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Mathematics for Data Science 1
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Lecture - 12
Rectangular Coordinate system

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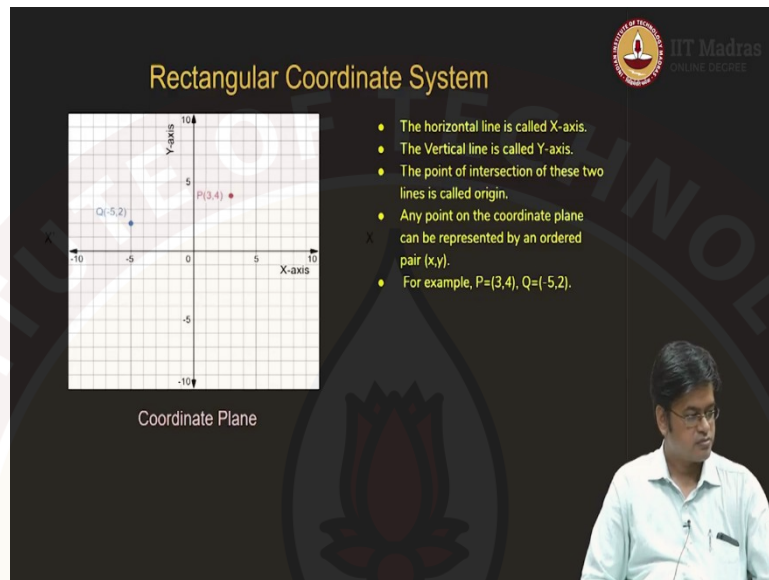
Elements of Coordinate Geometry

Axes, Points and Lines



So, hello students, today we are going to see some elements of coordinate geometry. Now, let us try to identify these elements as axes, points and lines. We have already seen in basic geometry what are points, lines and planes. So, we will further study this and we will study some algebraic properties using coordinate geometry of these particular geometric objects.

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So, in that context first we need to revise our Rectangular Coordinate System; why is rectangular coordinate system important and how we can study. Given a point on a plane; given a point on a plane you want to describe how this plane be how this point behaves or what is the location of this point. Now, if I want to consider this point and I want to describe the position of the point as of now I cannot say anything more than, this point is slightly towards the right top of the plane.

Now, if I introduce a horizontal line over here, then I can say the point is in the upper half of the plane. This gives a slightly better visibility to the point or slightly better description of a point. Now, if I consider a real number system associated with this line then I can say the point lies in 0 to 5, if I plot two perpendicular lines between 0 to 5 then I will get this point.

This is much better. Now, these perpendicular lines can also be replaced with one perpendicular line which is this which has a real number system associated with it. Now, when a real number system is associated with this point, then what you can actually see is if I can consider this, this particular structure or this particular square which is enclosed within 5

on the vertical line and 5 on the horizontal line; I am giving a much better description of a point.

Then I can enhance this further by putting up the grid lines. These grid lines now typically in this case locate the exact location of the point. So, what is the exact location of the point over here? If you look at this exact location of the point is on the horizontal line if you travel 3 units in one direction, horizontal direction and 4 units in the vertical direction then you will reach this point.

So, I can also name this point as in the horizontal direction I have to travel 3 units and in the vertical direction I have to travel 4 units. So, I can name this point as 3 comma 4 that will be a precise description of this point. So, in turn what we have seen just now is a reference system through which we are able to specify the location of a point in a specific manner. Let us analyze this reference system that we have introduced.

Now, in horizontal direction I have to travel 3 units and in vertical direction I have to travel 4 units; that means, I am actually specifying the coordinates in X direction and coordinates in vertical direction. So, in particular these horizontal directions and vertical directions are called X axis and Y axis respectively.

So, if you look at this horizontal direction, you can see the vertical line cuts the horizontal line into two parts; positive part of X axis and negative part of X axis. Similarly, the vertical line is cut by the horizontal line into two parts. On the upper side we have a positive part of Y axis and on the lower side we have a negative part of Y axis.

So, this is a typical structure which is called coordinate plane ok. Now, let us come to the nomenclature of this particular coordinate plane. As I mentioned if I am travelling 3 units in horizontal direction; I will call that as X coordinate and if I am travelling 4 units in vertical direction, I will call that as Y coordinate. Hence, the name coordinates.

These two lines X axis and Y axis meet each other at a 90 degrees angle; that means, both the lines are perpendicular to each other. Therefore, the name rectangular; recta means right in Latin so, rectangular means 90 degrees coordinate system; that means, a rectangular coordinate system. So, let us revise what we have studied just now in words.

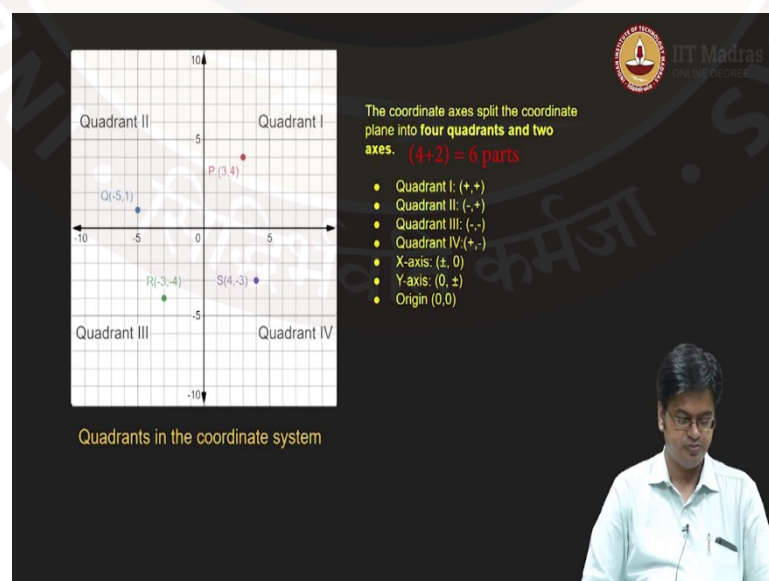
The horizontal line is called X axis, it allows you to move from left to right. The vertical line is called Y axis which allows the movement up and down, then there comes a point of intersection of these two axes which is called origin. The point of intersection of these two axes is called origin and if you look at the coordinates of these, then any point on this particular plane can be denoted by a ordered pair (x, y) .

You can see one blue point is also popping up now. Now, how to describe a point using a coordinate plane? So, for example, given a point $(3, 4)$ how will I locate this point? So, if you look at this $(3, 4)$, we have already seen how to locate it. We have travelled 3 units in horizontal direction and 4 units in vertical direction therefore, $(3, 4)$.

Now, suppose you are given another point which is $(-5, 2)$, then this x coordinate corresponding x coordinate is negative; that means, I have to go to the left of the vertical line. That means, I have to travel here a 5 units distance which is - 5 and on the positive side of Y axis I have to travel that is up upper up upper half divided by X axis I have to travel 2 units which will give me the point $(-5, 2)$.

So, this is how we can uniquely describe points using coordinate plane. Now, when I was when we were studying these two points $(3, 4)$ and $(-5, 2)$, you can easily see with respect to this coordinate axes you can have 4 parts of the coordinate plane.

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Let us study those parts in detail in the next slide. So, next slide is this coordinate plane. Now, I have identified 4 points in all 4 parts of the coordinate plane. So, you can see the first point P which lies in the positive side of X axis and positive side of Y axis has positive x and y coordinates which is given by quadrant I. So, any point in this plane, in this particular quarter will have positive X and positive Y axis.

Now, in general as a mathematical psychology we move in a anti-clockwise direction. So, now, I can move in a anti-clockwise direction to the next one fourth part, next quarter of the coordinate plane. And, see that my X axis has negative values and my Y axis has positive values. All points which have this form of values are called points on the second quadrant or the quadrant the one the quarter of this particular coordinate plane is called quadrant II.

Next we come in a anti-clockwise direction to the third side that is this. So, if you look at the point R which is lies in this particular quadrant is $(-3, -4)$; that means, the x value is negative and the y value is negative. Therefore, $(-3,-4)$ is a point which lies in quadrant III.

Remember it is easy to remember this that quadrant I and quadrant II, quadrant III that is odd quadrants have same parity of x and y coordinates. And, quadrant II and quadrant IV have opposite parity of x and y coordinates. So, let us go to quadrant IV, you can see a point S lies in quadrant IV which has coordinates 4 and -3. Now, this 4 and -3 which denotes x coordinate is positive and y coordinate is negative such a classification comes in quadrant IV.

So, this is how a coordinate plane is come split into four quadrants. Now, a question may arise in your mind; suppose I have this point which is $(5, 0)$. Now, in which quadrant this point lie? The answer is this point does not lie in any of the quadrants. This point lies on the X axis. Similar question can be asked for a point $(0, 5)$. The point does not lie on any quadrant, but lies on the Y axis.

So, based on this particular understanding, a coordinate plane its subdivided into first is four quadrants, two are axes. Let us try to see what are the typical features of the quadrants and these axes. Quadrant I, you will have x and y coordinates which are positive. Quadrant II, you will have x coordinate which is negative y coordinate which is positive. Quadrant III, you will have both negative values. Remember odd quadrants will have same parity that is quadrant I is positive, quadrant III is negative.

Now, quadrant IV will have positive and negative, x coordinate which is positive, y coordinate which is negative. Then comes the split into axes. So, on the X axis you will have points which can either take positive values or negative values for x coordinates and 0 for y coordinate. On the Y axis you will have points which can take positive and negative values for y coordinates, but 0 for x coordinate. Now, there remains only one point which is the point of intersection which is identified as origin ok.

So, this completes our understanding of the coordinate system. Why quadrants, quadrant system is helpful? Sometimes you have been given several points to plot. Now, those points if you look at them closely, you need not have to divide the system in a equally distance manner, like this manner. You may have many points in quadrant I, in that case you can scale this, you can bring this to the bottom right corner, bottom left corner and just focus on quadrant I.

So, if you have a good understanding of quadrants, you may be able to graph the functions better, graph the points better; that is why the coordinate system is important. This ends our discussion on coordinate system.

