Introduction to System Dynamics Modeling
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Dynamics of Stocks and Flow
Lecture - 5.2
Stock & flow diagram: Basics-I

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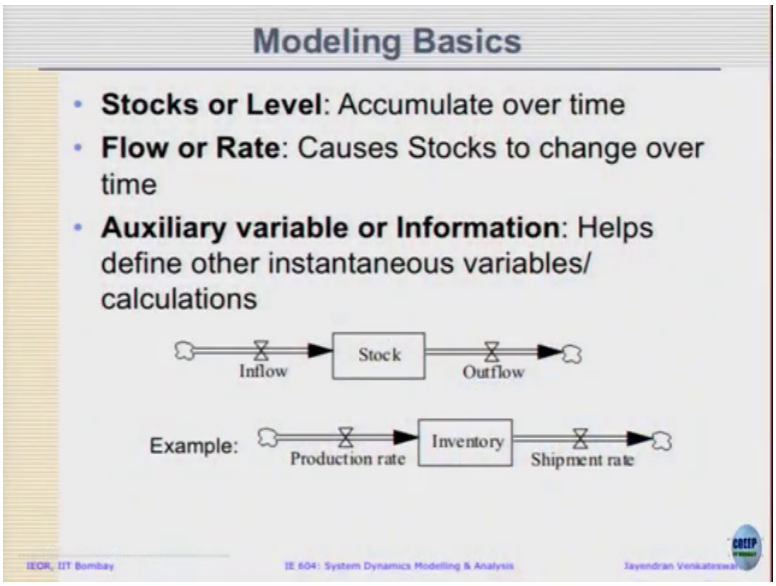

Now, let us go to the Modeling basics. Let us also learn and join this nice ecology. Actual teaching is very easy. I will be done teaching in another 5 minutes of the modeling basics. Essentially all system dynamics model consists of exactly 3 elements; one is a stock or level which accumulates over a time, second is flow or a rate and it causes stocks to change over a time. So, we have stocks, we have flows, then we have auxiliary variables information which help define other instantaneous variables or calculations.

Found a visual representation of them. We can look at it like this where the rectangle you see is called a stock. So, all stocks are represented as rectangles and the thick arrow with a valve you see is a inflow. I mean the direction of arrow represents inflow to be start and direction of arrow can represent you the outflow of the stock.

At the end of it you see kind of cloud kind of thing, this kind of represents an infinite sink and the infinite source. Sorry persons an example could be being a simple like you know modeling inventory, then production rate of x inventory and shipment rate of x inventory how it effects intuitive, right. As the production rate is more, the inventory is going to increase. The shipment rate is more, then inventory is going to fall down. So, we can represent it simply as just these rectangles for stocks and these thick arrows with a valve to represent the rates stock flows.

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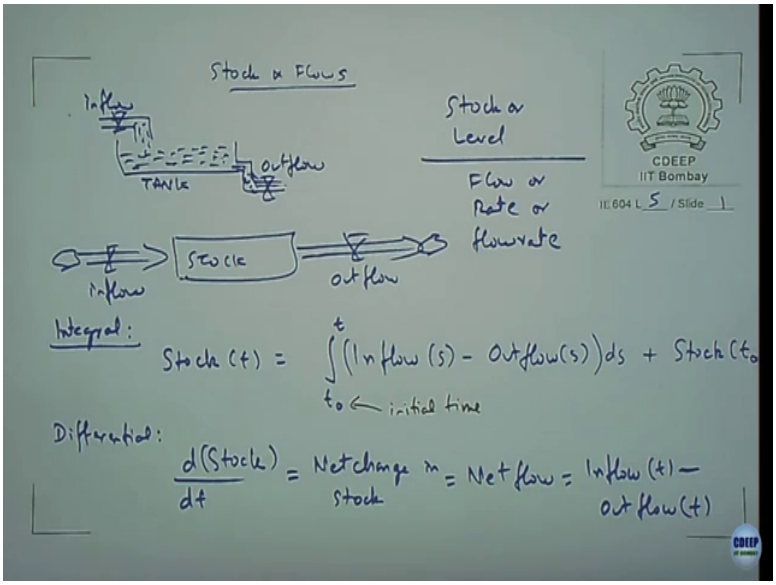

And this has only three constructs you need to model, however complex a system you want whatever we discussed yesterday we know we had looked at the examples for the road traffic and road conjunction modeling. To various examples you have being studying; they are just going to be modeling. It has stocks flows and auxiliary variables that's it.

So, if you want to imagine say for example hydraulic metaphor, you can imagine kind of a water tank right. I have inflow to the tank; inflow to the tank and then I have an outflow to the tank. So, very simplistic kind of metaphor of course. So, we can I know this inflows and outflows we are used to looking at it with say some kind of valves within the system.

So, this is the same idea that we are using it here outflow and inflow. So, again these are flows. So, it is called stock or level, it means the same thing flow or rate or some books even mention it as flow rate depends on what you look. They all mean the same thing. Flow rate or flow rate the quick word of caution. See here this Loyds and Hydraulic metaphor you know that for example when inflow is kind of say stops and out flow is always on, then after a point the tank will become empty and then no further water will flow, right.

So, if it becomes empty no further outflow occurs. So, that is for the hydraulic metaphor, but if you look at this just the basic model of it, it is nothing but a set of equation. So, in equations especially when you are trying to simulate it, inflows and outflows can take positive or negative values. There is nothing which restricts it. So, if you take outflow is positive, then stock will reduce, but outflow is negative. That means stock is going to increase yes.

So, there is no other check that is done automatically very computed. Here we are back to the real basics of how viewing as the equations for example we can view it as an integral because integral you can say stop at time t. This is an integral of time 0 to current time t if your time s minus if your time s ds plus initial value of stock, but t 0 is a let us say initial time.

So, the underlying model is nothing, but a now integral or you can write it as a differential equation where you can write it as d stock by dt is nothing, but net change in stock is nothing, but your net flow nothing, but your inflow and t minus outflow time t. So, once you make a

mapping of your model in terms of stocks and flows, automatically you have defined these differential equations into the system.

The system is the stock it is going to change by the inflows and outflows precisely in this manner and once you have set up a differential equation, we can simulate it. Some of you have done numerical analysis you may know it others the beauty of it is you do not need to know you can give it to a system and it will simulate it for your simplest approach between Euler method which is which can be stimulated for you.

So, we can see a bit of it. So, you understand how the underlying model works, but beyond that we do not need to implement the simulated person. We can try to use the simulator to model the systems at the front. So, you remember this. So, stock can only change through this double headed valid arrows, but will directional arrows which represent your inflows as well as your outflows and stocks what is going to be different show will here. So, change in stock is defined as inflows minus outflows. So, stock can only be changed through flows nothing else.

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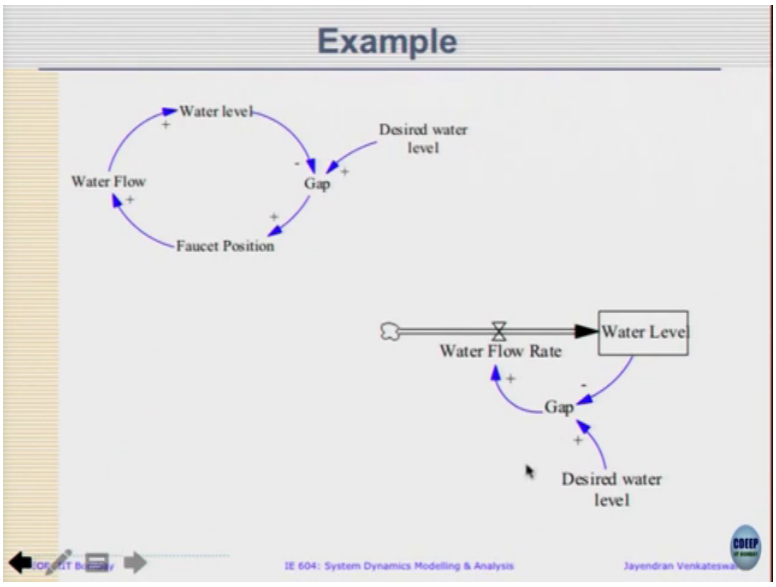

So, we have the desired you have seen this; this is a negative feedback system where we have water level and we have desired water level based on the gap. I decide how fast I want to open the tap and the water is going to flow in and as in as a desired water level it reach as actual water level reaches a desired water level. I turned on the faucet, I can automatically or manually whatever right.

So, this clean stocks. So, what is the stock here? Water level is the stock and what is the flow here? There is a word flow in it, there is only one variable water flow. So, you better guess the same thing and that is the only thing which is influencing water level and it all. Stocks can only be changed together flows. So, if water level is the stock, then whatever is coming is in should be the flow.

So, we simply define as water flow or a water flow rate affecting the water level, then there are other variables. I can simply map it as let us have desired water level which is an information that I have to outside this system and I have defined as a variable here. We move here, identified the gap, see at the same causal links and then the gap is again connected to the affects the flow rate.

So, now this is also what we call as a stock flow representation of the model. So, this is a causal loop representation, but just by moving to the stock flow representation, the problem becomes much more grounded actually now ok, water level is something that I need to measure. So, as soon as when it goes both ways if the stocks is lots of things that we can actually measure, ok. So, let us measure that, so that is the stock. How do the stock change? Basin water that is flowing, what is the information you need to control it?

So, I need to know about the beside water level, then I need to somehow figure out the gap. So, then those comes as what we call as informational auxiliary variable. Just be these three elements we can actually come up with a much richer representation of the same example we did in causal loop, but the stock flow represent.

So many papers, you may find that people quickly jump into stock flow representation to represent the same thing without bothering about the underling equations. How this gap affects water flow rate, we do not know right now its we have time for it, we will see later. So, this is representation. So, let us quickly understand the role of stocks and then look at some examples.