Defects in Crystalline Solids (Part-I)

Prof. Shashank Shekhar
Department of Materials Science and Engineering
Indian Institute of Technology, Kanpur

Lecture - 34
Dislocation intersection and step characteristics + Superjogs

So, last class we were discussing Dislocation Intersection.

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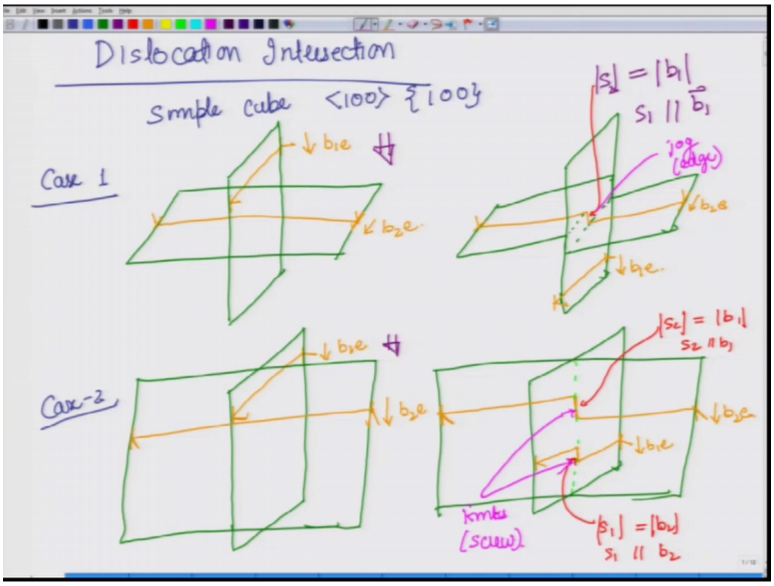

We looked at for examples and next we have we said we look at some more aspects of this intersections. So, what are these aspects?

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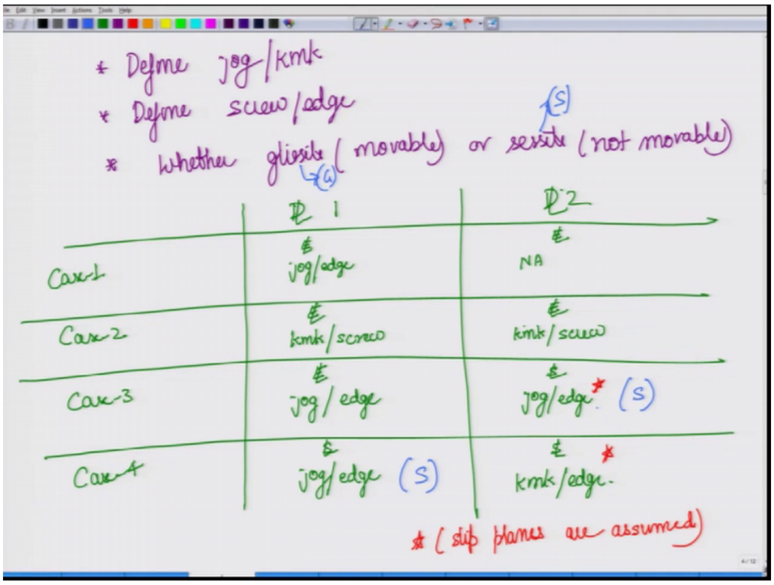

We want to define whether these steps are jog or kink we want to define whether these are screw or edge and we want to find out whether they are glissile which means they allow movement or they move themselves, whether they are movable or sessile, not movable ok.

So let us come back to our different cases; what do we see over here? Over here we see in this particular one there was no visible step formation. So, we can ignore this one over here what do we see? Over here we see that there is a step that has formed and which has lead to the displacement of the slip plane from here to here. So, this is no more in the same slip plane. So, first thing that we can say that this is a jog. So, the step here is a jog and is it a edge dislocation or screw dislocation? So, this is the Burger vector which remains perpendicular even at this point. So, it will erase a edge dislocation.

We will come to the glissile and sessile part, actually we have already discussed if you remember, but we will describe it in more detail later on. So, here now come let us come to case 2. So, here what we see the step is formed and it is in this plane the plane, on which it was moving. Here also step is formed and this step is also allowed the dislocation to remain in the same slip plane; therefore, the two of these must be kinks.

Moreover, what is the Burger vector? So, you see that both of them Burger vector are parallel; therefore, the step that is formed over here this is step is parallel to this Burger vector and therefore, it is parallel to this Burger vector which would mean this is a screw dislocation; here line vector is parallel to the Burger vector. So, both of these are kinks and in fact, we should know from what we discussed earlier that this will lead to a screw dislocation.

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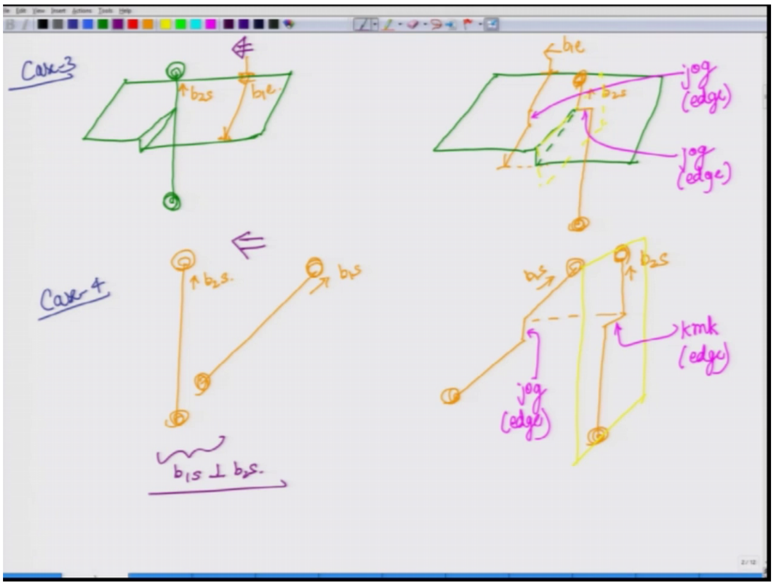

So, let us get to the step 3, case 3. So, first let us look at the simpler one which is the edge dislocation. So, here the edge dislocation as you can see it has moved away from the plane. So, clearly it is a jog and if it is a jog then by default it has to be a edge dislocations, for edge dislocation the jog is jog leads to edge dislocation. What about this screw dislocation? So, this is where when I said that it depends on what particular where I am drawing this ledge.

Now the way I drew this ledge, it means that this is the slip plane for this. So, this is the slip plane and this has moved it away from the slip plane and therefore, this one is a jog and what is the character? The Burger vector here is edge perpendicular to line vector. So, it is a edge dislocation. So, in both this cases we are getting jog and edge.

Now what do we get over here? So, here we are we have not defined any particular direction or ledge. So, we will not be able to say whether it is jog or kink. So, it will depend on a specific case, but if we assume that this particular plane is let us say this is the. So, if you assume that this is the slip plane for this then perhaps we can say that this is a kink because it is in the same plane. So, let us say this is kink and it is assuming that it is this particular plane and if it is and in the screw dislocation whether it is a jog or a kink it will always leads to edge dislocation.

Now here this we know already that it was moving, this particular screw dislocation this was moving in this particular plane, which would mean that this particular one has moved away from the plane and therefore, it must be a jog. Now, if you go back and actually we describe it a little different we said this dislocation is moving and if that is the case then we will have to revisit what we said over here or we can say that this dislocation was moving, in which case we can stick with what we have described. So, for this particular plane is the slip plane and after the step formation it have moved away from the slip. So, this is jog and we are assuming that this remains a stationary where it is in the in one of a slip plane and therefore, this particular step has formed in the slip plane and it is the kink.

So, for screw dislocation we get a edge dislocation in both the cases and for edge dislocation when we get a jog; it is a edge, when we get a kink it is a screw. So, we can let us summarize it, now what we see in the table over here. So, let us say we have a dislocation line 1, we have dislocation line 2 and we are looking at case 1. So, the in the first case we are talking about two edge dislocations. So, let us first write that down. This is two screw dislocation and what we obtained was that in this particular edge dislocation 1 what we obtained was a jog which has to be edge. In this particular one the step formation was in the line. So, it does not apply to this. So, that is case 1.

Case 2 we had again two edge dislocations. So, first (mark that edge dislocation line and in one of the cases in the step in the dislocation line 1, what we obtained was kink. And when it is kink in a edge dislocation thus character is screw character. For dislocation 2 in this particular case we saw that it was also a kink and hence the screw character. Case 3, we had one screw dislocation and one edge dislocation. So, we had dislocation 1 was edge and dislocation 2 was screw dislocation. So, the edge dislocation we saw obtained jog which has to be edge.

And for the screw dislocation assuming the given slip planes we say that it is jog and edge. So, I will put a star mark over here because this is to be remembered that it depends on where which particular because there can be several slip planes and just stationary dislocations cannot describe, where is the slip plane. While in a edge dislocation when a stationary dislocation can describe what is the slip plane. So, that is why here assumption is necessary with that which one you are describing as a slip plane. So, I will put a star mark over here.

Case 4, here two screw dislocation and again depending on the assumption, one of them we do not need to make the assumption which is for 1. For 1 we do not need to make the assumption because we assuming that it is moving in this particular plane. So, we know that it is moving and it. So, its slip plane is described and it is necessarily a jog. So, for screw dislocation 1 it is necessarily a jog which means edge and for the 2 we have to assume a certain plane. So, again we will put a put a star mark, but assuming that it was perpendicular to the direction of the other dislocation. So, it forms a step in the direction of the slip plane in the plane. So, it forms a kink and edge character and I will again put a star, star means slip planes are assumed, for other we do not need to assume slip planes ok.

So now the next question is whether glissile or sessile? Now, if you remember from our discussion, there were the steps that are formed whether the kink or jog in a edge dislocation it is always glissile. In a screw dislocation one type of step is glissile the others type of step is not glissile or what is called as sessile not movable and what is that? The one we have jog, when a jog is formed it forms a edge dislocations which remain confined to a particular plane and then it cannot move in the same direction as a slip direction. And therefore, it pins down the dislocation and therefore, it is a sessile dislocation or a sessile it is sessile in nature.

So here we will also put glissile or more simpler is to say which one is sessile. So, wherever edge there is a screw dislocation with jog character, it will be sessile. So, I will write s. So, here it is s and for glissile I will write g meaning it will move. So, these two are sessile and all the remaining once are gliss. So, here also sessile and all the remaining once are glissile. So, I will not mention it over here, but it by default you should understand that rest are glissile.

So, whenever something like this forms a jog forms in the screw dislocation, it will be sessile and it will lead to pinning of the boundaries and in other words also mean that some where it will add to increase in the strength of the material and the glissile or the sessile dislocations would cause more intersection or dislocations and hence more generation of such sessile parts which will add to the strength of the material.

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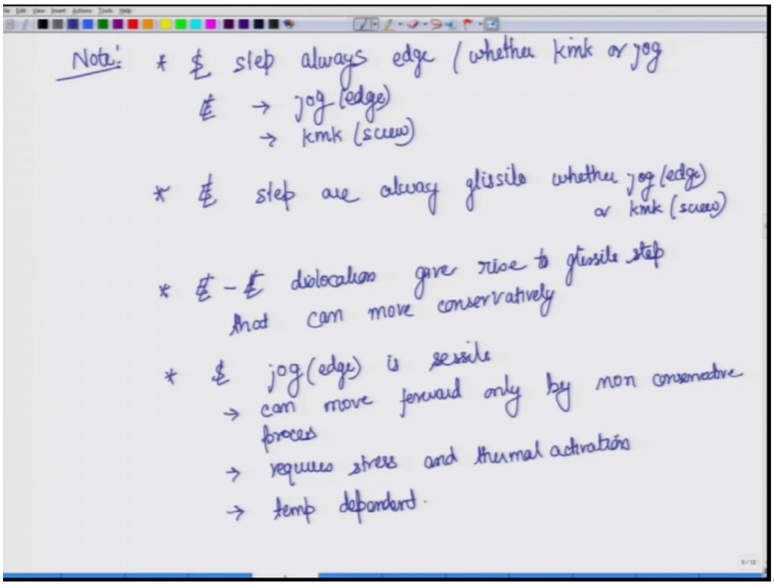

So, there are from this summary we can again note down some important steps, what are the important not important steps, but some important take away massages. Screw dislocation step, always edge right, we saw that whether you are using whether we get a kink or a jog, this part we saw it I think two lectures back, whether it is a kink or a jog it will always be edge dislocation.

And if you are writing this then we also need to write that for edge dislocation, jog is edge and kink is screw character. Another important aspect is that, edge dislocation step are always glissile. There may be some particular cases when there is a jog in the edge dislocation, it may not be in a desirable slip plane but and you may need extra additional to move it, but it will not be sessile like the jog in a screw dislocation. For now we will say that edge dislocation step are always glissile whether we are talking about jog which is edge or kink which is screw.

What are the other important take away massages from what we have seen today? That edge dislocation give rise to glissile step, that can move conservatively. So, meaning of sessile or glissile it is also that when it is glissile, it would move it will be more conservatively, when it is sessile then you need sessile activation it will have to climb to be able to move as we will see in few more where we look about other kinds of jog, which are called super jogs; but before that let us summarize what we have learned so, far. So, in edge dislocation we get glissile step that can move conservatively.

On the other hand, screw dislocation this is the most different in nature, in that screw dislocation jog which is edge character not with whenever it is screw dislocation step, it will always have a edge character whether jog or kink. So, screw dislocation jog is sessile, can still move forward remember that if sessile does not mean it cannot move forward. It can move forward only by non conservative process, which requires stress and thermal activation. So, stress is anyways necessary, but along with stress you need thermal activation.

So in other words it is temperature dependent. So, these are some important take home message from the intersection of dislocation and the steps which are jogs and kinks. Now, let us look at what we were talking about non conservative motion of these sessile edge dislocations that are formed in jogs that are formed in the screw dislocations. So, let us say we have.

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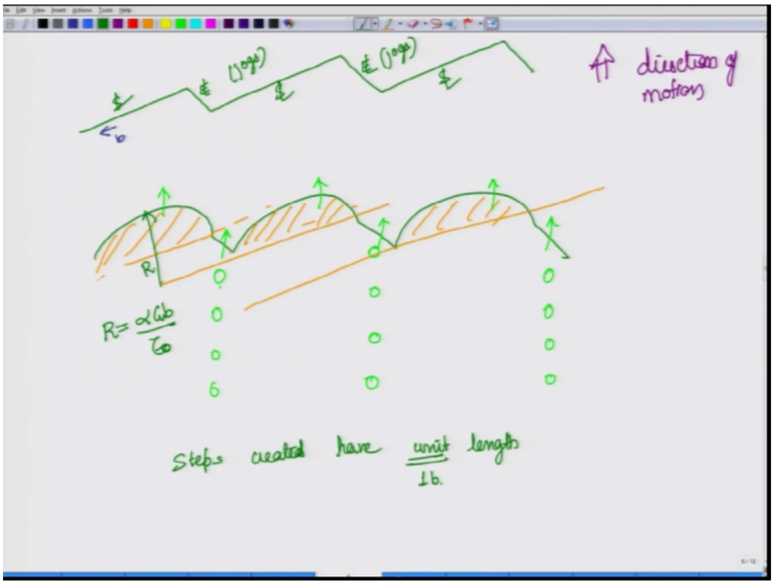

So, we have a dislocation line like this, where steps have formed and these are the screw dislocation part and these steps whether jog or kinks should have should be edge in character, but since we are talking about jog. So, this these are jogs because we are interested in what happens to this jogs why do if they are if they are sessile non movable what do they how do they influence. So, we will look at this. So, these are screw dislocation and this is the edge dislocation part, now if you if the dislocation motion is taking place in this particular direction. So, let us say this is the direction of motion and what will be the Burger vector? Now, that we are talking about dislocations. So, let us also describe what will be the Burger vector, it has to be parallel to the screw dislocation.

So, the Burger vector will be like this and which way would be the result shear stress result shear stress will have to be either like this or like this. If the result shear stress you remember, whenever it is causing the motion it we have to have a result shear stress along the Burger vector. So, we must have a result shear stress along the Burger vector, it may in this direction or in this direction depending on whether it is moving forward or backward. So, what will it lead to? It will lead to a motion like this; over here this is the slip plane for the screw dislocation and this is one plane. So, both all of them are in different planes as you can realize. So, this is one plane this is another plane, this is still another plane and all of them are moving, but this part is sessile it is not moving and it remains pinned over there.

So you can see a larger stress would be required to form a curvature over here and this is that what is the origin creese in the strength of the material because of the presence of this sessile dislocations. And let say you are applying thermal agitation and sufficient stress, then it would lead to the overall this sessile dislocations would also move upward along with the dislocation, but at the same time it will be leaving behind a trail of vacancies, you remember that whenever a climb of edge dislocation takes place it leaves behind vacancies there must be vacancies getting formed over here.

So, this is the motion and here you will have let us say we can describe a radius R. So, we can also say that the radius R which will be formed over here would be given by. If tau naught is the stress being applied, then radius of these curvature radius of these dislocations would be equal to the alpha Gb by tau naught.

In all this cases the steps that we have looked at what is the length? How much would be the length? The length would be one unit length unit length which is equal to one Burger vector. So, that jogs. So, for we have discussed are simple jogs.

Now, we will discuss something about what is called as super jogs. So, this is the behavior of a simple jog now how do these super jogs behave; what are these super jogs first of all.

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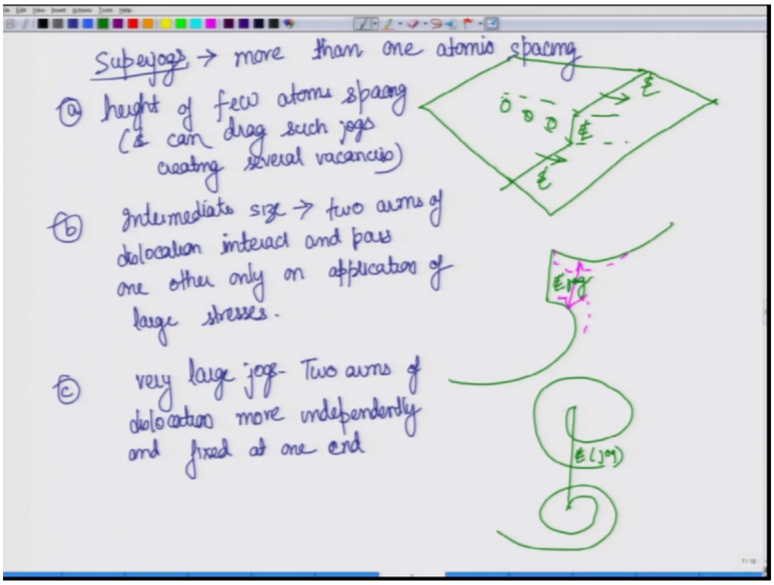

So, as you can realize the way we are describing, the super jogs would be something larger in size than a jog and that is true when more than one atomic spacing. So, the jogs would have one unit length in one atomic spacing, but when you have more than one atomic spacing then it is called super jogs. And there are three categories that you can put; first one is when height of few atoms.

So, it is more than one, but still only few atoms spacing; in this particular case you have something like this, screw dislocation there is a jog which is a little larger than size and if the whole thing is moving this will also drag the edge dislocation however leaving a trial of vacancies behind.

So, this can move what we are trying to say that, when it a few atoms thick it can still move and when it moves because this is climb of the edge dislocation, it will leave behind a trial of vacancies these are the screw dislocation parts. So and you must realize this is the edge dislocation part, which is few atoms thick.

So, if you want you can even draw. So, the screw dislocation can drag such jogs and creating several vacancies, intermediate size. So, this is the super jogs. So, super jog size now you can have intermediate size, what is the intermediate size? It is such size where that if you look at the dislocation now here it is the jog and if you have the two of these, then it is neither too small that it can be dragged it is sessile, but at the same time it is not so, big that there is interaction between the two.

So, the two arms keep interacting and they will and since they are interacting it will not overlap to this region for that overlapping you will need very large stress because there is interaction between the two arms of the dislocation. So, that is the intermediate size. So, in the intermediate size two arms of dislocations interact. So, that is the important thing, that they interact it is not too large that they become too far and there is no interaction between them, neither it is too small that it can be dragged. And can pass one other only on application of large stresses.

So, this the second size now you have the even larger size, very large jogs and what will be the characteristics of this? Based on this you can realize this one will be obviously, very large, but what will be more important is that this arm which is over here will be independent of the other arm. So, it can form anything any loop like this over here this one can form any loop like this. So, the other end is free, but this end of this dislocation it will act like a independent dislocation, whose one end is free and other end is fixed.

So, similarly over here, this will also act like a independent dislocation where one end is free and the other end is fixed. So, very large jogs two arms of dislocation move independently and fixed at one end. So, here you can realize that the distance between the two parts and let me to make it clear, let me clearly mention that this is the edge dislocation jog this is the edge dislocation jog.

So, this is the jog we are talking about, this is the jog we are talking about, this is the jog we are talking about and in this particular case the last one that we discussed very large jog this is. So, large in size that these two parts the other end of these dislocations they are independent, they do not feel any stress because of the other side and therefore, it can form loops or whatever because of the local stresses because of the effect of the local stresses, it can form or take shapes. It does not have to shape will not be determined by what is going on the other side of the dislocation.

So, now that we have looked at these jogs and kinks it is time to look at some very simple problems.

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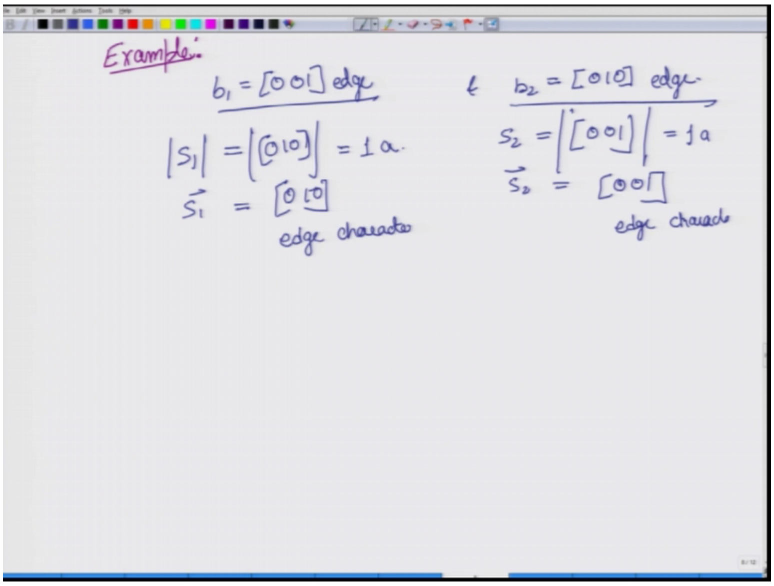

And so, far what I showed you was with respect the all the intersection of dislocation was with respect of drawing. But now let say you do not have a drawing and I like give you just the Burger vector and the line vector can you interpret these. So, let us look at it. So, in the first case what will give you is that the there are two dislocations; obviously, where you have Burger vector equal to for the one dislocation 001 and for the second dislocation the Burger vector is 010.

So, now we have to describe the intersection of these edge dislocation. So, assume that this is a edge dislocation and this is a in fact, I do not even need to mention that let us for the for the sake of simplicity, because there are some more information that we can extract. So, let us say that these are two edge dislocations. So, be the argument two edge dislocations one is 001 another is 010. So, we are assuming a simple cubic type of system, where the slip direction is 001 and the slip plane is 001.

So, what will be the step in here and what will be the direction what will be the magnitude what will be the character? So, let us look at first in the step in over here what will be the magnitude of the step over here? It will be equal to 001 magnitude of this equal to 1a and what will be the direction? It will be equal sorry I should also write 010 and the direction should be because we are talking about Burger vector screw dislocation 1. So, it should be equal to 010.

Similarly, for S 2 it should be equal to 001 magnitude of this, which is equal to 1a and direction should be equal to 001. Now this is the direction the Burger vector is these two are perpendicular therefore, it will be edge character here this is the direction this is the Burger vector these are again perpendicular therefore, this will be a edge character. So, we do not need to know what is the line direction over here, just by looking at that to Burger vectors we can say that this is how it will look like and this is what we get in this particular one and we will try to solve some more examples in the next time that we meet. So, we will end over here.