Cube

Rubik cube labels

Legend
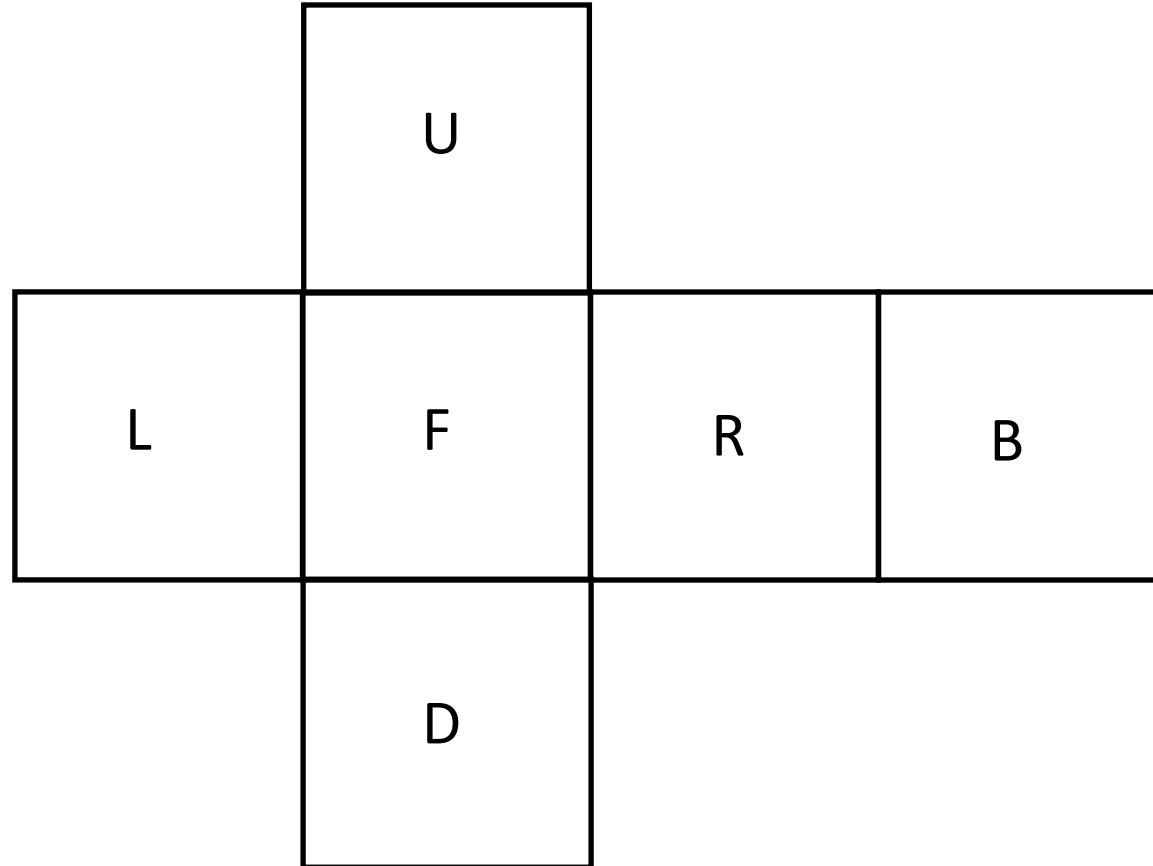- Front (F)
- Back (B)
- Up (U)
- Down (D)
- Left (L)
- Right (R)

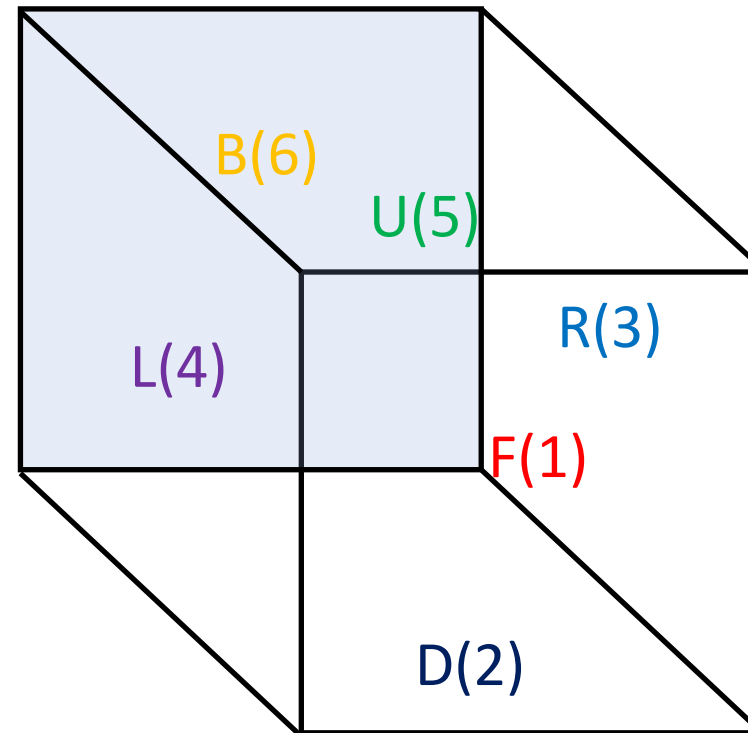Back

Top

Left

Right

Front

Bottom
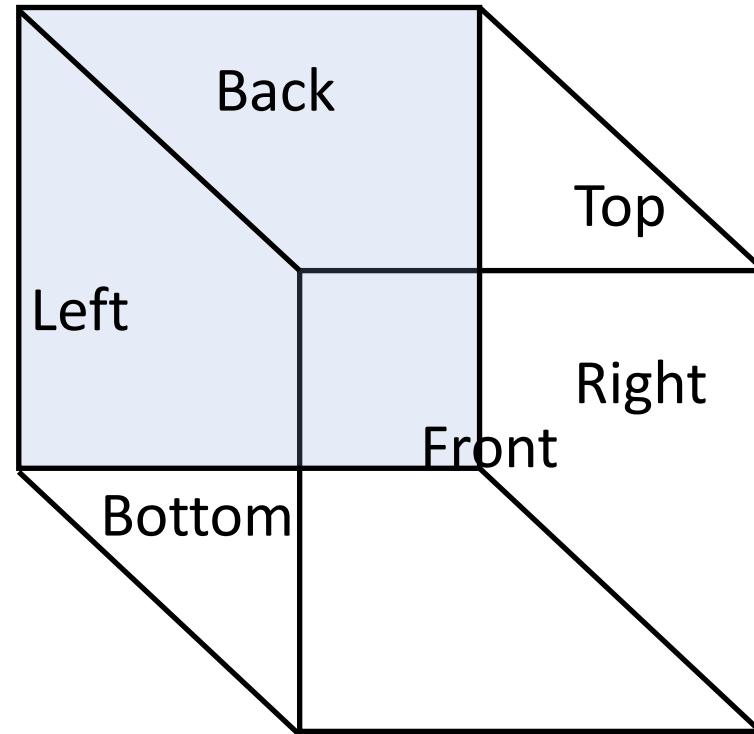
Cube

Legend
- Front (F)
- Back (B)
- Up (U)
- Down (D)
- Left (L)
- Right (R)

	U		
L	F	R	B
	D		

Cube

Standard dice order
Opposite sides add to 7

B(6)

U(5)

R(3)

L(4)

F(1)

D(2)
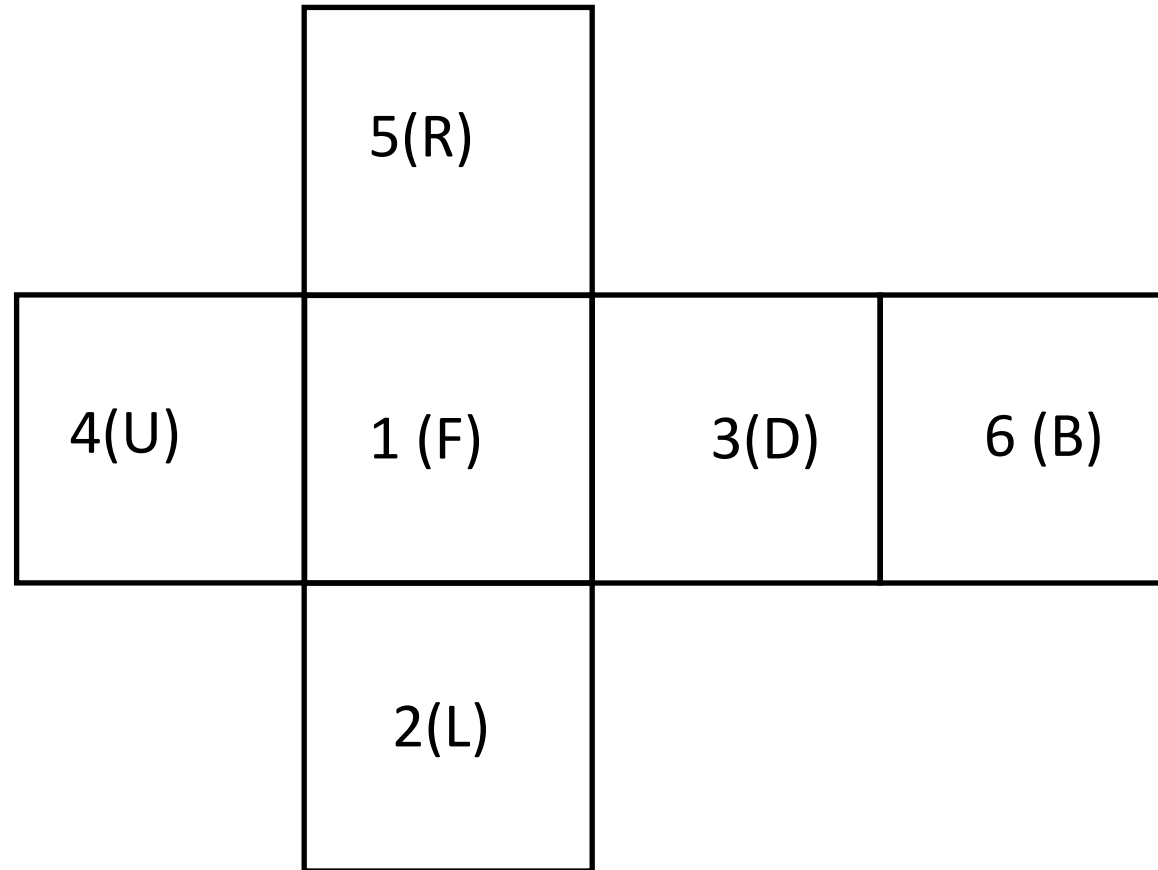
Cube

Face permutations of cube

FBUDLR 162534	Element	Order
162534	(1)	1
164325	(2453)	4
165243	(25)(34)	2
163452	(2354)	4
251643	(12)(56)(34)	2
253416	(123)(465)	3
256134	(1265)	4
254361	(124)(365)	3
342561	(1364)	4
341625	(132)(456)	3
345216	(13)(25)(46)	2
346152	(135)(264)	3

FBUDLR 162534	Element	Order
432516	(1463)	4
436125	(145)(263)	3
435261	(14)(25)(36)	2
431652	(142)(356)	3
521634	(1562)	4
524316	(153)(246)	3
526143	(15)(26)(34)	2
523461	(154)(236)	3
613425	(16)(23)(45)	2
615234	(16)(25)	2
614352	(16)(24)(35)	2
612543	(16)(34)	2

Face permutations of cube

FBLRDU	Element	Order	FBLRDU	Element	Order
FBLRDU	1	1	UDLRFB	(FUBD)	4
FBUDLR	(LURD)	4	UDBFLR	(FUR)(LBD)	3
FBRLUD	(LR)(DU)	2	UDRLBF	(FU)(LR)(DB)	2
FBDURL	(LDRU)	4	UDFBRL	(FUL)(DRB)	3
LRFBUD	(FL)(RB)(DU)	2	RLFBDU	(FRBL)	4
LRDUFB	(FLD)(UBR)	3	RLUDFB	(FRD)(LUB)	3
LRBF3U	(FLBR)	4	RLBFUD	(FR)(LB)(DU)	2
LRUDBF	(FLU)(DBR)	3	RLDUBF	(FRU)(LDB)	3
DULRBF	(FDBU)	4	BFDULR	(FB)(LD)(UR)	2
DUFBLR	(FDL)(URB)	3	BFRLDU	(FB)(LR)	2
DURLFB	(FD)(LR)(UB)	2	BFUDRL	(FB)(LU)(DR)	2
DUBFRL	(FDR)(LBU)	3	BFLRUD	(FB)(DU)	2

Subgroups

- G = {(1), (2453), (25)(34), (2354), (12)(34)(56), (123)(465),
  (1265), (124)(365), (1364), (132)(456), (13)(25)(46), (135)(264),
  (1463), (145)(263), (14)(25)(36), (142)(356), (1562), (153)(245),
  (15)(26)(34), (154)(236), (16)(23)(45), (16)(24)(35), (16)(25), (16)(34)}
- H = {(1), (25)(34), (123)(465), (124)(365), (132)(465), (135)(264),
  (145)(263), (142)(356), (153)(245), (154)(236), (16)(25), (16)(34)}
- V = {(1), (25)(34), (16)(25), (16)(34)}
- $H \lhd G, V \lhd G$
- C_1 = {(1), (2453), (25)(34), (2354)}
- C_2 = {(1), (123)(465), (132)(456)}
- N_1 = N(C_1) = {(1), (2453), (25)(34), (2354), (16)(25), (16)(34), (16)(24)(35), (16)(23)(45)}
- D_1 = <(15)(26)(34), (14)(25)(36)> = {(1), (15)(26)(34), (14)(25)(36), (123)(465), (132)(456), (16)(24)(35)}
- VC_2 = H, VC_1 = N_1, $N_1 \epsilon S_2(G), C_2 \epsilon S_3(G)$
- |C((12)(34)(56))| = 12, |C((25)(34))| = 8, |C((123)(465))| = 6
- ccls: $(4,4)_3$, $(3,2,2,2)_2$
- Subgroup orders: 1, 2, 3, 4, 6, 8, 12
- Element orders: 1 (1), 2 (9), 3 (8), 4 (6)
- G=S_4, H=A_4

Dodecahedron

Opposite sides add to 13
Face adjacency

      1: 2,a,5,6,4
      2: 1,4,8,7,a
      3: 4,6,b,c,8
      4: 1,6,3,8,2
      5: 1,a,9,b,6
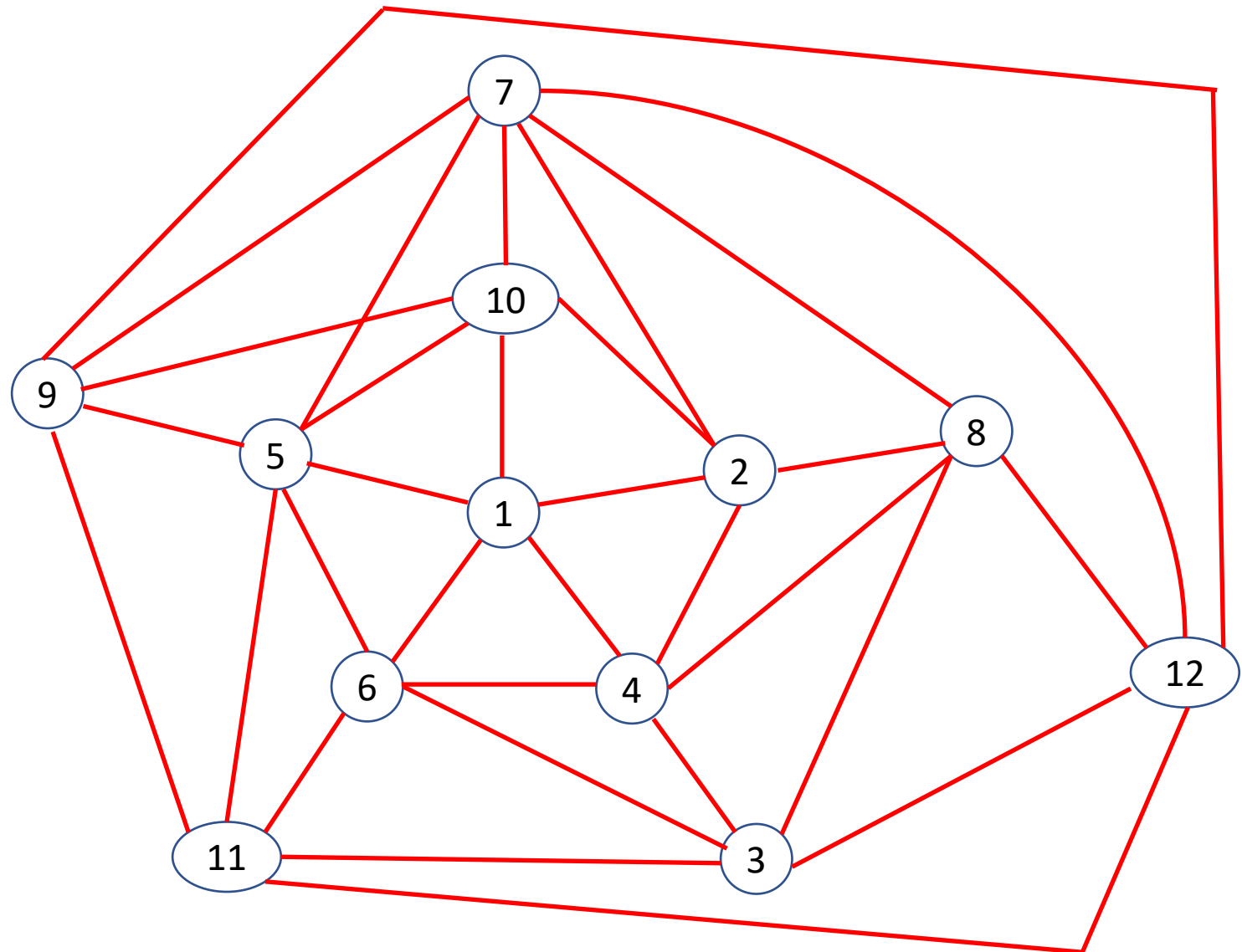   6: 1,5,b,3,4
      7: 2,8,c,9,a
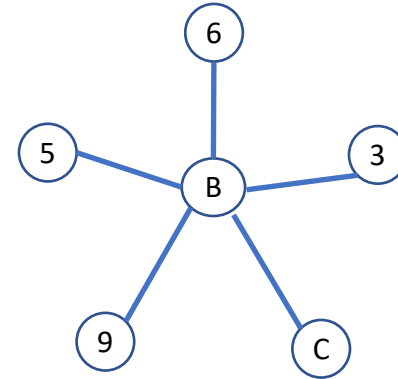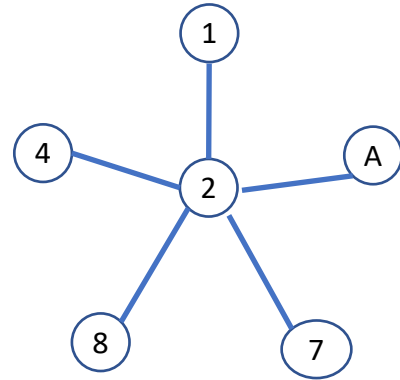   8: 2,4,3,c,7
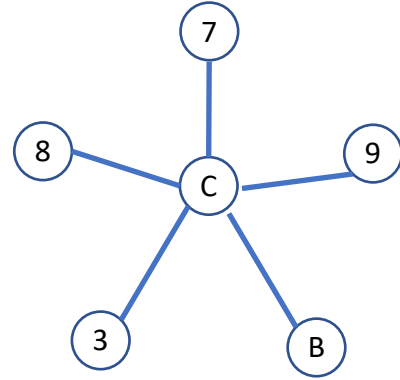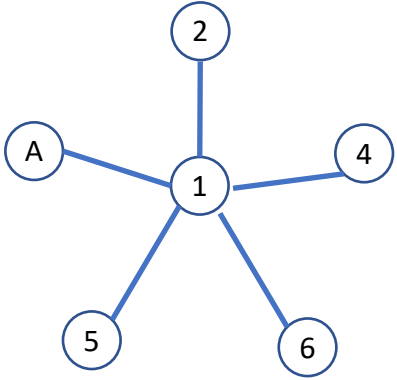   9: 5,a,7,c,b
      a: 1,2,7,9,5
      b: 3,6,5,9,c
      c: 3,b,9,7,8

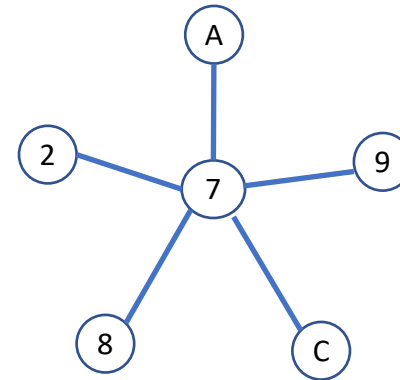$|G| = 60$, $G = A_5$
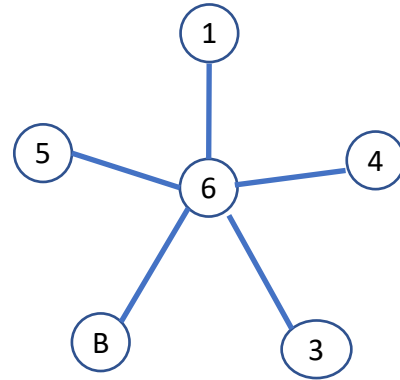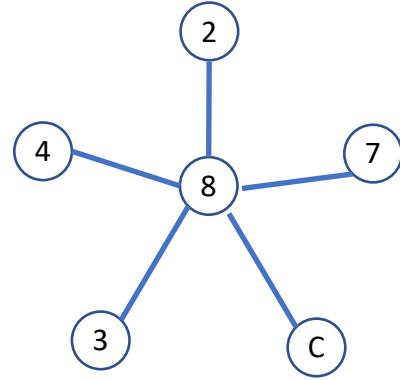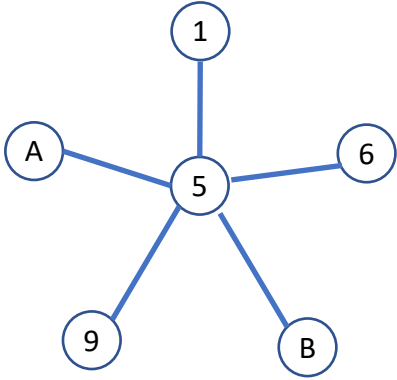
Dodecahedron

Dodecahedron
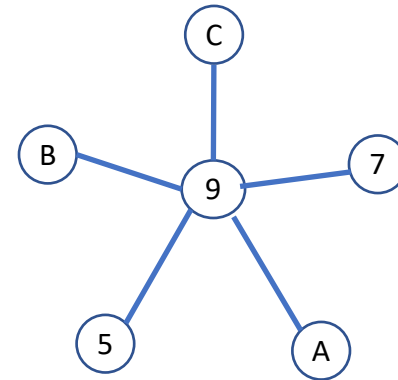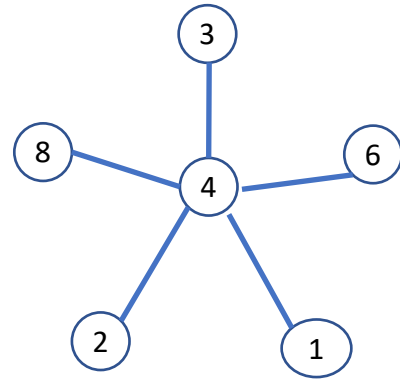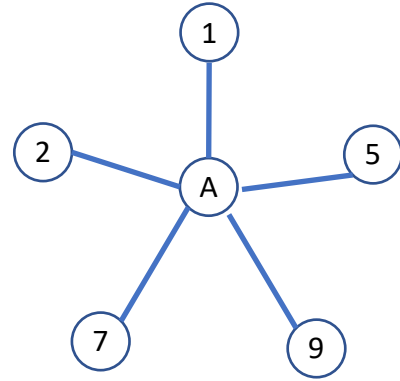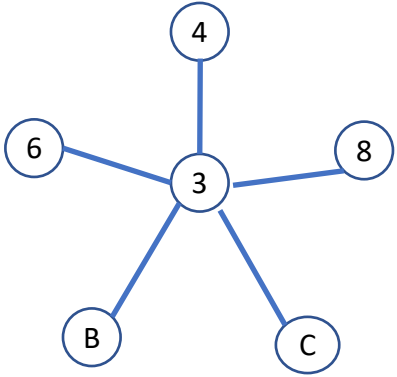
Dodecahedron

Dodecahedron Elements

```
123456789abc     Multiplier: (2a564)(79b38), (254a6)(7b893), (26a45)(7398b),(465a2)(83b97), (1)
123456789abc                 (1)


123456789abc     Multiplier: (1487a)(563c9), (18a47)(5396c), (174a8)(5c693),(a7841)(9c365), (1)
219a876534cb                 (12)(39)(4a)(58)(67)(bc)


123456789abc     Multiplier: (846bc)(21597), (86c4b)(25719), (8b4c6)(29175), (cb648)(79512), (1)
3478bc12569a                 (137)(248)(5b9)(6ca)


123456789abc     Multiplier: (5a7cb)(36128), (57bac)(31862), (5cab7)(32681), (bc7a5)(82163), (1)
435621cb78a9                 (146)(235)(7c9)(8ba)


123456789abc     Multiplier: (1a9b6)(427c3), (196ab)(4732c), (1ba69)(4c237), (6b9a1)(3c724), (1)
51369b247ac8                 (15972)(46bc8)


123456789abc     Multiplier: (15b34)(2a9c8),(1b453)(298ac), (1354b)(2ca89), (43b51)(8c9a2), (1)
6184b3a295c7                 (16382)(5bc7a)
```

Dodecahedron Elements

```
123456789abc      Multiplier: (15b34)(2a9c8),(1b453)(298ac), (1354b)(2ca89), (43b51)(8c9a2), (1)
7ab98c154236                  (17)(2a)(3b)(49)(58)(6c)


123456789abc      Multiplier: (1a9b6)(427c3), (196ab)(4732c), (1ba69)(4c237), (6b9a1)(3c724), (1)
82973c1a64b5                  (18a47)(396c5)


123456789abc      Multiplier: (5a7cb)(36128), (57bac)(31862), (5cab7)(32681), (bc7a5)(82163), (1)
9c275a386b14                  (196ab)(2c473)


123456789abc      Multiplier: (846bc)(21597), (86c4b)(25719), (8b4c6)(29175), (cb648)(79512), (1)
a1b5794682c3                  (1a2)(3bc)(457)(698)


123456789abc      Multiplier: (1487a)(563c9), (18a47)(5396c), (174a8)(5c693),(a7841)(9c365), (1)
b6839c14a572                  (1b7)(26c)(384)(59a)


123456789abc      Multiplier: (2a564)(79b38), (254a6)(7b893), (26a45)(7398b),(465a2)(83b97), (1)
c7593b2a4861                  (1c)(27)(35)(6b)(49)(8a)
```

Dodecahedron Element List

```
(1)
(2a564)(79b38)
(254a6)(7b893)
(26a45)(7398b)
(465a2)(83b97)
(12)(39)(4a)(58)(67)(bc)
(12)(39)(4a)(58)(67)(bc)  (1487a)(563c9)  =  (124)(357)(6a8)(9cb)
(12)(39)(4a)(58)(67)(bc)  (18a47)(5396c)  =  (28361)(5a7cb)
(12)(39)(4a)(58)(67)(bc)  (174a8)(5c693  =  (12795)(48cb6)
(12)(39)(4a)(58)(67)(bc)  (a7841)(9c365)  =  (12a)(3cb)(475)(689)
(137)(248)(5b9)(6ca)
(137)(248)(5b9)(6ca)   (846bc)(21597)  =  (13268)(5cab7)
(137)(248)(5b9)(6ca)  (86c4b)(25719)  =  (13)(2b)(46)(58)(79)(ac)
(137)(248)(5b9)(6ca)  (8b4c6)(29175)  =  (1354b)(2ca89)
(137)(248)(5b9)(6ca)  (cb648)(79512)  =  (139)(287)(4ca)(56b)
```

Dodecahedron Element List

```
(146)(235)(7c9)(8ba)
(146)(235)(7c9)(8ba)  (5a7cb)(36128)  =  (14)(26)(3a)(58)(7b)(9c)
(146)(235)(7c9)(8ba)  (57bac)(31862)  =  (142)(375)(68a)(9bc)
(146)(235)(7c9)(8ba)  (5cab7)(32681)  =  (1487a)(3c956)
(146)(235)(7c9)(8ba)  (bc7a5)(82163)  =  (143b5)(28c9a)
(16382)(5bc7a)
(16382)(5bc7a)  (1a9b6)(427c3)  =  (2a564)(79b38)
(16382)(5bc7a)  (196ab)(4732c)  =  (1a5)(296)(38c)(47b)
(16382)(5bc7a)  (1ba69)(4c237)  =  (19)(2b)(38)(4c)(5a)(67)
(16382)(5bc7a)  (6b9a1)(3c724)  =  (1b7)(26c)(384)(59a)
(15972)(46bc8)
(15972)(46bc8)  (1a9b6)(427c3)  =  (15b34)(2a9c8)
(15972)(46bc8)  (196ab)(4732c)  =  (156)(293)(4ab)(7c8)
(15972)(46bc8)  (1ba69)(4c237)  =a(15)(2b)(37)(49)(6a)(8c)
(15972)(46bc8)  (6b9a1)(3c724)  =  (15a)(269)(3c8)(467)
```

Dodecahedron Element List

```
(17)(2a)(3b)(49)(58)(6c)
(17)(2a)(3b)(49)(58)(6c)  (15b34)(2a9c8) = (17529)(4c68b)
(17)(2a)(3b)(49)(58)(6c)  (1b453)(298ac) = (17b)(2c6)(348)(5a9)
(17)(2a)(3b)(49)(58)(6c)  (1354b)(2ca89) = (173)(284)(59b)(6ac)
(17)(2a)(3b)(49)(58)(6c)  (43b51)(8c9a2) = (174a8)(35c69)
(18a47)(396c5)
(18a47)(396c5)  (1a9b6)(427c3) = (189)(27a)(3b6)(4c5)
(18a47)(396c5)  (196ab)(4732c) = (18b)(2c5)(364)(79a)
(18a47)(396c5)  (1ba69)(4c237) = (18623)(57bac)
(18a47)(396c5)  (6b9a1)(3c724) = (18)(24)(3a)(5c)(67)(b9)
(196ab)(2c473)
(196ab)(2c473)  (5a7cb)(36128) = (19)(2b)(38)(4c)(5a)(67)
(196ab)(2c473)  (57bac)(31862) = (19257)(4b86c)
(196ab)(2c473)  (5cab7)(32681) = (198)(2a7)(36b)(45c)
(196ab)(2c473)  (bc7a5)(82163) = (193)(278)(4ac)(5b6)
```

Dodecahedron Element List

```
(1a2)(3bc)(457)(698)
(1a2)(3bc)(457)(698)  (846bc)(21597)  =  (1a)(25)(3c)(49)(67)(8b)
(1a2)(3bc)(457)(698)  (86c4b)(25719)  =  (1a5)(296)(38c)(47b)
(1a2)(3bc)(457)(698)  (8b4c6)(29175)  =  (1a9b6)(27c34)
(1a2)(3bc)(457)(698)  (cb648)(79512)  =  (1a784)(3659c)
(1b7)(26c)(384)(59a)
(1b7)(26c)(384)(59a)  (1487a)(563c9)  =  (1ba69)(2374c)
(1b7)(26c)(384)(59a)  (18a47)(5396c)  =  (1b)(2c)(3a)(49)(56)(78)
(1b7)(26c)(384)(59a)  (174a8)(5c693)  =  (1b453)(298ac)
(1b7)(26c)(384)(59a)  (a7841)(9c365)  =  (1b8)(25c)(346)(7a9)
(1c)(27)(35)(6b)(49)(8a)
(1c)(27)(35)(6b)(49)(8a)  (2a564)(79b38)  =  (1c)(29)(36)(4b)(58)(7a)
(1c)(27)(35)(6b)(49)(8a)  (254a6)(7b893)  =  (1c)(2b)(34)(57)(68)(9a)
(1c)(27)(35)(6b)(49)(8a)  (26a45)(7398b)  =  (1c)(23)(48)(59)(67)(ab)
(1c)(27)(35)(6b)(49)(8a)  (465a2)(83b97)  =  (1c)(28)(3a)(47)(5b)(69)
```
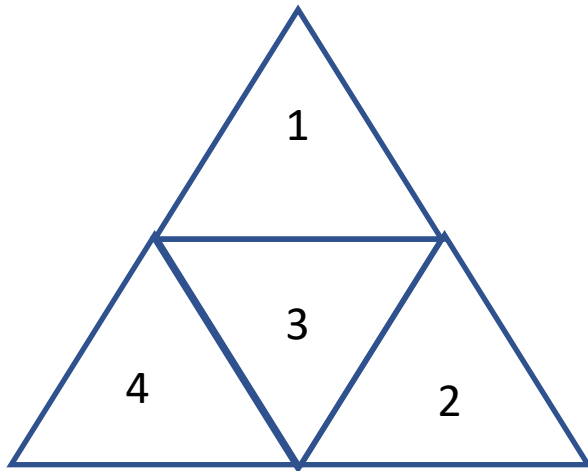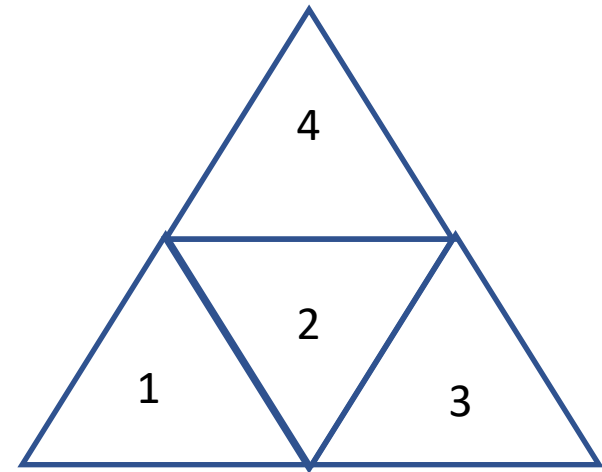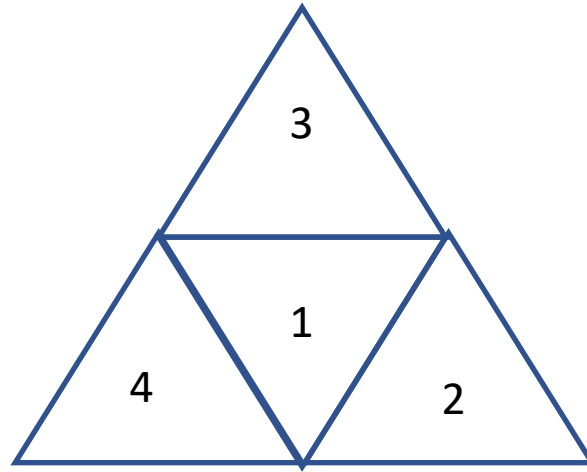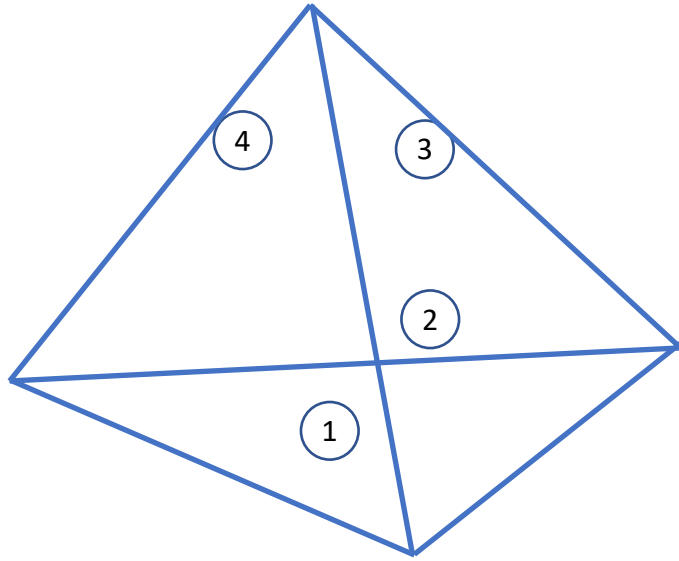
Tetrahedron
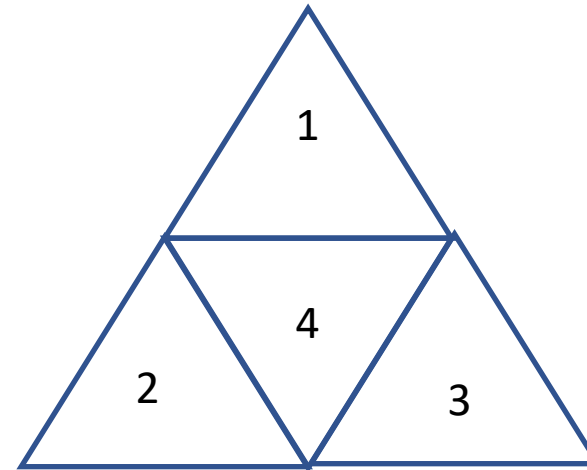
Tetrahedron elements

```
(1),  (234),  (243)
(12)(34),  (12)(34)(134)= (123),  (12)(34)(143)= (124)
(13)(24),  (13)(24)(142)= (134),  (13)(24)(124)= (132)
(14)(23),  (14)(23)(123)= (142),  (14)(23)(132)= (143)
```

```
(1),(234),(243),(12)(34),(123),(124),
(13)(24),(134),(132),(14)(23),(142),(143)
```
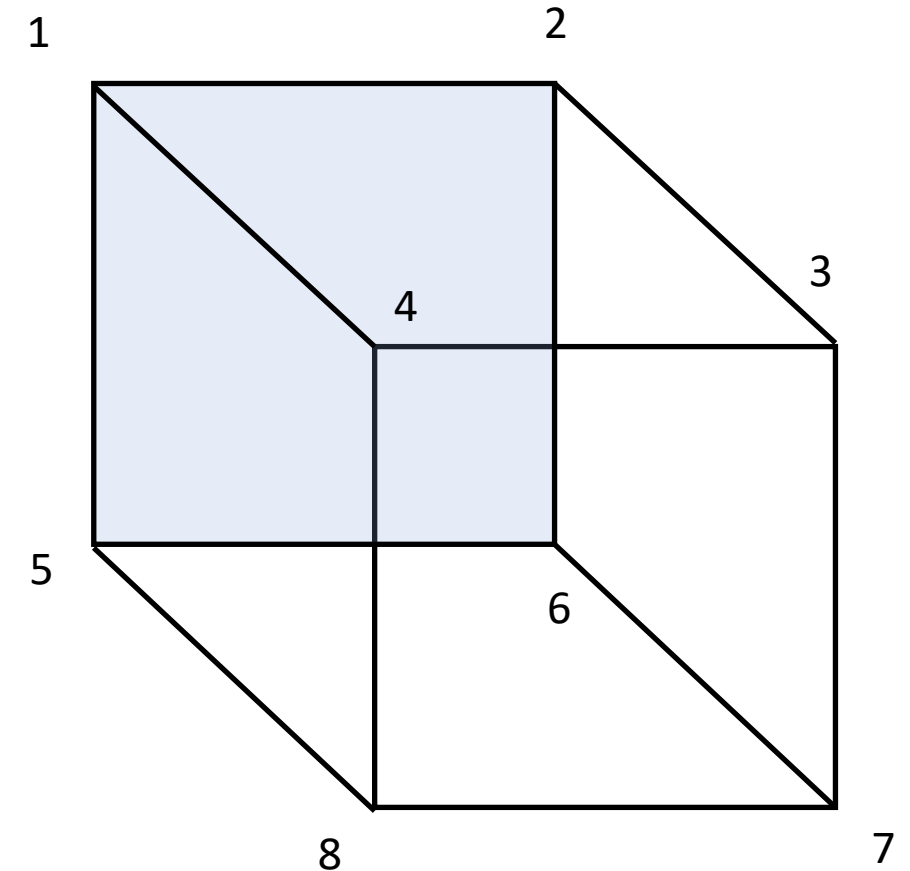
Cube

Group actions on vertices

1. (1)
2. (1234)(5678)
3. (1432)(5876)
4. (1562)(3487)
5. (1265)(4378)
6. (1485)(2376)
7. (1584)(2673)
8. (13)(24)(57)(68)
9. (16)(25)(38)(47)
10. (18)(45)(27)(36)
11. (17)(23)(46)(58)
12. (17)(48)(35)(26)

1. (17)(34)(48)(56)
2. (12)(35)(46)(78)
3. (14)(28)(35)(67)
4. (15)(46)(28)(37)
5. (245)(386)
6. (254)(368)
7. (168)(427)
8. (186)(247)
9. (136)(475)
10. (163)(457)
11. (138)(275)
12. (183)(257)

(1562)(3487)(13)(24)(57)(68)= (17)(23)(46)(58)
(1485)(2376))(13)(24)(57)(68)= (12)(35)(46)(78)

$P_G(x_1, x_2, x_3, x_4) = 24^{-1}[x_1^8+9x_2^4+8x_3^2x_1^2+6x_4^2]$
$P_G(2,2,2,2)= 24^{-1}[256+144+128+24]=23$