

Algorithms

How data is processed

Algorithm definitions

- Effective method expressed as a **finite list of well-defined instructions**—*Google*
- A set of rules to be followed in calculations or other problem-solving operations, especially by a **computer**—*Wikipedia*
- A **step-by-step** procedure for **solving a problem or accomplishing some end** especially by a computer—*M Webster*

Algorithm specification

- Plain English (prose)

Apple pie algorithm

Ingredients:

Pastry for 2 crusts (recipe below)
8 cups sliced, peeled assorted baking apples - about 3 lbs.
(Granny Smith, Cortland, Jonathan)
2 Tablespoons lemon juice
3/4 cup white sugar
1/4 cup brown sugar
1/4 cup all-purpose flour
1 teaspoon ground cinnamon
1/4 teaspoon ground nutmeg
2 Tablespoons butter
1 egg yolk
1 Tablespoon milk

Directions:

1. In a large bowl, toss the sliced apples with lemon juice.
2. Combine sugars, flour, cinnamon and nutmeg; add to apples and toss well to coat.
3. Fill pastry lined 9 inch pie pan with apple mixture. Dot with butter.
4. Place second crust on top of pie filling, cut slits in top of crust to vent. Seal the edges of the crust with a fork or by hand.
5. In a small bowl, beat the egg yolk and milk. Brush mixture over top crust.
6. Bake at 425 degrees F for 15 minutes.
7. Reduce heat to 350 degrees F and bake 40-45 minutes more or until crust is golden and filling is bubbly.



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Finite number of well defined instructions

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*Instructions for
repetitive actions*

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*Instructions for
(implicitly) repetitive
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Logical expressions

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Use of sub-algorithms

Flaky Pastry Pie Crust Recipe

Makes two 9-inch pie crusts

Ingredients:

2 1/2 cups all-purpose flour

1/2 teaspoon salt

1 cup butter, chilled and diced

1/2 cup ice water

Directions:

1. Combine the flour and salt in a large bowl.
2. Cut in the butter until the mixture resembles coarse crumbs.
3. Stir in the ice water, a Tablespoon at a time, until the crust mixture forms a ball.
4. Wrap dough in plastic wrap and refrigerate for 4 hours or overnight.
5. Sprinkle flour onto rolling surface. Roll dough out, then divide in half. Roll each half to fit a 9-inch pie plate.
6. Place crust in pie plate, pressing evenly into the bottom and sides.

Crust sub-algorithm

- *Another mechanism for implementing abstraction*
 - *First one: compound data structures*
- *Instructions for making crust separate from instructions for making apple pie*
- *If you buy crust, don't need to know how you can make it*
- *You can make apple pie with different types of crust, no changes to apple pie instructions needed*
- *You can use same crust algorithm for making other dishes (meat pockets)*
- *If you don't like how the crust tastes, you change the crust recipe, not the entire apple pie recipe*

Apple pie algorithm

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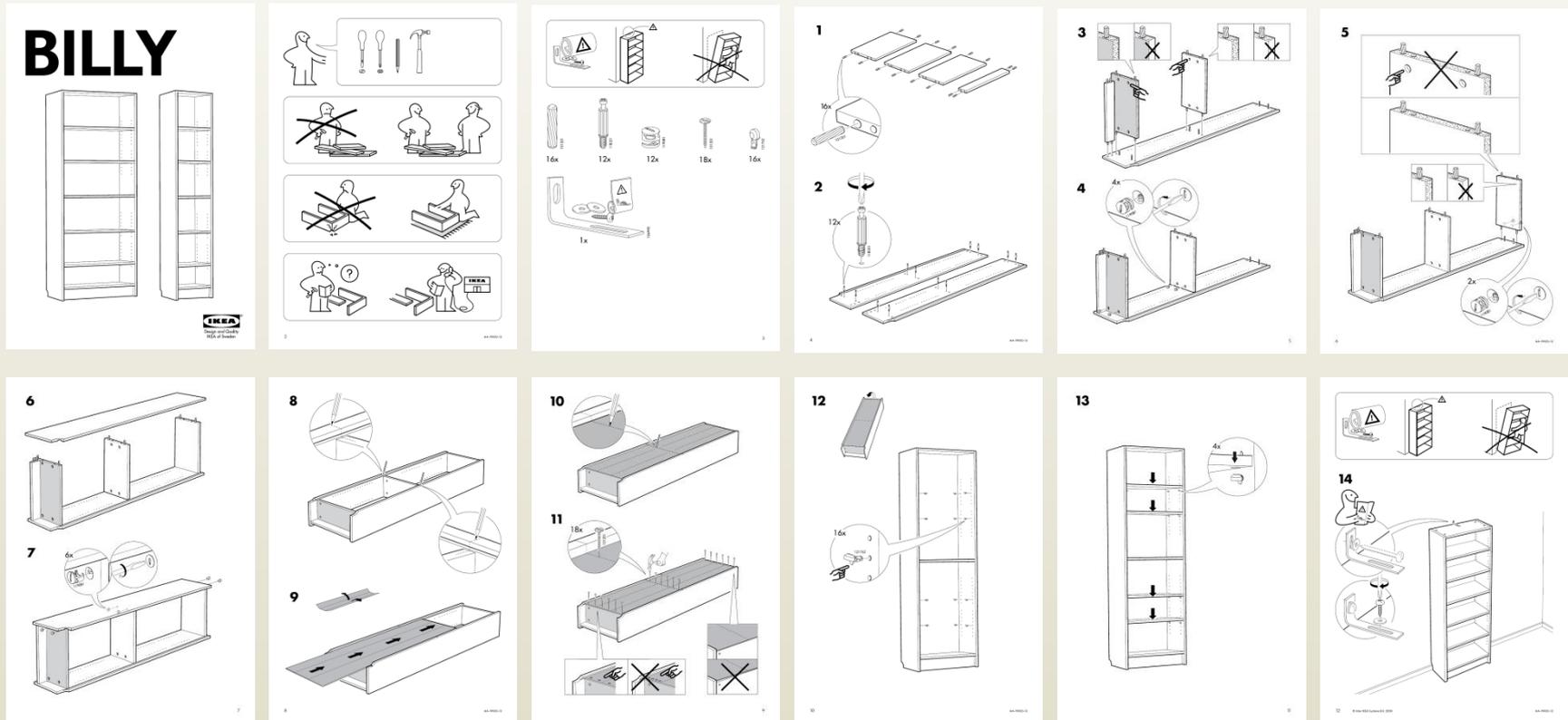
Generality

- Multiple apple types
- Any brand flour
- Any oven that can bake at 425

Algorithm specification

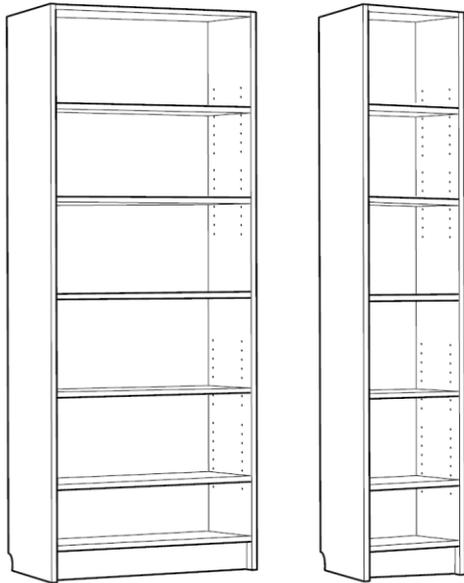
- Plain English (prose)
- Sequence of images

Billy bookcase assembly

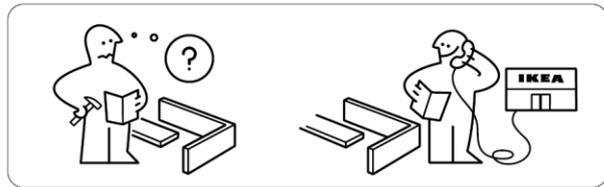
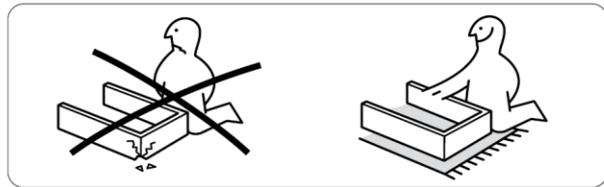
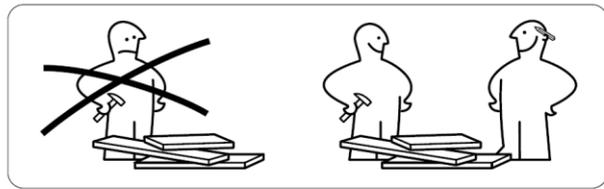
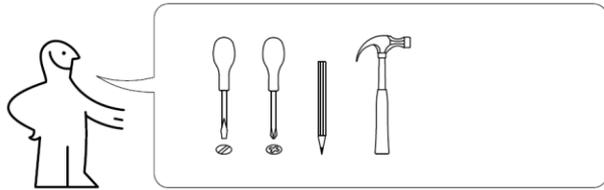


Output

BILLY



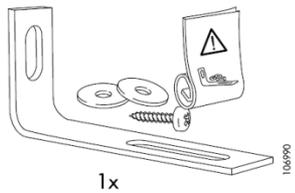
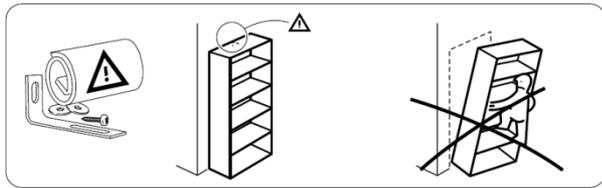
General rules



- These are the tools you need
- Don't work alone, work with someone else
- Don't work on a hard surface or else you'll damage the corners, work on a soft surface like a carpet
- If after reading instruction booklet you have questions call IKEA

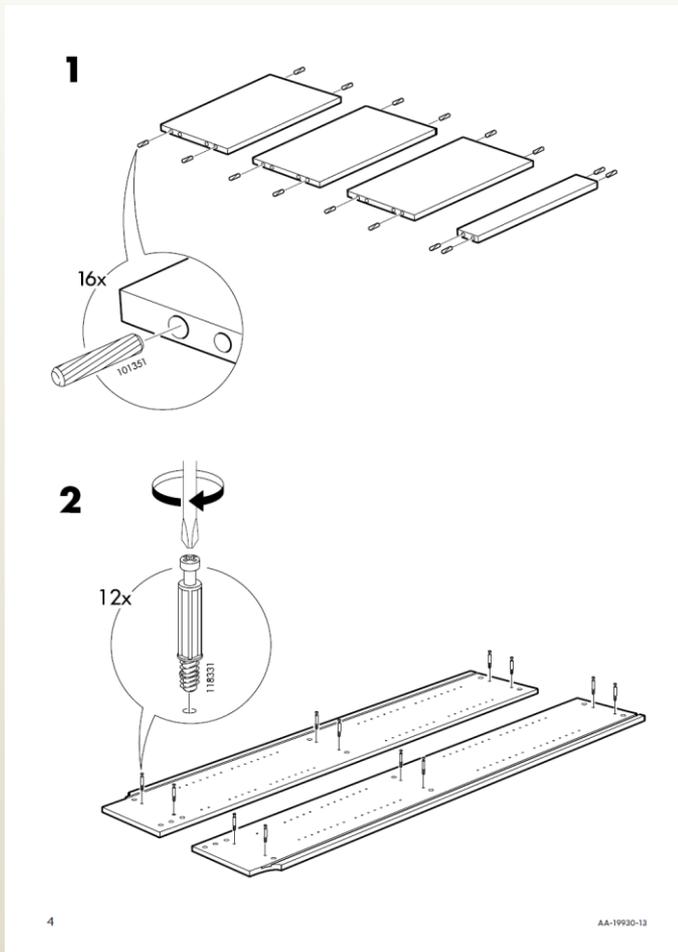
Input

- 16 pegs, 12 long screws,
...

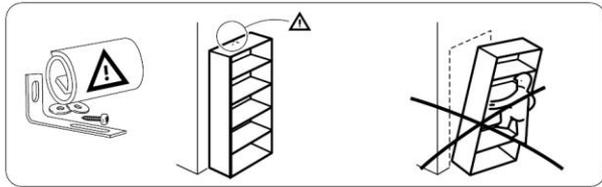


Step-by-step instructions

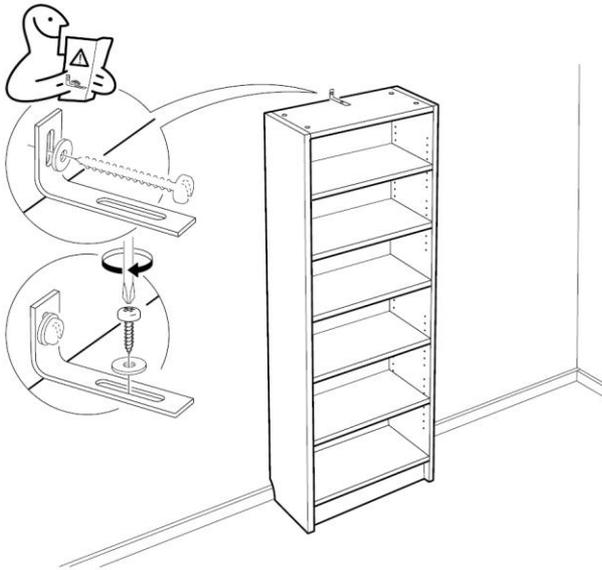
- Instruction 1
- Instruction 2
- ...



Step-by-step instructions

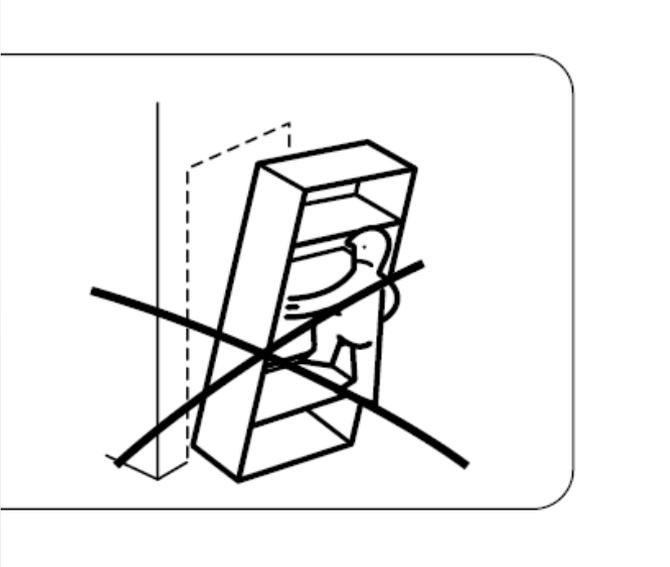


14



- Instruction 1
- Instruction 2
- ...
- Instruction 14
 - Last one, done!

iClicker questions



What does the image most likely mean?

- A. Do not allow children to climb on the bookcase as it might tip over.
- B. Children can climb on the bookcase safely as it'll never tip over.
- C. Place the bookcase in a spot where it does not cast a shadow (shown by dotted line).
- D. Never place the bookcase close to a corner.
- E. Hard to say, it's probably Swedish

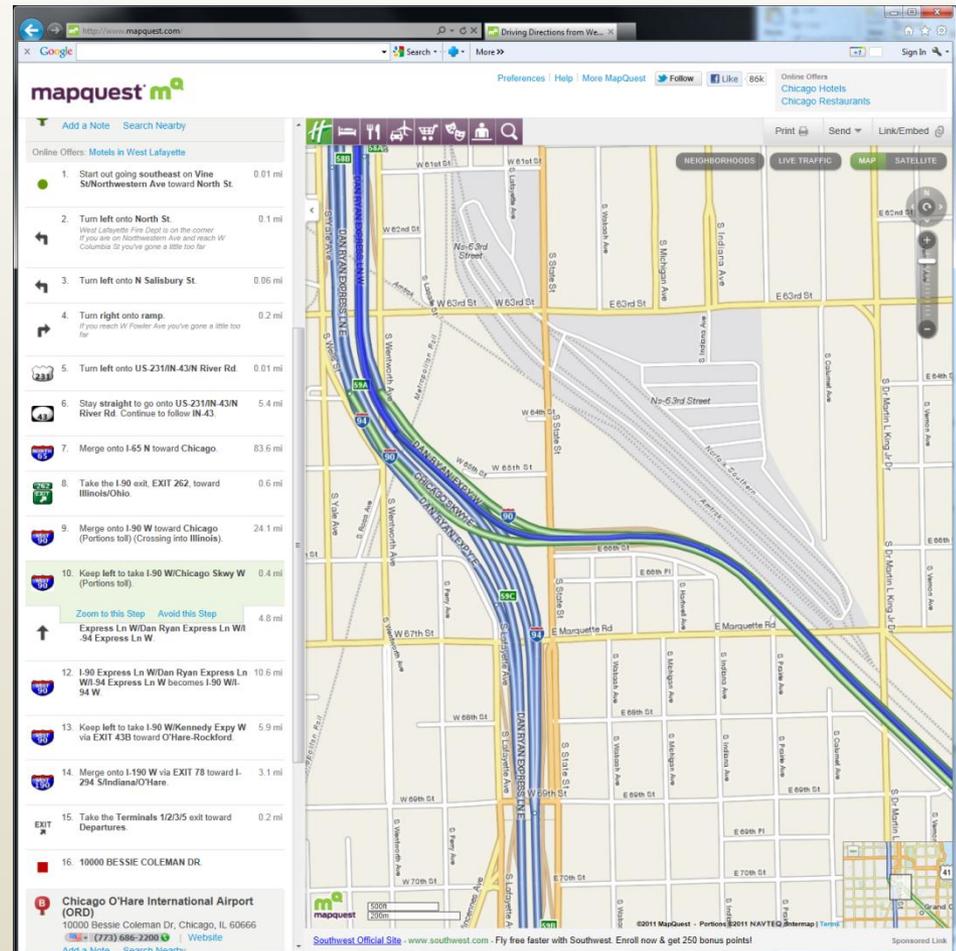
Algorithm specification

- Plain English (prose)
- Sequence of images
- Video sequence
 - E.g. cooking videos

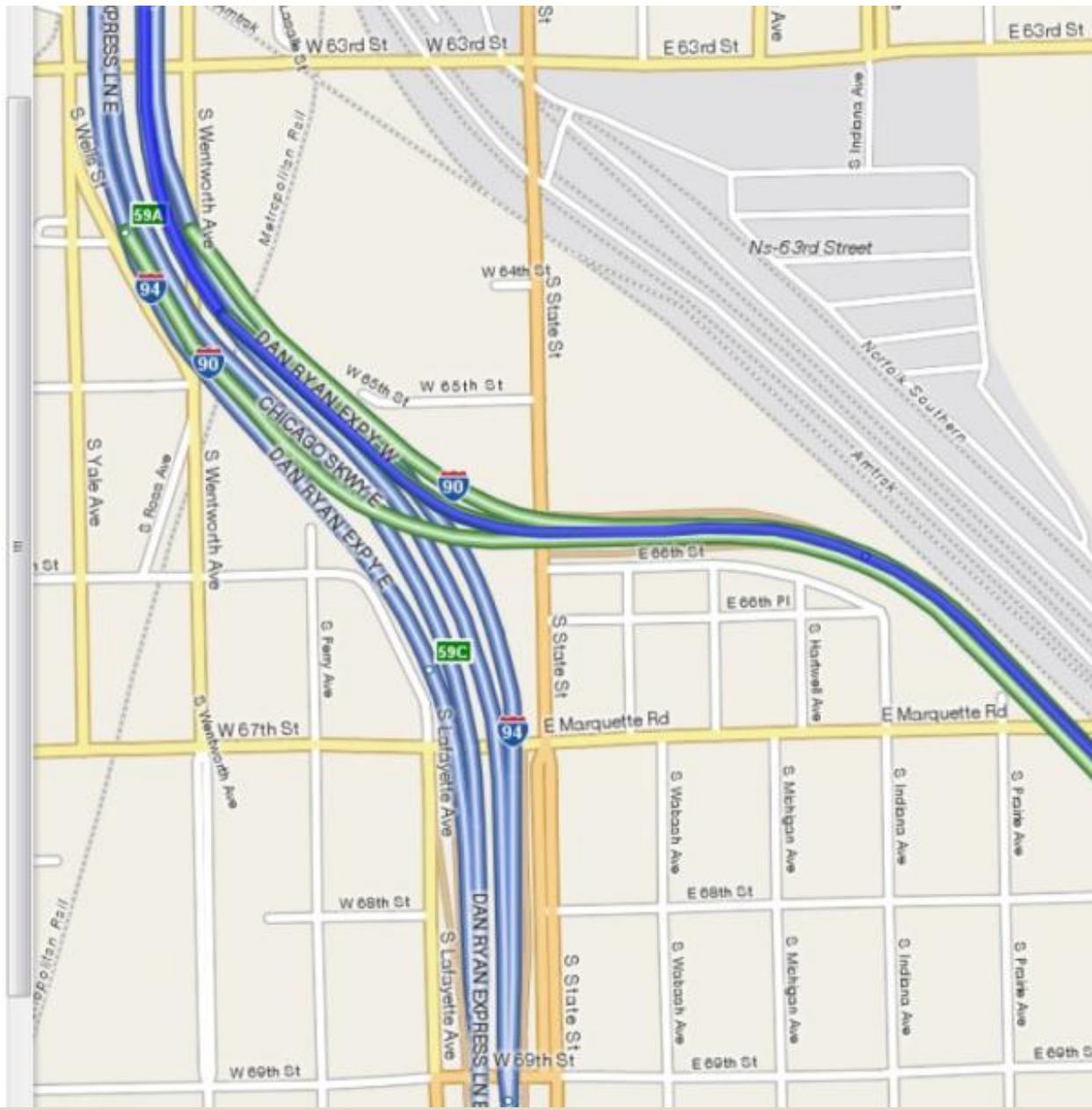


Algorithm specification

- Plain English (prose)
- Sequence of images
- Video sequence
- Hybrid
 - E.g. text and images



4. Turn right onto ramp. 0.2 mi
If you reach W Fowler Ave you've gone a little too far.
5. Turn left onto US-231/IN-43/N River Rd. 0.01 mi
6. Stay straight to go onto US-231/IN-43/N River Rd. Continue to follow IN-43. 5.4 mi
7. Merge onto I-65 N toward Chicago. 83.6 mi
8. Take the I-90 exit, EXIT 262, toward Illinois/Ohio. 0.6 mi
9. Merge onto I-90 W toward Chicago (Portions toll) (Crossing into Illinois). 24.1 mi
10. Keep left to take I-90 W/Chicago Skwy W (Portions toll). 0.4 mi
- Zoom to this Step Avoid this Step
- Express Ln W/Dan Ryan Express Ln W/ I-94 Express Ln W. 4.8 mi
12. I-90 Express Ln W/Dan Ryan Express Ln W/I-94 Express Ln W becomes I-90 W/I-94 W. 10.6 mi
13. Keep left to take I-90 W/Kennedy Expy W via EXIT 43B toward O'Hare-Rockford. 5.9 mi
14. Merge onto I-190 W via EXIT 78 toward I-294 S/Indiana/O'Hare. 3.1 mi
15. Take the Tompkins 40/16 exit toward 0.2 mi



Algorithm building blocks

- Input
- Instructions
- Sub-algorithms
 - “Make crust according to instructions below”
 - “Get to I-65 according to instructions below.”
 - “Mount bracket according to instructions on page 3.”
- Repetition
 - For
 - “For each of the four corners, attach one long screw”
 - “Mix for 15 minutes”
 - While
 - “While not golden brown bake”
 - Until
 - “Until golden brown”
 - “Tap in until flush with surface”
 - “Stay on I-65 until Merrillville”
- Conditionals
 - If then do this, else do that
 - “If tolls are acceptable, then take Skyway, else take I-80”
 - “If apples are large, then use only 2, else use 3”
 - “If 1000W microwave, then heat on high for 10 minutes, else if 500W microwave, then heat on high for 17 minutes, else use oven.”
- Output

Algorithm specification

- Plain English (prose)
 - Sequence of images
 - Video sequence
 - Hybrid
-
- These algorithm specifications are intended for humans
 - They are not sufficiently clear for computers

Not clear for computer

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Computer

For how long? How high should I toss them?

How many dots? How big are the dots? Where should they be placed?

How many slits? What shape? Where? Fork or hand, how should I decide?

What if in 20 minutes crust is golden and filling is not bubbly? Do I keep going? I might burn the crust?

iClicker question

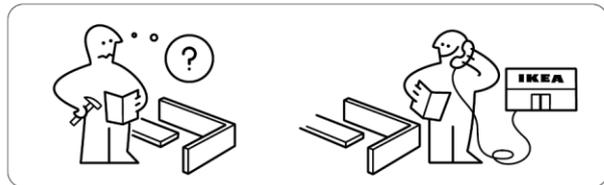
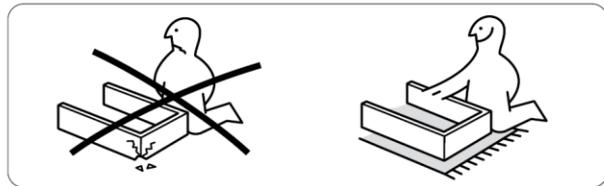
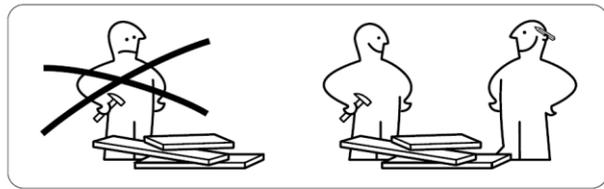
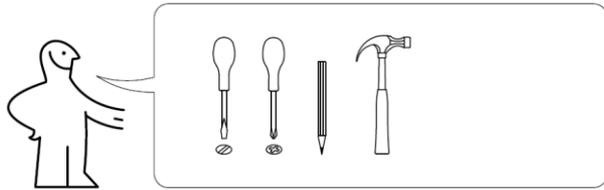
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What does this recipe fragment mean?

- A. If crust is golden and filling is not bubbly, keep baking until filling is bubbly, even if it means burning the crust.
- B. If crust is not golden and filling is bubbly, keep baking until crust is golden, even if it means drying out the filling.
- C. If crust is golden, stop baking regardless of whether filling is bubbly, to avoid burning the crust.
- D. If filling is bubbly, stop baking even if crust is not golden, to avoid drying out the filling.
- E. If crust is not golden or filling is not bubbly, keep baking, but use common sense, avoid burning crust or drying out filling. Stop as soon as crust is golden and filling is bubbly.

Not clear for computer

- For the computer some pixels are white some pixels are black...



2 steps for specifying algorithms for computers

- (1) Pseudocode
 - “Fake code”, “almost code”, “quasi-code”
 - English language and mathematical notations for specifying algorithms
 - Formatting and indentation rules
 - Concise, precise
 - Some syntax flexibility
 - Computers cannot execute it
- (2) Program
 - Algorithms specified using programming language
 - Strict syntax rules
 - Computers can execute programs
 - Compilers create machine code
 - Hardware executes machine code

Pseudocode motivation

- If computers cannot run pseudocode, why bother?
- Pseudocode is for humans, preliminary step before writing actual program
 - Third tool for abstraction: focus on big picture first
- Allows designing algorithm w/o worrying about programming language details and rigors
- Allows algorithm analysis
 - Memory consumption
 - Running time
- Allows algorithm testing, debugging
 - Humans can execute pseudocode and see algorithm output