



## Introduction

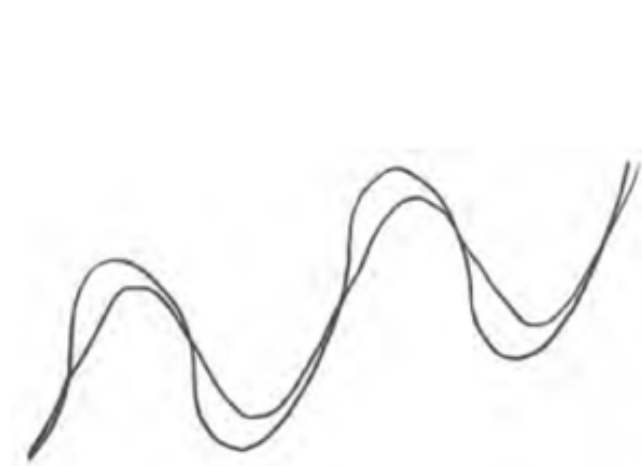
This task launches with a story retold by Ben Orlin about the famous detective Sherlock Holmes. In Ben's book, *Change is the Only Constant* (Orlin, 2019), he shares an extract from Sir Arthur Conan Doyle's description of a calamity in a school. We took the Sherlock Holmes mystery and made it into a task, that we have found provokes students' curiosity and creative thinking. In the beginning students are set a puzzle to solve – the delightful solution to which comes from the use of tangent lines. We recommend using the puzzle and time for students to explore as a reason to learn about tangent lines. Teachers often ask us: how do we present new content to students? We draw from research that has shown the best time to present content is after students have encountered a need for the content (Schwartz & Bransford, 1998). In this task students first explore the puzzle – which direction is the bike moving? - with different resources, and then pause to learn about tangent lines, or to revisit them if they have already met them. We have used this task both with students who have previously learned about tangent lines and appreciated a task that requires their use in a real situation, and with students who learned about tangent lines through this activity.

## Materials

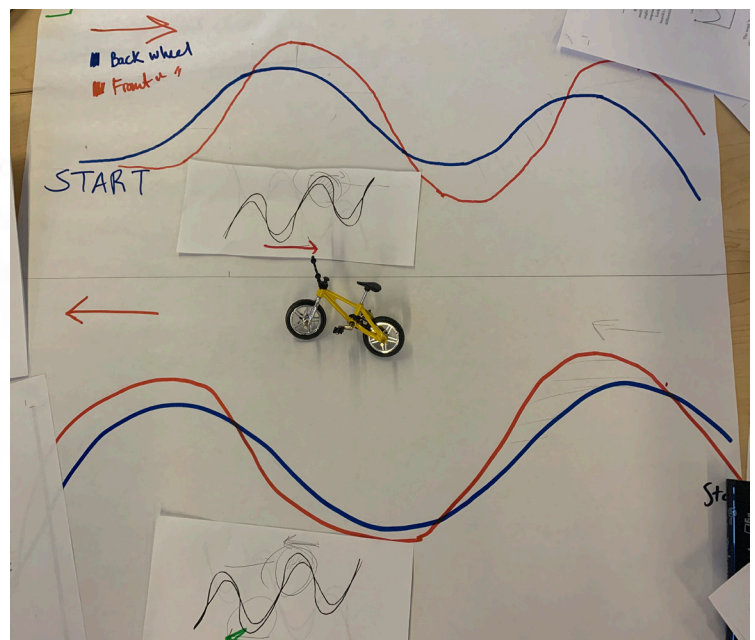
Gather materials for students to explore the puzzle,

We recommend:

- miniature bicycles ([https://www.amazon.com/VANKERTER-Extreme-Accessories-Creative-Skateboards/dp/B07VPJ5NGM?encoding=UTF8&ref=tsm1 tp tc](https://www.amazon.com/VANKERTER-Extreme-Accessories-Creative-Skateboards/dp/B07VPJ5NGM?encoding=UTF8&ref=tsm1%20tp%20tc))
- playdoh, different colored markers, chalk, rulers, meter sticks, string, one full-sized scooter or bicycle if there is space to push it around, chart paper, tape, water, string,
- handout with puzzle, pgs 4-5, taken from *Change is the Only Constant: The Wisdom of Calculus in a Madcap World*, by Ben Orlin (Black Dog & Leventhal, 2019).
- handout with path on it, pg 6, (1 per person)



Bike path, above  
Student work sample, right





## Agenda

Time	Task
20 - 30 mins	<p><b>Introduction</b></p> <p>Read the excerpt from Orlin's book that sets up the context of this puzzle in handout 1, pgs 4-5.</p> <ul style="list-style-type: none"> <li>Discuss in small groups of, ideally, 3 or 4 students: <ul style="list-style-type: none"> <li>What is the problem asking?</li> <li>What information do we have?</li> </ul> </li> <li>Work time: <ul style="list-style-type: none"> <li>Pass out copies of the path (in case students want to write on them) and have groups attempt in any way they want to try (paper and pen, no other supplies yet)</li> </ul> </li> </ul>
30 mins	<p><b>Exploration</b></p> <ul style="list-style-type: none"> <li>Once students have spent some time trying ideas with just paper and pencil, announce that they now have access to resources. This should be an exciting "reveal" moment where students are introduced to the various items that can help them investigate their ideas further.</li> <li>Each group should only be allowed to take two materials at a time. This encourages groups to come to a consensus about what materials they'd like to use first. <ul style="list-style-type: none"> <li>Students are given access to the following resources: miniature bicycles, playdoh, different colored markers, chalk, rulers, meter sticks</li> </ul> </li> </ul> <p>Optional Extension: Potential questions to support further investigation:</p> <p>Model several paths with your miniature bicycle.</p> <ul style="list-style-type: none"> <li>What patterns do you notice with a rightward moving bike vs a leftward moving bike?</li> <li>If time share at least two methods with another group</li> </ul>
20 mins	<p><b>Whole-Class Discussion</b></p> <ul style="list-style-type: none"> <li>Bring the whole class together and have each group share out at least one method they have tried and any conjectures they may have.</li> <li>Make sure to emphasize that the purpose of the share out is to hear the various creative methods students have tried.</li> </ul>



10 mins	<p><b>Introduce Tangent lines</b></p> <p>At this point, students will have spent a significant amount of time investigating various ways to solve the task. Let them know that you will be providing them with yet another resource: tangent lines!</p> <ul style="list-style-type: none"> <li>Show students various examples of tangent lines</li> </ul> <p>Ask the class:</p> <ul style="list-style-type: none"> <li>How can we utilize our newest resource to solve this task?</li> </ul>
30 mins	<p><b>Applying:</b></p> <ul style="list-style-type: none"> <li>Allow the students to go back to their small groups and utilize this new resource in their thinking</li> <li>Make sure all groups have rulers from the resource table to aid in their tangent line drawings</li> <li>Encourage students to draw many tangent lines for both curves to see what they can find.</li> </ul>
15 mins	<p><b>Whole-Class Share Out:</b></p> <ul style="list-style-type: none"> <li>Bring the whole class together once again and ask each group to share how they've applied tangent lines to the situation.</li> <li>Ask groups to reflect on their process <ul style="list-style-type: none"> <li>What things did you or your group do that supported your learning?</li> </ul> </li> </ul>

## References:

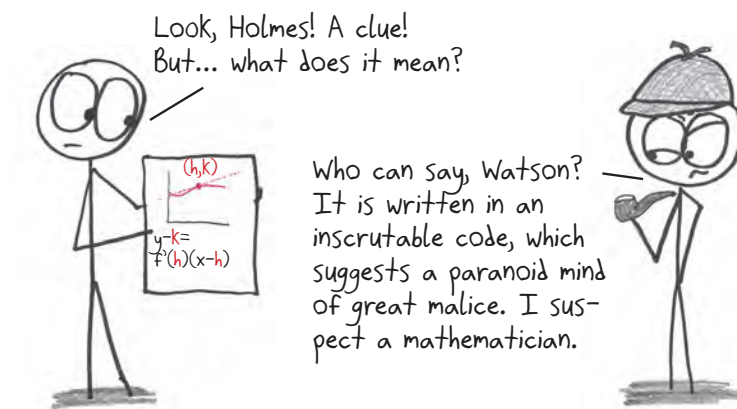
Orlin, B. (2019). Change is the Only Constant: The Wisdom of Calculus in a Madcap World, Black Dog & Leventhal.

Schwartz, D., & Bransford, J. (1998). A Time for Telling. Cognition and Instruction, 16(4), 475-522.

## VI. SHERLOCK HOLMES AND THE BICYCLE OF MISDIRECTION

In “The Adventure of the Priory School” by Sir Arthur Conan Doyle, calamity strikes a posh English boarding school. A wealthy duke’s 10-year-old son has vanished from the dormitory. Also missing: a German teacher, a single bicycle, and the commitment to serving a diverse population. With the local police befuddled, the school’s desperate headmaster staggers into 221B Baker Street to enlist the help of fiction’s most hallowed detective.

“Mr. Holmes,” he says, “if ever you put forward your full powers, I implore you to do so now, for never in your life could you have a case which is more worthy of them.”



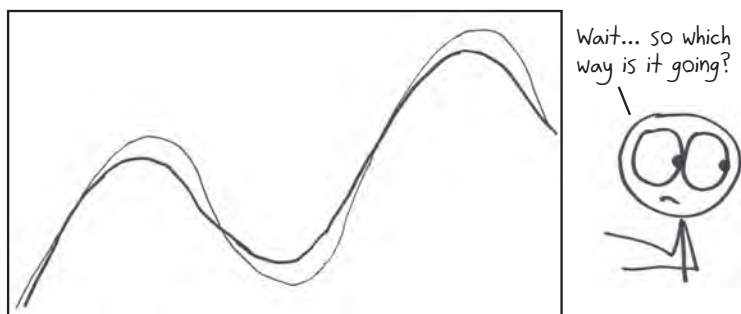
Hours later, Sherlock Holmes and Dr. Watson are prowling through a “great rolling moor” when they come across their first clue: “a small black ribbon of pathway. In the middle of it, clearly marked on the sodden soil, was the track of a bicycle.” That’s when Holmes launches into a classic piece of deductive reasoning:

*“This track, as you perceive, was made by a rider who was going from the direction of the school.”*

*“Or towards it?”*

*“No, no, my dear Watson. The more deeply sunk impression is, of course, the hind wheel, upon which the weight rests. You perceive several places where it has passed across and obliterated the more shallow mark of the front one. It was undoubtedly heading away from the school.”*

What feats of physics! What genius of geometry! There is only one small problem, which the mellifluous prose disguises and which a simple diagram will make clear:



Here we see the thicker track crossing the thinner one. Is it thus apparent which direction the bicycle is traveling? No, alas, because Holmes has committed an uncharacteristic error. The rear wheel *always* crosses the front. This fact is no clue to direction, but a simple consequence of bicycle design, wherein the front wheel pivots while the back remains fixed.

# Bicycle Path Handout

