they have been studying in their Pre-Calculus class.

1. The brochure for the coaster says that, for the first 10 seconds of the ride, the height of the coaster can be determined by \( h(t) = 0.3t^3 - 5t^2 + 2t \), where \( t \) is the time in seconds and \( h \) is the height in feet. Classify this polynomial by degree and by number of terms.

2. Graph the polynomial function for the height of the roller coaster on the coordinate plane at the right.

3. Find the height of the coaster at \( t = 0 \) seconds. Explain why this answer makes sense.

4. Find the height of the coaster 9 seconds after the ride begins. Explain how you found the answer.

5. Evaluate \( h(60) \). Does this answer make sense? Identify practical (valid real life) domain of the ride for this model. CLEARLY EXPLAIN your reasoning. (Hint: Mt. Everest is 29,028 feet tall.)
6. Next weekend, Fred, Elena, Michael, and Diane visit another roller coaster. Elena snaps a picture of part of the coaster from the park entrance. The diagram at the right represents this part of the coaster.

Do you think quadratic, cubic, or quartic function would be the best model for this part of the coaster? Clearly explain your choice.

7. The part of the coaster captured by Elena on film is modeled by the function below.

\[ h(t) = -0.2t^4 + 4t^3 - 24t^2 + 48t \]

Graph this polynomial on the grid at the right.

8. Color the graph blue where the polynomial is increasing and red where the polynomial is decreasing. Identify increasing and decreasing intervals.

9. Use your graphing calculator to approximate relative maxima and minima of this function. Round your answers to three decimal places.

10. Clearly describe the end behavior of this function and the reason for this behavior.

11. Suppose that this coaster is a 2-minute ride. Do you think that \( h(t) = -0.2t^4 + 4t^3 - 24t^2 + 48t \) is a good model for the height of the coaster throughout the ride? Clearly explain and justify your response.

12. Elena wants to find the height of the coaster when \( t = 8 \) seconds, 9 seconds, 10 seconds, and 11 seconds. Use synthetic division to find the height of the coaster at these times. Show all work.
Diane loves coasters that dip into tunnels during the ride. Her favorite coaster is modeled by $h(t) = -2t^3 + 23t^2 - 59t + 24$. This polynomial models the 8 seconds of the ride after the coaster comes out of a loop.

13. Graph this polynomial on the grid at right.

14. Why do you think this model's practical domain is only valid from $t = 0$ to $t = 8$?

15. At what time(s) is this coaster's height 50 feet? Clearly explain how you found your answer.

Diane wants to find out when the coaster dips below the ground.

16. Use the Rational Zeros Test to identify all possible rational zeros of $h(t) = -2t^3 + 23t^2 - 59t + 24$.

17. Locate all real zeros of this function. Clearly interpret the real-world meaning of these zeros.

18. Are there any non-real zeros for this polynomial? If so, identify them. Clearly explain your reasoning/show work.
You decided to become a structural engineer who specializes in roller coaster design. Your job is to design your own roller coaster ride. To complete this task, please follow these steps:

The amusement park you are designing for, gave you the following coaster requirements:
- your coaster ride must have at least 3 relative maxima and/or minima
- the ride length must be at least 4 minutes (make your x-axis scale in minutes, not seconds! TRUST ME)
- the coaster ride starts at 250 feet
- the ride dives below the ground into a tunnel at least once

Use a clean sheet of blank paper to complete the following tasks to write your report on your Roller Coaster Design. Label each part clearly. Your work MUST be neat, organized and must appear professional.

1. Draw a rough sketch of your "roller coaster" ride on a coordinate plane.
   Note: Be sure to illustrate your x-axis and y-axis scale to identify the length of the ride and the height of the ride you are designing. Make sure your design meets all the criteria listed above.

2. List All zeros or roots of your polynomial; be sure to include at least one of each of the following on your design: one double root (multiplicity of two), at least 2 real root, and imaginary roots.
   It might be necessary to go back to your design and modify it according to these root requirements.

3. Write the complete factored form of your roller coaster polynomial.

4. Find the equation in standard form that represents your roller coaster ride.

5. Perform long division and/or synthetic division to verify the correctness of your equation.

6. Describe the end behavior of your function and give a reason for this behavior.

7. Draw an accurate graph of your polynomial.

8. State the practical domain of your graph (that is, the actual ride).

9. State the practical range of your graph (that is, the actual ride).

10. Color the graph blue where the polynomial is increasing and red where the polynomial is decreasing and identify increasing, decreasing, and constant intervals.