Name _____

Date _____ Pd _____

Trigonometry: Sine Wave Estimation

Part 1: Select a city

Select a city from those listed in class. First come, first served—once a city is selected, nobody else in your period may select the same city.

Part 2: Data collection and display

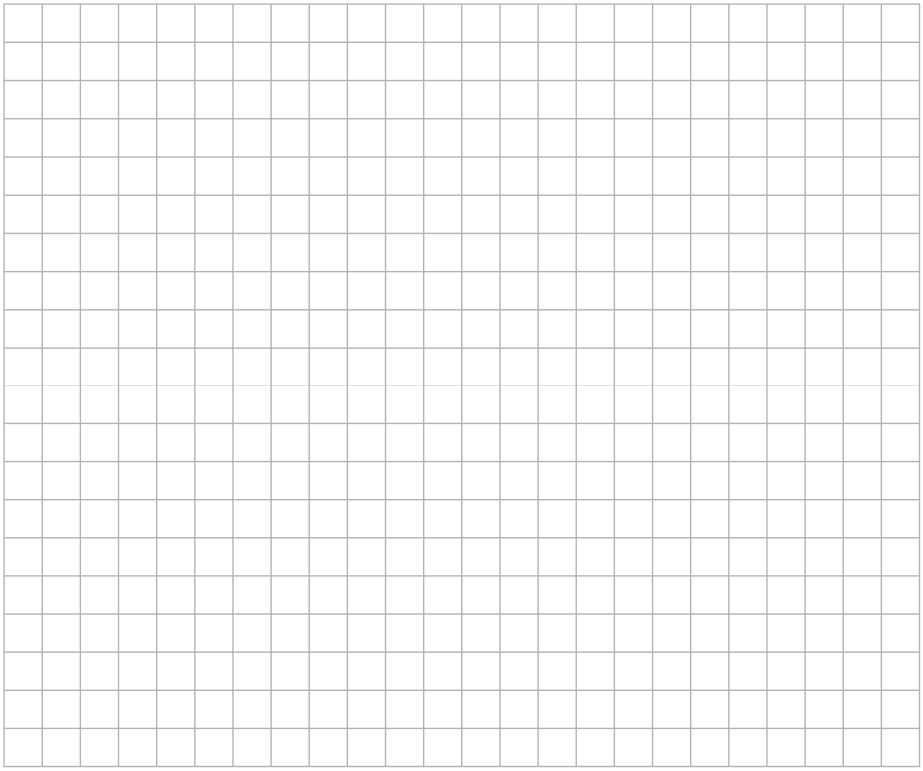
Go to **http://www.weatherbase.com** to obtain the monthly average temperature data for your city. Fill in the table below.

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Draw the *x*-axis and *y*-axis on the grid below. Make sure to place the *x*-axis low enough to accommodate the highest temperatures of your city.
The *x*-axis should be labeled **Month** with each division labeled for each month (0 = January, 1 = February, etc.)
The *y*-axis should be labeled **Temp °F** for the average monthly temperature in degrees Fahrenheit.

Plot the points of the temperature in two cycles for your city on the grid below.
You should have **25 data points** (January of year 1 to January of year 3).
Note that for the repeated data, 12 = January of year 2, 13 = February of year 2, etc.

Neatly sketch a sine wave that best fits the points you have plotted. The sketch should touch or be close to as many points as possible, but remain symmetrical. (Do not simply connect the points—the curve should be a smooth sine wave.)



Part 3: Model the data

You will now write an equation, in the form $T(x) = a\sin(b(x-h)) + k$, that models the weather pattern of your city.
Be sure to **show or explain** how each part of the equation is obtained.

1. What is the amplitude and vertical shift of your sine function? What are the values of a and k?

   amplitude = _____ vertical shift = _____ (include direction)

   a = _____ k = _____

2. What is the period of your sine function? What is the value of b?

   period = _____

   b = _____

3. What is the horizontal shift of your sine function? What is the value of h?

   horizontal shift = _____ (include direction)

   h = _____

4. What is the equation, in the form $T(x) = a\sin(b(x-h)) + k$, of your sine function?

   $T(x)$ = _____

Part 4: Graphically confirm your results

Use the online graphing calculator at **http://www.desmos.com** to confirm that the function you found in part 3 is a good model for the weather pattern of your city. Plot your city's original data points (from the table in part 2) and two periods of your function. Print the graph and glue or tape the printout in the space below.

Tips for using Desmos:

- To add points, use the **Tables** feature. To only graph two periods of your sine function, use the **Restrictions** feature.
- There are useful step-by-step "tours" under **Help (? icon)** that will show you how to create a table of values and a domain/range restriction.
- Change the color of your functions or points by clicking **Settings (the gear icon)**, then the colored circle for that function or table. Alternatively, you can hold down the colored circle for that function or table without having to press Settings.

Short reflection: When graphically comparing your points to the graph, how well does your function model the weather pattern of your city? Explain your reasoning.

Part 5: Numerical analysis of your model

The function you have written can be used to predict the temperature in any given month. The difference between the value predicted from your function and the actual value is called the **residual**.

$$\text{residual} = \text{actual value} - \text{predicted value}$$

Complete the table to analyze the accuracy of your function.

Month	x	Actual Temp	$T(x)$ (predicted temp)	Residual
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

Write a paragraph explain what causes residuals to exist. Give both mathematical and contextual reasons.

Based on the residuals, do you believe your function is a good model for the weather pattern of your city? Explain your reasoning.

Part 6: Transforming the model

Several scientists have predicted different changes in the climate of your city within 500 years. For each of the following three scenarios, use Desmos to graph your function $T(x)$ using a dashed curve. (Do not plot the individual data points.) On the same grid, graph the new model for each scenario using a solid curve. Be sure the graphs show two periods of each model. Label each graph with its function name.

A. Monthly temperatures are predicted to decrease by 15°F. Write a function, $A(x)$, that would represent this change.
Show or explain how this new function was obtained. Attach a printout with both $T(x)$ (dashed curve) and $A(x)$ (solid curve).

$A(x) =$ _____

B. Seasons are predicted to be delayed by four months. Write a function, $B(x)$, that would represent this change.
(That is, the temperature that typically occurs in January now occurs four months later, in May.)
Show or explain how this new function was obtained. Attach a printout with both $T(x)$ (dashed curve) and $B(x)$ (solid curve).

$B(x) =$ _____

C. The maximum temperature is predicted to increase by 10°. The minimum temperature is predicted to decrease by 10°.
The average temperature is predicted to remain the same. Write a function, $C(x)$, that would represent this change.
Show or explain how this new function was obtained. Attach a printout with both $T(x)$ (dashed curve) and $C(x)$ (solid curve).

$C(x) =$ _____

Part 7: Making predictions

A useful application of writing functions to model a situation is to make predictions based on your model.
What would happen if all three climate changes (A-C) happened at the same time? Write a function, $D(x)$, that would represent these changes.

$D(x) =$ _____

Use $D(x)$ to predict when we would expect to see "typical" coldest weather.
In other words, for what value of x would $D(x)$ equal the original minimum temperature?

Algebraically find your solutions. Leave your answers accurate to four decimal places.
Set $D(x) =$ "typical coldest weather" (the original minimum temperature in the table), and solve for x.
In what month(s) of the year would we expect to see "typical coldest weather"?

Graphically verify your solutions. Use Desmos to graph one period of $D(x)$. On the same grid, graph a line to represent the original minimum temperature for your city (i.e., $y =$ "typical coldest weather"). At what point(s) does the line intersect the graph of $D(x)$?
Attach a printout with $D(x)$, the line, and the intersection points. Label each graph with its function name.

Part 8: Overall Reflection

Write a 1-3 page reflection in **paragraph essay form** that addresses the following prompts:

- Explain why you selected the city that you chose.
- Discuss what went well and what was difficult about this project.
- Reflect on your usage of Desmos—what was easy and what was difficult.
- Explain how this project helped you to understand the concepts that we have covered so far this semester.

The reflection must be typed, double-spaced, using Times New Roman or Arial font in size 12, with 1" margins (not 1.25" margins) and no extra spacing. Your name and period number (and only this information, nothing else!) should be inserted at the top-right of the header, not in the body of the actual reflection.

Submission and Grading

Staple the graphs in order (A-D), then overall reflection to the back of this packet. Each sheet should be labeled with the student's name and period number.

Each student must submit their project in-person. Projects submitted by a friend, left outside the classroom door, or left in the office mailbox will not be accepted.

This project must be submitted to your teacher by **November 5, 2018** (pds 1-3) or **November 7, 2018** (pds 4-7), at the start of your class period. Any projects submitted after this will be marked late; late projects will only be accepted until **Wednesday, November 21, 2018** by 3:25 p.m. No late projects will be accepted after these dates.

	4 **Exceeds**	**3** **Meets**	**2** **Approaching**	**1** **Novice**	**0** **No Understanding**
General Learner Outcome (GLO) Self-Directed Learner Score: ____	Project is submitted prior to the due date.	Project is submitted on the due date.	Project is submitted 1-5 school days after the due date.	Project is submitted 6 or more school days after the due date.	Project was not submitted.
General Learner Outcome (GLO) Complex Thinker Score: ____	Student explanations and short responses show thorough analysis.	Student explanations and short responses show adequate analysis.	Student explanations and short responses show some superficial analysis.	Student explanations and short responses show very little analysis.	Student explanations and short responses are nonexistent or not relevant.
General Learner Outcome (GLO) Quality Producer Score: ____	All components of the student's project are neat, organized, and of high quality.	All components of the student's project are neat, organized, and of good quality.	Student's project is messy, disorganized, or incomplete.	Student project is messy, disorganized, and incomplete.	Student's project was not submitted.
General Learner Outcome (GLO) Effective Communicator Score: ____	Overall reflection is eloquent, with no grammar/spelling errors.	Overall reflection is effective, with only a few minor grammar/spelling errors.	Overall reflection is not always clear, due to grammar/spelling errors.	Overall reflection is riddled with significant grammar/spelling errors.	Overall reflection cannot be understood or is nonexistent.
General Learner Outcome (GLO) Effective and Ethical User of Technology Score: ____	Desmos graphs and overall reflection are printed according to all instructions.	Desmos graphs and overall reflection are printed according to most instructions.	Desmos graphs and overall reflection are printed according to some instructions.	Desmos graphs or overall reflection are hand-written.	No Desmos graphs or overall reflection are submitted.

All of the above GLO ratings must be a "meets" (3) or "exceeds" (4) in order to qualify for an "exceeds" (4) score on the graded standards on the next page. Otherwise, the highest score that you will be eligible for on the graded standards will be a "meets" (3).

	4 Exceeds	3 Meets	2 Approaching	1 Novice	0 No Understanding
F.IF.C.7.E Score: ____	Student correctly draws or prints all 6 graphs.	Student correctly draws or prints 4-5 graphs.	Student correctly draws or prints 2-3 graphs.	Student correctly draws or prints 1 graph.	Student is unable to correctly draw or print any graphs.
F.TF.B.5 Score: ____	Student correctly models all 5 functions and all 12 residuals.	Student correctly models 4 functions and 8-11 residuals.	Student correctly models 2-3 functions and 5-7 residuals.	Student correctly models 1 function and 1-4 residuals.	Student is unable to correctly model any functions or residuals.
F.TF.B.7 * Score: ____	Student correctly solves the equation to make a prediction.	Student makes a minor error in solving the equation to make a prediction.	Student makes a major error in solving the equation to make a prediction.	Student is barely able to progress in solving the equation to make a prediction.	Student is unable to begin solving the equation to make a prediction.