Electronic Journal of Graph Theory and Applications **8** (2) (2020), 265–300

Electronic Journal of
Graph Theory and Applications

Uniform edge betweenness centrality

Heather Newman[a], Hector Miranda[b], Rigoberto Flrez[c], Darren A. Narayan[b]

[a]*Department of Mathematics, Princeton University, USA*
[b]*School of Mathematical Sciences, Rochester Institute of Technology, USA*
[c]*Department of Mathematics and Computer Science, The Citadel, USA*

darren.narayan@gmail.com

Abstract

The *edge betweenness centrality* of an edge is loosely defined as the fraction of shortest paths between all pairs of vertices passing through that edge. In this paper, we investigate graphs where the edge betweenness centrality of edges is uniform. It is clear that if a graph G is edge-transitive (its automorphism group acts transitively on its edges) then G has uniform edge betweenness centrality. However this sufficient condition is not necessary. Graphs that are not edge-transitive but have uniform edge betweenness centrality appear to be very rare. Of the over 11.9 million connected graphs on up to ten vertices, there are only four graphs that are not edge-transitive but have uniform edge betweenness centrality. Despite this rarity among small graphs, we present methods for creating infinite classes of graphs with this unusual combination of properties.

Keywords: edge betweenness centrality, graph
Mathematics Subject Classification : 05C40
DOI: 10.5614/ejgta.2020.8.2.7

1. Introduction

The *betweenness centrality* of a vertex v is the ratio of the number of shortest paths between two other vertices u and w which contain v to the total number of shortest paths between u and w, summed over all ordered pairs of vertices (u, w). This idea was introduced by Anthonisse [2] and Freeman [6] in the context of social networks, and has since appeared frequently in both social

Received: 28 February 2018, Revised: 9 February 2020, Accepted: 17 February 2020.

network and neuroscience literature [8, 19, 4, 9, 13, 12, 10, 5, 15, 21].
We first give some background with some elementary results.

Definition 1.1. *The* ***edge betweenness centrality*** *of an edge e in a graph G, denoted $B'_G(e)$ (or simply $B'(e)$ when G is clear), measures the frequency at which e appears on a shortest path between two distinct vertices x and y. Let σ_{xy} be the number of shortest paths between distinct vertices x and y, and let $\sigma_{xy}(e)$ be the number of shortest paths between x and y that contain e. Then $B'_G(e) = \sum\limits_{x,y} \frac{\sigma_{xy}(e)}{\sigma_{xy}}$ (for all distinct vertices x and y).*

Definition 1.2. *A graph G has* ***uniform edge betweenness centrality****, or is* ***edge-betweenness-uniform****, if $B'_G(e)$ has the same value for all edges e in G.*

We note that, for undirected graphs, shortest paths from x to y are regarded as the same as shortest paths from y to x, though the associated contribution to the sum $B'_G(e)$ is double-counted. In our first lemma, we restate an elementary result from [10] with the lower and upper bounds of the betweenness centrality of an edge.

Lemma 1.1. *For a given graph G with n vertices, $2 \leq B'_G(e) \leq \frac{n^2}{2}$ for all vertices v in G. Furthermore, these bounds are tight.*

Proof. For edge e with end vertices u and v, the shortest paths from u and v and from v to u pass through the edge e. Hence $B'_G(e) \geq 2$. We note that edge betweenness centrality values are larger for graphs with no cycles, since between any pair of vertices there is a single path between each pair of vertices. Consider a tree T with n vertices and a cut-edge e. The highest edge betweenness centrality will occur when the two components of $T - e$ each have $\frac{n}{2}$ vertices. Here $B'_G(e) \leq 2\frac{n^2}{4} = \frac{n^2}{2}$. □

Many results on edge betweenness were obtained by Gago [10, 12], and [13]. However, we mention a small oversight in [10]. In the second part of Lemma 4 in their paper, the following result is stated.

Lemma 1.2. *[13] If C is a cut-set of edges connecting two sets of vertices X and $V(G)\backslash X$ and $|X| = n_x$, then $\sum\limits_{e \in C} B'_G(e) = 2n_x(n - n_x)$.*

It is certainly true that $\sum\limits_{e \in C} B'_G(e) \geq 2n_x(n - n_x)$ since shortest paths that have one vertex in X and one vertex in $V(G)\backslash X$ will certainly contain an edge in C. However, equality may not hold, as there may be shortest paths between vertices in the same part that use an edge in C. An example is given below.

Example 1.1. *Let $G = P_3$ with vertices u,v, and w and edges uv and vw. Let $C = \{uv, vw\}$ be a cut-set of edges. Then $X = \{v\}$ and $V(G)\backslash X = \{u, w\}$, and $n_x = 1$ and $n - n_x = 2$. The contributions to $B'_G(uv)$ and $B'_G(vw)$ from paths between the two different parts is $2(1)(2) = 4$. However the contributions from paths between u and w are $2(1)(1) = 2$. Hence $B'_G(uv) + B'_G(vw) = 6$.*

1.1. Elementary Results

In this subsection, we present a few simple results involving edge betweenness centrality and uniform edge betweenness centrality. We first give a formula for the edge betweenness centrality of any edge in a graph of diameter 2. We will use $N(v)$ to denote the open neighborhood of v, that is the set of all vertices that are adjacent to v.

Proposition 1.1. *Let G be a diameter 2 graph. For any edge $e = uw$ of G,*

$$B'(e) = 2 + 2 \sum_{v_i \in N(w), v_i \notin N(u)} \frac{1}{|N(u) \cap N(v_i)|} + 2 \sum_{v_i \in N(u), v_i \notin N(w)} \frac{1}{|N(w) \cap N(v_i)|}.$$

Proof. Any edge $e = uw$ is on the unique shortest path from u to w and from w to u, contributing 2 to the sum. Since G is of diameter 2, we now need consider all paths of length 2 containing $e = uw$. Let v_i be any vertex that is distance 2 from u and which is in the neighborhood of w, that is, v_i is not a neighbor of u. Then there is a unique path from u to v_i containing the edge $e = uw$, namely, the path $u - w - v_i$. The total number of possible paths from u to v_i is precisely given by the number of common neighbors of u and v_i. The same reasoning applies to any vertex v_i at distance 2 from w, resulting in the above sum. □

Corollary 1.1. *The uniform edge betweenness centrality of a complete bipartite graph $K_{m,n}$ is given by:*

$$2 + 2\left(\frac{n-1}{m}\right) + 2\left(\frac{m-1}{n}\right).$$

For even n, the uniform edge betweenness centrality of K_n minus a perfect matching is given by:

$$2 + \frac{4}{n-2}.$$

Corollary 1.1 shows that uniform edge betweenness values are unbounded, as seen by fixing $n = 1$. The same corollary shows that there are uniform edge betweenness values infinitely close to the lower bound of 2. We also have that $B'_G(e) = 2$ if and only if e is a component of G.

2. Edge Transitivity and Uniform Edge Betweenness Centrality

We recall the definition of vertex (edge) transitivity. A graph is vertex-transitive (edge-transitive) if its automorphism group acts transitively on its vertex (edge) set. That is, a graph is vertex-transitive (edge-transitive) if its vertices (edges) cannot be distinguished from each other. We will make use of the following alternative definition [1].

Theorem 2.1. *[1] A finite simple graph G is edge-transitive if and only if $G - e_1 \cong G - e_2$ for all pairs of edges e_1 and e_2.*

Remark 2.1. *Clearly if a graph is edge-transitive then it has uniform edge betweenness centrality. However, the converse is not true.*

We used the databases from Brendan McKay [16] and the Wolfram Mathematica 11 code for betweenness testing and found that of the over 11.9 million graphs on ten vertices or less, there are only four graphs that have uniform edge betweenness centrality but are not edge-transitive (see Figure 1). We note that the first three graphs were obtained in an independent investigation by Hurajová and Madaras [7].

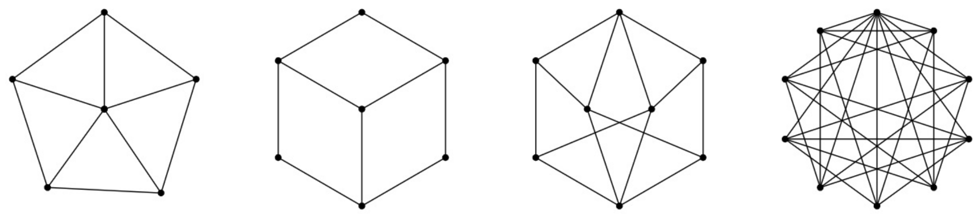

Figure 1. The four graphs on ten vertices or less that have uniform edge betweenness centrality but are not edge transitive.

Surprisingly, none of these four graphs are vertex-transitive. We will show that these properties can arise in a special class of vertex-transitive graphs.

Definition 2.1. *A circulant graph $C_n(L)$ is a graph on vertices $v_1, v_2, ..., v_n$ where each v_i is adjacent to $v_{(i+j)(\mathrm{mod}\, n)}$ and $v_{(i-j)(\mathrm{mod}\, n)}$ for each j in a list L. Algebraically, circulant graphs are Cayley graphs on finite cyclic groups. For a list L containing m items, we refer to $C_n(L)$ as an m-circulant.*

We note that a circulant graph has rotational symmetry about its vertices and is therefore vertex-transitive. We will show later that $C_{15}(1, 6)$ is not edge-transitive, but has uniform edge betweenness centrality and this example can be extended to an infinite class.

We again used the databases from Brendan McKay [16] and the Wolfram Mathematica 11 code for betweenness testing and found that $C_{15}(1, 6)$ is the smallest vertex-transitive graph that has uniform edge betweenness centrality but is not edge-transitive. For the sake of completeness the details are given below and in the appendix of this paper.

As noted above none of the four graphs in Figure 1 are vertex-transitive. In Propositions 2.1-2.5 we next check all graphs on 11-15 vertices to identify the graphs that are vertex-transitive and having uniform edge betweenness centrality, but are not edge-transitive.

Proposition 2.1. *There are no edge-betweenness-uniform graphs on 11 vertices that are vertex-transitive but not edge-transitive.*

Proof. There are seven vertex-transitive graphs with 11 vertices.

1. C_{11} (edge-transitive)
2. $\overline{C_{11}}$ (two different centrality values)
3. K_{11} (edge-transitive)
4. $C_{11}(1, 3)$ (two different centrality values)
5. $C_{11}(1, 2)$ (two different centrality values)

6. $\overline{C_{11}(1,3)}$ (three different centrality values)
7. $\overline{C_{11}(1,2)}$ (three different centrality values)

These cover all seven cases. □

Proposition 2.2. *There are no edge-betweenness-uniform graphs on 12 vertices that are vertex-transitive but not edge-transitive.*

Proof. There are 64 vertex-transitive graphs on 12 vertices, 11 of which are both edge-transitive and vertex-transitive and the remaining 53 of which are not edge-betweenness-uniform. (See the appendix for all 64 vertex-transitive graphs on 12 vertices.) □

Proposition 2.3. *There are no edge-betweenness-uniform graphs on 13 vertices that are vertex-transitive but not edge-transitive.*

Proof. There are 13 vertex-transitive graphs on 13 vertices, 4 of which are both edge-transitive and vertex-transitive and the remaining 9 of which are not edge-betweenness-uniform. (See the appendix for all 13 vertex-transitive graphs on 13 vertices.) □

Proposition 2.4. *There are no edge-betweenness-uniform graphs on 14 vertices that are vertex-transitive but not edge-transitive.*

Proof. There are 51 vertex-transitive graphs on 14 vertices, 6 of which are both edge-transitive and vertex-transitive and the remaining 45 of which are not edge-betweenness-uniform. (See the appendix for all 51 vertex-transitive graphs on 14 vertices.) □

Proposition 2.5. $C_{15}(1,6)$ *is the only graph on 15 vertices which is edge-betweenness-uniform and vertex-transitive and not edge-transitive. More specifically,* $C_{15}(1,6)$ *is the smallest graph satisfying these three conditions.*

Proof. There are 44 vertex-transitive graphs on 15 vertices, 10 of which are both edge-transitive and vertex-transitive and 33 of which are not edge-betweenness-uniform. The remaining graph is $C_{15}(1,6)$, which is edge-betweenness-uniform and vertex-transitive, but not edge-transitive. (See the appendix for all 44 vertex-transitive graphs on 15 vertices.) □

The only two properties of graphs identified in the literature thus far that individually imply uniform edge betweenness centrality are edge transitivity and distance regularity [11]. Recall that non-edge-transitive, edge-betweenness-uniform graphs appear to be very rare. However, we now introduce two infinite classes of graphs that we claim are edge-betweenness-uniform but neither edge-transitive nor distance-regular. Specifically, these classes are found among 2-circulants, and thus are vertex-transitive:

Class 1: $C_{18n-3}(1,6n), n \in \mathbb{N}$

Class 2: $C_{18n+3}(1,6n), n \in \mathbb{N}$

We determine that graphs in these classes are neither edge-transitive nor distance-regular. Not only is this information noteworthy on its own, for graphs that are edge-betweeenness-uniform but not edge-transitive are rare, but it also means that we must find a novel heuristic for demonstrating the uniform edge betweenness centrality of these graphs. Moreover, this is particularly challenging because counting shortest paths is a nontrivial problem. Ultimately, our method will *not* require making explicit shortest paths calculations in demonstrating uniform edge betweenness centrality.

- We arrange the vertices in graphs in Classes 1 and 2 in a circle, and label them counterclockwise and consecutively beginning with the label 1. The labels are viewed in modulo $18n-3$ for graphs in Class 1 and modulo $18n+3$ for graphs in Class 2.
- We refer to edges that connect consecutive vertices as outer chords or chords of length 1.
- We refer to edges that connect vertices that are $6n$ apart as inner chords or chords of length $6n$.

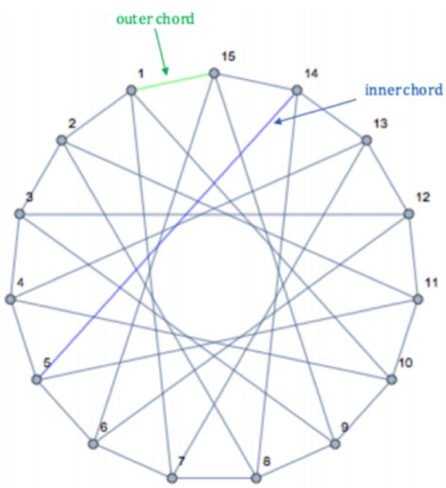

Figure 2. $C_{15}(1,6)$ with outer chords of length 1 (green) and an inner chords of length 6 (blue).

In reference to 2-circulants, we note for every pair of inner chords, there exists an automorphism mapping one to another, and for every pair of outer chords, there exists an automorphism mapping one to another (this is clear by defining the automorphism as a rotation). Thus, the edges of the graph split up into at most 2 orbits. In fact, for all graphs in Classes 1 and 2, the edges split up into exactly 2 orbits, since we now show that graphs in these classes are **not** edge-transitive (edges are all part of the same orbit).

Consider a 2-circulant graph $C_k(a,b)$. Define $\lambda_k(a,b)$ to be the unique nonnegative integer satisfying $gcd(k,a)b \equiv \lambda_k(a,b)a \pmod{k}$ and let $\Lambda_k(a,b) = \frac{\lambda_k(a,b)}{gcd(k,b)}$.

Lemma 2.1. *[18] Let $C_k(a,b)$ and $C_k(a',b')$ be two (connected) circulants. Without loss of generality, assume $gcd(k,a) \leq gcd(k,b)$ and $gcd(k,a') \leq gcd(k,b')$. Then $C_k(a,b) \cong C_k(a',b')$ if and only if one of the following two conditions holds:*

1. $gcd(k,a) = gcd(k,a') < gcd(k,b) = gcd(k,b')$ *and* $\Lambda_k(a,b) = \Lambda_k(a',b')$

2. $gcd(k,a) = gcd(k,a') = gcd(k,b) = gcd(k,b')$ *and either* $\Lambda_k(a,b)$=$\Lambda_k(a',b')$ *or* $\Lambda_k(a,b)$ = $\Lambda_k(b',a')$

Lemma 2.2. *Let* $k = 18n \pm 3$ *and let* $b = 6n$, $n \in \mathbb{N}$. *Then the circulant graph* $C_k(1,b)$ *is not isomorphic to any circulant of the form* $C_k(1,b')$ *for* $b' \leq \frac{k}{2}$, $b' \neq b$.

Proof.

$$\begin{aligned} gcd(k,1)b &\equiv \lambda_k(1,b) \text{ (mod } k) \\ \implies \lambda_k(1,b) &= b \\ \implies \Lambda_k(1,b) &= \frac{b}{3}. \end{aligned}$$

In order for one of the conditions in Lemma 2.1 to be satisfied, we must have $b = b'$. □

Lemma 2.3. *[20] If G is a tetravalent edge-transitive circulant graph with* k *vertices, then either:*

1. G *is isomorphic to* $C_k(1,b)$ *for some* b *such that* $b^2 \equiv \pm 1$ *(mod* k*), or*
2. k *is even,* $k = 2m$, *and* G *is isomorphic to* $C_{2m}(1, m+1)$.

Theorem 2.2. *Circulant graphs of the form* $C_{18n\pm3}(1,6n)$ *are not edge-transitive.*

Proof. By Lemmas 2.2 and 2.3, it suffices to show, letting $k = 18n \pm 3$ and $b = 6n$, that $b^2 \not\equiv \pm 1$ (mod k) and $(k-b)^2 \not\equiv \pm 1$ (mod k). This is easily seen by polynomial long division. □

We also verify that graphs of the form $C_{18n\pm3}(1,6n)$ are *not* distance-regular by appealing to the following theorem.

Theorem 2.3. *[17] A Cayley graph of a cyclic group (a circulant) is distance-regular if and only if it is isomorphic to a cycle, or a complete graph, or a complete multipartite graph, or a complete bipartite graph on a twice an odd number of vertices with a matching removed, or the Paley graph with a prime number of vertices.*

Corollary 2.1. *Circulant graphs of the form* $G = C_{18n\pm3}(1,6n)$, $n \in \mathbb{N}$ *are not distance-regular.*

Proof. It is clear that G is none of the following: a cycle, complete graph, Paley graph with a prime number of vertices (the order of G is not prime), complete bipartite graph on twice an odd number of vertices with a matching removed (the order of G is not even). It is also easily seen that G is not a complete multipartite graph of the form $K_{s\times t}$. For, $K_{s\times t}$ has order st and degree sum equal to $s^2t(t-1)$. This forces $st = 18n \pm 3$ and since G is 4-regular, $s(t-1) = 4$, which is impossible. □

We have established that graphs of the form $C_{18n\pm3}(1,6n)$ are neither edge-transitive nor distance-regular, so we must develop a novel way of demonstrating their uniform edge betweenness centrality. Importantly, the method we will introduce does not involve making explicit centrality calculations by means of counting shortest paths, and will provide insight into the specific conditions that allow these graphs to be edge-betweenness-uniform in the absence of the strong condition of edge transitivity.

We first focus on graphs of the form $C_{18n-3}(1, 6n)$, and then easily extend the method to graphs of the form $C_{18n+3}(1, 6n)$. We note two useful facts that we will exploit throughout the proofs:

1. Circulant graphs are vertex-transitive.
2. To demonstrate the uniform edge betweenness centrality of 2-circulants, it suffices to show that an inner chord has the same edge betweenness centrality as an outer chord (since the inner chords occupy the same orbit and the outer chords occupy the same orbit).

For $G = C_{15}(1, 6)$ $(n = 1)$, one can show explicitly that $B'(e) = 13$ for all edges e in G. We now consider all $n \geq 2$.

Lemma 2.4. *Let $G = C_{18n-3}(1, 6n)$ for $n \geq 2$ and fix any vertex s. Let $a = (3n-1)(6n)$. Then the only edges that do not lie on a shortest path originating at s are $E = \{(s+a, s+a+1), (s-a, s-a-1), (s-a, s+a), (s+a+1, s+a+1-6n), (s-a-1, s-a-1+6n), (s+a+1-6n, s-a-1+6n)\}$.*

Proof. To find all edges involved in a shortest path originating at vertex s, we use a breadth-first search algorithm. In the algorithm, we mark an edge as visited if it is part of a shortest path originating at s.

1. Initialize a boolean-valued array markedEdges() indexed by the edges $E(G)$ of G, so that markedEdges(e) = false for all $e \in E(G)$.
2. Initialize a boolean-valued array markedVertices() indexed by the vertices $V(G)$ of G, so that markedVertices(v) = false for all $v \in V(G)$.
3. Initialize an integer-valued array distTo() indexed by the vertices $V(G)$ of G, so that distTo(v) $=$ -1 for all $v \in V(G)$
4. Initialize a first-in/first-out queue q with operations enqueue and dequeue, with q.enqueue(v) being the operation that adds v to the queue, and q.dequeue() being the operation that returns the least recently added item to q and removes it from q.

```
Set markedVertices(s)=true
Set distTo(s)=0
q.enqueue(s)
while q is not empty
    Set v = q.dequeue()
    for each w ∈ N(v)
        if markedVertices(w) = false
            Set markedVertices(w) = true
            Set markedEdges((v, w)) = true
            Set distTo(w)= distTo(v)+1
            q.enqueue(w)
        if distTo(w) = distTo(v)+1
            Set markedEdges((v, w)) = true
```

Performing the algorithm up to and including marking all vertices that are distance 3 away from s, we find that the marked edges form the subgraph of G in Figure 3.

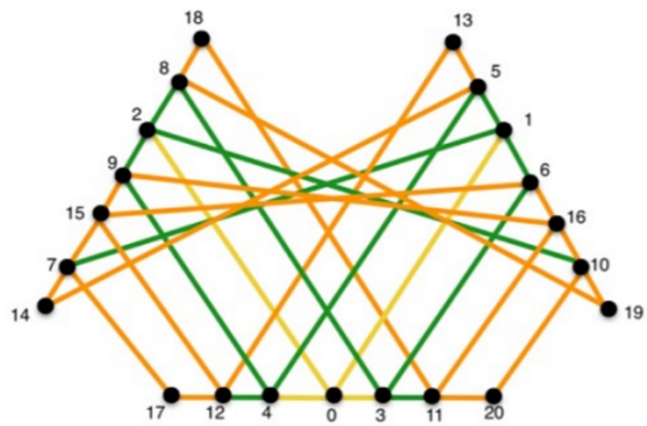

Figure 3. The subgraph of G consisting of all edges marked by the BFS up to and including marking all vertices that are distance 3 away from s. The numbers indicate the order in which vertices were added to the queue q, with 0 corresponding to the first number added and 20 corresponding to the most recent number added.

Continuing the algorithm until it terminates, we find that for each $4 \leq k \leq 3n-1$, the following 12 edges are marked, with all the same distance from the starting vertex s:

$(s+(6n)(k-1), s+(6n)(k))$,
$(s+(6n)(k), s+(6n)(k)-1)$,
$(s+(6n)(k-1), s+(6n)(k-1)+1)$,
$(s+(6n)(k)+1, s+(6n)(k+1)+1)$,
$(s+(6n)(k+1)+1, s+(6n)(k-2)+1)$,
$(s-(6n)(k-1), s-(6n)(k))$,
$(s-(6n)(k), s-(6n)(k)+1)$,
$(s-(6n)(k-1), s-(6n)(k-1)-1)$,
$(s-(6n)(k)+1, s-(6n)(k+1)-1)$,
$(s-(6n)(k+1)-1, s-(6n)(k-2)-1)$,
$(s-(6n)(k-2)-1, s-(6n)(k-1)-1)$, and
$(s+(6n)(k-2)+1, s+6n(k-1)+1)$.

It follows that the only edges that are not marked by the algorithm are those in the set E given in the statement of the lemma (see Figure 4).

□

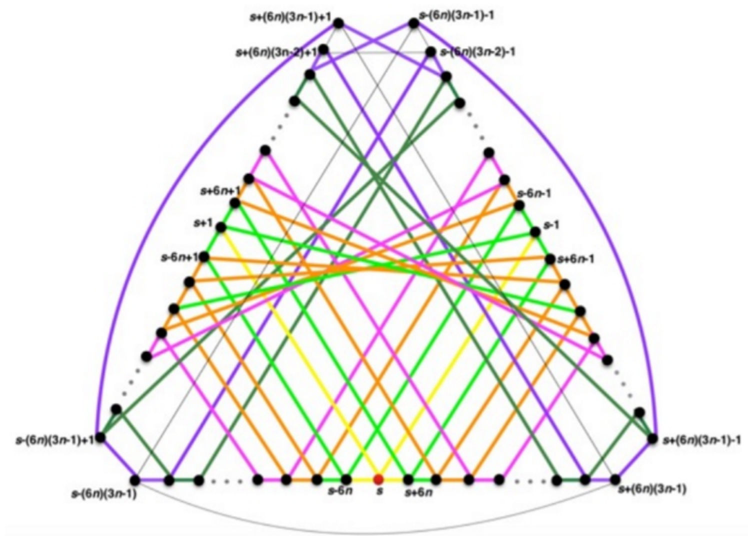

Figure 4. A generalized depiction of the algorithm performed on G, with the 6 edges that remain colored black being the edges that are not marked by the algorithm (and hence not occupying any shortest path originating at s).

Lemma 2.5. *Let* $G = C_{18n-3}(1, 6n)$ *for* $n \geq 2$ *and without loss of generality fix a source vertex* $s = 2 + (6n)(3n-1)$ *mod* $(18n-3)$ *and consider any vertex* a. *Let* $H = G - E$, *where* E *is the set of edges that do not lie on any shortest path originating at* s *(Lemma 2.4). Then there exists an automorphism* ϕ *of* H *mapping* $e_1 = (a, a+1)$ *to* $e_2 = (a, a+6n)$, *given by:*

$$\phi(v) = \begin{cases} a-(6n)(a-v), & a - a \bmod (6n-1) + 2 \leq v \leq a - a \bmod (6n-1) + 6n, \\ \phi(v+1) - 1, & v = a - a \bmod (6n-1) + 1, \\ \phi(v-1) + 1, & v = a - a \bmod (6n-1) + 6n + 1, \\ \phi(v-6n) + 1, & a - a \bmod (6n-1) + 2 + 6n \leq v \leq a - a \bmod (6n-1) + 12n - 1, \\ \phi(v+6n) - 1, & a - a \bmod (6n-1) + 3 - 6n \leq v \leq a - a \bmod (6n-1), \end{cases}$$

where vertices (v *and* $\phi(v)$) *are taken mod* $(18n-3)$.

Proof. By Lemma 2.4, $E = \{(12n, 12n-1), (1, 2), (6n, 12n), (1, 6n+1), (6n, 6n+1), (2, 12n-1)\}$.

To show that ϕ is indeed an isomorphism, our strategy is to show that $N(\phi(v)) = \phi(N(v))$.

Case 1a: $a - a \bmod (6n-1) + 2 < v < a - a \bmod (6n-1) + 6n$
Note that $N(v) = \{v-1, v+1, v+6n, v-6n\}$
$\Rightarrow \phi(N(v)) = \{a-(6n)(a-(v-1)), a-(6n)(a-(v+1)), a-(6n)(a-v)+1, a-(6n)(a-v)-1\}$
Also $\phi(v) = a - (6n)(a-v)$
$\Rightarrow N(\phi(v)) = \{a-(6n)(a-v)+1, a-(6n)(a-v)-1, a-6n(a-v)+6n, a-6n(a-v)-6n\}$
$\Rightarrow N(\phi(v)) = \phi(N(v))$.

Case 1b: $v = a - a$ mod $(6n-1) + 2$

Note that $v = 2$ or $v = 6n + 1$ or $v = 12n$. By definition of E,
$N(v) = \{v + 1, v + 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) + 6n, \phi(v) + 1\} = N(\phi(v))$.

Case 1c: $v = 6n + a - a$ mod $(6n - 1)$
Note that $v = 6n$ or $v = 12n - 1$ or $v = 1$. By definition of E,
$N(v) = \{v - 1, v - 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) - 6n, \phi(v) - 1\} = N(\phi(v))$.

Case 2: $v = a - a$ mod $(6n - 1) + 1$
Note that $v = 1$ or $v = 6n$ or $v = 12n - 1$. By definition of E,
$N(v) = \{v - 1, v - 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) - 6n, \phi(v) - 1\} = N(\phi(v))$.

Case 3: $v = 6n + 1 + a - a$ mod $(6n - 1)$
Note that $v = 6n + 1$ or $v = 12n$ or $v = 2$. By definition of E,
$N(v) = \{v + 1, v + 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) + 6n, \phi(v) + 1\} = N(\phi(v))$.

Case 4a: $a - a \bmod (6n - 1) + 2 + 6n < v < a - a \bmod (6n - 1) + 12n - 1$
We have $N(v) = \{v - 1, v + 1, v + 6n, v - 6n\}$ and
$\phi(N(v)) = \{\phi(v) - 6n, \phi(v) + 6n, \phi(v) + 1, \phi(v) - 1\} = N(\phi(v))$.

Case 4b: $v = a - a \bmod (6n - 1) + 2 + 6n$
We have $N(v) = \{v - 1, v + 1, v + 6n, v - 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) - 6n, \phi(v) + 1, \phi(v) + 6n, \phi(v) - 1\} = N(\phi(v))$.

Case 4c: $v = a - a \bmod (6n - 1) + 12n - 1$
Note that $v = 12n - 1$ or $v = 1$ or $v = 6n$. By definition of E,
$N(v) = \{v - 1, v - 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) - 6n, \phi(v) - 1\} = N(\phi(v))$.

Case 5a: $a - a \bmod (6n - 1) + 3 - 6n < v \leq a - a \bmod (6n - 1)$
Note that $N(v) = \{v - 1, v + 1, v - 6n, v + 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) + 6n, \phi(v) - 6n, \phi(v) - 1, \phi(v) + 1\} = N(\phi(v))$.

Case 5b: $v = a - a \bmod (6n - 1) + 3 - 6n$
Note that $v = 12n$ or $v = 2$ or $v = 6n + 1$. By definition of E,
$N(v) = \{v + 6n, v + 1\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) + 1, \phi(v) + 6n\} = N(\phi(v))$.

We have shown that ϕ is an isomorphism. Since $\phi(a) = a$ and $\phi(a+1) = a - (6n)(a - (a+1)) = a + 6n$, ϕ maps the edge $e_1 = (a, a + 1)$ to the edge $e_2 = (a, a + 6n)$. □

Corollary 2.2. *Let $G = C_{18n-3}(1, 6n)$ and fix a vertex s. Let $E_{s'}$ be the set of edges that do not lie on a shortest path originating at s' (Lemma 2.4). Then for every vertex s', there exists an automorphism of $G - E_{s'}$ mapping $(s, s+1)$ to $(s, s+6n)$.*

Proof. The corollary follows from Lemma 2.5 along with the fact that G is vertex-transitive. □

Theorem 2.4. *Circulant graphs of the form $C_{18n-3}(1, 6n)$ are edge-betweenness-uniform.*

Proof. Recall that since G is not edge-transitive, its edges fall into two different orbits: chords of length 1 and chords of length $6n$. Thus, all chords of length 1 have the same edge betweenness centrality value, and all chords of length $6n$ have the same edge betweenness centrality value. Thus, to show that G has uniform edge betweenness centrality, it suffices to show that a chord of length 1 has the same edge betweenness centrality as a chord of length of $6n$. Without loss of generality, we can choose any two chords with these lengths.

Fix any vertex s. We would like to show that the edges $(s, s+1)$ (a chord of length 1) and $(s, s+6n)$ (a chord of length $6n$) have the same edge betweenness centrality. By Lemma 2.4, we know that the only edges that do not lie on a shortest path originating at s are those in the set $E_s = \{(s+a, s+a+1), (s-a, s-a-1), (s-a, s+a), (s+a+1, s+a+1-6n), (s-a-1, s-a-1+6n), (s+a+1-6n, s-a-1+6n)\}$, where $a = (3n-1)(6n)$.

Recall that the edge betweenness centrality of an edge e is defined by the formula:

$$B'(e) = \sum_{x,y} \frac{\sigma_{xy}(e)}{\sigma_{xy}}$$

for distinct vertices x, y.

Without loss of generality, fix the pair of edges $e_1 = (s, s+1)$ and $e_2 = (s, s+6n)$. Since no edges in the set E_s are on shortest paths originating at s, we can ignore these edges in calculating the contributions to $B'(e_1)$ and $B'(e_2)$ from shortest paths originating at s. Since by Corollary 2.2 there exists an automorphism of $G - E_s$ mapping e_1 to e_2, we have that

$$\sum_{y \in V(G)} \frac{\sigma_{sy}(e_1)}{\sigma_{sy}} = \sum_{y \in V(G)} \frac{\sigma_{sy}(e_2)}{\sigma_{sy}}.$$

In other words, the contributions to $B'(e_1)$ and $B'(e_2)$ from all shortest paths originating at the vertex s are equal.

Moreover, by Corollary 2.2, for every vertex s', we can map $(s', s'+1)$ to $(s', s'+6n)$ through an automorphism of $G - E_{s'}$, so that the contributions to $B'(e_1)$ and $B'(e_2)$ from all shortest paths originating at the vertex s' are equal. Therefore:

$$\sum_{s' \in V(G)} \sum_{y \in V(G)} \frac{\sigma_{s'y}(e_1)}{\sigma_{s'y}} = \sum_{s' \in V(G)} \sum_{y \in V(G)} \frac{\sigma_{s'y}(e_2)}{\sigma_{s'y}}$$

$$\Rightarrow B'(e_1) = B'(e_2).$$

This completes the proof. □

The process of demonstrating the uniform edge betweenness centrality of graphs of the form $C_{18n+3}(1, 6n)$ is essentially the same, once we have identified the analogues of Lemma 2.4 and Lemma 2.5 and Corollary 2.2, which we present below.

For $G = C_{21}(1, 6)$ $(n = 1)$, one can show explicitly that $B'(e) = 22$ for all edges e in G. We now consider all $n \geq 2$.

Lemma 2.6. *Let $G = C_{18n+3}(1, 6n)$ for $n \geq 2$ and fix any vertex s. Let $a = (3n)(6n)$. Then the only edges that do not lie on a shortest path originating at s are $E = \{(s+a, s+a-1), (s-a, s+a), (s-a, s-a+1), (s+a-1, s+a-1-6n), (s-a+1, s-a+1+6n), (s+a-1-6n, s-a+1+6n)\}$.*

Lemma 2.7. *Let $G = C_{18n+3}(1, 6n)$ for $n \geq 2$ and without loss of generality fix a source vertex $s = 2 + (6n)(3n)$ mod $(18n + 3)$ and consider any vertex a. Let $H = G - E$, where E is the set of edges that do not lie on any shortest path originating at s (Lemma 2.6). Then there exists an automorphism ϕ of H mapping $e_1 = (a, a - 1)$ to $e_2 = (a, a + 6n)$, given by:*

$$\phi(v) = \begin{cases} a + (6n)(a - v), & a - a \bmod(6n + 1) + 3 \leq v \leq a - a \bmod(6n + 1) + 6n + 1, \\ \phi(v + 1) + 12n + 1, & v = a - a \bmod(6n + 1) + 2, \\ \phi(v + 1) + 6n, & v = a - a \bmod(6n + 1) + 1, \\ \phi(v + (6n + 1)) + (6n + 1), & a - a \bmod(6n + 1) - 6n \leq v \leq a - a \bmod(6n + 1), \\ \phi(v - (6n + 1)) - (6n + 1), & a - a \bmod(6n + 1) + 6n + 2 \leq v \leq a - a \bmod(6n + 1) + 12n + 2, \end{cases}$$

where vertices (v and $\phi(v)$) are taken mod $(18n + 3)$.

Proof. By Lemma 2.6, $E = \{(2, 3), (12n + 5, 12n + 4), (2, 12n + 5), (6n + 4, 6n + 3), (12n + 4, 6n + 4), (3, 6n + 3)\}$.

To show that ϕ is indeed an isomorphism, our strategy is to show that $N(\phi(v)) = \phi(N(v))$.

<u>Case 1a:</u> $a - a \bmod(6n + 1) + 3 < v < a - a \bmod(6n + 1) + 6n + 1$
We note that $N(v) = \{v - 1, v + 1, v - 6n, v + 6n\}$
$\Rightarrow \phi(N(v)) = \{a+(6n)(a-(v-1)), a+(6n)(a-(v+1)), a+(6n)(a-v)+1, a+(6n)(a-v)-1\}$.
Then $\phi(v) = a + (6n)(a - v) \Rightarrow N(\phi(v)) = \{a + (6n)(a - v) + 1, a + (6n)(a - v) - 1, a + 6n(a - v) + 6n, a + 6n(a - v) - 6n\}$.
Hence $N(\phi(v)) = \phi(N(v))$.

<u>Case 1b:</u> $v = a - a$ mod $(6n + 1) + 3$
Note that $v = 3$ or $v = 6n + 4$ or $v = 12n + 5$. By definition of E,
$N(v) = \{v + 1, v - 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) - 6n, \phi(v) + 1\} = N(\phi(v))$.

Case 1c: $v = a - a \text{ mod } (6n+1) + 6n + 1$
Note that $v = 6n + 1$ or $v = 12n + 2$ or $v = 18n + 3$. By definition of E,
$N(v) = \{v - 1, v + 1, v - 6n, v + 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) + 6n, \phi(v) - 6n, \phi(v) + 1, \phi(v) - 1\} = N(\phi(v))$.

Case 2: $v = a - a \text{ mod } (6n+1) + 2$
Note that $v = 2$ or $v = 6n + 3$ or $v = 12n + 4$. By definition of E,
$N(v) = \{v - 1, v + 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) + 6n, \phi(v) - 1\} = N(\phi(v))$.

Case 3: $v = a - a \text{ mod } (6n+1) + 1$
Note that $N(v) = \{v - 1, v + 1, v - 6n, v + 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) + 6n, \phi(v) - 6n, \phi(v) + 1, \phi(v) - 1\} = N(\phi(v))$.

Case 4a: $a - a \bmod(6n+1) + 3 - (6n+1) < v < a - a \bmod(6n+1) + (6n+1) - (6n+1)$
Note that $N(v) = \{v - 1, v + 1, v + 6n, v - 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) + 6n, \phi(v) - 6n, \phi(v) + 1, \phi(v) - 1\} = N(\phi(v))$.

Case 4b: $v = a - a \bmod(6n+1) + 3 + (6n+1)$
Note that $v = 3$ or $v = 6n + 4$ or $v = 12n + 5$. By definition of E,
$N(v) = \{v + 1, v - 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) - 6n, \phi(v) + 1\} = N(\phi(v))$.

Case 4c: $v = a - a \bmod(6n+1) + 2 + (6n+1)$
Note that $v = 2$ or $v = 6n + 3$ or $v = 12n + 4$. By definition of E,
$N(v) = \{v - 1, v + 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) + 6n, \phi(v) - 1\} = N(\phi(v))$.

Case 4d: $v = a - a \bmod(6n+1) + 1 + (6n+1)$
Note that $N(v) = \{v - 1, v + 1, v - 6n, v + 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) + 6n, \phi(v) - 6n, \phi(v) + 1, \phi(v) - 1\} = N(\phi(v))$.

Case 4e: $v = a - a \bmod(6n+1)$
Note that $N(v) = \{v - 1, v + 1, v - 6n, v + 6n\}$
$\Rightarrow \phi(N(v)) = \{\phi(v) + 6n, \phi(v) - 6n, \phi(v) + 1, \phi(v) - 1\} = N(\phi(v))$.

Case 5: $a - a \bmod(6n+1) + 6n + 2 \leq v \leq a - a \bmod(6n+1) + 12n + 2$
The proof reduces to the proof of Case 4.
We have shown that ϕ is an isomorphism. Since $\phi(a) = a$ and $\phi(a-1) = a + (6n)(a-(a-1)) = a + 6n$, ϕ maps the edge $e_1 = (a, a-1)$ to the edge $e_2 = (a, a+6n)$. □

Corollary 2.3. *Let $G = C_{18n+3}(1, 6n)$ and fix a vertex s. Let $E_{s'}$ be the set of edges that do not lie on a shortest path originating at s' (Lemma 2.6). Then for every vertex s', there exists an automorphism of $G - E_{s'}$ mapping $(s, s-1)$ to $(s, s+6n)$.*

Theorem 2.5. *Circulant graphs of the form $C_{18n+3}(1, 6n)$ are edge-betweenness-uniform.*

We have identified seven other infinite classes which we believe have the same unusual combination of properties. We pose these as open problems.

Conjecture 2.1. *The following classes of circulant graphs have uniform edge betweenness centrality but are not edge-transitive:*

Class 3: $C_{20+8(n-1)}(1, 2n+2, 2n+4)$, $n = 1, 2, 3, \ldots$

Class 4: $C_{32+8(n-1)}(1, 2n+5, 2n+7)$, $n = 1, 2, 3, \ldots$

Class 5: $C_{20+16(n-1)}(1, 4n, 8n+1)$, $n = 1, 2, 3, \ldots$

Class 6: $C_{28+16(n-1)}(1, 4n+4, 8n+5)$, $n = 1, 2, 3, \ldots$

Class 7: $C_{32+8(n-1)}(1, 2n+5, 4n+11)$, $n = 1, 2, 3, \ldots$

Class 8: $C_{32+8(n-1)}(1, 2n+7, 4n+11)$, $n = 1, 2, 3, \ldots$

Class 9: $C_{49+14(n-1)}(1, 2n+6, 4n+9)$, $n = 1, 2, 3, \ldots$

Acknowledgements

The authors are grateful to an anonymous referee whose comments improved the presentation of this paper. The authors are very grateful to Stanisław Radziszowski for useful discussion and for processing graph data on edge transitive graphs up to 20 vertices. Research was supported by National Science Foundation Research Experiences for Undergraduates Site Award #1659075.

References

[1] L. D. Andersen, S. Ding, G. Sabidussi, and P. D. Vestergaard, Edge Orbits and Edge-Deleted Subgraphs, *Graphs and Combinatorics* **8**, (1992), 31-44.

[2] J. M. Anthonisse, *The Rush in a Directed Graph*, Technical report, Amsterdam: University of Amsterdam Mathematical Centre, (1971).

[3] S. P. Borgatti, M. G. Everett, and J. C. Johnson, *Analyzing social networks*. SAGE Publications Limited, (2013).

[4] U. Brandes, S. Borgatti, L. Freeman, Maintaining the Duality of Closeness and Betweenness Centrality, *Social Networks*, **44** (2016), 153–159.

[5] E. Bullmore and O. Sporns, Complex brain networks: graph theoretical analysis of structural and functional systems, *Nature* **10** (2009), 186-196.

[6] L. Freeman, A set of measures of centrality based upon betweenness, *Sociometry* **40** (1977), 35–41.

[7] J. Coroničová Hurajová and T. Madaras, *The Edge Betweenness Centrality - Theory and Applications*, JIAS 5 Číslo 1, (2015), 20-29.

[8] L. Freeman, Centrality in social networks conceptual clarification, *Social Networks*, **1** (1978/79) 215–239.

[9] L. C. Freeman, S. P. Borgatti, and D. R. White, Centrality in valued graphs: A measure of betweenness based on network flow, *Social Networks*, **13** No 2, (1991), 141–154.

[10] F. Comellas and S. Gago, Spectral bounds for the betweenness of a graph, *Linear Algebra and its Applications* **423** (2007), 74–80.

[11] S. Gago, J. Coroničová Hurajová , and T. Madaras, Betweenness centrality in graphs. Chapter 7: Quantitative graph theory, *Discrete Math. Appl.*, (Boca Raton), CRC Press, Boca Raton, FL, (2015), 233–257.

[12] S.Gago, J. Coroničová Hurajová, and T. Madaras, On Betweenness-Uniform Graphs, *Czechoslovak Mathematical Journal*, **63** (138) (2013), 629–642.

[13] S. Gago, J. Hurajová, and T. Madaras, Notes on the betweenness centrality of a graph, (English summary) *Mathematica Slovaca* **62** (2012), 1–12.

[14] D. Gleich, https://www.mathworks.com/matlabcentral/fileexchange/10922-matlabbgl.

[15] R. Grassi, R. Scapellato, S. Stefani, and A. Torriero, *Networks, Topology and Dynamics*, Springer (Berlin), (2009), 161–175.

[16] http://users.cecs.anu.edu.au/~bdm/data/graphs.html.

[17] Š. Miklavič, P. Potočnik, Distance-regular circulants, *European Journal of Combinatorics*, **24** (2003), 777-784.

[18] S. Nicoloso, U. Pietropaoli, Isomorphism Testing for Circulant Graphs $C_n(a, b)$, *Utilitas Mathematica*, **87** (2012), 165.

[19] D. Schoch and U. Brandes, Re-conceptualizing centrality in social networks, *Euro. J. Applied Mathematics* **27** (2016), 971–985.

[20] S. Wilson and P. Potočnik, Recipes for Edge-Transitive Tetravalent Graphs, arXiv preprint arXiv:1608.04158 (2016).

[21] D. R. White and S. P. Borgatti. Betweenness centrality measures for directed graphs, *Social Networks*, **16** No. 4, (1994), 335–346.

Appendix

All graphs in the appendix are listed below are encoded in.g6 strings. For information about graphs encoded in .g6 strings, see
https://reference.wolfram.com/language/ref/format/Graph6.html.

Vertex-transitive graphs with 12 vertices
(With edge betweenness values for graphs that are not edge-transitive).

1. KqGG_CC?GA?B
C_{12}: (edge-transitive)

2. KsWOa?_B_J?[
{13.3333, 13.3333, 17.3333, 13.3333, 17.3333, 13.3333, 17.3333, 13.3333, 13.3333, 17.3333, 13.3333, 17.3333, 13.3333, 17.3333, 13.3333, 13.3333, 13.3333, 13.3333}

3. KsXP?_?@WT?[
{12., 18., 18., 18., 18., 12., 18., 12., 18., 18., 18., 12., 18., 12., 18., 18., 18., 12.}

4. KsXP?_DA_A_T
{10., 18., 18., 18., 18., 10., 18., 10., 18., 18., 18., 10., 18., 10., 18., 18., 18., 10.}

5. K{CY@?DA_B?R
{13., 13., 20., 13., 20., 20., 13., 13., 13., 20., 20., 13., 13., 13., 13., 13., 13., 20.}

6. Ks‘QPckW?d‘i
{8., 8., 10., 10., 10., 10., 8., 10., 10., 8., 8., 8., 10., 8., 8., 10., 10., 8., 10., 8., 8., 8., 10., 10.}

7. Ks‘jaOoE?F_m
{9.33333, 9.33333, 10.6667, 10.6667, 9.33333, 10.6667, 10.6667, 10.6667, 9.33333, 10.6667, 9.33333, 9.33333, 10.6667, 9.33333, 9.33333, 10.6667, 10.6667, 10.6667, 10.6667, 9.33333, 9.33333, 10.6667, 9.33333, 9.33333}

8. Ks‘raOgE?J_]
{9.33333, 9.33333, 9.33333, 12., 9.33333, 9.33333, 12., 9.33333, 9.33333, 12., 9.33333, 9.33333, 12., 9.33333, 9.33333, 9.33333, 12., 12., 9.33333, 9.33333, 9.33333, 9.33333, 9.33333, 9.33333}

9. Ks‘zB?WE?F_]
Wreath (6,2): (edge eransitive)

10. K{‘H_oMDaAcL
{8., 8., 10., 10., 8., 10., 10., 10., 10., 8., 10., 8., 8., 10., 8., 8., 10., 10., 8., 8., 8., 10., 10., 8.}

11. K{‘HackCGQ_r
{7., 7., 12., 12., 7., 12., 12., 12., 12., 7., 7., 12., 7., 7., 12., 7., 12., 7., 12., 12., 12., 7., 7., 7.}

12. K{‘QPgiE?K_N
{8., 8., 12., 12., 8., 12., 12., 12., 12., 8., 8., 12., 8., 8., 12., 8., 12., 8., 12., 12., 12., 8., 8., 8.}

13. K{dHaGbC_W_N
Cuboctahedral: (edge-transitive)

14. K}hPOSS?oH_N
{6., 6., 15., 15., 15., 6., 15., 6., 15., 6., 15., 6., 15., 6., 15., 6., 15., 6., 15., 6., 15., 15., 6., 6.}

15. K~‘GW[_CGD_N
{4., 9.33333, 9.33333, 17.3333, 9.33333, 9.33333, 17.3333, 4., 17.3333, 17.3333, 4., 9.33333, 9.33333, 9.33333, 9.33333, 4., 17.3333, 17.3333, 4., 9.33333, 9.33333, 9.33333, 9.33333, 4.}

16. KsaBrhkV@w?^
$K_{6,6}$ - perfect matching : (edge-transitive)

17. K{aAxxKLIQeT
{6.33333, 6.33333, 7.33333, 7.33333, 6.66667, 6.33333, 7.33333, 6.66667, 7.33333, 7.33333, 6.66667, 7.33333, 6.33333, 6.66667, 7.33333, 6.33333, 6.66667, 6.33333, 7.33333, 6.33333, 7.33333, 7.33333, 6.33333, 6.33333, 6.33333, 6.33333, 6.33333, 7.33333, 7.33333, 6.66667}

18. K{eAiglJaQeT
{6.66667, 6.66667, 6.66667, 6.66667, 7.33333, 6.66667, 7.33333, 6.66667, 6.66667, 6.66667, 7.33333, 6.66667, 6.66667, 6.66667, 7.33333, 6.66667, 7.33333, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 7.33333}

19. K|uBogKHWNGN
{7., 5., 5., 5., 12., 5., 5., 5., 12., 5., 7., 12., 7., 5., 12., 5., 12., 5., 5., 5., 7., 12., 5., 5., 7., 7., 5., 5., 5., 5.}

20. K}i?wxDHicdL
{6., 6., 6.66667, 6.66667, 8.66667, 6.66667, 6., 8.66667, 6.66667, 6., 8.66667, 6.66667, 6.66667, 8.66667, 6., 8.66667, 6.66667, 6., 6.66667, 6.66667, 6., 6., 6., 6., 6., 6., 6.66667, 6.66667, 6.66667, 8.66667}

21. K}iAwkhHOhhF
{5., 6., 7., 7., 9., 7., 6., 7., 9., 5., 7., 9., 5., 7., 9., 9., 6., 7., 7., 5., 6., 7., 6., 9., 7., 7., 5., 5., 7., 6.}

22. K}iZAciDOX_^
Icosahedral Graph: (edge-transitive)

23. K}mBqGKHWj?^
{6., 6., 6., 6., 12., 6., 6., 6., 12., 6., 6., 12., 6., 6., 12., 6., 12., 6., 6., 6., 6., 12., 6., 6., 6., 6., 6., 6., 6., 6.}

24. K~aAXWTEaJdU
{5.33333, 5.33333, 6., 8.66667, 8.66667, 6., 5.33333, 8.66667, 8.66667, 5.33333, 8.66667, 8.66667, 8.66667, 8.66667, 5.33333, 8.66667, 6., 5.33333, 8.66667, 5.33333, 6., 5.33333, 5.33333, 6., 5.33333, 6., 5.33333, 8.66667, 8.66667, 5.33333}

25. K~aAYWhH_rau
{4.66667, 6., 6., 8.66667, 8.66667, 6., 6., 8.66667, 8.66667, 4.66667, 8.66667, 8.66667, 8.66667, 8.66667, 8.66667, 4.66667, 6., 6., 4.66667, 8.66667, 6., 6., 6., 6., 6., 6., 4.66667, 8.66667, 8.66667, 4.66667}

26. K~aIQKiHWtAj
{6., 6., 6., 8., 8., 6., 6., 8., 8., 6., 8., 8., 8., 8., 8., 6., 6., 6., 6., 6., 6., 8., 6., 6., 6., 6., 8., 6., 6., 8.}

27. K~rH`cKBGF_^
{2., 9., 9., 9., 9., 9., 9., 9., 9., 2., 9., 9., 9., 9., 2., 9., 9., 9., 9., 2., 9., 9., 9., 9., 2., 9., 9., 9., 9., 2.}

28. KsaCB|}^b{No
$K_{6,6}$ (edge-transitive)

29. K}iSZLYNAZe]
$\overline{K_3 \times K_4}$: (edge-transitive)

30. K}i[BLZR`lfY
{5., 5., 5., 5., 5., 7., 5., 5., 5., 5., 7., 5., 5., 7., 5., 5., 5., 5., 7., 5., 7., 5., 5., 7., 5., 5., 5., 5., 5., 5., 5., 5., 5., 5., 5., 5.}

31. K}jLbXqBgmbN
{4., 4., 6.33333, 6.33333, 5.66667, 5.66667, 4., 5.66667, 6.33333, 5.66667, 6.33333, 5.66667, 6.33333, 6.33333, 5.66667, 4., 4., 5.66667, 6.33333, 4., 4., 5.66667, 6.33333, 4., 6.33333, 5.66667, 4., 5.66667, 6.33333, 6.33333, 5.66667, 6.33333, 5.66667, 4., 4., 4.}

32. K}mCB|MR`leu
{4.66667, 4.66667, 4.66667, 4.66667, 6.66667, 6.66667, 4.66667, 4.66667, 4.66667, 6.66667, 6.66667, 4.66667, 4.66667, 6.66667, 6.66667, 4.66667, 4.66667, 6.66667, 6.66667, 4.66667, 6.66667, 6.66667, 6.66667, 4.66667, 4.66667, 4.66667, 4.66667, 6.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667}

33. K}nDJpUJ_Van
{4., 4., 6., 6., 6., 6., 6., 4., 6., 6., 6., 4., 6., 6., 6., 6., 4., 6., 6., 4., 6., 6., 4., 4., 6., 6., 6., 4., 6., 6., 6., 6., 4., 4., 6., 4.}

34. K}nTRDdEox_~
{4.66667, 4.66667, 4.66667, 4.66667, 6.66667, 6.66667, 4.66667, 6.66667, 4.66667, 6.66667, 4.66667, 6.66667, 4.66667, 4.66667, 6.66667, 4.66667, 4.66667, 6.66667, 4.66667, 4.66667, 4.66667, 6.66667, 4.66667, 4.66667, 6.66667, 4.66667, 4.66667, 6.66667, 4.66667, 6.66667, 4.66667, 6.66667, 4.66667, 4.66667, 4.66667, 4.66667}

35. K}qm_|kBpdeN
{3., 5.83333, 6.33333, 5.33333, 5.83333, 5.66667, 5.33333, 5.66667, 5.83333, 6.33333, 5.83333, 5.83333, 3., 5.66667, 6.33333, 3., 5.83333, 5.33333, 5.83333, 3., 5.66667, 5.83333, 6.33333, 6.33333, 5.33333, 5.66667, 5.33333, 5.83333, 5.83333, 3., 5.83333, 6.33333, 5.66667, 5.83333, 5.33333, 3.}

36. K}qtRhiF_r_~
{4., 4., 6., 6., 6., 6., 4., 6., 6., 6., 6., 6., 6., 6., 6., 4., 4., 6., 6., 4., 4., 6., 6., 4., 6., 6., 4., 6., 6., 6., 6., 6., 6., 4., 4., 4.}

37.K}vD@[uFptGn
{4., 5., 5., 5., 6.5, 6.5, 6.5, 5., 5., 5., 6.5, 4., 6.5, 5., 5., 4., 6.5, 6.5, 5., 6.5, 5., 6.5, 5., 6.5, 5., 4., 5., 5., 6.5, 5., 4., 5., 4., 5., 5., 6.5}

38. K~rK@svJ_{g^
{4., 5., 5., 5., 5., 8., 5., 5., 5., 5., 8., 4., 5., 5., 8., 5., 5., 8., 4., 8., 5., 5., 8., 5., 5., 5., 5., 5., 5., 4., 4., 5., 5., 4., 5., 5.}

39. K~zLaWq@wf‘n
{3.33333, 3.33333, 5.33333, 5.33333, 7.33333, 7.33333, 5.33333, 7.33333, 3.33333, 5.33333, 7.33333, 3.33333, 7.33333, 5.33333, 7.33333, 3.33333, 5.33333, 7.33333, 3.33333, 5.33333, 7.33333, 3.33333, 7.33333, 5.33333, 3.33333, 7.33333, 5.33333, 5.33333, 7.33333, 3.33333, 5.33333, 3.33333, 7.33333, 3.33333, 3.33333, 5.33333}

40. K~~{ACbCwV_~
{4., 4., 4., 4., 4., 12., 4., 4., 4., 4., 12., 4., 4., 4., 12., 4., 4., 12., 4., 12., 12., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4.}

41. K}muUHnVp}E^
{3.33333, 4.16667, 4.16667, 4.16667, 4.16667, 5., 5., 5., 5., 4.16667, 4.16667, 4.16667, 4.16667, 4.16667, 4.16667, 3.33333, 4.16667, 5., 4.16667, 4.16667, 3.33333, 4.16667, 5., 3.33333, 5., 5., 4.16667, 3.33333, 5., 5., 4.16667, 4.16667, 4.16667, 5., 4.16667, 4.16667, 4.16667, 5., 4.16667, 4.16667, 4.16667, 3.33333}

42. K}n\v@VJqZe^
{3.8, 3.8, 3.8, 3.8, 4.6, 4.6, 5.6, 5.6, 4.6, 3.8, 3.8, 3.8, 4.6, 4.6, 3.8, 3.8, 3.8, 4.6, 4.6, 3.8, 3.8, 3.8, 5.6, 3.8, 3.8, 3.8, 5.6, 4.6, 5.6, 3.8, 5.6, 4.6, 3.8, 4.6, 4.6, 3.8, 3.8, 3.8, 3.8, 3.8,3.8, 4.6}

43. K}neT‘^Nq]e|
{3.46667, 3.46667, 4.13333, 4.13333, 4.93333, 4.93333, 4.93333, 4.93333, 4.93333, 3.46667, 4.13333, 4.13333, 4.93333, 4.93333, 3.46667, 4.13333, 4.13333, 4.93333, 4.13333, 3.46667, 3.46667, 4.93333, 4.93333, 3.46667, 4.93333, 3.46667, 4.93333, 4.93333, 4.93333, 4.13333, 4.13333, 4.13333, 4.93333, 3.46667, 4.93333, 4.93333, 4.13333, 4.93333, 3.46667, 3.46667, 3.46667, 4.13333}

44. K}ut^@VRxufl
{3.6, 3.6, 4.4, 4.4, 4.4, 4.4, 5.2, 5.2, 4.4, 4.4, 3.6, 4.4, 4.4, 4.4, 4.4, 3.6, 4.4, 4.4, 3.6, 4.4, 4.4, 5.2, 3.6, 4.4, 4.4, 3.6, 5.2, 3.6, 3.6, 5.2, 4.4, 5.2, 3.6, 4.4, 4.4, 4.4, 4.4, 4.4, 3.6, 4.4, 4.4, 3.6}

45. K~rLthlV‘Nb^
{3.6, 3.8, 3.8, 4.7, 4.7, 4.7, 4.7, 4.7, 4.7, 3.8, 3.8, 4.7, 4.7, 3.8, 4.7, 3.6, 4.7, 4.7, 3.6, 4.7, 4.7, 4.7, 3.8, 4.7, 4.7, 3.6, 4.7, 4.7, 3.6, 4.7, 4.7, 3.8, 4.7, 3.8, 3.8, 3.8, 4.7, 3.8, 4.7, 4.7, 3.8, 3.6}

46. K~rMEC~Nx}Fx
{2., 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 2., 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 2., 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 2., 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 2., 2.}

47. K~z\ShjTpNb^
{3.6, 3.8, 3.8, 3.8, 3.8, 5.6, 5.6, 3.8, 3.8, 3.8, 3.8, 5.6, 5.6, 5.6, 3.6, 3.8, 3.8, 5.6, 3.6, 3.8, 3.8, 5.6, 5.6, 3.8, 3.8, 5.6, 3.8, 3.8, 5.6, 3.6, 5.6, 3.8, 3.8, 5.6, 3.6, 3.8, 3.8, 3.8, 3.8, 3.8, 3.8, 3.6}

48. K˜z\SliTXf‘˜

{4., 4., 4., 4., 4., 5., 5., 4., 4., 4., 4., 5., 5., 5., 4., 4., 4., 5., 4., 4., 4., 5., 5., 4., 4., 5., 4., 4., 5., 5., 4., 4., 4., 4., 4., 4., 5., 4., 4., 4., 4., 4.}

49. K˜˜}DDJKwˆa˜

{3., 3., 4., 4., 4., 6., 6., 4., 4., 3., 4., 6., 6., 3., 4., 4., 6., 6., 4., 3., 6., 6., 3., 6., 6., 6., 6., 3., 3., 4., 4., 4., 4., 3., 4., 4., 4., 3., 4., 4., 3., 3.}

50. K˜˜}DDbEwn‘˜

{3., 3., 4., 4., 4., 6., 6., 3., 4., 4., 4., 6., 6., 4., 4., 4., 6., 6., 3., 3., 6., 6., 3., 6., 6., 6., 6., 3., 3., 4., 4., 4., 3., 4., 4., 4., 4., 4., 4., 3., 3., 3.}

51. K˜˜}ECrKwˆ‘˜

{2., 4., 4., 4., 4., 6., 6., 4., 4., 4., 4., 6., 6., 2., 4., 4., 6., 6., 4., 4., 6., 6., 2., 6., 6., 6., 6., 2., 4., 4., 4., 4., 4., 4., 4., 4., 2., 4., 4., 4., 4., 2.}

52. Kv˜vVJbVx˜B˜

{2.57143, 2.57143, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 2.57143, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 2.57143, 2.57143, 2.57143, 3.80952, 3.80952, 3.80952, 2.57143, 3.80952, 3.80952, 3.80952, 2.57143, 3.80952, 3.80952, 3.80952, 2.57143, 3.80952, 3.80952, 3.80952, 2.57143, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 2.57143, 2.57143}

53. K}rD|y{ˆz˜N{

$K_{12} - 3K_4$ (edge-transitive)

54. K˜zLmu{Vx˜K˜

{3.19048, 3.19048, 3.19048, 3.19048, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 3.80952, 3.19048, 3.80952, 3.19048, 3.19048, 3.80952, 3.19048, 3.80952, 3.80952, 3.19048, 3.19048, 3.80952, 3.19048, 3.19048, 3.80952, 3.80952, 3.80952, 3.19048, 3.80952, 3.19048, 3.80952, 3.80952, 3.80952, 3.19048, 3.19048, 3.80952, 3.19048, 3.19048, 3.80952, 3.19048, 3.19048, 3.19048, 3.80952, 3.80952, 3.80952, 3.19048, 3.80952, 3.19048, 3.19048}

55. K˜˜e\nwRxnb˜

{2.66667, 2.66667, 3.33333, 3.33333, 4., 4., 4., 4., 3.33333, 4., 2.66667, 4., 4., 3.33333, 4., 2.66667, 4., 4., 4., 3.33333, 4., 3.33333, 4., 2.66667, 4., 4., 4., 2.66667, 4., 4., 2.66667, 2.66667, 3.33333, 3.33333, 4., 3.33333, 2.66667, 4., 3.33333, 4., 2.66667, 3.33333, 4., 4., 4., 3.33333, 2.66667, 2.66667}

56. K˜˜vUUtRxnb˜

{2.66667, 2.66667, 3.33333, 3.33333, 4., 4., 4., 4., 3.33333, 4., 2.66667, 4., 3.33333, 4., 4., 2.66667, 4., 3.33333, 4., 4., 4., 4., 2.66667, 3.33333, 4., 4., 2.66667, 3.33333, 4., 4., 2.66667, 4., 3.33333, 4., 2.66667, 3.33333, 4., 4., 4., 2.66667, 4., 3.33333, 4., 2.66667, 3.33333, 3.33333, 2.66667, 2.66667}

57. K˜˜}UMr[xˆb˜

{2.66667, 3.33333, 3.33333, 3.33333, 3.33333, 4., 4., 4., 3.33333, 3.33333, 3.33333, 3.33333, 4., 4., 4., 2.66667, 3.33333, 3.33333, 4., 4., 4., 3.33333, 3.33333, 4., 4., 4., 2.66667, 4., 4., 4., 4., 4., 4., 2.66667, 3.33333, 3.33333, 3.33333, 3.33333, 3.33333, 3.33333, 3.33333, 3.33333, 2.66667, 3.33333, 3.33333, 3.33333, 3.33333, 2.66667}

58. K~~~FFbFw~b~
{2., 2., 4., 4., 4., 4., 4., 4., 2., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 2., 2., 4., 4., 4., 2., 4., 4., 4., 4., 4., 4., 2., 2., 4., 4., 4., 2., 4., 4., 4., 4., 4., 4., 2., 2., 2.}

59. K~ze}y~nr~n}
$K_{12} - 4K_3$: (edge-transitive)

60. K~~~VfNly~f~
{2.5, 2.5, 3., 3., 3., 3., 3., 3., 3., 3., 3., 2.5, 3., 3., 3., 3., 3., 2.5, 3., 3., 3., 3., 3., 3., 3., 2.5, 3., 3., 3., 3., 2.5, 3., 3., 3., 3., 3., 3., 3., 3., 2.5, 2.5, 3., 3., 3., 3., 2.5, 3., 3., 3., 2.5, 3., 3., 2.5, 2.5}

61. K~~~fVffy~f~
{2.5, 2.5, 3., 3., 3., 3., 3., 3., 3., 2.5, 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 2.5, 2.5, 3., 3., 3., 3., 2.5, 3., 3., 3., 3., 3., 3., 3., 3., 2.5, 2.5, 3., 3., 3., 2.5, 3., 3., 3., 3., 3., 3., 2.5, 2.5, 2.5}

62. K~~~ffNrx~f~
{2., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 2., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 2., 3., 3., 3., 3., 3., 3., 3., 3., 2., 3., 3., 3., 3., 3., 3., 3., 3., 2., 3., 3., 3., 3., 2.}

63. K~~~vnnv|~n~
K_{12} - perfect matching: (edge-transitive)

64. K~~~~~~~~~~~
K_{12}: (edge-transitive)

Vertex-transitive graphs with 13 vertices
(With edge betweenness values for graphs that are not edge-transitive).

1. LqGG_CC?GA?@?D
C_{13}: (edge-transitive)

2. Ls‘R?skOGWARGU
$C_{13}(1, 5)$: (edge-transitive)

3. Ls‘jaOoAGa_T@T
{9.66667, 9.66667, 12.3333, 12.3333, 9.66667, 12.3333, 12.3333, 12.3333, 9.66667, 12.3333, 9.66667, 9.66667, 12.3333, 9.66667, 9.66667, 12.3333, 12.3333, 12.3333, 12.3333, 9.66667, 12.3333, 9.66667, 9.66667, 9.66667, 9.66667, 12.3333}

4. L}hPOSS?oH?F?V
{6., 6., 18., 18., 18., 6., 18., 6., 18., 6., 18., 6., 18., 6., 18., 6., 18., 6., 18., 6., 18., 18., 6., 6., 18., 6.}

5. L}ecYdgPxiD\FM
Paley(13): (edge-transitive)

6. L}iCA{}R‘khTLT

{5.13333, 5.13333, 5.93333, 5.93333, 6.93333, 6.93333, 5.93333, 5.13333, 5.93333, 6.93333, 6.93333, 5.13333, 5.93333, 6.93333, 6.93333, 5.13333, 6.93333, 6.93333, 5.93333, 6.93333, 5.13333, 6.93333, 5.93333, 5.93333, 6.93333, 5.13333, 5.93333, 5.13333, 6.93333, 5.93333, 5.93333, 5.13333, 5.13333, 5.13333, 5.13333, 5.13333, 5.93333, 5.93333, 6.93333}

7. L}nDAwyBgmGfGv
{5., 5., 5.33333, 5.33333, 7.66667, 7.66667, 7.66667, 5.33333, 5., 5.33333, 7.66667, 5.33333, 5., 5.33333, 7.66667, 5., 5., 7.66667, 7.66667, 7.66667, 5., 7.66667, 5.33333, 7.66667, 5.33333, 5., 5.33333, 5.33333, 7.66667, 5., 5., 7.66667, 5., 7.66667, 5., 5.33333, 5.33333, 5., 5.33333}

8. L~zLaWqCgY_^@^
{3.33333, 3.33333, 5.33333, 5.33333, 9.33333, 9.33333, 5.33333, 9.33333, 3.33333, 5.33333, 9.33333, 3.33333, 9.33333, 5.33333, 9.33333, 3.33333, 5.33333, 9.33333, 3.33333, 5.33333, 9.33333, 3.33333, 5.33333, 9.33333, 3.33333, 5.33333, 9.33333, 3.33333, 9.33333, 5.33333, 3.33333, 5.33333, 9.33333, 9.33333, 3.33333, 5.33333, 5.33333, 3.33333, 3.33333}

9. L}nm~axSzMdnFn
{3.6, 3.6, 3.6, 3.6, 4.4, 4.4, 4.4, 4.4, 4.4, 4.4, 4.4, 3.6, 3.6, 4.4, 3.6, 4.4, 3.6, 3.6, 4.4, 4.4, 3.6, 4.4, 3.6, 4.4, 3.6, 3.6, 4.4, 3.6, 4.4, 3.6, 4.4, 3.6, 3.6, 3.6, 4.4, 4.4, 4.4, 4.4, 3.6, 3.6, 3.6, 4.4, 4.4, 4.4, 3.6, 4.4, 3.6, 4.4, 3.6, 3.6, 4.4, 3.6}

10. L}nneQpVx~H|L|
{3.2381, 3.2381, 3.80952, 3.80952, 4.47619, 4.47619, 4.47619, 4.47619, 4.47619, 4.47619, 3.80952, 3.2381, 4.47619, 3.80952, 4.47619, 4.47619, 3.2381, 3.80952, 4.47619, 3.80952, 4.47619, 4.47619, 3.2381, 3.80952, 3.2381, 4.47619, 4.47619, 3.2381, 3.80952, 4.47619, 3.2381, 4.47619, 4.47619, 4.47619, 3.80952, 4.47619, 4.47619, 4.47619, 4.47619, 3.80952, 3.2381, 3.80952, 4.47619, 3.2381, 4.47619, 4.47619, 3.80952, 4.47619, 3.2381, 3.2381, 3.2381, 3.80952}

11. L~~vUUsQxj`~D~
{2.8, 2.8, 3.6, 3.6, 4.4, 4.4, 5.2, 5.2, 3.6, 4.4, 2.8, 5.2, 3.6, 4.4, 5.2, 2.8, 4.4, 3.6, 5.2, 4.4, 5.2, 5.2, 2.8, 3.6, 4.4, 5.2, 2.8, 3.6, 4.4, 5.2, 2.8, 3.6, 5.2, 4.4, 2.8, 3.6, 4.4, 5.2, 2.8, 5.2, 3.6, 4.4, 5.2, 2.8, 4.4, 3.6, 4.4, 2.8, 3.6, 3.6, 2.8, 2.8}

12. L~~~vVtr|nj~N~
{2.44444, 2.44444, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.44444, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.44444, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.44444, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.44444, 2.88889, 2.88889, 2.88889, 2.88889, 2.44444, 2.88889, 2.88889, 2.88889, 2.88889, 2.44444, 2.88889, 2.88889, 2.88889, 2.88889, 2.88889, 2.44444, 2.88889, 2.88889, 2.88889, 2.88889, 2.44444, 2.88889, 2.88889, 2.88889, 2.44444, 2.88889, 2.88889, 2.44444, 2.44444}

13. L~~~~~~~~~~~~~
K_{13}: (edge-transitive)

Vertex-transitive graphs with 14 vertices
(With edge betweenness values for graphs that are not edge-transitive).

1. MqGG_CC?GA?@?C?@_
C_{14}: (edge-transitive)

2. MsP@@?OC?S‘K@g@S?
Heawood: (edge-transitive)

3. MsXP?_???I‘S?[?k?
{13.2, 24.4, 24.4, 24.4, 24.4, 13.2, 24.4, 13.2, 24.4, 24.4, 24.4, 13.2, 24.4, 13.2, 24.4, 24.4, 24.4, 13.2, 24.4, 13.2, 24.4}

4. MsXP?_??GI‘S?S?g_
{14., 24., 24., 24., 24., 14., 24., 14., 24., 24., 24., 14., 24., 14., 24., 24., 24., 14., 24., 14., 24.}

5. Ms‘Hi_gO‘GAEAR?]?
{12., 12., 11., 11., 11., 11., 12., 11., 11., 12., 12., 12., 11., 12., 12., 11., 12., 11., 11., 11., 12., 11., 12., 12., 11., 12., 11., 12.}

6. Ms‘aaOoI?o?l@e?{?
$(4,4)$-subgraph of $K_{7,7}$: (edge-transitive)

7. Ms‘jaOoA?_?V@U?]?
$(4,4)$-subgraph of $K_{7,7}$: (edge-transitive)

8. Ms‘zB?WE?E?W?N?N?
Wreath$(7,2)$: (edge-transitive)

9. M}hPOSS??E_e?L?U_
{7., 7., 21., 21., 21., 7., 21., 7., 21., 7., 21., 7., 21., 7., 21., 7., 21., 7., 21., 7., 21., 21., 21., 7., 7., 7., 7., 21.}

10. MsaBZhKLAOeDATCi_
{7.33333, 7.33333, 10.3333, 10.3333, 6.66667, 6.66667, 10.3333, 7.33333, 10.3333, 10.3333, 6.66667, 7.33333, 10.3333, 7.33333, 6.66667, 7.33333, 10.3333, 7.33333, 6.66667, 7.33333, 10.3333, 7.33333, 7.33333, 10.3333, 10.3333, 10.3333, 10.3333, 10.3333, 7.33333, 10.3333, 7.33333, 7.33333, 6.66667, 6.66667, 7.33333}

11. MsaBjpcU@WB_?^?n?
{8.91667, 8.91667, 8.91667, 9.625, 9.625, 8.91667, 8.91667, 9.625, 9.625, 8.91667, 9.625, 8.91667, 9.625, 9.625, 8.91667, 8.91667, 9.625, 8.91667, 8.91667, 9.625, 8.91667, 8.91667, 8.91667, 8.91667, 9.625, 9.625, 9.625, 9.625, 8.91667, 8.91667, 9.625, 8.91667, 8.91667, 8.91667, 8.91667}

12. M|q@wgUIAOgI@Z?^?
{9.11111, 5.66667, 8.33333, 8.33333, 12.5556, 8.33333, 5.66667, 8.33333, 12.5556, 9.11111, 8.33333, 12.5556, 5.66667, 12.5556, 8.33333, 12.5556, 8.33333, 9.11111, 8.33333, 8.33333, 5.66667, 9.11111, 9.11111, 9.11111, 5.66667, 8.33333, 8.33333, 12.5556, 5.66667, 8.33333, 9.11111, 12.5556, 8.33333, 8.33333, 5.66667}

13. M}iAHKLDa‘DAAfCZ?

{6., 6., 10., 10., 10., 10., 6., 10., 10., 6., 10., 10., 10., 6., 10., 10., 6., 10., 6., 6., 10., 10., 10., 6., 10., 6., 10., 10., 6., 10., 6., 10., 6., 6., 10.}

14. M}iApsKDAGcd?\?m_
{6.66667, 6.66667, 9.33333, 9.33333, 14., 9.33333, 6.66667, 9.33333, 14., 6.66667, 9.33333, 14., 6.66667, 9.33333, 14., 9.33333, 6.66667, 14., 9.33333, 9.33333, 6.66667, 6.66667, 6.66667, 14., 14., 6.66667, 6.66667, 9.33333, 6.66667, 9.33333, 6.66667, 9.33333, 9.33333, 9.33333, 6.66667}

15. M~rH`cKBGE?X?N?N_
{2., 12., 12., 12., 12., 12., 12., 12., 12., 2., 12., 12., 12., 12., 2., 12., 12., 12., 12., 2., 12., 12., 12., 12., 2., 12., 12., 12., 12., 2., 12., 12., 12., 12., 2.}

16. MsaCBxy\b[JoN_?^_
$K_{7,7}$ - perfect matching (edge-transitive)

17. MujLboMDiREIPFGj_
{7., 7., 6.33333, 6.33333, 6.66667, 6.66667, 6.66667, 6.33333, 6.33333, 7., 6.66667, 6.66667, 6.33333, 6.33333, 7., 6.66667, 7., 7., 6.66667, 6.33333, 7., 7., 6.66667, 6.33333, 6.33333, 6.66667, 7., 6.66667, 6.33333, 7., 6.66667, 6.66667, 7., 7., 6.33333, 7., 6.33333, 6.33333, 6.66667, 6.66667, 6.33333, 7.}

18. M{fLboUBiQeKPJGf_
{7., 7., 6.33333, 6.33333, 6.66667, 6.66667, 6.66667, 7., 6.33333, 6.33333, 6.66667, 7., 6.33333, 6.33333, 6.66667, 6.66667, 6.33333, 7., 6.66667, 7., 6.33333, 7., 6.66667, 7., 6.66667, 6.33333, 7., 6.33333, 6.66667, 7., 6.66667, 6.66667, 6.33333, 7., 7., 7., 7., 6.33333, 6.66667, 6.66667, 6.33333, 6.33333}

19. M}iCA[uUhyBoOjHT_
{6., 6., 6., 6., 8., 8., 6., 6., 8., 6., 8., 6., 8., 6., 8., 6., 6., 8., 8., 6., 8., 6., 8., 6., 8., 6., 6., 6., 8., 6., 6., 6., 6., 6., 6., 6., 6., 8., 8., 6., 6., 6.}

20. M}iCA[vU`wboOjHT_
{6., 6., 6., 6., 8., 8., 6., 6., 8., 6., 8., 6., 8., 6., 8., 8., 6., 6., 8., 8., 6., 6., 8., 6., 6., 8., 6., 6., 6., 6., 8., 6., 6., 6., 6., 6., 6., 8., 8., 6., 6., 6.}

21. M}nDAwyP`K`TDT?^_
{5., 5., 7., 7., 9., 9., 9., 7., 5., 7., 9., 7., 5., 7., 9., 5., 5., 9., 9., 9., 5., 9., 7., 5., 9., 7., 7., 9., 5., 7., 5., 9., 5., 9., 5., 7., 7., 7., 7., 9., 5., 5.}

22. M~rK@[NL?SgRCzKN?
4., 6.33333, 7.33333, 6.33333, 5.66667, 10.3333, 5.66667, 6.33333, 7.33333, 6.33333, 10.3333, 4., 10.3333, 6.33333, 7.33333, 5.66667, 10.3333, 6.33333, 4., 5.66667, 6.33333, 10.3333, 6.33333, 7.33333, 10.3333, 6.33333, 5.66667, 6.33333, 7.33333, 4., 4., 7.33333, 6.33333, 10.3333, 7.33333, 6.33333, 4., 4., 5.66667, 6.33333, 6.33333, 5.66667}

23. M~zLaWqCgY?V@V?^_
{3.83333, 3.83333, 6.33333, 6.33333, 10.8333, 10.8333, 6.33333, 10.8333, 3.83333, 6.33333, 10.8333, 3.83333, 10.8333, 6.33333, 10.8333, 3.83333, 6.33333, 10.8333, 3.83333, 6.33333,

10.8333, 3.83333, 6.33333, 10.8333, 3.83333, 6.33333, 10.8333, 3.83333, 6.33333, 10.8333, 3.83333, 6.33333, 10.8333, 3.83333, 10.8333, 6.33333, 10.8333, 3.83333, 6.33333, 6.33333, 3.83333, 3.83333}

24. MsaCC@~^r}Nw^o^o?
$K_{7,7}$: (edge-transitive)

25. M|qme`}JOmiYBrIN_
{3.66667, 5.16667, 5.16667, 6.66667, 5.83333, 5.66667, 5.83333, 5.66667, 5.83333, 5.16667, 6.66667, 5.16667, 5.83333, 5.83333, 5.16667, 3.66667, 5.83333, 6.66667, 3.66667, 5.16667, 6.66667, 5.83333, 5.66667, 3.66667, 5.16667, 5.66667, 5.83333, 5.16667, 5.66667, 5.16667, 5.83333, 6.66667, 5.83333, 6.66667, 5.16667, 5.83333, 5.83333, 5.16667, 3.66667, 5.66667, 5.83333, 5.16667, 6.66667, 3.66667, 3.66667, 5.66667, 5.16667, 5.83333, 5.16667}

26. M}nDC@^Nq]ExQtLY_
{4.46667, 4.46667, 5.13333, 5.13333, 5.93333, 5.93333, 6.93333, 5.93333, 5.13333, 4.46667, 5.13333, 5.93333, 6.93333, 5.13333, 4.46667, 5.13333, 5.93333, 6.93333, 4.46667, 4.46667, 5.93333, 6.93333, 5.93333, 5.93333, 4.46667, 6.93333, 5.93333, 5.13333, 6.93333, 4.46667, 5.93333, 5.13333, 6.93333, 5.13333, 5.93333, 4.46667, 5.13333, 5.93333, 5.93333, 5.13333, 5.13333, 4.46667, 4.46667, 4.46667, 4.46667, 4.46667, 5.13333, 5.13333, 5.93333}

27. M}zTCdFQxZBqLfMZ?
{4., 5., 5., 6., 6., 6., 6., 6., 6., 5., 5., 6., 6., 4., 6., 5., 6., 6., 4., 6., 5., 6., 6., 6., 6., 6., 5., 6., 6., 6., 5., 5., 6., 4., 6., 5., 4., 6., 6., 5., 5., 5., 6., 5., 6., 6., 4., 4., 6.}

28. M}zTCdFQxZBrLdMY_
{4., 5., 5., 6., 6., 6., 6., 6., 6., 5., 5., 6., 6., 4., 6., 6., 6., 5., 4., 6., 6., 5., 6., 6., 5., 6., 6., 6., 6., 5., 6., 5., 6., 4., 6., 5., 4., 6., 6., 5., 5., 5., 6., 5., 6., 6., 4., 4., 6.}

29. M}~tKpeUOU_|GnC^_
{4., 5., 5., 4.33333, 4.33333, 7.66667, 7.66667, 4.33333, 4.33333, 5., 5., 7.66667, 7.66667, 7.66667, 4., 4.33333, 5., 7.66667, 4., 7.66667, 4.33333, 5., 7.66667, 5., 4.33333, 7.66667, 5., 4.33333, 7.66667, 4., 7.66667, 4.33333, 5., 4., 4.33333, 7.66667, 5., 5., 4.33333, 7.66667, 5., 7.66667, 4.33333, 5., 4.33333, 4., 4., 4.33333, 5.}

30. M~zLc@NLoubkOvHZ_
{4.13333, 4.13333, 4.8, 4.8, 5.93333, 5.93333, 8.26667, 4.8, 5.93333, 4.13333, 4.8, 5.93333, 8.26667, 4.13333, 5.93333, 4.8, 5.93333, 8.26667, 4.13333, 4.8, 5.93333, 8.26667, 4.13333, 4.8, 8.26667, 5.93333, 4.13333, 8.26667, 4.8, 5.93333, 8.26667, 4.13333, 4.8, 5.93333, 5.93333, 5.93333, 4.8, 4.8, 4.13333, 4.13333, 4.13333, 4.8, 4.13333, 4.8, 4.13333, 5.93333, 5.93333, 4.13333, 4.8}

31. M~z\ShiTOM`\GnC^_
{4., 5., 5., 4.33333, 4.33333, 7.66667, 7.66667, 4.33333, 4.33333, 5., 5., 7.66667, 7.66667, 7.66667, 4., 5., 4.33333, 7.66667, 4., 5., 4.33333, 7.66667, 7.66667, 4.33333, 5., 7.66667, 4.33333, 5., 7.66667, 4., 7.66667, 4.33333, 5., 4., 4.33333, 7.66667, 5., 5., 4.33333, 7.66667, 5., 7.66667, 4.33333, 4.33333, 5., 4., 4., 5., 4.33333}

32. M~~~{@@GWb‘N@^?~_
{4., 4., 4., 4., 4., 4., 14., 4., 4., 4., 4., 4., 14., 4., 4., 4., 4., 14., 4., 4., 4., 14., 4., 4., 14., 4., 14., 14., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4., 4.}

33. Mv~neEcUxz@|D|W^_
3.66667, 3.66667, 4.13333, 4.13333, 4.26667, 4.26667, 5.93333, 5.93333, 4.13333, 4.26667, 5.93333, 4.13333, 4.26667, 3.66667, 5.93333, 4.26667, 4.13333, 4.13333, 5.93333, 4.26667, 3.66667, 5.93333, 3.66667, 3.66667, 4.26667, 5.93333, 5.93333, 3.66667, 5.93333, 4.26667, 5.93333, 3.66667, 4.13333, 4.26667, 5.93333, 3.66667, 4.13333, 5.93333, 4.26667, 4.13333, 5.93333, 4.26667, 4.13333, 3.66667, 5.93333, 4.13333, 4.13333, 4.26667, 3.66667, 3.66667, 4.26667, 3.66667, 4.26667, 3.66667, 4.13333, 4.13333}

34. M}nMTao^y^H{LzLz?
{3.83333, 3.83333, 3.83333, 3.83333, 5.16667, 5.16667, 5.16667, 5.16667, 5.16667, 5.16667, 3.83333, 3.83333, 3.83333, 5.16667, 5.16667, 5.16667, 3.83333, 3.83333, 3.83333, 5.16667, 5.16667, 5.16667, 3.83333, 3.83333, 3.83333, 5.16667, 5.16667, 3.83333, 3.83333, 3.83333, 5.16667, 5.16667, 5.16667, 3.83333, 3.83333, 5.16667, 5.16667, 5.16667, 3.83333, 3.83333, 5.16667, 5.16667, 5.16667, 5.16667, 5.16667, 3.83333, 3.83333, 5.16667, 5.16667, 5.16667, 3.83333, 3.83333, 3.83333, 3.83333, 3.83333, 3.83333}

35. M}nncUTVXvItJtW^_
{4.46667, 4.46667, 4.13333, 4.13333, 4.26667, 4.26667, 5.13333, 5.13333, 4.26667, 4.26667, 4.13333, 4.46667, 5.13333, 4.13333, 5.13333, 4.26667, 4.46667, 4.13333, 5.13333, 4.13333, 5.13333, 5.13333, 4.46667, 4.13333, 5.13333, 4.26667, 4.46667, 4.46667, 4.13333, 4.26667, 5.13333, 4.46667, 5.13333, 4.13333, 5.13333, 4.26667, 5.13333, 4.13333, 4.26667, 5.13333, 4.26667, 4.46667, 4.13333, 4.26667, 4.46667, 4.13333, 4.46667, 4.26667, 4.46667, 4.46667, 4.26667, 4.46667, 4.26667, 5.13333, 4.13333, 4.13333}

36. M}n~Ub@Jyz@}KzKn_
{2.66667, 4.46667, 4.3, 4.3, 4.13333, 5.1, 5.1, 5.93333, 5.1, 4.13333, 4.3, 5.93333, 4.46667, 5.1, 4.3, 4.13333, 4.3, 2.66667, 4.3, 5.93333, 5.1, 5.1, 4.46667, 4.3, 2.66667, 5.1, 5.93333, 2.66667, 4.3, 4.46667, 5.93333, 5.1, 5.1, 5.1, 5.93333, 4.13333, 4.3, 5.1, 4.46667, 2.66667, 5.93333, 4.13333, 5.1, 4.3, 5.1, 4.3, 4.46667, 4.13333, 4.3, 2.66667, 4.3, 4.46667, 5.1, 4.3, 4.13333, 2.66667}

37. M~~vUUs@yUefA~D^_
{3., 3., 4., 4., 5., 5., 6., 6., 4., 5., 3., 6., 4., 5., 6., 3., 5., 4., 6., 5., 6., 6., 3., 4., 5., 6., 3., 4., 5., 6., 3., 6., 4., 5., 3., 6., 4., 5., 5., 3., 4., 6., 5., 3., 6., 4., 4., 4., 3., 3., 6., 3., 5., 5., 3., 4.}

38. M~~~}A‘QXb‘^D^@~_
{3., 3., 4., 4., 4., 4., 7., 7., 4., 4., 3., 4., 4., 7., 7., 3., 4., 4., 4., 7., 7., 4., 3., 4., 7., 7., 4., 3., 7., 7., 3., 7., 7., 7., 7., 3., 3., 4., 4., 4., 4., 4., 3., 4., 4., 4., 4., 3., 4., 4., 4., 3., 4., 4., 3., 3.}

39. Mv~neu|xa]evS~J^_
{3.33333, 3.33333, 3.33333, 3.33333, 4., 4., 4., 4., 4.66667, 4., 4., 4.66667, 3.33333, 3.33333, 4., 3.33333, 4., 4., 4., 3.33333, 4.66667, 3.33333, 4., 3.33333, 4., 4., 3.33333, 3.33333, 3.33333, 4.66667, 4., 3.33333, 3.33333, 3.33333, 4.66667, 4., 4., 3.33333, 4., 4., 3.33333, 4., 3.33333, 4.,

4., 3.33333, 4., 4., 3.33333, 4.66667, 4., 4.66667, 3.33333, 3.33333, 3.33333, 4., 4., 4., 3.33333, 3.33333, 3.33333, 3.33333, 4.}

40. Mv~vVJ‘wi~f}F|F}_
{2.5, 2.5, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 2.5, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 2.5, 2.5, 2.5, 4.14286, 4.14286, 4.14286, 4.14286, 2.5, 4.14286, 4.14286, 4.14286, 4.14286, 2.5, 4.14286, 4.14286, 4.14286, 4.14286, 2.5, 4.14286, 4.14286, 4.14286, 4.14286, 2.5, 4.14286, 4.14286, 4.14286, 4.14286, 2.5, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 2.5, 2.5, 2.5}

41. M}nneUt}A~f}R|L}_
{3.07143, 3.07143, 3.57143, 3.57143, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 3.07143, 4.14286, 3.57143, 3.57143, 4.14286, 4.14286, 3.07143, 4.14286, 4.14286, 3.57143, 3.57143, 4.14286, 4.14286, 3.57143, 4.14286, 3.07143, 3.07143, 4.14286, 4.14286, 3.57143, 4.14286, 3.07143, 4.14286, 3.07143, 4.14286, 3.07143, 4.14286, 4.14286, 3.57143, 4.14286, 3.07143, 4.14286, 4.14286, 4.14286, 3.57143, 3.57143, 3.57143, 4.14286, 3.07143, 4.14286, 4.14286, 3.57143, 4.14286, 3.07143, 4.14286, 4.14286, 4.14286, 4.14286, 3.07143, 3.07143, 3.57143}

42. M~~~ffKrHfe^B~B~_
{2., 3.33333, 3.33333, 3.33333, 3.33333, 4.66667, 4.66667, 4.66667, 4.66667, 3.33333, 3.33333, 3.33333, 3.33333, 4.66667, 4.66667, 4.66667, 4.66667, 2., 4.66667, 4.66667, 3.33333, 3.33333, 4.66667, 4.66667, 4.66667, 4.66667, 3.33333, 3.33333, 4.66667, 4.66667, 2., 3.33333, 3.33333, 4.66667, 4.66667, 3.33333, 3.33333, 4.66667, 4.66667, 2., 3.33333, 3.33333, 4.66667, 4.66667, 3.33333, 3.33333, 4.66667, 4.66667, 2., 4.66667, 4.66667, 3.33333, 3.33333, 4.66667, 4.66667, 3.33333, 3.33333, 2., 3.33333, 3.33333, 3.33333, 3.33333, 2.}

43. M~~~~ARbYjh^M^H~_
{3.33333, 3.33333, 3.33333, 3.33333, 3.33333, 3.33333, 4.66667, 4.66667, 4.66667, 3.33333, 3.33333, 3.33333, 3.33333, 3.33333, 4.66667, 4.66667, 4.66667, 3.33333, 3.33333, 3.33333, 3.33333, 4.66667, 4.66667, 4.66667, 3.33333, 3.33333, 3.33333, 4.66667, 4.66667, 4.66667, 3.33333, 3.33333, 4.66667, 4.66667, 4.66667, 3.33333, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 3.33333}

44. M~~~~BHkYVenB~D~_
{2.66667, 2.66667, 3.33333, 3.33333, 4., 4., 4.66667, 4.66667, 4.66667, 3.33333, 4., 2.66667, 4., 3.33333, 4.66667, 4.66667, 4.66667, 2.66667, 4., 3.33333, 4., 4.66667, 4.66667, 4.66667, 4., 2.66667, 3.33333, 4.66667, 4.66667, 4.66667, 3.33333, 2.66667, 4.66667, 4.66667, 4.66667, 2.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 4.66667, 2.66667, 2.66667, 3.33333, 3.33333, 4., 4., 3.33333, 2.66667, 4., 3.33333, 4., 4., 2.66667, 4., 3.33333, 4., 2.66667, 3.33333, 3.33333, 2.66667, 2.66667}

45. M~~ne]v}nyH~L~F~_

{2.5, 2.5, 3., 3., 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3., 3.5, 2.5, 3.5, 3.5, 3.5, 3.5, 3., 3.5, 2.5, 3.5, 3.5, 3.5, 3.5, 3., 3.5, 3.5, 3.5, 3., 3.5, 2.5, 3.5, 3.5, 3.5, 3., 3.5, 3.5, 2.5, 3.5, 3.5, 2.5, 3.5, \
2.5, 3., 3.5, 3.5, 3.5, 2.5, 2.5, 3.5, 3., 3.5, 3.5, 3., 2.5, 3.5, 3., 3., 3.5, 2.5, 3., 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3., 2.5, 2.5}

46. M~~nm]v}Nqh~L~F~_
{2.5, 2.5, 3., 3., 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3., 3.5, 2.5, 3.5, 3.5, 3.5, 3.5, 3., 3.5, 2.5, 3.5, 3.5, 3.5, 3.5, 3., 3.5, 3.5, 3.5, 3.5, 3.5, 2.5, 3., 3.5, 3.5, 3.5, 3.5, 3., 2.5, 3.5, 3.5, 2.5, 2.5, \
3., 3., 3.5, 3.5, 3., 2.5, 3.5, 3., 3.5, 3.5, 3.5, 2.5, 3.5, 3., 3.5, 3.5, 2.5, 3., 2.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3., 2.5, 2.5}

47. M~~~~JXi{nm^R~N^_
{3., 3., 3., 3., 3., 3., 3.5, 3.5, 3.5, 3.5, 3., 3., 3., 3., 3., 3.5, 3.5, 3.5, 3.5, 3., 3., 3., 3., 3.5, 3.5, 3.5, 3.5, 3., 3., 3., 3.5, 3.5, 3.5, 3.5, 3., 3., 3.5, 3.5, 3.5, 3.5, 3., 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3., 3.}

48. M~~~vjjx}~v}V~N~_
{2.4, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.4, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.4, 2.4}

49. M~~~~rj|]^u~V~N~_
{2.4, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.4, 2.8, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.8, 2.4, 2.8, 2.8, 2.4, 2.4}

50. M~~~~zz|~^z~n~^~_
K_{14}- perfect matching: (edge-transitive)

51. M~~~~~~~~~~~~~~~_
K_{14}: (edge-transitive)

Vertex-transitive graphs with 15 vertices
(With edge betweenness values for graphs that are not edge-transitive).

1. NqGG_CC?GA?@?C??_?g
C_{15}: (edge-transitive)

2. Ns‘Ha_gOG‘@HGS@e?oo
$C_{15}(1,4)$: (edge-transitive)

3. Ns‘Ha_hOHAA@AD@a_q_
$C_{15}(1,6)$ (non-edge-transitive)

4. Ns‘jaOoA?__T@S?I_Ig

{11.6667, 11.6667, 16.3333, 16.3333, 11.6667, 16.3333, 16.3333, 16.3333, 11.6667, 16.3333, 11.6667, 11.6667, 16.3333, 11.6667, 11.6667, 16.3333, 16.3333, 16.3333, 11.6667, 16.3333, 11.6667, 16.3333, 16.3333, 11.6667, 11.6667, 11.6667, 11.6667, 16.3333, 16.3333, 11.6667}

5. N{‘HackC?O?D?T?e_b_
{9.5, 9.5, 18.5, 18.5, 9.5, 18.5, 18.5, 18.5, 18.5, 9.5, 9.5, 18.5, 9.5, 9.5, 18.5, 9.5, 18.5, 9.5, 18.5, 18.5, 18.5, 9.5, 9.5, 18.5, 9.5, 18.5, 9.5, 18.5, 9.5, 9.5}

6. N{‘QPgiC?O_P@D?J?IW
{10., 10., 18., 18., 10., 18., 18., 18., 18., 10., 10., 18., 10., 10., 18., 10., 18., 10., 18., 18., 18., 18., 10., 10., 10., 10., 18., 10., 10., 18.}

7. N{dAH¿C_WAEAQ@J?YO
Line Graph of the Petersen Graph: (edge-transitive)

8. N}hPOSS???_X@K?M_J_
{7.6, 7.6, 24.4, 24.4, 24.4, 7.6, 24.4, 7.6, 24.4, 7.6, 24.4, 7.6, 24.4, 7.6, 24.4, 7.6, 24.4, 7.6, 24.4, 7.6, 24.4, 7.6, 24.4, 7.6, 24.4, 24.4, 24.4, 7.6, 7.6, 7.6}

9. NsaCB|}[B_M?BfBf@r_
Trpl(C_5) (edge-transitive)

10. NuqtQdKKpXAeAqOXcBw
{8.66667, 8.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 8.66667, 6.66667, 6.66667, 6.66667, 6.66667, 8.66667, 8.66667, 8.66667, 6.66667, 6.66667, 8.66667, 8.66667, 6.66667, 6.66667, 6.66667, 8.66667, 6.66667, 6.66667, 8.66667, 6.66667, 6.66667, 8.66667, 6.66667, 6.66667, 8.66667, 6.66667, 8.66667, 6.66667, 8.66667, 6.66667, 6.66667, 6.66667, 6.66667, 6.66667, 8.66667}

11. N{aCA{}R‘kHPLDQIeIg
{7.13333, 7.13333, 7.93333, 7.93333, 6.93333, 6.93333, 7.13333, 7.93333, 6.93333, 6.93333, 7.93333, 7.93333, 6.93333, 6.93333, 7.93333, 7.13333, 6.93333, 6.93333, 7.93333, 7.13333, 6.93333, 7.13333, 6.93333, 7.93333, 7.13333, 7.93333, 6.93333, 7.13333, 7.93333, 7.13333, 6.93333, 7.93333, 7.93333, 7.13333, 7.13333, 7.13333, 7.13333, 7.13333, 7.93333, 7.13333, 7.93333, 7.93333, 6.93333, 6.93333, 6.93333}

12. N{eCIhSQqTEXKkJQde_
$(6, 2)$ Kneser graph: (edge-transitive)

13. N}iCA[vE_wIPJDOmcj_
{6.33333, 6.33333, 7., 7., 8.66667, 8.66667, 7., 6.33333, 8.66667, 7., 8.66667, 6.33333, 8.66667, 7., 8.66667, 8.66667, 8.66667, 7., 6.33333, 8.66667, 7., 8.66667, 6.33333, 6.33333, 7., 7., 8.66667, 6.33333, 7., 6.33333, 7., 8.66667, 6.33333, 6.33333, 7., 7., 6.33333, 6.33333, 8.66667, 6.33333, 8.66667, 6.33333, 8.66667, 7., 7.}

14. N}iCIs{RHe@gChOfcbo
{6.33333, 6.33333, 7.33333, 7.33333, 8.33333, 8.33333, 7.33333, 6.33333, 7.33333, 8.33333, 8.33333, 6.33333, 7.33333, 8.33333, 8.33333, 6.33333, 8.33333, 7.33333, 8.33333, 8.33333, 6.33333, 7.33333, 8.33333, 8.33333, 7.33333, 6.33333, 7.33333, 6.33333, 7.33333, 6.33333,

7.33333, 6.33333, 6.33333, 8.33333, 6.33333, 8.33333, 8.33333, 7.33333, 7.33333, 8.33333, 6.33333, 7.33333, 6.33333, 6.33333, 7.33333}

15. N}jLbXqB?c_T@TAVaFo
{4., 4., 9., 9., 9., 9., 4., 9., 9., 9., 9., 9., 9., 9., 9., 4., 4., 9., 9., 4., 4., 9., 9., 4., 9., 9., 4., 9., 9., 9., 9., 9., 9., 9., 4., 4., 9., 4., 9., 4., 9., 9., 4., 4., 9.}

16. N}nDAwyAgiGbGe?r_ew
{5., 5., 6., 6., 11., 11., 11., 6., 5., 6., 11., 6., 5., 6., 11., 5., 5., 11., 11., 11., 5., 11., 6., 6., 5., 11., 6., 6., 5., 11., 5., 11., 5., 11., 11., 6., 5., 6., 11., 5., 6., 5., 5., 6., 6.}

17. N}qtRhiD?SAJAM?n_jo
{4., 4., 9., 9., 9., 9., 4., 9., 9., 9., 9., 9., 9., 9., 9., 4., 4., 9., 9., 4., 4., 9., 9., 4., 9., 9., 4., 9., 9., 9., 9., 9., 9., 4., 9., 9., 4., 9., 4., 4., 9., 9., 4., 4., 9.}

18. N~zLaWqCgY?U@R?N_Jw
{4., 4., 7.33333, 7.33333, 12.6667, 12.6667, 7.33333, 12.6667, 4., 7.33333, 12.6667, 4., 12.6667, 7.33333, 12.6667, 4., 7.33333, 12.6667, 4., 7.33333, 12.6667, 4., 7.33333, 12.6667, 4., 7.33333, 12.6667, 4., 7.33333, 12.6667, 4., 7.33333, 12.6667, 4., 7.33333, 12.6667, 4., 12.6667, 7.33333, 12.6667, 4., 7.33333, 7.33333, 4., 4.}

19. N~}CAKeOhI@VDUCl@hW
{5.33333, 5.33333, 6., 6., 10.6667, 10.6667, 6., 5.33333, 6., 10.6667, 10.6667, 6., 5.33333, 10.6667, 10.6667, 5.33333, 10.6667, 10.6667, 10.6667, 10.6667, 5.33333, 10.6667, 5.33333, 6., 6., 10.6667, 5.33333, 5.33333, 6., 6., 6., 5.33333, 6., 6., 5.33333, 6., 6., 10.6667, 5.33333, 10.6667, 6., 5.33333, 5.33333, 5.33333, 10.6667}

20. N~}CIHBHPDaiCjBT@TW
{6., 6., 6., 6., 10., 10., 6., 6., 6., 10., 10., 6., 6., 10., 10., 6., 10., 10., 10., 10., 10., 6., 6., 6., 6., 6., 6., 6., 6., 10., 6., 6., 6., 6., 6., 6., 10., 6., 6., 6., 6., 10., 6., 6., 10.}

21. Nv~neEdUpxGmGzBNaZw
{3.8, 3.8, 4.93333, 4.93333, 5.13333, 5.13333, 6.13333, 6.13333, 4.93333, 5.13333, 6.13333, 4.93333, 5.13333, 3.8, 6.13333, 5.13333, 4.93333, 4.93333, 6.13333, 5.13333, 3.8, 6.13333, 3.8, 3.8, 5.13333, 6.13333, 6.13333, 3.8, 6.13333, 5.13333, 6.13333, 3.8, 4.93333, 6.13333, 5.13333, 3.8, 4.93333, 6.13333, 5.13333, 6.13333, 4.93333, 3.8, 5.13333, 4.93333, 4.93333, 5.13333, 3.8, 4.93333, 5.13333, 6.13333, 3.8, 5.13333, 3.8, 6.13333, 4.93333, 3.8, 4.93333, 4.93333, 3.8, 5.13333}

22. N}nLeA_Vx~H{LxQyemg
{4.0381, 4.0381, 4.60952, 4.60952, 5.27619, 5.27619, 6.07619, 6.07619, 6.07619, 5.27619, 4.60952, 4.0381, 4.60952, 5.27619, 6.07619, 5.27619, 4.60952, 4.0381, 4.60952, 5.27619, 6.07619, 4.60952, 4.0381, 4.0381, 5.27619, 6.07619, 6.07619, 4.0381, 5.27619, 4.0381, 6.07619, 6.07619, 4.60952, 6.07619, 4.0381, 6.07619, 5.27619, 6.07619, 4.60952, 6.07619, 4.0381, 5.27619, 5.27619, 6.07619, 4.60952, 5.27619, 4.0381, 4.60952, 6.07619, 5.27619, 5.27619, 4.60952, 4.60952, 4.0381, 4.0381, 4.0381, 4.0381, 4.60952, 4.60952, 5.27619}

23. N}nLeEd]rxI{JwAnajw

{4., 4., 5.33333, 5.33333, 5.33333, 5.33333, 5.33333, 5.33333, 5.33333, 4., 5.33333, 5.33333, 5.33333, 5.33333, 5.33333, 4., 5.33333, 5.33333, 5.33333, 5.33333, 5.33333, 5.33333, 5.33333, 4., 5.33333, 5.33333, 5.33333, 5.33333, 5.33333, 4., 5.33333, 5.33333, 4., 4., 5.33333, 5.33333, 5.33333, 4., 4., 5.33333, 5.33333, 5.33333, 5.33333, 5.33333, 4., 5.33333, 5.33333, 5.33333, 5.33333, 4., 5.33333, 5.33333, 5.33333, 5.33333, 5.33333, 5.33333, 4., 4., 5.33333, 4.}

24. N}nT^AWQyZe\L\XjByW

{4.4, 4.4, 4.4, 4.4, 5.2, 5.2, 6., 6., 5.2, 6., 4.4, 4.4, 6., 4.4, 5.2, 6., 4.4, 4.4, 4.4, 6., 5.2, 5.2, 4.4, 4.4, 6., 4.4, 5.2, 4.4, 4.4, 4.4, 6., 5.2, 5.2, 6., 6., 4.4, 4.4, 6., 6., 4.4, 4.4, 4.4, 5.2, 5.2, 4.4, 6., 5.2, 4.4, 4.4, 5.2, 6., 4.4, 5.2, 4.4, 5.2, 4.4, 4.4, 4.4, 4.4, 6.}

25. N}n\vB‘Th]HfKuBZa]w

{3.8, 3.8, 4.8, 4.8, 5.6, 5.6, 5.8, 5.8, 5.8, 5.6, 4.8, 5.8, 3.8, 4.8, 5.6, 5.6, 4.8, 3.8, 5.8, 4.8, 5.6, 5.6, 4.8, 3.8, 3.8, 5.8, 5.8, 3.8, 4.8, 3.8, 5.8, 5.8, 5.6, 5.8, 3.8, 5.8, 5.8, 5.6, 3.8, 5.8, 3.8, 5.6, 4.8, 4.8, 5.6, 5.6, 4.8, 5.6, 4.8, 4.8, 5.8, 3.8, 5.8, 4.8, 3.8, 3.8, 5.6, 5.6, 3.8, 4.8}

26. N}nfMQoUxz@|D{Qreew

{3.66667, 3.66667, 5.13333, 5.13333, 5.26667, 5.26667, 5.93333, 5.93333, 5.26667, 5.93333, 5.26667, 3.66667, 5.13333, 5.13333, 5.93333, 5.93333, 3.66667, 5.26667, 5.13333, 5.13333, 5.93333, 5.13333, 3.66667, 3.66667, 5.93333, 5.26667, 5.26667, 3.66667, 5.93333, 3.66667, 5.26667, 5.26667, 3.66667, 5.93333, 5.13333, 5.93333, 5.13333, 5.93333, 5.93333, 5.13333, 5.13333, 5.13333, 5.26667, 5.26667, 5.93333, 3.66667, 5.26667, 5.13333, 5.93333, 5.26667, 3.66667, 3.66667, 5.26667, 3.66667, 5.26667, 3.66667, 5.13333, 5.13333, 3.66667, 5.93333}

27. N}qtSqF[zZJsNoPvfFo

$\overline{K3 \times K5}$: (edge-transitive)

28. N~zDMQoFw~H\L\Rkexg

{3.6, 3.6, 4.93333, 4.93333, 5.73333, 5.73333, 5.73333, 5.73333, 4.93333, 5.73333, 3.6, 5.73333, 4.93333, 5.73333, 5.73333, 3.6, 5.73333, 5.73333, 4.93333, 5.73333, 5.73333, 3.6, 5.73333, 5.73333, 4.93333, 5.73333, 3.6, 5.73333, 5.73333, 4.93333, 5.73333, 3.6, 4.93333, 5.73333, 5.73333, 3.6, 4.93333, 5.73333, 4.93333, 5.73333, 4.93333, 3.6, 5.73333, 4.93333, 3.6, 5.73333, 5.73333, 4.93333, 5.73333, 5.73333, 3.6, 5.73333, 3.6, 3.6, 3.6, 3.6, 5.73333, 4.93333, 4.93333, 5.73333}

29. N~~DKmNXaihfKuIlbLw

$(6, 2)$ Johnson graph: (edge-transitive)

30. N~~EDIaFw~IlS{Jldxo

{3.6, 3.6, 4.93333, 4.93333, 5.73333, 5.73333, 5.73333, 5.73333, 4.93333, 3.6, 4.93333, 5.73333, 5.73333, 5.73333, 5.73333, 4.93333, 3.6, 5.73333, 5.73333, 5.73333, 5.73333, 3.6, 5.73333, 5.73333, 5.73333, 5.73333, 5.73333, 5.73333, 5.73333, 5.73333, 3.6, 5.73333, 4.93333, 3.6, 5.73333, 4.93333, 3.6, 4.93333, 5.73333, 3.6, 4.93333, 5.73333, 5.73333, 4.93333, 4.93333, 5.73333, 3.6, 4.93333, 5.73333, 5.73333, 4.93333, 3.6, 3.6, 3.6, 3.6, 3.6, 5.73333, 4.93333, 4.93333, 5.73333}

31. N~~vUUsQph?^@^DN‘Zw

{3., 3., 4.33333, 4.33333, 5.66667, 5.66667, 7., 7., 4.33333, 5.66667, 3., 7., 4.33333, 5.66667, 7., 3., 5.66667, 4.33333, 7., 5.66667, 7., 7., 3., 4.33333, 5.66667, 7., 3., 4.33333, 5.66667, 7., 3., 4.33333, 7., 5.66667, 3., 4.33333, 7., 5.66667, 3., 5.66667, 7., 4.33333, 3., 7., 5.66667, 4.33333, 4.33333, 5.66667, 7., 3., 5.66667, 4.33333, 3., 7., 3., 4.33333, 3., 3., 4.33333, 5.66667}

32. N~~~FFbF?wbb?~?~_^w

{2., 2., 6., 6., 6., 6., 6., 6., 2., 6., 6., 6., 6., 6., 6., 6., 6., 6., 6., 6., 6., 2., 2., 6., 6., 6., 2., 6., 6., 6., 6., 6., 6., 2., 2., 6., 6., 6., 2., 6., 6., 6., 6., 6., 6., 2., 2., 6., 6., 6., 2., 6., 6., 6., 6., 6., 6., 2., 2., 2.}

33. Nv~~uu|xNEhzLnS~dnw

{3.14286, 3.14286, 3.14286, 3.14286, 3.71429, 3.71429, 3.71429, 3.71429, 4.28571, 4.28571, 3.71429, 3.71429, 4.28571, 3.14286, 3.14286, 4.28571, 3.71429, 3.14286, 3.71429, 3.71429, 3.71429, 3.14286, 4.28571, 3.14286, 3.71429, 4.28571, 3.14286, 3.71429, 3.14286, 3.71429, 3.14286, 3.71429, 3.14286, 4.28571, 4.28571, 3.14286, 3.71429, 3.14286, 3.71429, 4.28571, 4.28571, 3.14286, 3.14286, 4.28571, 3.71429, 3.71429, 3.14286, 3.14286, 3.71429, 4.28571, 3.71429, 4.28571, 3.71429, 3.71429, 3.14286, 4.28571, 3.71429, 3.71429, 4.28571, 3.14286, 3.14286, 3.71429, 3.14286, 3.71429, 3.14286, 3.14286, 3.71429, 3.14286, 3.71429, 3.71429, 3.14286, 3.14286, 3.14286, 3.14286, 3.71429}

34. N}nnmUt}NqJ~N}R}e~g

{2.94444, 2.94444, 3.38889, 3.38889, 3.88889, 3.88889, 3.88889, 3.88889, 3.88889, 3.88889, 3.88889, 3.88889, 3.88889, 2.94444, 3.88889, 3.88889, 3.38889, 3.38889, 3.88889, 3.88889, 2.94444, 3.88889, 3.88889, 3.38889, 3.88889, 3.38889, 3.88889, 3.88889, 3.88889, 3.88889, 2.94444, 3.38889, 2.94444, 3.88889, 3.88889, 3.88889, 3.88889, 3.38889, 2.94444, 3.88889, 2.94444, 3.88889, 2.94444, 3.38889, 3.88889, 3.88889, 3.38889, 3.88889, 3.38889, 3.88889, 3.88889, 3.88889, 3.38889, 3.88889, 2.94444, 3.38889, 3.88889, 2.94444, 3.88889, 2.94444, 3.88889, 3.38889, 3.88889, 2.94444, 3.88889, 3.88889, 3.88889, 3.88889, 3.88889, 3.88889, 3.88889, 3.88889, 2.94444, 2.94444, 3.38889}

35. N}n~vVY|TxI~J}Q~enw

{3.07143, 3.07143, 3.07143, 3.07143, 3.57143, 3.57143, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 3.57143, 4.14286, 3.07143, 3.57143, 4.14286, 3.07143, 3.07143, 4.14286, 3.57143, 3.07143, 4.14286, 3.07143, 3.57143, 4.14286, 3.07143, 4.14286, 4.14286, 3.07143, 4.14286, 3.07143, 4.14286, 3.57143, 3.07143, 4.14286, 4.14286, 3.07143, 4.14286, 3.57143, 3.07143, 3.07143, 4.14286, 3.07143, 3.07143, 4.14286, 4.14286, 3.57143, 3.07143, 3.07143, 4.14286, 4.14286, 3.57143, 3.07143, 4.14286, 3.57143, 3.07143, 4.14286, 3.07143, 3.57143, 4.14286, 3.07143, 4.14286, 3.57143,4.14286, 4.14286, 3.07143, 4.14286, 3.57143, 4.14286, 3.07143, 3.07143, 3.07143, 3.07143, 3.07143, 3.57143}

36. N}n~}qxyniI~J}Q~enw

{3.07143, 3.07143, 3.07143, 3.07143, 3.57143, 3.57143, 4.14286, 4.14286, 4.14286, 4.14286, 4.14286, 3.57143, 3.57143, 3.07143, 4.14286, 4.14286, 3.07143, 3.07143, 4.14286, 3.57143, 3.07143, 3.57143, 4.14286, 3.07143, 4.14286, 3.07143, 4.14286, 4.14286, 3.07143, 4.14286, 3.07143, 4.14286, 3.57143, 3.07143, 4.14286, 4.14286, 3.07143, 4.14286, 3.07143, 3.57143, 3.07143, 4.14286, 3.07143, 3.07143, 4.14286, 4.14286, 4.14286, 3.07143, 4.14286, 4.14286, 4.14286, 3.07143, 3.07143, 3.57143, 4.14286, 3.07143, 3.57143, 3.07143, 4.14286, 3.57143, 3.57143, 3.07143, 4.14286, 3.57143, 3.07143, 4.14286, 3.57143, 4.14286, 4.14286, 3.07143, 3.07143, 3.07143, 3.07143, 3.07143, 3.57143}

37. N}rED}}nd{N~^}^}N~?
$K_{15} - 3K_5$: (edge-transitive)

38. N~z^c}nplqlzU}\^fvo
{3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 4., 4., 3.5, 3.5, 4., 3.5, 3.5, 3.5, 3.5, 4., 3.5, 3.5, 3.5, 3.5, 4., 3.5, 3.5, 4., 3.5, 4., 3.5, 3.5, 3.5, 3.5, 3.5, 4., 3.5, 3.5, 3.5, 3.5, 3.5, 4., 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 4., 4., 3.5, 3.5, 4., 3.5, 3.5, 3.5, 3.5, 4., 3.5, 3.5, 3.5, 3.5, 4., 3.5, 4., 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3.5, 3.5}

39. N~~]|yzxfBivRvK~dnw
{3.14286, 3.14286, 3.14286, 3.14286, 3.71429, 3.71429, 3.71429, 3.71429, 4.28571, 4.28571, 4.28571, 3.71429, 3.71429, 3.14286, 3.14286, 3.14286, 4.28571, 3.71429, 3.71429, 3.71429, 3.71429, 3.14286, 3.14286, 4.28571, 3.14286, 3.71429, 3.71429, 3.14286, 3.71429, 3.14286, 3.71429, 3.14286, 4.28571, 4.28571, 3.14286, 3.71429, 3.14286, 3.71429, 4.28571, 4.28571, 3.14286, 4.28571, 3.71429, 3.71429, 3.14286, 4.28571, 4.28571, 3.71429, 3.14286, 3.71429, 4.28571, 3.14286, 3.71429, 4.28571, 3.71429, 3.14286, 3.71429, 4.28571, 3.14286, 3.71429, 3.14286, 3.14286, 3.14286, 3.71429, 3.71429, 3.71429, 3.71429, 3.14286, 3.14286, 3.14286, 3.14286, 3.71429, 3.71429, 3.14286, 3.14286}

40. N~~~vjiqlih^L^B~a~w
{2.57143, 2.57143, 3.14286, 3.14286, 3.71429, 3.71429, 4.28571, 4.28571, 4.28571, 4.28571, 3.14286, 3.71429, 2.57143, 4.28571, 3.14286, 4.28571, 3.71429, 4.28571, 4.28571, 2.57143, 3.71429, 3.14286, 4.28571, 3.71429, 4.28571, 4.28571, 4.28571, 4.28571, 2.57143, 4.28571, 3.14286, 3.71429, 4.28571, 4.28571, 4.28571, 2.57143, 3.14286, 3.71429, 4.28571, 4.28571, 2.57143, 3.14286, 3.71429, 4.28571, 4.28571, 2.57143, 3.14286, 3.71429, 4.28571, 4.28571, 2.57143, 4.28571, 3.14286, 4.28571, 3.71429, 2.57143, 3.14286, 4.28571, 3.71429, 4.28571, 4.28571, 2.57143, 4.28571, 3.14286, 3.71429, 4.28571, 2.57143, 3.71429, 3.14286, 3.71429, 2.57143, 3.14286, 3.14286, 2.57143, 2.57143}

41. Nv~v~~}~Vx|^x~V~f~w
{2.36364, 2.36364, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.36364, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.36364, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364}

42. N~~vf^mv}~V~n}^~n~o
$K_{15} - 5K_3$ (edge-transitive)

43. N~~~~v{y~jx~l~V~f~w

{2.36364, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.72727, 2.36364, 2.72727, 2.72727, 2.36364, 2.36364}

44. N~~~~~~~~~~~~~~~~~w
K_{15}: (edge-transitive)