Introduction to Materials Science and Engineering
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Lecture - 03
Unit Cell

Hello. So, we are on the topic of geometrical crystallography last class we discussed.

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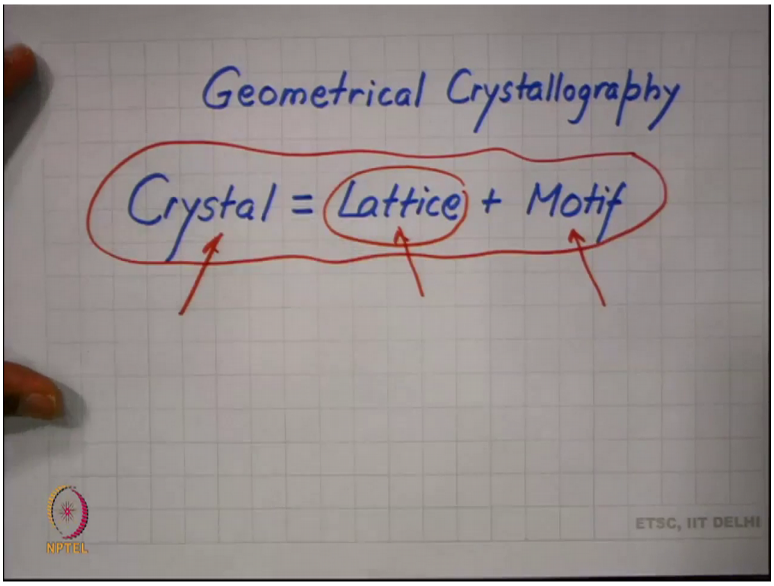

This important relationship crystal is equal to lattice plus motif, we defined crystal, we define lattice, and we define motif. Now in this class we will look at little bit more detail about some of the properties of lattice. So, lattice will be the focus of this session.

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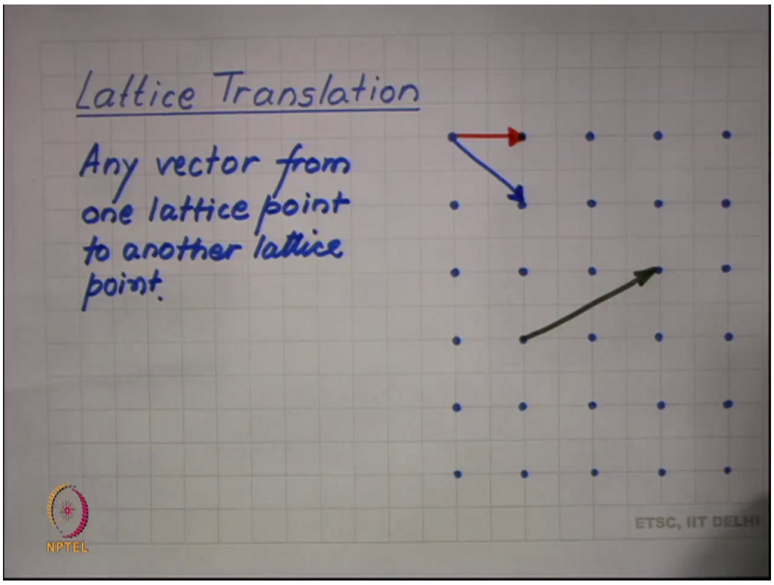

We begin with lattice translation, we already have a periodic set of points which is a lattice, and I have drawn an example here a nice simple is square lattice. Lattice translation is we can define as any vector from one lattice point to another lattice point, I will draw some examples here

So, for example, I take this this as my lattice point, and I draw a vector horizontal vector up to the next nearest neighbour, in the horizontal direction. So, this red vector is an example of a lattice translation, or if I wish I can draw another vector like this, there is also a lattice translation, for yet another I can start from here, and draw this vector this is a lattice translation. So, all these vectors are lattice translation of course, a lattice will have many such lattice translations. We will now define a unit cell.

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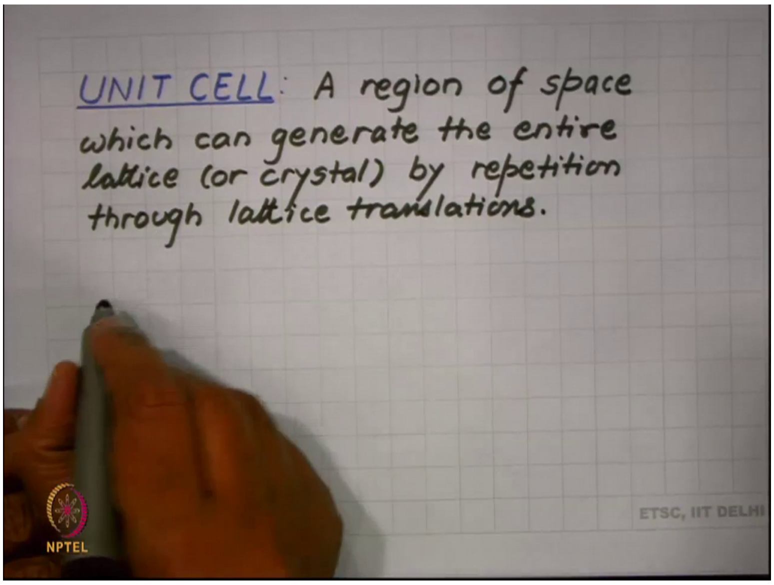

Let me first give a little abstract definition. So, I will define a unit cell as a region of space, which can generate the entire lattice or crystal by repetition through lattice translations.

So, connected region of space which can generate the entire lattice by repetition, through lattice translation will be called the unit cell. The unit cell can be either of lattice or of crystal. We will see let us see some examples.

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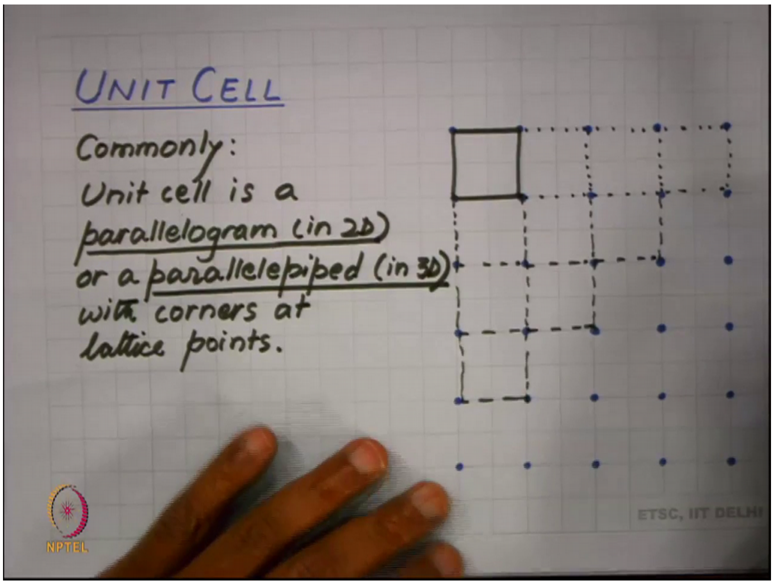

So, we have commonly although that is an abstract definition commonly a unit cell is selected unit cell is a parallelogram in 2D or a parallelepiped in 3D with corners at the lattice points, different shapes can be selected, but the common shape which is selected is a parallelogram in 2D or a parallelepiped in 3 d.

So, again I have an example of a 2D lattice here, and if we wish we can select a square in this lattice, this square will be the unit cell. Because if I repeat this square this is square has corners at the lattice point, and if I start repeating this square I see that I can get the entire lattice all the points can be obtained by such repetition. So, I have to periodically translate these unit cells, and I have to recognize that lattice points are at the corners; however, a given lattice has not one-unit cell, but many different unit cells. So, the unit cells are not unique.

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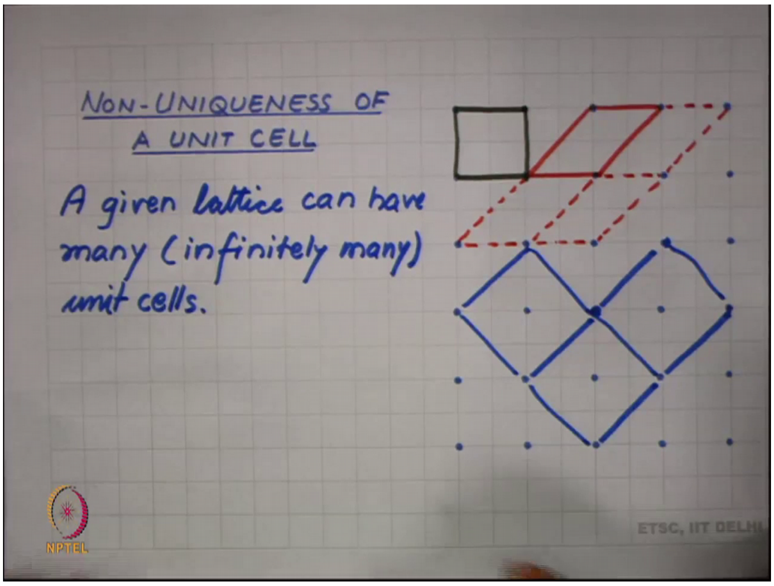

A given lattice can have many. In fact, infinitely many unit cells, we will see here for example, in the same square, lattice initially we had selected a nice square as our unit cell, but in the same lattice if I saw this I can select this red unit cell which is no more a square, but a parallelogram. And if I repeat this parallelogram, I again can generate the entire lattice, also we can select larger unit cells for example, if I saw this I can select a larger is square, in which now lattice points are not only at the corners, but also in the centre of the square this is also possible. So, we have many different unit cells for the same lattice. The unit cells which I showed you can be classified as primitive and non-primitive unit cell.

So, any unit cell. So, let us define that.

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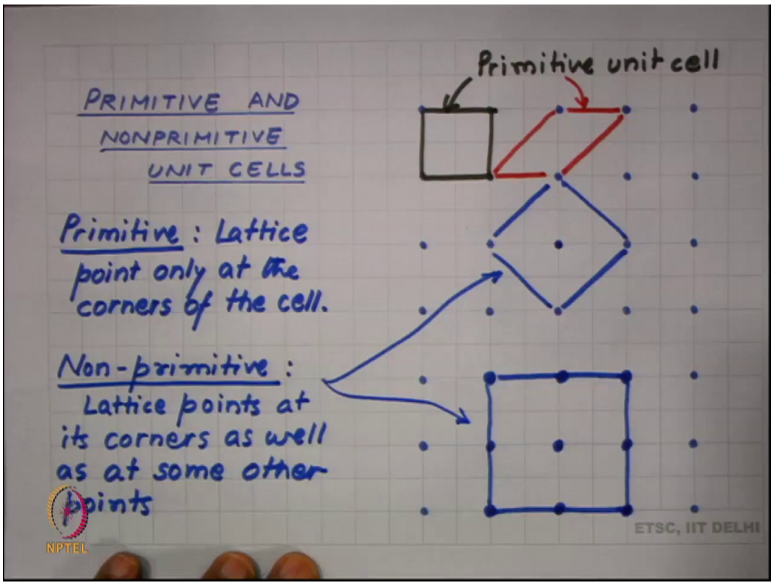

Primitive unit cell will have lattice points only at the corners of the cell. So, we have already seen for example, the square unit cell which we selected, will qualify as a primitive unit cell. The red unit cell the parallelogram unit cell this is also a primitive unit cell, because by this definition this also has lattice points only at the corners, but the larger group blue unit cell which we had selected last time this will be example of unit cell which is not primitive.

So, the non-primitive unit cell, non-primitive will also have lattice point at it is corner, but it will have some lattice points other than the corner points as well as at some other point. So, this will be example of a non-primitive unit cell, and both you can have many different primitive unit cells, you can have many different non-primitive unit cells as well for example, if I choose a still larger screen let us say like this, this also is a parallelogram with lattice point at it is corner. So, it qualifies as a unit cell, but apart from the corners it has lattice points cells edged, and it has a lattice point at it is centre. So, this will be another example of non-primitive unit cell.

We now define what is called a crystal coordinate system. Once we have selected our unit cell. So, let us select the unit cell.

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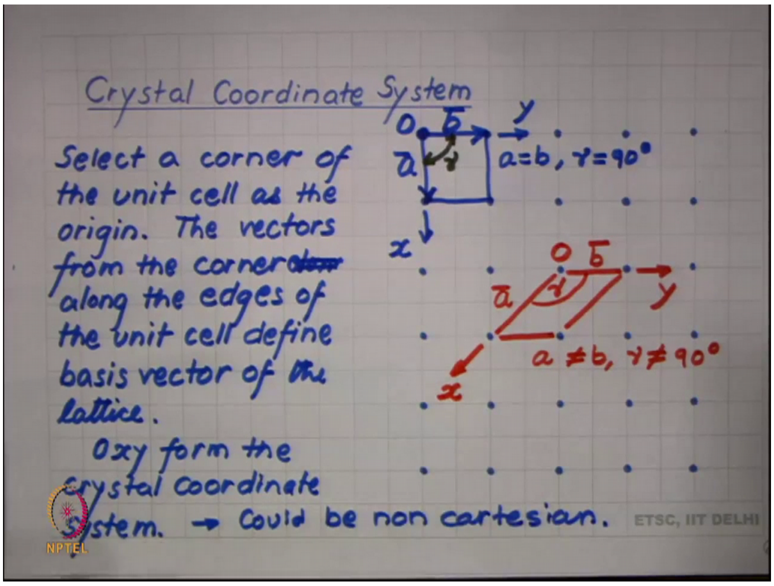

So, unit cell itself parallelogram or parallelepiped unit cell are defined by the vectors along it is edges. So, select a corner of the unit cell as the origin, the vectors from the corner along the edges of the unit cell define basis vectors of the lattice. So, we have selected this as the origin, along the edges we have these 2 vectors a and b. So, a and b becomes the angle between them is gamma, we can select or we can also define these as the axis these our x axis, this is our y axis, this was origin o. So, o x y form the crystal coordinate system.

So, of course, the crystal coordinate system is associated with the selection of a unit cell. So, if we select a different unit cell for example, if we select this parallelogram unit cell, then my x and y are no more orthogonal, my a and b are also not equal and the angle gamma is not 90 degree. So, in this case a was equal to b, and gamma was 90 degree, but here for the same lattice I have now selected a different coordinate system where a is not equal to b, and gamma is not equal to 90 degree.

So, crystal coordinate system can be non-cartesian, we now will define the lattice parameters.

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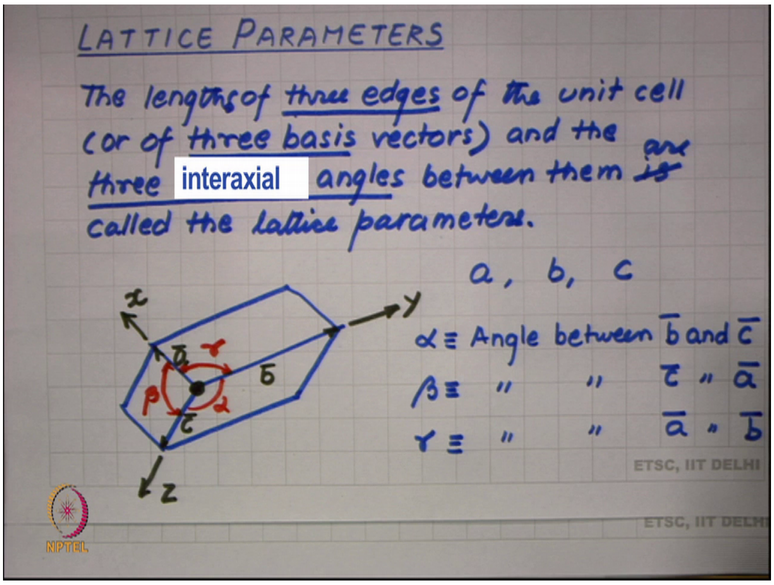

So, for any given unit cell the length of 3 edges of the unit cell or in other words of the 3 basis vectors. So, the lengths of 3 edges of the unit cell or the 3-basis vector, and the 3 interaxial angles between them are called the lattice parameters. Now I am talking in 3 d. So, that is why we are talking of 3 basis vectors, 3 edges and so on of course, in 2D there will be 2 basis vectors, and 2 edges and there will only be 1 angle, 3 interaxial angle in 3 d, one angle in 2D.

So, let me try to draw a parallelepiped unit cell to define these. So, suppose I have a parallelepiped unit cell and I choose this as my origin, and choose this as my x axis, y axis and z axis. So, they are not necessarily orthogonal, and the corresponding length a, b and c, these are also not necessarily equal, and we have 3 angles angle between b and c alpha, angle between a and c beta, an angle between a and b gamma. So, the 3 lengths a, b and c and the 3 angles alpha, angle between b and c, beta angle between c and a and gamma angle between a and b. This is the convention of naming alpha is always taken to be angle between b and c and so on.

So, once these 6 numbers are given we have the complete description of the. So, called lattice parameters of the crystal which means if we are given the lattice parameters, then we can construct the unit cell of the crystal.

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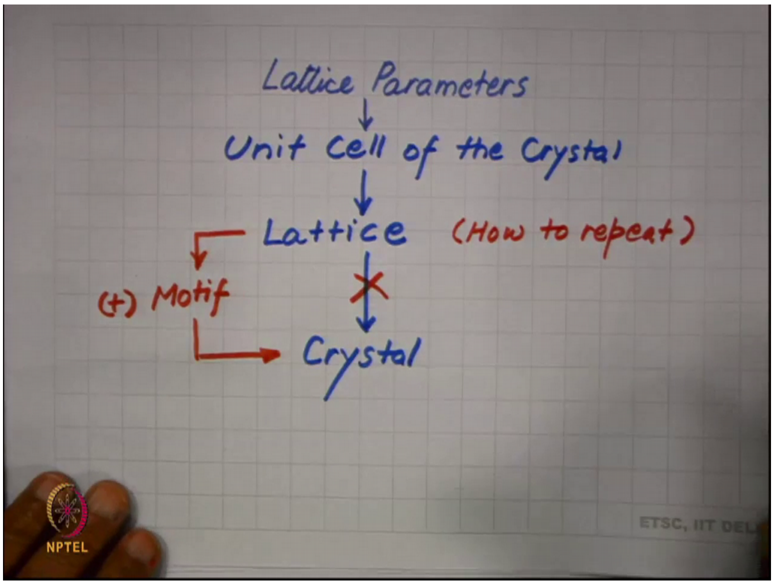

If we know the unit cell by repetition of the unit cell we know the lattice, and if we know the lattice then we have the information about crystal, or am I making a mistake here lattice parameter gives me the unit cell unit cell gives me the lattice, but lattice gives if you have been following this video till now you will be worrying about this lattice from lattice going to crystal, because we have said the lattice only gives me what how to repeat, lattice gives me, but it is not giving me what to repeat, and unless and until I know what is being repeated, that is unless and until I know the motive I do not know the crystal. So, this is not right I have to come through I need the information about motive. So, if the motif information is given then only I know about the crystal.

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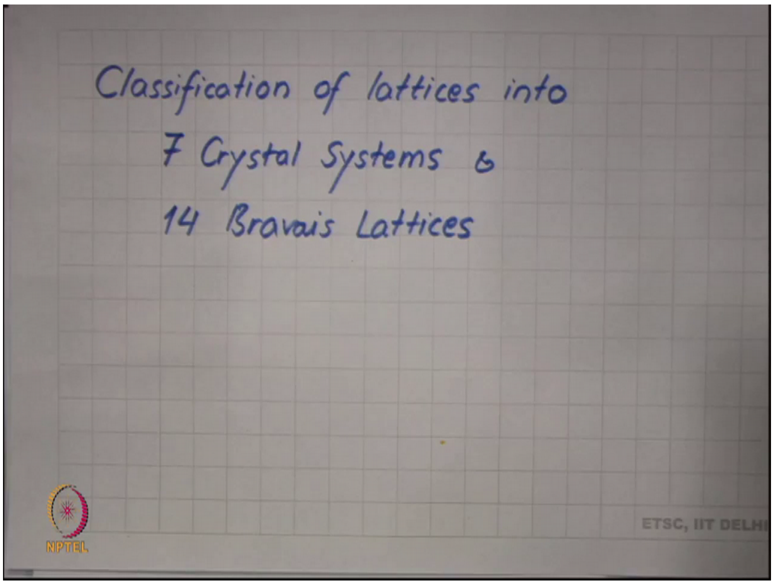

So, we will continue this in the next video which classification of lattices into 7 crystal systems and 14 bravais lattices, this will be our next topic thank you. So, thank you the next topic will be classification of lattices into 7 crystal systems and 14 bravais lattices.