

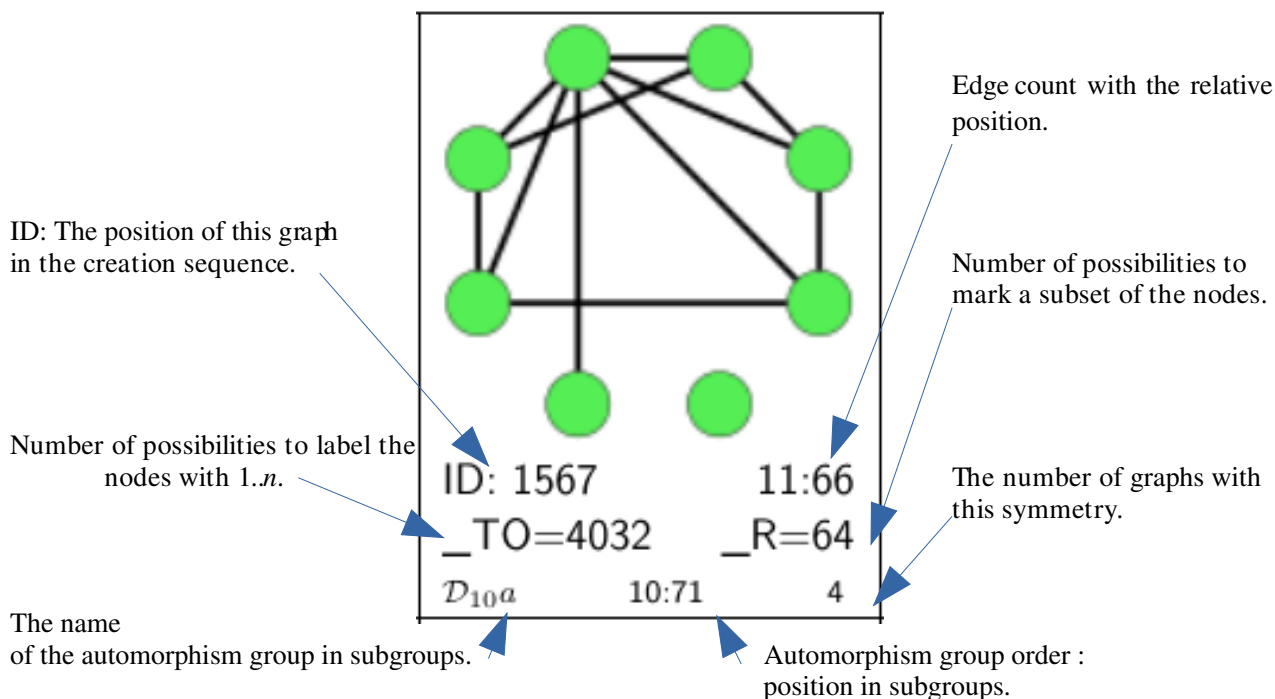
## How to read the ‘Graph Symmetry Tables’

A Graph Symmetry Table lists undirected graphs of the different symmetries to a given count of  $n$  nodes. The symmetry type of a graph is determined by its automorphism group. It is a permutation group on the nodes set, and therefore a subgroup of the symmetric group  $\mathcal{S}_n$ . The total number of these is determined by A000638. But not all of them occur as an automorphism group of a graph.

With A343592 the analogue was published for directed graphs. Since every undirected graph may be understood as a directed graph with symmetric edges, the automorphism group of a graph with  $n$  nodes is always an automorphism group of a digraph with the same nodes size. But the reverse is not true. So you will not find an undirected graph with 3 nodes, whose symmetry is determined by the cyclic group on three elements  $C_3$ . Also to construct a fully asymmetric graph, i.e. a graph with the trivial automorphism group  $\{id\}$ , I need at least six nodes. (See also  $n = 6$ (ID:045) and A003400.)

The Graph Symmetry Tables presented here bases on an enumeration algorithm sorting out graphs with a symmetry already found. Therefore the shown graphs are each the first one of its symmetry type found by the algorithm. Since it lists the graphs with increasing edge count, those minimality is guaranteed for each symmetry type.

Example:



The assignment of the permutation group name bases on the calculation of the cycle type of each group in subgroups for  $n = 5, \dots, 8$  with the GAP2021 system. In fact the cycle type does not identify the group uniquely. But however, the cycle types of the graph automorphism groups are unique for  $n = 3, \dots, 8$ , but only one for  $n = 8$ . In this one case the group orbit helps to identify the automorphism group. (It is a matter of the symmetry class of the graph with ID: 427, whose automorphism group is  $C_2^2k$  with orbit  $[4, 2, 1^2]$  having the same cycle type as  $C_2^2h$  with orbit  $[2^4]$ , but never occurring as automorphism group of a graph.)

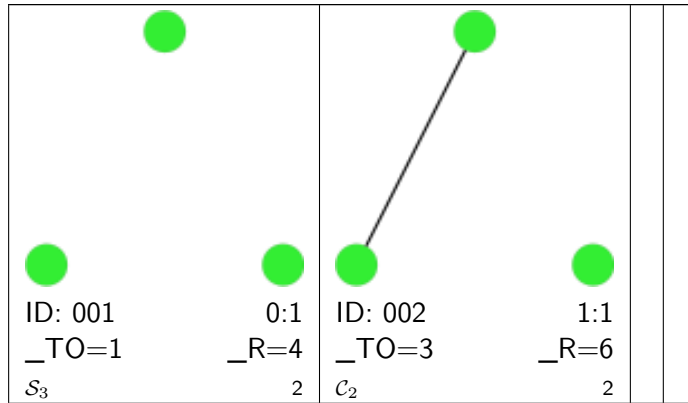
Since each graph is assigned to a symmetry type in a unique way, it is not surprising, that the sum of the counts of one table results in  $A000088(n)$ , the number of graphs on  $n$  unlabeled nodes.

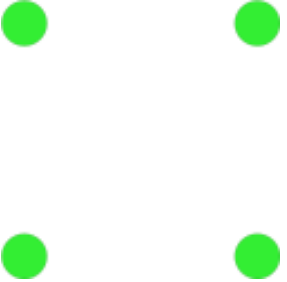
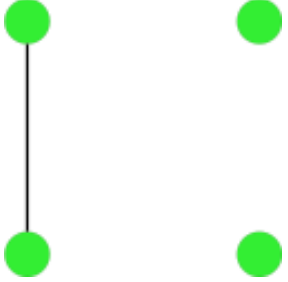
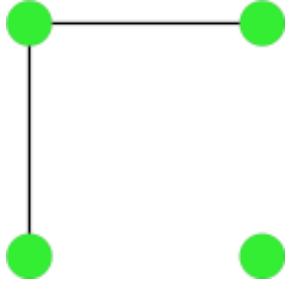
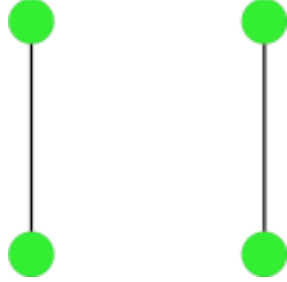
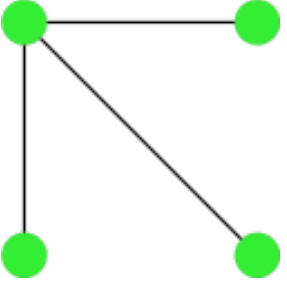
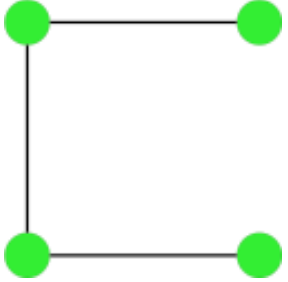
The measures  $\_TO$  and  $\_R$  are calculated on the base of the cycle type as shown in the document to A343592. Analogous to there we come to A006125 (i.e.  $2^{(n^2-n)/2}$ ) summing up the  $\_TO$  values over all graphs. The  $\_R$  values lead us to A000666 representing the number of undirected graphs having  $0, \dots, n$  nodes with loop edges.

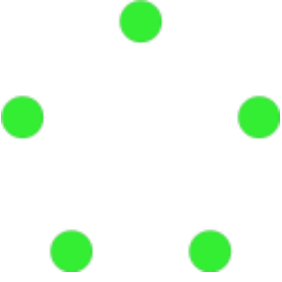
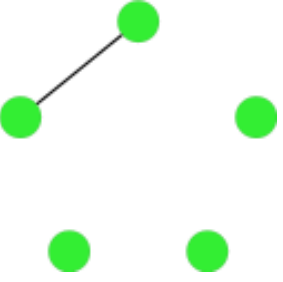
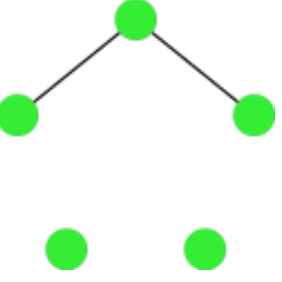
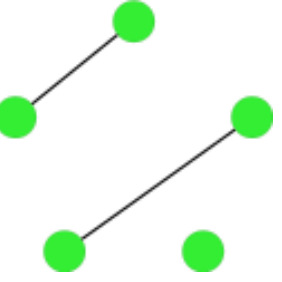
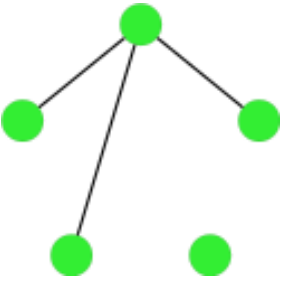
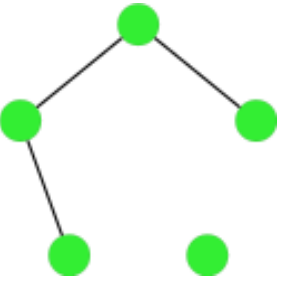
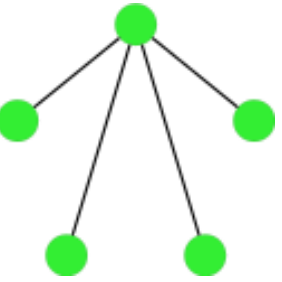
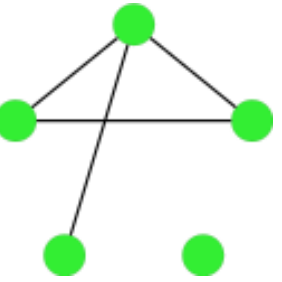
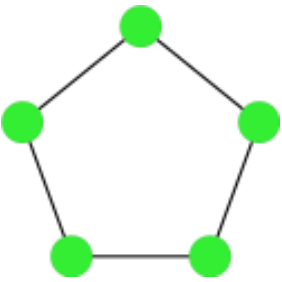
subgroups lists all the permutation groups of degree  $n = 5, \dots, 12$ . The group identifications referring [ATLAS] are taken from there with the exception that  $C_n$  is used instead of simply „ $n$ “ for the cyclic group with  $n$  elements. Note, that different permutation groups may have the same group structure, i.e. they may be isomorph as groups. So we have 3 different permutation groups of the group isomorphism class  $C_2$  for  $n = 6$ :  $C_{2a}$ ,  $C_{2b}$ , and  $C_{2c}$ , with orbits  $[2, 1^4]$ ,  $[2^3]$ , and  $[2^2, 1^2]$ . The cycle types were assigned using the criteria: order, orbit, the number of the contained subgroups and of the contained conjugacy classes in regard to  $S_n$ , and, if these were not unique, the directly contained subgroup classes, indicated with the marker "Above".

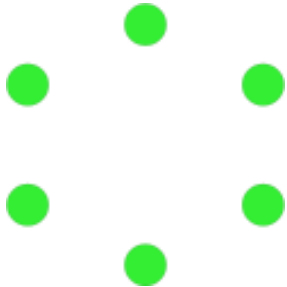
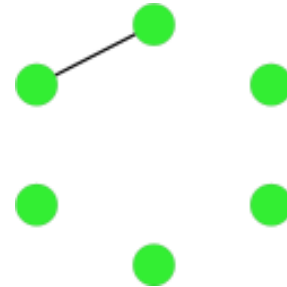
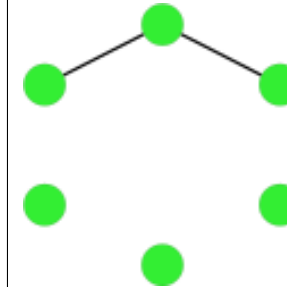
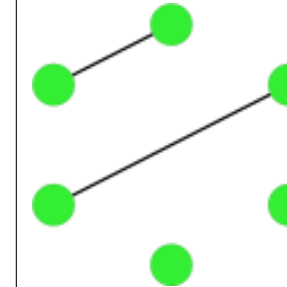
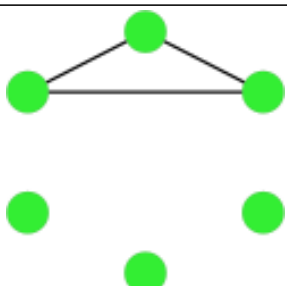
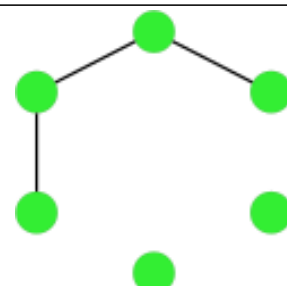
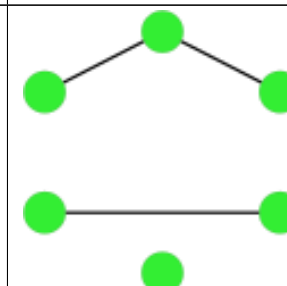
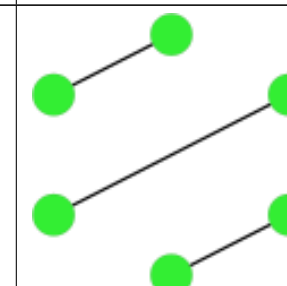
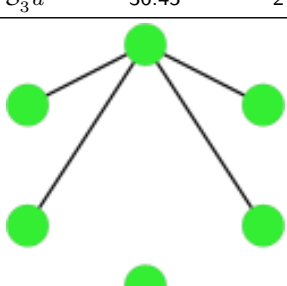
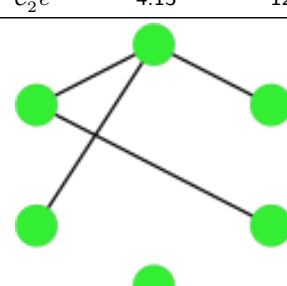
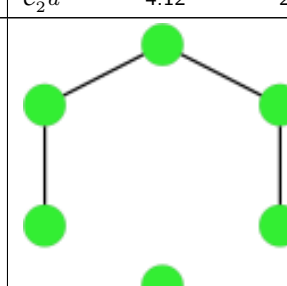
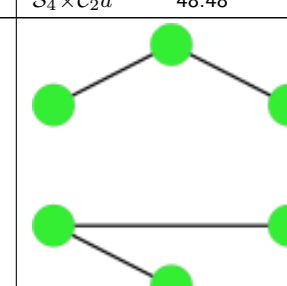
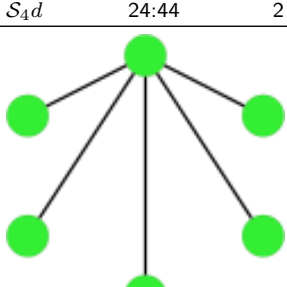
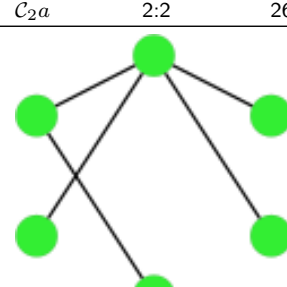
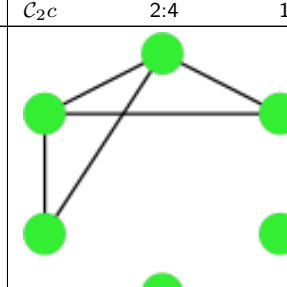
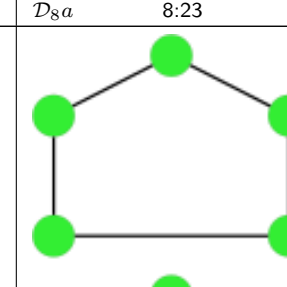
## References

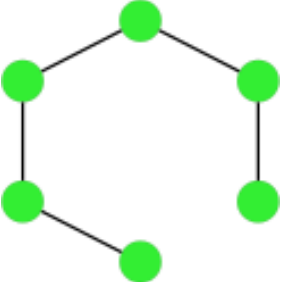
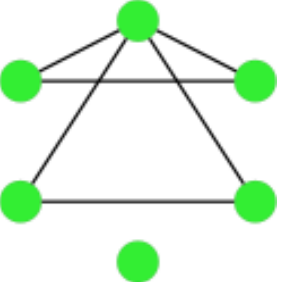
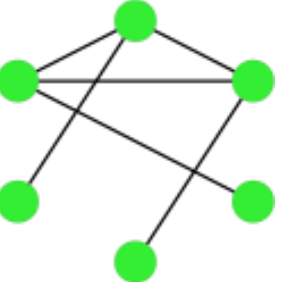
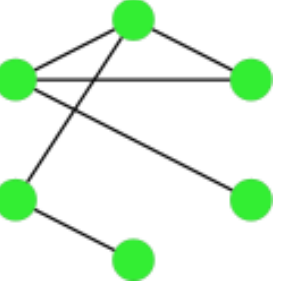
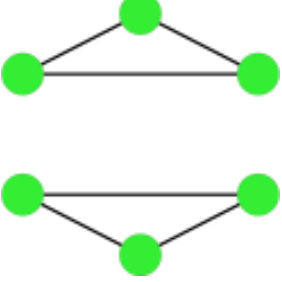
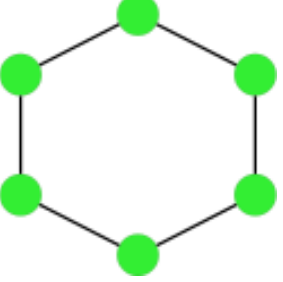
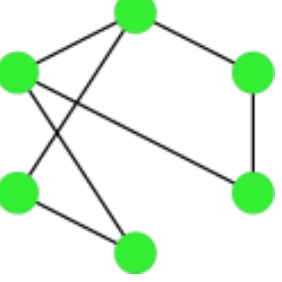
[ATLAS]	John H. Conway, Robert T. Curtis, Simon P. Norton, Richard A. Parker, and Robert A. Wilson: Atlas of finite groups, Oxford University Press, 1985.
subgroups	<a href="http://schmidt.nuigalway.ie/subgroups/alt.html">http://schmidt.nuigalway.ie/subgroups/alt.html</a> ©Götz Pfeiffer
GAP2021	The GAP Group, GAP – Groups, Algorithms, and Programming, Version 4.11.1; 2021. ( <a href="https://www.gap-system.org">https://www.gap-system.org</a> )

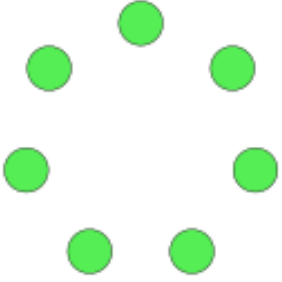
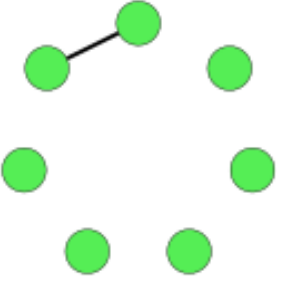
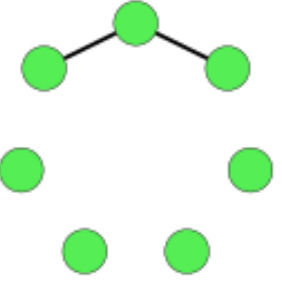
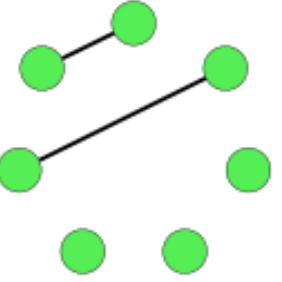
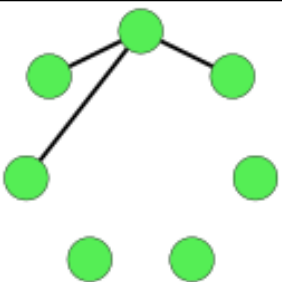
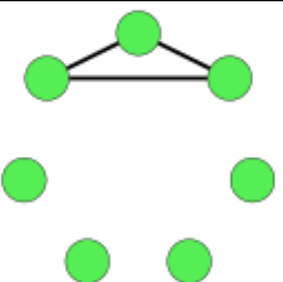
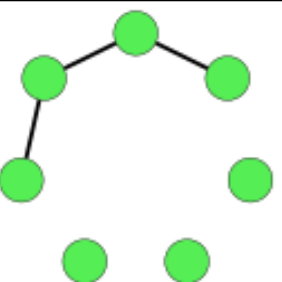
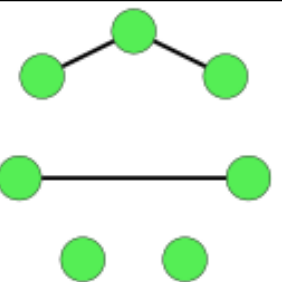
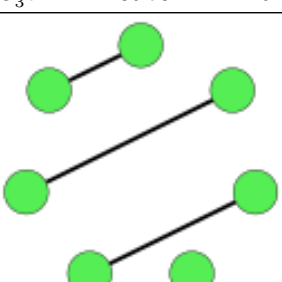
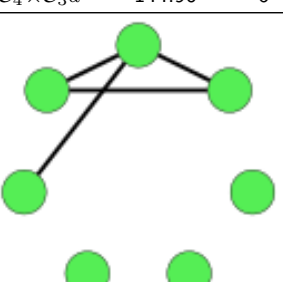
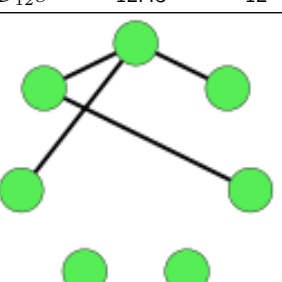
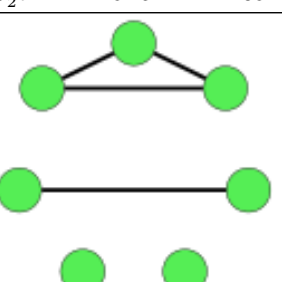
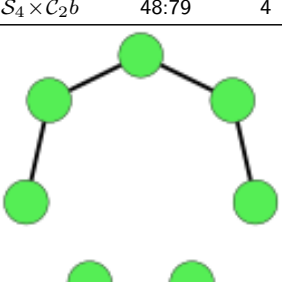
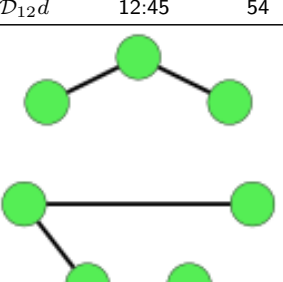
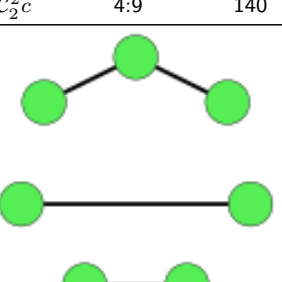
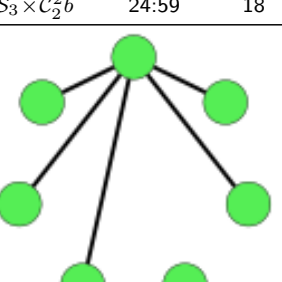


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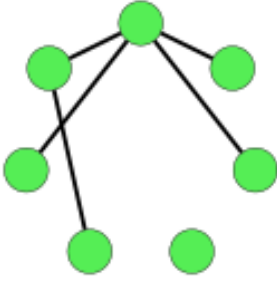
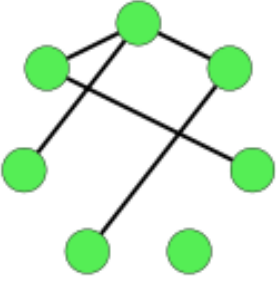
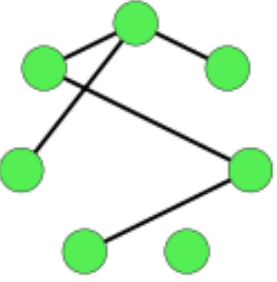
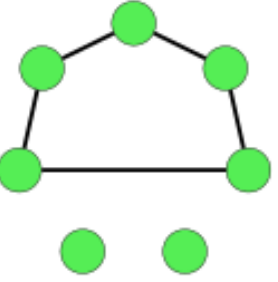
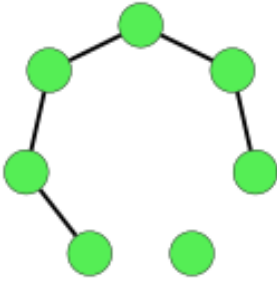
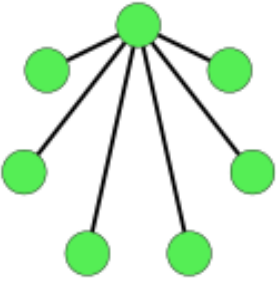
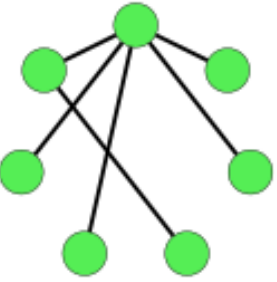
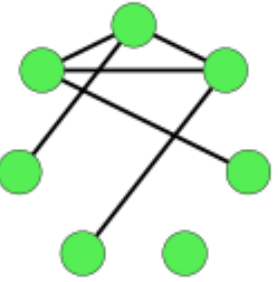
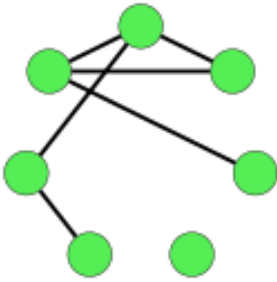
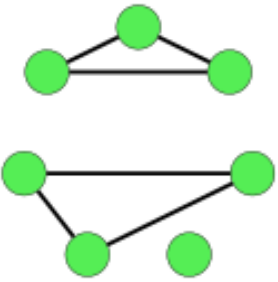
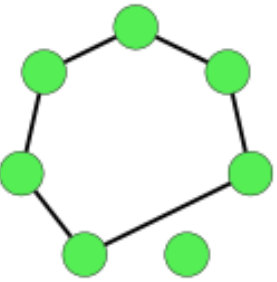
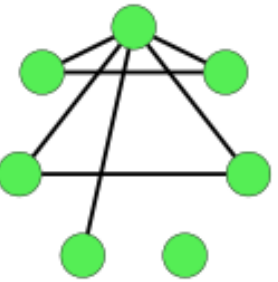
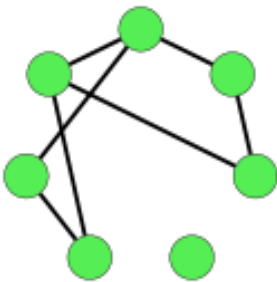
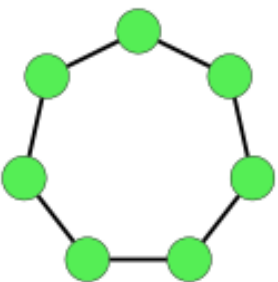
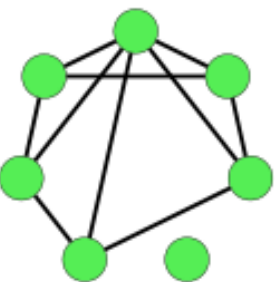
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 <p>ID: 005                      3:1            _TO=20              _R=16  <math>S_{3a}</math>            6:9            2</p>	 <p>ID: 007                      3:3            _TO=60              _R=20  <math>C_{2b}</math>            2:3            5</p>	 <p>ID: 009                      4:1            _TO=5                _R=10  <math>S_4</math>            24:17            2</p>	 <p>ID: 010                      4:2            _TO=60              _R=24  <math>C_{2a}</math>            2:2            6</p>
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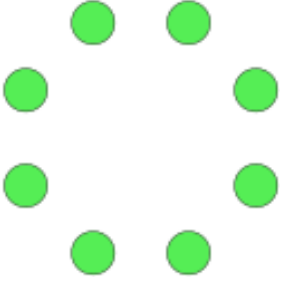
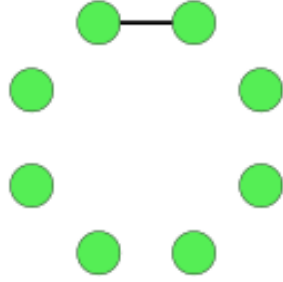
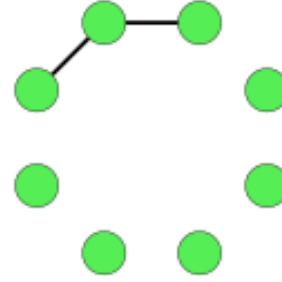
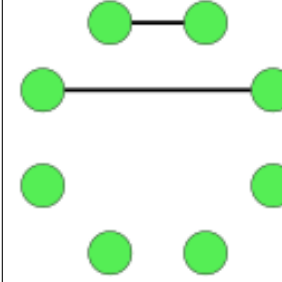
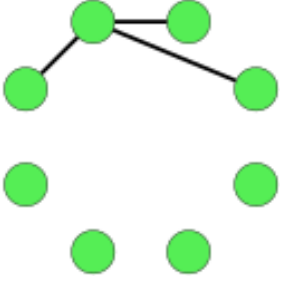
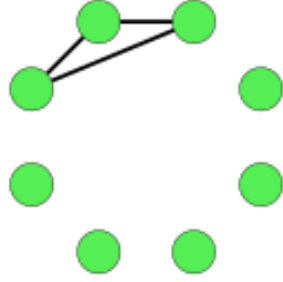
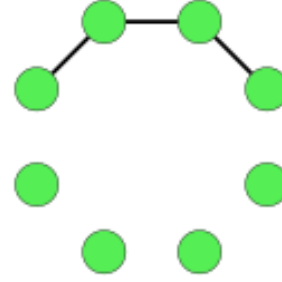
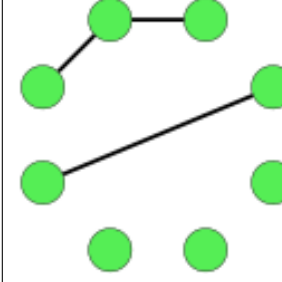
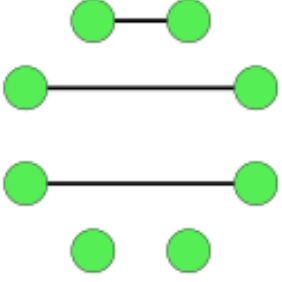
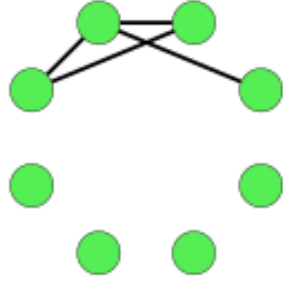
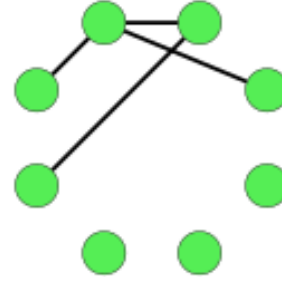
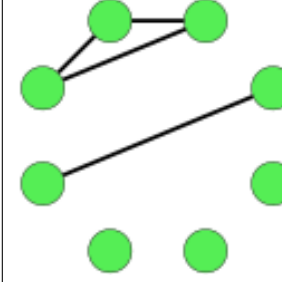
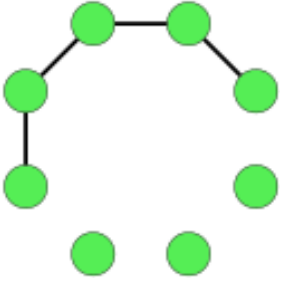
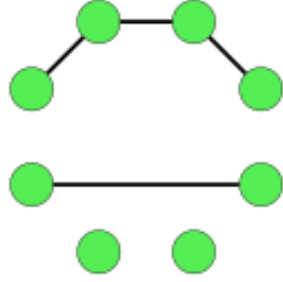
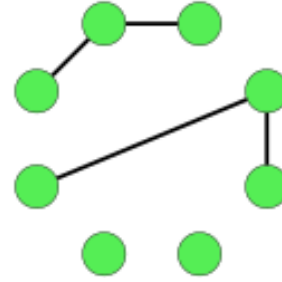
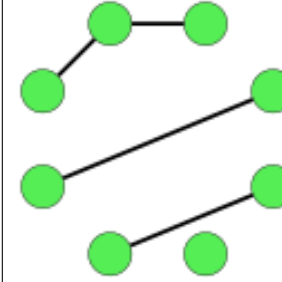
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 <p>ID: 006                      3:2            _TO=20                _R=16  <math>S_3^2a</math>                      36:45                      2</p>	 <p>ID: 007                      3:3            _TO=180                _R=30  <math>C_2^2e</math>                      4:13                      12</p>	 <p>ID: 008                      3:4            _TO=180                _R=36  <math>C_2^2d</math>                      4:12                      22</p>	 <p>ID: 009                      3:5            _TO=15                _R=10  <math>S_4 \times C_2a</math>                      48:48                      2</p>
 <p>ID: 010                      4:1            _TO=30                _R=20  <math>S_4d</math>                      24:44                      2</p>	 <p>ID: 012                      4:3            _TO=360                _R=48  <math>C_2a</math>                      2:2                      26</p>	 <p>ID: 016                      4:7            _TO=360                _R=40  <math>C_2c</math>                      2:4                      16</p>	 <p>ID: 018                      4:9            _TO=90                _R=21  <math>D_8a</math>                      8:23                      6</p>
 <p>ID: 019                      5:1            _TO=6                    _R=12  <math>S_5a</math>                      120:53                      2</p>	 <p>ID: 021                      5:3            _TO=120                _R=32  <math>S_3b</math>                      6:16                      6</p>	 <p>ID: 022                      5:4            _TO=90                _R=27  <math>C_2^3b</math>                      8:23                      4</p>	 <p>ID: 032                      5:14            _TO=72                _R=16  <math>D_{10}</math>                      72:29                      2</p>

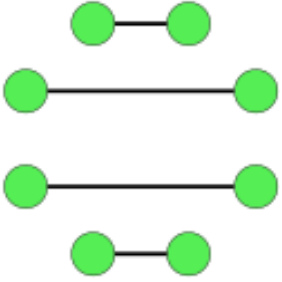
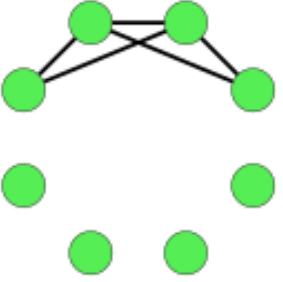
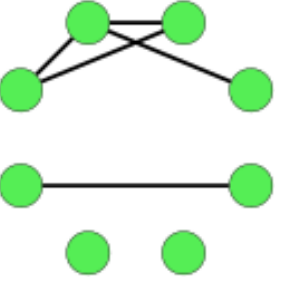
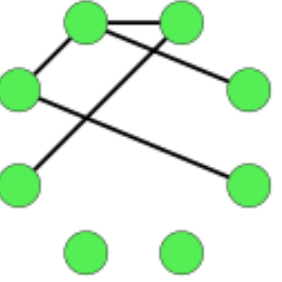
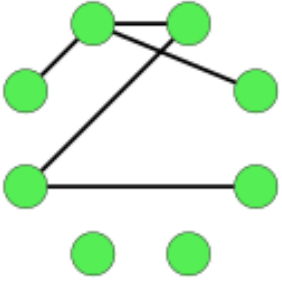
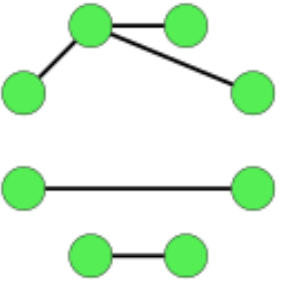
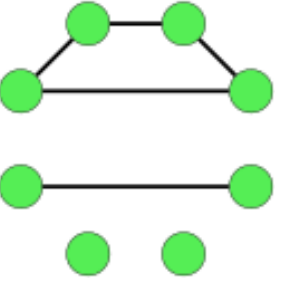
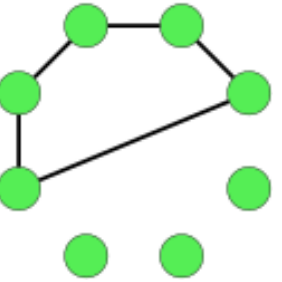
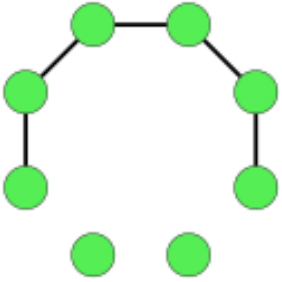
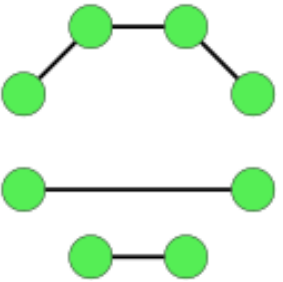
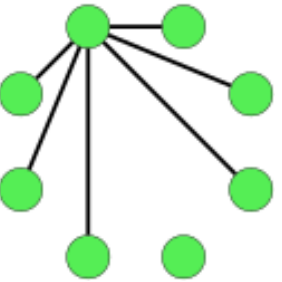
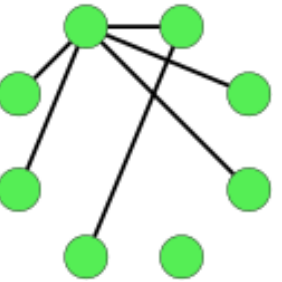
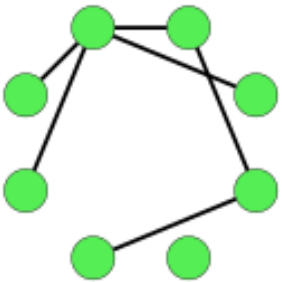
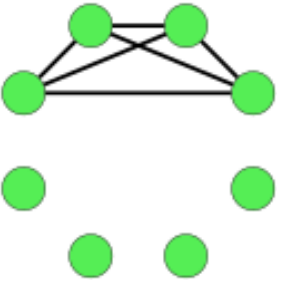
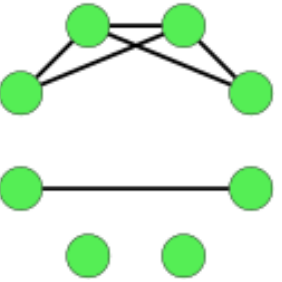
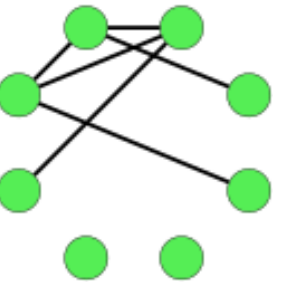
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 <p>ID: 053                      6:20        _TO=10                      _R=10  <i>S</i><sub>3</sub> ∪ <i>C</i><sub>2</sub>                      72:52                      2</p>	 <p>ID: 054                      6:21        _TO=60                      _R=13  <i>D</i><sub>12b</sub>                      12:33                      2</p>	 <p>ID: 077                      7:23        _TO=180                      _R=24  <i>C</i><sub>2</sub><sup>2</sup><i>c</i>                      4:10                      2</p>	

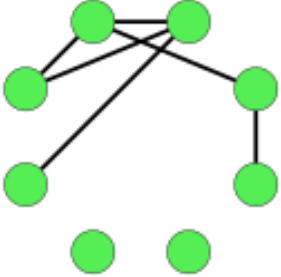
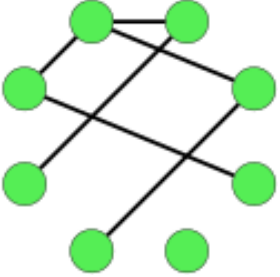
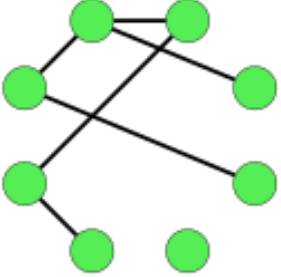
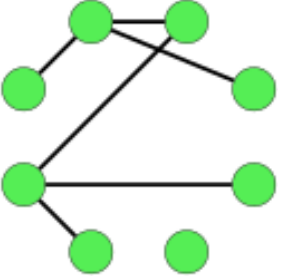
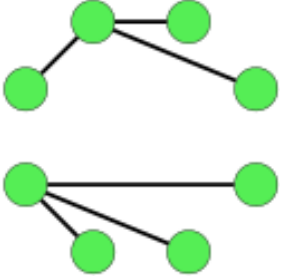
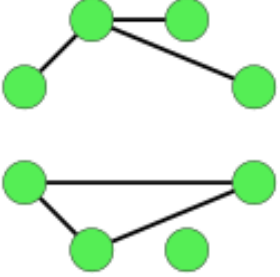
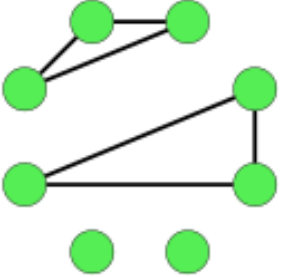
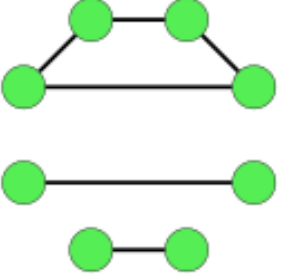
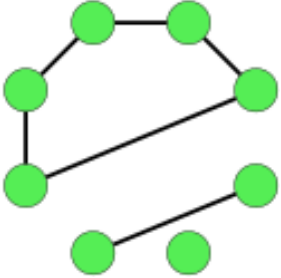
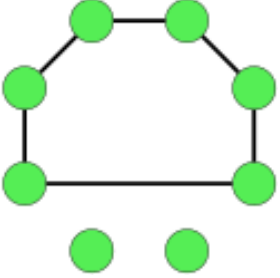
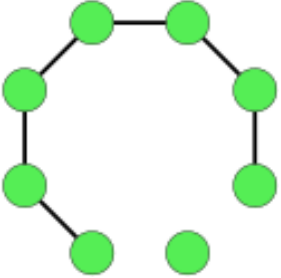
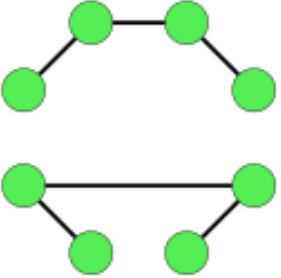
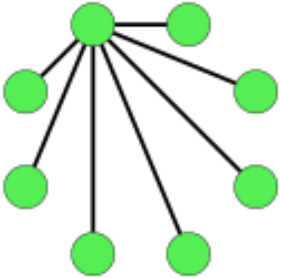
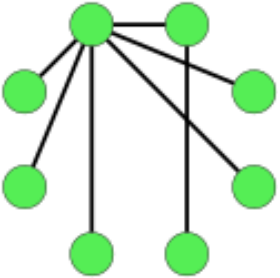
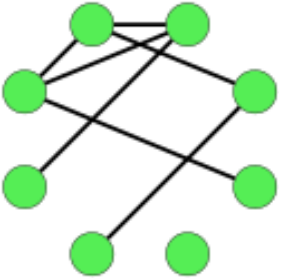
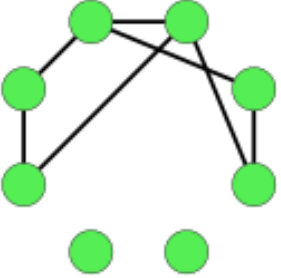
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 <p>ID: 005                      3:1 _TO=140                      _R=32 <math>S_3^2 b</math>                      36:73                      6</p>	 <p>ID: 006                      3:2 _TO=35                      _R=20 <math>S_4 \times S_3 a</math>                      144:90                      6</p>	 <p>ID: 007                      3:3 _TO=420                      _R=40 <math>D_{12} c</math>                      12:43                      12</p>	 <p>ID: 008                      3:4 _TO=630                      _R=54 <math>C_2^3 b</math>                      8:25                      38</p>
 <p>ID: 009                      3:5 _TO=105                      _R=20 <math>S_4 \times C_2 b</math>                      48:79                      4</p>	 <p>ID: 011                      4:2 _TO=420                      _R=48 <math>D_{12} d</math>                      12:45                      54</p>	 <p>ID: 012                      4:3 _TO=1260                      _R=72 <math>C_2^2 c</math>                      4:9                      140</p>	 <p>ID: 014                      4:5 _TO=210                      _R=36 <math>S_3 \times C_2^2 b</math>                      24:59                      18</p>
 <p>ID: 016                      4:7 _TO=1260                      _R=60 <math>C_2^2 e</math>                      4:13                      96</p>	 <p>ID: 018                      4:9 _TO=630                      _R=42 <math>D_8 c</math>                      8:29                      28</p>	 <p>ID: 019                      4:10 _TO=315                      _R=36 <math>D_8 \times C_2</math>                      16:49                      20</p>	 <p>ID: 020                      5:1 _TO=42                      _R=24 <math>S_5 a</math>                      120:86                      2</p>

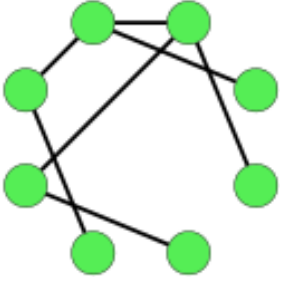
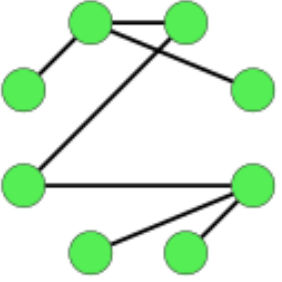
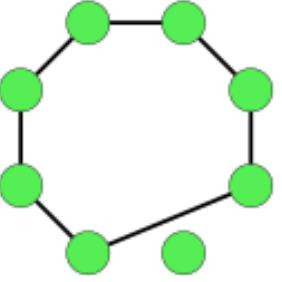
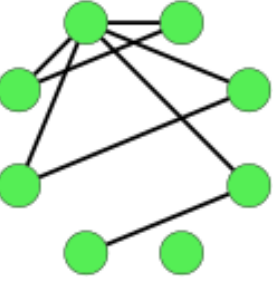
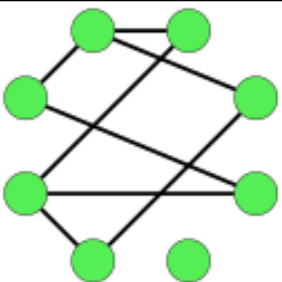
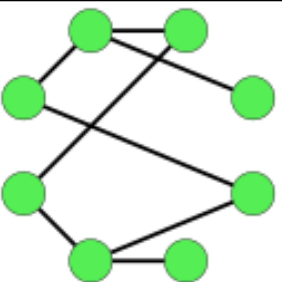
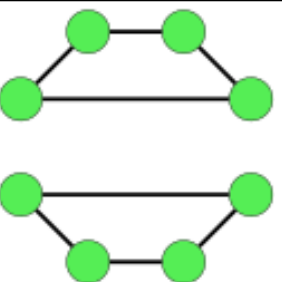
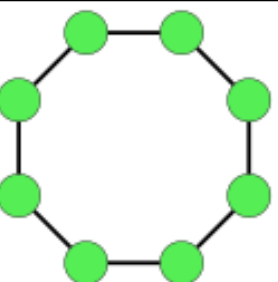
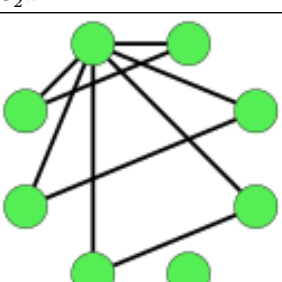
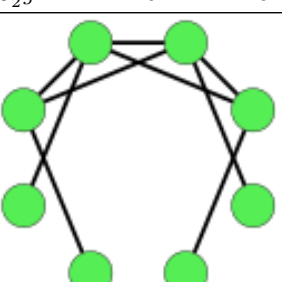
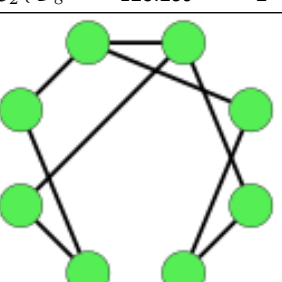
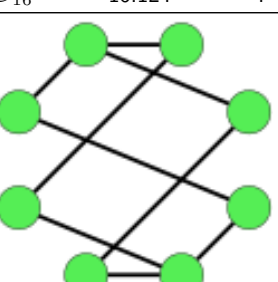
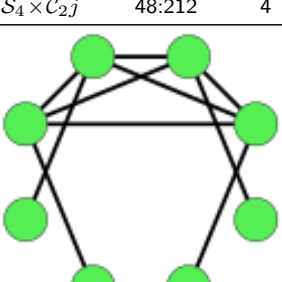
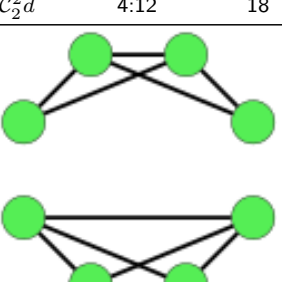
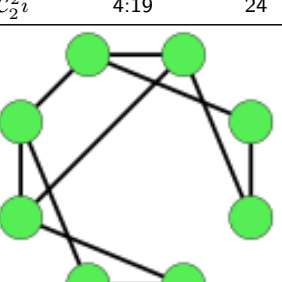
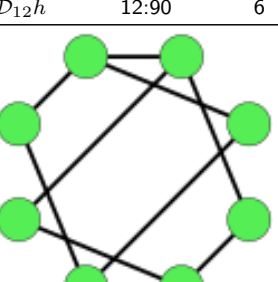


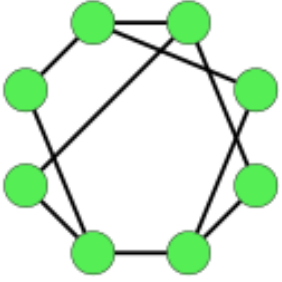
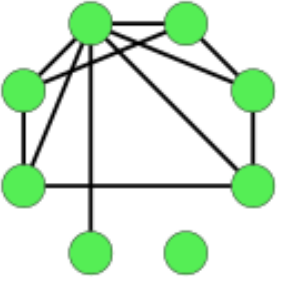
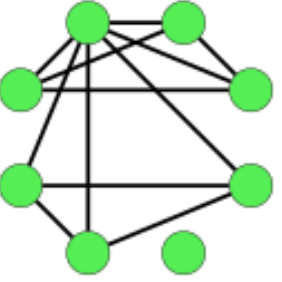
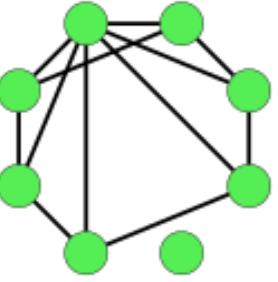
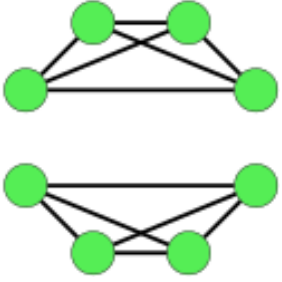
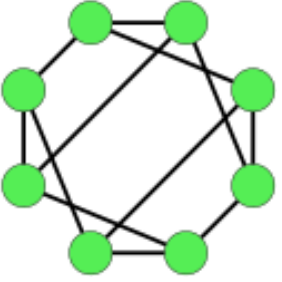
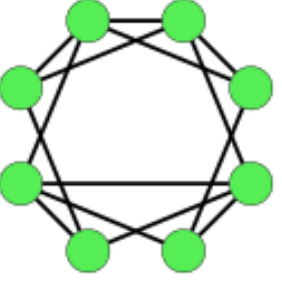
 <p>ID: 022                      5:3            _TO=840            _R=64  <i>S</i><sub>3a</sub>            6:15            26</p>	 <p>ID: 030                      5:11            _TO=2520          _R=80  <i>C</i><sub>2b</sub>            2:2              86</p>	 <p>ID: 031                      5:12            _TO=2520          _R=96  <i>C</i><sub>2a</sub>            2:3              214</p>	 <p>ID: 037                      5:18            _TO=252            _R=24  <i>D</i><sub>20</sub>            20:54            4</p>
 <p>ID: 038                      5:19            _TO=2520          _R=72  <i>C</i><sub>2c</sub>            2:4              54</p>	 <p>ID: 041                      6:1            _TO=7              _R=14  <i>S</i><sub>6</sub>            720:94            2</p>	 <p>ID: 043                      6:3            _TO=210            _R=40  <i>S</i><sub>4a</sub>            24:57            6</p>	 <p>ID: 056                      6:16            _TO=840            _R=40  <i>S</i><sub>3e</sub>            6:22              12</p>
 <p>ID: 058                      6:18            _TO=5040          _R=128  {id}            1:1              152</p>	 <p>ID: 076                      6:36            _TO=70             _R=20  <i>S</i><sub>3</sub> ∩ <i>C</i><sub>2</sub>    72:85            4</p>	 <p>ID: 080                      6:40            _TO=420            _R=26  <i>D</i><sub>12f</sub>            12:47            4</p>	 <p>ID: 085                      7:4            _TO=630            _R=48  <i>D</i><sub>8a</sub>            8:26              8</p>
 <p>ID: 134                      7:53            _TO=1260          _R=48  <i>C</i><sub>2</sub><sup>2d</sup>            4:12              12</p>	 <p>ID: 146                      7:65            _TO=360            _R=18  <i>D</i><sub>14</sub>            14:48            2</p>	 <p>ID: 419                      10:45            _TO=504            _R=32  <i>D</i><sub>10b</sub>            10:33            2</p>	

 <p>ID: 001                      0:1            _TO=1                _R=9  <math>S_8</math>      40320:296      2</p>	 <p>ID: 002                      1:1            _TO=28              _R=21  <math>S_6 \times C_2</math>    1440:292      6</p>	 <p>ID: 003                      2:1            _TO=168             _R=36  <math>S_5 \times C_2b</math>    240:273      16</p>	 <p>ID: 004                      2:2            _TO=210             _R=30  <math>S_4 \times D_8</math>    192:271      8</p>
 <p>ID: 005                      3:1            _TO=280             _R=40  <math>S_4 \times S_3</math>    144:262      16</p>	 <p>ID: 006                      3:2            _TO=56              _R=24  <math>S_5 \times S_3</math>    720:289      6</p>	 <p>ID: 007                      3:3            _TO=840             _R=50  <math>S_4 \times C_2b</math>    48:201      12</p>	 <p>ID: 008                      3:4            _TO=1680            _R=72  <math>S_3 \times C_2^2b</math>    24:153      134</p>
 <p>ID: 009                      3:5            _TO=420             _R=30  <math>S_4 \times C_2^2c</math>    96:251      6</p>	 <p>ID: 011                      4:2            _TO=840             _R=60  <math>S_4 \times C_2h</math>    48:209      54</p>	 <p>ID: 012                      4:3            _TO=3360            _R=96  <math>D_{12}b</math>      12:78      316</p>	 <p>ID: 014                      4:5            _TO=560             _R=48  <math>S_3^2 \times C_2a</math>    72:231      18</p>
 <p>ID: 016                      4:7            _TO=3360            _R=80  <math>D_{12}e</math>      12:84      96</p>	 <p>ID: 017                      4:8            _TO=5040            _R=90  <math>C_2^3i</math>      8:52      96</p>	 <p>ID: 018                      4:9            _TO=2520            _R=63  <math>D_8 \times C_2k</math>    16:121      56</p>	 <p>ID: 019                      4:10            _TO=2520            _R=72  <math>D_8 \times C_2l</math>    16:122      68</p>

 <p>ID: 020                      4:11            _TO=105        _R=15  <math>C_2 \wr S_4</math>    384:282    2</p>	 <p>ID: 025                      5:5            _TO=420        _R=45  <math>S_4 \times C_2^2 b</math>    96:249    18</p>	 <p>ID: 028                      5:8            _TO=5040        _R=108  <math>C_2^3 e</math>        8:44        320</p>	 <p>ID: 031                      5:11            _TO=10080        _R=120  <math>C_2^2 j</math>        4:20        696</p>
 <p>ID: 032                      5:12            _TO=10080        _R=144  <math>C_2^2 c</math>        4:11        1350</p>	 <p>ID: 035                      5:15            _TO=840         _R=48  <math>S_3 \times D_8</math>    48:214    24</p>	 <p>ID: 038                      5:18            _TO=1260        _R=54  <math>D_8 \times C_2^2 b</math>    32:179    18</p>	 <p>ID: 039                      5:19            _TO=672         _R=32  <math>S_3 \times D_{10}</math>    60:222    4</p>
 <p>ID: 040                      5:20            _TO=10080        _R=108  <math>C_2^2 f</math>        4:14        112</p>	 <p>ID: 043                      5:23            _TO=2520        _R=60  <math>D_8 \times C_2 i</math>    16:117    12</p>	 <p>ID: 045                      6:1            _TO=56            _R=28  <math>S_8 a</math>        720:286    2</p>	 <p>ID: 047                      6:3            _TO=1680        _R=80  <math>S_4 a</math>        24:138    26</p>
 <p>ID: 057                      6:13            _TO=6720        _R=128  <math>S_3 a</math>        6:24        214</p>	 <p>ID: 060                      6:16            _TO=70            _R=25  <math>S_4^1</math>        576:284    2</p>	 <p>ID: 062                      6:18            _TO=2520        _R=81  <math>C_2^4 b</math>        16:97        16</p>	 <p>ID: 063                      6:19            _TO=3360        _R=60  <math>D_{12} f</math>        12:88        24</p>

 <p>ID: 065                      6:21            _TO=20160   _R=192  <i>C</i><sub>2a</sub>            2:2            3034</p>	 <p>ID: 079                      6:35            _TO=6720   _R=80  <i>S</i><sub>3g</sub>            6:35            38</p>	 <p>ID: 081                      6:37            _TO=40320  _R=256  {<i>id</i>}            1:1            3696</p>	 <p>ID: 083                      6:39            _TO=5040   _R=84  <i>D</i><sub>8k</sub>            8:64            92</p>
 <p>ID: 087                      6:43            _TO=560     _R=36  <i>S</i><sub>3</sub> ∩ <i>C</i><sub>2a</sub>    72:232        6</p>	 <p>ID: 088                      6:44            _TO=1120   _R=64  <i>S</i><sub>3</sub><sup>2</sup><i>c</i>            36:189        22</p>	 <p>ID: 090                      6:46            _TO=280     _R=30  <i>S</i><sub>3</sub> ∩ <i>C</i><sub>2</sub> × <i>C</i><sub>2</sub> 144:261      8</p>	 <p>ID: 094                      6:50            _TO=630     _R=36  <i>D</i><sub>8</sub><sup>2</sup>            64:224        2</p>
 <p>ID: 095                      6:51            _TO=2016   _R=48  <i>D</i><sub>20</sub>            20:136        12</p>	 <p>ID: 096                      6:52            _TO=1680   _R=39  <i>S</i><sub>3</sub> × <i>C</i><sub>2</sub><sup>2</sup><i>c</i>    24:161        8</p>	 <p>ID: 097                      6:53            _TO=20160  _R=144  <i>C</i><sub>2d</sub>            2:5            468</p>	 <p>ID: 100                      6:56            _TO=5040   _R=55  <i>D</i><sub>8m</sub>            8:67            10</p>
 <p>ID: 101                      7:1            _TO=8       _R=16  <i>S</i><sub>7</sub>            5040:294      2</p>	 <p>ID: 103                      7:3            _TO=336     _R=48  <i>S</i><sub>5a</sub>            120:252      6</p>	 <p>ID: 158                      7:58            _TO=20160  _R=160  <i>C</i><sub>2c</sub>            2:4            802</p>	 <p>ID: 180                      7:80            _TO=5040   _R=72  <i>C</i><sub>2</sub><sup>3</sup><i>j</i>            8:60            24</p>

 <p>ID: 187                      7:87            _TO=20160   _R=136  <i>C</i><sub>2b</sub>            2:3            127</p>	 <p>ID: 204                      7:104            _TO=5040   _R=78  <i>D</i><sub>8d</sub>            8:53            42</p>	 <p>ID: 214                      7:114            _TO=2880   _R=36  <i>D</i><sub>14</sub>            14:94            4</p>	 <p>ID: 237                      8:22            _TO=5040   _R=96  <i>D</i><sub>8a</sub>            8:41            32</p>
 <p>ID: 427                      8:212            _TO=10080   _R=96  <i>C</i><sub>2k</sub>            4:22            44</p>	 <p>ID: 432                      8:217            _TO=10080   _R=88  <i>C</i><sub>2g</sub>            4:16            18</p>	 <p>ID: 435                      8:220            _TO=315      _R=21  <i>C</i><sub>2</sub> ∩ <i>D</i><sub>8</sub>    128:259        2</p>	 <p>ID: 436                      8:221            _TO=2520   _R=30  <i>D</i><sub>16</sub>            16:124            4</p>
 <p>ID: 449                      9:13            _TO=840      _R=40  <i>S</i><sub>4</sub> × <i>C</i><sub>2j</sub>    48:212            4</p>	 <p>ID: 554                      9:118            _TO=10080   _R=100  <i>C</i><sub>2d</sub>            4:12            18</p>	 <p>ID: 832                      9:396            _TO=10080   _R=84  <i>C</i><sub>2i</sub>            4:19            24</p>	 <p>ID: 838                      9:402            _TO=3360   _R=46  <i>D</i><sub>12h</sub>            12:90            6</p>
 <p>ID: 1091                    10:253            _TO=1680   _R=35  <i>S</i><sub>4i</sub>            24:158            2</p>	 <p>ID: 1453                    10:615            _TO=1260   _R=45  <i>C</i><sub>2</sub><sup>2</sup> ∩ <i>C</i><sub>2c</sub>    32:173            6</p>	 <p>ID: 1493                    10:655            _TO=10080   _R=76  <i>C</i><sub>2b</sub>            4:9            2</p>	 <p>ID: 1500                    10:662            _TO=2520   _R=51  <i>D</i><sub>8</sub> × <i>C</i><sub>2j</sub>    16:119            8</p>

 <p>ID: 1501      10:663        _TO=5040    _R=51  <math>\mathcal{D}_{8f}</math>      8:58      6</p>	 <p>ID: 1567      11:66        _TO=4032    _R=64  <math>\mathcal{D}_{10a}</math>      10:71      4</p>	 <p>ID: 2639      12:158        _TO=560      _R=40  <math>S_3 \wr C_2d</math>    72:236      4</p>	 <p>ID: 2647      12:166        _TO=3360    _R=52  <math>\mathcal{D}_{12k}</math>      12:93      4</p>
 <p>ID: 3788      12:1307        _TO=35      _R=15  <math>S_4 \wr C_2</math>    1152:290    2</p>	 <p>ID: 3792      12:1311        _TO=840      _R=22  <math>S_4 \times C_2l</math>    48:215      2</p>	 <p>ID: 6975      14:1625        _TO=5040    _R=58  <math>C_2^3d</math>      8:42      1</p>	