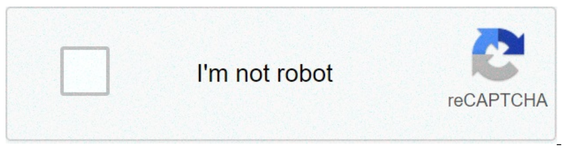

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Distance formula and midpoint formula

Learning Objectives (13.1.1) – Using the distance formula (13.1.2) – Using the midpoint formula (13.1.3) – Using the standard form of equations of circles Derived from the Pythagorean Theorem, the distance formula is used to find the distance between two points in the plane. The Pythagorean Theorem, [latex]{a}^{2}+{b}^{2}={c}^{2}[/latex], is based on a right triangle where a and b are the lengths of the legs adjacent to the right angle, and c is the length of the hypotenuse. The relationship of sides [latex]|{x}_{2}-{x}_{1}|[/latex] and [latex]|{y}_{2}-{y}_{1}|[/latex] to side d is the same as that of sides a and b to side c. We use the absolute value symbol to indicate that the length is a positive number because the absolute value of any number is positive. (For example, [latex]|-3|=3[/latex].) The symbols [latex]|{x}_{2}-{x}_{1}|[/latex] and [latex]|{y}_{2}-{y}_{1}|[/latex] indicate that the lengths of the sides of the triangle are positive. To find the length c, take the square root of both sides of the Pythagorean Theorem. [latex]{c}^{2}={a}^{2}+{b}^{2}\rightarrow c=\sqrt{{a}^{2}+{b}^{2}}[/latex] It follows that the distance formula is given as [latex]{d}^{2}={\left({x}_{2}-{x}_{1}\right)}^{2}+{\left({y}_{2}-{y}_{1}\right)}^{2}\to d=\sqrt{{\left({x}_{2}-{x}_{1}\right)}^{2}+{\left({y}_{2}-{y}_{1}\right)}^{2}}[/latex] We do not have to use the absolute value symbols in this definition because any number squared is positive. Given endpoints [latex]\left({x}_{1},{y}_{1}\right)[/latex] and [latex]\left({x}_{2},{y}_{2}\right)[/latex], the distance between two points is given by [latex]d=\sqrt{{\left({x}_{2}-{x}_{1}\right)}^{2}+{\left({y}_{2}-{y}_{1}\right)}^{2}}[/latex] Find the distance between the points [latex]\left(-3,-1\right)[/latex] and [latex]\left(2,3\right)[/latex]. Find the distance between two points: [latex]\left(1,4\right)[/latex] and [latex]\left(11,9\right)[/latex]. Let’s return to the situation introduced at the beginning of this section. Tracie set out from Elmhurst, IL, to go to Franklin Park. On the way, she made a few stops to do errands. Each stop is indicated by a red dot. Find the total distance that Tracie traveled. Compare this with the distance between her starting and final positions. (13.1.2) – Using the midpoint formula When the endpoints of a line segment are known, we can find the point midway between them. This point is known as the midpoint and the formula is known as the midpoint formula. Given the endpoints of a line segment, [latex]\left({x}_{1},{y}_{1}\right)[/latex] and [latex]\left({x}_{2},{y}_{2}\right)[/latex], the midpoint formula states how to find the coordinates of the midpoint [latex]M[/latex]. [latex]\displaystyle M=\left(\frac{{x}_{1}+{x}_{2}}{2},\frac{{y}_{1}+{y}_{2}}{2}\right)[/latex] A graphical view of a midpoint is shown below. Notice that the line segments on either side of the midpoint are congruent. Find the midpoint of the line segment with the endpoints [latex]\left(7,-2\right)[/latex] and [latex]\left(9,5\right)[/latex]. Find the midpoint of the line segment with endpoints [latex]\left(-2,-1\right)[/latex] and [latex]\left(-8,6\right)[/latex]. (13.1.3) – Using the standard form of equations of circles CIRCLES A circle is all points in a plane that are a fixed distance from a given point in the plane. The given point is called the center, [latex](h,k)[/latex] and the fixed distance is called the radius, [latex]r[/latex], of the circle. We look at a circle in the rectangular coordinate system. The radius is the distance from the center, [latex](h,k)[/latex], to a point on the circle, [latex](x,y)[/latex]. To derive the equation of a circle, we can use the distance formula with the points [latex](h,k)[/latex] and [latex](x,y)[/latex] and the distance, [latex]r[/latex]. [latex]r=\sqrt{(x-h)^2+(y-k)^2}[/latex] Square both sides: [latex]r^2 = (x-h)^2+(y-k)^2[/latex]. This gives us the standard form of the equation of the circle of radius [latex]r[/latex] and center [latex](h,k)[/latex]. The standard form of the equation of a circle with center, [latex](h,k)[/latex] and radius, [latex]r[/latex], is: [latex]r^2 = (x-h)^2+(y-k)^2[/latex] The diameter of a circle has endpoints [latex]\left(-1,-4\right)[/latex] and [latex]\left(5,-4\right)[/latex]. Find the center of the circle. By the end of this section, you will be able to: Use the Distance Formula Use the Midpoint Formula Write the equation of a circle in standard form Graph a circle Before you get started, take this readiness quiz. Find the length of the hypotenuse of a right triangle whose legs are 12 and 16 inches. If you missed this problem, review (Figure). Factor: If you missed this problem, review (Figure). Solve by completing the square: If you missed this problem, review (Figure). In this chapter we will be looking at the conic sections, usually called the conics, and their properties. The conics are curves that result from a plane intersecting a double cone—two cones placed point-to-point. Each half of a double cone is called a nappe. There are four conics—the circle, parabola, ellipse, and hyperbola. The next figure shows how the plane intersecting the double cone results in each curve. Each of the curves has many applications that affect your daily life, from your cell phone to acoustics and navigation systems. In this section we will look at the properties of a circle. We have used the Pythagorean Theorem to find the lengths of the sides of a right triangle. Here we will use this theorem again to find distances on the rectangular coordinate system. By finding distance on the rectangular coordinate system, we can make a connection between the geometry of a conic and algebra—which opens up a world of opportunities for application. Our first step is to develop a formula to find distances between points on the rectangular coordinate system. We will plot the points and create a right triangle much as we did when we found slope in Graphs and Functions. We then take it one step further and use the Pythagorean Theorem to find the length of the hypotenuse of the triangle—which is the distance between the points. Use the rectangular coordinate system to find the distance between the points and Plot the two points. Connect the two pointswith a line. Draw a right triangle as if you were going tofind slope. Find the length of each leg. Use the Pythagorean Theorem to find d, thedistance between the two points. Substitute in the values. Simplify. Use the Square Root Property. Since distance, d is positive, we can eliminate The distance between the points and is 5. Use the rectangular coordinate system to find the distance between the points and Use the rectangular coordinate system to find the distance between the points and The method we used in the last example leads us to the formula to find the distance between the two points and When we found the length of the horizontal leg we subtracted which is When we found the length of the vertical leg we subtracted which is If the triangle had been in a different position, we may have subtracted or The expressions and vary only in the sign of the resulting number. To get the positive value-since distance is positive- we can use absolute value. So to generalize we will say and In the Pythagorean Theorem, we substitute the general expressions and rather than the numbers. This is the Distance Formula we use to find the distance d between the two points and Distance Formula The distance d between the two points and is Use the Distance Formula to find the distance between the points and Use the Distance Formula to find the distance between the points and Use the Distance Formula to find the distance between the points and Use the Distance Formula to find the distance between the points and Write the answer in exact form and then find the decimal approximation, rounded to the nearest tenth if needed. Use the Distance Formula to find the distance between the points and Write the answer in exact form and then find the decimal approximation, rounded to the nearest tenth if needed. Use the Distance Formula to find the distance between the points and Write the answer in exact form and then find the decimal approximation, rounded to the nearest tenth if needed. It is often useful to be able to find the midpoint of a segment. For example, if you have the endpoints of the diameter of a circle, you may want to find the center of the circle which is the midpoint of the diameter. To find the midpoint of a line segment, we find the average of the x-coordinates and the average of the y-coordinates of the endpoints. Midpoint Formula The midpoint of the line segment whose endpoints are the two points and is To find the midpoint of a line segment, we find the average of the x-coordinates and the average of the y-coordinates of the endpoints. Use the Midpoint Formula to find the midpoint of the line segments whose endpoints are and Plot the endpoints and the midpoint on a rectangular coordinate system. Write the Midpoint Formula. Label the points, and substitute. Simplify. The midpoint of the segment is the point Plot the endpoints and midpoint. Use the Midpoint Formula to find the midpoint of the line segments whose endpoints are and Plot the endpoints and the midpoint on a rectangular coordinate system. Use the Midpoint Formula to find the midpoint of the line segments whose endpoints are and Plot the endpoints and the midpoint on a rectangular coordinate system. Both the Distance Formula and the Midpoint Formula depend on two points, and It is easy to confuse which formula requires addition and which subtraction of the coordinates. If we remember where the formulas come from, is may be easier to remember the formulas. As we mentioned, our goal is to connect the geometry of a conic with algebra. By using the coordinate plane, we are able to do this easily. We define a circle as all points in a plane that are a fixed distance from a given point in the plane. The given point is called the center, and the fixed distance is called the radius, r, of the circle. Circle A circle is all points in a plane that are a fixed distance from a given point in the plane. The given point is called the center, and the fixed distance is called the radius, r, of the circle. We look at a circle in the rectangular coordinate system.The radius is the distance from the center, to apoint on the circle, To derive the equation of a circle, we can use thedistance formula with the points and thedistance, r. Substitute the values. Square both sides. This is the standard form of the equation of a circle with center, and radius, r. Standard Form of the Equation a Circle The standard form of the equation of a circle with center, and radius, r, is Write the standard form of the equation of the circle with radius 3 and center Use the standard form of the equation of a circle Substitute in the values and Simplify. Write the standard form of the equation of the circle with a radius of 6 and center Write the standard form of the equation of the circle with a radius of 8 and center In the last example, the center was Notice what happened to the equation. Whenever the center is the standard form becomes Write the standard form of the equation of the circle with radius 2 and center Use the standard form of the equation of acircle. Substitute in the values. Simplify. Write the standard form of the equation of the circle with a radius of 7 and center Write the standard form of the equation of the circle with a radius of 9 and center In the next example, the radius is not given. To calculate the radius, we use the Distance Formula with the two given points. Write the standard form of the equation of the circle with center that also contains the point The radius is the distance from the center to any point on the circle so we can use the distance formula to calculate it. We will use the center and point Now that we know the radius, and the center, we can use the standard form of the equation of a circle to find the equation. Write the standard form of the equation of the circle with center that also contains the point Write the standard form of the equation of the circle with center that also contains the point Any equation of the form is the standard form of the equation of a circle with center, and radius, r. We can then graph the circle on a rectangular coordinate system. Note that the standard form calls for subtraction from x and y. In the next example, the equation has so we need to rewrite the addition as subtraction of a negative. Find the center and radius, then graph the circle: Use the standard form of the equation of a circle.Identify the center, and radius, r. Center: radius: 3 Graph the circle. Find the center and radius, then graph the circle: The circle is centered at with a radius of 2. Find the center and radius, then graph the circle: The circle is centered at with a radius of 4. To find the center and radius, we must write the equation in standard form. In the next example, we must first get the coefficient of to be one. Find the center and radius and then graph the circle, Divide each side by 4. Use the standard form of the equation of a circle.Identify the center, and radius, r. Center: radius: 4 Graph the circle. Find the center and radius, then graph the circle: The circle is centered at with a radius of 3. Find the center and radius, then graph the circle: The circle is centered at with a radius of 5. If we expand the equation from (Figure), the equation of the circle looks very different. This form of the equation is called the general form of the equation of the circle. General Form of the Equation of a Circle The general form of the equation of a circle is If we are given an equation in general form, we can change it to standard form by completing the squares in both x and y. Then we can graph the circle using its center and radius. Find the center and radius, then graph the circle: We need to rewrite this general form into standard form in order to find the center and radius. Group the x-terms and y-terms.Collect the constants on the right side. Complete the squares. Rewrite as binomial squares. Identify the center and radius. Center: radius: 3 Graph the circle. Find the center and radius, then graph the circle: The circle is centered at with a radius of 4. Find the center and radius, then graph the circle: The circle is centered at with a radius of 3. In the next example, there is a y-term and a -term. But notice that there is no x-term, only an -term. We have seen this before and know that it means h is 0. We will need to complete the square for the y terms, but not for the x terms. Find the center and radius, then graph the circle: We need to rewrite this general form into standard form in order to find the center and radius. Group the x-terms and y-terms. There are no constants to collect on theright side. Complete the square for Rewrite as binomial squares. Identify the center and radius. Center: radius: 4 Graph the circle. Find the center and radius, then graph the circle: The circle is centered at with a radius of 2. Find the center and radius, then graph the circle: The circle is centered at with a radius of 5. Key Concepts Distance Formula: The distance d between the two points and is Midpoint Formula: The midpoint of the line segment whose endpoints are the two points and is To find the midpoint of a line segment, we find the average of the x-coordinates and the average of the y-coordinates of the endpoints. Circle: A circle is all points in a plane that are a fixed distance from a fixed point in the plane. The given point is called the center, and the fixed distance is called the radius, r, of the circle. Standard Form of the Equation a Circle: The standard form of the equation of a circle with center, and radius, r, is General Form of the Equation of a Circle: The general form of the equation of a circle is Use the Distance Formula In the following exercises, find the distance between the points. Write the answer in exact form and then find the decimal approximation, rounded to the nearest tenth if needed. and and and and and and and and and and Use the Midpoint Formula In the following exercises, find the midpoint of the line segments whose endpoints are given and plot the endpoints and the midpoint on a rectangular coordinate system. and Midpoint: and and Midpoint: and Write the Equation of a Circle in Standard Form In the following exercises, write the standard form of the equation of the circle with the given radius and center Radius: Radius: In the following exercises, write the standard form of the equation of the circle with the given radius and center Radius: 1, center: Radius: 10, center: Radius: center: Radius: center: For the following exercises, write the standard form of the equation of the circle with the given center with point on the circle. Center with point Center with point Center with point Graph a Circle In the following exercises, find the center and radius, then graph each circle. The circle is centered at with a radius of 1. The circle is centered at with a radius of 4. The circle is centered at with a radius of 5. The circle is centered at with a radius of The circle is centered at with a radius of 8. The circle is centered at with a radius of 2. In the following exercises, identify the center and radius and graph. Center: radius: 1 Center: radius: 6 Center: radius: 2 Center: radius: = 2 Explain the relationship between the distance formula and the equation of a circle. Is a circle a function? Explain why or why not. In your own words, state the definition of a circle. In your own words, explain the steps you would take to change the general form of the equation of a circle to the standard form. After completing the exercises, use this checklist to evaluate your mastery of the objectives of this section. If most of your checks were: …confidently. Congratulations! You have achieved the objectives in this section. Reflect on the study skills you used so that you can continue to use them. What did you do to become confident of your ability to do these things? Be specific. …with some help. This must be addressed quickly because topics you do not master become potholes in your road to success. In math every topic builds upon previous work. It is important to make sure you have a strong foundation before you move on. Who can you ask for help? Your fellow classmates and instructor are good resources. Is there a place on campus where math tutors are available? Can your study skills be improved? …no – I don’t get it! This is a warning sign and you must not ignore it. You should get help right away or you will quickly be overwhelmed. See your instructor as soon as you can to discuss your situation. Together you can come up with a plan to get you the help you need. circle A circle is all points in a plane that are a fixed distance from a fixed point in the plane.

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