Engineering/Architectural Graphics – Part 1 Orthographic Projection
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Lecture – 15
Locus of Points

Good morning. Welcome to the last lecture of this week 3 of the ongoing online course on architectural graphics or engineering graphics and by this time we have already covered the orthographic projection of points. And what we have already covered is also the curves used in engineering practice which is cycloids, epicycloids, trochoids. One thing which remains is locus of points.

Locus is as you might have already learnt in your schools, in previous education is, it is the path traced by a particular point given certain conditions. So, the simplest example of locus is a circle. So, what is a circle? Circle is the path or locus of a point which is moving at the same fixed distance from another given point which is the center of the circle. So, when a point moves about this point which is the center at a fixed distance it is the circle which is the simplest form of the locus.

Some of the shapes which I have already discussed with you, for example, ellipse, hyperbola, parabola are also locus. Now, why at all do we need to understand about locus and why at all in architectural graphics or engineering drawing? Now the reason is because we make a lot of machines, we make a lot of objects which will have movement and there will be a fixed movement.

So, for example, a very simple examples the door. So, what happens in a door, the hinge acts as a pivot and the straight line is where this panel is fixed. So, the point on the edge of the door or thickness of the door is at the same distance from this fixed frame that again traces an arch which is part of a circle which has its center fixed on this frame. So, that is a locus. We have several, this is the simplest one.

We have slider window that is again a locus. So, if you look at the projection of lines which is what we have covered. We have seen that when inclined a line to either one of the planes its locus remains a straight line that was especially visible when we were looking at the doubly inclined line. So, what is happening in a slider window that its locus, its distance from the two fixed rails that remains the same.

And that is how it moves and it is a movement which is in one single plane. There could be complicated locus also where the plane of movement of this object may change as well that is what we would need. And why do we need this in orthographic projections or engineering drawing is? Because when we are designing these machines, when we have to say design an internal combustion engine.

Now how will the piston moves, how is it moving along a defined path that is the locus and when you design this combustion engine, internal combustion engine you not only have to know the physics of it, how much force, how much energy will be generated, what will be volume and all that. But you also have to understand the mechanical aspects of it that how will the piston the move, what will be its path, what will be movement of the crank which is going to move this piston, this slider.

So, you have to understand both and once you have understood that we also have to draw it because you will be designing the machine. That designed machine will then go into manufacturing and it will then be produced, manufactured and it will be worked out, it will have its function. The more accurate your drawing is and the understanding of this movement is, the better will be the output in terms of machines.

That is why we need to understand about the locus. There are a variety of locus but here in this lecture as part of this course we will be understanding about very few simple locus. There is no limit to what all possibilities are there. You can understand them I am sure you must be watching some of the series which is available on a NATGEO and a lot of other channels where they talk about food factories, you know, the huge food factories and various other factories.

Now all that you see there is how these machines are working. And these machines are nothing, but they are complicated movements of different parts. How one machine picks up an object from this point and puts it to the other and it is always a repeated motion which implies that there is always a locus which is there. The part of the machine moves along that locus and it keeps repeating.

The speed of it how fast, how slow at what appropriate time and then interconnection of various different locus what you will ultimately be doing it will be leading to, but I will start with the simple locus here. Circle is one.

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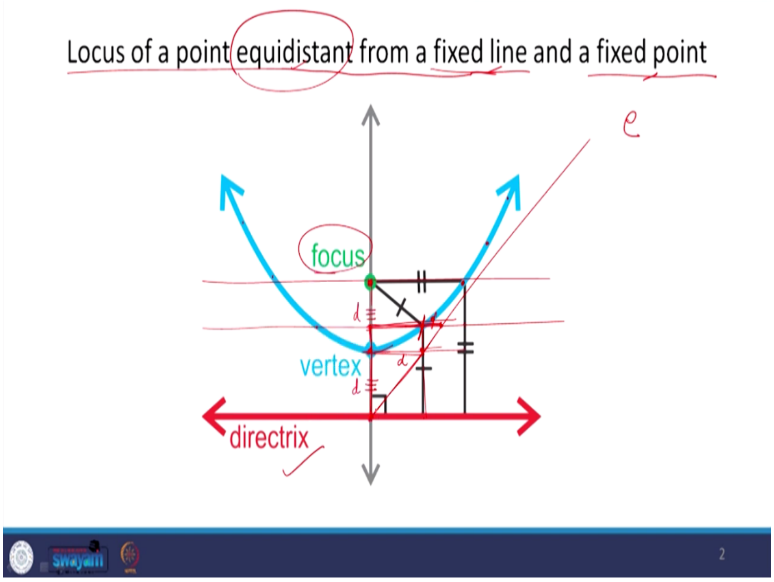

The other which we have already talked about is a parabola. Now, what is a parabola? Parabola is the locus of a point which is equidistant which means at the same distance from a fixed line and a fixed point. So, this is the fixed point which is called the focus of the parabola and this fixed line is called the directrix of this parabola. Now, the path the locus of this point which is at equidistant from these two is parabola.

So, what we are doing here is the first thing that you do is locate the vertex which is what we have also seen in the geometric construction sometimes. So, we locate the vertex which is equidistant from both directrix and focus and which is lying on the perpendicular passing through the focus and which is perpendicular to the directrix. Now, what we have to do? We have to trace different points which are equidistance from the focus and the directrix.

And we have already seen the process, the mechanism of drawing it. The simple thing is we draw parallel lines, lines which are parallel to the directrix. Now any point on this line the distance that it has from the directrix will be the same distance which we will have from the focus. And what it be? So, suppose we look at this point which is the vertex so this was the same distance we had.

Now if this was the distance d, suppose and I make another line perpendicular to it which is at d. So, these two are equidistant and if I join this line then I will all the time get this distance equal to this distance. So, what we will do? This distance is the distance that will be on this line say this. And if I take the same distance from focus f or from this focal point f I will get a point.

So, what I am getting actually is say this distance and I will cut it on to this line and I get a point the points of a parabola. This was exactly the similar process which we used to draw hyperbola. The only thing being it was not equidistant, it had eccentricity. In case of ellipse this point was closer to the focus and farther from the directrix which is the straight line. In case of hyperbola it was opposite it was closer to the directrix and farther from the focus and that is how three different curves, three different locus are arrived at.

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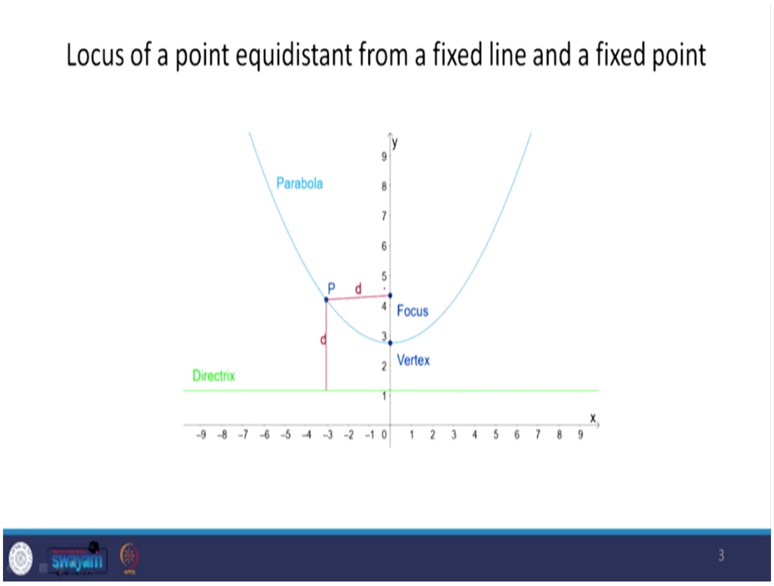

So, if you see this is how we will get a parabola generated. So, this parabola all the points on this parabola which is the locus they remain equidistant from this line directrix and the point which is focus. So, this is one of the simplest type of locus and the path traced the parabola is one of the most common types of locus which we will be using which in engineering we often use.

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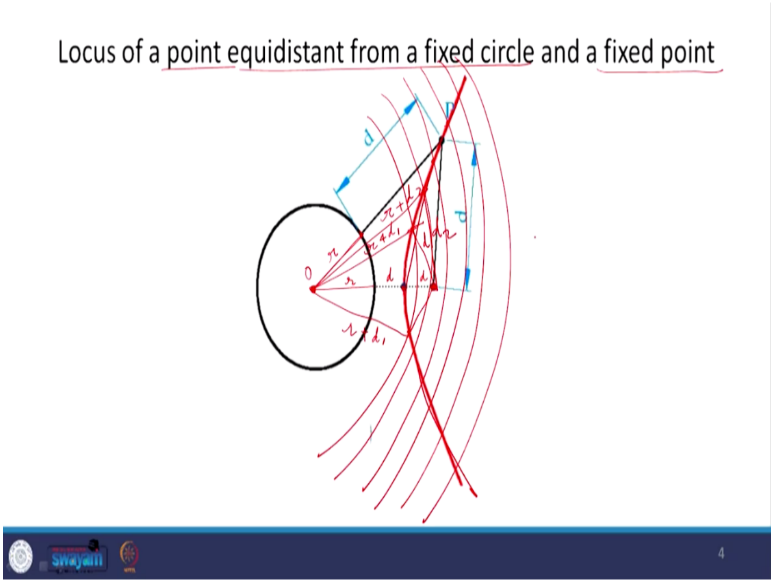

Another type of locus is where we have a point the locus of the point which is equidistant from a fixed circle. So, instead of a line it is equidistant from a circle and a fixed point. In that case, any point which is at a distance d from this circle and say there is a radius r. So, the point will be at a distance d from the circle and d + r center from the center. It will always be through the center that this distance will be measured perpendicular to the circle.

So, what do we do here is very simply to draw it if you look at the construction procedure. We will draw concentric circles. So, we draw several concentric circles with the same center O. So, the center remains the same and we draw several concentric circles. Now, what happens in this case this distance is d and from the center it is d + r and from this point it is d this is the vertex.

Now, the next point say anywhere so if I take a distance of any distance say d 1 so when I take d 1. So, if this d 1 if I mark d 1. From the next distance that I will be marking will be from the center of the circle which will be r + d 1 that is the next point say this is again here symmetric here. So, this is r + d 1. Next, I choose any distance d 2 which is here so this is d 2 the distance from the center will be r + d 2.

And I keep getting these points as a distance of d + r from the point d nth + r which is constant fixed which is the radius of the circle, from the center of the circle and from this point it will be only be this distance d n which is the nth distance we could vary and in this manner we will get this curve. Now, this is also a very commonly used mechanism in the movement of parts of machine not holistically. So, this is another commonly used locus.

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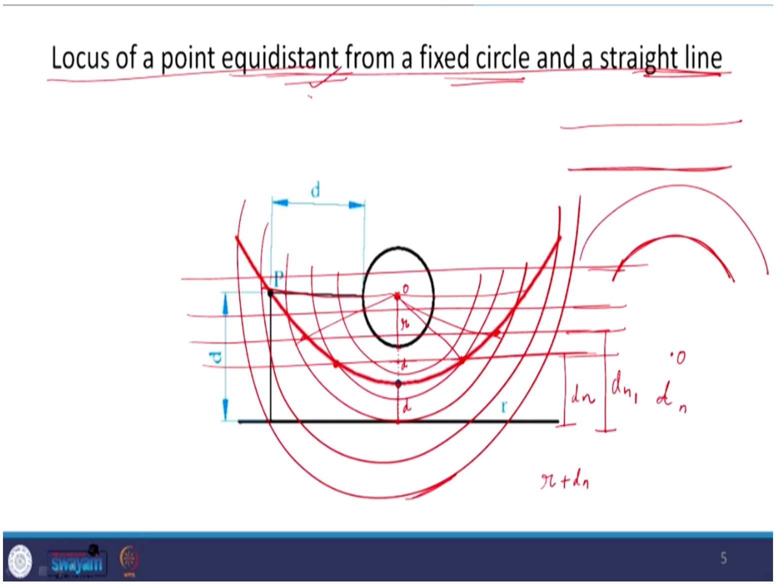

The next is when we have a point which is equidistant from a fixed circle and a straight line. Now, in all these different kinds of drawings where the point is going to be equidistant or even if it has an eccentricity that it is closer to the point or closer to the line. We will always locate the vertex first it is always the vertex that we locate. So, here also what we have done it we have located the vertex.

Now, exactly similar to what we did in the previous example just before this. We will locate the center of the circle and whatever distance this point will have from this circle which is say d it will always be added by a distance r if we are to measure it from the center and which is easier because the point of this circle itself is a locus it will move, but the center of the circle will not move.

So, we will always take it r + d and then this remains d that is what we are going to be taking. So, from this straight line now in this case what do we do? In the previous case, it was a fixed point and a circle. In this case it is a circle and a line. So, what we draw? We draw concentric circle with this point o as the center. It remains constant. So, I mistakenly drew the curves parallel to this locus, but what we have to draw is we have to draw concentric circles.

So, it will be concentric circles where the center of the circle remains the same. So, these are concentric circles. Now, the other thing that we draw is we draw lines parallel. So, we also have parallel lines. Now I will take any distance. So, if I take any distance d n .We will take this distance d n at which this line has been drawn which is the same distance. So, this is the distance d n. Now this is this distance d n and r + d n will be the distance from the circle.

So, I will draw a circle of radius r + d n and whatever the circle intersects this line at a distance d n will be the point on this locus. Similarly, you have say d n 1. So, the radius for this DN 1 somewhere where it say intersects will be r + d n 1 and then r + d n 2 and likewise. So, that is how we will draw this and this will be the locus of a point which is equidistant from a fixed circle and a straight line.

So, in a sense whenever we are drawing a point equidistant from a circle we will take concentric circles and the locus will be passing through those concentric circles. In case when it is equidistant from a straight line, we will be drawing parallel lines to that given straight line which is often called the directrix. So, that is again one of the fundamentals which is if the locus of a point which is equidistant from a straight line will always be a line which is parallel to the given line.

In case this line is a curve it is not a straight line in that case the locus of a point which is equidistant from this curve will be a concentric curve having the same center. These two are basics which we have to remember and then with the help of these by drawing concentric circles or parallel lines we should be able to achieve any given condition which is incorporating some given distance from a fixed circle and a fixed straight line.

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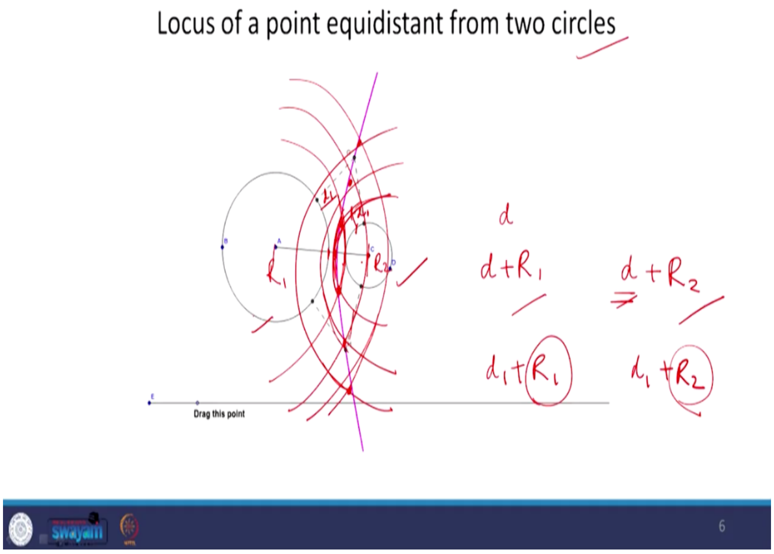

So, there is another one which is quite interesting where the point is equidistant from two circles and that generates a very different curve altogether. Now in that case what will happen if you remember what I have just told that we will be drawing concentric circles to both these circles the given circles and then. So, this curve is where I am not drawing it freehand properly, but this curve will actually be the intersection of both of these circles.

Wherever both these circles will intersect will be where we will get this curve that is what this curve is. In this case it will be there will be this radius R 1 and say R 2. So, whenever we take is the point is going to be equidistant from the two circles which mean that this distance. So, the point is at a distance of say d from circle a and circle b. So, the distance it has from the center of the bigger circle is d + R 1 and from the smaller circle is d + R 2.

So, this d remains constant and R 1 and R 2 remain constant and this d changes. Every time we have to get a different point. We will just decide okay the next is say d 1 and the distance that we will measure is d 1 + R 1 and here d 1 + R 2 and we will measure it from the center. So, suppose this is a circle which is offset at a distance d 1 we will draw another circle which is offset at the same distance d 1.

And the intersection of these two will be a point which will be defining the locus of this point which is equidistant from the given two circles which is this and this. Now depending upon what are the radii of these two circles we will get a different curve and also how far are these two circles placed. If they are placed too close then we will get a different curve if they are placed too far we will get a different curve. So, that is how we will get the new curve, get the locus of this point.

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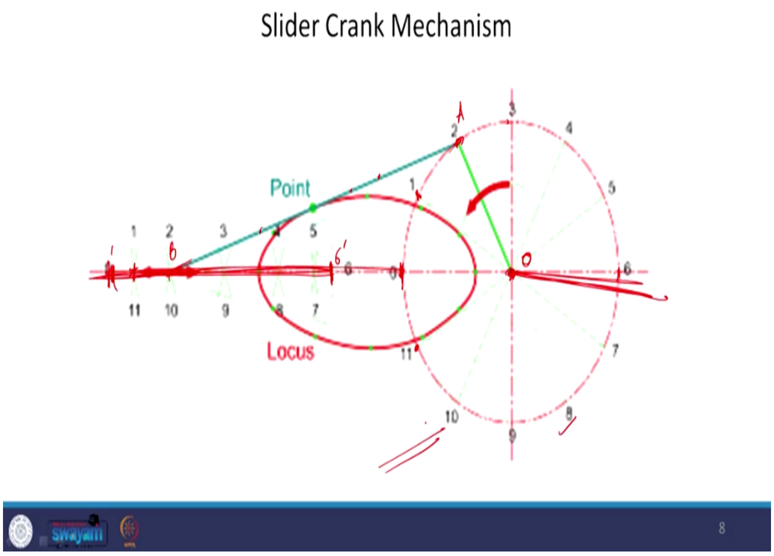

Now the last one which I am going to discus here is this slider crank mechanism which is the most common example of the locus that I can give you. Now in this case what is actually happening is that we actually have a crank which is this green line say O A and we have a shaft or the slider which is this line a b which is exactly how the internal combustion engine or your sewing machine in very common sense you must have seen a sewing machine.

So, what happens we move this crank. So, the handle of the machine is actually moving the crank of this machine which is sewing machine and this crank is connected to a shaft which moves in the case of sewing machine it moves in a linear manner up and down. So, it moves up and down. In this case, this move likes this. So, it will move horizontally along a slider that is how it will be moving.

Now, what happens to do this we have this O A and the locus of this O A this crank is a circle we have already seen that this is the simplest. So, what we will do just as whenever we have to divide or we have to locate the locus of any point on a circle we will divide this circle into certain number of parts some equal parts. So, in this case we have divided it into 12 parts like this and every time this point moves.

So, in the position O 0 we will have O A which is the length of the crank and then a b which will be or say the next zero position O dash so 0, 0 dash will be equal to a b which is fixed. So, this is the extreme position of this shaft a b and when it goes back here. So this O A remains the same and a b is what comes back as this. So, this will be point 6 dash. So 6, 6 dash will be equal to a b again.

And then every time we take it in a position. So, if this is O A in 1 so 1, 1 dash just that the distance between these two. So, we will have 1, 1 dash equal to a b 2,2 dash equal to a b 3, 3 dash equal to a b. The only thing remains that this b moves in a linear line, it moves on a straight line and we say that it just slides. So, it is moving in a linear line while we are moving this crank in a circular manner.

So, if you look at this movement again what is happening? This crank is moving in a circular manner on a circular path which is the locus of this point a and this point b is moving along a straight line it is just sliding. So, this is the slider crank mechanism which is most commonly used in a lot of machines. Our internal combustion engine and sewing machines are the most common and the easiest example that I can show you.

A lot of other mechanism. Now here before I move on to explain other mechanisms the movement here is determined by determining the locus and in between any point on this bar a will neither be a straight line nor be a circle and the resultant will be a curve similar to a regular ellipse. So, that is what we are going to get. Now, here we have only figured out how it will be moving.

Now imagine or assume it is coupled with equations where the force is being applied. So, how the force is being applied if it is a perpendicular force perpendicular to this which is in the third dimension. So, there will be force supplied from the third dimension and then it will be translated into a circular movement here on this crank and then it will be further translated we have all mechanics coming into play here.

We have all of the physics coming into play here, but all of it starts here with this diagram of movement of this machine. So, it is of utmost importance that we understand how the path is being traced by different points, what is the locus and how do you draw them. Once you have learned to draw them properly you can go on couple them up with a lot of physics and mechanics equations and you will get a full fledged machine.

So, I will close my lecture here you can go on to read about a lot of different types of locus. We cannot possibly cover all of them here. I have just introduced you to this topic so that you can explore more and you can know about all different types of locus and you will be able to draw these on the sheet and hence be able to design certain machines. So, thank you very much for being with me in this lecture. See you again next week till then bye.