Varun Khadayate A016 (Var)

AI

Assignment

Q1. x = Water in 4 Gallon Jug
y = Water in 3 Gallon Jug.

1. Fill 4-gal jug

(x, y)
$x < 4$ $\rightarrow$ $(4, y)$

2. Fill 3-gal jug

(x, y)
$y < 3$ $\rightarrow$ $(x, 3)$

3. Empty 4-gal jug on ground

(x, y)
$x > 0$ $\rightarrow$ $(0, y)$

4. Empty 3-gal jug on ground

(x, y)
$y > 0$ $\rightarrow$ $(x, 0)$

5. Pour water from 3-gal jug to fill 4-gal jug

(x, y)
$0 < x + y \geqslant 4$ and $y > 0$ $\rightarrow$ $(4, y - (4-x))$

6. Pour water from 4-gal jug to fill 3-gal jug

(x, y)
$0 < x + y \geqslant 3$ and $x > 0$ $\rightarrow$ $(x - (3-y), 3)$

7. Pour all of water from 3-gal jug into 4-gal jug

(x, y)
$0 < x + y \leqslant 4$ and $y \geqslant 0$ $\rightarrow$ $(x + y \neq 0)$

8. Pour all of water from 4-gal jug into 3-gal jug

(x, y)
$0 < x + y \leqslant 3$ and $x \geqslant 0$ $\rightarrow$ $(0, x + y)$

Solution

Gallons in 4-Gal Jug	Gallons in 3-Gal Jug	Rules Applied
0	0	1
4	0	6
1	3	6
1	0	4
0	1	8
4	1	1
2	3	6

Q2.

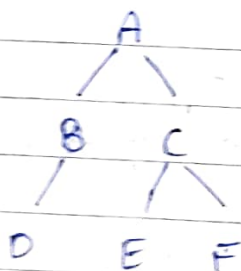### 1. Bread First search
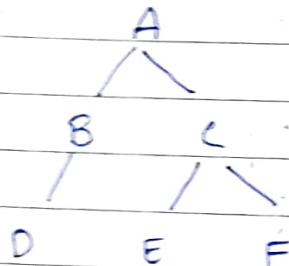
Path
A, B, C, D, E, F

2. Depth First search

Path
A, B, D, C, E, F

3. Local Beam Search


```
              A
     H=1  /      \  H=3
         B        C
       /   \     /   \
 H=2  D  H=2   H=3  H=0
         E    F    G
```
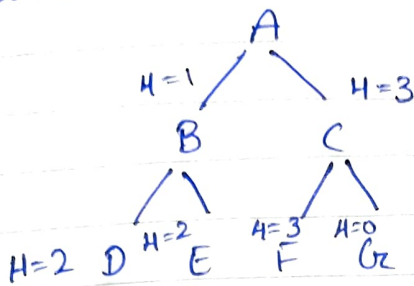
B = 3, Start Node = A , Goal Node = G

① OPEN = {A}

② OPEN = {B, C, G}

③ OPEN = {G}

④ OPEN = { }

∴ Goal Node Reached.

4. Best First Search


```
            A (15)
          /      \
      B(11)      C (6)
                /    \
            D(4)     E (2)
                    /    \
                 F(3)    G (0)
```
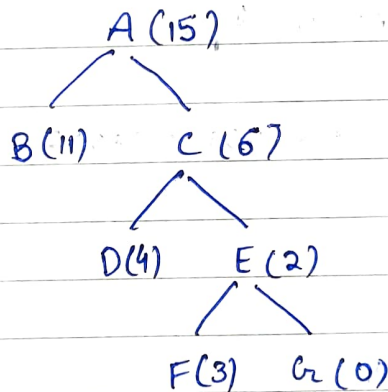
Iteration	Open	Closed
Initialization	B, C	A
Iteration 1	B	A, BC
Iteration 2	E, D, B	A, BC
	D, B	3, C, E
Iteration 3	F, G, D, B	A, C, E
	F, B, B	A, C, E, G

5. AO* Algorithm
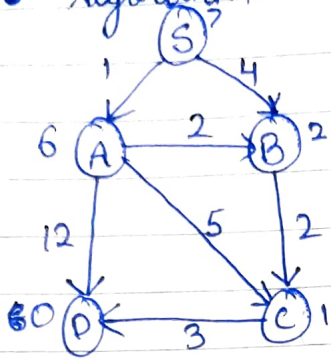
B. I. $S \to A = 1 + 6 = 7$

II. $S \to B = 4 + 2 = \cancel{8}6$

III. $S \to B \to C = 4 + 2 + 1 = 7$

IV. $S \to B \to C \to D = 4 + 2 + 3 + 0 = 9$

V. $S \to A \to B = 1 + 2 + 2 = 5$

VI. $S \to A \to C = 1 + 5 + 1 = 7$

VII. $S \to A \to D = 1 + 12 + 0 = 13$

VIII $S \to A \to B \to C = 1 + 2 + 2 + 1 = 6$

IX $S \to A \to B \to C \to D = 1 + 2 + 2 + 3 + 0 = 8$

X $S \to A \to C \to D = 1 + 5 + 3 + 0 = 9$

Best Path : $S \to A \to B \to C \to D = 1 + 2 + 2 + 3 + 0 = 8$

6. AO* Algorithm

Q3

a.
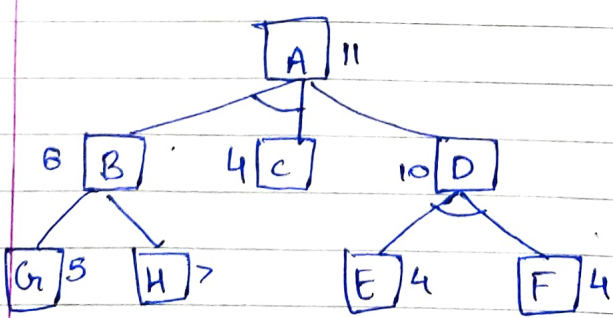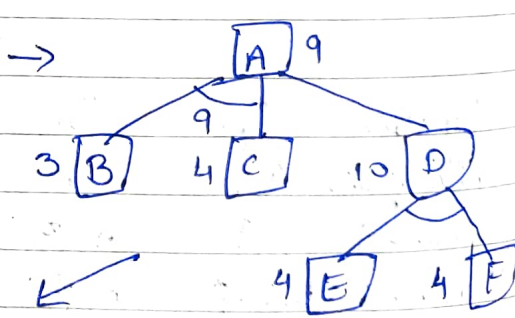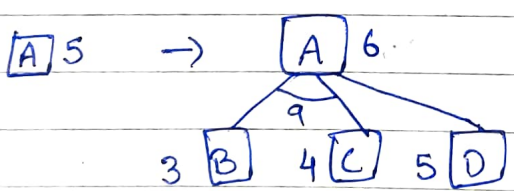
$$B^7 \quad A^4 \quad S^8 \quad E^3$$
$$B^7 \quad A^4 \quad L^5 \quad L^5$$
$$\underline{G^1 \quad A^4 \quad M^9 \quad E^3 \quad S^8}$$

$G = 1$ $M = 9$ $E = 3$

$B = 7$ $L = 5$

$A = 4$ $S = 8$

b.

$$D^5 \quad O^2 \quad N^6 \quad A^4 \quad L^8 \quad D^5$$
$$G^1 \quad E^9 \quad R^7 \quad A^4 \quad L^8 \quad D^5$$
$$\underline{R^7 \quad O^2 \quad B^3 \quad E^9 \quad R^7 \quad T^0}$$

$D = 5$ $A = 4$ $E = 9$ $T = 0$

$O = 2$ $L = 8$ $R = 7$

$N = 6$ $G = 1$ $B = 3$

Q4.

1. $\forall a \, (Hound(x) \rightarrow Howl(x))$

    $\neg Hound(x) \lor Howl(x)$

2. $\forall x \, \forall y \, (Howl(x,y) \land Cat(y) \rightarrow \neg \exists z \, (Have(x,y) \land Mouse(z)))$

    $\neg(Have(x,y) \lor \neg Cat(y) \lor \neg Have(x,z) \lor \neg Mouse(z))$

3. $\forall x \, (LS(x) \rightarrow \neg \exists y \, (Have(x,y) \land \overset{Howl}{\cancel{Hound}}(y)))$

    $\neg LS(x) \lor \neg Have(x,y) \lor \neg Howl(y)$

4. $\exists x \, (Have(John,(x) \land (Cat(x) \lor Hound(x))$

    $Have(John, a) \land Cat(a) \lor Hound(a)$

5. $\neg[LS(John) \rightarrow \neg \exists z \, (Have(John, z) \land Mouse(z))]$

    $LS(John) \land Have(John, b) \land Mouse(b)$

∴ CNF Clauses are: —

1) $\neg Hound(x) \lor Howl(x)$

2) $\neg Have(x,y) \lor \neg Cat(y) \lor \neg Have(x,z) \lor \neg Mouse(z)$

3) $\neg LS(x) \lor \neg Have(x,y) \lor \neg Howl(y)$

4) a. $Have(John, a)$

    b. $Cat(a) \lor Hound(a)$

5) a. LS(John)

    b. Have(John, b)

    c. Mouse(b)

6) Cat (a) V Howl (a)   [By 1,4(b)]

7) ¬Have (x,y) V ¬Cat(y) V ¬Have(x,b)   [By 2,5(c)]

8) ¬Have (John, y) V ¬Cat(y)   [By 7,5(b)]

9) ¬Have (John, a) V Howl(a)   [By 6,8]

10) Howl (a)   [By 4(a), 9]

11) ¬LS (x) V ¬Have (x, a)   [By 3,10]

12) ¬LS(John)   [By 4(a), 11]

13) Empty

Q5. CNF Clauses

1) ¬American (x) V ¬Weapon (y) V ¬Sells (x, y, z) ¬Hostile (z)
       V Criminal (x)

2) Owns (Nono, M_1)

3) ¬Missile (x) V ¬Owns (Nono, x) V Sells (West, x, Nono)

4) ¬Missile (x) V Weapon (x)

5) ¬Enemy (x, America) V Hostile (x)

6) American (West)

7) Enemy (Nono, America)

8) Missile(M_1)

9) ¬Criminal (West)

∴ CNF Clauses are :-

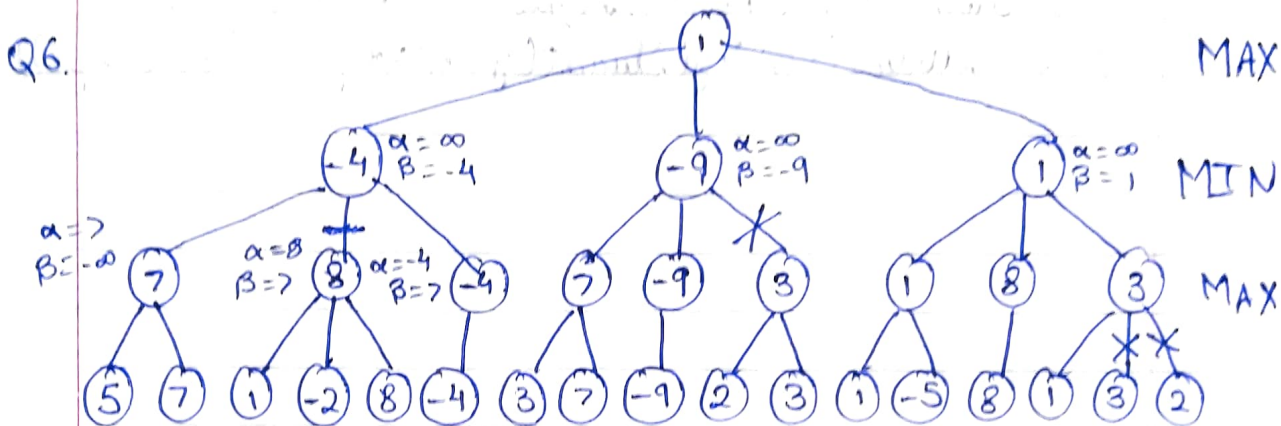10) ¬American (West) V ¬Weapon (y) V ¬Sells (West, y, z)
           V ¬Hostile (z)   [By 1,9]

11) ¬Weapon (y) V ¬Sells (West, y, z) V ¬Hostile (z) [By 10,6]

12) ¬Missile (y) V ¬Sells (West, y, z) V ¬Hostile (z) [By 11,4]

13) ¬Sells (West, M_1, z) V ¬Hostile (z) [By 12,8]

12   14) ¬Missile (M₁)∨¬Owens (Nono, M₁)∨¬Hostile (Nono)   [By 13,9]
     15) ¬Owens(Nono, M₁)∨¬Hostile (Nono)   [By 14,8]
     16) ¬Hostile(Nono)   [By 15,2]
     17) Enemy (Nono, American),   [By 16,5]
     18) Empty   [By 17,7]

Q6.

Q7. 1) ∀x (Student (x) → Smart (x))
     2) ∃x Student (x)
     3) ∃x (Student (x) ∧ Smart (x))
     5) ∀x (Student (x) → ∃y (Student (y) ∧ ¬ (x=y) ∧ Loves (x,y)))
     4) ∀x (Student (x) → ∃y (Student (y) ∧ Loves (x, y)))
     6) ∃x (Student (x) ∧ ∀y (Student (y) ∧ ¬ (x==y) → Loves (y,x)))
     7) Student (Bill)
     8) Takes(Bill, Analysis) ⟷ ¬Takes (Bill, Geometry)
     9) Takes(Bill, Analysis) ∨ Takes (Bill, Geometry)
     10) Takes(Bill, Analysis) ∧ Takes (Bill, Geometry)
     11) ¬Takes (Bill, Analysis)
     12) ¬∃x (Student (x) ∧ Loves (x, Bill))
     13) ∃x Brother (x, Bill)
     14) ¬∃x Sister (x, Bill)
     15) ∀x,y (Brother (x, Bill) ∧ Brother (y, Bill) → x= y)

16) $\exists_{x,y} (Brother (x, Bill) \wedge Brother (y, Bill) \wedge \neg (x = y))$

17) $\forall_x (Student (x) \rightarrow \exists y (Course (y) \wedge Takes (x,y)))$

18) $\exists_x (Students (x) \wedge Failed (x, History) \wedge \forall y (Student (y) \wedge$
$$Failed (y, History) \rightarrow x = y))$$

19) $\neg \exists_x (Student (x) \wedge Failed (x, Chemistry)) \wedge \exists_x (Student$
$(x) \wedge Failed (x, History))$

20) $\forall_x (Student (x) \wedge Takes (x, Analysis) \rightarrow Takes (x, Geometry))$

21) $\neg \exists_x (Student (x) \wedge \forall y (Student (y) \wedge \neg (x = y) \rightarrow Fools (x,y)))$