As opposed to describing things simply in terms of their static properties, the patterns we observe all around us in how the state of things change over time is an alternative way through which we can describe the phenomena we see in our world.
A state space, also called a phase space.
Is a model used within dynamic systems to capture this change in a system state over time.
A state space.
Of a dynamical system is a two or possibly three-dimensional graph in which all possible states of the system are represented, with each possible state of the system corresponding to one unique point in the state space. Now we can model the change in a system state in two ways as continuous or discrete. Firstly, as continuous, meaning the time intervals between our measurement are negligibly small, making it appear as one long continuum. And this is done through the language of calculus. Calculus and differential equations have formed a key part of the language of modern science since the day of Newton and Leibniz. Differential equations are great when we're dealing with quite few elements. They give us lots of information, but they also become very complicated very quickly. On the other hand, we can measure time as discrete, meaning there is a discernible time interval between each measurement. And we use.
What are.
Called iterative maps to do this. Iterative maps or iterative functions give us less information but are much simpler and much better suited to deal with very many entities.
Where feedback is important. Whereas differential equations are central to.
Modern science, iterative maps are central to the study of nonlinear systems and their dynamics.
As they allow us to take the output to.
The previous state of the system and feed it back into the next iteration, thus making them well designed to capture the feedback loops that are.
Characteristic of nonlinear systems. The first type of motion we might encounter is simple transient motion.
That is to say, some system that gravitational towards.
A stable.
Equilibrium and then stays there.
Such as putting a ball in a bowl. It will.
Roll around.
For a short period before it settles at the point of least potential gravity, its so-called equilibrium, and then will just stay there until they're still perturbed by some external force. Next, we might imagine some periodic motion. For example, the motion of the planets around the sun is periodic.
This type.
Of periodic motion.
Is, of course, very predictable. We can.
Predict far out into the future and way back into the past when eclipses happened. In these systems, small perturbations are often rectified and do not increase to alter the system's trajectory very much in the long run. The rising and receding of the tides or the change in traffic lights are also examples of periodic motion. Whereas in our first type of motion, the system simply moved towards its equilibrium point. In this second periodic motion, it is more like it is cycling around some equilibrium. All dynamic systems require some input of energy to drive them. In physics, they are referred to as dissipative systems, as they are constantly dissipating the energy being inputted to the system in the form of motion or change. A system in this periodic motion is bound to its source of energy, and its trajectory will follow some periodic motion around it or towards and away from it. In our example of the planet's orbit, it is following a periodic motion because of the gravitational force the Sun exerts on him. If it were not for this driving force, the motion would cease to exist. Another example would be the human body that requires the input of food on a periodic basis.

We consume food, then dissipate this through some activity, and then consume more and dissipate it again in a somewhat periodic fashion. Like other biological systems, we are bound to cycle through this set of states. The same is true for a car or a business that are constrained by the input of fuel or finance. The dissipation and the driving force tend to balance each other, settling the system into its typical behavior. This typical set of states the system follows around its point of equilibrium is called an attractor. In the field of dynamical systems, an attractor is a set of values or states towards which a system tends to evolve for a wide variety of starting conditions to the system. System values that get close enough to the attractor remain close, even if slightly perturbed. There are many examples of attractors, such as the use of addictive substances. Whilst being subject to the addiction, our body cycles in and out of its physiological influence, but continuously comes back to it in a periodic and predictable fashion, that is, until we're able to break free from it. A so-called basin of attraction then.
Describes all.
The points within our state space that will move a system towards a particular attractor. We could think of a planet's gravitational field as a basin of attraction. If we place some matter that is large enough into the gravitational field, it will be drawn into the planet's orbit irrespective of its starting condition. In this module, we've started our discussion on the dynamics and nonlinear systems by talking about the two simplest forms of motion and change. Firstly, those that simply gravitate towards some equilibrium and then remain there, such as a ball in a bowl that is determined to find the point of lowest potential gravity and then remain there in equilibrium until perturbed. We then discussed a second type of change, periodic motion, a very common type of motion that follows a regular periodic pattern in statespace. Under this regime, the system receives some input of energy and then dissipates this energy to maintain a periodic state of change around its energy source. In this way being constrained within a so-called attractor. As you may have noticed, we've been dealing with relatively simple systems with a single point equilibrium characteristic of linear systems. In the coming modules, we'll be discussing the dynamics of non-linear systems that may have multiple
equilibrium.