ANSWERS

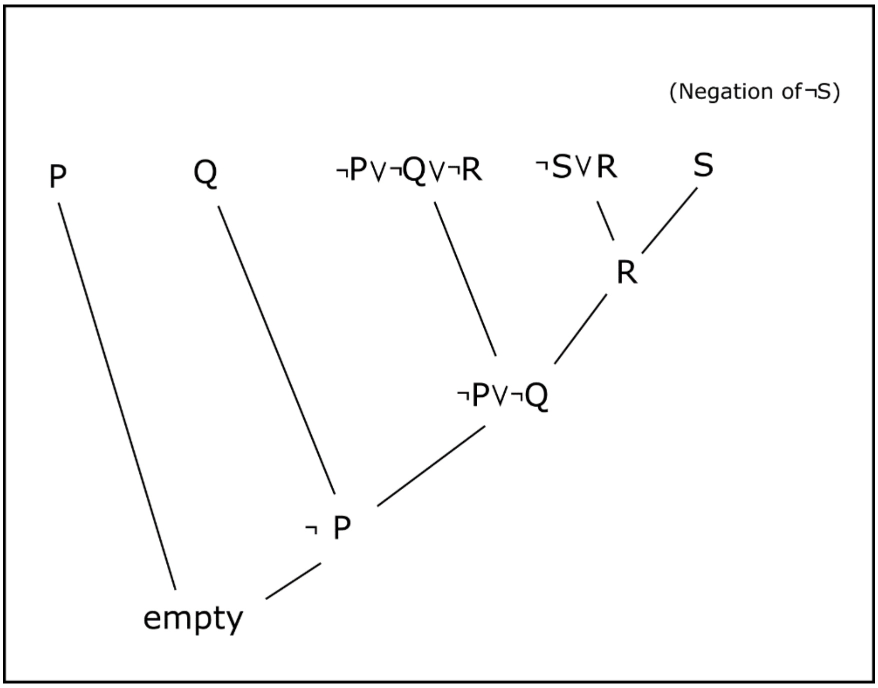
PROBLEM 1 – LOGIC

a)

1. $P \wedge Q$ given (premise)
2. P (from 1, decomposing a conjunction)
3. Q (from 1)
4. $P \rightarrow \neg(Q \wedge R)$ given
5. $\neg(Q \wedge R)$ (from 2,4)
6. $\neg$ Q $\vee$ $\neg R$ (from 5)
7. $\neg R$ (from 3,6)
8. $S \rightarrow R$ given
9. $\neg S$ (from 7,8)

b) Draw the truth table and see there is one row where 1,2, and 3 is true and $\neg$ S is also true there.

c)



d) First, we need to convert the definition of Green into CNF.

- $\forall x$: Green(x) $\leftrightarrow$ Bikes(x) $\vee$ [$\exists y$: Drives(x, y) $\wedge$ Electric(y)]

  Break the double-implication into 2 conjoined implications

- $\forall x$: [Green(x) $\rightarrow$ Bikes(x) $\vee$ [$\exists y$: Drives(x, y) $\wedge$ Electric(y)]] $\wedge$

  [[Bikes(x) $\vee$ [$\exists y$: Drives(x, y) $\wedge$ Electric(y)]] $\rightarrow$ Green(x)]

  Convert implications to disjunctions

- $\forall x$: [$\neg$Green(x) $\vee$ Bikes(x) $\vee$ [$\exists y$ Drives(x, y) $\wedge$Electric(y)]] $\wedge$

  $\neg$[Bikes(x) $\vee$ [$\exists y$ Drives(x, y) $\wedge$ Electric(y)] $\vee$ Green(x)

  Move negations inward

- $\forall x$: [$\neg$Green(x) $\vee$ Bikes(x) $\vee$ [$\exists y$: Drives(x, y) $\wedge$ Electric(y)]] $\wedge$

  $\neg$Bikes(x) $\wedge$ $\neg$[$\exists y$ Drives(x, y) $\wedge$ Electric(y)] $\vee$ Green(x)

  Continue moving negations inward

- $\forall x$: [$\neg$Green(x) $\vee$ Bikes(x) $\vee$ [$\exists y$ Drives(x, y) $\wedge$ Electric(y)]] $\wedge$

  $\neg$Bikes(x) $\wedge$ [$\forall y$ $\neg$Drives(x, y) $\vee$ $\neg$Electric(y)] $\vee$ Green(x)

  Skolemizing produces an F(x) in place of the existential-quantified y:

- $\forall x$: [$\neg$Green(x) $\vee$ Bikes(x) $\vee$ [Drives(x, F(x)) $\wedge$ Electric(F(x))]] $\wedge$
  $\neg$Bikes(x) $\wedge$ [$\forall y$: $\neg$Drives(x, y) $\vee$ $\neg$Electric(y)] $\vee$ Green(x)

  Remove the universal quantifications, since all remaining variables are universally quantified.

- [$\neg$Green(x) $\vee$ Bikes(x) $\vee$ [Drives(x,F(x)) $\wedge$Electric(F(x))]] $\wedge$

  $\neg$Bikes(x) $\wedge$ [$\neg$Drives(x, y) $\vee$ $\neg$Electric(y)] $\vee$ Green(x)

  Distribute the disjunction in the first half

- [$\neg$Green(x) $\vee$Bikes(x) $\vee$Drives(x,F(x))] $\wedge$
  [$\neg$Green(x) $\vee$ Bikes(x) $\vee$ Electric(F (x))] $\wedge$
  $\neg$Bikes(x) $\wedge$ [$\neg$Drives(x, y) $\vee$ $\neg$Electric(y)] $\vee$ Green(x)

  Distribute the disjunction in the second half to produce a conjunction of 4 disjuncts (CNF).

- [¬Green(x) ∨ Bikes(x) ∨Drives(x,F(x))] ∧

  [¬Green(x) ∨ Bikes(x) ∨ Electric(F (x))] ∧

  [Green(x) ∨ ¬Bikes(x)] ∧
  [¬Drives(x, y) ∨ ¬Electric(y) ∨ Green(x)]

  Next, combine these 4 clauses with the other givens and add in the negation of the goal sentence: Green(Sophie). Then keep applying the resolution rule until θ = False is derived, indicating the contradiction.

  1. ¬Green(x) ∨Bikes(x) ∨Drives(x,F(x)) Given
  2. ¬Green(x) ∨Bikes(x) ∨Electric(F(x))] Given
  3. Green(x) ∨ ¬Bikes(x)] Given
  4. ¬Drives(x, y) ∨ ¬Electric(y) ∨Green(x) Given

  5. Electric(Tesla) Given

  6. Drives(Sophie,Tesla) Given
  7. ¬Green(Sophie) (Assuming negation of target sentence)
  8. ¬Drives(x, Tesla) ∨ Green(x) (Resolving 4 and 5 with θ = {y/Tesla})

  9. Green(Sophie) (Resolving 6 and 8 with θ = {x/Sophie})

  10. (Resolving 7 and 9 with θ = {})

  Notice that only 1 of the 4 clauses derived from the definition of Green was used to prove the target sentence.

PROBLEM 2 --INFORMED AND UNINFORMED SEARCH

a) Uniform cost:

Expanded nodes: SADBCE G2

Solution path: S D C G2

Path cost: 13. Optimal path. Uniform cost search is optimal when there are no negative path costs.

b) Breadth first:
Expanded: S A G1. (goal check is when childs are generated)
S. Path: S A G1

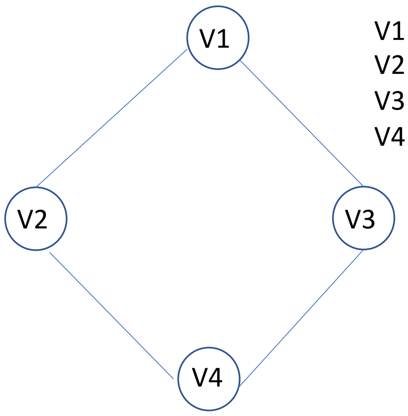
Path cost: 14. Not optimal. BFS is cost optimal only when the steps costs are identical

c) Depth first
Expanded nodes: S A B C F D E G3
Solution cost: 45

d) A*
Expanded nodes: S A B D C E G2
Solution path: S D C G2
Path cost: 13. Optimal.

PROBLEM 3 ---CSP CROSS WORD PUZZLE

a)



V1: 1-across
V2: 2-down
V3: 3-down
V4: 4-accross

b) C1: V1 has 5 letters

C2: V2 has 3 letters

C3: V3 has 3 letters

C4: V4 has 4 letters

C5: 3rd letter of V1 is the same letter as the first letter of V2

C6: 5th letter of V1 is the same letter as the first letter of V3

C7: 2nd letter of V4 is the same letter as 3rd letter of V2

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c) Domains, according to node consistency:

V1 ----Domain1={ astar, happy, hello, hoses}

V2 ----Domain2={ live, load, loam, peal, peel, save, talk, anon, nerd, tine }

V3 ----Domain3={ ant, oak, old, run, ten}

V2 ----Domain2={ live, load, loam, peal, peel, save, talk, anon, nerd, tine}

d)

Arc consistency Queue	Set to consider arc consistency	Set domains of the 2 variables of the arc	Domains of the 2 variables after consistency checked
V1V2, V1V3, V2V1, V2V4, V3V1, V3V4, V4V2, V4V3	V1V2	V1{astar, happy, hello, hoses} V2{live, load, loom, peal, peel, save, talk, anon, nerd, tine}	V1{astar, happy, hello, hoses} V2{live, load, loom, peal, peel, save, talk, anon, nerd, tine}
V1V3, V2V1, V2V4, V3V1, V3V4, V4V2, V4V3	V1V3	V1{astar, happy, hello, hoses} V3{ant, oak, old, ten, run}	V1{astar, hello} V3{ant, oak, old, ten, run}
V2V1, V2V4, V3V1, V3V4, V4V2, V4V3	V2V1	V2{live, load, loom, peal, peel, save, talk, anon, nerd, tine} V1{astar, hello}	V2{live, load, loom, talk, tine} V1{astar, hello}
V2V4, V3V1, V3V4, V4V2, V4V3, V1V2	V2V4	V2{live, load, loom, talk, tine} V4{live, load, loom, peal, peel, save, talk, anon, nerd, tine}	V2{load, loom, tine} V4{live, load, loom, peal, peel, save, talk, anon, nerd, tine}
V3V1, V3V4, V4V2, V4V3, V1V2	V3V1	V3{ant, oak, old, ten, run} V1{astar, hello}	V3{oak, old, run} V1{astar, hello}

V3V4, V4V2, V4V3, V1V2, V1V3	V3V4	V3{oak, old, run} V4{live, load, loom, peal, peel, save, talk, anon, nerd, tine}	V3{oak, old, run} V4{live, load, loom, peal, peel, save, talk, anon, nerd, tine}
V4V2, V4V3, V1V2, V1V3	V4V2	V4{live, load, loom, peal, peel, save, talk, anon, nerd, tine} V2{load, loom, tine}	V4{load, loom, save, talk, anon} V2{load, loom, tine
V4V3, V1V2, V1V3, V2V4, V3V4	V4V3	V4{load, loom, save, talk, anon} V3{oak, old, run}	V4{load, talk, anon} V3{oak, old, run}
V1V2, V1V3, V2V4, V3V4	V1V2	V1{astar, hello} V2{load, loom, tine}	V1{astar, hello} V2{load, loom, tine}
V1V3, V2V4, V3V4	V1V3	V1{astar, hello} V3{oak, old, run}	V1{astar, hello} V3{oak, old, run}
V2V4, V3V4	V2V4	V2{load, loom, tine} V4{load, talk, anon}	V2{load, loom, tine} V4{load, talk, anon}
V3V4	V3V4	V3{oak, old, run} V4{load, talk, anon}	V3{oak, old, run} V4{load, talk, anon}

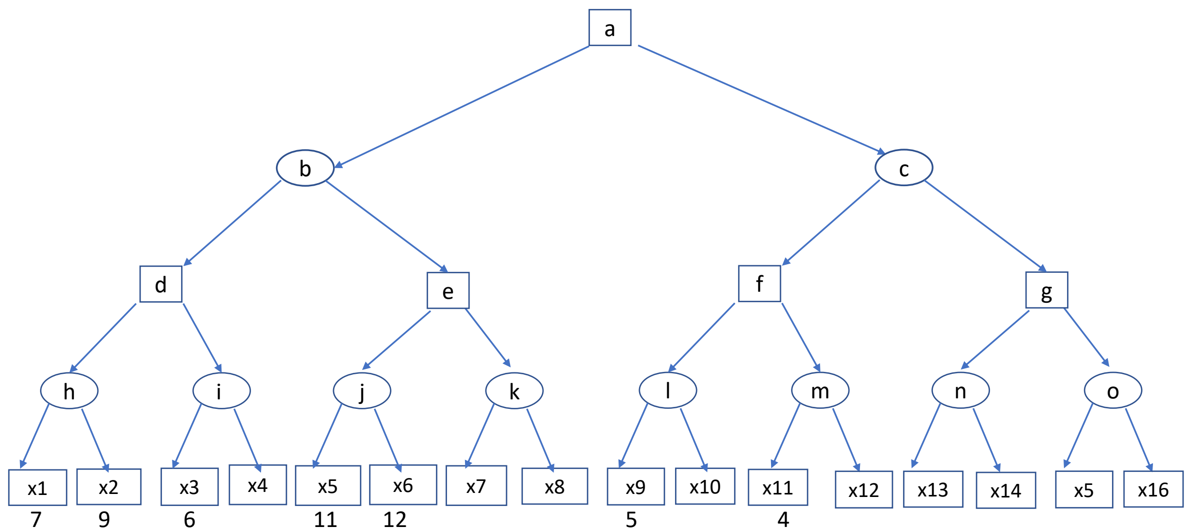
e) One of the possible solutions is:

A	S	T	A	R
		I		U
	A	N	O	N
		E		

PROBLEM 4 ---- ADVERSARIAL SEARCH

a) H=7,i<=6, d=7, j=11, e>=11, b= 7, c<=5, f<=5, l <=5, m<=4. solution=7

b) x4, k, x10, x12, and g are pruned



PROBLEM 5--- GAME THEORY

a) N={A1, A2}, Domains of A1=A2 ={0,10,20,30,40,50}, and the payoff fns are are specified by the following matrix

A1, Agent2	0	10	20	30	40	50
0	40, 0	0, 30	0, 30	0, 30	0, 30	0, 30
10	40, 0	30, 0	0,20	0, 20	0, 20	0, 20
20	40, 0	30, 0	20, 0	0, 10	0, 10	0, 10
30	40, 0	30, 0	20, 0	10, 0	0, 0	0, 0
40	40, 0	30, 0	20, 0	10, 0	0, 0	0, -10
50	40, 0	30, 0	20, 0	10, 0	0, 0	-10 , 0

b) There is no weakly dominant strategy eq. as neither player has a weakly dominant action. Notice that for both players, actions 30 and 40 weakly dominate every other action. But not wach other.

c) D) There is no strictly dominated action for either player and and hence all the action profiles survive IESD actions

d) We can eliminate the weakly dominated actions in the following order:
A:0
A2:0
A1: 50
A2: 50
A1:10
A2: 10
A1: 20
Which leads to the following set of outcomes {30,40} x {20,30,40}. However, tehre are other orders of elimination which lead to different outcomes.

e) The game is not dominance solvable.