Effective Engineering "Teaching" in Practice

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Lecture – 01a
Introduction to the course

Welcome to the 10 hour NPTEL online certification course on effective engineering teaching in practice. If you notice the word teaching is in quotes; that is because teaching is the term that we are all familiar with, it really represents the facilitation of learning by the people who are learning students, others and so on so forth and that is the reason why the word teaching is in quotes. In this course we will look at teaching as facilitation of the learning process.

My name is GK Suraish Kumar, GK for short, I am in the department of biotechnology IIT madras. I have an interest in the learning process, I have been doing experiments in the learning process for a very long time, pretty much right from my second or third semester of teaching at IIT Bombay initially. And this particular course will be offered in collaboration with the teaching learning centre - TLC for short at IIT madras. The TLC faculty who would be involved in about 3 topics out of 12 are Dr Edamana Prasad who is actually the head of the teaching learning centre.

Shreepad Karmalkar; Professor Shreepad Karmalkar who is in electrical engineering, who has interests in the learning process and Dr Richa Verma who is with the teaching and learning center right now. Teaching engineering needs knowledge and skills on teaching.

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That is well known; however, engineering teachers, lecturers or professors have never been trained to teach. Knowledge in that area of teaching is usually considered sufficient to teach that particular subject and I believe therein lies the difficulty. Merely knowledge is not really sufficient to facilitate learning in others.

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On the other hand, education is a very old research area. A wealth of information on effective strategies for learning as well as understanding of the learning process is available which have the backing of evidence. It is not complete of course, it can never be complete, but a lot of knowledge is available. And most Indian engineering teachers are unaware of the knowledge on learning. It is not in a form that they can access, it is not in a form that can be directly used and so on.

Therefore, this course is also designed to begin, just begin, barely scratch the surface, to begin to address this particular shortcoming or the above two shortcomings; one - absolutely no training in the facilitation of learning process as well as access to knowledge, huge knowledge in this particular area, this is what the course is designed to do.

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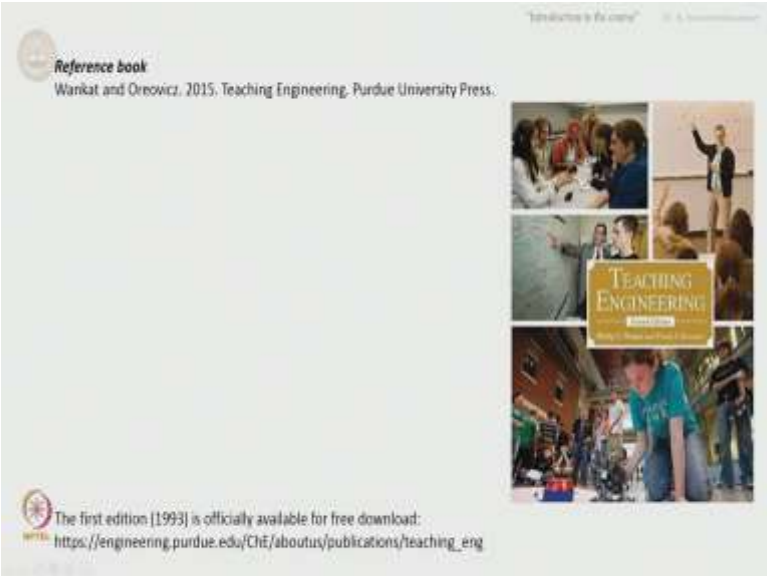

This would be your reference book, you have the cover of the second addition the title is teaching engineering by Philip Wankat and Oreovicz. This was published in 2015, the second addition was published in 2015 by the Purdue university press. The first addition of this book was published way back in 1993 and that addition is officially available for free download, from this particular website. You can go to this website and download the entire book officially.

In fact, I happened to begin, began teaching in 1993, the July December semester of 1993 at IIT Bombay, and I had an opportunity to read this book pretty much from cover to cover, just before I took my very first course. I was really hooked on to this book. I learnt a lot from this book and glad that there is a second addition available now and we would use this as a reference book. Whatever we are going to do here, will not have the same sequence, or even the same information as this and so on so forth.

But some fundamentals are essentially the same and we will point it out to you from time to time, the names are all the same. So, that should not be a problem. With this, let us begin the first aspect of this course. We will need to begin at a place which is comfortable to most people and therefore, an inexperienced engineering teacher’s view, which is what many people are when they begin to teach because they are essentially not trained.

To effectively get this across I am first going to present three scenarios and I would like you to watch those scenarios. I am going to teach mass balance-a useful form of the mass balance. So, I am sure all engineering people would be able to appreciate it. I have chosen things such that it appeals to all engineering teachers. The examples that I have chosen are not highly specialized and therefore, you would be able to appreciate it.

Let us begin with the first scenario. For this I am going to go to the board which is typically available in all classrooms, I will use the board to hopefully demonstrate how various things are. Note this is a course or this is a section on material balances; the first scenario is pretty much an inexperienced teacher walking into the class probably for the first time. So, approach one, scenario one, let us begin.

Good morning we are all here to discuss material balance. It is a very important principle that you should all know. Pay attention. You know if you choose a system like this and there could be inputs, there could be outputs to the system.

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And if the rate of input is r_{in} and the rate of output is r_{out} and the rate of generation is r_{gen}, the rate of consumption is r_{con}. This is very important. You should all remember this. You should memorize this. That is end of approach one. It might have seemed funny, but you might want to see a video recording of many first time teachers.

Now let us move on to the same thing taught by somebody maybe with a couple of years of experience. The person has realized that there is a class in front. The person needs to facilitate the learning or teach the class at least, facilitation of learning probably comes later, to teach the class and therefore, the person is probably like this.

So, right now - on to approach two. A slightly experienced approach. Good morning class. I am sure you are all bright and sunny, willing to pay attention. Today we will discuss a very important principle called mass balance.

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It is a highly important principle and this is based on the law of conservation of mass, which is essentially saying that total mass is a constant. That is the fundamental principle and we are going to look at a useful form of this particular principle. We will be using this to analyze various different systems and therefore, let us take a look at this.

If we consider a system, a system I am going to represent by this dotted line here. In reality it could be anything. In reality it is something that we decide to focus our attention on. It could be this classroom, it could be even as small as this pen or even a small cell which is a few microns in size or it could be the entire university, the entire building the entire universe whatever you want, the entire world and so on so forth whatever you want to call it, whatever we focus our attention on.

And there could be inputs, there could be output streams that come out of the system input streams go into the system. And if we follow the mass of a species - a species could be anything, it could be molecules, it could be compounds, it could be substances and so on so forth. We can consider anything as a species. So, there are only a few things that can happen in this context, the species is input into the system at a rate of r_{in}.

So, species is input, it could be input into the system at the rate, time rate amount per time of r_{in}. Species could be brought out or output from the system at a rate of r_{out}. One or two species could be generated in the system. What I mean by in is this particular space inside the system. Input is from outside to inside, output is from inside to outside.

It crosses the system boundaries input and output whereas, the generation is in the system at a rate of r_{gen} and species could be consumed in the system at a rate of r_{con}.

These are the only four things that can happen to any species that is being considered over a particular system. The system is very important. Over this system, these are the various things that can happen. Over a different system, over a different volume that we want to focus our attention on, different things will happen.

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If you look at the net rate, it is quite easy to see by logic that it has to equal the rate in minus the rate out plus the rate of generation minus the rate of consumption. This is net rate of the species in the system.

The net rate of the species in the system is the rate at which the species gets accumulated in the system. The variation of the mass of the species with time that when of course, writing the same thing here out consumption. This equation, can be considered as a useful form of the mass balance equation of the conservation of mass principle, which can be applied to analyze a system. This is an important principle and you need to know this.

So, that is I think that is all I have here, right yeah. That is scenario two or approach two in this case. There is one more approach that I would like to show. What I would like you to do is carefully note the differences between the various approaches. We will of course, discuss that, but I would like you to carefully note the differences between the various approaches.

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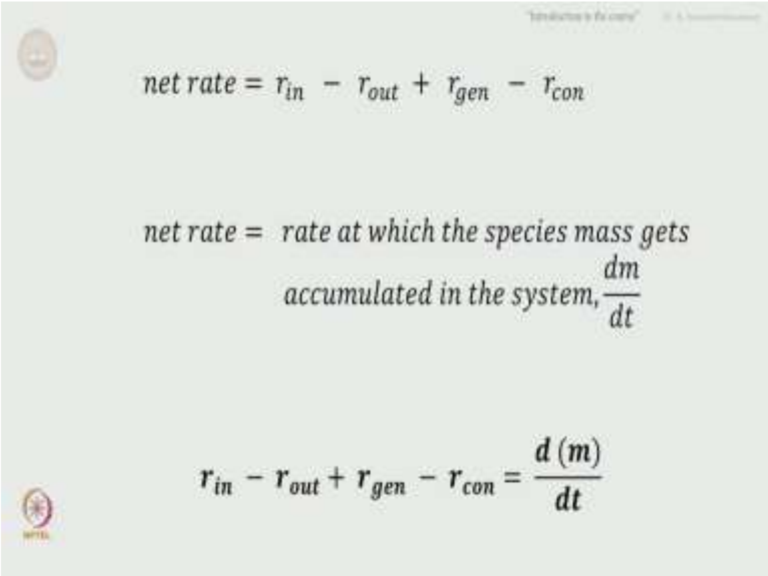

Now, on to approach three. Let us begin. Good morning class, I am sure you are all doing well; today we are going to talk of, talk about a very very important principle especially in the context of analysis, which is the mass balance principle. And when we talk about mass balance, we will be talking about mass rates ok.

What is rate? Can you tell me? Right yeah, rate is amount per time. And if you have done some engineering course, you would already realize that in engineering we typically talk about rates- rate of this, rate of that, rate of this and so on so forth. And it is already a part of you, may not have even realized that we are talking only about rates. We rarely talk about amount volume or mass volume and so on and so forth which we were very comfortable with till the school level. When we made a transition to engineering, we started talking about rates and that has become a part of you.

Why did we actually do that? Would you know? Let me ask you this question; you have all seen water tankers, especially in Chennai, where we go through water shortage in every summer. And these water tankers are the ones that fulfill the water needs for a wide variety of the public. I mean everybody uses water tankers to fulfill their water needs. The water tankers come in various sizes. The small ones are about 8,000 liters, the large ones are about 16,000 liters.

Let us choose an average of 12000 liters.

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They have a figure here 12,000 liters and that is a water tanker that I just drew right.

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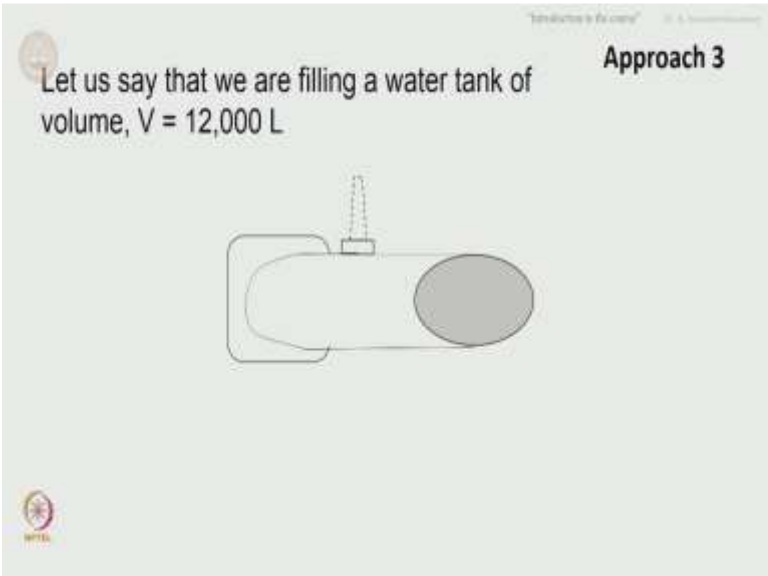

And let us say that we are filling water in the water tanker here. These go to the filling stations, they get filled with water from a source, and then they come and distribute to various communities.

The volume is 12,000 liters and this is water. Can somebody tell me what the mass of water in the tank would be when it is full? Yes right yeah you need the density of water. The density of water happens to be one gram per centimeter cubed or 10^3 kg/ m^3 and therefore, we are looking at 12,000 liters. I would like you to work this out, I am not going to tell you how I got this, work it out. If you have any difficulty in working it out, please get back to me. So, the mass because of the density being one gram per centimeter cubed of 12,000 liters of water is going to be 12,000 kilogram.

So, now let us ask a question. It is a very valid question, an engineering question. How long would it take to fill the tank right. Also, inturn, these water tankers need to go to a filling station to fill up it is going to take too longer time, it does not really serve the purpose. As short a time as practical as possible would be nice. So, how long does it take to fill a tank. This is a very standard engineering question. And can somebody tell me how would you go about it? Yes you need the rate of filling. Without knowing the rate of filling, you would not be able to find out the time right.

Now you see the rate coming in right.

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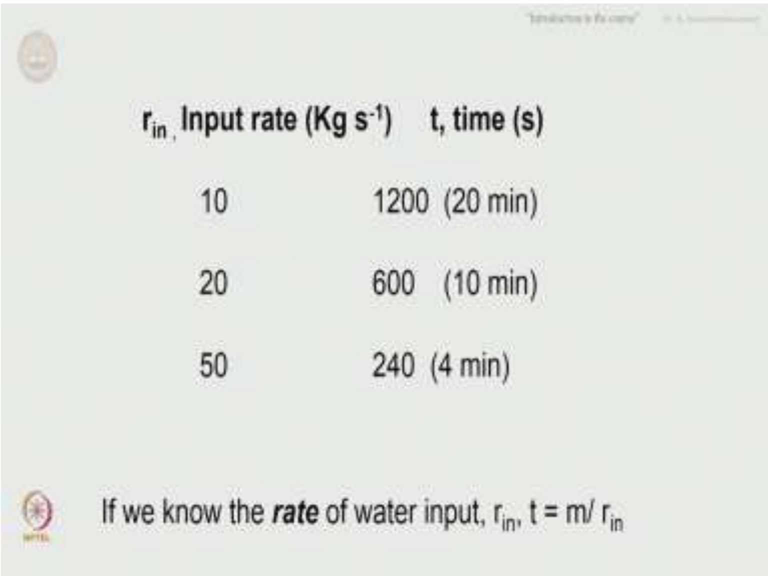

So, if you take a look at this, if the input rate happens to be in kilograms per second, it happens to be 10, you can figure this out. The time it is going to take is 1200 seconds divided by 60; 20 minutes. if the input rate is 20 it is going to take 600 seconds or 10 minutes. If the input rate is 50 kilogram per second then the time that is taken is 240 seconds or 4 minutes.

So, if you would have done it intuitively, if you think about how you did this. If you know the rate of water input that is r_{in}, you know the time is mass per rate because rate is amount or mass per time and therefore, time is amount by rate right. So, there you have one direct use of rates and these are the questions that we will ask in engineering, that we will be interested in engineering and therefore, we need to work with rates. Let me take this further. Let me tell you with this, this is simple we would do it intuitively. There are times when intuition is not immediately available and it becomes difficult, especially in things that you are not really comfortable with. That is a typical rate of 20 kilogram per second, it takes about 10 minutes to fill in a tanker, midsize tanker. Therefore, we will choose that rate for further discussion ok.

Now let me slightly change whatever we are looking for. Suppose there is a hole in the tanker which oozes water at a rate of 5 kilogram per second. It is filling in at a rate of 20 kilogram per second; it has a hole that oozes water at the rate 5 kilogram per second how long would it take to fill the tank. So, can you work it out. You see it is not so simple. It is not so intuitive. You think about it, think about it and then if you see here - you need to look at the net rate.

Once you fix on the net rate, then you would be able to solve this particular problem, this particular question. It is rate of input minus rate of output. Water is getting filled into the tank, water was going out through the hole. Therefore, the net rate is the difference between the two rates. 20 kg/s is the rate at which it comes in, 5 kg/s is the rate at which it goes out. Therefore, it is 20 – 5 = 15 kg/s.

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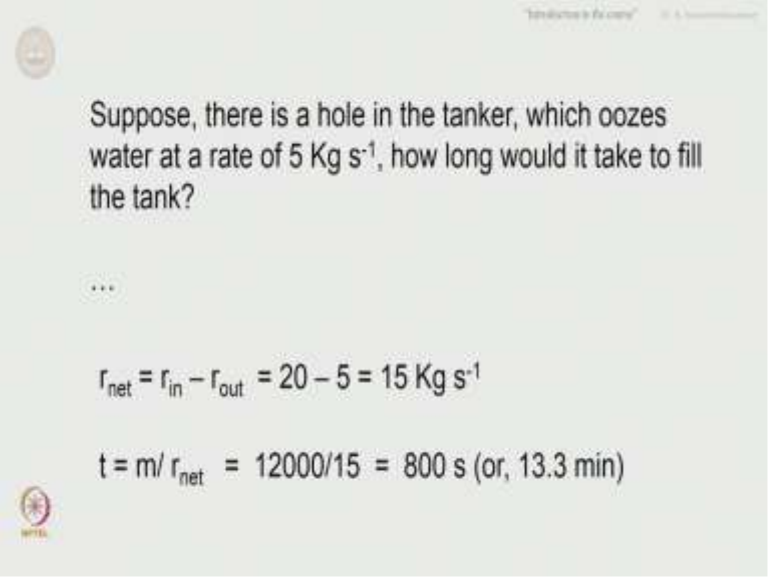

Once you have this, you know it is straightforward to find out time.

The time is

$t = m/ r_{net} = 12000/15 = 800$ s (or, 13.3 min)

So, now, you know that intuitively you may not be able to manage it. I will even complicate this further and then you would be convinced that intuitively you cannot really manage it every time.

Now, suppose that in addition to the leak, there is some mechanism inside the tank itself that is generating water at say one kilogram per second - some reaction maybe. And some reaction in which the water is used up in the tank at 0.25 kilogram per second, and all of which simultaneously occur. That is the killer thing the simultaneous occurrence is the one that confuses our intuition a lot. If this is happening how long would it take to fill the tank ok?

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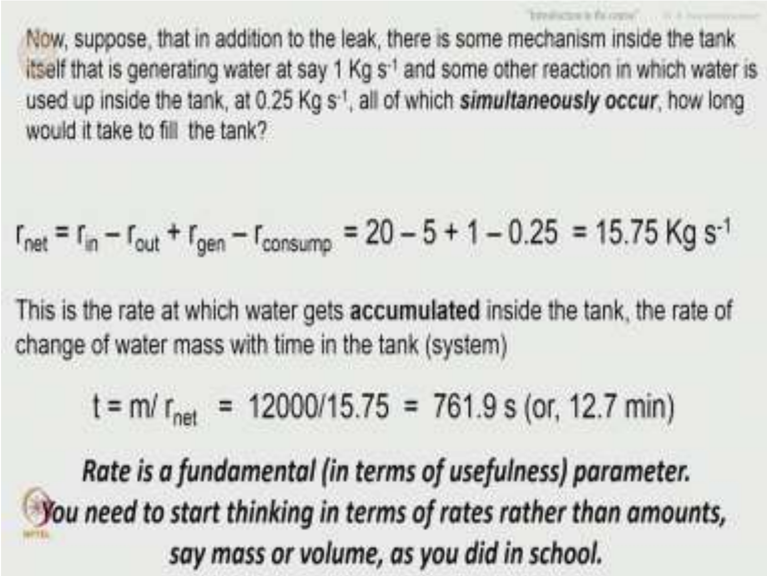

Now, you know the approach you need to get at the net rate. The net rate in this case would be

$r_{net} = r_{in} - r_{out} + r_{gen} - r_{consump} = 20 - 5 + 1 - 0.25 = 15.75$ Kg s^{-1}

1 kilogram per second is the rate at which it is generated now, 0.25 kilogram per second is the rate at which it is getting consumed by a reaction. You put it all together it is 15.75 kilogram per second. This is the rate at which water gets accumulated inside the tank, and the rate of change of water mass with time in the tank, which is a system. And you try to do this with intuition in the beginning, I am sure you would find it difficult.

So, the net rate turns out to be

$t = m/ r_{net} = 12000/15.75 = 761.9$ s (or, 12.7 min)

In other words, rate is a fundamental in terms of usefulness parameter. And you need to start thinking in terms of rates rather than in terms of amounts say mass or volume that you did in school. Now you need to have this firmly set in your mind.

Now, let us look at a very important principle based on the law of conservation of mass, the total mass is a constant and as long as we do not deal with nuclear reaction where there is mass to energy conversion or we travel at speeds close to that of light when there is mass dilation we can certainly use this principle. So, for all terrestrial purposes, it is perfectly fine as long as we do not deal with nuclear reactions.

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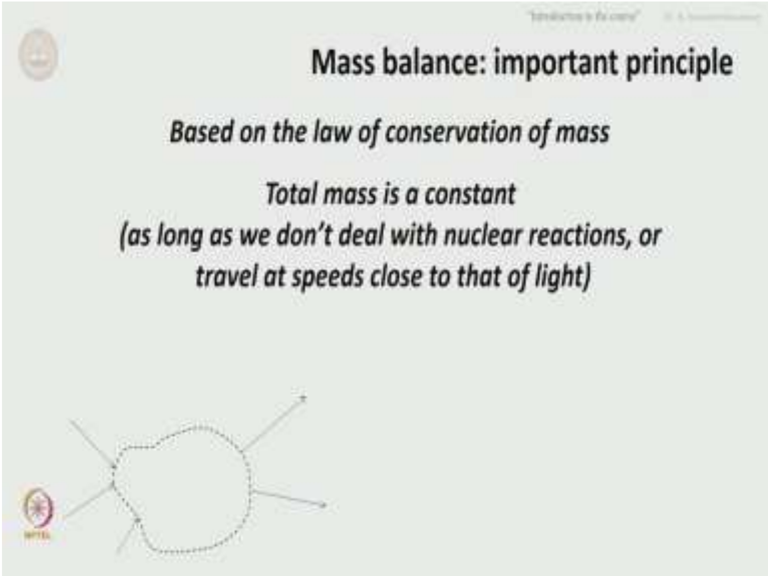

Let us consider a system.

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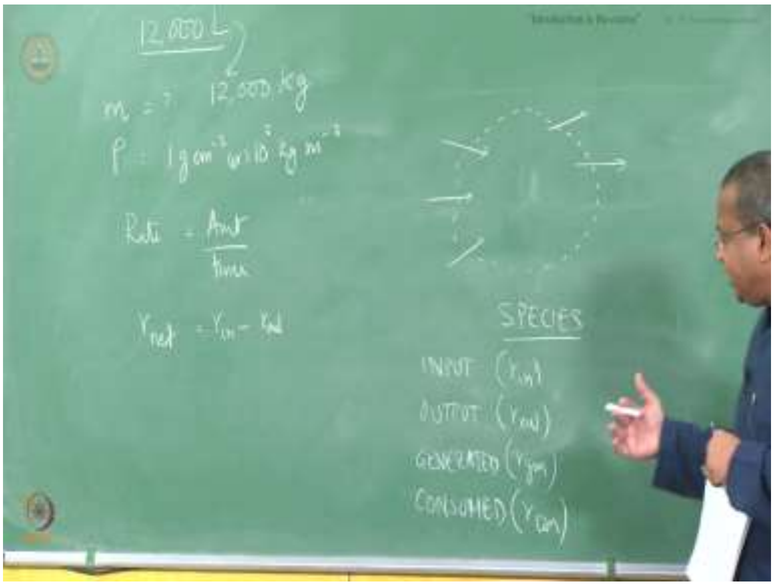

You know what a system is from thermodynamics and so on right? Yeah that is something that we focus our attention on and leave everything out all right. It could be as simple as the classroom here, the building here or the cell here, you know a biological cell which is a few microns in size or it could be as large as a country and so on and so forth. It is something that we want to focus our attention. To this system there could be inputs, there could be outputs and these are the input streams to the system, these are the output streams to the system. There are only four things that can happen. Say they could the; if we are focusing on the mass of a particular species.

Species could be molecules such as oxygen, nitrogen and so on so forth. Species could be some complex compounds such as lipids or carbon dioxide and so on so forth right. It could be anything that is an inherent or something that can be considered a whole, the whole amount. And if we follow a particular species, then it could be input into the system at a rate of r_{in}.

Everything around the system, if you change the system everything changes, therefore be very careful about the focus of this particular analysis or input. It could be output from the system at a rate of r_{out}. It could be generated in the system at the rate of r_{gen}. It could be consumed in the system at a rate of r_{con}. These are the only four things that can happen. You can think whatever you want. Apart from these four things, nothing else can happen to that particular species.

Therefore, if you apply the principle of mass - mass cannot be created not destroyed. Whatever mass exists before the process must or at the beginning of the process must be the same at the end of the process and therefore, if you are looking at the net rate of the species in this particular system, the net rate.

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It will be the rate at which it comes in, it is coming in therefore it is coming into the system minus the rate at which it goes out plus the rate at which it is being generated in the system itself minus the rate at which it is getting consumed in the system.

Therefore the net rate of species change in the system is the rate at which the species gets accumulated in the system, which we can represent mathematically as a derivative of the time change of mass, of the change of mass with respect to time. You know the derivative right. This is not dm dt. You cannot cancel d and d out, this is d by dt of mass, d by dt is an operator, and this is nothing but rate of input minus rate of output plus rate of generation minus the rate of consumption.

In fact, it will be helpful if you just memorize this it is rather simple to memorize. So, that you can directly use it in any situation, you can blindly write this, fit in the various terms and you would have a very powerful tool for analysis. So, that is I think all I have yeah.

So, let me stop here. First class I think we are a little over 30 minutes. So, it is about the time that you would feel comfortable with and I stopped here. You think about it. When we come back, we will discuss what were the essential differences between these three approaches.

Thank you.