Matrix Method of Structural Analysis
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Lecture - 32
Computer Implementation (Contd.)

Hello everyone, this is the second class of this week. In the first class, we will discuss a computer 2D computer code for 2D analysis of truss. Today, we will just demonstrate that code through some examples and also some of the important things that we mentioned many times, but we never checked, we also do that exercise during that demonstration. To start with we will take these example and then see how to solve it ok.

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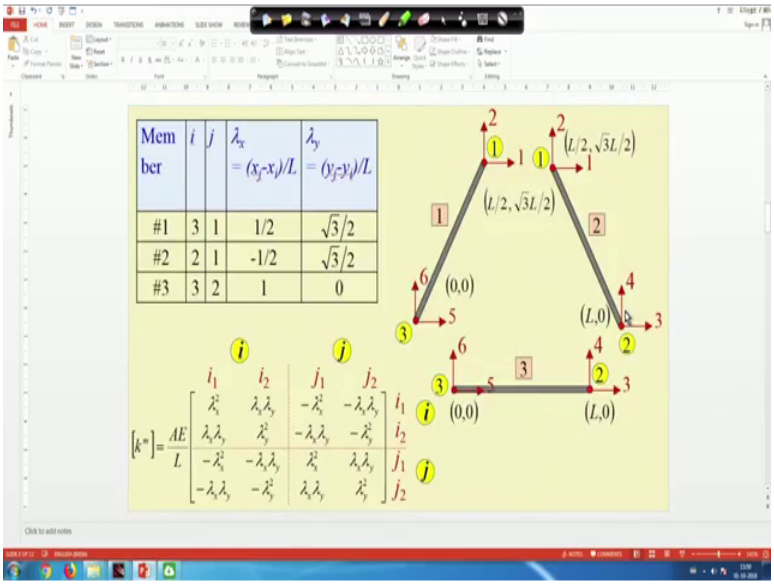

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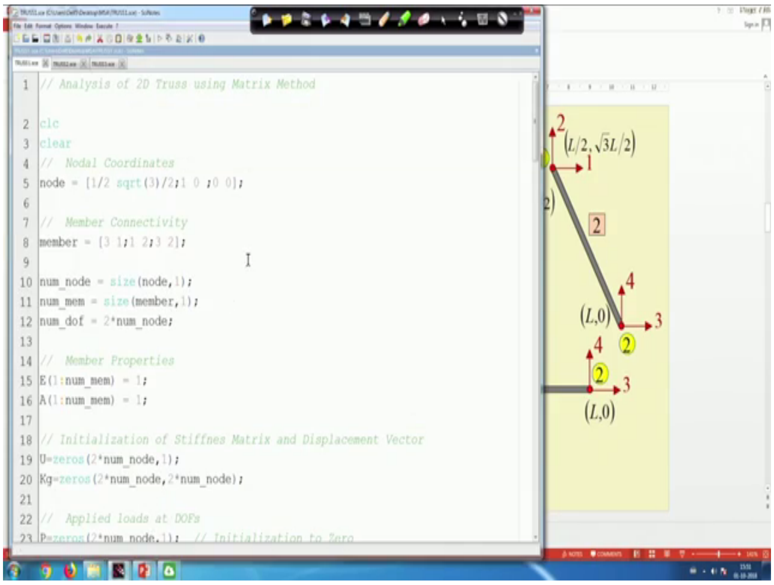

So, this is the example we have already this is the card, this is the code that we discussed in the last class. Now, these are the nodes coordinate, these are the member connectivity. And all these informations are given; we can have this Young's modulus and the area and Young's modulus. And let us the let us solve this ok now, if we solve it, if we press F5, then it gives you the solution ok so, this is solved.

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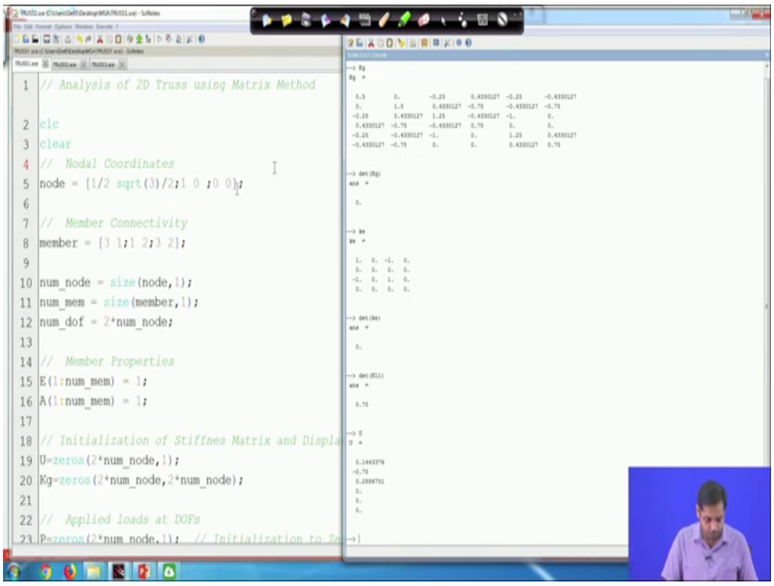

Now, now we have already done the solution. Let us see let us try to see the solution, let us first see the global stiffness matrix. The global stiffness matrix was kg and this is the global stiffness matrix. If you check the global stiffness matrix is symmetric and the size of the global stiffness matrix is 1, 2, 3, 4, 5, 6, 6 by 6 ok. Now, another important thing global stiffness matrix if you global stiffness matrix is not invertible, it is a singular matrix. Because, when you take the global stiffness matrix means, it has no information about what constraint you have given to the structure and that information that will be manifested in some way.

And here if you find the determinant of this stiffness matrix global stiffness matrix, you check the determinate of the global stiffness matrix is 0. Even if you take the element stiffness matrix say k e is the element stiffness matrix k, it is element stiffness matrix for member number 3. And if you take the determinant of this element stiffness matrix, this will also be 0 and which is obvious, because, it has no information about the constant about constant provided.

Now, once you have given the constraint and then partition this partition the matrix like this. If you this K 1 1, then K 1 2, K 2 1 and K 2 2, then this part is this is the partition stiffness matrix essentially this K 1 1, this will be the partition stiffness matrix. And if you take the, if you check the what is the determinant of that whether that matrix is singular or not. Let us find out that K 1 1 that is not singular and which is obvious, because K 1 1 is the K 1 1 you obtained is a reduced matrix by substituting the degrees information about the degrees of freedom in the system ok. So, this is consistent with the intuition ok.

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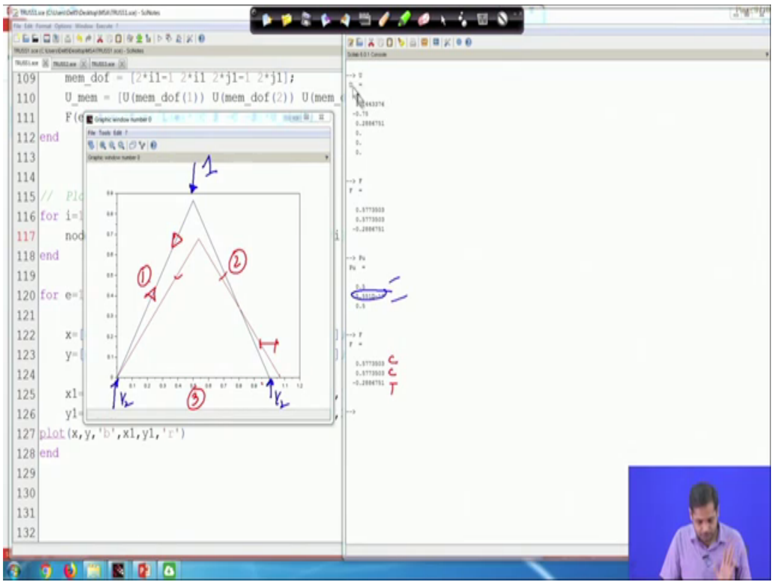

Now, let us find out the solution. Solution of this is you let us find out what is the force vector, if you substitute U, the total force total displacement is this, if you recall this the if let us plot the deformed shape of this the deformed shape will be if you deform shape will be this, this will be the deform shape ok.

And in this deform shape if you yes, so this will be the yes this is this was node number 1 this was degrees of freedom if you recall, this was degrees of freedom 1, 2 and then 3, 4 and then 5 and 6 like this. So, 4, 5, 6 are 0, because this is constrained and then this U will be the degree this U will be this is U ok. And this is this is your these degrees of freedom. This is this U is this is the degrees of freedom ok and then minus 0.75 is zero point 0. 75 is this and then these value is your this degrees of freedom so, this is the deformed shape.

Now, once we have the deformed shape, we can have we can also see the what is the load vector. If we check F, F is the first frame let us find out support reactions, support reactions are P u, P u are the support reactions. And these reactions are we had a load of we have a load of P here, 1 here. So, naturally the reactions will be half here and the reactions will be half here. And the horizontal reaction will be 0; this is a very small value which is 0 so, this is consistent.

Now, similarly we have we can see the what is the force vector, what is the force in different members the forces are this. So, this force is this the red one so, this force is in member this member this member, this member, member number 1, member number 2 and member number 3. Here at least you we you have to be consistent with your sign convention, whether we are taking compression as positive or tension as positive. Whatever sign convention we take depending on that, we get the sign convention here ok. So, if you change the sign convention the same value you may get this, you will get the same value, but the opposite sign.

So, interpretation of this result is very important that depends on your sign convention. So, the this is a sign convention that we use here is this is compression, this is compression, this force is compression, this is compression, this is tension. Which is very obvious if you look at the deformed shape which is very obvious, because this member this point is moving from this to this. So, therefore there will be tension in this member, whereas this member and this member will be in compression ok.

Now, so let us so this is the solution of the system. Now, before we move on to another problem let us do some, let us check some important you see here Young's modulus was taken as point 1 ok. Let us now, now you calculate the displacement, let us see the displacement is this was the displacement. At the centre the downward displacement was minus 0.75 ok. Now, what we do let us check the Young's modulus instead of 0.1, you make it 0.1 ok.

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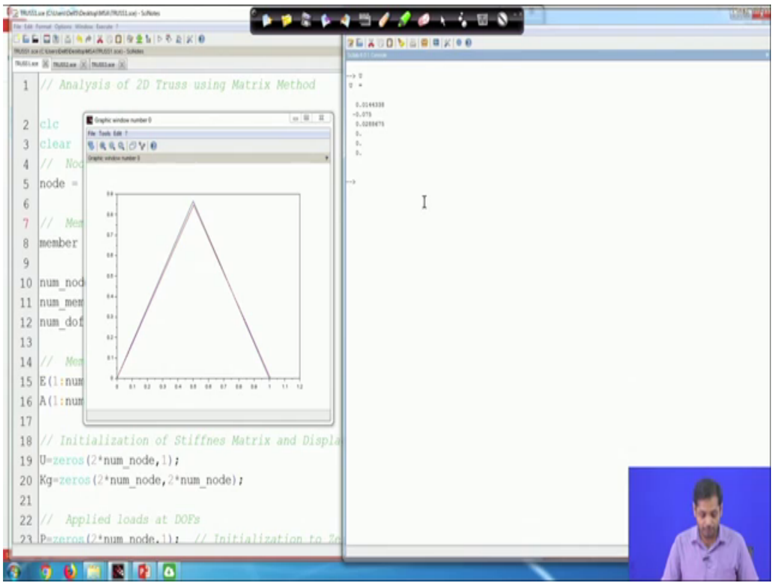

If you make it 0.1 what will happen, if you see, the displacement is 7.5 ok, so which is obvious, you see the thing is what we are discussing is a very obvious thing. But, these through the discussion of the obvious in through this check, you can check your you can check whether your results your quotes are correct or not ok.

Now, which is very obvious, because the linear problem, the force displacement is still linear. So, if you change linearly the Young's modulus the effect on the displacement will be linear. So, if you increase the Young's modulus, this displacement will be decrease and if you decrease the Young's modulus, displacement will be increase. And the same thing, we have for here as well if we make it and if we change the area to 0, then let us see what happens, this will be your U will be this ok. So, it is decreased by 10 times ok, so this was obvious right.

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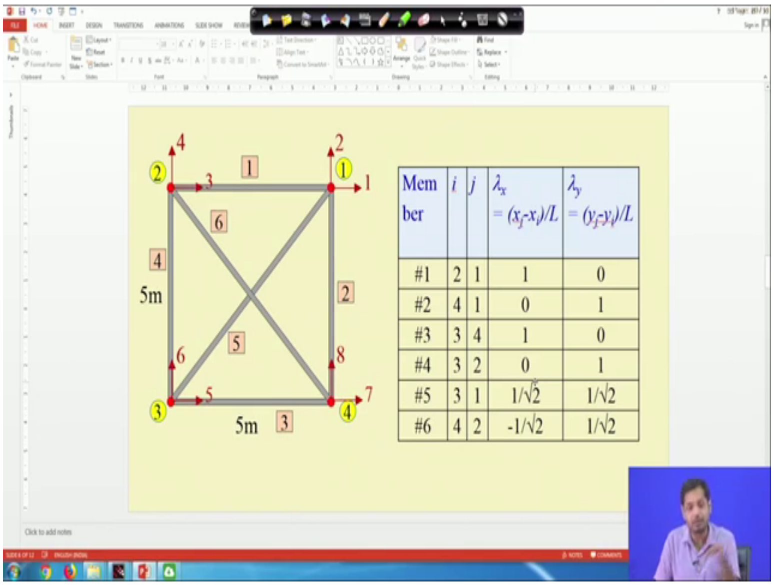

Now, so once this problem is we have solved we have solved this where the solution of this problem. Next move to the next problem; where this also to the problem we discussed in when we in some of the classes and the solution of these problems are also known to us. The solution of this problem is if you recall, the solution of the problem is ok, before we have the solution. So, this is the numbering system of this these are this is the way the degrees of freedoms are number.

And then this is for different numbers these are the i and j point and corresponding lambda x lambda y, we have to just give these information in the code. So, what information we have to give here is this. So, these are the four nodes, these are the coordinates of four nodes and the corresponding members of the corresponding member connectivity at this.

And let us take Young's modulus and E is 1. And then important is the P 1 and P 2 if you look at, this your force we have is here the P 1 and P 2. This is the degrees of freedom 1, this is the freedom 2 so, P 1 we have 5, and P 2 we have minus 10. So, we have P 1 is equal to 5, and P 2 has minus 10. And then boundary conditions are if you recall, this is hinge this is hinge and this is roller support, so if we see the 7 and 8 are constrained, 5 and 6 are constrained and then 4 degrees of freedom 4 constraints.

So, only unknown degrees unknown displacements are degrees of freedom 1, degrees of freedom 2 and degrees of freedom 3 rest all are known displacement field. So, unknown displacement is 1, 2, 3 and lest 4, 5, 6, 7, 8 are the are the known displacement are the known displacement fill means did it is 0 here.

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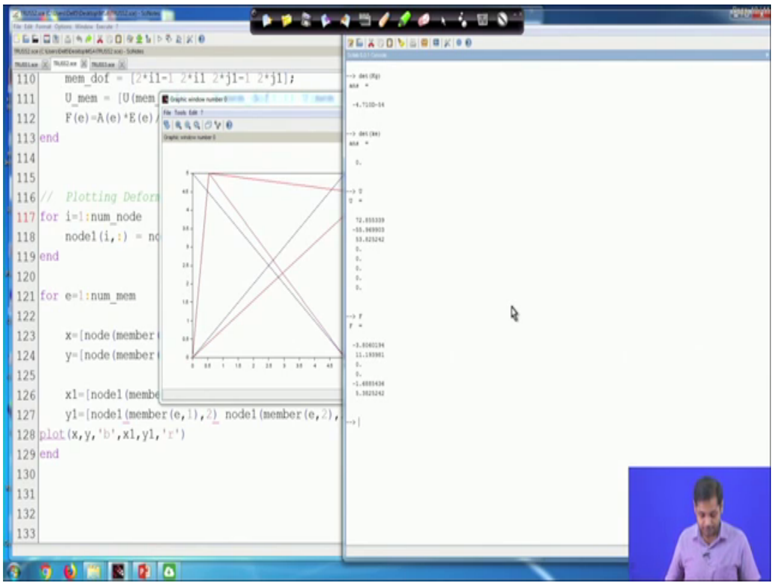

So, rest of the thing is again same and then if you run it and you get a solution like this get a solution like this you know. Again similarly, if you plot, if you take the kg determinant of kg determinant of kg, if you take determinant kg will be 0, which is very small number is 0. Similarly, if you take the determinant of elements the member stiffness matrix say ke, any ke this is the last one, this will also be 0.

So, similar exercise you can do ok, the force the forces are displacements are this. These are the displacements, please check the displacement we have the solution, we discuss the solution in one of the classes, you check the solution with these values. And similarly, we have the forces, member forces the member forces are this and similarly, we can check the values of the member forces ok.

Now, you see let us do one exercise that let us make this structure. Let us now let us just one minute yes, let us make all degrees of freedom. Let us provide constraint only in 7 and 8 and other degrees of freedom 1, 2, 3, 4, 5, 6 they all are there is no constraint in other degrees of freedom.

So, only hinge we have, now the problem is now is this so, we have just one hinge here that is it, and there is no other degrees of freedom right. So, corresponding if we change in the code in the input file in the input, this will be the change your force will remain same yes. U known will be only U unknown, U known will be only at the 7 and 8 and all other degrees of freedoms are unknown and let us solve let us find out the solution.

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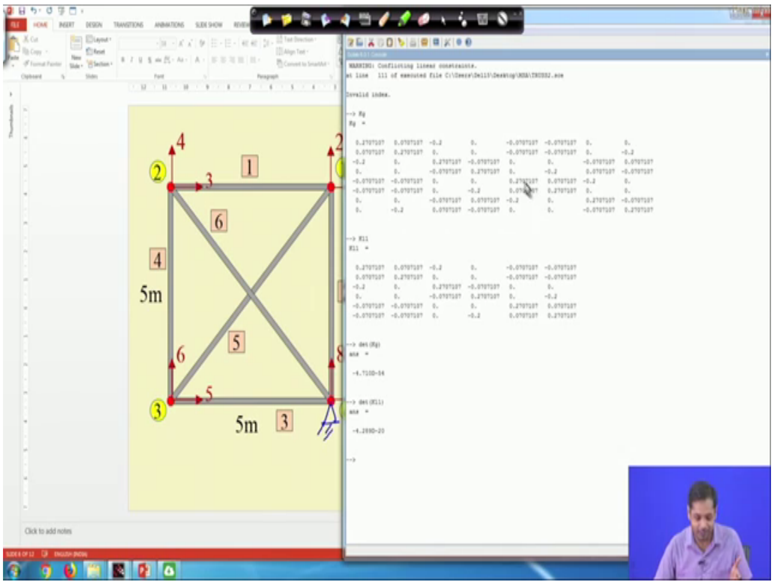

Now, if you see the solution, you see there is an error ok. Let us see kg, kg is absolutely fine you see (Refer Time: 12:42) the error ok. There is say this same code worked just now, but just to change the boundary conditions it does not work now. Now, why does not work, let us understand that you probably know that, but still we are emphasizing in order to emphasize the fact, it is very important that is what let us discuss that again. The kg is there is absolutely no problem, it is symmetric it has been calculated perfectly. Let us see K 1 1, K 1 1 is also fine. Let us find out determinant of K 1 1, kg determinant of kg is 0, which was expected. Determinant of K 1 1 determinant of K 1 1 is determinant of K 1 1 is also 0 here. Now, the why determinant of K 1 1 is 0 it is very obvious, you look at the look at this structure.

If we have a structure trust like this and support only at this point hinge and then what is the is that structure stable. This structure is not stable, because the number of constraint required to stabilize this structure we have not provided that many constraint in this structure that is why, this structure is not stable. And this will be manifested this will be manifested in the solution. When you run this code, you will see that that this is there is something wrong in the structure. So, that is the reason why you could not solve this structure.

Now, let us provide let us give one degrees of freedom, let us provide one constraint to make this structure stable. Let us make 6 also here, so 6 you remove and then check whether it is or not then it is fine ok. Now, the structure is stable, 3 constraint required, you have provided 3 degrees a 3 constraint and the structure is stable ok. Now, moving on the last example, this is the solution of this problem that we already discussed that we already discussed some of the classes ok. And now let us take this example, this was the solution of this problem and please check this solution with your this is the solution please can check the solution ok.

Now, let us take this example, this is a relatively complex example. Complex in the sense, here the number of degrees of number of members and the orientation of members and the number of degrees of freedom is relatively larger as compared to the previous two examples ok. Now, all the dimensions and the load is given here, you can prepare the input. Prepare the input means, what is the input, what is the nodal coordinates and what is the member connectivity? And I have done it for you.

This is this one, so these are the different nodes and the corresponding member connectivity. And then we have this is degrees of freedom 3, 5 and 7. And this is the degrees of freedom 3, 5 and 7, we have these forces and then these are the known displacement, and this is the unknown displacement. Known displacement here only this and this means 3 known this 4 known displacement, this is also hinge support this is also a hinge support also in support. Otherwise, you will see it is not stable structure, now it is also hinge support. So, we have four constraint so, these are the four constraint corresponding degrees of freedom and the corresponding degrees of freedom, which for which displacements are not known and then rest of the thing is same.

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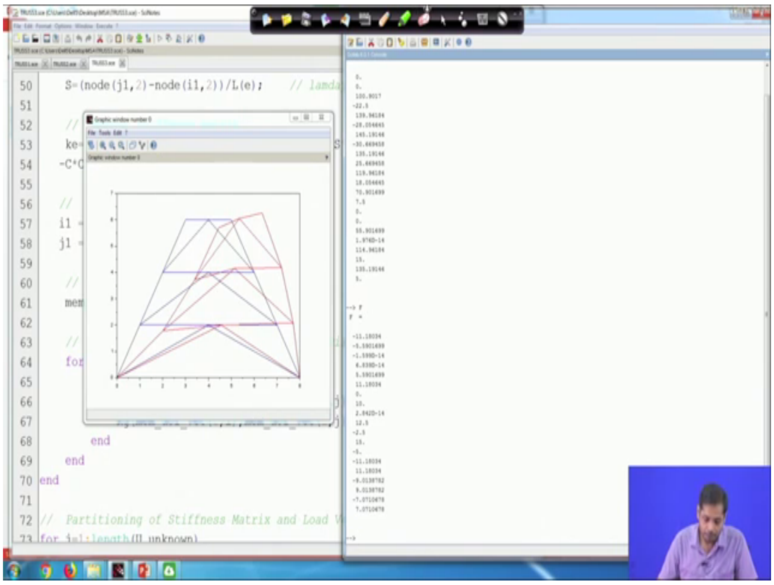

And then if we solve it, this will be the solution, this will be this is how the structure deform. And if we get U, these will be the different displacement at different nodes. You can see the displacements are very large that is because of we have taken a random arbitrary value of Ae and these are the member forces, these are the member forces and these are the ok. So, what you have to do is now if you take any structural analysis book, there are either structure and basic the first structure analysis book or matrix method of structure analysis book.

There are many examples given in the book, you take every example each one and create the input dissolves. The solutions are given in the sum of the for some of the example solutions are given exercise problem solution solutions are given in the book. You take those examples prepared the input means the what is the node number, what is the connectivity and so on? And then you solve it and then compare this solution with the solution that you obtained from structural analysis one or method of section method of joints, whatever methods we know for solving truss and then you compare this.

Now, you see the same thing if we have a truss, which has say 500 member, just an arbitrary number I am giving whether 500 members. And the same 500 you just create the input file and then just amount click we can get the results, we can get the displacements, we can get the forces, we can get all the information that we need about the structure and that is the beauty of this method.

This method can be translated is can be translated into a computer code very easily ok. So, next class we do the similar exercise for beams. And again get the and try to solve some beams and then in the subsequent classes we will have the similar exercise for frames. Then I stop here today; see you in the next class.

Thank you.