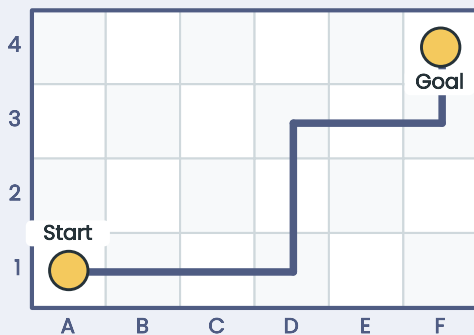


Unplugged Algorithm Thinking: Trace It, Squeeze It, Fix It

6 complete activities from Unplugged Algorithm Thinking, each with a worked answer.



1 Forward 3

2 Turn left, forward 2

3 Turn right, forward 2

HOW TO USE

1. Read the situation and the evidence first.
2. Show your thinking in the work boxes, not only an answer.
3. Explain how you know your answer makes sense.
4. Try the new problem at the bottom of the page.

6 activities • 3 answer pages • From the 24-activity collection

10 US Letter pages • Print at 100% / Actual Size

Original Bobotemp educational printable • Fictional names, places and prices

Name _____ Date _____

Booklet Builder: Which Order Works?

LEVEL 1



Read the four steps and the three rules. Cross out every proposed order that breaks a rule.

Jordan is making an 8-page paper booklet. The steps are S = Stack 2 sheets of paper, F = Fold the stack in half, T = Staple along the fold, and W = Write the title on the front cover. Four classmates proposed these orders: S-F-T-W, S-T-F-W, F-S-T-W, and W-S-F-T. Exactly one order follows all three rules in the box. Which one is it?

PROPOSED ORDERS (CROSS OUT)

S-F-T-W

S-T-F-W

F-S-T-W

W-S-F-T

EVIDENCE TO USE

- Steps: S stack, F fold, T staple, W write title
- Rule 1: Both sheets must be stacked before folding.
- Rule 2: The staple goes on the fold line, so fold before you staple.
- Rule 3: The front cover exists only after folding.

1. Cross out each order that breaks a rule, and write that rule's number next to it.

2. Write the one order that works.

3. Explain why F must come before T.

TRY IT • A bookmark has three steps: C = Cut a strip of paper, P = Punch a hole near the top, and R = Tie a ribbon through the hole. Which step must come last, and why?

Name _____ Date _____

Grid Walk: Trace the Pencil

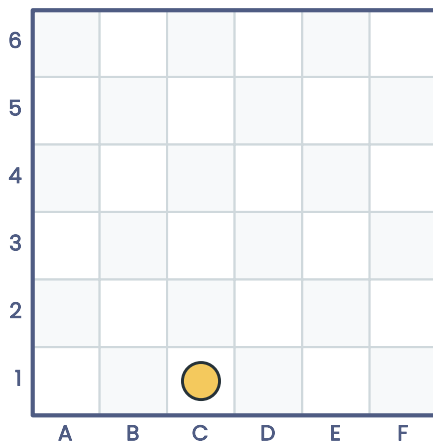
LEVEL 1



Put your finger on the start square. Read one command at a time, and record the square and heading after each one.

A robot pencil starts on square C1 facing north. Trace this program on your grid, one command at a time: 1) FORWARD 2, 2) TURN RIGHT, 3) FORWARD 3, 4) TURN LEFT, 5) FORWARD 1. Record the square and heading after each command. Where does the pencil finish, and which way is it facing?

PENCIL GRID



Row 1 is at the bottom.
North = up
East: toward column F.
Dot in C1 = start, facing north



EVIDENCE TO USE

- Grid: columns A-F from left to right; rows 1-6 with row 1 at the bottom.
- North means toward higher row numbers. East means toward column F.
- FORWARD n moves n squares in the facing direction.
- TURN RIGHT and TURN LEFT rotate 90 degrees in place, relative to the pencil's own heading.
- Moving off the grid is an error.

1. Record the square and heading after each command.

2. Write the final square and heading.

3. Explain how you decided which way the pencil faced after the TURN LEFT in step 4.

TRY IT • Start on A6 facing east. Run FORWARD 2, TURN RIGHT, FORWARD 3. Where do you finish, and which way are you facing?

Name _____ Date _____

Reach the Target: Flower Bed Route

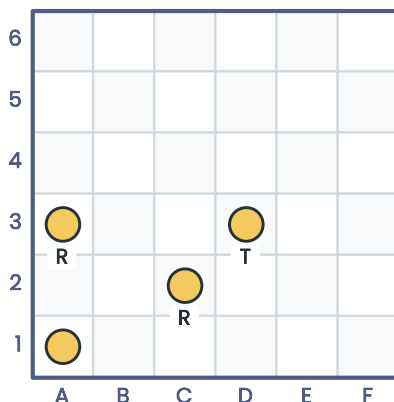
LEVEL 2



Trace every program square by square. A program works only if every square it enters is safe. Grid: columns A–F from left to right; rows 1–6 with row 1 at the bottom. North means toward higher row numbers, and east means toward column F. Turns rotate in place, relative to the robot's own heading.

A garden robot starts on A1 facing north and must reach the flower bed at D3. Squares A3 and C2 are blocked by rock piles, marked R. Four programs were proposed. P1: FORWARD 2, TURN RIGHT, FORWARD 3. P2: TURN RIGHT, FORWARD 3, TURN LEFT, FORWARD 2. P3: FORWARD 1, TURN RIGHT, FORWARD 3, TURN LEFT, FORWARD 1. P4: TURN RIGHT, FORWARD 3, TURN RIGHT, FORWARD 2. Trace each one. Which program ends on D3 while staying on the grid and never entering a blocked square?

GARDEN GRID



Row 1 is at the bottom.
North = up
East: toward column F.
Dot in A1 = start, facing north
T = flower bed (target)
R = rock (blocked)



EVIDENCE TO USE

- Start: A1 facing north
- Target: D3
- Blocked squares: A3 and C2 (marked R)
- Passing through a blocked square fails, even if the robot ends on D3.
- Moving off the grid is an error.

1. List every square each program enters.

2. Circle the one program that works.

3. Write your own different program that also works, and trace it to prove it.

TRY IT • Write a program that reaches D3 by passing through square B3.

Name _____ Date _____

Two-Way Choices: Shelf Card Counter

LEVEL 2



For each card, decide which branch runs: the THEN branch or the ELSE branch. Record it in the trace table.

A library helper runs a two-way rule on shelf cards. A counter starts at 5. For each card: IF the card's number is even, THEN add 2 to the counter, ELSE subtract 1. The cards, in order, are 14, 7, 22, 9, 30, 15, 8. Make a trace table with the columns Card, Even?, Change, and Counter. What is the final counter value?

TRACE TABLE

Card	Even?	Change	Counter
Start	—	—	5
14			
7			
22			
9			
30			
15			
8			

EVIDENCE TO USE

- Start: counter = 5
- IF even THEN add 2
- ELSE (odd) subtract 1
- Every card takes exactly one branch.
- Cards: 14, 7, 22, 9, 30, 15, 8

1. Fill in the table for all 7 cards.

2. Write the final counter value.

3. Explain why no card can both add 2 and subtract 1.

TRY IT • Use the same rule with a starting counter of 5 and the cards 3, 12, 11. What is the final value?

Name _____ Date _____

Shortest Program Challenge: Staircase

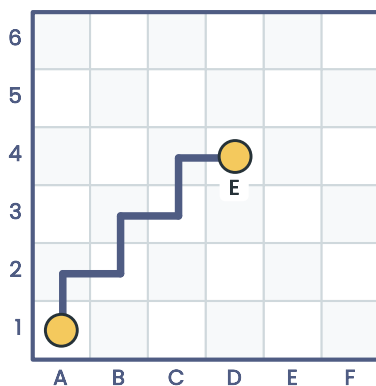
LEVEL 3



Write the shortest program that produces the identical path. Use the counting rule, and prove that your program is equivalent. Turns rotate in place, relative to the robot's own heading.

A pen-down robot starts on A1 facing north. It draws a staircase through A2, B2, B3, C3, C4, and D4, ending on D4 facing north. The long program is FORWARD 1, TURN RIGHT, FORWARD 1, TURN LEFT, written 3 times (12 lines). Write the shortest program that draws exactly the same path: the same squares in the same order and the same final heading. Use the counting rule. What is the fewest number of lines possible?

THE STAIRCASE PATH



Row 1 is at the bottom.
North = up
East: toward column F.
Dot in A1 = start, facing north
E = end, facing north



EVIDENCE TO USE

- Counting rule: each command = 1 line. A REPEAT header = 1 line. Brackets do not count.
- The new program must visit the same squares in the same order.
- Final position: D4 facing north
- Long program: 12 lines

1. Write your shortest program.

2. State its line count and how many lines it saves.

3. Explain why no correct program can be shorter.

TRY IT • Make the staircase 4 steps tall instead (16 lines in the long program). What is the fewest number of lines, and where does the robot finish?

Name _____ Date _____

Search Showdown: One by One or Halving?

LEVEL 3



Count every card you flip, including the target card. Compare both strategies for each target.

Fifteen library shelf cards lie face down in order: 3, 7, 10, 14, 18, 21, 25, 29, 33, 36, 40, 44, 47, 51, 55. Strategy 1 checks the cards one by one from the left. Strategy 2, halving, flips the middle card of the cards still possible, then uses the higher or lower hint to discard half. Count the checks each strategy needs to find card 47. Then count both strategies for card 7. Which strategy wins in each case?

SHELF CARDS, LEFT TO RIGHT (FACE DOWN)

Card	3	7	10	14	18	21	25	29	33	36	40	44	47	51	55
One by one															
Halving															

EVIDENCE TO USE

- Cards in positions 1-15: 3, 7, 10, 14, 18, 21, 25, 29, 33, 36, 40, 44, 47, 51, 55
- Every card flipped counts as 1 check, including the target.
- Halving: flip the middle card of the remaining range.
- Worst cases: 15 checks one by one, 4 checks with halving

1. Record each card flipped by both strategies for target 47.

2. Repeat for target 7.

3. Write one sentence about when each strategy is the better choice.

TRY IT • How many checks does each strategy need to find card 3?

1. Booklet Builder: Which Order Works?

LEVEL 1

S-F-T-W is the only order that follows all three rules.

WORKED REASONING • Rule 1 (S before F) removes F-S-T-W. Rule 2 (F before T) removes S-T-F-W, because that order staples before there is a fold. Rule 3 (W after F) removes W-S-F-T, because the title would be written before the cover exists. Only S-F-T-W survives all three rules. Rules 1 and 2 are forced dependencies, because each of those steps needs the result of an earlier step.

WATCH FOR • Students may think any order is fine as long as every step appears. In an algorithm, later steps depend on the results of earlier steps, so a step's position matters even when the list of steps stays the same.

TRANSFER • R must come last. The ribbon needs the hole (P), and the hole needs the cut strip (C), so the order is C-P-R.

2. Grid Walk: Trace the Pencil

LEVEL 1

The pencil finishes on F4 facing north.

WORKED REASONING • Start on C1 facing north. 1) FORWARD 2 moves to C2, then C3: C3 facing north. 2) TURN RIGHT: still on C3, now facing east. 3) FORWARD 3 moves to D3, E3, then F3: F3 facing east. 4) TURN LEFT: a left turn from east faces north, and the pencil stays on F3. 5) FORWARD 1 moves to F4. Final: F4 facing north.

WATCH FOR • Some students move a square during a turn, or they use the paper's left instead of the pencil's left. A turn never changes the square, and left and right always depend on the current heading arrow.

TRANSFER • C3 facing south. The pencil moves from A6 to C6, turns to face south, then moves through C5 and C4 to C3.

9. Reach the Target: Flower Bed Route

LEVEL 2

P2 is the only proposed program that works. It ends on D3 and avoids both A3 and C2.

WORKED REASONING • P1 enters A2 and then A3, which is blocked, so it fails even though it ends on D3. P2 turns east, enters B1, C1, and D1, turns north, then enters D2 and D3. It is safe and on target. P3 enters A2, then goes east through B2 and C2, which is blocked, so it fails. P4 enters B1, C1, and D1, then TURN RIGHT faces south, so FORWARD 2 leaves the grid. Only P2 passes both tests.

WATCH FOR • Students often check only the final square. A path algorithm must be checked at every square it enters, not just at the square where it stops.

TRANSFER • Sample solution: TURN RIGHT, FORWARD 1, TURN LEFT, FORWARD 2, TURN RIGHT, FORWARD 2. It enters B1, B2, B3, C3, then D3. Any program is accepted if its trace avoids A3 and C2, stays on the grid, and ends on D3.

10. Two-Way Choices: Shelf Card Counter

LEVEL 2

The final counter value is 10.

WORKED REASONING • 14 is even: $5 + 2 = 7$. 7 is odd: $7 - 1 = 6$. 22 is even: 8. 9 is odd: 7. 30 is even: 9. 15 is odd: 8. 8 is even: 10. Check: 4 even cards give +8 and 3 odd cards give -3, so $5 + 8 - 3 = 10$.

WATCH FOR • With if-then-else, some students skip the ELSE branch and leave odd cards unchanged, which gives 13. ELSE means the other branch always runs when the condition is false.

TRANSFER • 5. The counter goes 5 to 4, then 6, then 5.

17. Shortest Program Challenge: Staircase

LEVEL 3

The minimum is 5 lines, for example REPEAT 3 [FORWARD 1, TURN RIGHT, FORWARD 1, TURN LEFT]. This saves 7 lines.

WORKED REASONING • Sample solution: REPEAT 3 [FORWARD 1, TURN RIGHT, FORWARD 1, TURN LEFT]. That is 1 header + 4 commands = 5 lines. Trace: A2, face east, B2, face north. Then B3, east, C3, north. Then C4, east, D4, north. It cannot be shorter, because each stair needs two moves, a right turn, and a left turn, so the loop body needs 4 commands plus 1 header. FORWARD 3, TURN RIGHT, FORWARD 3 is shorter, but it draws a different path.

WATCH FOR • Students may think a shorter program is always better, even if it takes a different route. A shorter program counts as more efficient only when its result, including the path, is identical.

TRANSFER • Still 5 lines: REPEAT 4 [FORWARD 1, TURN RIGHT, FORWARD 1, TURN LEFT]. This saves 11 lines, and the robot ends on E5 facing north.

18. Search Showdown: One by One or Halving?

LEVEL 3

For card 47, one by one takes 13 checks and halving takes 4, so halving saves 9 checks. For card 7, one by one takes 2 checks and halving takes 3, so one by one wins.

WORKED REASONING • 47 is in position 13, so one by one needs 13 checks. Halving: flip card 8 (29) and go higher. Cards 9–15 remain, so flip card 12 (44) and go higher. Cards 13–15 remain, so flip card 14 (51) and go lower. Then flip card 13 (47), found. That is 4 checks, and $13 - 4 = 9$ saved. For 7, one by one flips 3 and then 7, for 2 checks. Halving flips 29 (lower), then 14 (lower, with cards 1–3 left), then 7, for 3 checks.

WATCH FOR • Students may conclude that halving is always faster. Halving usually wins on long ordered lists, but when the target is near the start, checking one by one can take fewer checks.

TRANSFER • One by one takes 1 check. Halving takes 4 checks: 29, 14, 7, then 3. One by one wins.