The term **dynamics** refers to change over time. If something is

dynamic, it is constantly changing in response to the stimuli influencing it.

A dynamic system is thus a system in which the variables interact to

stimulate changes over time. **System dynamics** is a methodology used to

understand how systems change over time.

One feature which is common to all systems is that a system’s structure

determines the system’s behavior. System dynamics links the behavior of a

system to its underlying structure. System dynamics can be used to analyze

how the structure of a physical, biological, or literary system can lead to

the behavior which the system exhibits.

System dynamics can also be used

to analyze how structural changes in one part of a system might affect the

behavior of the system as a whole. Perturbing a system allows one to test

how the system will respond under varying sets of conditions.

J.E. Lovelock has the following to say about system analysis:

"Think about a temperature controlled oven. Is it the supply of

power that keeps it at the right temperature? Is it the thermostat, or

the switch that the thermostat controls? Or is it the goal that we

established when we turned the dial to the required cooking

temperature? Even with this very primitive control system, little or

no insight into its mode of action or performance can come from

analysis, by separating its component parts and considering each in

turn, which is the essence of thinking logically in terms of cause and

effect. The key to understanding systems is that, like life itself, they

are always more than merely the assembly of constituent parts. They

can only be considered and understood as operating systems ...

whereby the behavior of the system is analyzed in terms of its

underlying structure."

Systems dynamics provides a common communication tool connecting

many academic disciplines.

The reason that a student cannot complete the task is

because the mental model of the system he has created based on lecturing

or reading does not fit reality. A **mental model** is one’s mental

perception or representation of system interactions and the behavior those

interactions produce.

System dynamics offers a source of direct and immediate feedback for

students to test assumptions about their mental models of reality through

the use of computer simulation.

A **system dynamics model** is the representation of the structure of a system.

**Stock**—A stock is a generic symbol for anything that accumulates or

drains.

**Flow**—A flow is the rate of change of a stock.

**Converter**—A converter is used to take input data and manipulate or

convert that input into some output signal.

**Connector**—A connector is an arrow which allows information to pass

between converters and converters, stocks and converters, stocks and

flows, and converters and flows.

However, before adding to the structure of the model, it is essential to ask: What is the purpose of this model? How is the model useful in achieving the

purpose? These questions should be asked before any model is developed.

The motion model describes the position

of an object being changed by the object’s velocity. Position and velocity

can be either positive or negative quantities. Velocity’s ability to act as an

inflow or outflow to the position stock makes it a one-dimensional vector

quantity where the magnitude of the velocity is its absolute value and the

direction is its sign.

The motion model can also be used to teach generic integration

principles and problem solving techniques to students which are common to

all stock-and-flow systems.

FREE FALL: An obvious point of expansion is to bring acceleration into the model.

Acceleration and velocity share the identical structural relationship

that is shared between velocity and position. Acceleration is the rate of

change of velocity over time.

The only difference between the two structures lies in the units of

measure.

*The flow is always measured in the same units as the stock divided by a measure of time.*

When a flow causes a stock to

decrease (become more negative) the flow is given a negative value. Since

the acceleration (flow) causes velocity (stock) to decrease, it must be

negative. This means that as the object falls, the acceleration causes the

velocity to become more and more negative so the object moves faster and

faster toward the ground. The same relationship holds for the velocity

(flow) and the position (stock).

One key aspect of system dynamics is that it allows one to make the

connection between structure and behavior. The structure of the free fall

system is two stock-and-flow substructures. These structures combine to

produce the behavior in position as shown in Figure 21. We can analyze

these stock-and-flow structures one at a time to see how they combine to

produce the overall behavior of the system.

The vertical velocity is 0 m/sec at the beginning of the simulation and

decreases linearly after 0 seconds. Examining the graph in Figure 23, we

can see that the magnitude (absolute value) of the flow, velocity is

increasing with time. You learned before that the steepness of the curve

depicting a stock depends on the magnitude of the flow affecting that stock.

So, as the magnitude of the velocity flow increases over time, so must the

steepness of the curve depicting the position stock. The increasing

magnitude of the velocity causes the object to fall faster and faster.

Jay begins 20 meters behind the train. The train is moving

away from Jay at a velocity of 2 meter/sec and is accelerating at .5

meters/sec/sec. Jay begins running at 7 meters/sec with no additional

acceleration. Can he catch the train? If so, during what time

interval?

Unfortunately, many classrooms do not go beyond the simple problems to

discuss more realistic physical systems because of the mathematical

complexity associated with solving such problems.

However, unlike typical mechanics instruction,

system dynamics does not need to limit students to solving idealized

problems because of mathematical complexity.

System

dynamics and STELLA can be used to model such situations without any

knowledge of complex mathematics or differential equations. These

models can give students an exact analytical solution to problems of

complex motion, and, more importantly, help them develop an intuitive

sense for how more complex systems behave qualitatively.

By holding an open hand out of the window of a speeding automobile,

This suggests that a greater

surface area will result in a greater air resistance force than a smaller

surface area.

This suggests that a hand moving relatively fast

through the air has a higher frictional force than a hand moving slowly

through the air.

A further addition might be to analyze the energy associated

with free fall.

One parameter can be labeled as the “Weight”, and it can be

defined as the gravitational acceleration times the mass. The other new

parameter can be labeled as the “Potential Energy”, and it can be defined as

the weight times the position.

The kinetic energy is defined as one-half the mass times the velocity

squared. It is the energy in and object due to being in motion. By creating

a new converter labeled “Kinetic Energy” and defining its equation to be

the mass times the velocity times the velocity, we can keep track of kinetic

energy in the system.