SHUBHAM KUMAR DAS
21CS60R28

Task 1 clauses:

Following steps that I followed while making the assignment 3:-

1.> First I assign some numeric code to all 8 colors
(Red, Green, Blue, Yellow, Orange, Purple, Violet, Silver)

Colors	Red	Green	Blue	Yellow	Orange	Purple	Violet	Silver
Code	1	2	3	4	5	6	7	8

2.> I gave some numeric code for different position hold by different colors.

1	2	3	4	5	6	7	8
R1	R2	R3	R4	G1	G2	G3	G4
9	10	11	12	13	14	15	16
B1	B2	B3	B4	Y1	Y2	Y3	Y4
17	18	19	20	21	22	23	24
01	02	03	04	P1	P2	P3	P4
25	26	27	28	29	30	31	32
V1	V2	V3	V4	S1	S2	S3	S4

It means that -

"2" specifies that Red is in 2nd position.

"7" specifies that Green is in 3rd position.

"27" specifies that Violet is in 3rd position.

3.> I add three initial clauses to SAT solver.
(constraints)

Constraint 1: " No repeatation of color "

If red is in first position. then it should not present in any other position.

$$1 \rightarrow \neg 2 \wedge \neg 3 \wedge \neg 4$$
$$= \neg 1 \vee \neg 2 \wedge \neg 3 \wedge \neg 4.$$
$$= (\neg 1 \vee \neg 2) \wedge (\neg 1 \vee \neg 3) \wedge (\neg 1 \vee \neg 4).$$

2021/9/15 10:54

Similarly - $2 \rightarrow \neg 1 \wedge \neg 3 \wedge \neg 4$

$= \neg 2 \vee \neg 1 \wedge \neg 3 \wedge \neg 4$

$= (\neg 2 \vee \neg 1) \wedge (\neg 2 \vee \neg 3) \wedge (\neg 2 \vee \neg 4)$

Similarly -

$3 \rightarrow \neg 1 \wedge \neg 2 \wedge \neg 4$

$= \neg 3 \vee \neg 1 \wedge \neg 2 \wedge \neg 4$

$= (\neg 3 \vee \neg 1) \wedge (\neg 3 \vee \neg 2) \wedge (\neg 3 \vee \neg 4)$

Similarly -

$4 \rightarrow \neg 1 \wedge \neg 2 \wedge \neg 3$

$= \neg 4 \vee \neg 1 \wedge \neg 2 \wedge \neg 3$

$= (\neg 4 \vee \neg 1) \wedge (\neg 4 \vee \neg 2) \wedge (\neg 4 \vee \neg 3)$

As same way, we can do for other colors Like Green, Blue, Yellow, Orange etc.

Constraint 2: "No two color will present at same place"

If Red is in 1st position, then no other color should be present in that position.

$1 \rightarrow \neg 5 \wedge \neg 9 \wedge \neg 13 \wedge \neg 17 \wedge \neg 21 \wedge \neg 25 \wedge \neg 29$

$= \neg 1 \vee \neg 5 \wedge \neg 9 \wedge \neg 13 \wedge \neg 17 \wedge \neg 21 \wedge \neg 25 \wedge \neg 29$

$= (\neg 1 \vee \neg 5) \wedge (\neg 1 \vee \neg 9) \wedge (\neg 1 \vee \neg 13) \wedge (\neg 1 \vee \neg 17) \wedge (\neg 1 \vee \neg 21)$
$(\neg 1 \vee \neg 25) \wedge (\neg 1 \vee \neg 29)$

Similarly

$2 \rightarrow \neg 6 \wedge \neg 10 \wedge \neg 14 \wedge \neg 18 \wedge \neg 22 \wedge \neg 26 \wedge \neg 30$

$= \neg 2 \vee \neg 6 \wedge \neg 10 \wedge \neg 14 \wedge \neg 18 \wedge \neg 22 \wedge \neg 26 \wedge \neg 30$

$= (\neg 2 \vee \neg 6) \wedge (\neg 2 \vee \neg 10) \wedge (\neg 2 \vee \neg 14) \wedge (\neg 2 \vee \neg 18) \wedge (\neg 2 \vee \neg 22)$
$(\neg 2 \vee \neg 26) \wedge (\neg 2 \vee \neg 30)$

Similarly -

$3 \rightarrow \neg7 \wedge \neg11 \wedge \neg15 \wedge \neg19 \wedge \neg23 \wedge \neg27 \wedge \neg31$.

$= \neg3 \vee \neg7 \wedge \neg11 \wedge \neg15 \wedge \neg19 \wedge \neg23 \wedge \neg27 \wedge \neg31$.

$= (\neg3 \vee \neg7) \wedge (\neg3 \vee \neg11) \wedge (\neg3 \vee \neg15) \wedge (\neg3 \vee \neg19) \wedge (\neg3 \vee \neg23)$
$\wedge (\neg3 \vee \neg27) \wedge (\neg3 \vee \neg31)$.

Similarly -

$4 \rightarrow \neg8 \wedge \neg12 \wedge \neg16 \wedge \neg20 \wedge \neg24 \wedge \neg28 \wedge \neg32$

$= \neg4 \vee \neg8 \wedge \neg12 \wedge \neg16 \wedge \neg20 \wedge \neg24 \wedge \neg28 \wedge \neg32$.

$= (\neg4 \vee \neg8) \wedge (\neg4 \vee \neg12) \wedge (\neg4 \vee \neg16) \wedge (\neg4 \vee \neg20) \wedge (\neg4 \vee \neg24)$
$\wedge (\neg4 \vee \neg28) \wedge (\neg4 \vee \neg32)$.

As same way, we can do for other color's position.

Constraint 3: " There should be exactly one color in each position "

For position 1 -

$1 \vee 5 \vee 9 \vee 13 \vee 17 \vee 21 \vee 25 \vee 29$.

For position 2 -

$2 \vee 6 \vee 10 \vee 14 \vee 18 \vee 22 \vee 26 \vee 30$.

For position 3 -

$3 \vee 7 \vee 11 \vee 15 \vee 19 \vee 23 \vee 27 \vee 31$.

For position 4 -

$4 \vee 8 \vee 12 \vee 16 \vee 20 \vee 24 \vee 28 \vee 32$.

4.) Random selection of 4 distinct color by Code Maker. as Hidden code

ie - $\boxed{R \ B \ G \ Y}$

5.) Some random guess made by Code Breaker.

ie - $\boxed{A \ B \ C \ D}$

6.) Now Code Make take the code maker guess code and compare it with its hidden code. Based on this, he return "white" and "black" pegs.

Now I make different cases based on Black pegs.. for eg -

If Black = 0 (No color matched).

$\neg A \wedge \neg B \wedge \neg C \wedge \neg D$ ------ we add this clause.

If Black = 1. (One color matched).

$A \rightarrow \neg B \wedge \neg C \wedge \neg D$.

$= \neg A \vee \neg B \wedge \neg C \wedge \neg D$.

$= (\neg A \vee \neg B) \wedge (\neg A \vee \neg C) \wedge (\neg A \vee \neg D)$.

Similarly -

$B \rightarrow \neg A \wedge \neg C \wedge \neg D$.

$= \neg B \vee \neg A \wedge \neg C \wedge \neg D$.

$= (\neg B \vee \neg A) \wedge (\neg B \vee \neg C) \wedge (\neg B \vee \neg D)$.

Similarly -

$C \rightarrow \neg A \wedge \neg B \wedge \neg D$.

$= \neg C \vee \neg A \wedge \neg B \wedge \neg D$.

$= (\neg C \vee \neg A) \wedge (\neg C \vee \neg B) \wedge (\neg C \vee \neg D)$.

Similarly-

$$D \rightarrow \neg A \land \neg C \land \neg B.$$

$$= \neg D \lor \neg A \land \neg C \land \neg B.$$

$$= (\neg D \lor \neg A) \land (\neg D \lor \neg C) \land (\neg D \lor \neg B).$$

We add one more clause that is one of the position.
is true.

$$A \lor B \lor C \lor D.$$

If black == 2 (Two color matched).
We make following clauses -

$$(A \land B) \rightarrow \neg C \land \neg D. \text{ (means two color are correct while other two are incorrect).}$$

$$= \neg A \lor \neg B \lor \neg C \land \neg D.$$

$$= (\neg A \lor \neg B \lor \neg C) \land (\neg A \lor \neg B \lor \neg D).$$

Similarty -

$$(B \land C) \rightarrow \neg A \land \neg D.$$

$$= \neg B \lor \neg C \lor \neg A \land \neg D.$$

$$= (\neg A \lor \neg B \lor \neg C) \land (\neg B \lor \neg C \lor \neg D).$$

Similarly-

$$(C \land D) \rightarrow \neg A \land \neg B.$$

$$= \neg C \lor \neg D \lor \neg A \land \neg B.$$

$$= (\neg A \lor \neg C \lor \neg D) \land (\neg B \lor \neg C \lor \neg D).$$

Similarly -

$$(A \land C) \rightarrow \neg B \land \neg D.$$

$$= (\neg A \lor \neg C \lor \neg B) \land (\neg A \lor \neg C \lor \neg D).$$

Similarly -

$$(A \land D) \rightarrow \neg C \land \neg B.$$

$$\neg A \lor \neg D \lor \neg C) \land (\neg A \lor \neg D \lor \neg B)$$

Similarly -

$(B \wedge D) \rightarrow \neg A \wedge \neg C.$

$= (\neg B \vee \neg D \vee \neg A) \wedge (\neg B \vee \neg D \vee \neg C).$

We add one more clause that is two of the position.
is true.

$(A \wedge B) \vee (A \wedge C) \vee (A \wedge D) \vee (B \wedge C) \vee (B \wedge D) \vee (C \wedge D).$

Convert it into CNF -

$(A \vee B \vee D) \wedge (A \vee B \vee C) \wedge (A \vee C \vee D) \wedge (B \vee C \vee D).$

If Black = 3. (Three colors matched).
we make following clauses -

$(A \wedge B \wedge C) \rightarrow \neg D.$ (A, B, C are correct implies D is not correct).

$\equiv \neg A \vee \neg B \vee \neg C \vee \neg D.$

Similarly -

$(B \wedge C \wedge D) \rightarrow \neg A.$

$= \neg A \vee \neg B \vee \neg C \vee \neg D.$

We add one more clause that is three of the.
position is true.

$(A \wedge B \wedge C) \vee (B \wedge C \wedge D) \vee (A \wedge B \wedge D) \vee (A \wedge C \wedge D).$

Convert it into CNF -

$(A \vee B) \wedge (A \vee C) \wedge (A \vee D) \wedge (B \vee C) \wedge (B \vee D) \wedge (C \vee D).$

If black == 4
   then exit from loop.
else.

go to step 5 .and repeat.

Task 2 clauses :-

In Task 2, I follow these steps -

① I remove constraint 1 : "No repeatation of color".
   I add only two constraints as my initial clause -

      cons 1 :- "No two color will be in same position"

      Cons 2 :- "Exactly one color will be present in each
                    position"

② I modified the code for the Codemaker so that it can.
   generate repeated combination of color.
       Like-

        R G R Y

        Y Y G Y

        O O O R.

        O P P G.

I just make two changes in Task 1 to acheive.
the Task2.: