

Challenge 38 Step by Step

by *DonV*

The Turing Tumble Puzzle Book Challenge 38 provides practice in using crossovers, ramps, and binary numbers. The purpose of this step-by-step presentation is to encourage students to solve the puzzle by thinking things through rather than using trial and error. The solution presented here differs from that shown in the Puzzle Book, and still other solutions can be found at <https://community.turingtumble.com/c/puzzle-solutions/puzzle-38/20>. This lesson will work best with students who have completed the Elementary TT: Intro to Binary.

This step-by-step package has three parts, this lesson plan, a setup diagrams page, and a pictures page. The diagrams and the pictures show the same setups and, in general, they are more for the teacher's use than the students'. An instructor might want to white out the ramps and crossovers and allow students to see only the bits. In this way they will be challenged to discover the ramp and crossover configurations. It will probably be more beneficial for students to trace paths with their fingers rather than to drop balls in order to see where their mistakes are.

- 1) Complete TT Puzzle Book challenge 23 as described in the puzzle book. Make sure exactly four blue balls reach the end. (Intercept the fifth.).
- 2) Call this setup Register C (for “Counter”) and call the bits “1, 2, and 3” labelling from the top down. Set register C to 100, in other words, bit 3 = 1, bit 2 = 0, bit 1 = 0.
- 3) Have students run the program and record which bit in register C drops each ball down to the lever:
 - First ball drops from bit C3.
 - Second ball drops from C1.
 - Third ball drops from C2.
 - Fourth ball drops from C1.
 - A fifth ball drops from C3 into the interceptor.
- 4) Next your students will create a setup that corresponds to diagram 1 and picture 1. Do not show the diagram and picture to them. Instead, clear the board, help the students set up the bits for the structure, and then challenge them to place the ramps on their own.
- 5) Test the setup to make sure that it produces the same output as challenge 23. Note: Student ramps may differ from picture 1, but if their setup gets the job done, they did well. When the students have finished, show them picture 1 and, if necessary, have them rearrange their ramps to match the picture.
- 6) Add a bit to the setup (see diagram 2 and picture 2) and call it bit A1. Challenge the students to add ramps such that, when the first ball is triggered and drops from bit C3, it hits bit A1. If A1 = 1 the ball should trigger the blue lever, else if A1 = 0 the ball should trigger the red lever. After that second ball is released you can simply ignore the third and fourth balls. The ball you really care about is the second one. Is it the right color?
- 7) In this step modifications are made to the present setup in order to create what is shown in diagram 3/picture 3. Call the new bits A2 and A3. Notice that A3 is nonfunctional here—it is

placed merely to complete the three bit register. Show the students diagram 3 and/or picture 3. Explain what is supposed to happen: The first ball hits bit A1 and the second ball hits A2. The first ball does what it did in step 6, above. Then, when the second ball hits A2, if A2 was set to 1, the ball triggers the blue lever, else it triggers the red lever. Explain to the students that the setup won't work as shown, and see if they can figure out and explain why it doesn't work.

SOLUTION: The culprit is the circled bit shown in diagram 4 and picture 4). When bit A1 = 0, there is no problem. But if A1 = 1, when the first ball falls it changes the value of the bit A2.

- 8) Refert to diagram 4/picture 4 and replace the circled bit with a crossove (see diagram 5/picture 5.). Test this setup with all four combinations of A1 and A2, i.e, 00, 01, 10, and 11. The results should be as follows:

When register A is 00, the first ball is blue, the second is red, and the third is red. What happens after the third ball is not important.

When register A is 01, the first ball is blue, the second is blue, and the third is red. What happens after the third ball is not important.

When register A is 10, the first ball is blue, the second is red, and the third is blue. What happens after the third ball is not important.

When register A is 11, the first ball is blue, the second is blue, and the third is blue. What happens after the third ball is not important.

- 9) Modify the setup with ramps and crossovers such that, when the third ball it triggered, it will fall from C2 and hit A3 and, as before, if A3 = 1 then trigger the blue lever, else trigger the red lever. And this is challenge 38. Diagram 6 and picture 6 show the solution. Note that it is different from the solution shown in the Puzzle Book, but the output is \the same as described in the book.