Course on Integrated Waste for a Smart City
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Module 12
Tutorial

Hello! And welcome to the integrated solid waste management for the smart city tutorial I am Harish Sharma research scholar and TA for this course. In this part of the tutorial we will be discussing about the numerical that were opposing the problem in the assignment as well as in the course. We will be discussing some of the questions related to the statistics, some of the programs related to the waste to energy plant and 1 numerical that is related with the transportation problem.

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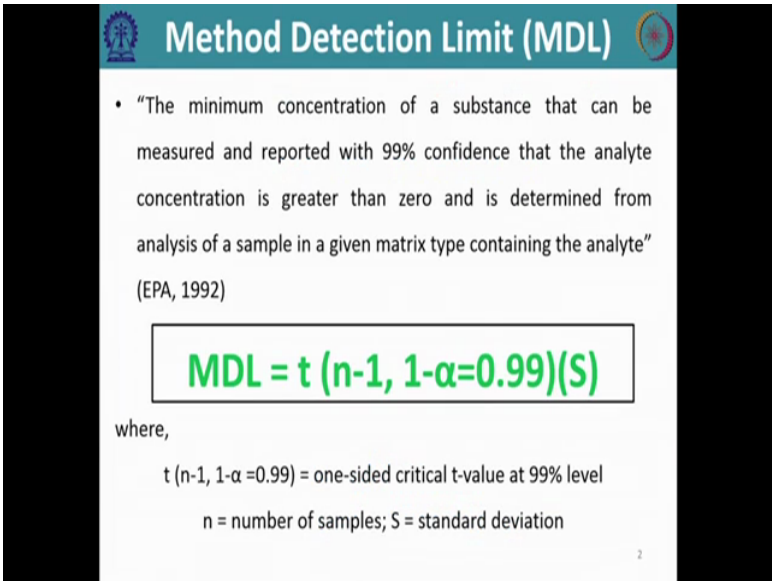

So let us start the numerical, the very first numerical that would be I will be dealing with is related with method detection limit. We received few of the queries in the NPTEL forum regarding this statistical problem, so we will be discussing that problem here. Before solving the numerical let us find out what is MDL small definition. The minimum concentration of a substance that can be measured and reported with 99 percent confidence that analyte concentration is greater than 0 and is determined from analyses of a sample in a given matrix type concentration the analyte.

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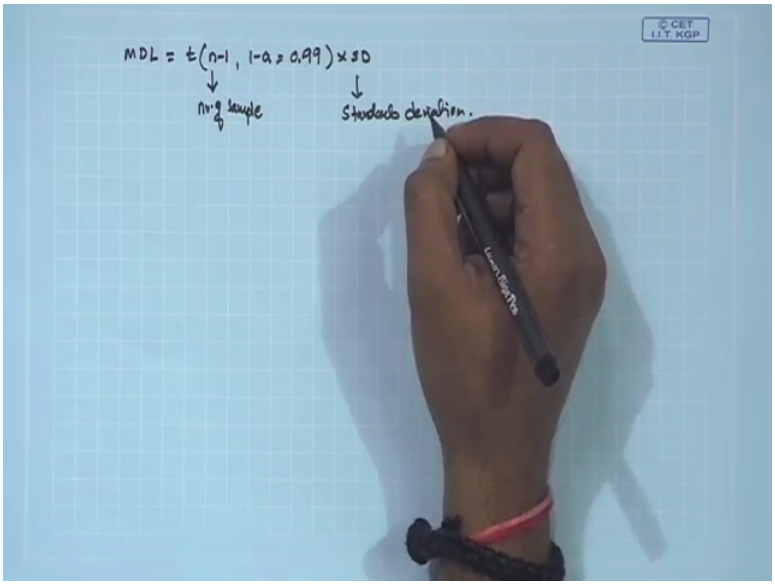

So MDL, what is MDL? Is method detection limit MDL is equal to student t-test, t value n minus 1, n is equal to the number of sample, n minus 1 will give you degree of freedom. 1 minus Alpha here is 99 percent confidence level into standard deviation. So we know that n is equal to number of samples and SD is equal to standard deviation, so to understand better let us solve one numerical.

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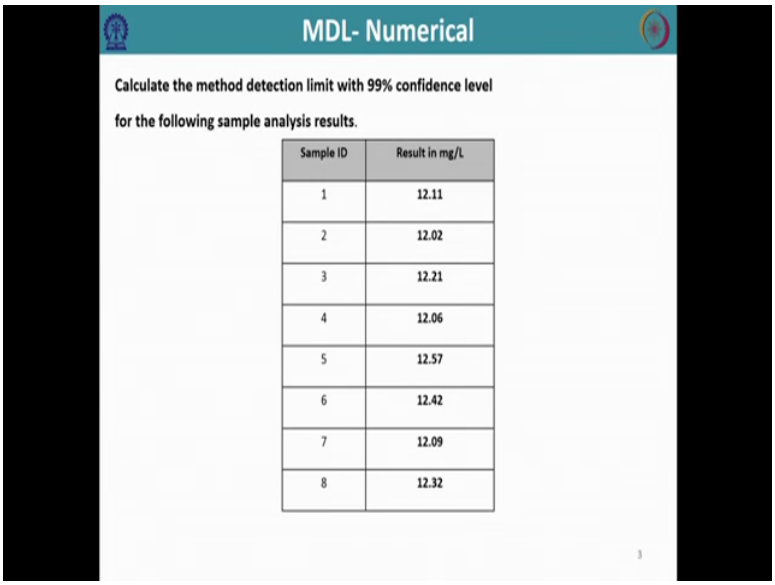

The numerical is, calculate the method detection limit with 99 percent confidence level for the following sample analysis results. We are given the 8 sample ID with its value, we need to find what is the minimum concentration that it can be detected.

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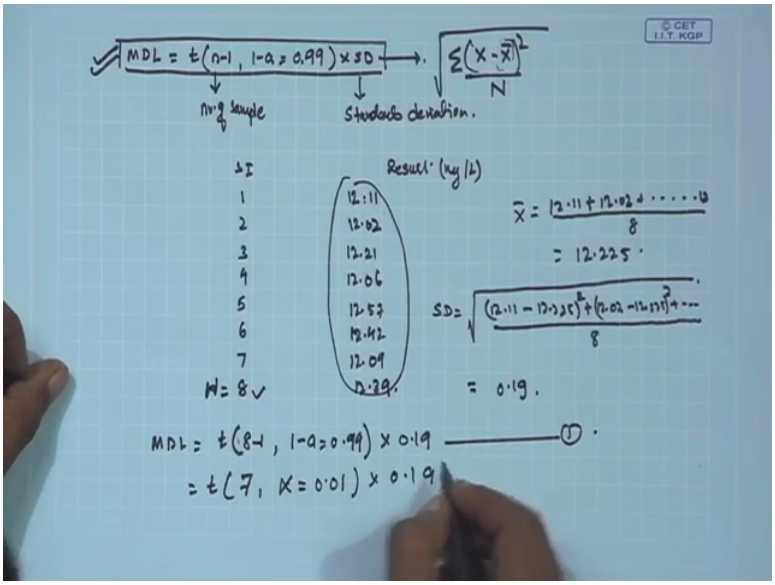

So sample ID and result 1,2,3,4,5,6,7,8 and the value corresponding to each ID this in mg per litre 12.11,12.02,, 12.21, 12.06, 12.57, 12.42, 12.09, 12.32. Since to find MDL in the formula we are given, we need to first find standard deviation that is standard deviation. The formula for the standard deviation as we know is, the individual sample concentration minus mean of these value mean of these value square number of sample we put this in the square root, this will give you a standard deviation.

So we see this is a mean, so we need to first find the mean. How do you find the mean? We add all these values and divided by 8 that would be the mean value. 12.02 plus likewise to 12.39 divided by 8 that would give us the standard deviation mean value 12.225. So to find the standard deviation put this mean value here an individual result and divided by and take the square root we will find the standard deviation.

So SD is equal to 12.11 minus 12.225 square, plus second value 12.02 minus 12.225 square, likewise up to last divided by N, N here is 8, total number N here is 8 and we take the square root of whole, this will give us 0.19. So we will put this value in our first formula, MDL is equal to t, N is equal to 8 we know that N is equal to 8 here we will find 8, 8 minus 1, 1 minus Alpha is equal to 0.99 into standard deviation we have found here is 0.19, till now it is clear right.

So the next step is to find t value using student t discharge, so n minus 1 is nothing but degree of freedom that is 8 minus 1 is equal to 7, 1 minus Alpha is only 0.9. So to check the value of

Alpha in the student t table, we need to find the value of Alpha from here for the 99 percent of confidence level, if we rearrange this value here, the alpha value will be 0.01 into 0.19.

So how do we know the value of t for degree of freedom 7 and alpha value is 0.09 for that we have a table, critical value of t distribution table that table will be provided and the table will be available, for your practice you can download the table from the Internet. The table will be provided in a exam as well if table is not provided the value of the will be given.

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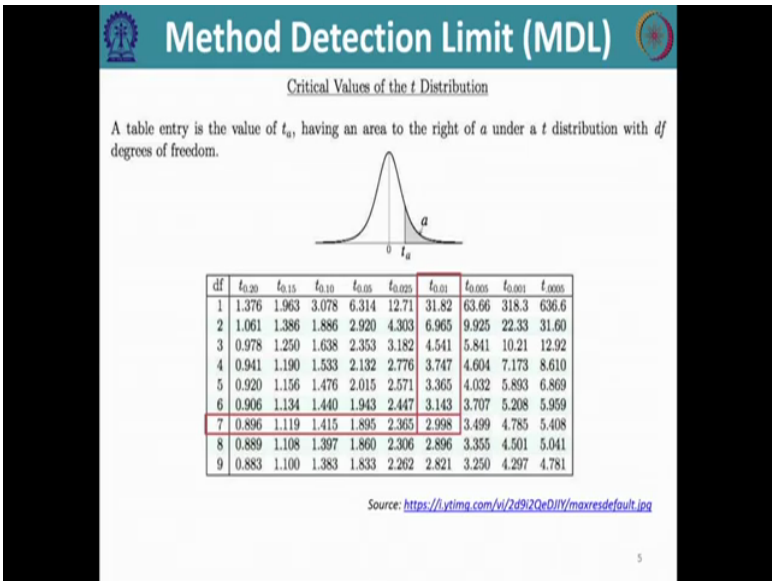
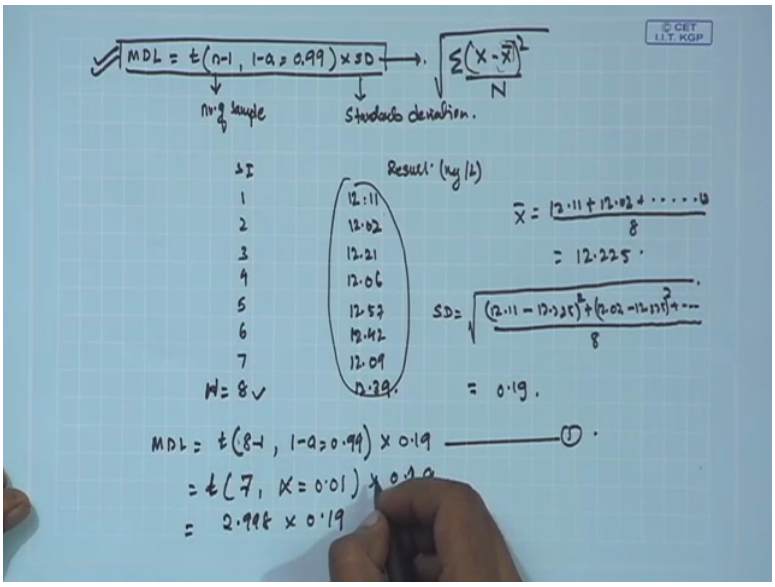


df	$t_{0.20}$	$t_{0.15}$	$t_{0.10}$	$t_{0.05}$	$t_{0.025}$	$t_{0.01}$	$t_{0.005}$	$t_{0.001}$	$t_{0.0005}$
1	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.3	636.6
2	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.33	31.60
3	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.21	12.92
4	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.920	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781



So how do we see how do we calculate the t value using the table? You can see in the table t value corresponding to degree of freedom 7 the red line and the t value corresponding to the 0.01 where that value intersect that intersected value would be the t student table was 2.99, here in this case 0.19.

So what do you do is in the table you look for alpha value corresponding to the t value where you will see there is lot of t value the 0.20, 0.15, 0.10 likewise t point 0.9 it will depend upon the confidence level given, but for the MDL is 99 percent confidence level for this alpha value would be 0.01 that would be related with the 0.70 value and the degree of freedom 7 if we criss-cross the value it will be around 2.99 as per as the student t-test value.

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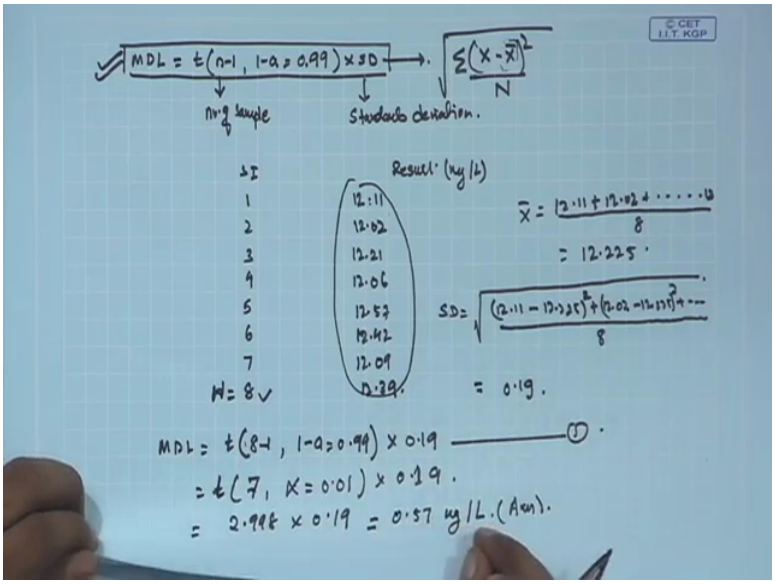

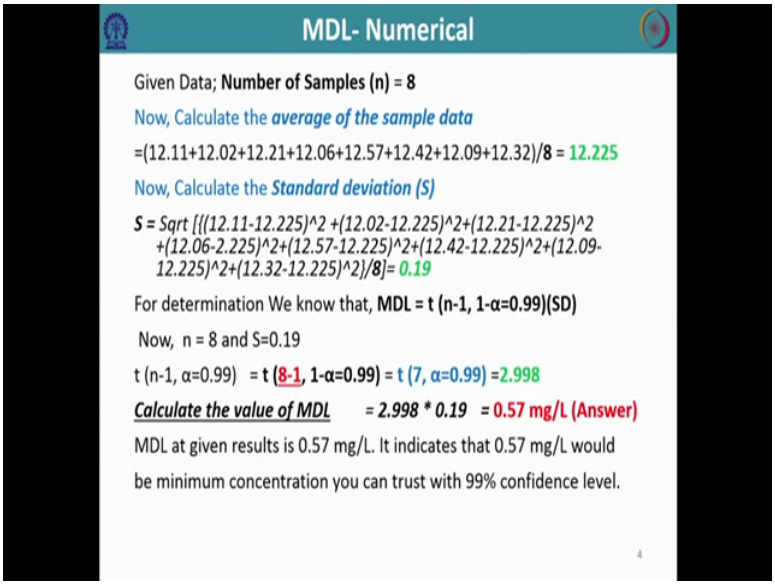

So if you calculate these value if you calculate these values, these values could be around t value this thing this value would be around 2.99 the value and if you multiply this value this would be around 0.57 mg per litre, so this is the answer of MDL. So MDL at 0.57 it indicates that this value could be minimum concentration you can trust with 99 percent confidence level, this is the minimum value you can trust with the 99 percent confidence level that would

solve our MDL numerical and the problem. How do you find the t value using the t-statistical table and how do we find the standard deviation and we put in the MDL value and we will find the minimum concentration that we went trust with 99 percent confidence level, this is the first question that we solved.

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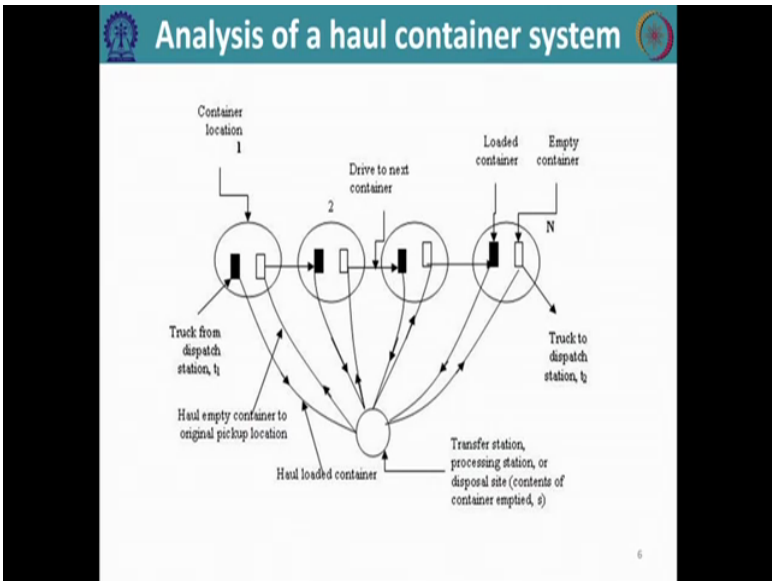

And moving onto the next question it is related with the haul container system we receive a lot of queries related with the haul container system. Before solving the haul container system we know that the collection system consist of 2 type of stationary container system and Haul container system. In the stationary container system the collecting container is not moved, in the Haul container system the collecting connector itself is moved from the collecting centre to the transfer station.

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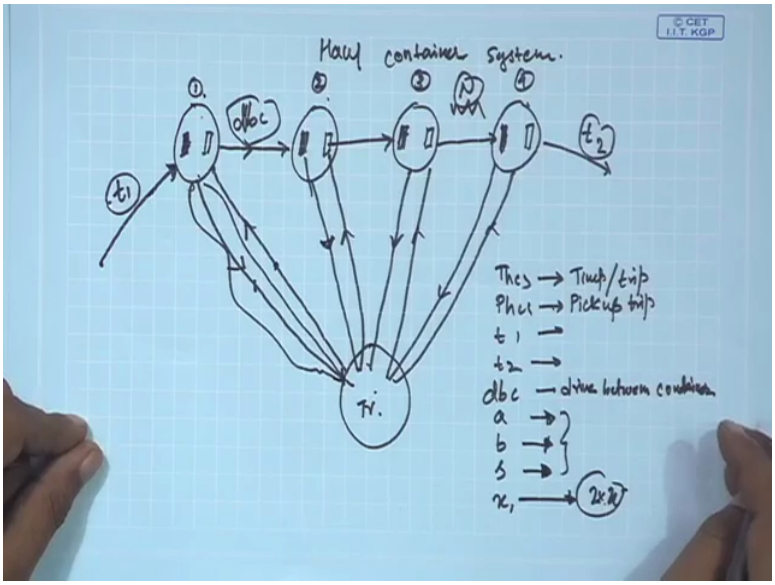

So let us understand what is all container system? Before solving the numerical, because the numerical involves lot of formulas that has to be understood. Here you can see here can see that the number of container sites like site 1, site 2, site 3, site 4, there is 1 transfer station which is made. Because this is haul container system, this is station 1, station this different location where containers will be there, which will be filled, the dark one will give us the filled container and the light one is the emptied container and this is a dispatch station and this is.

The truck from the dispatch station will come to a location container location 1 and from the dispatch station it will take certain time to reach the container 1 that would be t 1 and from here it will pick because this is Haul container system, it will pick the container and all the containers along with the waste will be hauled to a transfer station.

Here it will empty the container and that emptied container it will haul back to a station 1 and from here it will unload that emptied container and it will move to a next station. Likewise it will do same here, it will carry that loaded container, unload in a transfer station this is transfer station and haul back that empty here and it will unload here and it will drive to the next station it will come here, likewise it will do to all the number of stations and from the last edition it will go back to its dispatch location where it will take another t time because this time this has to be considered and this time also has to be considered.

Now you can see, while solving the numerical we can come across lot of terminologies like Thcs, Phcs, t 1, t 2, dbc, a, b, s, x , we came across lot of terminologies while we were solving

the numerical in the assignment as well. So this is nothing but a time taken time per trip, how much time? That time will be on hour. Maximum most of the time it has to be calculated in hour time per trip.

This is pickup time per trip, per trip means it will carry this loaded container here, unload it here at the transportation, it will come back it will bring that emptied container to station 1, coming back and going entire this will count as a trip 1. That mean emptying one container and bring back to its original location this will be counted as one trip.

This is what would be that pickup time? t 1 is as have told you the first value, t 2 is the last value it will go to the dispatch station and dbc is like, dbc is nothing but drive between container. Drive between the container means this one dbc, container 1, container 2, it will unload, come here and it will drive to another container this is the dbc value, drive between the container.

a, b, s value these are empirical constants value that will depend on type of truck, type of location, road and lot of other values. This will be given either in hour per mile, hour per kilometre, it will depend, we will be solving here in hour per kilometre and hour per mile and x is nothing but the haul distance.

Now you can see you can see, what is haul? Haul is this value, this is called hauling, this one-way is hauling. Some of the time in numerical it is given one way haul distance or two way haul distance, if one way haul distances given to find the total haul distance you will multiply by 1 plus 1 2, 2 x. If one way haul distances given you have to multiply by 2 and if two way haul distances is given you have to use as it is, so make sure you to read the question nicely.

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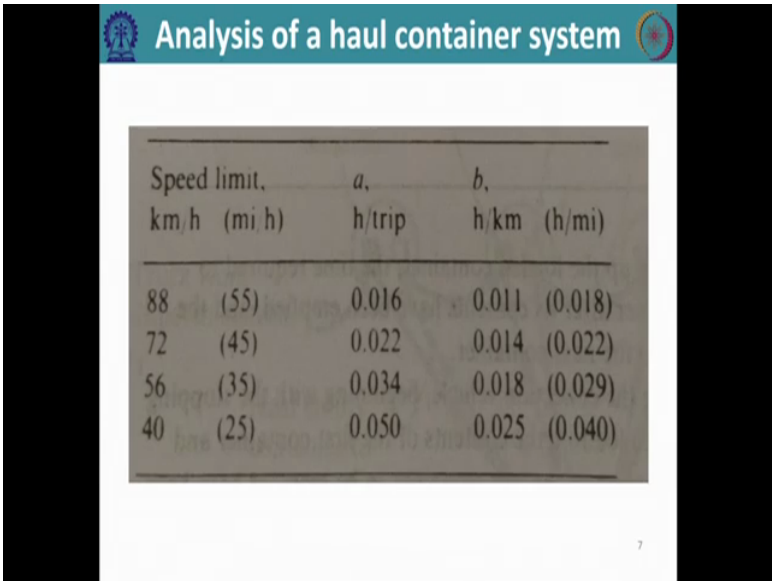

So with this concept let us all the numerical, before solving the numerical quick look at the table that I was talking about a, b, c, x value, x values is nothing but time spend in the transfer station. So you can see for different speed limit a value, b value changes, speed limit value can be given in kilometre per hour also the same value in mile per hour.

If mile-per-hour is given you have to use mile per hour or hour per mile in the b value also. If it is given in kilometres per hour you will be using b value in kilometre per hour per kilometre same value corresponding. So 55 if mile-per-hour given that would be 88 kilometre per hour and its corresponding value for 88 would be 0.011 hour per kilometre not 0.018 that is your numerical.

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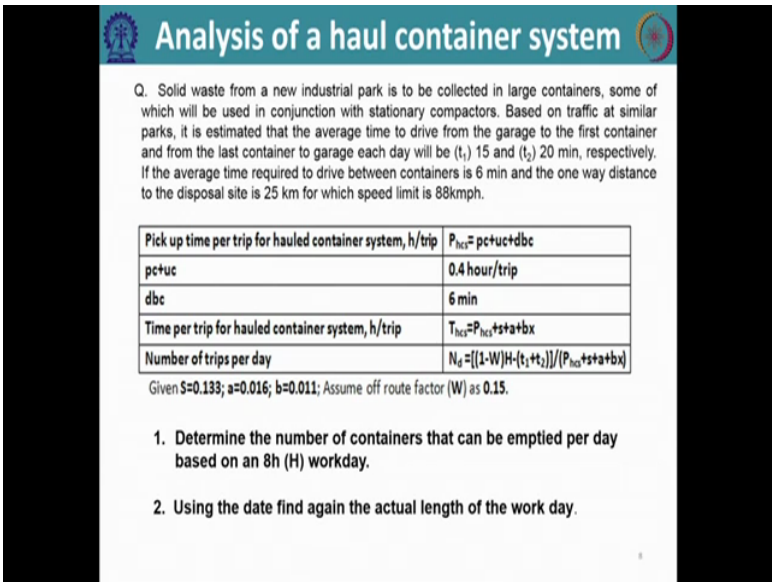

Let us solve the numerical. The numerical for the haul container system is, solid waste from a new industrial park is to be collected in a large container, some of which will be used in conjunction with stationary compactor. Based on traffic at similar park, it is estimated that average time to drive from the garage to the first container to the garage will be t 1 that is 15 minute and t 2 20 minutes, remember 15 and 20 are in given in minutes you to convert this into hour respectively.

If the average time required to drive between the container dbc, drive between the container means dbc that is 6 minutes this also you to convert into hour and one-way haul distance that I was talking is given one way not two way haul distance, you have to multiply this by 25 km by 2 to find the total haul distance. In this 25 km for which the speed limit is given is 88 kilometre per hour, so it is 88 kmph the value is given.

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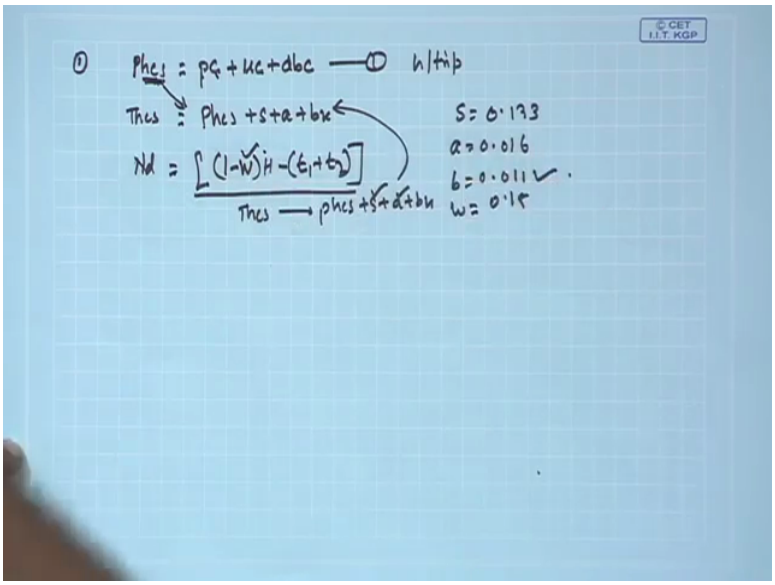

So you can see in the numerical as well pickup time formula is given, the Phcs that is pickup time for haul container system, hcs means haul container system equals to Pc that is pickup time pickup of container plus unloading of container plus drive between the container that is Phcs. And another formula that you will be using with time per trip of haul container system, this value would be in our per trip and Phcs is time per trip per haul distance, that would be the Phcs that is nothing but this value here plus s value plus a plus bx, the x you will be using will be 2 haul distance.

The a value, b value, s value, all value will be given in the numerical as well and in the exam also it will be given. And nd here is equal to nothing but 1 minus W that is offload factor that

would be given always, hour walk hour per day minus t 1 plus t 2 and if you divide this by the Thcs, this Thcs is nothing but Phcs plus s plus a plus bx that is this one. So here we are given we are provided with s value, that is this value is given, we are given a value 0.016 in the question itself that is this value and the b value of 0.011 that is also given and W that is offload factor that you will be using here is also given as 0.15.

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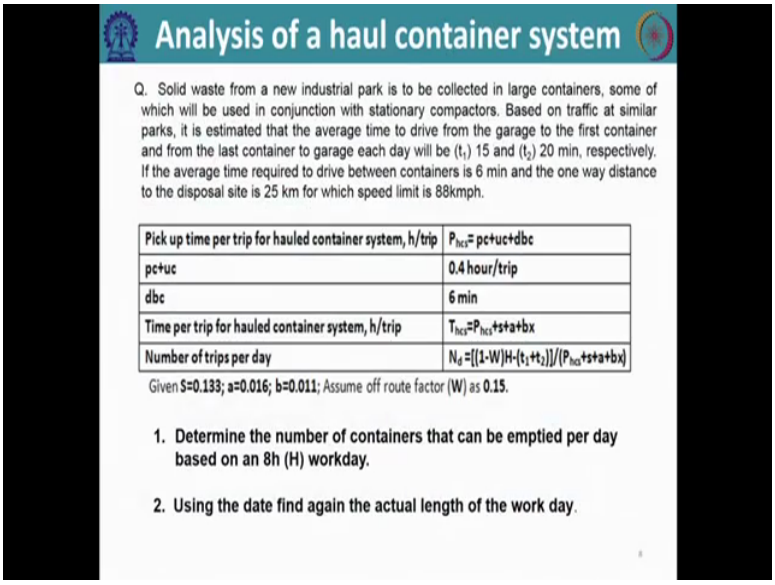

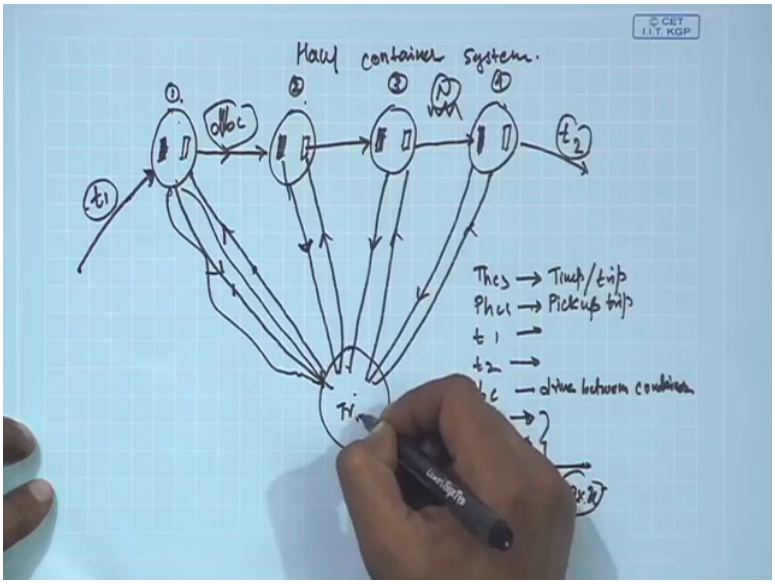

So here in the question you can see the first question that is asked is determine the number of container that can be emptied per day based on 8 hour workday. So number of container emptied means number of trip, how it is number of trips? To empty one container it has to go to a transfer station emptied here and we will bring back, so this number of emptied container

at one trip that would give number of number of trip. So number of trip means number of container emptied.

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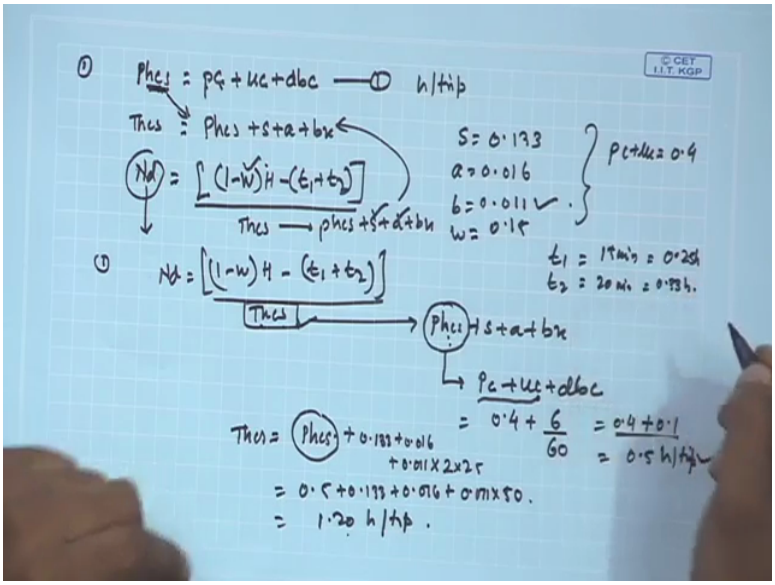

So the first question is number of container that can be emptied per day. So you can we can see use directly this formula, number of container that is nd, nothing but number of trip per day that is equal to the number of container emptied. So nd is equal to 1 minus W, H minus t 1 plus t 2 you will divide whole by Thcs. Now we can see in the question we have provided with everything but we are not provided with a value of Thcs, to find the value of Thcs we will use Phcs plus s plus a plus bx, but the problem again comes we do not know the value of Phcs.

So to find the value of Phcs we have to use the formula Pc plus uc plus dbc. This is nothing but pickup time, it will pick the container, it will unload the container and it will drive between the container, this 3 value will give you the pickup for the haul container system. So this value is given in the numerical as we are given as Pc plus uc equal to 0.4, it is given in the numerical in the second row 0.4 plus dbc in the numerical it is given drive between the container is 6 minutes that you have to convert into hour that would be 0.4 plus 0.1, that would be 0.5 hour per trip.

So we found be found Phcs, now we can use this value here to find the value of Thcs. So let us find what is Thcs, Thcs is equal to Phcs plus s value is given 0.133 plus a value is given 0.016 plus b value is given 0.011 into one way haul distances given,, that is 25 km, so for the

two-way it has to be 2 into 25. So Phcs these value we found it here that is 0.5 plus 0.133 plus 0.016 and 0.011 into 50, if we calculate this value we will get 1.20 hour per trip.

So we found the value of Thcs by using Phcs and now we have to put all these value here, before that let us find the value of t 1 and t 2 which is given as 15 minutes and 20 minutes that has to be converted into hour. So 15 minute it would be 0.25 hour and that would be 0.33 hour. So we will we know the value of W that is given, we know the value of H 8 hour as given in the question, in the first question we have given 8 hour workday, so will put all these value and find out, what is the number of container in day?

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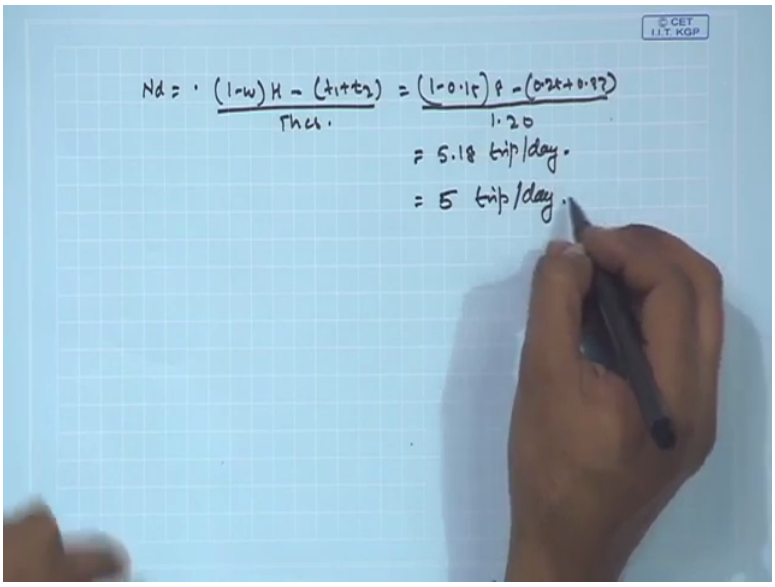

So nd is equal to and is equal to 1 minus W H minus t 1 plus t 2 by Thcs, 1 minus W is 0.15, H is equal to 8 hour minus t 1 is equal to 0.25 plus 0.33, Thcs we have just found that is 1.20 and if we found if you calculate this value it would be 5.18 trip per day. So you can you say per day it will do 5 trip, that would solve our first part of the question.

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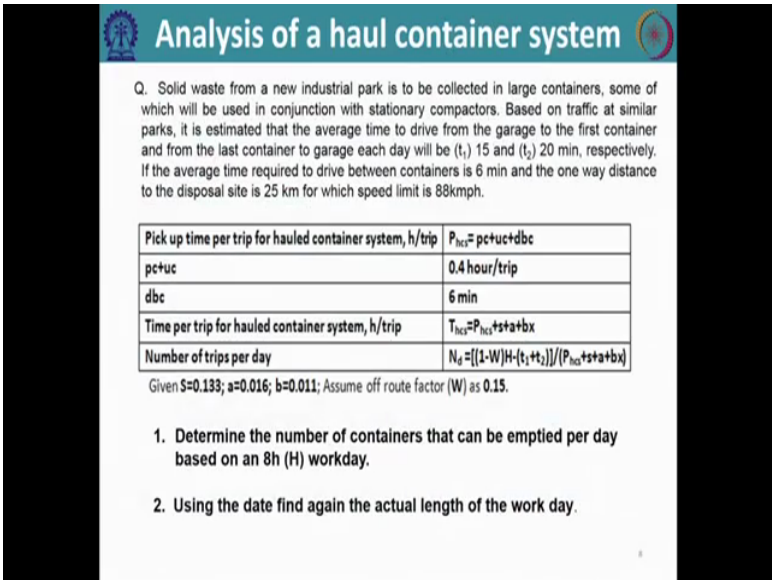

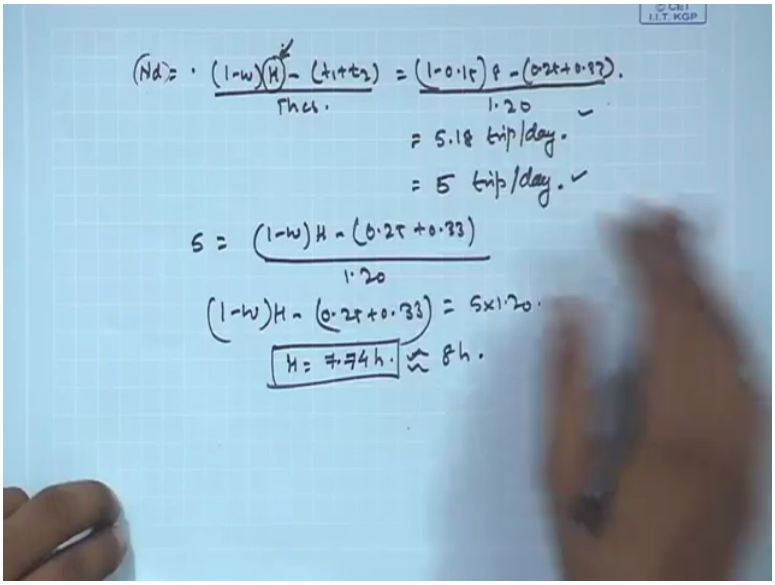

In the second part of the question we are told to find using this value is find the actual workday length, so actual workday length we are being asked to find the value of H here. Initially we were knowing all these value and we found these values and now we these values and now they are asked us to find the value of H.

So just to rearrange these value is like more proving the value that H is equal to near to 8 hour, that is given in the first question. So rearrange this value rearranging this just give us, nd will be directly put here nd is equal to 5, 1 minus W, the H we have to find, t 1 and t 2 is same value and Thcs is also the same value, so you will just find the value of 1 minus W into H minus 0.25 plus 0.33 is equal to 5 into 1.20 and if you rearrange these value, the H would be around 7.74 hour, you can see that 7.74 or is almost near to 8 hours.

So the value given in the question is was 8 hour we found everything for the 8 hour and by using whatever we found when we back check we found 8 working hours was almost near to 8 hours. So it is our first transportation question related to the haul container system, likewise there in there you can solve another numeric as well.

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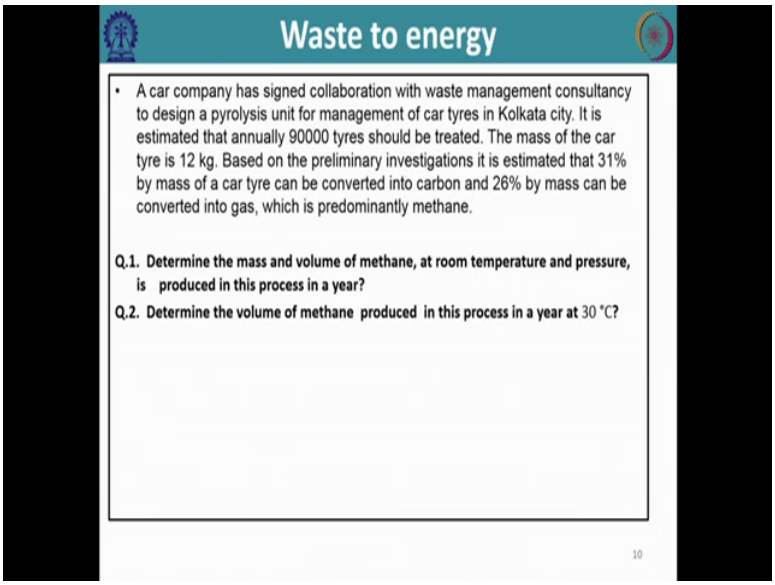

In the last part of the tutorial we will be using the waste-to-energy numerical that is related with the pyrolysis. The question is, the car company has signed collaboration with waste management consultancy to design a pyrolysis unit for management of car tyres in Kolkata city. It is a city that annually 9000 tyres could be treated. The mass of the tyre, of one tyre 12 KG per, based on the preliminary investigation it is estimated that 31 percent by mass of car tyre can be converted into carbon and 26 percent by mass can be converted into gas, what is predominantly methane? The gases methane. The first question we have been asked is define the determine the mass and the volume of the methane.

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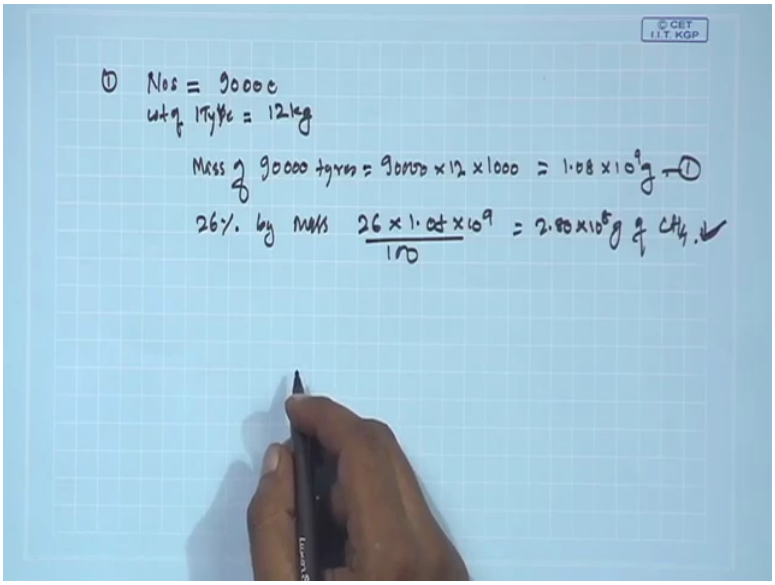

So let us solve the question. The number of tyres we are given in the question the number of tyre is equal to 90000 and the weight of 1 tyre is equal to 12 KG. So mass of the 12 tyre we will calculate them mass of the tyre, mass of 90,000 tyres is equal to 90,000 into individual tyre what is 12 into 1 KG is equal to1000 grams that would give us 1.08 into 10 to power 9 gram.

In the numerical it is said that, we are concerned with the methane 26 percent can be converted into gas, so we can say of mass 26 percent by mass can be converted. So this is a mass so of this 26 percent can be converted, so 26 percent by mass means that would be 26 into 1.08 into 10 to power 9 divided by 100 that would give us around 2.80 into 10 to power 8 g of CH 4, so this will solve first part of our question that we were asked to determine the mass of the gas generated.

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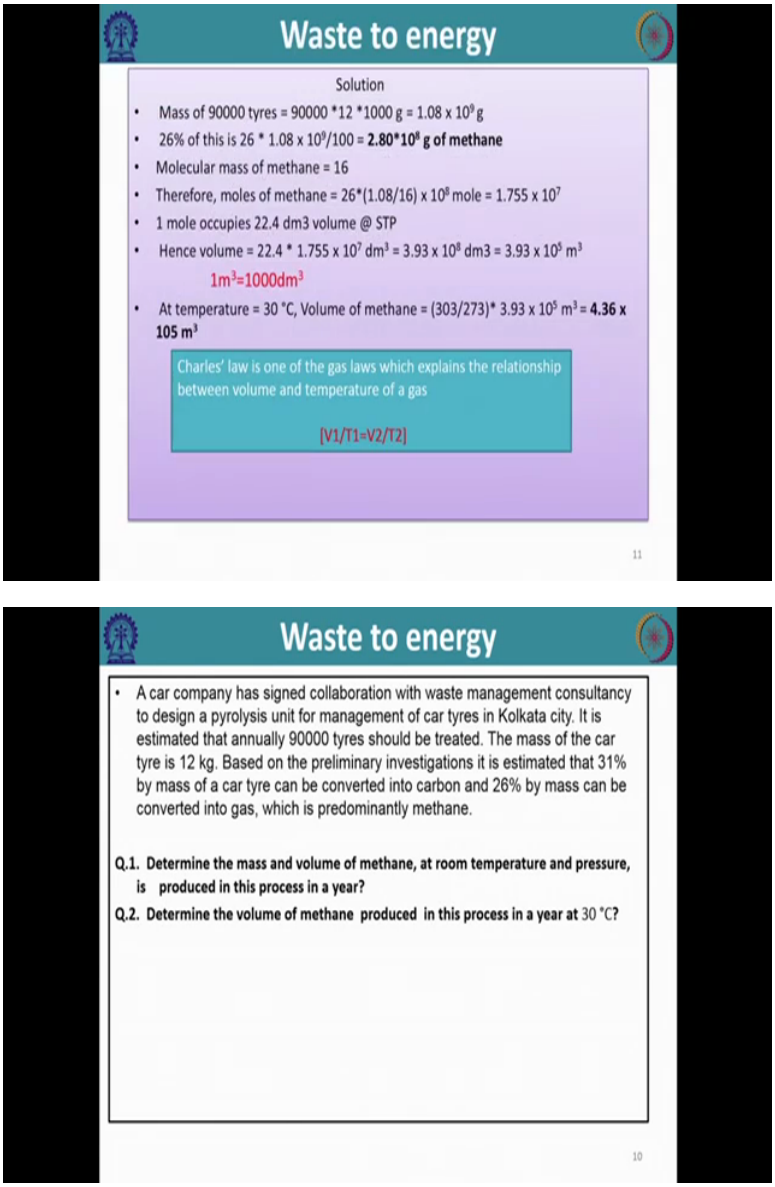

So the next question here would be volume we have to calculate, so to find the volume determine the volume in the standard temperature and pressure and also determine the volume at 30°C we have to find.

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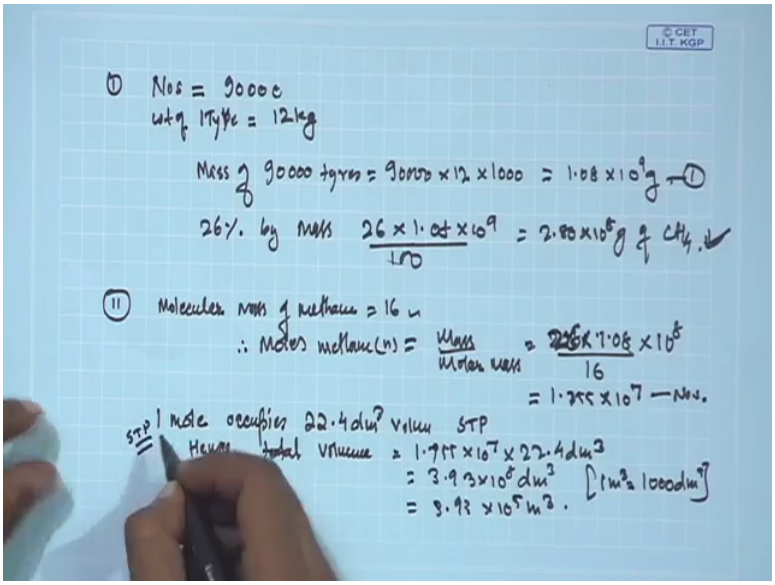

So to solve the second part, we know that we know that molecular mass molecular mass of methane is equal to 16, so therefore moles of methane, we know that it is mass by molar mass, that would give us around if you just put the value of the mass what we have calculated and what is molar mass we know that 16, so the value if you just put the value of 2.80 that is into 1.08 by 16 is molar mass, if we just put the value this is not to 2.6 this is 26 and this value is 1.755 into 10 to power 7.

You can see we have put just put on this value and divided by molar mass which is 16, so this is the number of moles this is number of molar of methane gas. So we know by standard value that 1 mole occupies 22.4 decametre cube volume and that is at STP standard temperature pressure that is zero degree centigrade in standard temperature pressure if you are talking the temperature is at STP.

Hence we know the volume of 1 mole and we know the number of mole and the total volume. So hence the total volume would be number of mole 1.755 into 10 to power 7 into 22.4 decametre cube, if you just multiply this value that would be 3.93 into 10 to power 8 decametre cube, and since 1 meter cube is equal to 1000 decametre cube, if you convert this into metre cube we will get 3.93 into 10 to power 5 metre cube.

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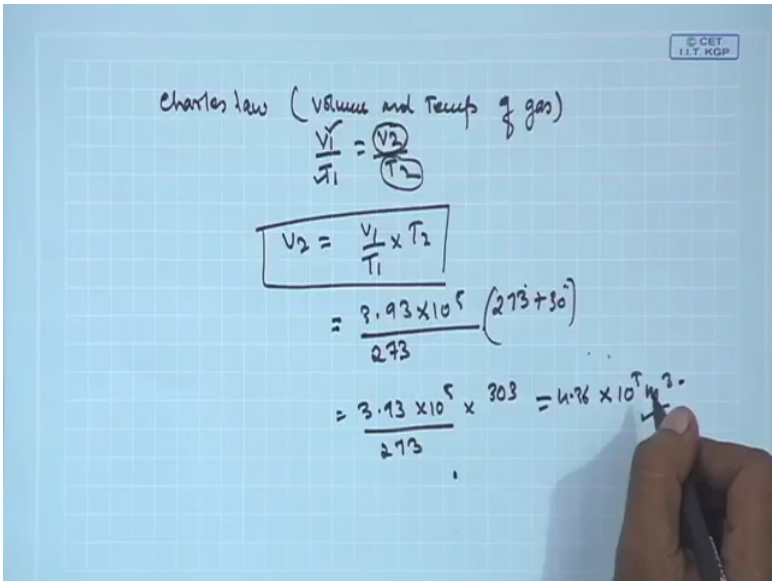

So can see this value in STP, but in the question we have also been told that 30 degree centigrade we have to find the determine the volume we can produce at 30 degree centigrade. So we know the relation between the temperature and the volume explained by in the Charles Law that explains the relation between the volume and the temperature of gas that explain the relationship is something given V 1 by T 1 is equal to V 2 by T 2. So we know the volume we just calculate, we know the standard temperature pressure temperature we know that we have to find the value of V 2 at 30 degree Celsius it is also given.

So if we just put this value, rearranges the value over here, V 2 is equal to V 1, T 1 into T 2. So V1 we have calculated 3.93, from here 3.93 into 10 to power 5, T 1 is temperature standard temperature pressure at Kelvin it is 273 degree Kelvin in the standard temperature pressure and T 2 is at question we asked that T 2 is 30 degree centigrade that would be 273 plus 30 this is Kelvin we are converting degrees Celsius into Kelvin. So 3.93 into 10 to the power 5, 273 into 303 this would give us 4.36 into 10 to power 5 metre cube.

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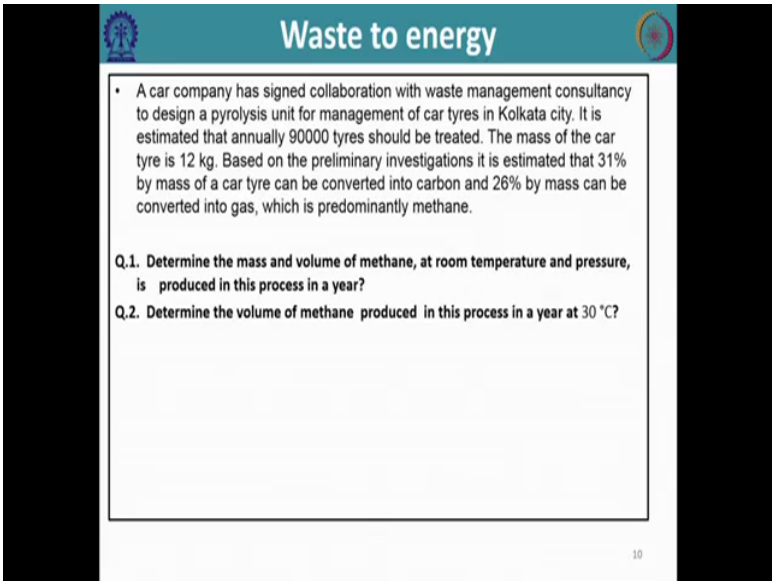

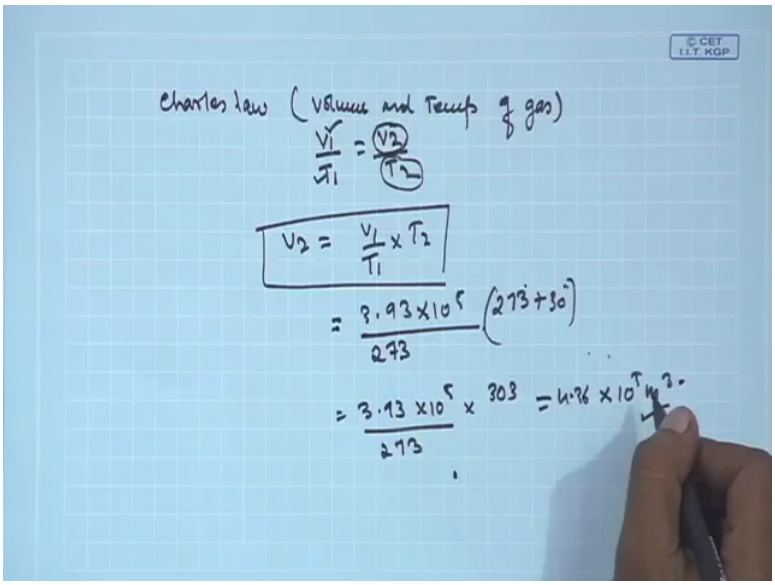

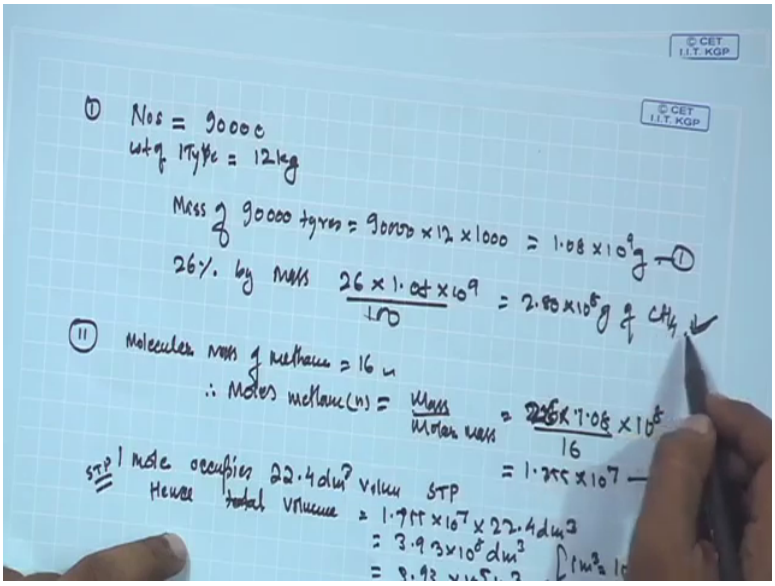

So the second part of the question was determine the volume of methane producing this proselytising researchers, so we found it is 4.36 into 10 to the power 5 and the first part where we have asked to find the mass of methane gas by from the pyrolysis process. So mass of methane is this and the volume is this.

So we generally solved 3 question, we generally solved 3 question in this part of the tutorial, the first question was related to the MDL, second was related was related to the Haul container system, that is transportation of the waste collected and the third was related with the waste to energy part. Thank you for joining us in this part of the tutorial, hope you enjoy, thank you.