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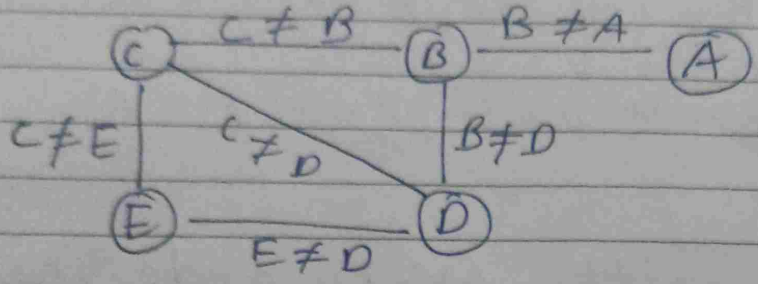
T4 Comp Div1

Assignment 4
Constraint Satisfaction Problem

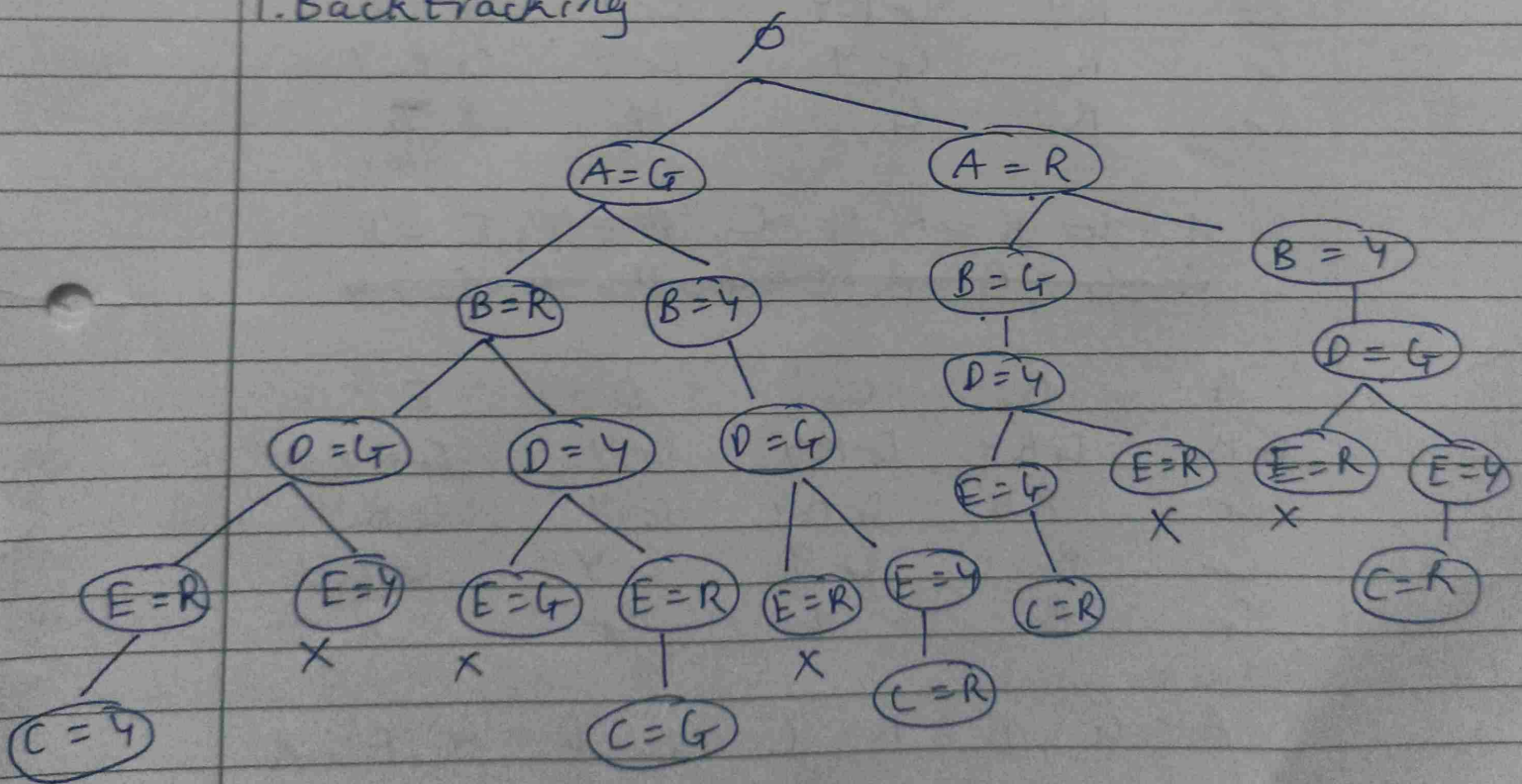
1.



$A \neq Y$
$D \neq R$

Variable = {A, B, C, D, E}
Domain = {G, R, Y}

1. Backtracking



∴ Possible Assignments

1. A=G, B=R, D=G, E=R, C=Y
2. A=G, B=R, D=Y, E=R, C=G
3. A=G, B=Y, D=G, E=Y, C=R
4. A=R, B=G, D=Y, E=G, C=R
5. A=R, B=Y, D=G, E=Y, C=R

2. Filtering with MVR ordering

a.

A	B	C	D	E
GR	GRY	GRY	GY	GRY
G	RY	GRY	GY	GRY
G	R	GY	GY	GRY
G	R	G	Y	R

∴ A=G, B=R, G=C, D=Y, E=R

~~A=G, B=R, C=G, D=Y, E=Y~~

b.

A	B	C	D	E
GR	GRY	GRY	GY	GRY
G	RY	GRY	GY	GRY
G	R	GY	GY	GRY
G	R	Y	G	R

∴ A=G, B=R, C=Y, D=G, E=R

c)

A	B	C	D	E
GR	GRY	GRY	GY	GRY
G	RY	GRY	GY	GRY
G	Y	~~G~~R	G	~~R~~ Y

∴ A = G, B = Y, C = R, D = G, E = Y

d)

A	B	C	D	E
GR	GRY	GRY	GY	GRY
R	GY	GRY	GY	GRY
R	G	R	Y	G

∴ A = R, B = G, C = R, D = Y, E = G

e)

A	B	C	D	E
GR	GRY	GRY	GY	GRY
R	GY	GRY	GY	GRY
R	Y	R	G	Y

∴ A = R, B = Y, C = R, D = G, E = Y

3. AC-3

Remove	A	B	C	D	E	Add	Queue
	GRY	GRY	GRY	GRY	GRY		A≠B, B≠D, D≠E, E≠C, C≠B, B≠C, C≠E, E≠D, D≠B, B≠A C≠D, D≠C
A≠B	GR	GRY	GRY	GY	GRY		B≠D, D≠E, E≠C, C≠B, B≠C, C≠E, E≠D, D≠B, B≠A C≠D, D≠C

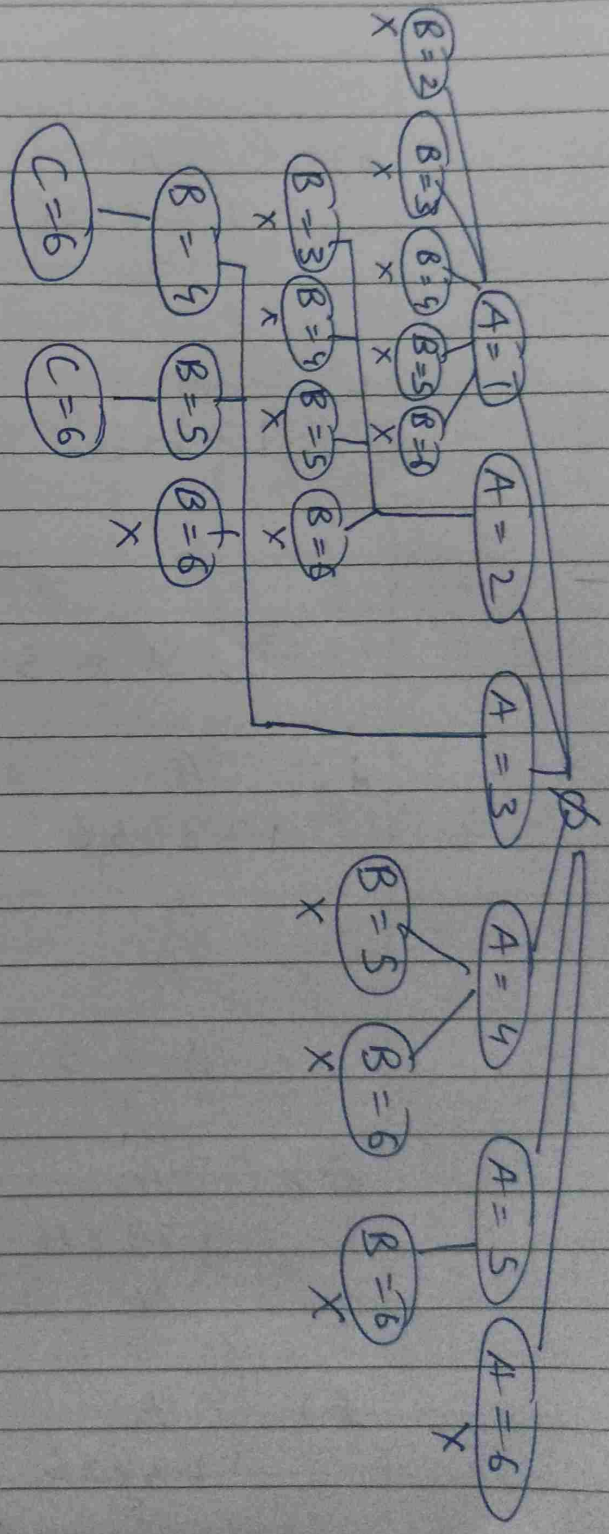
Remove	A	B	C	D	E	ADD	Queue
B ≠ D	GR	GRY	GRY	GY	GRY		D≠E, E≠C, C≠B, B≠C, C≠E, E≠D, D≠B, B≠A C≠D, D≠C
D ≠ E	GR	GRY	GRY	GY	GRY		E≠C, C≠B, B≠C, C≠E, E≠D, D≠B, B≠A C≠D, D≠C
E ≠ C	GR	GRY	GRY	GY	GRY		C≠B, B≠C, C≠E, E≠D, D≠B, B≠A C≠D, D≠C
C ≠ B	GR	GRY	GRY	GY	GRY		B≠C, C≠E, E≠D, D≠B, B≠A C≠D, D≠C
B ≠ C	GR	GRY	GRY	GY	GRY		C≠E, E≠D, D≠B, B≠A, C≠D, D≠C
C ≠ E	GR	GRY	GRY	GY	GRY		E≠D, D≠B, B≠A C≠D, D≠C
E ≠ D	GR	GRY	GRY	GY	GRY		D≠B, B≠A C≠D, D≠C
D ≠ B	GR	GRY	GRY	GY	GRY		B≠A, C≠D, D≠C
B ≠ A C≠D, D≠C	GR	GRY	GRY	GY	GRY		

∴ Possible Assignments

1. A = G, B = R, D = G, E = R, C = Y
2. A = G, B = R, D = Y, E = R, C = G
3. A = G, B = Y, D = G, E = Y, C = R
4. A = R, B = G, D = Y, E = G, C = R
5. A = R, B = Y, D = G, E = Y, C = R

2. Variable = {A, B, C}
Domain = {1, 2, 3, 4, 5, 6}
Constraints = {A < B, B < C, A + C = 9}

1. Backtracking.



∴ Possible Assignments

A = 3, B = 4, C = 6
A = 3, B = 5, C = 6

2. Filtering with MVR ordering

a)

A	B	C
123456	123456	123456
1	23456	∅

b)

A	B	C
123456	123456	123456
2	3456	∅

c)

A	B	C
123456	123456	123456
3	456	6
3	4	6

∴ A = 3, B = 4, C = 6

d)

A	B	C
123456	123456	123456
3	456	6
3	5	6

∴ A = 3, B = 5, C = 6

e)

A	B	C
123456	123456	123456
4	56	∅

f)

A	B	C
123456	123456	123456
5	6	∅

g) A: 123456 6 | B: 123456 ∅ | C: 123456 ∅

3. A < 3

Remove	A	B	C	Add	Queue
	123456	123456	123456		A<B, B<C, A+C=9 C+A=9, C>B, B>A
A<B	12345	123456	123456	C+A=9	B<C, A+C=9, C+A=9 C>B, B>A, C+A=9
B<C	12345	12345	123456	A<B	A+C=9, C+A=9, C>B B>A, C+A=9, A<B
A+C=9	345	12345	123456	B>A	C+A=9, C>B, B>A, C+A=9, A<B, B>A
C+A=9	345	12345	456	B<C	C>B, B>A, C+A=9 A<B, B>A, B<C
C>B	345	12345	456		B>A, C+A=9, A<B, B>A, B<C
B>A	345	45	456	C>B	C+A=9, A<B, B>A, B<C, C>B

Remove	A	B	C	Add	Queue
C+A=9	3 4 5	4 5	4 5 6		A<B, B>A, B<C, C>B
A<B	3 4	4 5	4 5 6	C+A=9	B>A, B<C, C>B, C+A=9
B>A	3 4	4 5	4 5 6		B<C, C>B, C+A=9
B<C	3 4	4 5	4 5 6		C>B, C+A=9
C>B	3 4	4 5	5 6	A+C=9	C+A=9, A+C=9
C+A=9	3 4	4 5	5 6		A+C=9
A+C=9	3 4	4 5	5 6		

∴ Possible assignments

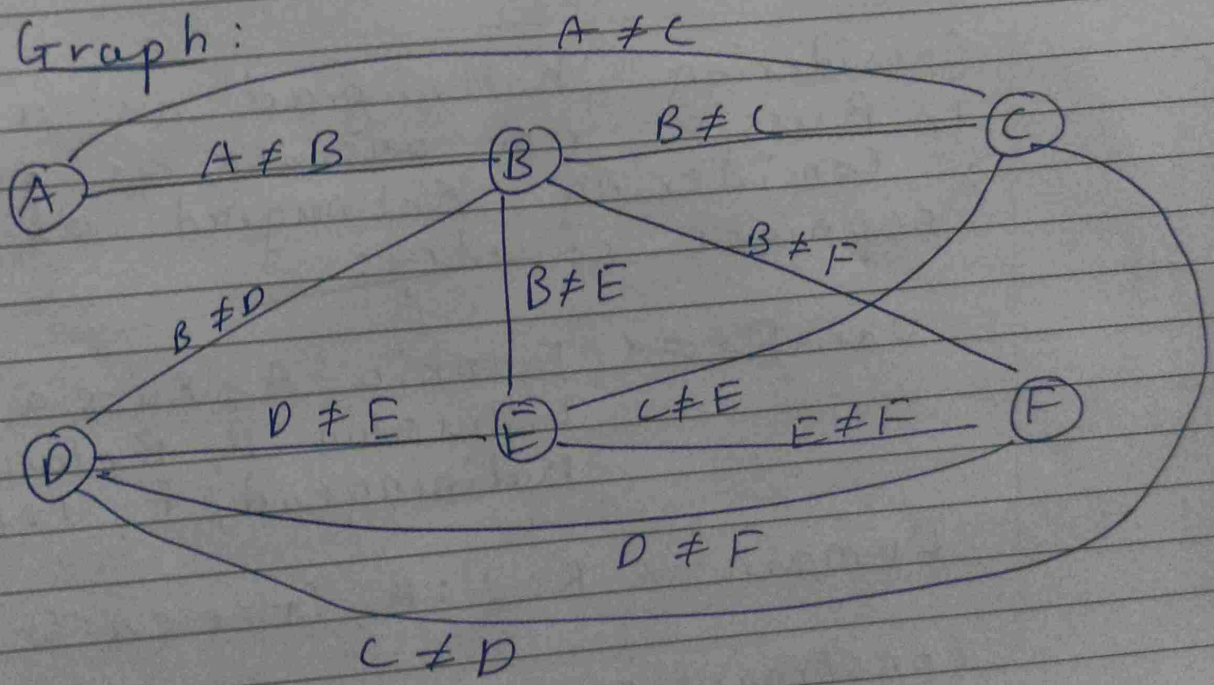
A=3, B=4, C=6
A=3, B=5, C=6

3. 1. Variable = { Estonia : A, Russia : B, Latvia : C, Lithuania : D, Betarus : E, Poland : F }

Domain = { Red, Blue, Green }

Constraint = { $A \neq B$, $A \neq C$, $B \neq C$, $B \neq E$, $B \neq D$, $B \neq F$, $C \neq E$, $C \neq D$, $D \neq E$, $D \neq F$, $E \neq F$ }

2. Graph:



3. Filtering with MVR:

A	B	C	D	E	F
RGB	RGB	RGB	RGB	RGB	RGB
R	GB	GB	RGB	RGB	RGB
R	G	B	R	∅	B

A	B	C	D	E	F
RGB	RGB	RGB	RGB	RGB	RGB

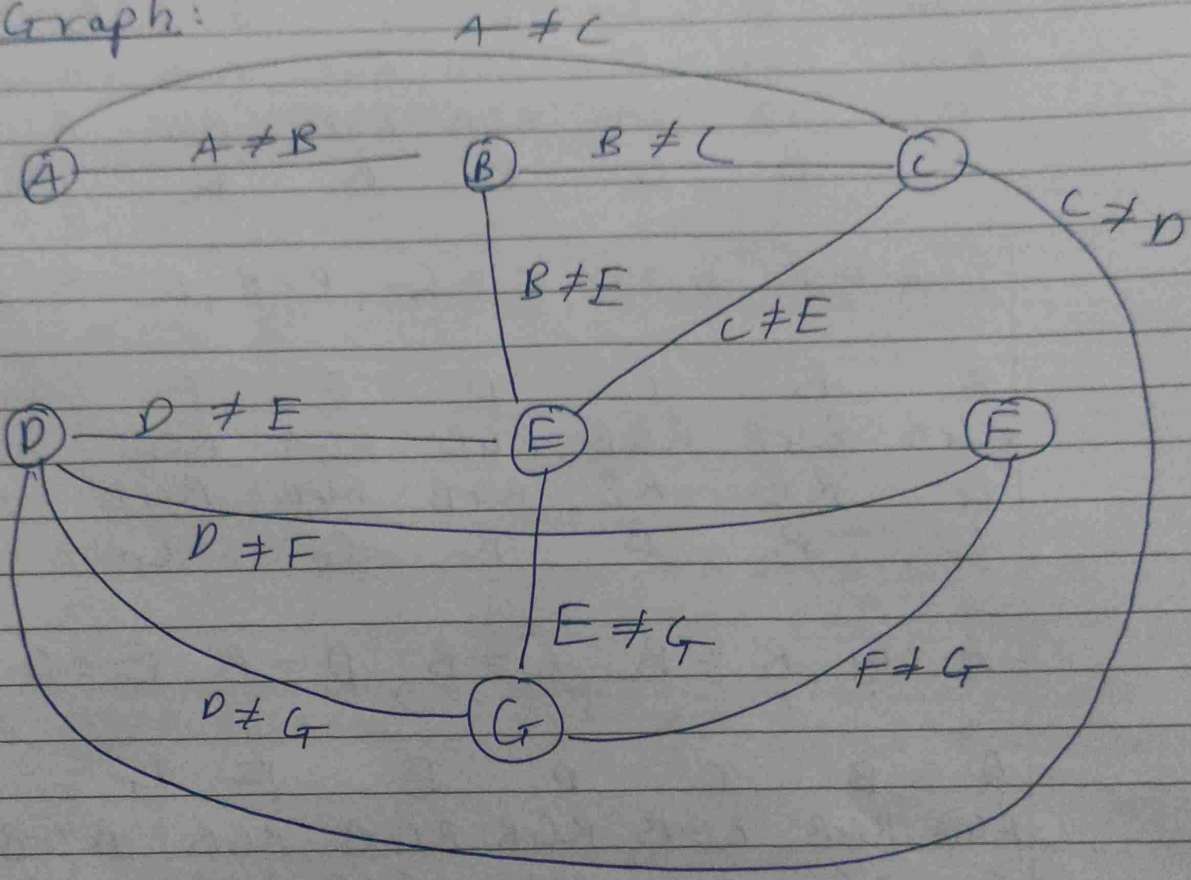
Considering Kaliningrad as a city in Russia no answer is possible.
∴ Considering Kaliningrad as a separate country:

1. Variable = { Estonia : A, Russia : B, Latvia : C, Lithuania : D, Belarus : E, Kaliningrad : F, Poland : G }

Domain = { Red : R, Green : G, Blue : B }

Constraints = { A ≠ B, A ≠ C, B ≠ C, B ≠ E, C ≠ E, C ≠ D, D ≠ E, D ≠ F, D ≠ G, E ≠ G, F ≠ G }

2. Graph:



3. Filtering with MRV

A	B	C	D	E	F	G
RGB	RGB	RGB	RGB	RGB	RGB	RGB
R	GB	GB	RGB	RGB	RGB	RGB
R	G	B	G	R	RB	B
R	G	B	G	R	R	B

A = R, B = G, C = B, D = G, E = R, F = R, G = B

A	B	C	D	E	F	G
RGB	RGB	RGB	RGB	RGB	RGB	RGB
R	GB	GB	RGB	RGB	RGB	RGB
R	B	G	B	R	R	R

$\therefore A = R, B = B, C = G, D = B, E = R, F = R, G = G$

A	B	C	D	E	F	G
RGB	RGB	RGB	RGB	RGB	RGB	RGB
G	RB	RB	RGB	RGB	RGB	RGB
G	R	B	R	G	G	B

$A = G, B = R, C = B, D = R, E = G, F = G, G = B$

A	B	C	D	E	F	G
RGB	RGB	RGB	RGB	RGB	RGB	RGB
G	RB	RB	RGB	RGB	RGB	RGB
G	B	R	B	G	G	R

$A = G, B = R, C = B, D = R, E = G, F = G, G = B$

A	B	C	D	E	F	G
RGB	RGB	RGB	RGB	RGB	RGB	RGB
B	RG	RG	RGB	RGB	RGB	RGB
B	G	R	G	B	B	R

$A = B, B = G, C = R, D = G, E = B, F = B, G = R$

A	B	C	D	E	F	G
RGB	RGB	RGB	RGB	RGB	RGB	RGB
B	RG	RG	RGB	RGB	RGB	RGB
B	R	G	R	B	B	G

A = B, B = R, C = G, D = R, E = B, F = B, G = G

4. B = R.

Remove	A	B	C	D	E	F	G	Add	Queue
	RGB	R	RGB	RGB	RGB	RGB	RGB		~~A≠B~~, A≠C, B≠C, B≠E, C≠E, C≠D, D≠E, D≠F, D≠G, E≠G, F≠G ⊃
A ≠ B	GB	R	RGB	RGB	RGB	RGB	RGB	C≠A	A≠C, B≠C, B≠E, C≠E, C≠D, D≠E, D≠F, D≠G, E≠G, F≠G, G≠F, G≠E, G≠D, F≠D, E≠D, D≠C, E≠C, E≠B, C≠B, C≠A, B≠A, C≠A
A ≠ C	GB	R	RGB	RGB	RGB	RGB	RGB		B≠C, B≠E, C≠E, C≠D, D≠E, D≠F, D≠G, E≠G, F≠G, G≠F, G≠E, G≠D, F≠D, E≠D, D≠C, E≠C, E≠B, C≠B, C≠A, B≠A, C≠A.

Remove	A	B	C	D	E	F	G	Add queue
B ≠ C	GB	R	RGB	RGB	RGB	RGB	RGB	B≠E, C≠E, C≠D, D≠E, D≠F, D≠G, E≠G, F≠G, G≠F, G≠E, G≠D, F≠D, E≠D, D≠C, E≠C, E≠B, C≠B, C≠A, B≠A, C≠A
B ≠ E	GB	R	RGB	RGB	RGB	RGB	RGB	C≠E, C≠D, D≠E, D≠F, D≠G, E≠G, F≠G, G≠F, G≠E, G≠D, F≠D, E≠D, D≠C, E≠C, E≠B, C≠B, C≠A, B≠A, C≠A
C ≠ F	GB	R	RGB	RGB	RGB	RGB	RGB	C≠D, D≠E, D≠F, D≠G, E≠G, F≠G, G≠F, G≠E, G≠D, F≠D, E≠D, D≠C, E≠C, E≠B, C≠B, C≠A, B≠A, C≠A
C ≠ D	GB	R	RGB	RGB	RGB	RGB	RGB	D≠E, D≠F, D≠G, E≠G, F≠G, G≠F, G≠E, G≠D, F≠D, E≠D, D≠C, E≠C, E≠B, C≠B, C≠A, B≠A, C≠A
D ≠ E	GB	R	RGB	RGB	RGB	RGB	RGB	D≠F, D≠G, E≠G, F≠G, G≠F, G≠E, G≠D, F≠D, E≠D, D≠C, E≠C, E≠B, C≠B, C≠A, B≠A, C≠A
D ≠ F	GB	R	RGB	RGB	RGB	RGB	RGB	D≠G, E≠G, F≠G, G≠F, G≠E, G≠D, F≠D, E≠D, D≠C, E≠C, E≠B, C≠B, C≠A, B≠A, C≠A

Remove	A	B	C	D	E	F	G	Add	Queue
D≠G	GB	R	RGB	RGB	RGB	RGB	RGB		E≠G, F≠G, G≠F, G≠E, G≠D, F≠D, E≠D, D≠C, E≠C, E≠B, C≠B, C≠A, B≠A, C≠A
E≠G	GB	R	RGB	RGB	RGB	RGB	RGB		F≠G, G≠F, G≠E, G≠D, F≠D, E≠D, D≠C, E≠C, E≠B, C≠B, C≠A, B≠A, C≠A
F≠G	GB	R	RGB	RGB	RGB	RGB	RGB		G≠F, G≠E, G≠D, F≠D, E≠D, D≠C, E≠C, E≠B, C≠B, C≠A, B≠A, C≠A
G≠E, G≠D, F≠D, E≠D, D≠C, E≠C,	GB	R	RGB	RGB	RGB	RGB	RGB		E≠B, C≠B, C≠A, B≠A, C≠A
E≠B	GB	R	RGB	RGB	GB	RGB	RGB	~~B≠E~~, C≠E	C≠B, C≠A, B≠A, C≠A, ~~B≠E~~, C≠E, D≠E, G≠E
C≠B	GB	R	GB	RGB	GB	RGB	RGB	~~B≠E~~, D≠C, E≠C,	~~E≠B~~, C≠A, B≠A, C≠A, C≠E, D≠E, G≠E, D≠C, E≠C

Remove	A	B	C	D	E	F	G	Add	Queue
C≠A	GB	R	GB	RGB	GB	RGB	RGB		
B≠A									
C≠A									
C≠E									
D≠E									
G≠E									
F≠C									
E≠C									

S. ∴ Solutions

A=G, B=R, C=B, D=R, E=G, F=G, G=B

A=G, B=R, C=B, D=R, E=G, F=G, G=B

A=B, B=R, C=G, D=R, E=B, F=B, G=G