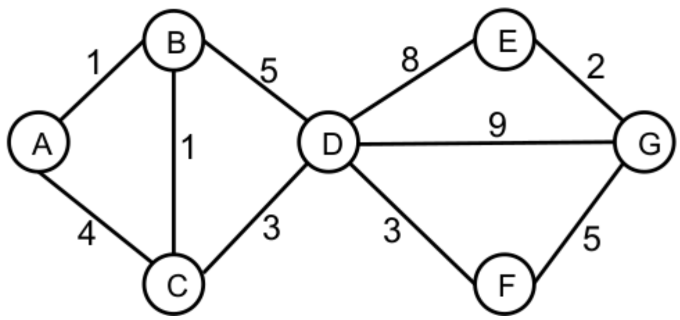
Please use LaTeX to produce your writeups. See the Homework Assignments page on the class website for details.

1 Uninformed Search

Consider the state space graph shown below. A is the start state and G is the goal state. The costs for each edge are shown on the graph. Each edge can be traversed in both directions.



Execute the following search algorithms using priority queues, by filling in the search table for each part. (Not all steps will necessarily be used.)

1. **Breadth First Graph Search.**

Step	**Priority Queue**	**Expand**
1	(A,1)	A
2	(A-B,2), (A-C,2)	B
3	(A-B-C,3), (A-B-D,3), (A-C,2)	C
4	(A-B-C,3), (A-B-D,3), (A-C-D,3)	D
5	(A-B-D-E,4), (A-B-D-F,4), (A-B-D-G,4), (A-C-D,3)	G
6	(A-B-D-G,4)	

2. **Depth First Graph Search.**

Step	**Priority Queue**	**Expand**
1	(A,1)	A
2	(A-B,2), (A-C,2)	B
3	(A-B-C,3), (A-B-D,3), (A-C,2)	C
4	(A-B-C-D,4), (A-B-D,3), (A-C,2)	D
5	(A-B-C-D-E,5), (A-B-C-D-G,5), (A-B-C-D-F,5), (A-B-D,3), (A-C,2)	G
6	(A-B-C-D-G,5)	

3. **Uniform Cost Graph Search.**

Step	**Priority Queue**	**Expand**
1	(A,0)	A
2	(A-B,1), (A-C,4)	B
3	(A-B-C,2), (A-B-D,6), (A-C,4)	C
4	(A-B-C-D,5), (A-B-D,6), (A-C,4)	D
5	(A-B-C-D-E,13), (A-B-C-D-G,14), (A-B-C-D-F,8), (A-B-D,6)	F
6	(A-B-C-D-E,13), (A-B-C-D-G,14), (A-B-C-D-F-G,13)	E
7	(A-B-C-D-E-G,15), (A-B-C-D-G,14), (A-B-C-D-F-G,13)	G
8	(A-B-C-D-F-G,13)	

2 Heuristic Search

1. Consider the two heurisitics h_1 and h_2, only one of which is consistent. Which one is consistent?

   h_1 is consistent, h_2 is not.

Node	A	B	C	D	E	F	G
h_1	9.5	9	8	7	1.5	4	0
h_2	10	12	10	8	1	4.5	0

2. Then do A* search with that heuristic.

Step	**Priority Queue**	**Expand**
1	(A,9.5)	A
2	(A-B,10), (A-C,12)	B
3	(A-B-C,10), (A-B-D,13), (A-C,12)	C
4	(A-B-C-D,12), (A-B-D,13), (A-C,12)	D
5	(A-B-C-D-E,14.5), (A-B-C-D-F,12), (A-B-C-D-G,14), (A-B-D,13)	F
6	(A-B-C-D-E,14.5), (A-B-C-D-F-G,13), (A-B-C-D-G,14), (A-B-D,13)	G
7	(A-B-C-D-F-G,13)	

3. Suppose you are completing the new heuristic function h_3 shown below. All the values are fixed except $h_3(B)$.

Node	A	B	C	D	E	F	G
h_3	10	?	9	7	1.5	4.5	0

   For each of the following conditions, write the set of values that are possible for $h_3(B)$. For example, to denote all non-negative numbers, write [0, ∞], to denote the empty set, write $\emptyset$, and so on.

   (a) What values of $h_3(B)$ make h_3 admissible?

   To make h_3 admissible, $h_3(B)$ has to be less than or equal to the actual optimal cost from B to goal G, which is the cost of path B-C-D-F-G, i.e. 12. The answer is $0 \leq h_3(B) \leq 12$, or [0,12].

(b) What values of $h_3(B)$ make h_3 consistent?

All the other nodes except node B satisfy the consistency conditions. The consistency conditions that do involve the state B are:

$$\begin{array}{ll} h(A) \leq c(A,B) + h(B) & h(B) \leq c(B,A) + h(A) \\ h(C) \leq c(C,B) + h(B) & h(B) \leq c(B,C) + h(C) \\ h(D) \leq c(D,B) + h(B) & h(B) \leq c(B,D) + h(D) \end{array}$$

Filling in the numbers shows this results in the condition: $9 \leq h_3(B) \leq 10$

(c) What values of $h_3(B)$ will cause A* graph search to expand from node A to C, then node A to B, then node A to C to D in that order?

The A* search tree using heuristic h_3 is on the right. In order to make A* graph search expand node A, then node C, then node B, suppose $h_3(B) = x$, we need

$$1 + x > 13$$
$$5 + x < 14 \quad (expand\ B') \quad or \quad 1 + x < 14 \quad (expand\ B)$$

so we can get $12 < h_3(B) < 13$