Swapnoneel Kayal

Roll No: 200100154 B

CS 499 Topics in Artificial Intelligence Programming

Final Exam: Nov 9, 2022 (17:05 - 19:00)

No books, calculators, mobiles, laptops.

Do rough work (using **very small font**) on back sides only. Then plan and write *concise clear* answers within the space provided. No doubts allowed.

Qn. No.	1	2	3	4	5	Total (= 100)
Marks	20+1 => 21	14	18	16	17	86

1. (21 marks) Aditya, Bhaskar and Chandra took the Logic exam Using three proposition symbols (A,B,C) with meanings- A: "Aditya passed the exam", B: "Bhaskar passed the exam", and C: "Chandra passed the exam" represent each of the following sentences as a propositional logic formula. Simpler answers will get more marks.

   (a) Chandra is the only one who passed.

   $(\neg A) \wedge (\neg B) \wedge (C)$ (3)

   (b) Aditya is the only one who failed.

   $(\neg A) \wedge (B) \wedge (C)$ (3)

   (c) Only one of the three passed the exam.

   $(\neg A \wedge \neg B \wedge \not C) \vee (\neg A \wedge B \wedge \neg C) \vee (A \wedge \neg B \wedge \neg C)$

   ↑ $(\neg A \wedge \neg B \wedge C)$ should be here. (3)

   (d) At least one of the three passed.

   $A \vee B \vee C$ (3)

   (e) At least two passed.

   $(\neg A \wedge B \wedge C) \vee (A \wedge \neg B \wedge C) \vee (A \wedge B \wedge \neg C) \vee (A \wedge B \wedge C)$ (3)

   (f) At most two passed.

   $(\neg A) \vee (\neg B) \vee (\neg C)$ (3)

   (g) Exactly two passed.

   $(\neg A \wedge B \wedge C) \vee (A \wedge \neg B \wedge C) \vee (A \wedge B \wedge \neg C)$ (3)

(1)

A	B	C
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

(a) $\bar{A}\bar{B}C$

(b) $\bar{A}B\bar{C}$

(c) $\bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C}$ ✓

(d) $\bar{A}\bar{B}C + \bar{A}B\bar{C} + \dots$
$\dots + ABC$
(all terms ORed except $\bar{A}\bar{B}\bar{C}$)

(e) $\bar{A}BC + A\bar{B}C + AB\bar{C}$
$+ ABC$

(f) $\bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + \dots$
$\dots + \bar{A}B\bar{C}$ (all terms ORed except ABC)

(g) $\bar{A}BC + A\bar{B}C + AB\bar{C}$

Note :— $\bar{A} \equiv \neg A$

$A + B \equiv A \vee B$

$AB \equiv A \wedge B$

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2. (14 marks)

Consider the following Prolog program (a,b,c are constants and p, q are predicates). List all the answers (in the correct order) for query $q(U, V)$.

```
p(a,b).
p(a,c).
p(b,c).
p(c,X):-p(b,Z), p(a,X).
q(X,Y) :- p(X,Y), p(Y,X).
q(X,Y) :- p(X,X).
```

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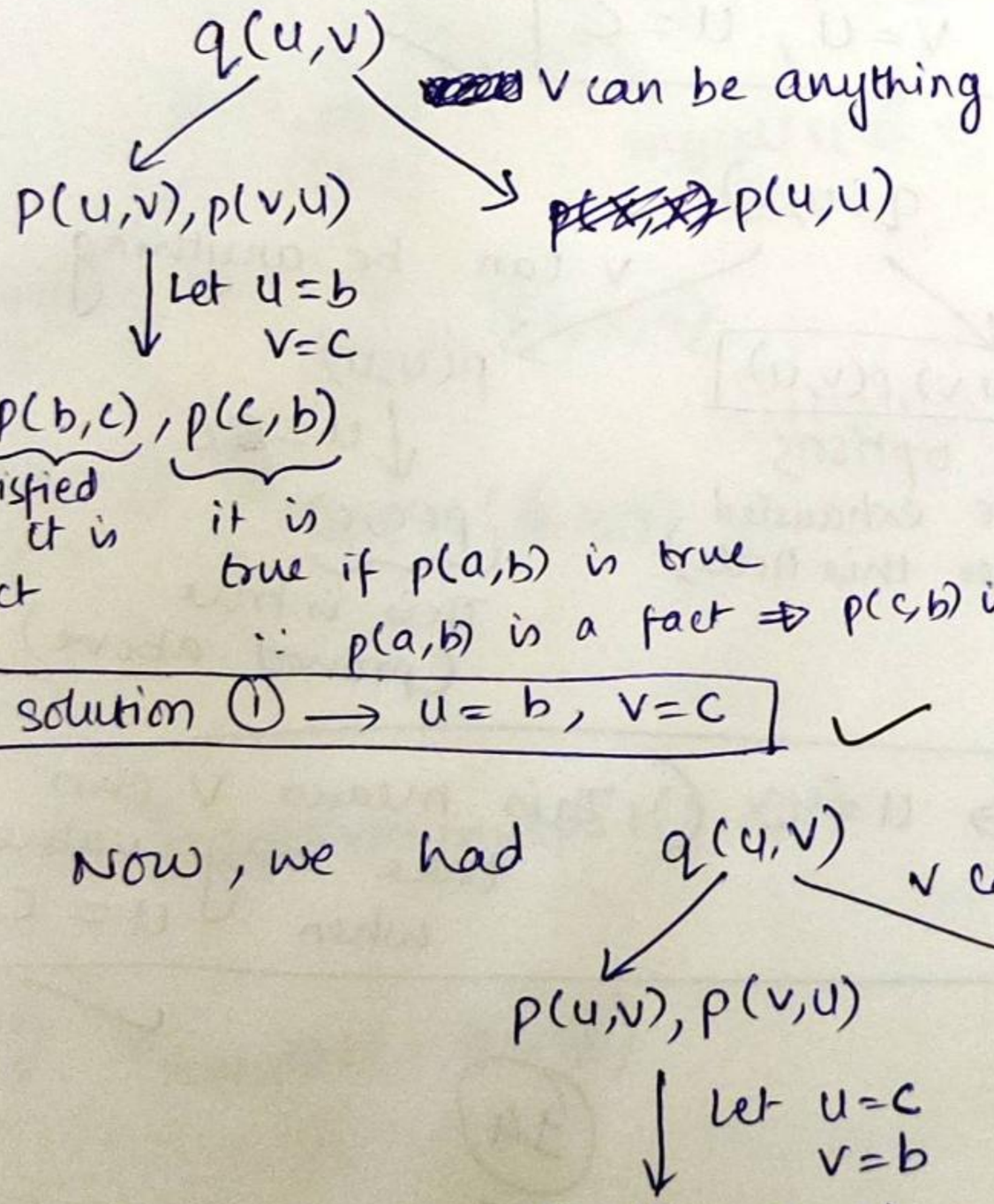
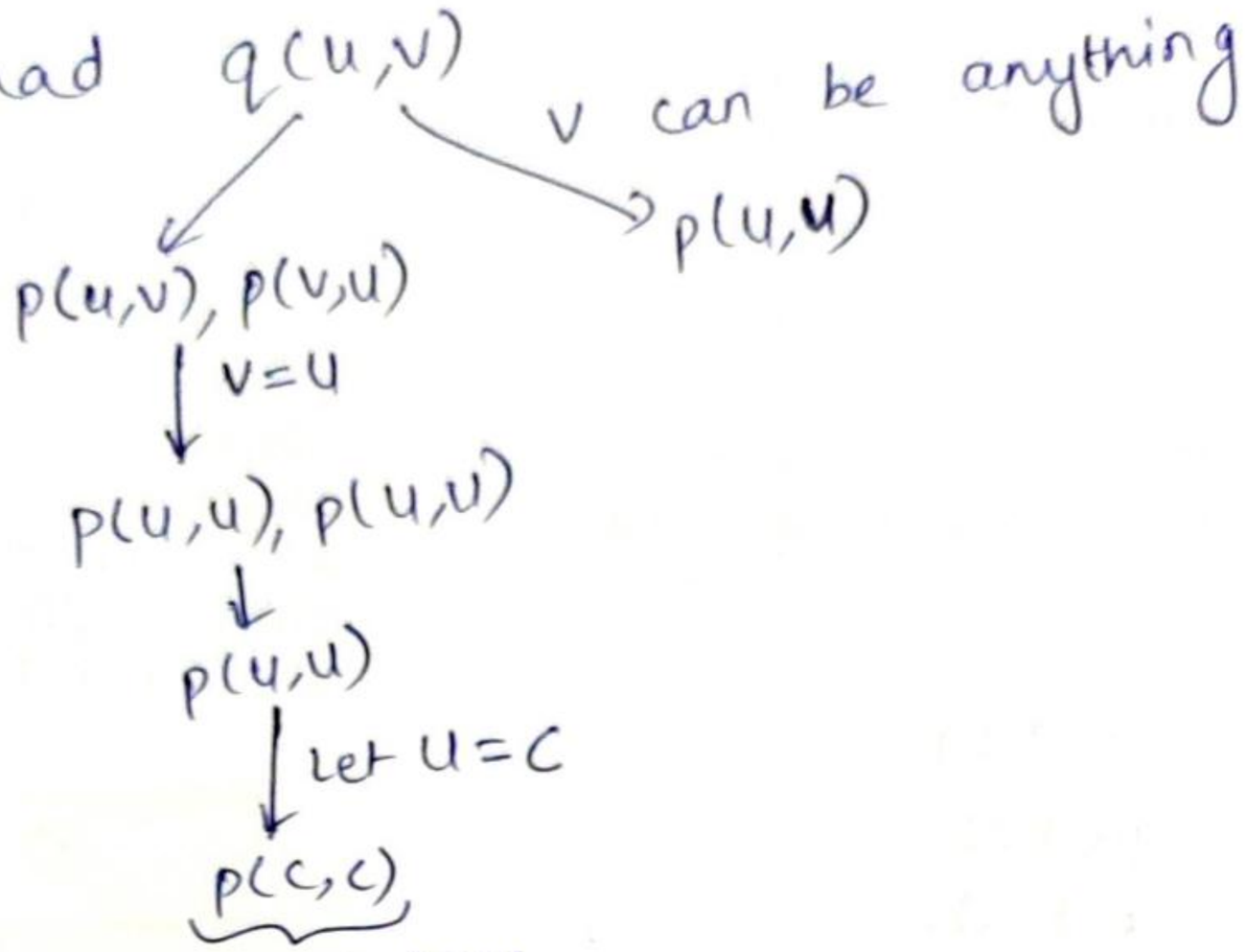
Facts :- p(a,b).
p(a,c).
p(b,c).

Rules :- ① p(c,x) :- p(b,z), p(a,x). // this gives us p(c,b) and p(c,c)
② q(x,y) :- p(x,y), p(y,x)
③ q(x,y) :- p(x,x).

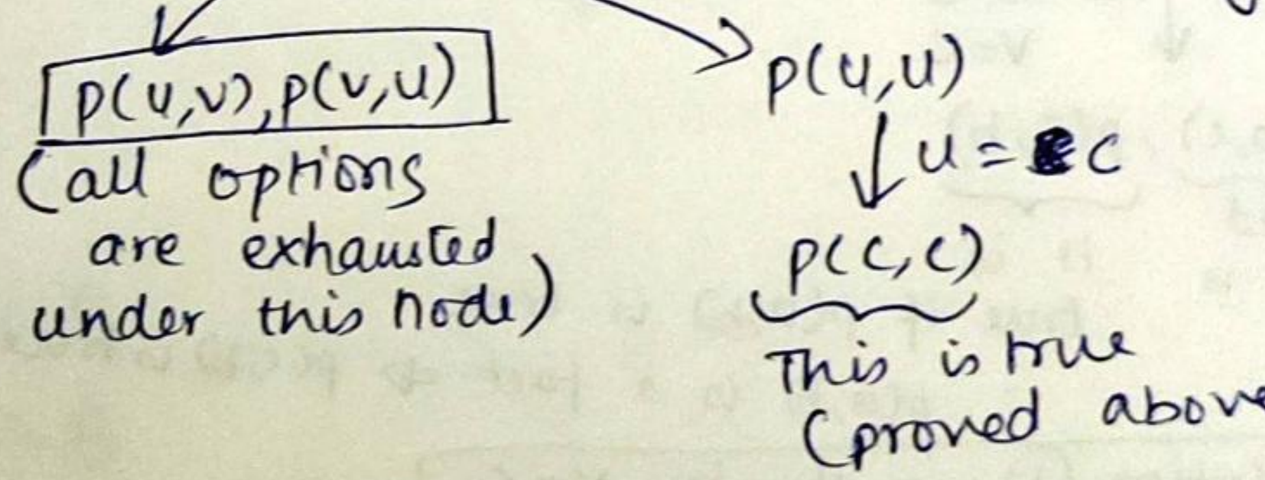


Now, we had q(u,v)



So, sol^n ~~(1)~~ (3) → v=u, u=c ✓

Now, we had q(u,v)



So, sol^n (4) → u=c (This means v can take any value when u=c)

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3. (25 marks) Consider the following Prolog program.

```
pr(N,[X,Y]) :- N > 0, N1 is N - 1, pr(N1,[X,Y]).
pr(N,[X,Y]) :- N > 0, mysplit(N,X,Y).

mysplit(0,0,0).
mysplit(N,0,N) :- N > 0.
mysplit(N,X,Y) :- N > 0, N1 is N-1, mysplit(N1,X1,Y), X is X1 + 1.
```

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(a) • How many answers will be generated for the goal pr(8,Ans)? List the first 8 answers.

$\Rightarrow 2+3+4+5+6+7+8+9 = (1+2+\cdots+9)-1$

$= \frac{9\times10}{2} - 1 = 45-1 = 44$ ✓

(b) • Repeat previous part if the following line is added at the top of the file.

```
mysplit(N,N,0) :- N > 0.
```

(a)

Let us understand what mysplit does with the help of an example :-

From mysplit(2,X,Y) we get → X=0, Y=2
X=1, Y=1
X=2, Y=0

3(a). # answers for goal pr(8, Ans) =

$2 + 3 + 4 + 5 + 6 + 7 + 8 + 9$

$= 44$

First 8 answers →

	X	Y
①	0	1
②	1	0
③	0	2
④	1	1
⑤	2	0
⑥	0	3
⑦	1	2
⑧	2	1

(15)

3(b). Now we have 4 rules for mysplit

mysplit(2, X, Y)

① X = 2, Y = 0

② X

③ X = 0, Y = 2

④ mysplit(1, X-1, Y)

① X-1 = 1, Y = 0

② X

③ X-1 = 0, Y = 1

④ mysplit(0, X-2, Y)

X-2 = 0, Y = 0

2	0
0	2
1	1

} different order

answers for goal pr(8, Ans) =

$2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 = 44 \times$ (80) should be the ans

First 8 answers !-

X	Y
1	0
0	1
2	0
0	2
1	1
3	0
0	3
1	2

(# answers remain same !)

(change in order)

→ few incorrect answers.

(3)

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4. (20 marks) CSE department wants to offer 5 courses each with 3 lecture slots per week (55 mins each) on Mon, Wed, Friday. Course names and starting times are ToC (8am), DBMS (8.30am), AI (9am), NW (9am), PL (9.30am). Only 3 professors are available (SB, PB, GS) to run courses. SB can teach ToC, AI, PL, DBMS. PB can teach DBMS, NW, PL. GS can teach ToC, AI, NW. Formulate this as a Constraint Solving Problem and draw the constraint graph below clearly. Solve this problem systematically (need not show the steps) and list all feasible assignments.

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understanding the constraint :-

~~SB :-~~

3 professor

SB → ToC, AI, PL, DBMS

PB → DBMS, NW, PL

GS → ToC, AI, NW

courses = 5

days = 3

lectures = 5 × 3 = 15 i.e. 15 slots

Mon	wed	Friday
ToC → 2 choices	TOC	Toc
DBMS → 2 "	DBMS	DBMS
AI → 2 "	AI	AI
NW → 2 "	NW	NW
PL → 2. "	PL	PL

Assumption (Note this can be put down as a constraint as well)

No 2 professors can teach the same course (i.e. AI cannot be taught by SB on monday and by GS on friday).

Hence, the number of possible assignments $= 2^5 = 32$. Are they all feasible? No!

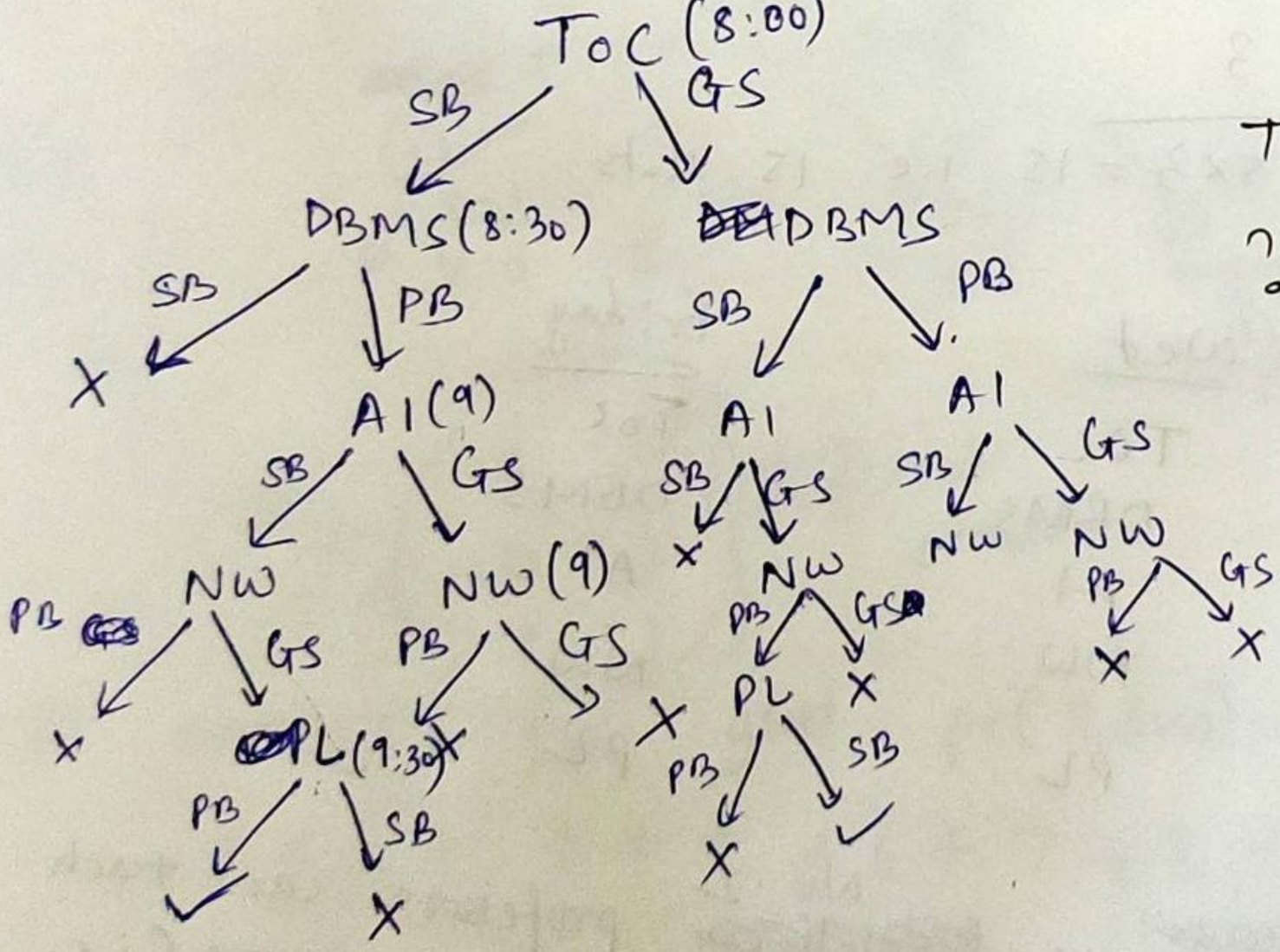
~~Feasible assignments~~

If SB takes TOC at 8 then he cannot take DBMS at 8:30 since lecture lasts for 55 mins.

For SB, if he takes TOC at 8 then DBMS has to be taken by PB at 8:30.

For this, we can formulate a tree as shown below →

what is the constraint here? The fact that every slot needs to be assigned one professor and that the professor cannot be assigned any 2 overlapping slots.



TA's Remark:

? No constraint graph

One more feasible soln. exists:

GS → TOC, NW

SB → AI

PB → DBMS, PL

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One feasible assignment :-

TOC → SB

DBMS → PB

AI → SB

NW → GS

PL → PB

TOC → GS

DBMS → SB

AI → GS

NW → PB

PL → SB.

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5. (20 marks) Consider the following answer set program stored in file cc.lp.

```
coin(1;3;5).
1 {used(I,0..m/I)} 1 :-  coin(I).
:- not m #sum{ (I * J) : used(I,J)} m.
#show used/2.
```

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Explain briefly but clearly what this program will do. If run as - *clingo 0 -c m=10 cc.lp* - what will be the output?

→ coin change problem

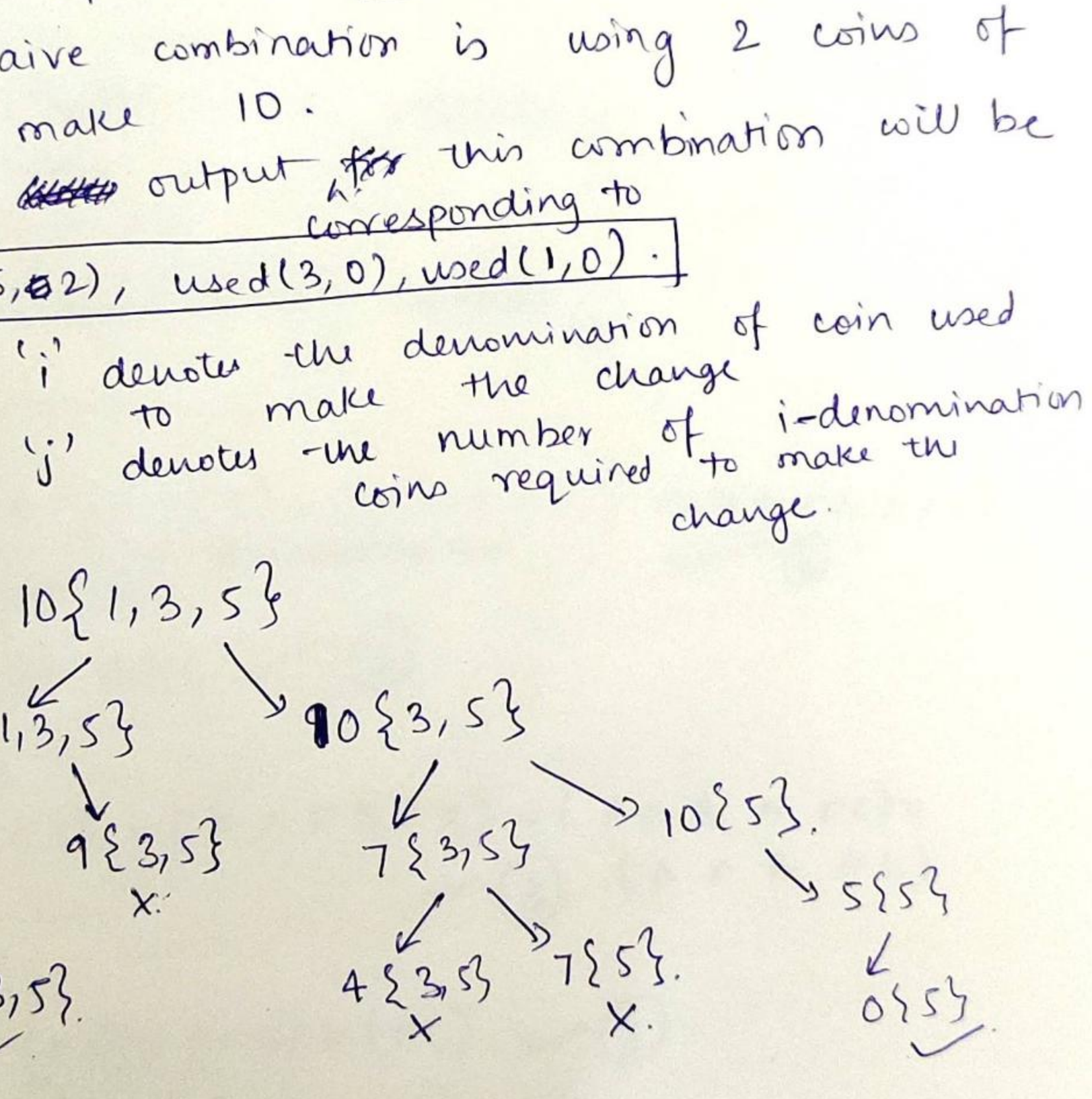
The program calculates the ~~amount~~ number of coins (that is in discrete values of denomination 1, 3 and 5) and finds the correct combinations assuming infinite supply of every coin such that the total amount of the coins adds up to the sum. (here the sum = 10) ✓ (5)

one clear naive combination is using 2 coins of 5 to make 10.

So, the ~~output~~ for this combination will be corresponding to

used(5,2), used(3,0), used(1,0).

used(i,j) → 'i' denotes the denomination of coin used to make the change
'j' denotes the number of i-denomination coins required to make the change.



→ Coin change problem formulated as a tree

At every node, we have 2 choices :-
(1) Pick the coin and make change
(2) Discard the coin completely

Output :-

① used (5,2), used(3,0), used(1,0).
② used(5,1), used(3,1), used(1,2).
③ used(5,1), [illegible] used(3,0), used(1,5).
④ used(5,0), [illegible] used(3,1), used(1,7).
⑤ [illegible] used(5,0), used(3,0), used(1,10).

(12)

TA's remark :

Two more feasible solns possible :

- used(5,0), used(3,2), used(1,4)
- used(5,0), used(3,3), used(1,1)