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a) Date and Time of examination : 04/04/2022 ; 9:00 AM

b) Examination Roll number : 21234747057

c) Name of the Program : M.Sc. Computer Science

d) Semester / Year : I / 1st year

e) Unique Paper code (UPC) : 223411102

f) Title of the Paper : Artificial Intelligence

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Answer 1:- Cryptarithmetic problem :- It is a type of constraint satisfaction problem where we define a problem in the form of game/puzzle by converting digits to alphabets and with the condition that each alphabet holds the unique digit. Sometimes to increase the complexity, people often uses different symbols along with alphabets to define this cryptarithmetic problem.

Relation with constraint satisfaction problem.

Usually a CSP is defined as -

* a finite set of variables, where variable has a domain.

* a set of constraints that restricts variables or combination of variables.

We have both of these properties for cryptarithmic problem while solving it.

To solve
$$\begin{array}{r} USA \\ +\ USSR \\ \hline PEACE \end{array}$$

Variables $\Rightarrow$ { U, S, A, R, P, E, C, $X_1$, $X_2$, $X_3$, $X_4$ }

where $X_1$, $X_2$, $X_3$, $X_4$ are carries

Domain $\Rightarrow$ { 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 }

where no leading '0' allowed

Good Write

Constraints

1. $U \neq S \neq A \neq R \neq P \neq E \neq C$
2. $A + R = E + 10X_1$
3. $X_1 + S + S = C + 10X_2$
4. $X_2 + U + S = A + 10X_3$
5. $X_3 + U = E + 10X_4$
6. $X_4 = P$

Now solving above 6 constraints -

1. Initially we know, $X_1 = X_2 = X_3 = X_4 = 1$ or $0$ because from domain we have 9 as the largest number, where $9+9 = 18$, carry will always be 1.

Now since $X_4 = 1$, ~~when~~ we have $\boxed{P = 1}$

2. Now, consider constraint 5

$$\Rightarrow X_3 + U = E + 10X_4$$

from above, we have

$$X_3 = X_4 = 1$$

Now, $1 + 4 \leq 10$, this can only be possible if $\{U \leq 9\}$

verify :-

$$1 + U \leq 10$$
$$U \leq 10 - 1$$
$$U \leq 9$$

from our domain, we can only have

$$\boxed{U = 9}$$

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Since $U=9, X_3=1, X_4=1$. Substituting these values in (5) we get

$$1+9=E+10$$
$$10=E+10$$
$$\boxed{E=0}$$

If $X_3=0, X_4=1$ we can't solve the equations as $\boxed{E=-1}$ {not in domain}.

3. Now moving to constraint 4,

i) Let $X_2=0, X_3=1, U=9$ we get

$$0+9+S=A+10$$

$$9+S=A+10$$

Possible values for $S=\{A+1\}$

| A | 2 | 3 | 4 | 6 | 5 | 7 |
|---|---|---|---|---|---|---|
| S | 3 | 4 | 5 | 7 | 6 | 8 |

Now, solving i)

$$A+R=E+10X_1$$

we have, $E=0, X_1=1$ {$X_1=0, A+R=0$, $A=0, R=0$ not possible}

$$\boxed{R=10-A}$$
$$\boxed{X_1=1}$$

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Again constraint 3,

$$X_1 + S + S = C + 10X_2$$

we have $X_1 = 1, X_2 = 0$

$$1 + 2S = C$$

$$2S = C - 1$$

$$\boxed{S = \frac{C-1}{2}}$$

from above formula, we have solve them and get the following -

| S | A = S - 1 | R = 10 - A | C = 2S + 1 | Outcome. |
|---|---|---|---|---|
| 3 | 2 | 8 | 7 | Possible |
| 4 | 3 | 7 | 9 | Not Poss. [as U = 6 = 9] |
| 5 | 4 | 6 | 11 | Not Poss [C < 9] |
| 6 | 5 | 5 | — | Not Poss [as A = R = 5] |
| 7 | 6 | 4 | 15 | Not Poss |
| 8 | 7 | 3 | 17 | Not Poss. |
| | | | | |
| | | | | |

Similarly for

$$X_2 = 1, X_3 = 1, U = 9$$

$$1 + U + S = A + 10$$

$$10 + S = A + 10$$

$S = A$ is not possible, as $S = A$ is not allowed

Hence, the possible values for the given problem can be.

$$\begin{array}{r} USA \\ +\ USSR \\ \hline PEACE \end{array} \quad \Rightarrow \quad \begin{array}{r} 932 \\ +\ 9338 \\ \hline 10270 \end{array}$$

Here, $P=1$, $U=9$, $E=0$
$S=3$, $A=2$, $C=7$
$R=8$