A General Model of Simple and Complex Systems

By David Alderoty © 2015

Chapter 9) Systems in Relation to Waves, Energy, Disorder, Order, and Work

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THE FOCUS AND PURPOSE OF THE SYSTEM PERSPECTIVE PRESENTED IN THIS E-BOOK

To prevent confusion, I am placing the following statement at the beginning of each chapter in this e-book. Keep the ideas presented in the following three paragraphs, in mind as you read this e-book.

The main utility of a systems theory, especially the **General Model of Simple and Complex Systems,** is to assist in the study of systems, especially in terms of problem solving, goal attainment, and observational and experimental research. From a system perspective, all the relevant factors of a system are considered to obtain an objective. This can include the behavior and overall functionality of the system, its environment, its components, its structure, and related dynamics, cause-and-effect sequences, inputs, outputs, forces, energy, rates, time, and expenditures.

Examples of a system are atoms, molecules, chemicals, machines, electronic circuits, computers, planets, stars, galaxies, bridges, tunnels, skyscrapers, forests, rivers, streams, oceans, tornadoes, hurricanes, microorganisms, plants, animals, human beings, social groups, small businesses, organizations, political parties, cultures, and the human mind of an individual, including related behaviors and personality traits.

A systems perspective is also useful for writing projects. This involves writing about all the relevant factors of a system, in terms of a thesis, or topic.

The purpose of this e-book is to discuss and explain the many details associated with the systems perspective described above. This required twelve chapters, which are relatively short.

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Systems and the Physical Sciences

Introductory Note on Physics Related Concepts

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Many of the concepts of physics and chemistry applied to most systems. However, these concepts may **not** be relevant for certain types of problems, goals, studies, and research projects. For example, if you carry out psychological experiments with a group of people, the laws of physics and chemistry are in fact involved, but they are not relevant. This usually applies to any practical work, or research, in the social and psychological sciences. Generally, the concepts of physics and/or chemistry might be relevant for biological, ecological, medical, electrical, or mechanical systems.

In the following paragraphs, I discuss some concepts that relate to physics, from the perspective of a system. This includes energy, work, and entropy.

What is Energy?

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Energy is simply moving or vibrating particles. The type of particles that are involved, determine the type of energy that is produced. This will become obvious with the following six examples:

1) Electricity is comprised of moving electrons.

2) Heat energy involves vibrating or randomly moving atoms or molecules.

3) Wind, is a form of energy, which is comprised of moving air masses. This is obvious when windmills are used to create mechanical or electrical energy.

4) Fluids, such as water, air, or gas, flowing through pipes are a form of energy. This is obvious when the flow involves high-pressure.

5) A falling mass, such as an object or a particle is a form of energy. This is obvious when falling water, from a waterfall, is used by a hydroelectric plant to generate electricity.

6) A bullet fired from a gun, is a moving particle, and it is a form of energy.

Energy in the form of Waves

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Certain types of energy consist of waves. This involves particles vibrating at specific frequencies and wavelengths. In some cases, the vibrating particles may move in the same direction as the wave. However, with certain types of waves, the particles do **not** move, and the energy is transferred in the form of vibrations, from one particle to another. A good example of this is seen when sound waves travel through solid objects, such as steel.

Below there are six examples of energy that involve waves.

1) Light is a form of energy that involves moving photons, which are vibrating at relatively high frequencies, with very short wavelengths. The energy of light is apparent when solar cells are used to convert sunlight to electricity.

2) Radiation is a form of energy that is similar to light, but the frequency is higher, and the wavelengths are shorter.

3) Microwaves and radio waves are a form of energy, which are similar to light, but the frequency is lower, and the wavelengths are longer.

4) Ocean waves, involve vibrating masses of water. In some cases, there are significant movements of the masses of water, in the direction of the wave. This can be seen when large waves strikes a beach. The water movement is especially significant when waves are produced by hurricanes or tsunamis.

5) Sound waves are a form of energy, comprised of vibrating masses of air, gas, liquids, or solids. The vibrations range in frequency from approximately 20 to 20,000 Hz.

6) Ultrasonic sound waves are similar to the above, except there frequency can range from 20,000 Hz to over 10,000 kHz

Some Systems are Comprised of Energy

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Systems can be comprised of energy, which are vibrating or moving particles, as described above. Most of the examples of energy given in the previous two subsections can be defined as a system. This includes a beam of light, a tsunami, and the falling water of a waterfall. Other, more obvious examples of systems that are comprised of energy are hurricanes, and tornadoes.

The concept of systems comprised of energy, might have scientific and practical utility. For example, applying systems theory to tornadoes might be useful in predicting, or even preventing tornadoes. The systems approach would include the interaction of the tornado with physical structures in the environment, such as houses, trees, automobiles, and people. Evaluations of this nature might indicate how to create safer structures in areas that encounter many tornadoes.

Energy and Work

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Energy can be used to do work, when it moves from higher concentration to lower concentration. In terms of moving particles, this involves rapidly moving particles, transferring some of their motion to slower moving particles. This process continues until all particles in a system have the same energy as the surrounding environment. A simple example is a steam engine, which involves high-pressure steam moving a piston. In this process, the heat energy from the steam is released into the surrounding environment. If the surrounding environment were at the same pressure and temperature of the steam, no energy would be released into the environment, and the steam engine would not function. That is, the steam engine would not move its pistons, and it would not produce any work.

The above process involves, transferring heat energy into the environment, to operate the steam engine, which produces work. Work can also be produced by a process that is just the opposite of the above. Specifically, it involves moving heat energy from the environment, into the boiler of the steam engine, to produce pressure from a liquefied gas, such as liquid nitrogen. The conventional process involves boiling water to produce steam to operate the steam engine. This alternative process involves boiling liquid nitrogen, to produce high-pressure nitrogen gas to operate the steam engine. Liquid nitrogen will be boiling at room temperature. (The boiling point of liquid nitrogen is -320.33 °F or 195.79 °C.)

Of course, the above is **not** a practical method of producing energy or operating a steam engine, assuming liquid nitrogen is more expensive than gasoline or coal. Liquid nitrogen requires conventional fuel to produce, such as electricity or engines that operate with fossil fuels.

For additional information, see the following websites. **1)** MEGATECH STEAM -FREON-ENGINE, **2)** Liquid Nitrogen Engine - YouTube, **3)** Liquid Nitrogen Steam Engine, **4)** Liquid Nitrogen Car.

Systems that Use Energy

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Biological systems produce their own energy, at a cellular level, from slow combustion of nutrients. Green plants capture sunlight as an energy source, which is stored in the form of potential energy in chemicals, such as glucose. Biological systems use energy to build and repair structures, as well as for growth, and for reproduction.

Most systems that are designed and built by humans, consume energy, to do work, or to store, transmit, and process information. Some of these systems contain their own internal source of energy, such as gasoline-powered cars, the batteries in portable computers, and cell phones.

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Energy, Disorder, Order, and Work

Energy Disorder and Order

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As explained in the previous section, energy consists of moving and/or vibrating particles. When a solid, liquid, or gas is heated, its molecules vibrate faster and/or move at an increased rate. When gases are heated to high temperatures, the molecules decompose into atoms, which move and vibrate at a fast rate. At very high temperatures, gases decompose into electrons, and positively charged ions. The movements of all of the **above** are random, and represent a disorderly state. This is obvious, if you heat a highly ordered substance to very high temperatures, such as a diamond. This will result in destruction of the crystal structure of the diamond. The result will be vigorously moving and vibrating carbon atoms, which will form carbon dioxide if there is oxygen available. This is certainly, a very disorderly state, when compared to the original diamond.

In general heating a solid, liquid, or gas increases the disorder of the system. High levels of energy usually destroy structure, and the result is a disorderly or random state.

Low temperatures can increase the order of a system. For example, a cup of water placed in the freezer will increase in order, as ice is formed. Ice has a precise crystal structure, which is more orderly than liquid water. When the cup is placed at room temperature, the ice it contains will melt, and there will be an increase in disorder.

Certain chemical reactions produce heat, and when the reactants cool, a very orderly structure is produced. For example, chlorine gas reacts with potassium, and this will result in potassium chloride. This represents a structure that is more stable and orderly than the chlorine and the potassium.

In thermodynamics, the disorder or randomness described above is called entropy. When an object is heated, it increases in entropy. When the object cools its entropy is reduced, and it releases heat into the surrounding environment. When this happens, the entropy of the environment increases. However, when ice melts, or if you run an engine with liquid nitrogen, the entropy of the environment decreases.

Work can Increase Order & Reduce Entropy

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There is a very important exception to the ideas presented in the previous subsection. Specifically, **energy does not always result in disorder. A highly controlled form of energy within a system can build structures, increase order, and reduce randomness.** The highly controlled form of energy that builds structures, or is used to obtain an objective, is called **work**. The **work** generally reduces the entropy of the system, but it increases the entropy of the surrounding environment.

However, demolition work increases the entropy of a system, and it might destroy the entire system. This includes the behavior of anti-bodies in animals and humans, which destroyed viruses and bacteria. Work of this nature, represents a controlled form of energy, because it only destroys specific structures.

Work is usually the result of one or more mechanisms that converts energy into a highly controlled form, and directs it in a specific way. An example is the genetic mechanism comprised of DNA, which directs and controls the building of the limbs, skeleton, and organs of a developing animal. Another example is the brains, hands, and equipment of a team of engineers and construction workers, designing and building a skyscraper.

The control mechanisms described above generally involve information, consisting of a series of signals, in the form of a relatively weak energy flow. This controls and directs a stronger primary energy source, to perform a specific type of work.

The work that creates order in a system, involves energy that is eventually released into the environment. This increases the entropy of the surrounding environment, and theoretically the entropy of the entire universe.

The Relativity of Order and Disorder

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Order can be thought of as a relative concept. From **this perspective**, order is a state that is deemed desirable. This can involve a specific state that is needed to solve a problem, obtain a goal, carry out a scientific study, build a cabinet, create a sculpture, or cook a pot of beef stew. These ideas, and the relativity of order and disorder, will be clarified in the following paragraph.

For example, if you have a large number of insects crawling around in your bedroom that is a problem, which can be defined as a disorderly state. To put the bedroom in an orderly state, the insects would have to be killed, and the related mess from their caucuses would require a thorough cleaning. However, the insects in the bedroom, from another perspective can be defined as an orderly state. For example, if use decide to use the bedroom as a laboratory enclosure, to study the behavior, and reproductive cycle of household pests, the insects in the bedroom represents an orderly state. In this case, the order in the bedroom would increase, if the insect population increased.

Another example of the relativity of order and disorder is preparing food. Food preparation usually involves the destruction of a plant or animal. In addition, the chemical composition of the plant or animal material is broken down by cooking. All of this represents an increase in disorder from the perspective of the plants and animals that are used for food. It also represents an increase in disorder from the perspective of physics and chemistry. However, from the perspective of the chef, food preparation requires work, and prepared food represents an orderly state.

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Randomness, and Related Concepts

Randomness is a Relative Concept,

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Randomness is a relative concept. Specifically, behavior, movements, and results, are random when we **do not** have the information to determine the outcome in advance. Sometimes, it might be **impossible** to obtain the needed information to make an accurate prediction.

A simplified example of the relativity of randomness can be illustrated with numbers. I wrote a four-digit number on paper. From my point of view, this number is **not** random. Even if I do not remember it, I have it written on paper. From your point of view, the number is random, because you do **not** have access to the information I wrote on a sheet of paper. If you had access to this information, the number would **not** be random from your perspective.

Another example is a roulette wheel. When someone spins a roulette wheel, it will stop at a random number. However, if you were able to measure all the forces involved with the spinning of the roulette wheel, including the force used to spin it, friction of its axle, and air resistance, you could calculate exactly how many spins the roulette wheel will make, before it stops. In such case, if you know the starting point of the roulette wheel, you could determine the number that it will point to when it stops spinning. Such a case, the results of the spin of the roulette wheel would not be random from your point of view. However, in actual practice, it would be impossible to measure all of the forces involved with the spin of a roulette wheel.

As the Number of Experimental Samples Increase, Randomness is Reduced

There are many statistical methods that can be used for randomness. One of the simplest and most interesting involves a large number of experimental samples. For example, the behavior of individual subatomic particles, atoms, and molecules are random. However, if you use several trillions samples, the results are perfectly predictable. It is very easy to use hundreds of trillions of subatomic particles, atoms, or molecules in an experiment. For example, in one gram of hydrogen there are approximately: 602,000,000,000,000,000,000,000 atoms. As a result, of the above, most experiments that involve chemistry, and/or physics are perfectly predictable.

In general, randomness is reduced as the number of experimental samples increase. However, even with massively large numbers, the results are never absolutely certain. For example, there is always an **infinitesimally small chance** that an unexpected occurrence will happen by random chance, such as a pot of water freezing, instead of boiling, when it is placed on the stove. Theoretically, this is possible, but most likely it never happened, and probably will never happen. This is because the pot of water contains many billions of water molecules. However, if you were placing four molecules of water on the stove, probably freezing would occasionally happen, by random chance, for a fraction of a second or longer.

Time, Rate, and Related Concepts

Time and Systems

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Time is often an important concept when evaluating or building a system. Some dynamic systems involve a sequence of movements or actions that take place in precise time intervals. This can involve precise units of time for a series of actions.

Rate and Systems

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The concept of rate applies to many types of systems. This may involve inputs and/or outputs from a system that take place at a specific rate. A general equation for rate is

Rate multiplied by Time=Quantity, or RT=Q As can be seen from the above, rate involves time. Below there are a few examples of systems that involve rate.

- *Rate multiplied by time equals distance*. For example, a car moving at 10 mph, for time interval of three hours, travels 30 miles.

- *Rate of pay multiplied by time= money.* For example, an employee makes $40 an hour, and works for 40 hours, earned $1,600

- *Rate of profit:* For example, if a small business makes a profit of $200 a day, in seven days the total profit would be $1400

- *Rates can be positive, or negative:* An example is rate of profit of -$100 a day, in seven days results in **-**$700. This means a loss of $700, which is indicated with the minus sign.

- *Rate of production:* For example, a company manufactures 50 widgets per hour, and in eight hours, it will produce 400 widgets.

- *If a business is losing money* at the rate of $100 a day, in 30 days, it will lose $3000.

- *Rate of return on an investment:* For example, if the investment in a small business is $200,000, and the business brings in $20,000 a year, The rate of return on the investment is 10%

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