

# MYSTERY PICTURE

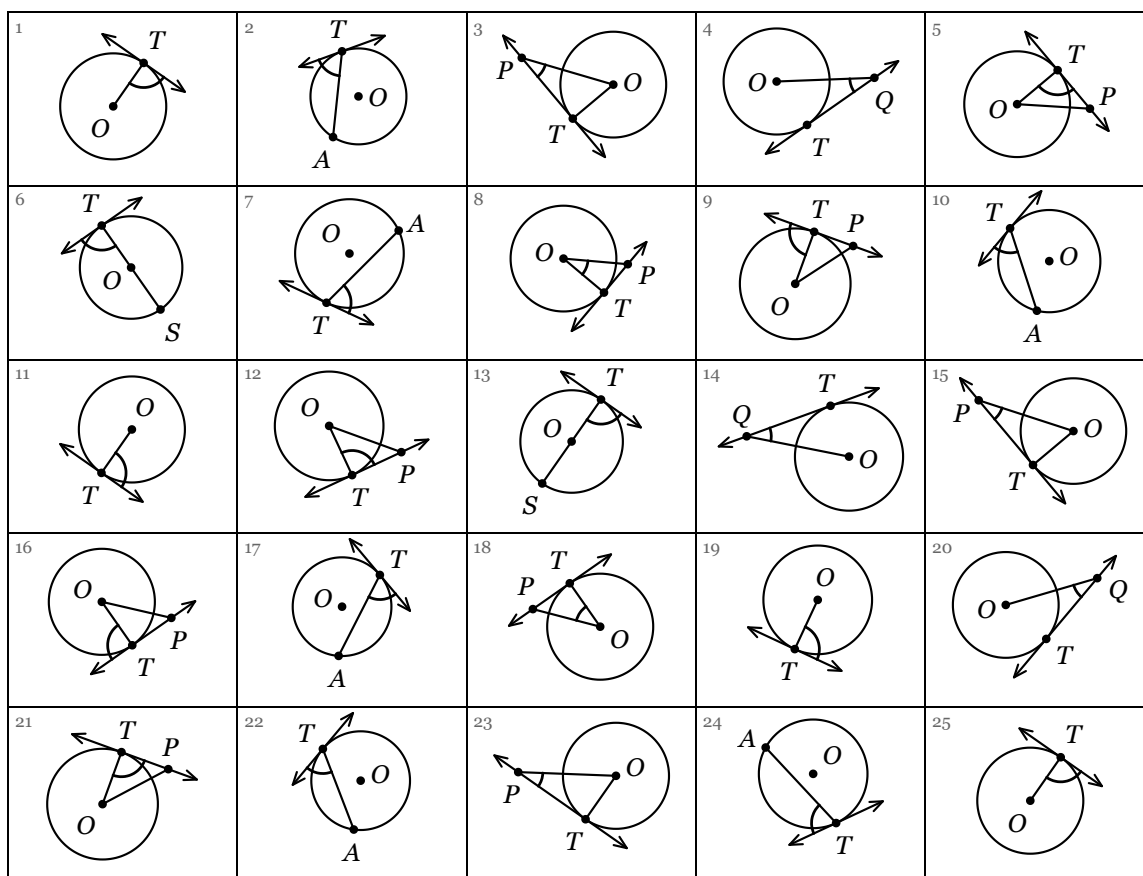


## TANGENT LINES AND THE RADIUS

### Tangent Lines: Where Is the Right Angle?

25 circles · the radius and the tangent · no numbers · a picture appears

FREE



1. **Give each student page 3** and a pencil. No calculator is needed.
2. **Say this once:** *“In every square the line is tangent to the circle at T. One angle is marked with a small arc. Is it the right angle between the tangent and the radius at T? If yes, fill the square with slanted lines. If not, leave it white.”*
3. **Let them work.** The picture shows when they are right. Nothing else is needed.

|                      |                                                                                                        |
|----------------------|--------------------------------------------------------------------------------------------------------|
| <b>Student sheet</b> | page 3, one per student. A box at the top shows the right angle between a tangent line and the radius. |
| <b>Answers</b>       | pages 4–5, for you.                                                                                    |

**A tangent line is perpendicular to the radius drawn to the point of tangency.** So a marked angle is a right angle exactly when its corner is the point of tangency T and its two sides are the tangent line and the radius OT, or the diameter through T. Eleven squares are filled. No square marks a right angle with a small square, so the student has to find it.

**The white squares show the usual mistakes.** In three squares the arc is at P and in two it is at the center O: the triangle OTP has a right angle, but it is at T. In three squares only a segment from O to some other point Q of the line is drawn, and that segment is not a radius to the point of tangency. In six squares the arc is at T, but its second side is a chord TA that misses the center. Those squares catch a student who only checks that the arc is at T.

If part of a student’s picture looks wrong, the mistake is in that square. Ask: *“Where is the point of tangency? Is the other side of the angle the radius to it?”* Guessing does not work. Every simple guessing rule, such as filling every square whose arc is at T, gets at least six squares wrong. This sheet calls a tangent a line that touches the circle at exactly one point. Some textbooks use other definitions, so tell the class which ones this sheet uses.



**This is the free lesson this activity came from.** The worksheet, the full answers and the lesson plan are on it, at three levels of difficulty.  
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# Mystery Picture — where is the right angle?

*Tangent lines and the radius*

Name \_\_\_\_\_

Period \_\_\_\_\_

Date \_\_\_\_\_

In every square, the line with arrowheads is tangent to the circle at  $T$ , and  $O$  is the center. One angle is marked with a small arc. **Is the marked angle a right angle? If yes, fill the square with slanted lines. If no, leave it white.** Use the rule in the box, not your eyes. A picture appears. If part of it is missing, or one square does not fit, check that square again.

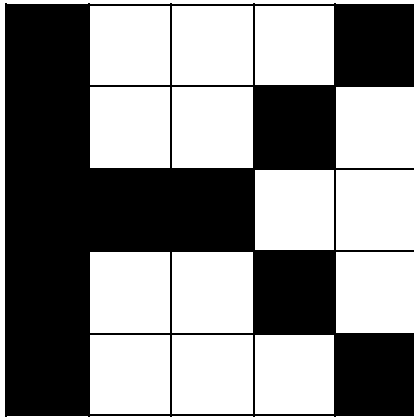
|    |                                                                                                                                                                                                                                                                                                |    |    |    |
|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|----|
|    | <p>The line is tangent at <math>T</math>. The radius <math>OT</math> meets it at a right angle.<br/>         The diameter through <math>T</math> meets it at a right angle too, because it runs along <math>OT</math>.<br/>         No other angle in the drawing has to be a right angle.</p> |    |    |    |
| 1  | 2                                                                                                                                                                                                                                                                                              | 3  | 4  | 5  |
| 6  | 7                                                                                                                                                                                                                                                                                              | 8  | 9  | 10 |
| 11 | 12                                                                                                                                                                                                                                                                                             | 13 | 14 | 15 |
| 16 | 17                                                                                                                                                                                                                                                                                             | 18 | 19 | 20 |
| 21 | 22                                                                                                                                                                                                                                                                                             | 23 | 24 | 25 |



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# Mystery Picture — answers

For the teacher



The finished picture is **the letter K**. Eleven squares are filled.

To check a square, find the point of tangency T. The marked angle is right only when its corner is T and its sides are the tangent line and the radius OT (or the diameter through T). The table gives the reason for every square. It goes on over the page.

|    | The square                                                                                   | Answer | Why                                                                                                                                                                                            |
|----|----------------------------------------------------------------------------------------------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | The radius OT is drawn. The arc is at T, between the line and OT.                            | fill   | The arc is at the point of tangency T, between the tangent line and the radius OT. A tangent is perpendicular to the radius there.                                                             |
| 2  | The chord TA is drawn. It does not pass through O. The arc is at T, between the line and TA. | white  | The arc is at T, but TA is a chord that misses the center O, not a radius. Only the radius (or the diameter) at T is perpendicular to the tangent.                                             |
| 3  | Triangle OTP is drawn, P on the line. The arc is at P.                                       | white  | The arc is at P, not at the point of tangency. The right angle of triangle OTP is at T, so the angle at P is smaller than $90^\circ$ .                                                         |
| 4  | Only the segment OQ is drawn, Q on the line. The arc is at Q.                                | white  | OQ goes from the center to a point Q of the line that is not the point of tangency. OQ is not a radius to T, so nothing makes the angle at Q right. It is smaller than $90^\circ$ .            |
| 5  | Triangle OTP is drawn, P on the line. The arc is at T, inside the triangle.                  | fill   | The arc is at T, between the radius OT and the tangent line. A tangent is perpendicular to the radius at the point of tangency.                                                                |
| 6  | The diameter TS is drawn through O. The arc is at T, between the line and TS.                | fill   | The diameter TS lies along the radius OT. The tangent is perpendicular to it at T.                                                                                                             |
| 7  | The chord TA is drawn. It does not pass through O. The arc is at T, between the line and TA. | white  | The arc is at T, but TA is a chord that misses the center O, not a radius. Only the radius (or the diameter) at T is perpendicular to the tangent.                                             |
| 8  | Triangle OTP is drawn, P on the line. The arc is at O.                                       | white  | The arc is at the center O. The right angle of triangle OTP is at T, so the angle at O is smaller than $90^\circ$ .                                                                            |
| 9  | Triangle OTP is drawn, P on the line. The arc is at T, outside the triangle.                 | fill   | The arc is at T, between the radius OT and the tangent line (on the other side of OT from P, which is still a right angle). A tangent is perpendicular to the radius at the point of tangency. |
| 10 | The chord TA is drawn. It does not pass through O. The arc is at T, between the line and TA. | white  | The arc is at T, but TA is a chord that misses the center O, not a radius. Only the radius (or the diameter) at T is perpendicular to the tangent.                                             |
| 11 | The radius OT is drawn. The arc is at T, between the line and OT.                            | fill   | The arc is at the point of tangency T, between the tangent line and the radius OT. A tangent is perpendicular to the radius there.                                                             |
| 12 | Triangle OTP is drawn, P on the line. The arc is at T, inside the triangle.                  | fill   | The arc is at T, between the radius OT and the tangent line. A tangent is perpendicular to the radius at the point of tangency.                                                                |

# Mystery Picture — answers, squares 13 to 25

For the teacher

|    | The square                                                                                   | Answer | Why                                                                                                                                                                                            |
|----|----------------------------------------------------------------------------------------------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 13 | The diameter TS is drawn through O. The arc is at T, between the line and TS.                | fill   | The diameter TS lies along the radius OT. The tangent is perpendicular to it at T.                                                                                                             |
| 14 | Only the segment OQ is drawn, Q on the line. The arc is at Q.                                | white  | OQ goes from the center to a point Q of the line that is not the point of tangency. OQ is not a radius to T, so nothing makes the angle at Q right. It is smaller than $90^\circ$ .            |
| 15 | Triangle OTP is drawn, P on the line. The arc is at P.                                       | white  | The arc is at P, not at the point of tangency. The right angle of triangle OTP is at T, so the angle at P is smaller than $90^\circ$ .                                                         |
| 16 | Triangle OTP is drawn, P on the line. The arc is at T, outside the triangle.                 | fill   | The arc is at T, between the radius OT and the tangent line (on the other side of OT from P, which is still a right angle). A tangent is perpendicular to the radius at the point of tangency. |
| 17 | The chord TA is drawn. It does not pass through O. The arc is at T, between the line and TA. | white  | The arc is at T, but TA is a chord that misses the center O, not a radius. Only the radius (or the diameter) at T is perpendicular to the tangent.                                             |
| 18 | Triangle OTP is drawn, P on the line. The arc is at O.                                       | white  | The arc is at the center O. The right angle of triangle OTP is at T, so the angle at O is smaller than $90^\circ$ .                                                                            |
| 19 | The radius OT is drawn. The arc is at T, between the line and OT.                            | fill   | The arc is at the point of tangency T, between the tangent line and the radius OT. A tangent is perpendicular to the radius there.                                                             |
| 20 | Only the segment OQ is drawn, Q on the line. The arc is at Q.                                | white  | OQ goes from the center to a point Q of the line that is not the point of tangency. OQ is not a radius to T, so nothing makes the angle at Q right. It is smaller than $90^\circ$ .            |
| 21 | Triangle OTP is drawn, P on the line. The arc is at T, inside the triangle.                  | fill   | The arc is at T, between the radius OT and the tangent line. A tangent is perpendicular to the radius at the point of tangency.                                                                |
| 22 | The chord TA is drawn. It does not pass through O. The arc is at T, between the line and TA. | white  | The arc is at T, but TA is a chord that misses the center O, not a radius. Only the radius (or the diameter) at T is perpendicular to the tangent.                                             |
| 23 | Triangle OTP is drawn, P on the line. The arc is at P.                                       | white  | The arc is at P, not at the point of tangency. The right angle of triangle OTP is at T, so the angle at P is smaller than $90^\circ$ .                                                         |
| 24 | The chord TA is drawn. It does not pass through O. The arc is at T, between the line and TA. | white  | The arc is at T, but TA is a chord that misses the center O, not a radius. Only the radius (or the diameter) at T is perpendicular to the tangent.                                             |
| 25 | The radius OT is drawn. The arc is at T, between the line and OT.                            | fill   | The arc is at the point of tangency T, between the tangent line and the radius OT. A tangent is perpendicular to the radius there.                                                             |