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Exam in
Systems Analysis for Sustainable Development, TN0268
Wednesday 9 February 2011, 9-12

Mark on every sheet: Code and problem number.

Aid: Pens/pencils and paper.

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Mark clearly one option, unless otherwise stated. Each question can give 1, 2 or 4 points, as indicated, amounting to a max of 40 points, of which half is sufficient for passing.

Questions that can give 1 p each (1-20)

1. System

A system consists of two types of entities: 1) some kind of components, and 2) the relationships between them. The set of components and relations chosen should form: (chose the missing words that best correspond to the definition):

a) a complex pattern
b) an integrated whole
c) an organic structure
d) a simple rule
e) a specific model

2. IIASA

What does IIASA stand for?

a) Integrated Institute for Advanced Studies in America
b) Independent Institute Association for Systems Analysis
c) International Institute of Applied Systems Analysis
d) Intergovernmental Institute of Advanced Systems Analysis
e) International Independent Applied Systems Agency

3. Sustainable systems

The U.S. Environmental Protection Agency (EPA) has proposed a new scientific framework for a more systematic and holistic approach to environmental protection that considers the complex nature of environmental issues and the welfare of future generations. The EPA has come to understand that designing sustainable systems encompasses several important challenges. Which of the following statements is included in the list?

a) Securing a long lived environment for generations
b) Representing people in different parts of the world
c) Ensuring a stable climate locally and globally
d) Addressing multiple scales over time and space
e) Managing natural resources in an optimal way

4. Micro-meso-macro in social systems

If a city could be considered a microscale entity, and a country a macroscale entity, what could be considered a mesoscale entity?

a) a farm
b) a continent
c) a village
d) a union of states
e) a region.

5. Simple systems

In contrast to complex systems, which of the following characteristics does best describe a "simple" system, (in contrast to a complex system):

a) linear
b) self-organizing
c) emergent
d) behaviour often unpredictable
e) often have large number of components

6. Emergent properties

Which of the following statements fits best for *emergent* properties?

a) Properties that can be understood fully from knowledge of the parts
b) New qualities that may arise above a certain threshold of complexity
c) Certain system qualities that are indeterministic but predictable
d) Hierarchical structures that are interlinked with the environment
e) Self-organised stochastic features of complex systems

7. Chaos

Which of the following does best describe chaos:

a) indeterministic, but predictable
b) deterministic, but unpredictable
c) deterministic and predictable
d) stochastic and irregular
e) insensitive to initial conditions

8. A double pendulum

An ideal ordinary, single pendulum swings with a regular frequency in a predictable way. What will happen if you attach another pendulum to the first one, so that you will get a double pendulum (assuming there is no friction losses to the air or hinges)?

a) Both parts of the double pendulum will swing in opposite direction
b) Both parts of the double pendulum will swing with the same frequency
c) The second pendulum will swing with higher frequency
d) The second pendulum will swing with lower frequency
e) The second pendulum will swing in an unpredictable way

9. Models

Which of the following statements is correct?

a) A model gives a true picture of a real system
b) A model is a complex description of a simple system
c) A model is a simplified reproduction of a real system
d) A mathematical model can always be solved analytically
e) The best model is a model with many free parameters

10. A model of a cow

A sphere may be a good model of a cow, if the purpose is to

a) describe its movement in the environment
b) predict its total milk production
c) study the interaction with other cows in a herd
d) determine the heat exchange with the environment
e) investigate its contribution to farm pollution

11. Modelling guideline

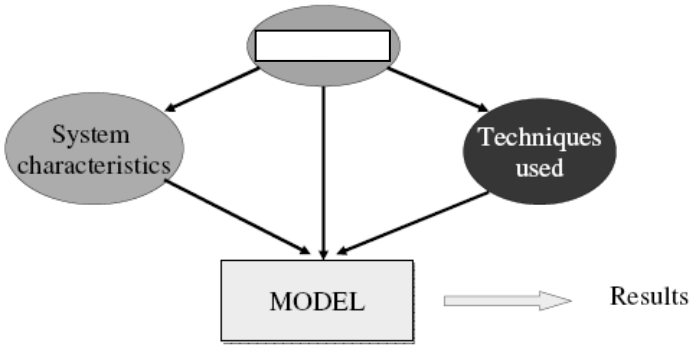
A common rule in science says that you use as few unknown assumptions as possible in any theory or model, and believe in the simplest explanation. This rule is often referred to as:

a) Einstein's rule
b) Bacon's law
c) Descarte's error
d) Occam's razor
e) Gordon's sword

12. What affects a model

Many things may affect how a model is constructed and how it may behave when producing results. In the course, we have pointed at some specific factors to be aware of, as described in the figure below. What should be written in the top bubble (oval) in that figure?

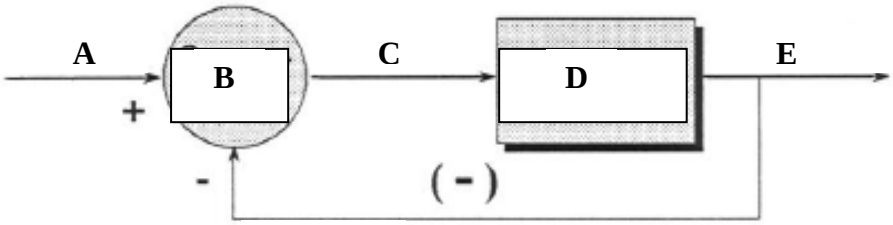
a) Environment
b) Complexity
c) Concepts
d) Laws
e) Purpose



12. Control

A negative feedback mechanism enables control by comparing the ”real value” to the ”goal” for natural, technical, as well as for social systems. In the figure below, where should the word “goal” be put?

a) At A
b) At B
c) At C
d) At D
e) At E



13. Control

In the figure above, where should the word “difference” be put?

a) At A
b) At B
c) At C
d) At D
e) At E

14. Lotka-Volterra model

The famous Lotka-Volterra model is used to describe

a) the heating of a house
b) a predator-prey interaction
c) the environmental impact of a farm
d) a socio-ecological system
e) a weather system

15. Differential equations

With two coupled differential equations, like in the example below for two variables *x* and *y* and two parameters $\alpha = 0.5$ and $\beta = 0.8$, it is possible to get oscillations in the system dynamics.

$$\frac{dx_1}{dt} = x_1 - \alpha x_1 x_2$$

$$\frac{dx_2}{dt} = -x_2 + \beta x_1 x_2$$

What do you have to do to make the system chaotic?

a) Increase the value of α
b) Decrease the value of β
c) Add a constant term to any of the equations
d) Couple yet another differential equation to the system
e) Multiply the equations by a factor 2

16. Internal and external models

There are typically two major types of models, referred to as *internal* and *external* models. Internal models include explicit information about the internal structure with its interacting components. What are *external* models sometimes called?

a) Structural models
b) Numerical models
c) Analytical models
d) Black box models
e) White box models

17. Systems thinking in theory and practice

The *mechanistic* and *reductionistic* worldview regards the world as a machine, which can be taken apart and understood by studying the parts alone. In contrast to this, the world can be considered more as an organism than a machine, where the whole is much greater than the sum of its parts (*c.f.* the discussion in the movie *Mindwalk*). Such a worldview which is *opposite to a reductionistic* worldview is often called:

a) Deterministic
b) Stochastic
c) Chaotic
d) Dynamic
e) Holistic

18. Optimisation

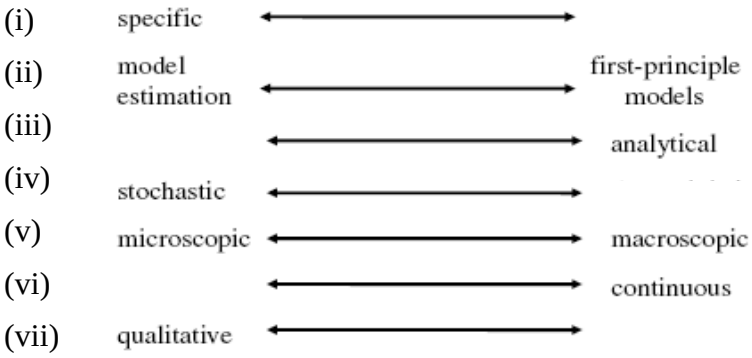
What is meant by optimisation?

a) To find out where a system is stable and unstable
b) To find out how sensitive a system is to disturbances
c) To find the extremum of a function under given conditions
d) To determine where a function is increasing
e) To determine if a function is continuous in the entire interval

Questions that can give more than 1 p each (as indicated)

21. Mathematical model building (2 p)

Match the missing word with correct counter word at other side of arrow (write the line number (i) – (vii) by each one of letters (a) – (e)



a) deterministic

b) quantitative

c) discrete

d) general

e) numerical

22. Negative feedback (2 p)

If you have a system with a negative feedback loop, increasing this feedback effect will generally

a) reduce the output signal
b) reduce the input signal
c) increase the input signal
d) increase the output signal
e) none of the above

23. Fractals (2 p)

A fractal is a fragmented geometrical shape that best can be characterised by one of the following words:

a) Self-similarity
b) Self-organisation
c) Self-regulation
d) Complexity
e) Hierarchy

24. Game of Life (2 p)

The *Game of Life* is an example of how global patterns may arise from simple local rules. Once the "pieces" are placed in the starting position, the rules determine everything that happens later. In most cases, it is impossible to look at a starting position (or pattern) and see what will happen in the future. The only way to find out is to follow the rules of the game. The *Game of Life* is played on a grid of square cells - like a chess board but extending infinitely in every direction. A cell can be *live* or *dead*. A live cell is shown by putting a marker on its square. A dead cell is shown by leaving the square empty. Each cell in the grid has a neighbourhood consisting of the eight cells in every direction, including diagonals.

Which of the following sets of rules apply to the Game of Life?

a) (i) A live cell with exactly three dead neighbours dies.
(ii) A live cell with two or three live neighbours dies.
(iii) In all other cases, a cell becomes alive or remains alive.

b) (i) A dead cell with exactly two live neighbours becomes a live cell.
(ii) A live cell with four or five live neighbours dies.
(iii) In all other cases, a cell becomes alive or remains alive

c) (i) A dead cell with exactly three live neighbours becomes a live cell.
(ii) A live cell with two or three live neighbours stays alive.
(iii) In all other cases, a cell dies or remains dead.

25. Planetary boundaries (2 p)

Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change, argue Rockström and colleagues in *Nature*, 24 Sep 2009. Nine different planetary boundaries are suggested in the article. Which one of the following earth-system processes is NOT listed in the paper:

a) Climate change
b) Rate of biodiversity loss
c) Sulphur cycle
d) Stratospheric ozone depletion
e) Change in land use

26. Planetary boundaries (2 p)

According to the Nature paper by Rockström et al., which boundary of the nine planetary systems have been exceeded the most (is most critical in the current situation):

a) Climate change
b) Rate of biodiversity loss
c) Sulphur cycle
d) Stratospheric ozone depletion
e) Change in land use

27. Socio-ecological system property (2 p)
The capacity of a socio-ecological system both to withstand perturbations from e.g. climate or economic shocks and to rebuild and renew itself afterwards, is best termed**:**

a) Self-organisation
b) Vulnerability
c) Sensitivity
d) Resilience
e) Stability…

28. A challenge to systems approach (2 p)
The identification of a system, selecting what should belong to the system and what should be left out of consideration, i.e. what should be considered a part of the system's environment, is *the* crucial issue that always has to be initially dealt with in applying a systems approach in science. This has been called:

a) The environment problem
b) The boundary problem
c) The abstraction solution
d) The emergence principle
e) Sensitivity analysis

29. Earth features and forces (2 p)
According to Torsten Hägerstrand, one of the leading persons in Swedish systems theory, there is a need to look for a common way of approaching the *totality* of the features and "forces" on the surface of the Earth. Observations and theories must be launched at an appropriate level in order to suit the needs to combine the relevant spheres of intellectual approaches. Which two intellectual traditions should be combined to grasp the temporal and spatial aspects of the world?

a) Mathematics and physics
b) Religion and science
c) Biology and psychology
d) Chemistry and geology
e) Geography and history

30. Systems analysis for policy making (4p)

What can Systems Analysis offer to policy makers? What are the similarities and differences in how scientists and policy makers perceive systems analysis? Discuss briefly the interdependence of boundary judgements, observations, and evaluations, preferably by drawing a figure and explain. You may base your answers and discussion on the chapter, "*Systems and Systems Theory*" by Olsson & Sjöstedt (2005) in the course literature, or on the lecture by Uno Svedin. (Write your answer on the empty page. Max one page!)

Good luck!
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