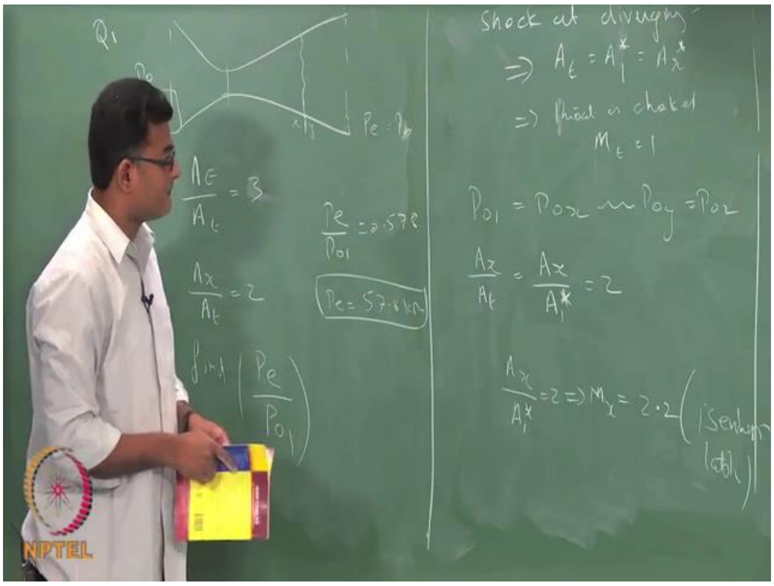
Fundamentals of Gas Dynamics
Dr. A. Sameen
Department of Aerospace Engineering
Indian Institute of Technology, Madras

Week – 09
Lecture – 35.1
Shocks in C-D Nozzles (cont'd)

(Refer Slide Time: 00:21)

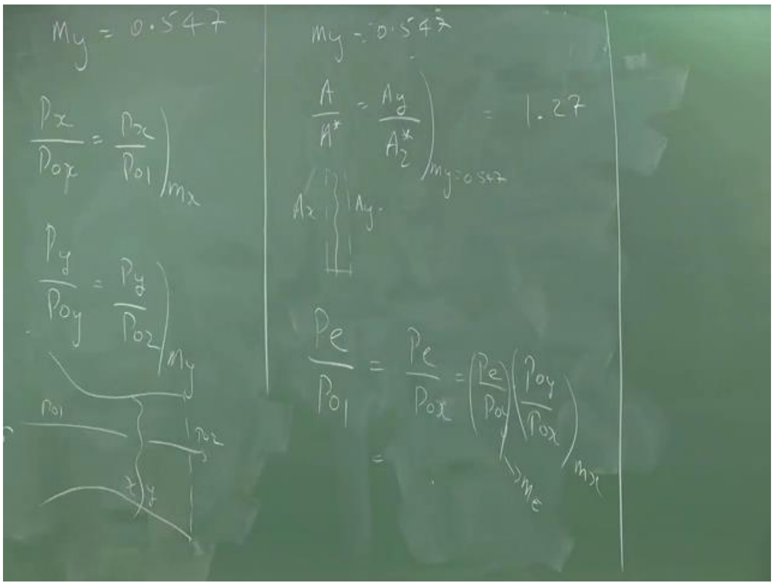


I have a nozzle where my A exit by A throat is 2 and there is this 3, there is a shock sitting at some location where my area ratio is 2, find P e by P 01? So, I have a P 0 I have a P exit, now after the shock it is going to be subsonic, this can also be your P b. So, the pressure ratio P exit to P 0 that is what we need to find. All that is given is this area ratio nothing else, from this area ratio you have to find your pressure ratio P e by P exit again.

We start from the information we have there is a shock diverging section implies A throat is your A star 1 which is your A star, throat is choked m throat s 1. So, whatever pressure you would have P 01 is same as your P 0 x then it encounters a shock you use some of your stagnation pressure which would be retained till the exit.

Now, you are given A x by A t which is also A x by a star. So, this is A star 1 because that is something that is happening before the shock, so we call this as this; this is 2. So, the mach number associated with A x equals 2 is, I look at the isentropic tables find A x by A star 2 will give me a mach number of 2.2, mach number of around 2.2. Now the shock is happening at M x equals 2.2.

(Refer Slide Time: 04:38)

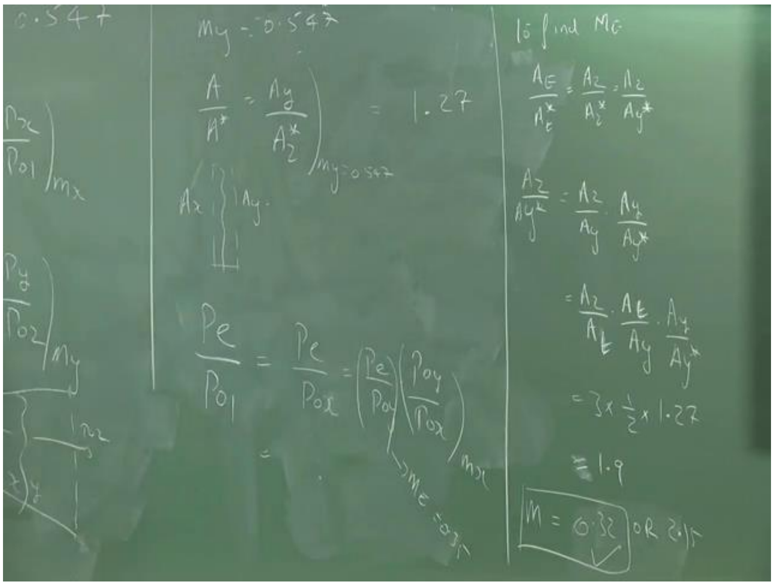


So, your M y equals this is from isentropic tables, now M y is I look at the shock tables for mach number 2.2; M y is 0.547. So, I have M y that is generated at this. So, your P x by P 0x is P x by P 01 at m x and your P y by P 0 y is your P y by P 0 2 or P 0 exist at M y. So, what I would written here is have a shock and then this is x, this is y, if that is your value this is my P 02 this is my P 01 which is constant up to the shock and constant after the shock, that is one information.

Second information, I can get A y by after the shock I have my equals 0.545 which implies my A by A star associated with this is my A y by A 2 star, A y star or A 2 star. But in the shock derivation we have taken the control volume around the shock and we have assumed A x equals A y. So, this I can get it for M y equals 0.74 which is I look at the isentropic tables I get A by A star is a 0.547, A by A star is on the around 1.27.

Now I know my A x, I need to find P exit by P 01 which I can rewrite it as P exit by P 0 x, which is P exit into P 0 y into P 0 y by P 0 x into P 0 x, I can rewrite the P 0 x in this particular form. So, I know this pressure ratio P exit by P 01 as P x into P 0 x into P exit I rewrite in this particular form. This is associated with my m x this is associated with my m exit, if there is a shock and if there is a pressure that is here. So, I need to find my m exit. So, if I know my m exit I can find this ratio and that multiplied by this should give me the pressure ratio.

(Refer Slide Time: 09:35)



Now, there is something to find M exit I need to find A exit by A exit star which is nothing but, what is we called it as A 2 by A 2 star, A 2 star is also is my A y star. So, I need to find A 2 by A y star which I can rewrite it as A 2 by A y into A y by A y star, I can write it as a by A 1 into A 1 by A y into A y by A y star. So, I need to find A exit by A exit star, so I replace this A quantity in terms of quantities I know.

So, A 2 by A 1 is already given which is A 2 by A 1 is A exit by A 1 is I thought so, I will write this as my throat area, I divide it by throat area. So, A 2 by A 2 by A throat area and A throat area by A y and A y by A y star. So, A 2 by A throat area is our area ratio which is 3 and A throat by A y is the location where your shock is happening which is given as 2, it is 1 by 2 into A y by A y star we already have found based on my M y which is 1.27. So, this is my A exit by A exit star which is.

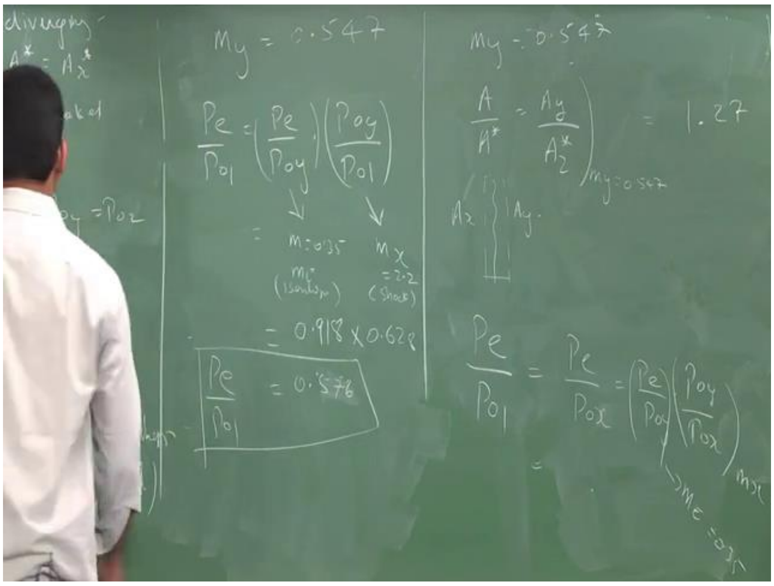
Student: (Refer Time: 12:00).

1.9. So, your M associated with this 1.9 is, look at the isentropic table 1.9 this subsonic value. So, we will write both, or.

Student: (Refer Time: 12:58).

2.1, around 2.15, now we are talking about A section which is after the shock. So, the supersonic solution cannot happen there it is always subsonic flow. So, this is our M exit. So, your P by P 0 corresponding to 0.35 is your value that has to be substituted here.

(Refer Slide Time: 13:43)



So, your P exit by P 01 is P exit by P 0 y into P 0 y by P 01. So, this is corresponding to M equal 0.35 which is our M exit, this is your corresponding to your m x which is before the shock, these 2 values should give me the pressure ratio. So, M equals 3.5 my P exit by P e is 0 is 0.918 multiplied by, I look at the shock tables m is m x equals m x equals 2.2, 2.2 P 0 y by P 0 x is 0.628 this is equals 2.2. So, this is form shock tables, this is from isentropic tables; this is around.

Student: point five (Refer Time: 15:14).

0.756.

Student: 0.576.

0.576. So, that is my P exit by P 01. So, if I have this pressure ratio; you come back to the question if I have that pressure ratio P exit by P 01 is 0.576 I will have shock at a location where you have this. So, if your P 0 is; let us put say P exit some value then the ratio would be this. So, your let us take P 0 as say 100 kilopascal, your P exit is 57.8 kilopascal, 57.8 kilopascal is a region between P critical 1 and P critical 2. So, there is a shock in the diverging section, and that happens at a location where area ratio is 2.

The key is, you consider shock as the non isentropic process everywhere else it is a isentropic process, and what all be the case before and after if I have a long depth you do not need have the C-D nozzle information where the shocking condition or throat condition is not there. But if it is a nozzle you have this condition.

Same is true for a diverging diffuser. So, if I have a diverging portion, if I do not consider this portion and I have a diffuser and there is shock sitting here you do the same kind of analysis and get the tables to do the problems the values before the shock and after shock and this normal shock tables for the properties across the shock. And that should solve the entire shock problem, now (Refer Time: 17:47) standing normal shock problem.

Thank you.