The Census of Edge-Transitive Tetravalent Graphs

SCDO, Queenstown, MiGawdItsBeautiful, New Zealand

18 February, 2016
The Site

http://jan.ucc.nau.edu/~swilson/C4FullSite/index.html

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A Census of edge-transitive tetravalent graphs
The Full Census

Welcome to the Degree-4 census. This site will provide information about edge-transitive graphs of degree 4. This fourth edition shows graphs of up to 512 vertices. It is known to be incomplete in a few ways. We have chosen a limit of 512 vertices to reach and include Bouwer's generalization of the Gray Graph, and we invite your comments and contributions.

The main part of the census is the **Table**. This is a list of all graphs in the census, telling the name, the size of the symmetry group, girth, diameter and other information. Each line has a link to an individual page for that graph, with more information about the graph. A [spreadsheet](#) version of the Table is available. In either form, the Table is the place to browse for graphs of a certain Order.

Notation, definitions, vocabulary can be found in the **Glossary**. The Glossary is the textbook of the Census and contains all the careful descriptions of the graphs. This is not a paper Glossary, so use your browser's search function. If you meet a graph in the Table called "SDD(DG(F32))", and have no idea what that means, go to the Glossary and search for SDD, for DG and for F to find out. The Glossary also explains what notations on the summary pages tells you. Look in the Glossary to find out what Ivanov vectors or cyclic coverings are.

Summaries of the contributions of individual constructions is available at **Families**. Here, every construction of each
# A Census of edge-transitive tetravalent graphs

## Full Census Table

<table>
<thead>
<tr>
<th>[N,i]</th>
<th>V</th>
<th>E</th>
<th>Tr</th>
<th>W?</th>
<th>lAGl</th>
<th>vs</th>
<th>ds</th>
<th>#STO</th>
<th>gi</th>
<th>dm</th>
<th>NAME</th>
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<tbody>
<tr>
<td>C4[5,1]</td>
<td>5</td>
<td>10</td>
<td>DT</td>
<td>W</td>
<td>NB</td>
<td>120</td>
<td>24</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>1 K5</td>
</tr>
<tr>
<td>C4[6,1]</td>
<td>6</td>
<td>12</td>
<td>DT</td>
<td>U</td>
<td>NB</td>
<td>48</td>
<td>8</td>
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<td>1</td>
<td>3</td>
<td>2 Octahedron</td>
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<td>16</td>
<td>DT</td>
<td>U</td>
<td>Bip(2^7)(3^2)</td>
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<td>36</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>K_4,4</td>
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<td>2 DW(3,3)</td>
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<td>DT</td>
<td>U</td>
<td>NB</td>
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<td>DT</td>
<td>W</td>
<td>Bip</td>
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<td>3 C_10(1,3)</td>
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<td>(2^8)(7^1)</td>
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<td>(2^11) 512 1 4 5</td>
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<td>(2^12) (2^10) 3 4 6</td>
<td>W(12,2)</td>
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<td>4 1 3 4 4</td>
<td>C_24(1,5)</td>
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<td>32 8 2 4 4</td>
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<td>C4i 24,5</td>
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<td>4 1 2 3 4</td>
<td>R_12(11,4)</td>
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<td>C4i 24,6</td>
<td>24 48 DT W NB 96</td>
<td>4 1 2 5 3</td>
<td>R_12(5,10)</td>
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<td>C4i 24,7</td>
<td>24 48 SS U Bip (2^10)(3^1)</td>
<td>256 64 0 4 4</td>
<td>SDD(Octahedron)</td>
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<td>4 1 0 4 3</td>
<td>C_25(1,7)</td>
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<td>C4i 25,2</td>
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<td>8 2 1 4 4</td>
<td>{4,4}_5,0</td>
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<tr>
<td>C4i 26,1</td>
<td>26 51 DT U NB (2^14)(13^1)</td>
<td>(2^13) (2^11) 1 4 6</td>
<td>W(13,2)</td>
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<td>26 52 DT W Bip 104</td>
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<td>C_26(1,5)</td>
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</table>
Summary for $C_4[24,5] = R_{12}(11,4)$

Graph

Constructions

Related Graphs

Distance-Orbit Chart:

```
0 1 2 3 4  
1 4 4^2 2,4^2 1
```

Lengths of Consistent Cycles

```
3 8 12
```

Cycle structures of semi-regular symmetries = $12^2, 8^3, 8^3$
Graph forms for \( C_4[24, 5] = R_{12}(11, 4) \)

On this page are computer-accessible forms for the graph \( C_4[24, 5] = R_{12}(11, 4) \).

(I) Following is a form readable by MAGMA:

\[
g := \text{Graph}\langle 24 | \{ \{2, 3\}, \{10, 11\}, \{8, 9\}, \{4, 5\}, \{6, 7\}, \{12, 13\}, \{1, 2\}, \{9, 10\}, \{5, 6\}, \{16, 20\}, \{17, 21\}, \{18, 22\}, \{19, 23\}, \{3, 4\}, \{11, 12\}, \{16, 24\}, \{1, 13\}, \{20, 24\}, \{2, 14\}, \{3, 15\}, \{1, 12\}, \{2, 15\}, \{1, 14\}, \{7, 8\}, \{3, 16\}, \{7, 20\}, \{11, 24\}, \{4, 16\}, \{7, 19\}, \{5, 17\}, \{6, 18\}, \{12, 24\}, \{4, 17\}, \{6, 19\}, \{5, 18\}, \{13, 21\}, \{14, 22\}, \{15, 23\}, \{8, 20\}, \{10, 22\}, \{9, 21\}, \{11, 23\}, \{13, 17\}, \{14, 18\}, \{15, 19\}, \{8, 21\}, \{10, 23\}, \{9, 22\} \rangle;
\]

(II) A more general form is to represent the graph as the orbit of \( \{2, 3\} \) under the group generated by the following permutations:

\[
a: (2, 12)(3, 11)(4, 10)(5, 9)(6, 8)(13, 14)(15, 24)(16, 23)(17, 22)(18, 21)(19, 20)
b: (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12)(13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24)
\]
Summary for C4[24, 5] = R_{12}(11,4)

<table>
<thead>
<tr>
<th>V</th>
<th>E</th>
<th>IAGl</th>
<th>vs</th>
<th>ds</th>
<th>Transitivity</th>
<th>Worthy?</th>
<th>Bipartite?</th>
<th>girth</th>
<th>diameter</th>
<th>#STO's</th>
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<tbody>
<tr>
<td>24</td>
<td>48</td>
<td>96</td>
<td>4</td>
<td>1</td>
<td>Dart-Transitive</td>
<td>Worthy</td>
<td>NB</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Graph

Constructions

Related Graphs

Distance-Orbit Chart:

```
0 1 2 3 4
1 4 4^2 2,4^2 1
```

Lengths of Consistent Cycles

```
3 8 12
```

Cycle structures of semi-regular symmetries = 12^2, 8^3, 8^3
Constructions for $C_4[24,5] = R\_12(11,4)$

On this page are all constructions for $C_4[24,5]$. See Glossary for some detail.

$R\_12(11,4) = Pr\_8(1,1,5,5) = KE\_6(2,0,1,1,2)$

$= UG(ATD[24,7]) = UG(ATD[24,8]) = L(F\_16)$

$= MG(Rmap(24,3)\{3,8\mid 8\}_12) = DG(Rmap(24,3)\{3,8\mid 8\}_12) = DG(Rmap(24,5)\{3,12\mid 12\}_8)$

$= AT[24,3] $
Diagrams

mod 12:

\[
\begin{array}{cccc}
1 & 2 \\
1 & 1 & 1 & 0 & 1 \\
2 & 0 & 1 & 1 & 4 & 8 \\
\end{array}
\]

mod 8:

\[
\begin{array}{cccc}
1 & 2 & 3 \\
1 & - & 0 & 1 & 0 & 5 \\
2 & 0 & 7 & - & 5 & 7 \\
3 & 0 & 3 & 1 & 3 & - \\
\end{array}
\]

\[
\begin{array}{cccc}
1 & 2 & 3 \\
1 & 1 & 7 & 0 & 7 & - \\
2 & 0 & 1 & - & 2 & 7 \\
3 & - & 1 & 6 & 3 & 5 \\
\end{array}
\]
Summary for $C_4[24,5] = R_{12}(11,4)$

| V | E | $|\text{AG}|$ vs $d_s$ | Transitivity | Worthy? | Bipartite? | girth | diameter | #STO's |
|---|---|-----------------|--------------|---------|-----------|-------|----------|--------|
| 24 | 48 | 96 | 4 | 1 | Dart-Transitive | Worthy | NB | 3 | 4 | 2 |

**Graph**

**Constructions**

**Related Graphs**

**Distance-Orbit Chart:**

$$
\begin{array}{cccccc}
0 & 1 & 2 & 3 & 4 \\
1 & 4 & 4^2 & 2,4^2 & 1
\end{array}
$$

**Lengths of Consistent Cycles**

$$
\begin{array}{c}
3 & 8 & 12
\end{array}
$$

Cycle structures of semi-regular symmetries = $12^2, 8^3, 8^3$
Covers Down

Graphs related to $C_4[24,5] = R_{12}(11,4)$.

On this page are all graphs related to $C_4[24,5]$.

**Graphs which this one covers**

- 4-fold cover of $C_4[6,1] = Octahedron$
- 2-fold cover of $C_4[12,2] = R_6(5,4)$
Graphs which cover this one

2-fold covered by $C_4[48, 12] = KE_{12}(1,3,8,5,1)$

3-fold covered by $C_4[72, 6] = R_{36}(11,28)$

3-fold covered by $C_4[72, 13] = Pr_{24}(1,1,5,5)$

4-fold covered by $C_4[96, 36] = UG(ATD[96, 11])$

4-fold covered by $C_4[96, 39] = UG(ATD[96, 55])$

4-fold covered by $C_4[96, 40] = UG(ATD[96, 61])$

5-fold covered by $C_4[120, 11] = R_{60}(47,16)$

5-fold covered by $C_4[120, 25] = Pr_{40}(1,33,37,29)$

6-fold covered by $C_4[144, 25] = KE_{36}(1,3,20,17,1)$

6-fold covered by $C_4[144, 40] = UG(ATD[144, 69])$

6-fold covered by $C_4[144, 41] = UG(ATD[144, 72])$
Aut-Orbitals

Aut-Orbital graphs of this one:

\[ C4[8, 1] = K_{4,4} \]
\[ C4[24, 5] = R_{12}(11,4) \]
\[ C4[24, 6] = R_{12}(5,10) \]
Glossary

**GRAPH:** In this census, the word *graph* means a simple graph, a collection $V$ of things called "vertices" and a set $E$ of unordered pairs from $V$, the edges of the graph.

**SYMMETRY:** A *symmetry*, also called an *automorphism*, of a graph is a permutation of its vertices which preserves edges. If $\Gamma$ is a graph, the symmetries of $\Gamma$ form a group under composition, called $\text{Aut}(\Gamma)$.

**Graphs in this Census:** This Census concerns graphs of degree 4 (*tetravalent* graphs) which are *edge-transitive*, i.e., those for which, given edges $e$ and $e'$, there is $\sigma$ in $\text{Aut}(\Gamma)$ which sends $e$ to $e'$. A *dart* (or *arc* or *directed edge*) is one of the two ordered pairs of vertices corresponding to an edge. If $AG = \text{Aut}(\Gamma)$ is transitive on darts, we naturally call $\Gamma$ *dart-transitive* (abbreviated DT); the word "symmetric" is often used with this meaning. If $AG$ is transitive on edges and vertices, but not on darts, we say that $\Gamma$ is *$1/2$-arc-transitive* or HT. If $AG$ is transitive on edges but not on vertices, we say that $\Gamma$ is *semi-symmetric*, or SS for short.

The headings in the Table and the spreadsheet version of the Census:

**Tag:** The tag "C4[20,5]" means this graph is number 5 in the list of graphs having 20 vertices.
Constructions for $C_4[24, 5] = R_{12}(11, 4)$

On this page are all constructions for $C_4[24, 5]$. See Glossary for some detail.

$R_{12}(11, 4) = Pr_8(1, 1, 5, 5) = KE_6(2, 0, 1, 1, 2)$

$= UG(ATD[24, 7]) = UG(ATD[24, 8]) = L(F16)$

$= MG(Rmap(24, 3) \{3, 8|8\}_12) = DG(Rmap(24, 3) \{3, 8|8\}_12) = DG(Rmap(24, 5) \{3, 12|12\}_8)$

$= AT[24, 3]$
Propellor Graphs: The graph $Pr_n(a, b, c, d)$ is given by the diagram below.

This means that it has $3n$ vertices. They are $A_i$, $B_i$ and $C_i$ for numbers $i$ mod $n$. There are 3 kinds of edges:

1. Tip: $\{A_i, A_{i+a}\}, \{C_i, C_{i+d}\}$,
2. Flat: $\{A_i, B_i\}, \{B_i, C_i\}$,
3. Blade: $\{B_i, A_{i+b}\}, \{B_i, C_{i+c}\}$.

Those which are edge-transitive must, as a result, be dart-transitive. **Matthew Sterns** has found three families (one is finite) which are edge-transitive. He has recently proved that these include all edge-transitive Propellor graphs.

(a) $(a, b, c, d) = (1, 2d, 2, d)$ for $d$ satisfying $d^2 = \pm 1$.
(b) $(a, b, c, d) = (1, b, b+4, 2b+3)$, for $n$ divisible by 4, $b = 1 \pmod{n}$, $8b+16 = 0 \pmod{n}$.
(c) $[n, a, b, c, d] = [5,1,1,2,2], [10,1,1,2,2], [10,1,4,3,2], [10,1,1,3,3], \text{ or } [10, 2, 3, 1, 4]$. 
A Census of edge-transitive tetravalent graphs
NewMini Census by Families

This page lists the tag and then the name of each graph resulting from any of the constructions listed in the [Glossary].

*AMC(2, 3 [0 1: 2 2]) = C4[18, 2] = DW(6,3)
*AMC(2, 4 [0 1: 3 3]) = C4[16, 2] = R_8(6,5)
*AMC(2, 5 [0 2: 3 0]) = C4[50, 3] = {4,4}_5,5
*AMC(2, 7 [5 3: 6 2]) = C4[98, 2] = {4,4}_7,7
*AMC(2, 8 [1 2: 2 7]) = C4[32, 4] = PX(4,3)
*AMC(2, 8 [1 7: 0 7]) = C4[64, 5] = {4,4}_8,0
*AMC(2, 9 [1 6: 6 4]) = C4[54, 2] = DW(18,3)
*AMC(2, 12 [1 3: 0 7]) = C4[48, 5] = R_24(22,13)
*AMC(2, 12 [1 4: 0 1]) = C4[36, 3] = DW(12,3)
*AMC(2, 12 [1 11: 0 11]) = C4[144, 12] = {4,4}_12,0
*AMC(3, 3 [0 1: 2 2]) = C4[27, 3] = AMC(3, 3 [0 1: 2 2])
*AMC(3, 5 [0 1: 4 4]) = C4[75, 3] = AMC(3, 5 [0 1: 4 4])
*AMC(3, 7 [0 1: 6 6]) = C4[147, 6] = AMC(3, 7 [0 1: 6 6])
*AMC(3, 7 [0 4: 3 3]) = C4[147, 5] = MSZ(21,7,8,2)
*AMC(3, 8 [5 5: 5 2]) = C4[48, 14] = AMC(3, 8 [5 5: 5 2])
The Recipes Paper

"Recipes for Edge-Transitive Tetravalent Graphs"

Contains:
  Recipes for all families of graphs in the Census
  Connections and overlaps between Families
  Theorems and lesser results
  A dozen open problems
Other Page