This video includes module number 3, titled Lattice Translation vectors of Unit-1, that is Crystal structure. In this video we will be covering crystalline state and lattice translation vectors. After learning these topics, the students will be able to construct lattice translation vector in space lattice and also will be able to identify lattice translation vectors in space lattice. What is crystalline state? A solid is said to be a crystal if the atoms are arranged in such a way that their positions are exactly periodic. The distance between any two nearest neighbours along the X direction is a along the Y direction is b and along the Z direction is c. It is important to note here that the X Y & Z axes are not necessarily orthogonal. A perfect crystal maintains this periodicity in all three directions from -- Infinity to + Infinity. To an observer located at any of these atomic sites, the crystal appears exactly the same. Now let us try to understand, what are lattice translation vectors for a 3-dimensional space lattice? For any type of lattice, there exist three fundamental translation vectors a, b & c, as defined before. They are the shortest vectors along the three crystallographic axes. We specify the condition that if we go from any initial point in a crystal to another point by the translation vector T. The translation vector T can be represented in terms of fundamental translation vectors a b c, as n1 a + n2 b + n3 c, where n1 n2 and n3 are integers. The new point, which we arrive has identically the same environment as the initial point. A translation vector can connect any 2 lattice points inside the space lattice. The significance of lattice translation vector is to retain the translation symmetry in space lattice. Let's consider an example of three-dimensional unit cell. The lattice translation vectors if you see here a b & c, they represent three fundamental translation vectors whereas the T, it is starting from this lattice point and it is reaching this lattice point, that is represented by the vector T. And T can be defined as we discussed before, n1 a + n2 b + n3 c, in terms of a b c, three fundamental lattice vectors. And at this point it is interesting to notice that it is moving in this way, so the multiplicative factor with a is 0, the multiplicative factor with b is 2 and the multiplicative factor with c is 1, so n1 n2 n3, all three being integers, so T can be considered as a lattice transition vector for this 3D space lattice. Now coming to the fundamental translation vectors for 2D space lattice. Always it is easy to understand the concept using 2-dimensional pictures. So, the two vectors a b form a set of fundamental translation vectors for the lattice and here this is a and this is b could be giving us a unit cell in this 2D lattice. This is shaded one represents that unit cell. Similarly, a & b’ also could be considered as another unit cell, where this lightly shaded portion represents that. So, it is not hard and fast that it has to a space lattice has to have this specific or particular shape of unit cell. It depends on the type of crystal structure. Now coming to the lattice translation vector of the two-dimensional space lattice we discussed in the previous slide, look at here the translation vector T can be presented as n1 a + n2 b, a and b being fundamental translation vectors and let us check the point D. The point D Starting from origin O, we can reach point D as n1 being zero and n2 being 2. Similarly, the point F we can reach starting from this O, n1 being zero and n2 being --1 because it is going in the reverse direction or negative direction. And the Point C can be represented n1 being 1 and n2 being 1. Similarly, the point P can be represented n1 being 2 and n2 being 2. And the point Q can be represented n1 being 3 and n2 being 2. So, all the translational vectors could be used to start from O to reach either point D or F or C or P or Q can be called as translation vectors because n1 and n2, in all these examples, they are integers. Now let's come to another example. Yeah, already we have discussed a & b are fundamental translation vectors and O here any lattice point could be taken as the origin. And if it is at point P this is a point P, if I have to get a translation vector for the point P it could be represented as a +

2 b. Similarly, Q, it will be represented as – a, because in the negative X axis we are going and – 2 b, negative Y axis we are going. Now let us consider that to start from the point X, which is not a lattice point, it is the midpoint between the two lattice points here, and we go to the point Y again, that's a midpoint of two lattice points. OK, so how do we do it using a translation vector / lattice translation vector? The point X is represented by the vector R. And the point Y is represented by the vector R'. The simple vector addition gives you R' is equal to vector addition of R & T, where T is the translation vector. Now let's see what is the translation vector, whether it is a translation vector? So, from this midpoint to this midpoint when we go, it is just 1, 1 into a, so that is a and then from here when we go 2 units up that is 2 into b. So, in this case the point situated at X & Y have identical orientation, with respect to the neighbouring lattice points. Similarly, here another example been taken. Yeah, a & b, are the fundamental lattice vectors and three vectors are drawn here and **PQ**, one vector with the tip, and here **RS**, another vector with this way the tip and then, **MN**, another vector, this way the tip. If we present these vectors, considering this as a origin, then **PQ** can be represented by 3a + b, **RS** is represented by -- 4a – 2b, whereas **MN** is represented as 2.5 a -- 1.5 b. From these three vectors, it is obvious that **PQ** and **RS**, n1 and n2 are integers, whereas in case of **MN**, n1 and n2 values: they are not integers, they are fractions. So, **MN** vector is not a translational vector. The significance of lattice translational vector is as I said, to retain the translation symmetry in space lattice. And, it identifies the location of any point within a crystal cell. It identifies the direction of any vector and also it gives the orientation of any plane in the crystal. With this we come to the end of model 3.