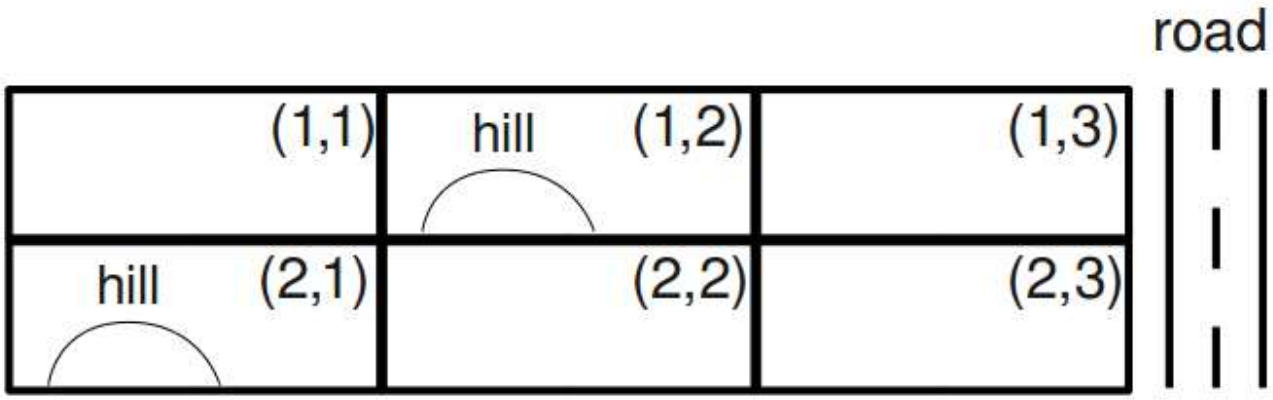
hw2_csps_q1_campus_layout

Question 1: Campus Layout

2/2 points (ungraded)

You are asked to determine the layout of a new, small college. The campus will have four structures: an administration structure (A), a bus stop (B), a classroom (C), and a dormitory (D). Each structure (including the bus stop) must be placed somewhere on the grid shown below.



The layout must satisfy the following constraints:

i. The bus stop (B) must be adjacent to the road.

ii. The administration structure (A) and the classroom (C) must both be adjacent to the bus stop (B).

iii. The classroom (C) must be adjacent to the dormitory (D).

iv. The administration structure (A) must not be adjacent to the dormitory (D).

v. The administration structure (A) must not be on a hill.

vi. The dormitory (D) must be on a hill or adjacent to the road.

vii. All structures must be in different grid squares.

Here, *adjacent* means that the structures must share a grid edge, not just a corner.

Keep Constraints Always Visible

We recommend you work out the solutions to the following questions on a sheet of scratch paper, and then enter your results below.

Part 1: Unary Constraints

(a) Which of the constraints above are unary constraints?

- [x] i
- [ ] ii
- [ ] iii
- [ ] iv
- [x] v
- [x] vi
- [ ] vii
- [ ] None of the above

✔

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✔ Correct (2/2 points)

problem

4/4 points (ungraded)

(b) Select the domains of all variables after unary constraints have been applied.

A	B	C	D
☑ (1,1)	☐ (1,1)	☑ (1,1)	☐ (1,1)
☐ (1,2)	☐ (1,2)	☑ (1,2)	☑ (1,2)
☑ (1,3)	☑ (1,3)	☑ (1,3)	☑ (1,3)
☐ (2,1)	☐ (2,1)	☑ (2,1)	☑ (2,1)
☑ (2,2)	☐ (2,2)	☑ (2,2)	☐ (2,2)
☑ (2,3)	☑ (2,3)	☑ (2,3)	☑ (2,3)
✔	✔	✔	✔

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2/2 points (ungraded)

Part 2: Arc Consistency

Let's start from the table above (the answer to Part 1) and enforce arc consistency. Initally, the queue contains all arcs (in alphabetical order).

Let's examine what happens when enforcing A → B. After enforcing unary constraints, the domains of A and B are:

A	B
(1,1) (1,3) (2,2) (2,3)	 (1,3) (2,3)

(c) Which of the following contains the correct domains after enforcing A → B? Pay attention to which variable's domain changes and which side of the arc it's on.

A	B
(1,1)	
	(1,2)
(1,3)	(1,3)
(2,2)	
(2,3)	(2,3)

i

A	B
(1,3)	(1,3)
(2,2)	
(2,3)	(2,3)

ii

A	B
(1,1)	
(1,3)	
(2,2)	
(2,3)	(2,3)

iii

A	B
(1,1)	
(1,3)	(1,3)
(2,2)	
(2,3)	

iv

- ○ i
- ◉ ii ✔
- ○ iii
- ○ iv

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✔ Correct (2/2 points)

problem

4/4 points (ungraded)

(d) Starting from the answer to Part 1 (in which unary constraints are enforced), select the domains of all variables after A → B is enforced.

A	B	C	D
☐ (1,1)	☐ (1,1)	☑ (1,1)	☐ (1,1)

☐ (1,2)	☐ (1,2)	☑ (1,2)	☑ (1,2)
☑ (1,3)	☑ (1,3)	☑ (1,3)	☑ (1,3)
☐ (2,1)	☐ (2,1)	☑ (2,1)	☑ (2,1)
☑ (2,2)	☐ (2,2)	☑ (2,2)	☐ (2,2)
☑ (2,3)	☑ (2,3)	☑ (2,3)	☑ (2,3)
✔	✔	✔	✔

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✔ Correct (4/4 points)

problem

4/4 points (ungraded)

(e) You should verify that enforcing consistency for A → C, A → D, B → A, B → C, B → D, and C → A do not change the domains of any variables. After enforcing these arcs, the next is C → B.

Continuing from the previous parts, select the domains of all variables after C → B is enforced.

A	B	C	D
☐ (1,1)	☐ (1,1)	☐ (1,1)	☐ (1,1)
☐ (1,2)	☐ (1,2)	☑ (1,2)	☑ (1,2)
☑ (1,3)	☑ (1,3)	☑ (1,3)	☑ (1,3)
☐ (2,1)	☐ (2,1)	☐ (2,1)	☑ (2,1)

☑ (2,2)	☐ (2,2)	☑ (2,2)	☐ (2,2)
☑ (2,3)	☑ (2,3)	☑ (2,3)	☑ (2,3)
✔	✔	✔	✔

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✔ Correct (4/4 points)

problem

3/3 points (ungraded)

(f) What arcs got added to the queue while enforcing C → B? Remember that the queue contained C → D, D → A, D → B, and D → C prior to enforcing C → B.

- ☐ A → B
- ☑ A → C
- ☐ A → D
- ☐ B → A
- ☑ B → C
- ☐ B → D
- ☐ C → A
- ☐ C → B
- ☐ C → D

- [ ] D → A
- [ ] D → B
- [ ] D → C
- [ ] None

✔

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✔ Correct (3/3 points)

problem

4/4 points (ungraded)

(g) Continuing from the previous parts, select the domains of all variables after enforcing arc consistency until the queue is empty. Remember that the queue currently contains C → D, D → A, D → B, D → C, and any arcs that were added while enforcing C → B.

A	B	C	D
☐ (1,1)	☐ (1,1)	☐ (1,1)	☐ (1,1)
☐ (1,2)	☐ (1,2)	☑ (1,2)	☑ (1,2)
☑ (1,3)	☑ (1,3)	☑ (1,3)	☑ (1,3)
☐ (2,1)	☐ (2,1)	☐ (2,1)	☑ (2,1)
☑ (2,2)	☐ (2,2)	☑ (2,2)	☐ (2,2)
☑ (2,3)	☑ (2,3)	☑ (2,3)	☐ (2,3)
✔	✔	✔	✔

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✔ Correct (4/4 points)

problem

3/3 points (ungraded)

Part 3: Search with Arc Consistency

(h) If arc consistency had resulted in all domains having a single value left, we would have already found a solution. Similarly, if it had found that any domain had no values left, we would have already found that no solution exists. Unfortunately, this is not the case in our example (as you should have found in the previous part). To solve the problem, we need to start searching. Use the MRV (minimum remaining values) heuristic to choose which variable gets assigned next (breaking any ties alphabetically).

Which variable gets assigned next?

- A
- B ✔
- C
- D

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✔ Correct (3/3 points)

problem

3/3 points (ungraded)

(i) The variable you selected should have two values left in its domain. We will use the least-constraining value (LCV) heuristic to decide which value to assign before contuing with the search. To choose which value is the least-constraining value, enforce arc consistency for each value (on a scratch piece of paper). For each value, count the total number of values remaining over all variables.

Which value has the largest number of values remaining (and therefore is the least constraining value)?

- (1,1)
- (1,2)
- (1,3)
- (2,1)
- (2,2)
- (2,3) ✔

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✔ Correct (3/3 points)

problem

4/4 points (ungraded)

(j) After assigning a variable, backtracking search with arc consistency enforces arc consistency before proceeding to the next variable.

Select the domains of all variables after assignment of the least-constraining value to the variable you selected and enforcing arc consistency. Note that you already did this computation to determine which value was the LCV.

A **B** **C** **D**

☐ (1,1)	☐ (1,1)	☐ (1,1)	☐ (1,1)
☐ (1,2)	☐ (1,2)	☐ (1,2)	☐ (1,2)
☑ (1,3)	☐ (1,3)	☐ (1,3)	☐ (1,3)
☐ (2,1)	☐ (2,1)	☐ (2,1)	☑ (2,1)
☐ (2,2)	☐ (2,2)	☑ (2,2)	☐ (2,2)
☐ (2,3)	☑ (2,3)	☐ (2,3)	☐ (2,3)
✔	✔	✔	✔

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✔ Correct (4/4 points)

problem

1/1 point (ungraded)

(k) Is the answer to the previous part a solution to the CSP?

- ◉ Yes ✔
- ○ No

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✔ Correct (1/1 point)