

## MTH545: Mathematical Modeling

**Credit Hours:** 3

**Contact Hours:** This is a 3-credit course, offered in accelerated format. This means that 16 weeks of material is covered in 8 weeks. The exact number of hours per week that you can expect to spend on each course will vary based upon the weekly coursework, as well as your study style and preferences. You should plan to spend 14-20 hours per week in each course reading material, interacting on the discussion boards, writing papers, completing projects, and doing research.

### Faculty Information



Faculty contact information and office hours can be found on the faculty profile page.

### Course Description and Outcomes



#### Course Description:

This graduate-level course will cover several techniques in mathematical modeling. The focus will be given to simulation using Excel. Special attention will be given to situations involving exponential growth, compound interest, combat models and disease spread. This course will offer best practices for Dual Credit course instruction and discussions of pedagogy. (3 credits total).

#### Course Overview:

In this course students will learn how to model real world phenomena using equations and Excel. Students will then use these models to analyze situations in order to understand them and make predictions.

#### Course Learning Outcomes:

1. Understand and use density-independent population models.
2. Explain the role of exponential growth in population models.
3. Understand and use various combat models.
4. Model personal finances mathematically.
5. Model the spread of infectious disease.
6. Compare and contrast population, combat, and disease models.
7. Use relevant technology to solve modeling problems.
8. Reflect on implications for application of mathematical concepts in the classroom.

### Participation & Attendance



Prompt and consistent attendance in your online courses is essential for your success at CSU-Global Campus. Failure to verify your attendance within the first 7 days of this course may result in your withdrawal. If for some reason you would like to drop a course, please contact your advisor.

Online classes have deadlines, assignments, and participation requirements just like on-campus classes. Budget your time carefully and keep an open line of communication with your instructor. If you are having technical problems, problems with your assignments, or other problems that are impeding your progress, let your instructor know as soon as possible.

## Course Materials



### Required:

Barton, J.T. (2016). *Models for life: An introduction to discrete mathematical modeling with Microsoft Office Excel*. Hoboken, NJ: John Wiley & Sons. ISBN: 9781119039754

### Suggested:

**NOTE:** All non-textbook required readings and materials necessary to complete assignments, discussions, and/or supplemental or required exercises are provided within the course itself. Please read through each course module carefully.

## Course Schedule



### Due Dates

The Academic Week at CSU-Global begins on Monday and ends the following Sunday.

- Discussion Boards: The original post must be completed by Thursday at 11:59 p.m. MT and Peer Responses posted by Sunday 11:59 p.m. MT. Late posts may not be awarded points.
- Students have one attempt on the midterm and final exams. The time limit is 400 minutes for each exam, and the exam must be completed in one sitting.
- Critical Thinking: Assignments are due Sunday at 11:59 p.m. MT.
- Live Classroom: Although participation is not required, Live Classroom sessions are held during Weeks 3 and 6. There are two total sessions.

Week #	Readings	Assignments
1	<ul style="list-style-type: none"><li>• Chapter 1.1 – 1.3 in <i>Models for Life: An Introduction to Discrete Mathematical Modeling with Microsoft Office Excel</i></li></ul>	<ul style="list-style-type: none"><li>• Discussion (25 points)</li></ul>
2	<ul style="list-style-type: none"><li>• Chapter 1.4 – 1.5 in <i>Models for Life: An Introduction to Discrete Mathematical Modeling with Microsoft Office Excel</i></li></ul>	<ul style="list-style-type: none"><li>• Discussion (25 points)</li><li>• Critical Thinking (65 points)</li></ul>
3	<ul style="list-style-type: none"><li>• Chapter 2.1 – 2.2 in <i>Models for Life: An Introduction to Discrete Mathematical Modeling with Microsoft Office Excel</i></li></ul>	<ul style="list-style-type: none"><li>• Discussion (25 points)</li><li>• Critical Thinking (65 points)</li><li>• Live Classroom (0 points)</li></ul>

4	<ul style="list-style-type: none"> <li>Chapter 2.3 – 2.5 in <i>Models for Life: An Introduction to Discrete Mathematical Modeling with Microsoft Office Excel</i></li> </ul>	<ul style="list-style-type: none"> <li>Discussion (25 points)</li> <li>Critical Thinking (65 points)</li> <li>Midterm Exam (200 points)</li> </ul>
5	<ul style="list-style-type: none"> <li>Chapter 3.1 – 3.2 in <i>Models for Life: An Introduction to Discrete Mathematical Modeling with Microsoft Office Excel</i></li> </ul>	<ul style="list-style-type: none"> <li>Discussion (25 points)</li> <li>Critical Thinking (65 points)</li> </ul>
6	<ul style="list-style-type: none"> <li>Chapter 3.3 – 3.5 in <i>Models for Life: An Introduction to Discrete Mathematical Modeling with Microsoft Office Excel</i></li> </ul>	<ul style="list-style-type: none"> <li>Discussion (25 points)</li> <li>Critical Thinking (65 points)</li> <li>Live Classroom (0 points)</li> </ul>
7	<ul style="list-style-type: none"> <li>Chapter 4.1 – 4.2 in <i>Models for Life: An Introduction to Discrete Mathematical Modeling with Microsoft Office Excel</i></li> </ul>	<ul style="list-style-type: none"> <li>Discussion (25 points)</li> <li>Critical Thinking (75 points)</li> </ul>
8	<ul style="list-style-type: none"> <li>Chapter 4.3 – 4.4 in <i>Models for Life: An Introduction to Discrete Mathematical Modeling with Microsoft Office Excel</i></li> </ul>	<ul style="list-style-type: none"> <li>Discussion (25 points)</li> <li>Final Exam (200 points)</li> </ul>

## Assignment Details



This course includes the following assignments/projects:

### Module 1

N/A

### Module 2

#### CRITICAL THINKING ASSIGNMENT (65 points)

Choose one of the following two assignments to complete this week. Do not complete both assignments. Identify your assignment choice in the title of your submission.

Note that while there are two options for the Critical Thinking Assignment, there is only one rubric. Review the rubric to confirm you are meeting the assignment requirements.

#### Option #1: Hacking Program for Cranes

Suppose a population of cranes declines by 6% per year without human intervention. A hacking program is begun with 100 cranes added the first year. Each subsequent year the number of cranes added increases by 10%. Thus, in year 2, 110 cranes are added, and in year 3, 121 are added.

- Give a flow diagram for the crane population.
- Give the corresponding DDS.
- Implement the model in Excel where the growth rate,  $r$ , the initial hacking number,  $a_0$ , and the annual percentage increase in the hacking number,  $s$ , are all stored as parameters.
- Project the crane population in year 10 if initially there are 400 cranes.

Review the **Module 2 Critical Thinking Rubric** for full details on how you will be graded on this assignment.

#### Option #2: Crane Population Sensitivity Analysis

Suppose a population of cranes declines by 6% per year without human intervention. A hacking program is begun with 100 cranes added the first year. Each subsequent year the number of cranes added increases by 10%. Thus, in year 2, 110 cranes are added, and in year 3, 121 are added.

Perform a sensitivity analysis on the exponential growth model with harvesting.

- Is the model more sensitive to changes in the growth rate or the harvesting number?
- What are the practical implications of this result?

Review the **Module 2 Critical Thinking Rubric** for full details on how you will be graded on this assignment.

### Module 3

#### CRITICAL THINKING ASSIGNMENT (65 points)

Choose one of the following two assignments to complete this week. Do not complete both assignments. Identify your assignment choice in the title of your submission.

Note that while there are two options for the Critical Thinking Assignment, there is only one rubric. Review the rubric to confirm you are meeting the assignment requirements.

#### Option #1: Savings Account with Compounded Interest

For this assignment, complete 2.13 Section Exercises, Extension Problem #14 from your textbook as described here:

Suppose a savings account earns 3% interest compounded monthly. After the first month \$100.00 is deposited into the account. Each subsequent month the deposit increases by 1%. Thus, in month 2, \$101.00 is deposited, and in month 3, \$102.01 is deposited.

- Give a flow diagram for this situation.
- Give the corresponding DSS.
- Implement the model in Excel where the interest rate,  $r$ , the initial monthly payment,  $a^0$ , and the monthly percentage increase in the monthly deposit,  $s$ , are all stored as parameters.
- Find the account balance after 2 years if initially there is \$400.00 in the account.

Review the **Module 3 Critical Thinking Rubric** for full details on how you will be graded on this assignment.

#### Option #2: Analysis of a New Car Dealer Promotion

For this assignment there are two steps:

1. Review Example 2.26 from your textbook, reproduced below.
2. Using the spirit of this example, find and analyze a new car dealer promotion that offers a choice between cash back and a more attractive APR.

Example 2.26:

Find the present value of a series of 10 annual payments of \$400 beginning 1 year from today. Assume that you could earn 5% compounded annually during this time.

Find the amount of money you would need to deposit into an account today that would exactly generate the 10 annual payments of \$400. In other words, how much do you need to start with so that you could make 10 annual \$400 withdrawals and end up with a balance of zero after the 10<sup>th</sup> one? The presence of regular withdrawals from the account requires the use of the explicit formula given by

$$B(t) = (1 + r)^t B(0) + a \frac{(1+r)^t - 1}{r}$$

Here  $a$  is the annual withdrawal, so  $a = -\$400.00$ ,  $r$  is the assumed interest rate of 5%,  $t$  is 10 years, and  $B(0)$  is the initial balance that you are looking for. Since you require the account to be empty after the 10<sup>th</sup> payment, you must have that  $B(10) = 0$ . Plug in all the known values and solve for  $B(0)$ .

$$B(10) = (1.05)^{10} B(0) - 400 \frac{(1.05)^{10} - 1}{0.05}$$

$$0 = 1.62889B(0) - 400 \frac{0.62889}{0.05}$$

$$5031.157 = 1.62889B(0)$$

$$3088.70 = B(0)$$

Thus the present value of 10 future payments of \$400.00 is \$3,088.70, assuming you could earn 5% interest. Note that this number is quite a bit less than the face value of all of the payments:  $\$400.00 \times 10 = \$4000.00$ . This is again due to present value accounting for not just the face value of money but the time value of money as well; future payments are not worth as much to you as payments made today because of the availability of interest.

Review the **Module 3 Critical Thinking Rubric** for full details on how you will be graded on this assignment.

## Module 4

### **CRITICAL THINKING ASSIGNMENT (65 points)**

Choose one of the following two assignments to complete this week. Do not complete both assignments. Identify your assignment choice in the title of your submission.

Note that while there are two options for the Critical Thinking Assignment, there is only one rubric. Review the rubric to confirm you are meeting the assignment requirements.

#### **Option #1: Present Value of Future Loan Payments**

Consider the mortgage loan question of points vs. no points. Use the present value of all future loan payments to compare the two.

Review the **Module 4 Critical Thinking Rubric** for full details on how you will be graded on this assignment.

#### **Option #2: Present Value of My Future Earnings**

Estimate the present value of your entire future earnings based on your choice of occupation.

Review the **Module 4 Critical Thinking Rubric** for full details on how you will be graded on this assignment.

### **Midterm Exam (200 points)**

## Module 5

### **CRITICAL THINKING ASSIGNMENT (65 points)**

Choose one of the following two assignments to complete this week. Do not complete both assignments. Identify your assignment choice in the title of your submission.

Note that while there are two options for the Critical Thinking Assignment, there is only one rubric. Review the rubric to confirm you are meeting the assignment requirements.

#### **Option #1: Lotka-Volterra Predator-Prey Model vs. Lanchester's Basic Combat Model**

Research the Lotka-Volterra predator-prey model (and its modifications) and compare and contrast it with Lanchester's basic combat model.

Review the **Module 5 Critical Thinking Rubric** for full details on how you will be graded on this assignment.

#### **Option #2: Lanchester's Square Law Problem**

For this assignment, complete 3.15 Section Exercises, Extension problem #10 as reproduced here:

Modify the basic Lanchester model to include "foxholes" for one or both combatants. Consider a foxhole to be a safe place where a unit can still attack the opposing side but cannot be harmed. Include the concentration of fire parameter.

Review the **Module 5 Critical Thinking Rubric** for full details on how you will be graded on this assignment.

## Module 6

### CRITICAL THINKING ASSIGNMENT (65 points)

Choose one of the following two assignments to complete this week. Do not complete both assignments. Identify your assignment choice in the title of your submission.

Note that while there are two options for the Critical Thinking Assignment, there is only one rubric. Review the rubric to confirm you are meeting the assignment requirements.

#### Option #1: Model of a Three-Way Battle

In the spirit of 3.1.5 Section Exercises, extension problem #9, model a three-way battle with reinforcements, especially with a concentration of fire parameter. The Excel implementation should not be too difficult, but investigating possible equilibrium points will involve solving three equations in three unknowns.

Problem #9 for your reference:

Suppose there is a three-way battle among Red, Blue, and Green forces. Develop a modification of the Lanchester model for this situation. You may wish to introduce additional parameters.

Review the **Module 6 Critical Thinking Rubric** for full details on how you will be graded on this assignment.

#### Option #2: Using the Hughes or Armstrong Model

By assigning costs to fleet increases in each model parameter, investigate the optimum way to equip a fleet to fight a known enemy under the Hughes or Armstrong models.

For example, you might set a budget of \$10 million with the following:

- Increasing offensive power costs by \$2,000,000 per unit
- Increasing defensive power costs by \$1,000,000 per unit
- Increasing staying power costs by \$500,000 per unit.

How should a fleet's parameters be improved within the budget to best fight an enemy with known parameter values?

Review the **Module 6 Critical Thinking Rubric** for full details on how you will be graded on this assignment.

## Module 7

### CRITICAL THINKING ASSIGNMENT (75 points)

Choose one of the following two assignments to complete this week. Do not complete both assignments. Identify your assignment choice in the title of your submission.

Note that while there are two options for the Critical Thinking Assignment, there is only one rubric. Review the rubric to confirm you are meeting the assignment requirements.

#### Option #1

In this module, we study various ways to model and control epidemics. Do a research study on disease epidemics worldwide. Make a list of the five historical epidemics that you read about. Be sure to provide a holistic description of the who/why/where and how of the epidemics. Pick one of these five historical epidemics and examine its spread in light of one of the models we studied in this module.

1. Your written paper should be 4-6 pages in length, not counting the title and reference pages, which you must include.
2. You need to cite 4 – 6 sources. The [CSU-Global Library](#) is a great place to find resources.

3. You should have an introduction, which will tell the reader what your paper is about. You should have a conclusion paragraph, which will summarize your paper.
4. Your paper must be formatted according to [CSU-Global Guide to Writing and APA Requirements](#).
5. If you need assistance with your writing style, start with the links under the Research Help and Writing Help tabs on the [CSU-Global Library's](#) homepage.

### Option #2

For this option, you will create a video presentation. Using physical props (a bag of plastic army men, piles of poker chips, a box of animal crackers, etc.) illustrate and explain the S–I–R model. Assume the person hearing your video is not familiar with this model but has a background in mathematical modeling, so start at the beginning and define terms and work out examples of how S-I-R works.

Requirements:

1. Submit a .mp4 file via Canvas or make a Youtube video and submit the URL.
2. The video should be over 10 minutes in length.
3. Your instructor will be looking for you the use of props in your explanation, a definition of terms, and at least two demonstration examples.

## Module 8

### Final Exam (200 points)

## Course Policies



### Course Grading

20% Discussion Participation  
40% Critical Thinking Assignments  
40% Midterm and Final Exams

### Grading Scale and Policies

A	95.0 – 100
A-	90.0 – 94.9
B+	86.7 – 89.9
B	83.3 – 86.6
B-	80.0 – 83.2
C+	75.0 – 79.9
C	70.0 – 74.9
D	60.0 – 69.9
F	59.9 or below

### In-Classroom Policies

For information on late work and incomplete grade policies, please refer to our [In-Classroom Student Policies and Guidelines](#) or the Academic Catalog for comprehensive documentation of CSU-Global institutional policies.

### Academic Integrity

Students must assume responsibility for maintaining honesty in all work submitted for credit and in any other work designated by the instructor of the course. Academic dishonesty includes cheating, fabrication, facilitating academic dishonesty, plagiarism, reusing /re-purposing your own work (see *CSU-Global Guide to Writing and APA Requirements* for percentage of repurposed work that can be used in an assignment), unauthorized possession of academic materials, and unauthorized collaboration. The CSU-Global Library provides information on how students can avoid plagiarism by understanding what it is and how to use the Library and Internet resources.

**Citing Sources with APA Style**

All students are expected to follow the *CSU-Global Guide to Writing and APA Requirements* when citing in APA (based on the APA Style Manual, 6th edition) for all assignments. For details on CSU-Global APA style, please review the APA resources within the CSU-Global Library under the “APA Guide & Resources” link. A link to this document should also be provided within most assignment descriptions on your course’s Assignments page.

**Disability Services Statement**

CSU–Global is committed to providing reasonable accommodations for all persons with disabilities. Any student with a documented disability requesting academic accommodations should contact the Disability Resource Coordinator at 720-279-0650 and/or email [ada@CSUGlobal.edu](mailto:ada@CSUGlobal.edu) for additional information to coordinate reasonable accommodations for students with documented disabilities.

**Netiquette**

Respect the diversity of opinions among the instructor and classmates and engage with them in a courteous, respectful, and professional manner. All posts and classroom communication must be conducted in accordance with the student code of conduct. Think before you push the Send button. Did you say just what you meant? How will the person on the other end read the words?

Maintain an environment free of harassment, stalking, threats, abuse, insults or humiliation toward the instructor and classmates. This includes, but is not limited to, demeaning written or oral comments of an ethnic, religious, age, disability, sexist (or sexual orientation), or racist nature; and the unwanted sexual advances or intimidations by email, or on discussion boards and other postings within or connected to the online classroom.

If you have concerns about something that has been said, please let your instructor know.