Explosion and Explosion Safety
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Atmospheric Dispersion
Lecture – 37

Good morning, you know in the last class we looked at the solution for the dispersion equation namely we called it as a defection equation. And we found the dissolution to the deflation equation given by something like the concentration.

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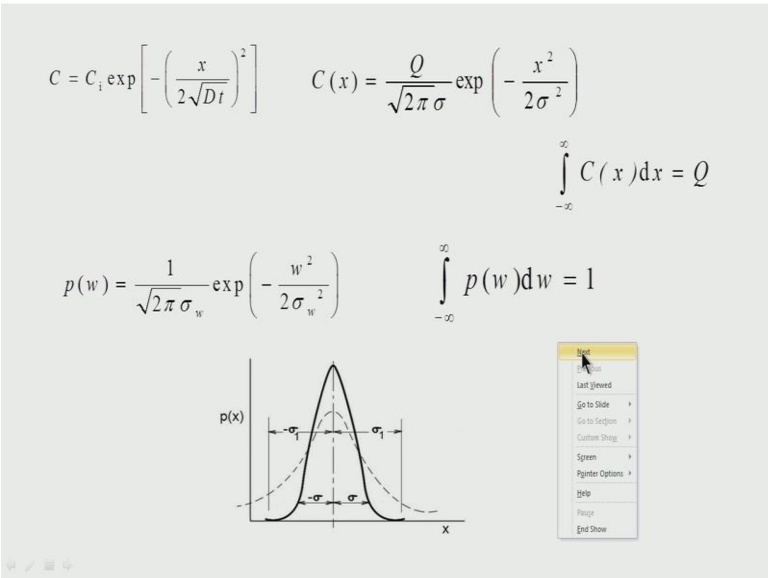

If at any distance away from the source, where at the source the wherein at the source we have a concentration lets Ci that is kilo gram per meter, at a distance storm the source and at a time t away and a time t from the time that the source released the particular concentration, when the concentration C is equal to Ci exponential minus of the distance divided by under route of time and we also added multiplied by the defection question; that means, under route 2 d and the whole thing minus x by 2 under route Dt whole square.

Now, we look at this particular equation this which we solved for the concentration at any distance x at time t, and we found well this equation some at similar it as the deaking characteristics and something like a got ion distribution and we also found well. If I have something like distribution, let us the distribution function divided by p is given by p is the distribution function p is given by 1 over under route of 2 pie into the standard deviation explation minus dummy variable w divided by 2 into the standard deviation square.

Now, this is the standard distribution function and the standard distribution function which we say, which we always gotient besides that, the area under the distribution function, under the entire area the minus infinity is equal to 1 infinity. What does the signify let us say; however, distribution function which is sort of p over shown by the black line, all which shows is maybe it is p ever standard deviation which is minus sigma on the left hand that plus sigma the standard deviation is sigma. The area the whole cover starting from a to here is 1; if I have a distribution which is sort of distributed the p down like distance, the concentration sort of defuses. Then what happens is that, the diffusion statured.

In other words, it is the standard deviation increase, but still the area of minus infinity to infinity is equal to 1, and this is what the probably the probabilistic distribution function gives you. Now when I look at the value of the concentration as a function of distance, as a function of t; you know I find, if I can substitute let us say, under route dt by, let us see sigma or other I we said well. If sigma square is equal to let us a dt, then I can write the particular concentration as let us see, the massively at the particular source divided by under route 2 pie into the standard deviation in to expanncial of minus x square by 2 sigma square, further this particular dilution equation, which gives the concentration at a distance x at time t is similar to the gortion distribution convention.

Further the distribution of the concentration taken from minus infinity to infinity namely C x dx from minus infinity to infinity is equal to Q and this is some similar to this 3 for we say the institution of solving for this particular equation and why we were take to solve this equation in terms of d is the diffusing co efficient d which was given in meter square per second. You know, it is a function of the turbulence, the medium, the wine Velocity set is the agulosity .And you know what it is very difficult to have a assessment of d the innumeracy solve this equation even in 1 d its difficult. And there for, because the value of d depends on a holes of a parameter, but we found when we describe the atmosphere, we were able to describe the atmosphere at a atmosphere is constable and atmosphere is stable, then there for we could get the experimentally the standard deviation from it based on a experiment, and then use this type of equation to be able to solve a problem and having a decided how to go about it.

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$$C(x) = \frac{Q}{\sqrt{2\pi}\,\sigma}\exp\left(-\frac{x^2}{2\sigma^2}\right) \qquad \int_{-\infty}^{\infty} C(x)\,dx = Q$$

$$\chi(x,y,z) = \frac{Q}{(2\pi)^{3/2}\sigma_x\sigma_y\sigma_z}\exp\left[-\frac{x^2}{2\sigma_x^2}-\frac{y^2}{2\sigma_y^2}-\frac{z^2}{2\sigma_z^2}\right]$$

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\chi(x,y,z)\,dx\,dy\,dz = Q$$

Let's go to the next 1 here; we see the well, I write this equation again and again we said well. The concentration in any distance x, cannot be returned as if I substitute dt is equal to sigma square, I have the maths which is released at the source divided by 2 pie sigma expansional of minus x square and over the entire range, because I am talking of 1 dimension from minus infinity to infinity. The concentration when integrated gives meet them maths over here. Now, this in 1 dimension, but in a diffusion does not accruing 1 dimension, it could accrue round the x direction, it could occur round the exit direction it could accrual in the wide direction. And therefore, the general problem if aware to concentration as sky and we said unit of concentration of kilo gram per meter Q; that why, I consider the maths release is the source is Q kilo gram, I can write, I has a function of x, y. z all what I say is Q is released.

I have under route 2 pie sigma x corresponding to the x direction, have under route 2 pie sigma y; that means, I multiplied by 2 pie into sigma pie under route to 2 pie sigma z and therefore, I get 2 pie to the power of 3 by 2 into sigma x into sigma y into sigma z into explanation, this was 1 term minus x square by 2 sigma square. I have now, the fusion taking place in y it is in the lateral direction or let us say the x direction in the y direction have diffusion taking place; there for, along y I have the diffusion co efficient sigma y over here, which is the standard deviation in the y direction. I have also have 2z square corresponding to the vertical direction to sigma is at square .Well, this is what the value of concentration should be; there for, if I can determined experimental the value of the standard deviation in sigma x, the standard deviation sigma y, the standard deviation sigma z; well I can determined the concentration.

At any location x, y, z and up course, the constant comes from this and this constantan was in 1 dimension. If I have to put it in all the 3 dimension well, I write concentration now as pie x, y, z at any point, I intrigated on along the x direction from minus infinity to infinity, in the y direction from minus infinity to plus infinity d along the and this gives me the total maths. There for, this is the final form of my dispersion relation, in which now, if I can take into account the mobiest stability and get value of sigma x, sigma y, and sigma z. I can find out the concentration at any x, y, z for the particular maths Q at a given point. And this is what, we will be doing to today; that means, in this case I a m consuming Q to be release at Q kilo gram of the substance or the particular wrapper or the particular gas to be release at a point.

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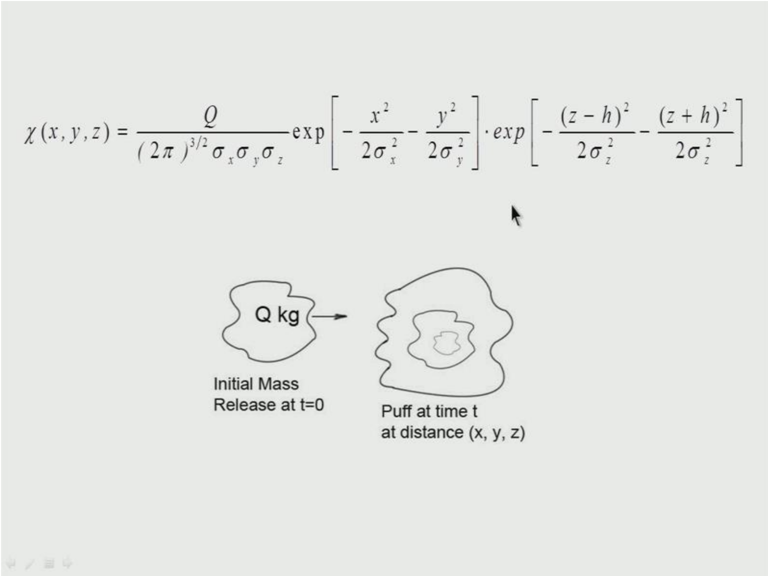

Now I have said that, well I thought the restated over here. Let us say, I have something like a spill, which is in the form of a pof; that means, all of a sudden, I release Q kilo gram of let us say sagacious mixer at this particular point at time t is equal to 0. What is going to happen, I release as t is equal to 0, what is going to happen in release the sustain over here, when the sustains diffuses throughout it meeting increases its volume and has the volume of the sub staining increases, the concentration which was originally quite high will keep on decreasing as the time progress; rather, this is the time t is equal to 0 when I look at it, we at x increasing y, increasing z, increasing the volume increasing and this is where i say as the volume as increase there for, if I have something like the release of Q kg at time t is equal to 0.

I call it like something like puff generally something released at a time t is equal to 0, which subsequent time 12 the puff or the maths which is release in the puff keeps on increasing its volume. And how does it increasing the volume; well, we said Q divided by 2 pie to the power of 3 by 2 sigma x, sigma y, sigma z into explanation of minus x square by 2 the standard deviation x square minus y square 2 sigma square into we had minus is z square by 2 sigma is, if z square if we look at the previous expression over here, we had 2z square by 2 sigma ez square, but in case the puff released let us say at a height h from the bottom.

Let us say, I have the ground over here the puff is released at a height h, like from chimney I have a burst of maths of which is coming out let us say or a balloon at a height releasing a certain maths, then vat is going to happen this particular maths which is released. You know the distance and interested this is a there for z minus h 2 the distance about there for, I have corresponding to minus z square by 2 sigma z square, I have z minus h square divided by 2 sigma z square, but the part of the burst also are the mask comes down to the ground, gets reflected on the ground; that means, I have h coming over here h to 2h plus is z minus thats gives me is z minus h.

And there for, I have another term due to the reflected 1 and there for, whenever I have let us say a puff of the maths which is released at the height h above the ground. The concentration of at any x, y, z point is given by this particular expression. Namely Q divided by 2 pie to the power of 3 by 2, the standard deviation in the x directions, standard deviation in the y direction, standard deviation in the z direction in expansion of minus x square by 2 sigma x square minus y square by 2 sigma y square into explanation of the forward term and the reflected from the particular form well, This is how, calculated you will do 1 or 2 module problems after looking at different types of leases in this cases puff over here.

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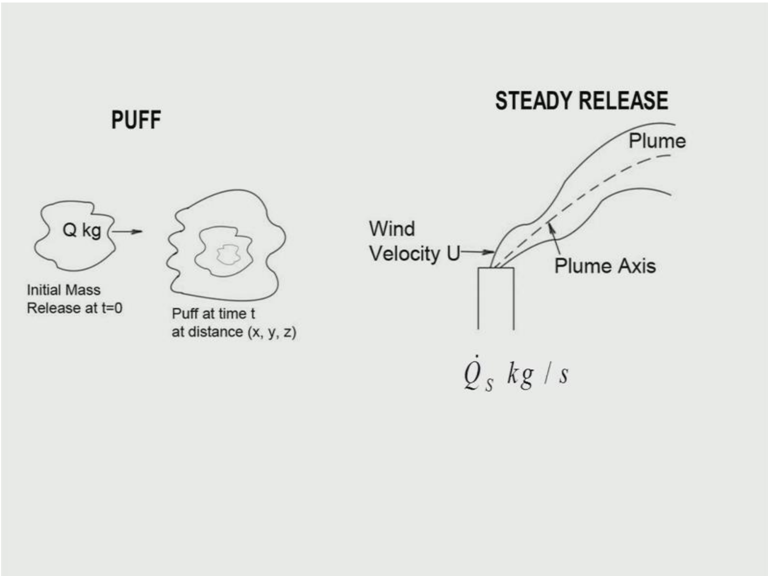

Let us consider some other releasing we said well, I release a maths values defuses out in their direction, I could also think instead of release mask Q in a supposing I have certain leak which expanse on the ground.

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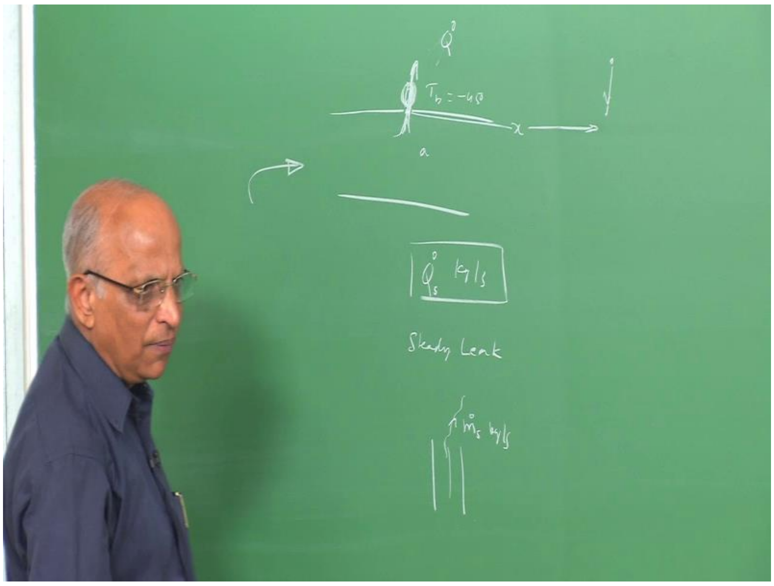

Let us consider the case plume axis leak, let me go to the board and explain what time trying to do; well, I have the pipe line which is released, which is containg liquid propane. The pipe line like a burst and there for, I have liquid propane which crushes up when the liquid propane comes, well it is ambient temperature corresponding to the height pressior here, but, then it is boiling points under the ambient condition is something like minus 45, but the ambient temperature is higher over here. There for, it flashes in to wrapper there for you have, the leak taking place are and leak does not take place 0 time, it is keep on leaking considering the amount of wide in the pipe line and the fluid is pumped by the by a station which is a quite a distance away from where the leak happen.

The constant source of leak; that means, among this having something like m dot or in this case, I will call it has Q dot which is taking place over a constrable period of time; that means, the amount of leak is so, much kilo gram per second and it accrues steadily let us say, for the period of 2 minutes or may be if the leak is for long happen for a period of 1 hour. There for, we want to find out if I haves something like a steady link like this. Steadily taking place, what is the effect, is the concentration at a distance from over here at a distance x over here, may be at a distance y and may be above the ground at a distance is a to what we want to calculate. There for, when we talk about the steadily is something like, let us a chimney in which gas continually flowing something like I have and m dot is so, much kilo gram per second instead of talking in terms of m dot, I talking terms of Q dot lets also say, it is the steadily lets a Q dot s so, much kilo grams per second is being spilled.

There for, in the problem what I want to consider as let me get back to the slide, I have something like Q dot s kilo gram per second which is coming out to over here, form may be pipe line fracture or the leak which is a steadily and what is happening, if I have wind condition see yesterday, we are in the last class we also considered the effect of wind we said wind will affect the stability of the atmosphere. And always in even when it is summer we have some small wind let say 1.5 to 2 meters per second some time we have heavy wind; in at the wind what it does sequence something in leaking, it tends to carry the leak along in the form of plume.

By plume minus mean, in other the shape of the sustains which is getting leaked out; that means, the concentration of the particular substance which leaks out, expanse out in the form of a plume over here. There for, when I talk about steady release namely Qs kg per second, I am looking at this particular plume and this particular plume is carried by the particular mineral oxide, just had an equation in for a puff. I would like to have a equation for the steady release which takes place due to the consistent leak. It is not just 1 size releases maths and keep quiet, but a leak continues sometimes.

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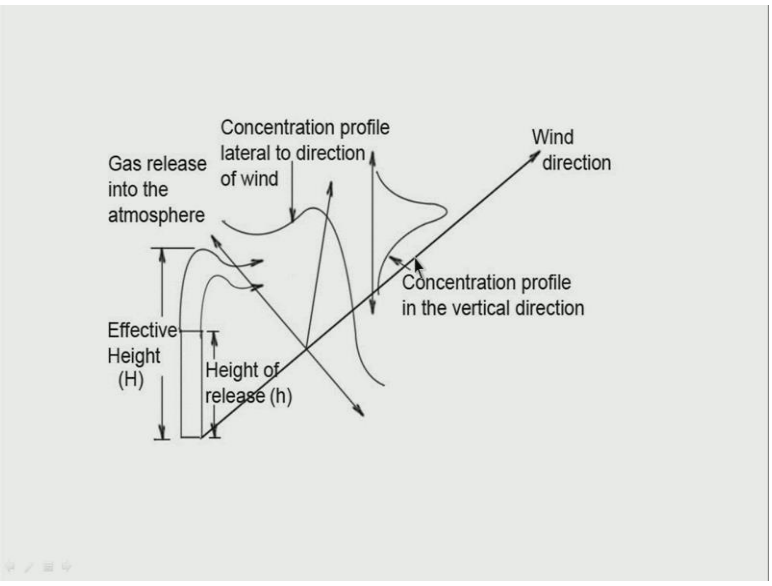

there for to do this problem, well; I have to again focus on the coordination system well I have may be the height which the leak accrue is given by the small age value. And because there is a particular velocity which the leaking gasses are propelled forward, well it comes forward it reaches an effective height h and over here the effect of the initial velocity is lost; that means, I am considering a gas whose monocular maths is near, to the monocular maths of air it is being released it is a initial movement and it comes to an effective height h. And release an effective height h well.

The winds take it has puff of and if the direction of the wind in a particular direction that say x direction. You know, the wind takes the plume of the leak gas away and what happens, when the wind is taking it away let us say in the wind, in the x direction. I show the wind direction is x. I have the lateral direction over here which is the y direction along the y direction, may be initially along the center line over here the maximum concentration and along the lateral direction well. The maths defuses of disperses of there for, the concentration is maximum along the center line, and then the concentration decreases in along the negative y direction decrease along the positive y direction. And if still furthering decreases well the concentration, further it defuses like further it defuses the center line concentration defuses and the concentration along the lateral direction defuses.

Similarly you know, when the concentration released over here and the wind is taking it forward in this particular direction, may be in the vertical direction of also you know in the vertical direction when the maths released over here. In the direction down ward when, the concentration is over at the central line, when the concentration is maximum well above it, when the concentration decreases and you have something like a gotient distribution here has the steady released progress forward when the concentration becomes something like this well it becomes even shall over like this; that means, the standard deviation keeps increasing, and this is how steady release changes it is distribution in the lateral direction changes distribution in the vertical direction, but along the wind direction, well just it carried forward by the wind. There for, it does not match the distribution because we are talking of the direction along the wind.

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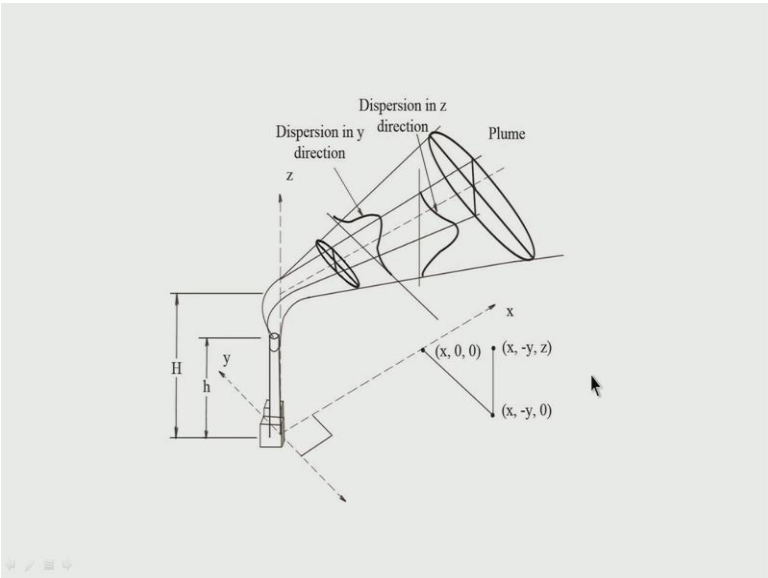

Let me clarified to another figure over here. Well, I have the height of my release which is the steady state release corresponding to Qx dot over here. In what happen, in the initial movement pushes it over here, this somewhat a point at which it has lost its initial momentum. And at this point well the wind is taking it forward, the wind is taking the release Q dot x forward and along the lateral direction. Well, I have the distribution at the center line, I have maximum at the edges have this, if I look at a vertical, if I take a section over here, well I have the vertical along the center line. Well, I have the maximum concentration, if I go further and further in the vertical direction in the concentration decreases have a distribution in the vertical direction. There for, I show in this vertical figure the x direction along the wind, the y is the lateral direction and well z is the vertical direction in finding out the concentration in any distance.

Let us say this is my release over here, I am interested in x, y, z and I am interested in the x, y, z and how we do the problem. So, see we know how to do a problem; I want to do it for the case of study plume.

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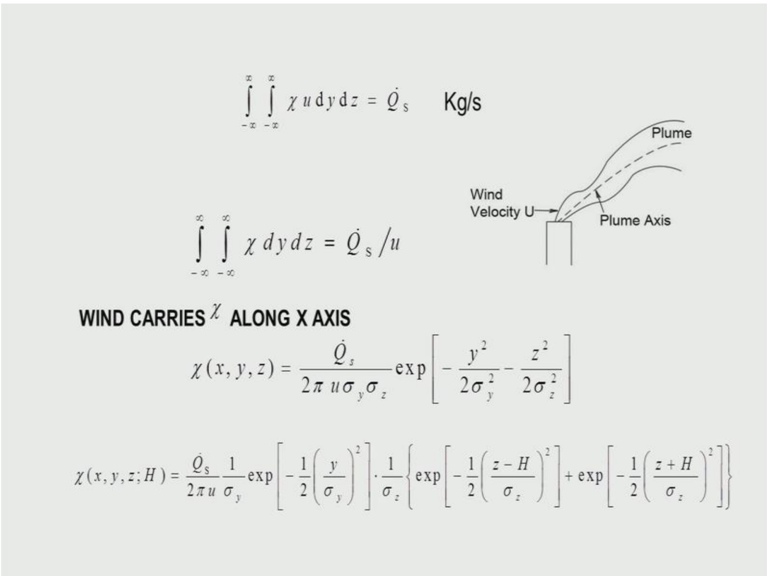

There for, first we recognize when the wind is taking the concentration high and is a concentration for units at any distance let us say, x, y, z. We said it I pulled to kilo gram per meter Q; kie into the velocity into dy into dz. Well, this is kilo gram per meter q this is meter per second this is meter, this gives me kilo gram per second and there for, if I intrigate this particular maths the plume which is travelling forward; from, let us say, at this particular point being let us say a 0 correspond to infinity because in this direction have nothing, the wind is taking it forward, I integrate from let us say, the y going from.

I can take it out side and there for I have kie into dy by dz is equal to Q dot s by u there for I have the value of Q dot s by u and if I know plus thins equation into the standard equation, I look at the particular maths getting defuse. What does I get, I get Q dot s divided by u is corresponding to the maths, corresponding to particular value of the x over here, and there for, if I go to find out what the dispersion taking place along the lateral direction y, along the vertical direction is z, then I get few dot s divided by 2 pie into sigma y into 2 pie into sigma z.

Now, the minus now the maths question is Q dot s divided by u into expositional of minus y square into 2 sigma square 2 sigma y square that is the standard deviation in the y direction minus 2z square by 2 sigma 2z square. And well this is my concentration because 2 to pie into 2 to pie gives you 2 pie Q into this and this is the way, the wind carries the concentration along the particular x; that means, wind carries Q dot s and I am look that dispersion in the y direction in the vertical direction wee in other words this is the formula the concentration for a steady release. And if now, I consider another accept namely, I consider well you have a vertical wind at which you have a steady release like a chimney, like consider this example again on the board.

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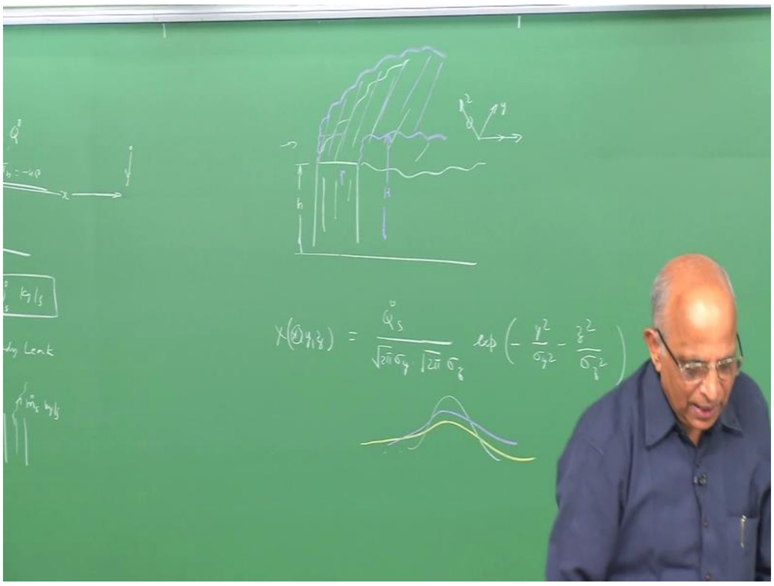

Let us consider ch means. And in you have seen like for instant, whenever this take a power plant or something you have the chimney and what does the chimney do, it produces smoke. And 3 is a wind there for how the smoke does travel like. You know this is the way, the smoke travel from a particular chimney. Well I have the hide of the chimney h well you know immediately the think does not reverse and what happens in dragonesses, because I have the initial lost over here, well. There little bit of smoke comes out like this. And there after it begins troubles here; there for, this is what I call as the effective height of the chimney, because the initial movement of this is the dispersion from this point to the point shown by the little line over here.

There for, this is the straight dispersion what we get. Well, the ground is over here and there for now, if I interested in my wind direction is a long well, I considered the lateral direction y there for it could be lateral direction y, and this could be my z vertical direction. There for, I have something like this, something vertical over here; there for, I am looking at the release Q dot s divided by route 2 pie or sigma x rather in dispersion in the long wide in the maths carried the long u direction by the particular wind. There for, 2 sigma y into 2 pie into sigma is z. And a up course, you have the value corresponding to the expansion to the coming as minus.

I have corresponding to y square into sigma y square, I also have may be value of is z square corresponding sigma is z square and this gives me the value of the coma sedration at x y and is z square along x well the wind carries at forward, along y and z well the standard deviation; that means, I have distribution like this after some time well, it comes out like this after some time it defushes forward and the concentration along this center line decreases, and also the concentration along the lateral line of this changes.

This is a type of model you have, but if I have something like an effective height is what I shown; there h over here I again get just in the case of puff. I have the 1 which is forward. The 1 which is reflected and there for, when I have dispersion at a point x, y, z from a released which takes place at a height h about the ground the values, Q dot s divided by 2 pie u divided by 1 over standard deviation y corresponding y; and corresponding to the is z term over here.

I get the forward thing which corresponded to is z square namely non my chimney or my hide of the release h is z minus h. Instead of is z and I also get the reflected 1 reflected 1 goes by h goes by h 2h by 2 is z minus h plus 2h is plus h and y this is the reflected 1 from the ground. And this is how, we which I calculated the different values and all we done.

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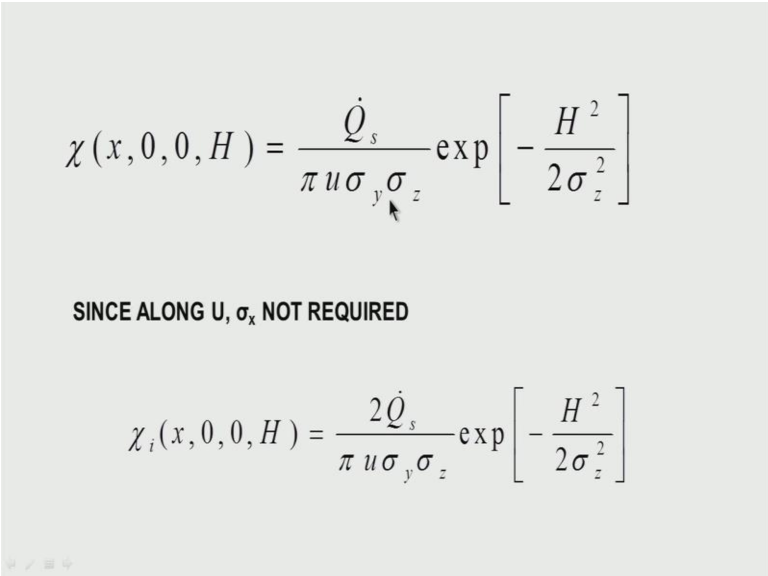

We have done is shifted the problem from, trying to solve the diffusion equation to trying to find out what is a value of the a standard deviation y, standard deviation is z and these all experimentally determined and can determined quite well, tables are available I come back to this and if I try to focus back to on the particular problem. This is the hide this is the value of concentration of x, y, z; when the height of release of the particular steady value of the leak.

Let us secured or test is given by this; if I am interested along these center line that means, y is equal to 0 and on the surface of the ground, namely is z is equal to 0. And what is it, I do I substitute y is equal to 0 in which case this factor becomes 1, I substitute is z equal to 0 in which case, I get minus half h square by sigma is z square plus, I get is z is equal to 0 plus explanation of half into is z h; that means, 0; that means, explanation o x square by sigma z this gives me to 2 times the x expanation of h square sigma is z square plus, I get is z is equal to 0 plus expanational; of half is equal to i get is z is equal to 0; that means, explanation of x square by sigma x this gives me 2 times the explanation of x square by sigma is z square and the expression of become the the first term that q dot s divided by pie sigma y, z into explanation of minus x square by 2 sigma square and what is a difference from the previous 1 let us go back, in what is happening in a we had is z square is z square and you had 2 over here and there for 2, which 2 canceled by pie q into sigma y and sigma z .And there for, the concentration of any x as it disperses on the surface of the ground along the center line of the wind it is on the surface of the ground, along the surface line of the wind has the maths defuses of is given, by this particular expression. So, y do not get at sigma term because wind is giving forward.

So, sigma x is required it is whenever we measure value of the standard deviation sigma y sigma is z; a in what happens is that w measure it over a period like 10 as an hour. If I want the local concentration, in the local concentration will be little bit higher and there for, the practices instead of having Q is dot divided by pie q sigma y sigma is z residing the dispersion in the vertical direction. We multiply by take care by this particular factor and this is we estimate the concentration well; we do a problem before I do a problem.

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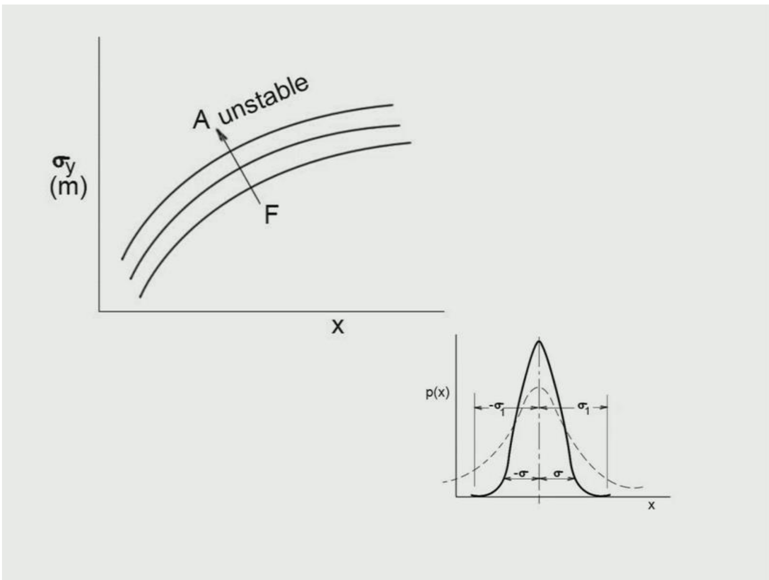

It must be cleared, how we get the value of sigma y and sigma x for a steady release; see we, already done something earlier and let us see, what did I you do in the last class.

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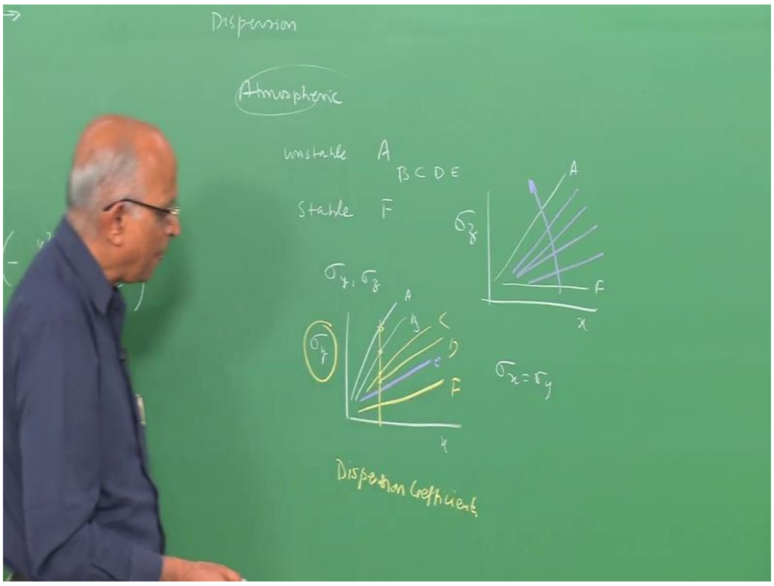

We discuss about the diffusion at the dispersion of gases and what if tell the atmosphere, is not that easy to handle. We said well atmosphere could either very unstable, when we see unstable, we meant at the temperature meant at the surface of the earth decreased. We also said well, there could be inversion or it could be stable well that atmosphere could be very unstable. We said, it is a that is pass skils trasification; atmosphere could be very stable, that we have very cold night and there is no wind at all and there for everything nothing really lives here, which extremely stable called it as F. And in between A and F we had d which was unstable C B was moderately stable moderately unstable sorry c was moderately unstable again or weekly unstable, then at D, which was weekly stable we have E which have moderately stable and f, was moderately stable.

There for, we a clasification like A B C D E and F and there for, would like to see all the atmosphere stability criteria under conditioncy A to F willing to the value of sigma y and sigma is z. The experiment had done and what we get is plots of sigma y as a function of a x and what is we observed. Well when, the condition is very unstable the defuses very fast because of the unstable nature; well, it could be summer over here well, when the for the condition F could be summer over here because it is not stable the atmosphere is stable it not stable to defuse to comes back to the original point. And in between this tools we have further different condition well.

I could have V over here, maybe I could have a E over here, I could have other line C over here. I could have a line D over here and corresponding to the atmosphere condition for, when the spill goes over a distance let's see x the we wind shifted from here to here. I can find what my values the standard deviations are and this standard deviation sigma y sigma z are known, as dispersion co efficient we determined the co efficient sigma y.

Similarly, we also determined the sigma y values and these are available both are plots and as equation; that means, in the down ward direction sigma z could be here, for the condition a for the condition F it could be over here, not at all increasing small, number. May be, B for C for D for E these are the different values. As we go from x stable to the unstable condition well the dispersion co efficient increases both in the sigma y and sigma z, when they consider as steady case we don't consider sigma x, but we consider of particular puff we also consider the value of sigma x and normally for puff we will have the value of sigma x is equal to sigma y.

Because it travels in the same direction because there is no wind we are not cionsider the wind, condition, because we are also consider the wind of puff with wind shortly, but when there is no wind sigma x is equal to sigma y, because we calculate the dispersion coefficient.

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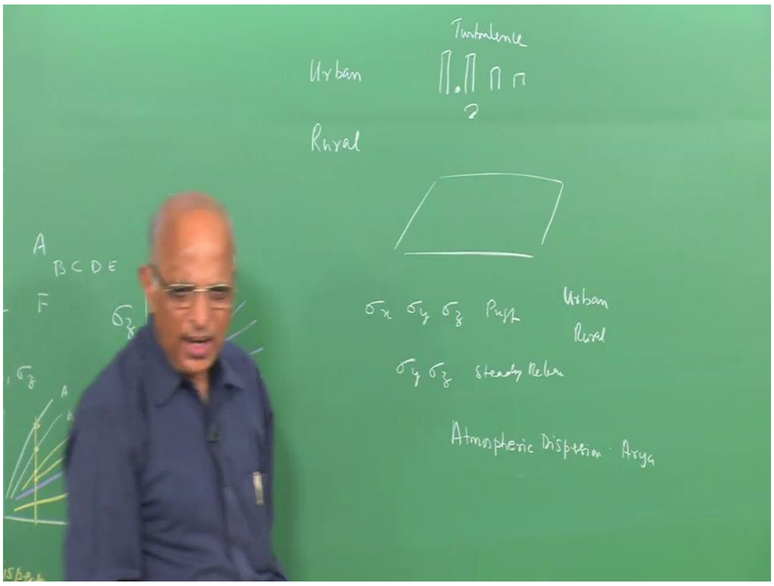

Now, there is 1 problem though in a like for instant all of us are used to living inb urban environment that, is means; in city where as in a village which we call as rural spilting when the condition could be different in a village everything in open, in a open area in a city. You have a lot of tall building available may be small building, tall building, roads vehicles all these things are more in an urben area compare to the rural area. There for, what would happen if there is a spill or if there is a steady release in urban area it means more of the resistances due to the buildings and all that? Well some it is a form may be weeks are form the truouble in label.

Whenever I talk terms of an urban area well it is much highier than in a rural area there for when the co efficient are determined lets the dispersion co efficient lets sigma x, sigma y, sigma is z, for a puff and you have sigma y, sigma is z, for a steady release in a its not expected that in open area like village. The same thing should be applicable for a city and there for, you have separates 1 for urban urban area, you have separated plots for rural area and not only either plot available which are used available in standard books on at atmospherics dispersion.

Now, 1 of the good books on this is buyer Arya in a you have this expression available for urban areas, rural areas for may be a puff all a study release. And this is how it is and let me get back to the slide now, and therefore, you have A unstable y you have sigma y and what is going to happen as the puff or the study release keeps increasing in distance while it keeps initially it as a small dispersion coefficient. And thereafter, it diffuses come. So, warrior the value of sigma increases it goes still further the sigma value increases and this is how the slandered deviation or the dispersion coefficient changes and these are all measured for different conditions of the atmosphere, stable atmosphere unstable atmosphere different degrees of unstable and stable atmosphere.

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Dispersion coefficients for continuous release (RURAL)

Atmospheric Stability	σ_y (m)	σ_z (m)
A	$0.22x(1+0.0001x)^{-1/2}$	$0.20x$
B	$0.16x(1+0.0001x)^{-1/2}$	$0.12x$
C	$0.11x(1+0.0001x)^{-1/2}$	$0.08x(1+0.0002x)^{-1/2}$
D	$0.08x(1+0.0001x)^{-1/2}$	$0.06x(1+0.00055x)^{-1/2}$
E	$0.06x(1+0.0001x)^{-1/2}$	$0.03x(1+0.0003x)^{-1}$
F	$0.04x(1+0.0001x)^{-1/2}$	$0.016x(1+0.0003x)^{-1}$

So, sigma z is measured I did this on the board and again you have the value of sigma is changing with respect to the direction along which the study release propagates. And as I told you in a addition to have in flots; you also have, may be dispersion coefficient for continuous release in villages, rural areas, open surroundings. Well, it is given in term of x which is the downwind distance for different values of atmospheric stability, which I just now, said is A B C D E and F. Well F is most stable, a is most unstable and these are the coefficient and imediatly you see for the value of most stable while the value of sigma y and sigma z are were much greater than if it is stable; that means, in stable environment the diffusion is much very much less.

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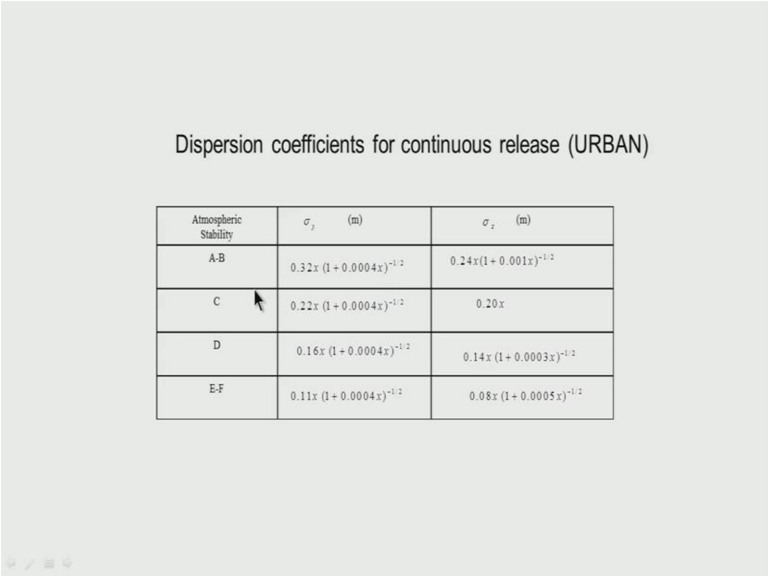
Dispersion coefficients for continuous release (URBAN)

Atmospheric Stability	σ_y (m)	σ_z (m)
A-B	$0.32x\,(1+0.0004x)^{-1/2}$	$0.24x(1+0.001x)^{-1/2}$
C	$0.22x\,(1+0.0004x)^{-1/2}$	$0.20x$
D	$0.16x\,(1+0.0004x)^{-1/2}$	$0.14x\,(1+0.0003x)^{-1/2}$
E-F	$0.11x\,(1+0.0004x)^{-1/2}$	$0.08x\,(1+0.0005x)^{-1/2}$

Therefore, similarly you have for the value for urban earlier in the last led I showed it for villages may be for towns and cities because your blockage is a buildings turbulence, well atmospheric stability. The values of dispersion coefficient at different condition of atmospheric stability, here you have a condition between A and B between, E and F; because, what is happening is you know B also in an urban setting, makes it more turbulent and the for coefficient are stipulated between A and B that is for both and B is therefore, E and F. This is the value of course; different authors give different estimates depending on the type of experiment they use and this is how we estimate?

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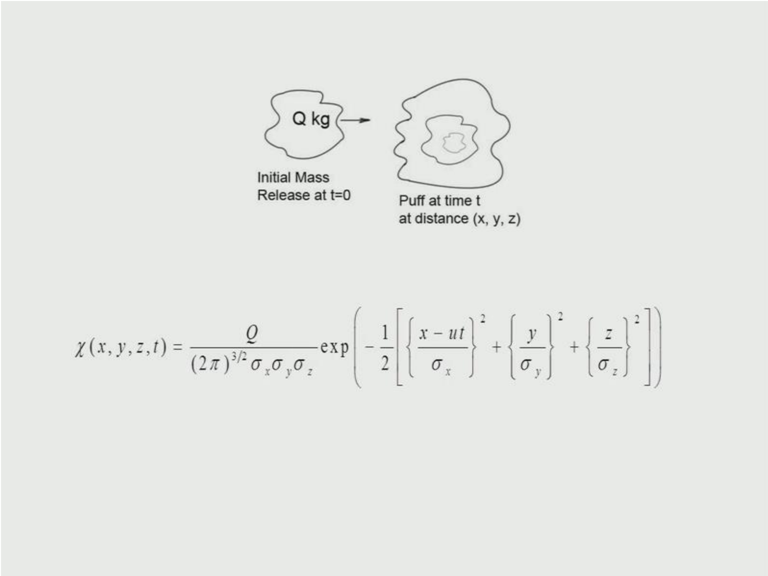

Now, the last point which I want to cover, in this release is we talked in terms of puff being released in a medium in which there is no wind. Now, supposing release Q kg at time t is equal to 0 and you have a wind direction. Therefore, what is it I have, I am talking of my release with respect to the wind therefore, in the frame of reference of the wind my x direction is x minus ut; and therefore, I just modify x you know, you recall when we had a puff you have Q divided by 2 pi 3 by 2 sigma x, sigma y, sigma is a exponential minus half into x squared by sigma x square plus y squared by sigma y square they should have been; yes I have taken the minus sign over here. I have taken the minus sign for is it by sigma is square to sign is also taken out.

Now, instead of x in the frame of reference of wind have x minus ut square and therefore, my dispersion coefficient at x corresponding to x minus ut, y is at n time t is given by this particular relation 1.

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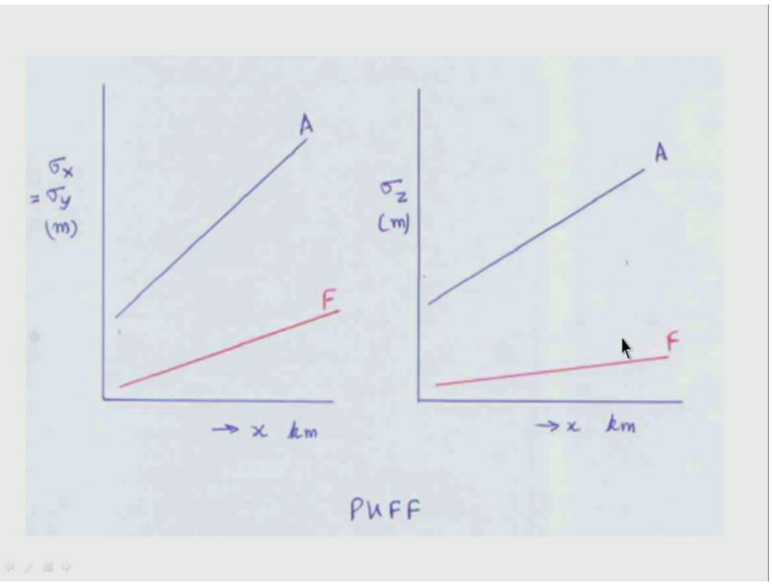

You can use this and has I said for a puff well normally, sigma x is equal to sigma y, A most unstable condition F. The most stable condition, dispersion coefficient, along x and y this is nothing, but standard deviation similarly, sigma is z for condition most unstable, most condition, we have sirios of lines which are all available to us.

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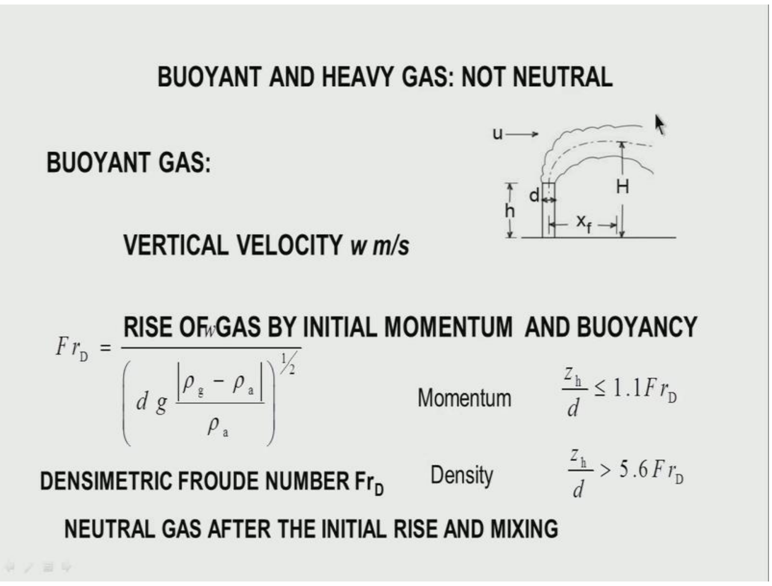

Therefore this is all about atmospheric dispersion, but the problem which we have considered so for is, we consider only the case of a neutral gas; that means, the gas which comes out is same. The molecular mass is same as the molecular mass of air, but supposing I have hydrogen which is a very highly buoyant gas low density. And let us say from the chimeneas pussed out therefore, what is going to happen it is pussed out a distance from the height of the chimney or height of the release to a larger height depending on it buoyancy and also the initial momentum.

Therefore, in such problems you know, it is necessary for us to be able to precise the calculate the height, at which a neutral gas namely diluted gas, of the buoyant gas and air is being form which there after i can use a regular formula for dispersion, but to able to do that we define something like a froude number and froude number is the is something like the like the density affects that is weight of the gas divided by the buoyancy, recall it as dens metric froude number and we estimate that when I talk at the term of ez h. if I have a froude number if i have the height of the release given by the diameter of my particular release, is equal to 1.1 froude number well e d; it is dominated by momentum if it z h is greater than around 5.6 it is dominated by the particular buoyancy.

and we can estimate this particular heights from this height well the splish take place after sometime. Well we want to form a nertral gas; that means, the gas does not have any buoyancy it is a mixture of air, the small amount of hydrogen which than defuses forward and this is about diffusion.

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PASQUILL'S CLASSIFICATION OF ATMOSPHERIC STABILITY

Surface Wind (m/s)	Insolation			Night	
	Strong	Moderate	Slight	Overcast with cloud cover > 1/2	Cloud cover <3/8
<2	A	A–B	B	E	F
2–3	A–B	B	C	E	F
3–5	B	B–C	C	D	E
5–6	C	C–D	D	D	D
>6	C	D	D	D	D

But 1 point I want to make before we try to solve a few problems and whenever we slove problems we understand, the equation better and we understand the theory better. We must remember you know, whenever we talking of this we always stops in terms of wind, the cloud cover we say, insolation is the radiation which comes on it, may be if have a cloud the insolation on the ground is moderate and we categorised the entire atmosphere in terms of A B C D and E and also very stable condition F and this is how, we did the problem, therefore we will do some problems in which, we will be able to specify given the question, weather it is a winter day or a winter night or a summer day, hot summer day.

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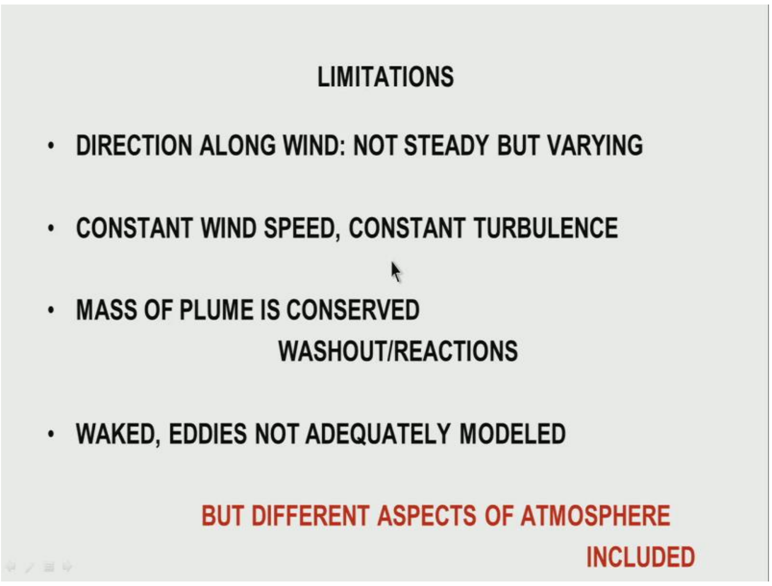

We will able t o find these coefficients and do the problem, but we must also remember there are some limitations in this. In half the limitation is you know we are talking of for a steady heat release, we stipulate the direction along the wind, which means the problem is not very steady in of the wind direction is always not a constant you go and stand outside sometime a wind is blowing, sometimes the wind is not blowing suddenly the wind changes in direction therefore, since we do the problem along a wind direction which we assume, to be constant. Well to making a mistake, we also assume that, the wind speed is a constant which mean, which may not be vacased because the wind speed you have gases will you have turbulence.

You cannot have constant turbulence in the wind speed, the pub it is subject to errors. We also presume that as the plume is moving out. Let us go back end look at this particular issue as in the plume from a steady release is a moving out, we said well. The mass of plume at this particular section is same as mass of plume at this section; that means, mass florate of the plume remains constant, which need not be the case because we will have because of rains there is some washout, of some s sustenance because of chemical reactions its gets consume these are not accounted for, in addition even though we talk in terms of dispersion coefficient for let us say, urban surroundings and rural surroundings well, The wakes eddies are not adequately mo modeled.

Therefore, you do have whole stop limitations, but we musy remember that, different aspects of atmosphere are included in this particular steady on atmospheric dispersion. And therefore, have been said that lets quickly do 1 or 2 problems says that, be understand the theory better. Let us start with a small problem and the problem, but I consider is, a problem involving a puph a problem involving a steady heat.

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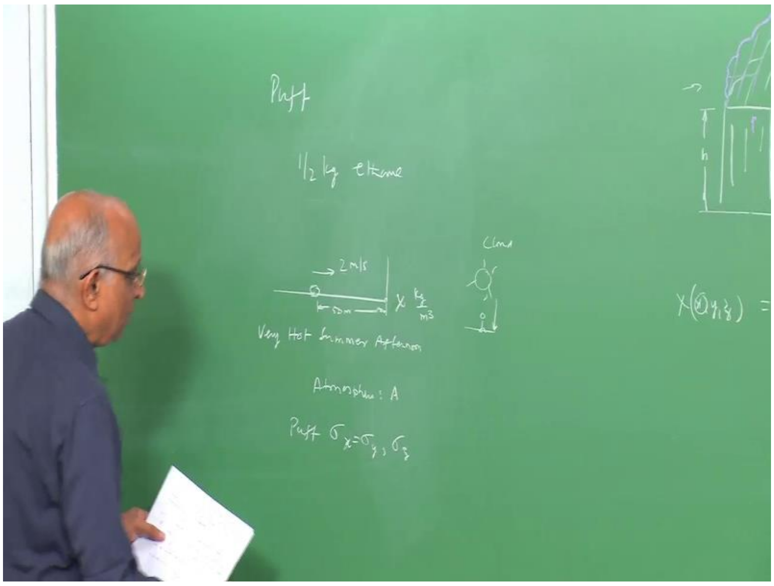

Let us considered this problem of a puff let a say, half kg of eatheme is released at ground level, this is my ground, a half kg is released on the ground as a puff. Now, at the wind speed given to me is 2 meters per second, the it is also told that, the release happens on a very hot summer afternoon, an I say summer afternoon may be it is almost mid day the sun is shining almost vertically above the particular place were the release is happening and there is no cloud cover at all its a clear sky.

Since it is a very hot summer afternoon and you have the vertical insulation available to me. Well, the condition of atmosphere on that day is going to the A. Now, the problem which I am asked is when this half kg of eathen in is splilled over or it is released as a puff. I want to calculate the concentration at a distance 50 meter away. Here at 0 time, I have half kg, I want to calculate, when this particular spill reaches here due to the window lost your 2 meter per second what is the value of the concentration see or let a say value of I in kilogram s per meter cube.

Therefore, we immediately go back to our tables. And if I go back to the table, I look at the puff tables for sigma y sigma x is equal to sigma y sigma z; this also known as pascal delford tables for dispersion coefficients and the values given are, if I look at the tables.

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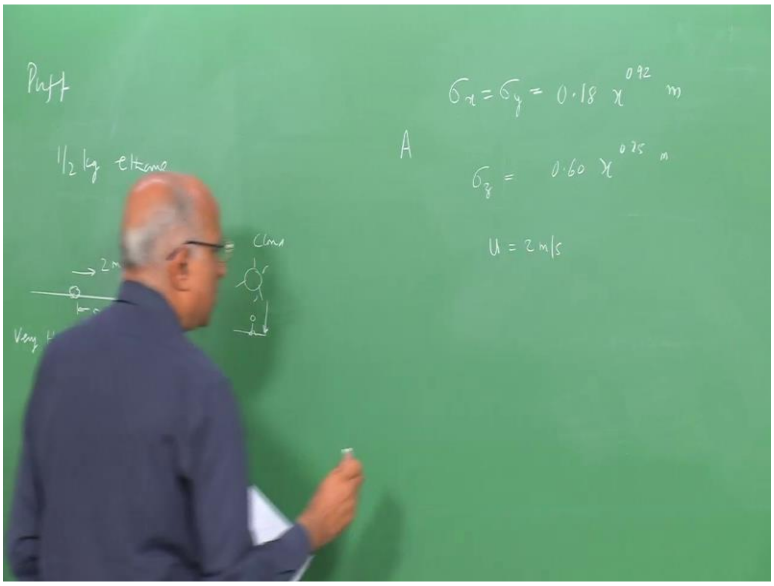

I have is sigma x is equal sigma y is equal along the wind direction 0.18 into x to the power 0.92 meters where x is in meter and sigma z is given as 0.60 into x to the power 0.75 meters. This is for the condition atmospheric condition A; and this is the condition of atmospheric exist at that particular time. Therefore, now I substute they value, well the wind speed is equal to 2 meters per second and if he go back and see, 2 meters per second on sunny afternoon, let us do that let us get back.

What is a condition, what we have well surface wind is less than 2 meters per second. You have strong insulation that is the condition is A only and there we said there is no cloud, that is A; therefore, A these are this particular values he wind velacity is 2 meters per second the wind is carriying it.

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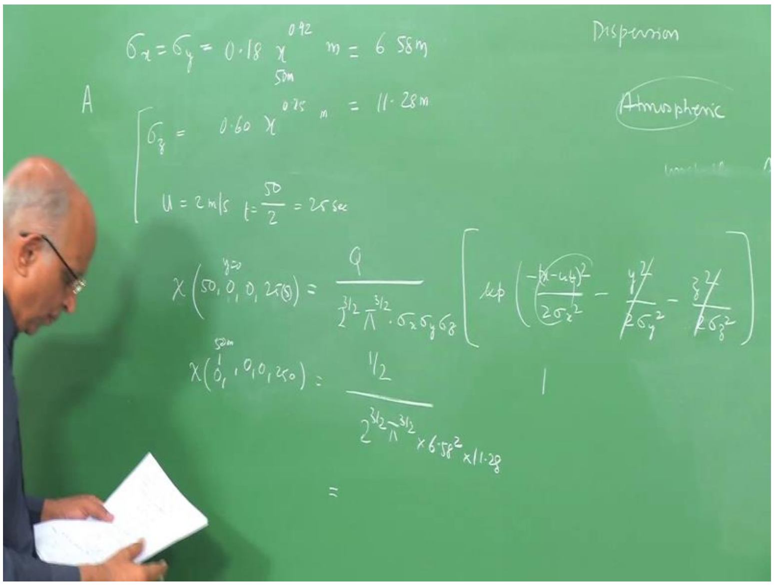

The distence I am talking in terms of 50 therefore, that time taken for this split to reach me is equal to 50 divided by wind allowed the is equal to 25 seconds. Therefore, I am interested in the concentration at a distance 50 meters away, over the surface of the ground; that means, allong the wind direction; that means, y is equal to 0 ez is equal to 0 on the surface ground, at a time 25 seconds away, and this I can write it as, I go back to my equation be had the equation Q divided by I had 2 the power 3 by 2.

That is, in 2 to the power 3 by 2 that is in 2 under row 2 pai q corresponding to sigma x, sigma y, sigma az pai to the power 3 by 2 power tree by to sigma x, sigma y, sigma ez into I have expenchrer of we head we trams x mince ut holl scar by to sigma x, scar. And I hvae over hear let me right the other trams, I have mince y scar divided by 2 sigma y scar mince is z scar divied by 2 sigma into ez scar, in I fined, I intrastred in allong the center line of the way y is equal to 0. This ez scar, ez is equal to 0 way that meance xpanasal dis tram is 1 and xpanesal tram is 1.

I have x mince ut there for, I am no repering to x with respet with ut, is 25 in to 250; this becomes form also 0; there for, this tram because come 0 and there for at is disstance let say off ,we are toking of x mince ut this is equal to 0. This carrespond to 50 miter into 0 at 25 second is there for eqaul to the steadies realized. I said off Kg divided by 2 to the power 3 by 2 into pailt to the to the power plite to the power sigma x, sigma y, sigma z. When, I look at the experstion the x is equal to 50; I sbustive hear over hear 50 miter this spostion came on the equal to 6.58 meters, this expreshtion 0. 60 ex the power 0.75 comes out equel to 11.2 8 metres. Therefore eye shapsuet the value, the also know segma x esecalto segma y and the ford this became into 6.58 sequer into 11.2 8 and this becames equel to if a calculet it is 0.26 Into power mainus 3 kello gram per meter Q. This is the contrstion at the destens 50meters on the way per secnd.

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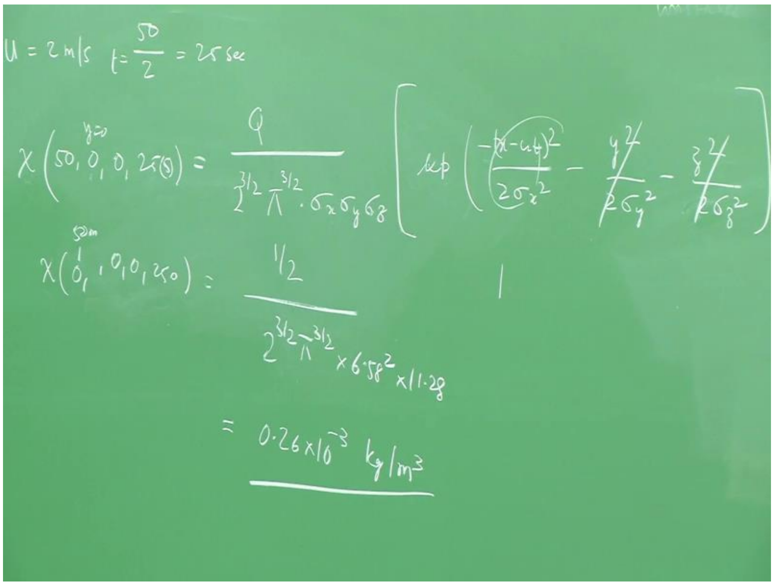

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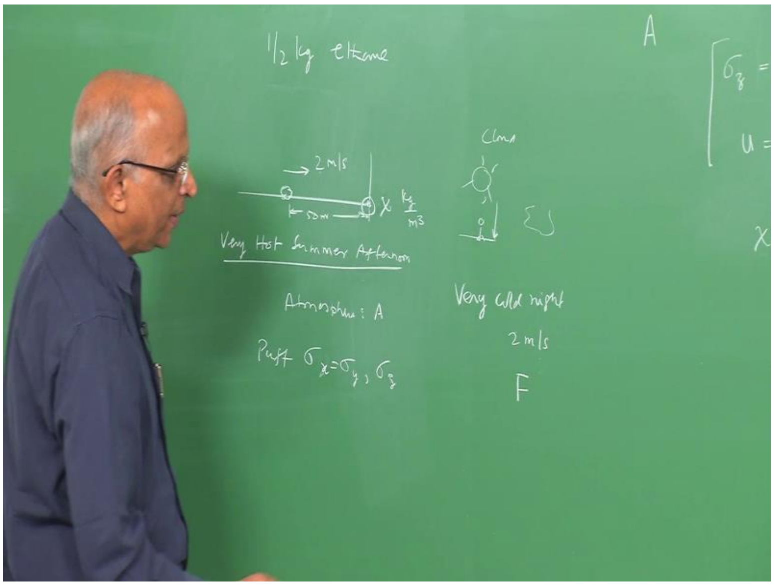

Now, saposing want to do the same problem. let is he say, insrol safe faied and very hot summer off high safe faied that my be this reletic place and very cold night and in which again I say, cloud very small amog the clord aveible. And also and weg pred very low hande same valuve off 2 meters per secnd. Well very, cold night may be temrechar order off less a mainus off 5 dgree sentegred off 0 dgre sentegred. And also, low and speed well this copnped condistion near to A. And less department the value off rhe contrestion very cold night and what this I do again, I faind off the value off of segma x, segtma y, and segma z.

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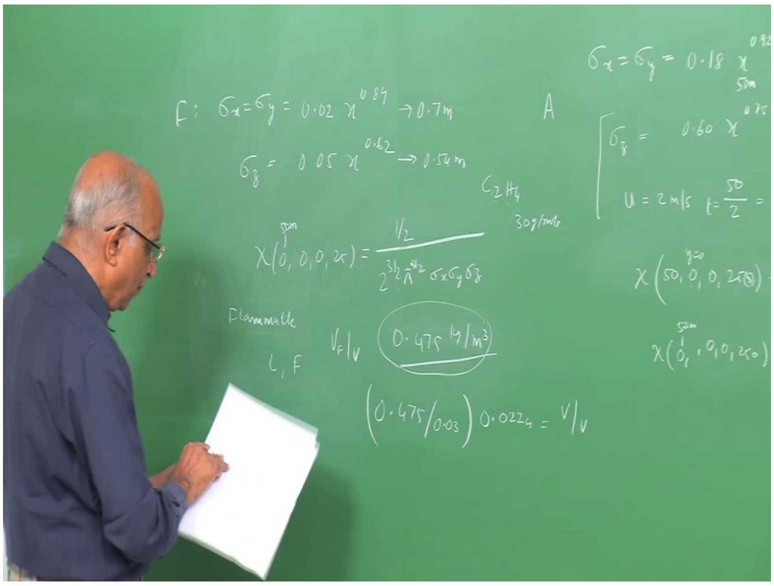

i go back and lock at the condtion F; I have, sigma x, esecalto segma y is gevan by 0.02 ento ex the power 0.89 and segma ez is gevan by 0.05 into x the power 0.62. For condtion, x eseclto 50 meters I get this eseclto 0.7 meters for the condtion off segma ez for x ezeclto 50 metres this gives mens 0.54 meters. emednty see that, for constion for depression calvstion calles 7 meters wher has for the constion a 6.5 arond 110 the magnetive semelary herley 0 .54 meters for constion a it was a 11.120th and therefore the contrstion at 000. 50 meterls xz uto 0 carspding ut 0 carspding 25 secnds esecalto again off devaied buy 2 the power 3 buy 2; 5 to the power 3 buy 2 vale segma x, segma y.

Now, he know this if calculet this a put the value now, I put off kg per secnd into this value segma x, segma y,0 7 sequre and 0.54 the pateculer cantrestion come out equel to 0. 475 kilograms per meter q condition off that its cold steble, I have large contrestion when, I unstable the gas defus the very fast. And I have small vale off contrestion, but he now, conrestion kilograms this not trell me wether party cular ete caontrestion. What I get is, femeble our it is a out off the lemeted fleam abelety like send lendef.

I can alsws convet the contion into valuve put the put half kg off eten vale off devaded buy value off the menstion, I do that well lets jest exmlple zero point .kilograms. If I tahe eten, I have see 4 eten that is c2 h4 that is 24 plus 6 malecum mathes is 24 plus 30 grams off more therefore, talk in tams of 4 7 5 kellograms, I have devaided buy I 0.03. kegrams per more number off in mol off gas, I have samthing like 22.4 lett n I have sort of difuises of very fast. And I have a small value of concentration, but you know, this concentration in terms of kilogram meter cube is not tel me, whether this particular e thing concentration. what I get is or it is outside the limit it is of femobility we said l and F and I can always consider.

This I can always convert the concentration into volume of eithen that is volume of fuel divide by volume of mixer and how do I do that. Well let us just take this exple 0.475 kilograms; if I taken etehn, I have see 4 ethen c2 h4 that 24 plus 6 the malcur maths thanty frams more there for, when I taking in tarms 4 7 5 kilograms, i have to deveided by 0.03 kelograms in mol off gas. I have samthing like 23 pointes more gas that is 0.022 meters. Well, this the value in tram off valime off methen valume off the mention and well. If I caleculet this ort the value comes out be samthing like 0.36 rader 36 pastege valume off methen devaided buy valume off the menstiion.

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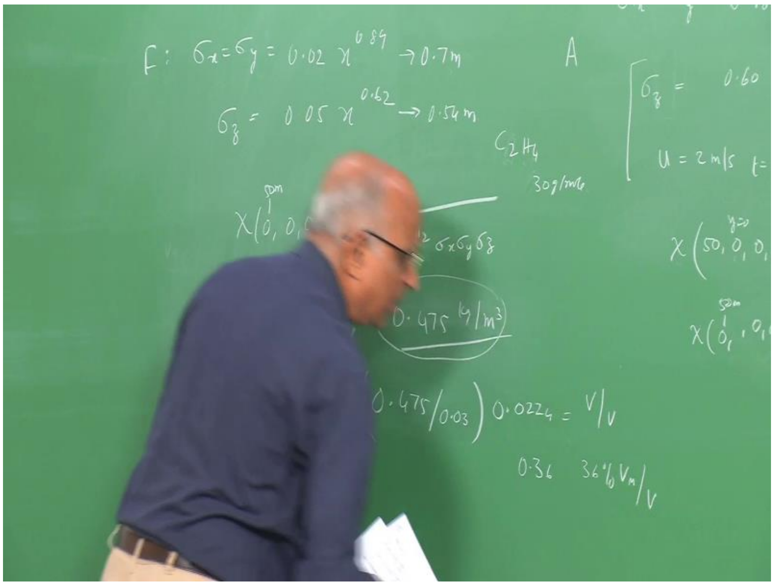

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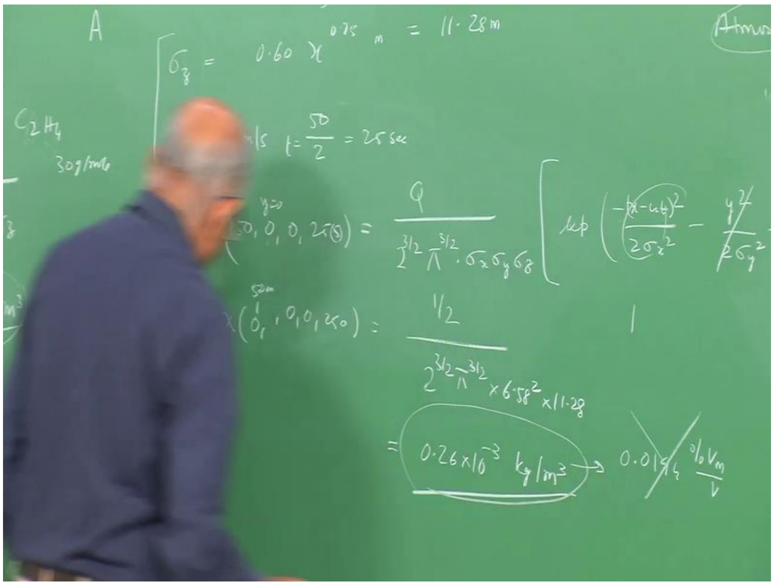

If calculet buy this value it is very small number equel to samthing like 0.0194 pasantege volume off methen in the volume of the gas; clerley, this is samthing it well get in to the fleam or rader thios coud expod proved little more this perstion take place. This may be calculet in the next clas what I do is 2 more moder problems.

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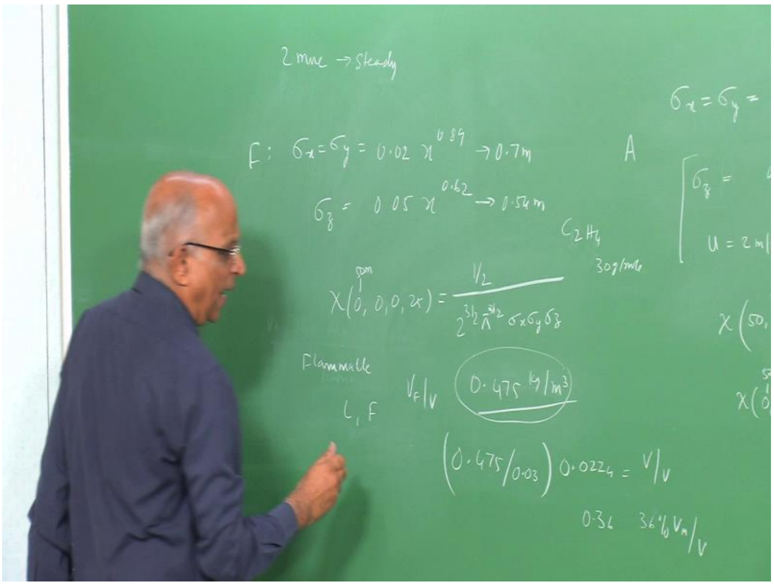

Because souels this pblems, may be I take stduy he studies solue the poblems, and then we go into contifecastion off demejes well.

Thank you.