MISSOURI WESTERN STATE UNIVERSITY

COLLEGE OF LIBERAL ARTS AND SCIENCES

DEPARTMENT OF COMPUTER SCIENCE, MATHEMATICS, AND PHYSICS

COURSE NUMBER: MAT 401

COURSE NAME: Advanced Modeling

COURSE DESCRIPTION:

A study of the modeling process including creative and empirical model constructions, model analysis, and model research.

PREREQUISITE:

A grade C or better in MAT 317

TEXT:

COURSE OBJECTIVES:

The purpose of this course is to provide a sound and accurate exposure to theory, techniques, and applications of mathematical modeling. Students will learn how to:

1. Create linear differential equations that represent real world applications.

2. Use a computer to form analysis of the numerical solutions of a non-linear model.

3. Examine the importance of the assumptions in a model and the testing of the sensitivity and appropriateness of those assumptions against real-world data.

4. Understand compartmentalization in terms of construction of a homogeneous system of differential equations.

5. Use various techniques for solving differential equations.

6. Motivate further study of applied mathematics through the formulation of models and their uses in discovering aspects of the real world

7. Construct accurate models of non-linear fluid dynamical systems.

8. Construct models representing harmonics with sound.

9. Construct Heat transfer models.

10. Provide student practice in creative and empirical model construction, model analysis, and model research. More specifically, the students will be afforded an opportunity to practice:

    a. Creative and Empirical Model Construction: given a real-world scenario, the student must identify a problem, make assumptions, collect data, propose a model, test the assumptions, refine the model as necessary, fit the model to data if appropriate, and analyze the underlying mathematical structure of the model in order to appraise the sensitivity of the conclusions in relation to the assumptions. Furthermore, the student should be able to generalize the construction to related scenarios.

    b. Model Analysis: given a model, the student must work backward to uncover the implicit underlying assumptions, assess critically how well the assumptions reflect the scenario at hand, and estimate the sensitivity of the conclusions when the assumptions are not precisely met.

    c. Model Research: the student investigates an area of interest to gain knowledge, understanding, and an ability to use what already has been created or discovered.

STUDENT COMPETENCIES:

1. Determine what type of models are necessary for various applicable situations.

2. Create solution spaces for various models in multi-dimension systems.

3. Classify the Heat equation and discuss its characteristics.

4. Find solutions to linear systems of differential equations.

5. Describe what chaos is and show where the butterfly effect comes from.

6. Be able to create solutions of the Lorentz attractor in various dimensions and solution spaces.

7. Use differential equations to solve analysis problems of population growth, radioactive decay, and chemical mixtures.

8. Build mathematical models for real-world problem situations.

9. Utilize writing skills incorporating mathematical terminology and symbolism to represent relationships and communicate ideas in expository, theorem-proof, and abstract formats

10. Interact verbally with others to clarify and extend understanding of mathematical situations.

11. Use a high-level computer language to assist in solving problems.

COURSE OUTLINE:

This course will be an inquiry-based course with projects leading the way, below are the subjects and the appropriate subjects we are setting the examples from;

I. SIR-Model, *Biology*

- A. Compartmentalization
- B. Bifurcations of systems of dynamical systems

II. Chandrasekhar's model of a white dwarf star, *Physics*

- A. Non-linear coupled systems
- B. Non-analytic solutions

III. Fluid flow around a circular plate, *Engineering*

1. Partial differential equations
2. Fluid-flow 2-d

IV. Motion of a circular drumhead when struck, *Physics and Engineering*

- A. Coupled partial differential equations
- B. 3-dimensional fluids

V. Poincare sections of strange attractors, *Mathematics and Biology*

- A. Chaos Theory
- B. Analysis of periodic solutions