COURSE SYLLABUS FORMAT
Southeast Missouri State University

Department of Physics and Engineering Physics Course No. IU317

Title of Course: Systems Thinking for Everyone Revision Fall 2012

New

I. Catalog Description and Credit Hours of Course:

A. Catalog Description Course Description

Basic concepts in system theory, system models, applications in social, economical, ecological, biological, chemical and physical systems. Two one-hour lectures and one two-hour lab. 3 credit hours

B. Course Content

This course covers the basic concepts in system theory: stock and flow, positive and negative feedback. It also discusses logistic growth with carrying capacity, oscillation in linear systems, limit cycle and chaos in nonlinear systems. After learning the simulation software, systems in six different areas will be discussed: physical systems, engineering systems, chemical/biological systems, ecological systems, economic systems and social systems. Students are required to investigate one out of these six areas listed above by constructing asystem model and simulation, and then write a project report and give a presentation. In addition, students also need to write three essays on three of the remaining areas.

II. Interdisciplinary Nature of the Course:

This course satisfies the requirements of a 300 level interdisciplinary course because it integrates all three perspectives, and two or more categories within each perspective. Systems can be analyzed at different levels. The highest level is on the fundamental relationship, such as positive and negative feedback, etc. At the next level, mathematics is involved, which describes such relationships in a specific way. At the bottom level is the applications in specific systems. Therefore, systems in different areas can be described by the same mathematic equation, and the fundamental relationships can be found in all the systems. Specifically, the topics of this course integrate *Living Systems, Logical Systems,* and *Physical Systems* from the *Perspective on Natural Systems*, and *Economic Systems* and *Social Systems* from the *Perspective on Human Institutions*. In addition, each student needs to write a project report and give an oral presentation, and thus this course also integrates *Oral Expression* and *Written Expression* in the *Perspective on Individual Expressions*.

Although the phenomena in natural systems and human institutions are quite different, they share some basic system dynamics. First, birth and death are common phenomena, i.e. something seems to appear from nowhere and then grows rapidly, while something else will subside and gradually disappear. Second, there are phenomena with periodic oscillations, such as economic cycles and chemical clocks. Third, there is competition and collaboration among the entities sharing the same environment, and their relationship will largely determine their survivability.

III. Prerequisite (s): Completion of core University Study courses in logical systems, physical systems, oral expression and written expression is recommended.

IV. Purposes or Objectives of the Course:

A. Have a better understanding of the physical world and human society. U.S. Objectives: 2, 4, 6.

B. Develop skills on information gathering and analysis. U.S. Objectives: 1, 2.

C. Understand the behaviors of systems. U.S. Objectives: 2, 6, 7.

D. Learn how to take actions to achieve expected results. U.S. Objectives: 7, 9.

E. Provide an opportunity for creative investigation. U.S. Objectives: 1, 2.

F. Develop written and oral communication skills in reporting and presenting scientific results. U.S. Objectives: 3

V. Student Learning Outcomes (Minimum of 3)

A. Students will demonstrate the understanding of basic concepts of systems, such as stock and flow, positive and negative feedback.

B. Students will demonstrate the knowledge of the characteristics of systems, such as exponential growth and decay, oscillation, and chaos.

C. Students will be able to set up system models and simulate them with simulation software, as well as predict the outcome.

VI. Expectations of Students:

A. Be inquisitive and actively engaged in class activities.

B. Learn the basic concepts and analyzing methods in dynamic systems.

C. Learn to use the software to simulate system behavior.

D. Do homework and practice the simulations.

E. Gather information and find relevant topics to investigate.

F. Write three essays on different systems.

G. Do research and simulation on a selected project, write a report and present the result.

H. Perform satisfactorily on course exam(s).

VII. Course Content or Outline (Indicate number of class hours per unit or section):

A. Introduction to system thinking (U.S. Objectives 1, 2, 4, 6)
   1. Identification of systems 1
   2. Basic elements in systems: stock and flow 1
   3. Positive and negative feedback 2
   4. Growth and carrying capacity 1
   5. Steady state, oscillation and chaos 1

B. Introduction to STELLA /iThink (software) 3

C. Application in different systems (U.S. Objectives 1, 2, 3, 4, 6, 7, 9)
   1. Physical System (*motion of projectiles, simple pendulum, etc.*) 6
   2. Engineering System (*automobile suspension systems, resonance, etc.*) 6
   3. Chemical/Biological System (*chemical clock, neuron, etc.*) 6
   4. Ecological System (*predator-prey, interspecific competition, etc.*) 6

5. Economic System (*supply and demand, deficit and debt, etc.*) 6
6. Social System (*urban dynamics, epidemic disease, etc.*) 6

Total 45

VIII. Textbook(s) and/or Other Required Materials or Equipment:

A. Bruce Hannon, Matthias Ruth, *Dynamic Modeling* (*Modeling Dynamic Systems*); 2nd ed., Springer: New York, 2001.

IX. Basis for Student Evaluation:

A. Homework 30%

B. Essay* (3) 3x10%

C. Project** Report (1) 15%

D. Oral Presentation (1) 5%

E. Final Exam 20%

* An essay is a review of the application of system theory in a particular area.
** A project is an investigation of a specific topic with the system tools, and students are required to set up new models and explain its outcome from the simulation results.

X. Justification for Inclusion in the University Studies Program

Objective 1: Demonstrate the ability to locate and gather information.
Emphasis: **SIGNIFICANT**

Content
This course covers a wide range of topics in different systems; within each system we will also discuss multiple topics. Therefore, students are exposed to abundant information.

Teaching Strategies
The instructor will provide some information on specific topics, but students are encouraged to find more sources by themselves. On the other hand, as the students are from different disciplines, they are also encouraged to share information with their classmates.

Student Assignments
Each student will write three essays in different areas, and complete a project that requires construction of system models at multiple levels. Therefore, it is imperative for students to locate and gather relevant information for their essays and project. In addition, as the topics of this course cover a wide variety of systems at different levels, students have to obtain information from multiple sources.

Evaluation of Student Performance
In students' essays and projects, the references cited are an important component. The primary criterion for citations is on how many and what kinds of sources are cited, and the secondary criterion is on whether the information is relevant and well understood.

Objective 2: Demonstrate capabilities for critical thinking, reasoning, and analyzing.
Emphasis: **SIGNIFICANT**

Content

In order to analyze complex systems, critical thinking and reasoning is indispensible. Even in simple systems, the behavior can be complicated. For example, a system with only three elements can demonstrate chaotic behavior. This course will analyze many systems with various behaviors.

Teaching Strategies
The instructor will first present examples in different systems, and then ask the students to predict the outcome. After the students' curiosity is aroused, the instructor will demonstrate how to analyze the systems and show the simulation results.

Student Assignments
Besides writing three essays, each student is also required to work on a project related to the systems listed in the course outline, where he/she must be able to justify the system model constructed and show that the judgment is sound. Eventually they need to use the software to simulate the system behavior and be able to interpret the results. Sometimes the result from simulation does not make any sense, and students must avoid making such mistakes.

Evaluation of Student Performance
The primary criterion in evaluating the project reports is whether the results are credible. It is very easy to get spurious results in complex systems, and thus the capability of critical thinking, reasoning and analyzing is very important here.

Objective 3: Demonstrate effective communications skills
Emphasis: **SIGNIFICANT**

Content
Communication, in general, is the exchange of information. In dynamic systems, feedback plays a very important role. In physical and engineering systems, feedback can cause stability or instability. In economic and social systems, the communication between citizen and government determines the characteristics of the society.

Teaching Strategies
A system can be divided into two basic categories: elements and relationships between them. Usually people pay more attention to the elements, but the relationships often play a more critical role. In this class, students' attention will be directed to the feedback relationships, which can be considered as communication between the units in a system.

Student Assignments
Each student will write three essays and one formal project report, as well as give an oral presentation.

Evaluation of Student Performance
The essays, project report and presentation constitute 50% of the grade for the course. The criteria in grading include correctness of technical content, sound reasoning, good organization, clarity, and effective presentation.

Objective 4: Demonstrate an understanding of human experiences and the ability to relate them to the present.
Emphasis: **SOME EMPHASIS**

Content
Many examples discussed in this course are historic events, such as engineering failures, ecological disasters and social upheavals. However, we investigate the underlying systems of these events, so that the root cause can be illustrated.

Teaching Strategies
When a new system is introduced, a history event is often a good starting point. After the students' curiosity is aroused, the underlying system will be illustrated and analyzed.

Student Assignments
In this course we start with studying simple physical systems and gradually progress to the study of ecological and social systems. Students will set up their own models to explain the phenomena in nature as well as in human society. Furthermore, each student will also write three essays, which are often with the background of historic events.

Evaluation of Student Performance
Students are required to test their models against historic events, and without the support of sound evidence the predictions are considered unreliable. The grading of the project reports will emphasize the credibility the system models.

Objective 5: Demonstrate an understanding of various cultures and their interrelationships.
Emphasis: **NOT EMPHASIZED**

Objective 6: Demonstrate the ability to integrate the breadth and diversity of knowledge and experience
Emphasis: **SIGNIFICANT**

Content
The interdisciplinary nature of this course exposes students to several different fields (*see course outline*), with universal system theory being the common thread. For example, negative feedback is the stabilizing mechanism for many systems, such as thermostat, animal glucose regulation, market price, etc. By taking this course students can realize that there are hidden connections between different fields, and thus they can respond to new challenges with a broader perspective in the future.

Teaching Strategies
The sequence of topics in this course progresses from simple systems to complex systems, but the same set of concepts are engaged. Students will realize that the skills they developed in dealing with simple physical systems can be applied to ecological and economic systems, etc. In this way, the knowledge they learned in different fields can be synthesized.

Student Assignments
In homework assignments students are required to construct models and analyze systems at different levels. The models of complex systems (e.g. ecological system) are based on models of simple systems (e.g. physical, chemical, and biological systems). Sometimes complex systems can demonstrate the similar behaviors of simple systems, but they also have a richer inventory of behaviors beyond simple systems.

Evaluation of Student Performance
The ability to construct complex models from simple ones is of crucial importance in analyzing large systems. Therefore, the projects of complex systems can demonstrate such ability. In addition, in the final exam students are also required to construct models of relatively complex systems.

Objective 7: Demonstrate the ability to make informed, intelligent value decisions.
Emphasis: **SOME EMPHASIS**

Content

Valuing is the ability to make informed decisions after considering ethical, moral, aesthetic, and practical implications. The decisions people make frequently have moral and ethical dimensions, because those decisions often deal with how time, money, and natural resources will be used. In addition, they sometimes deal with potential conflicts of interest as well as issues of public safety.

In learning system theory students can develop a sense of responsibility, as the action one takes can cause a reaction from the system one is dealing with. A quote from Donella Meadows can illustrate this point clearly: "Most people wouldn't think that a progression of questions that began with nature and then led to science and then to complex systems would end up with questions about virtue. But for me it did. As I see how systems work, and how they break down, I began to feel a sense of responsibility for them. I got more and more committed to making them work."

Teaching Strategies

The response to stimulus from a complicated system often takes some time to show up. With the help of the simulation software the outcome in the future can be demonstrated at present. If one can see clearly the long term result of one's action, one will refrain from doing reckless things. The instructor will prompt considerations of various alternatives by making some comments, which will stimulate the student's thinking in a direction of long term outcome and sustainability.

Student Assignments

The homework assignments and project provide the opportunity for students to investigate system behaviors. By using the simulation software, students can investigate the outcomes of systems with different inputs. Sometimes a seemingly harmless input can cause havoc in a complex system; on the other hand, a counter-intuitive input can bring the system to a better state. In analyzing ecological and social systems one can come to a conclusion: cooperation is the best and cheapest way to success.

Evaluation of Student Performance

The response to external stimuli is an important issue in system theory, and thus this aspect will be emphasized in grading.

Objective 8: Demonstrate the ability to make informed, sensitive aesthetic responses
Emphasis: **NOT EMPHASIZED**

Objective 9: Demonstrate the ability to function responsibly in one's natural, social, and political environment.
Emphasis: **SOME EMPHASIS**

Content

The existence of mankind depends on countless interrelationships among people and with the environment. Students will learn to interact responsibly with their natural environment and with citizens of their society. In system theory the interaction between the elements is often more important than the properties of the individual elements; therefore, people should be actively engaged in social activities.

Teaching Strategies

Throughout this course the interactive relationship between the elements in a system is emphasized. For example, in the situation of interspecific competition, if the coefficient of impact is small enough, two species will always survive in the same environment. On the other hand, if this coefficient is higher, one of the species must perish.

Student Assignments

This is a homework assignment on ecological system, and students will investigate predator-prey and interspecific competition relationships. In addition, competitioncooperation relationship will also be analyzed in economic system.

Evaluation of Student Performance

As the relationship between elements plays such a vital role in systems, it will be reflected in students' homework, essays, and project reports. The simulation results will show this effect clearly, which is an important indicator in grading students' work.

XI. Background:

This course should be taught by an instructor who is familiar with system theory and also has the experience using STELLA /iThink software. Therefore, a number of faculty members in the College of Sciences and Mathematics can teach this course.

XII. Class size:

The optimal class size is 18 students. Due to the limitation of the number of computers and software license in the computer lab, only 18 students can be accommodated in one lab session. If this course becomes very popular in the future, two lab sessions can be opened, and then the optimal class size becomes 36.