SYSTEM DYNAMICS FINAL

**Question 2 (1 point)**

Describe the problem exploration phase of the System Dynamics modeling process.

The “Problem Exploration” phase of the SD modeling process is the portion in which you first focus your efforts. This phase is meant to clearly define the explicit purpose of the model, establish a Reference Behavior Pattern, and create a diagram of the system being modeled.

**Question 3 (1 point)**

Discuss the types of problems or characteristics of problems that might lead an analyst   
to consider using the System Dynamics methodology?

The types of problems which lend themselves to System Dynamics methodology have dynamic complexity, which is to say that they have segments which influence their own behavior through another segment of the system. The problems involve strategic and/or policy decisions. The methodology can be used to analyze policies for unintended and long developing side-effects. Good candidate problems have defied prior attempts at solution. The method is good for problems which have involved controversy about long-term pros and cons of alternative courses of action, the system can be used implemented to explore long term forecasting when asked specific questions. The SD method can be used to create a base impact model, then push the sphere-of-impact outward to include further removed agents. It is even possible to model systems when data is missing. It is necessary to document and well-explore those areas of “inferred data”. The methodology is not useful for exploring policies which have fast-developing consequences, are already well-defined, or easily computed.

**Question 4 (1 point)**

What does the term model "validation" refer to? Use a specific example to clarify your answer.

Validation refers to three points. A validated model has Conceptual Validity, in that it has been compared to the real-world system for adequate representation. adequate representation, in turn, is used to recursively underscore another three bullet points.

The model must be consistent with accepted theories. The model must be checked for and free of deficiencies: irrelevant variables (cromulent variables ), missing variables (Type I error: omission), relevant variables characterized wrong (important variables improperly described and/or quantified), bad structure (Type II error: commission. [incorrect equations or connections]), bad problem definition (Type III error: solved the wrong problem). The model’s clarity and economy must be germane.

The model must have Operational Validity which simply means that the model has been checked for functioning representative of the real-world system’s behavior. The model must also have Believability, in that it must have qualities and function worthy of putting confidence in from the perspective of a viewer, not a creator.

**Question 5 (1 point)**

Describe the model development phase of the System Dynamics modeling process.

The model development phase of the System Dynamic process is broached with the formulation and representation of a dynamic hypothesis. This is to say that the hypothesis has to do with a system which is highly susceptible to variability. You will need to create a dynamic principle and use that to map your hypothesis. Identify storages and feedback loops and quantify flows. Finally determine the equations and parameters, then calibrate them to behave in an anticipated fashion. This will prepare for the testing phase.

**Question 6 (1 point)**

Describe what the "growth" behavior mode often exhibited by dynamic systems looks like. Explain the feedback mechanism/structure that generates this particular behavior mode.

Growth processes are dominated by a self-perpetuating, or a reinforcing feedback loop. In nearly every instance of a growth process, the value of a storage influences its rate of change. For example; assume that we have a pond with an infinite amount of space and food. There is a population (or a stock) of fish in this pond, and we would like to chart the quantitative data about the stock of fish. In examining the behavior of the stock, we see that the number of fish being born outstrips the number of fish dying. This means that there are an ever-increasing number of adults breeding, which means an ever-increasing base of juvenile fish. This progression will remain non-linear to the point of asymptotic unless a limiting factor is introduced.

**Question 7 (1 point)**

Describe what the "goal-seeking" behavior mode often exhibited by dynamic   
systems looks like. Explain the feedback mechanism/structure   
that generates this particular behavior mode.

A goal seeking process is one which is governed by a self-regulating feedback loop. A control system is a human-made goal-seeking process, like a thermostat. One type of thermostat is controlled by a resistor called a thermistor. A control circuit tries to maintain a stable voltage, and a thermistor is placed in the room which is to be temperature controlled. The thermistor can either increase or decrease its resistance dependent on temperature. The control circuit is always trying to turn on a bank of relays, but the resistance in the thermistor will not allow that to happen until the temperature in the room drops enough. The resistance drops enough o allow the relays to turn on and the heater is enabled. This eventually heats up the thermistors, and their resistance climbs again until the relays are turned off. This turns off the heater until the thermistors cool enough to allow the relays to turn the heater back on. In an equation form, this would be expressed with subtraction.

**Question 8 (1 point)**

Describe what the "S-shaped" behavior mode sometimes exhibited by dynamic   
systems looks like. Explain the feedback mechanisms/structure that  
generates this particular behavior mode.

An S-shaped Growth Process is one which employs both a growth phase as well as a goal-seeking phase of its process. First there is a growth phase which resembles most others of its ilk. At some point, however, the goal-seeking process will begin to have an increasing influence over the growth. There will be a point at which the goal-seeking process will become more dominant than the growth process and growth will slow to an asymptotic flatline. If we take our last example of a fish populace in an infinitely large pond with an infinite supply of food, and begin to place limits, we will see an S-shaped growth that finds an equilibrium in correspondence with the limiting factor.

**Question 9 (1 point)**

Describe what the "oscillation" behavior mode sometimes exhibited by dynamic   
systems looks like. Explain the feedback mechanisms/structure that   
generates this particular behavior mode.

An oscillation is often caused by either an “overshoot-and-collapse” or by a delayed response from a limiting factor, like a predator/prey model will often display. As the prey populace grows, there is more food for the predators, and the limiting factor is lessened. As a consequence, after a delay, the predator populace grows which increases a limiting factor for the prey populace. This winnows the prey populace limiting the food resources for the predator population. That decreases the predator population which removes the limiting factor for the prey population, …

**Question 10 (1 point)**

In what ways are model verification and model validation similar, and how   
are they fundamentally different?

Model verification and validation are similar in that they both challenge the model and seek points of failure to mitigate, thus building confidence in the model. The user should be involved throughout this process and walked through the model by the modeler. The modeler should approach the model with a skeptical view, and should enlist the doubts of others whenever possible.

They differ most fundamentally in the sense that verification is the process of comparing the computer model (what you did), with the modeler’s conceptual model (what you meant to do); while validation is the comparison of the computer model to reality. The verification process must necessarily come first, and then the validation process can take place. Verification is a little like calibrating a scale. You can weigh an object on a scale without taring the scale first, but you can’t be sure how far off of reality your measurement is. Any further extrapolation is likely to be off by an equal margin at each step, but you can’t be certain by how much. Verification is half of the calibration process, in that it ensures that the equations and the variables are the correct ones (gross adjustments), before the fine tuning can commence.

**Question 11 (1 point)**

How do you increase confidence (yours and others) that the behavior generated   
by a System Dynamics model is plausible and merits serious consideration?

To increase confidence in a model, one must try their level best to disprove it and find any points of failure to address. Once addressed, the process must begin again until no points of failure can be found. If any will not go away, the entire model must be examined for credibility or incorrect data. The model must also be scrutinized for relevance to the real-world question and representation. It is preferable to introduce external ideas and skepticism by way of the user or any subject specialists. The modeler should walk the user through the model to introduce the methods and conventions; the model layout; and point out variables, stocks and flows. The modeler should include the user in as much of the process as is viable and should invite questions and scrutiny. These actions will all serve additionally to perform redundant error checking routines for the modeler at the same time.

**Question 12 (1 point)**

Briefly describe a specific problem or issue that might be productively addressed via   
System Dynamics, and indicate why you picked this example.

A foundry like Intel has two functions; they innovate chips and their manufacture, and they manufacture chips. Periodically, they must make the decision to budget more money for the foundry itself, more money in the manufacture of chips, or more money in R&D. More money that is put into the foundry means more numerous chips manufactured faster with fewer waste batches. More money put into R&D translates to a delayed advance in either chip manufacture or in the chips themselves. More money put into manufacturing chips means the company has more money to spend on the other two after a delay. Systems Dynamics allows for the experimentation with permutations of the value sets before committing resources to examine the outcome in the long term. I have selected this example because it is one permutation of the classic quandary faced by nearly every business, it is also one which I have faced myself.

**Question 13 (1 point)**

What are the primary sub-phases of the model testing phase of the System   
Dynamics modeling process?

* Eliminate error messages
* Create flow diagrams from the outset, and keep logic explicit during the design
* Document every step and every decision. Going forward, when in doubt about documenting something, document it. Keep your documentation organized and legible by anyone, even if you aren’t there to explain it.
* Seek points of failure and “special case” failures. Document them well while you are correcting the errors.
* Incorporate outside “model doubters”. They should be knowledgeable about the modeled system, but not directly involved with the development of the model.
* Conduct model walkthroughs for small groups who are familiar with the system being modeled.
* Perform test runs after every adjustment. Document the change and results. Break the system into parts and test each part individually as well. Perform tests which you expect to “break” the model, just to ensure that they do break the model in the expected fashion. Document the tests, the results, and if they match the expectation.
* Temporarily set variables to constant values, to test for expected results. Document the tests, the results, and if they match the expectation.
* Set initial conditions to 0 to see if the results match predictions. Document the tests, the results, and if they match the expectation.
* Create a hypothetical situation, make predictions about it, and model it. Compare the results to the predictions. Document the tests, the results, and if they match the expectation.
* Use animation to watch the assorted values changing over time by way of a histograph.
* At every step, if errors are noted, they must be addressed in a manner appropriate to assuage the cause and not just symptomatic responses. Document the errors, how the error was discovered, resolution attempts & results, and ultimate resolution.

#### Organize all of that documentation into a format which is Question 14 (1 point)

Based on your experience,what specific methods or techniques are the most   
useful/helpful during model testing?

**Question 14 (1 point)**

Based on your experience,what specific methods or techniques are the most   
useful/helpful during model testing?

I like to use triangulation strategies to isolate causes instead of symptoms. I will change a value and see how sensitive the system is to that change. I find that there are two extremes which tell me that I have found a causal problem. If I change the value and only one other value changes a commensurate amount, but when I change the second value, the first remains the same; the first is likely to be a causal factor. If I change a value and the entire model’s values change, I have found a causal factor. If I change a value and several others change, especially if they go in different directions, I have found a symptomatic factor. If I change a value and no other values change, I have found a symptomatic value. If I change a value and once the model is run the value changes back, I have found a symptomatic factor.

I also favor intentionally “breaking” the model in different ways to make certain that it reacts as anticipated. Charting results along with documentation has been invaluable as well.

**Question 15 (1 point)**

What types of problems or characteristics problems might indicate to an analyst   
that the System Dynamics methodology would probably NOT be a good choice?

If the problem has impacts which all occur quickly, then System Dynamics modeling is not a good choice. If the problem is well-defined and easily computed, the problem is not a good candidate for System Dynamics methodology.

**Question 16 (1 point)**

Describe the model application/transfer phase of the System Dynamics modeling process.

Analyze and evaluate strategies and policy alternatives. Now that the model is proven to be valid and calibrated, it is finally time to experiment with the variables and policy changes. In doing so, you will find leverage points and more fully understand the nature of the system being modeled.

Include users as much as is feasible, at every step if possible. Try to get internal champions, management is of particular importance here. Score an early victory by doing something useful for clients early in the project.

Make your presentations excellent. Take the time to polish them and to make them easy to follow. Your documentation should follow suit and be easily ready by anyone, without your intervention. The model itself should be polished and easy to follow without your intervention. Labels should be self-explanatory, accurate, precise and clear. Where reasonable, include terms, nomenclature and jargon which is familiar to both users and management. Incorporate the model into existing methods and practices instead of presuming that all methods and practices are boundlessly flexible. Leave 30ish percent of the allotted project time for transfer.

Your documentation should contain a clear and concise executive summary. The body should be as short as is possible, but no shorter than is reasonable. Any necessary details should be addended by way appendices. Use clear diagrams and pictures which are discernable without captions but have captions anyway. The captions should be no longer than three sentences and should not detract from the clarity of the picture or diagram. Include a video in some common format. Create a users guide for the model which includes an index. Create a separate technical/reference document for modelers.