Corona Related V_4 Cordial graphs

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Abstract

*Let $< A , *>$ be any abelian group. A graph G = (V(G), E(G)) is said to be A-cordial[6,9] if there is a mapping f: V(G) →A which satisfies the following two conditions with each edge e= uv is labeled as f(u)*f(v),*

$$(i)\left|v_f(a) - v_f(b)\right| \leq 1, \forall\ a,b \in A$$
$$(ii)\left|e_f(a) - e_f(b)\right| \leq 1, \forall\ a,b \in A$$

where $v_f(a)$= the number of vertices with label a
$v_f(b)$= the number of vertices with label b
$e_f(a)$= the number of edges with label a
$e_f(b)$= the number of edges with label b

*We note that if A = < V_4 , *> is a multiplicative group. Then the labeling is known as **V_4 Cordial Labeling.** A graph is called a **V_4 Cordial graph** if it admits a V_4 Cordial Labeling. In this paper F_n^+, C_n^+ , and H_n^+ are **V_4 Cordial graphs**.*

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Keywords and Phrases: *Cordial labeling, V_4Cordial Labeling and **V_4**Cordial Graph.*

1. Introduction:

By a graph, it means a finite undirected graph without loops or multiple edges. For graph theoretic terminology, we referred Harary[4]. For labeling of graphs, we referred Gallian[1].

A vertex labeling of a graph G is an assignment of labels to the vertices of G that induces for each edge *uv* a label depending on the vertex labels of *u* and *v*.

A graph *G* is said to be labeled if the *n* vertices are distinguished from a given set, which induces distinguish edge values satisfying certain conditions. The concept of graceful labeling was introduced by Rosa[3] in 1967 and subsequently by Golomb[2]. In this paperF_n^+, C_n^+ , and H_n^+ are V_4 Cordial graphs.

2. Preliminaries

Definition 2.1:

Let G = (V,E) be a simple graph. Let f:V(G)→{0,1} and for each edge uv , assign the label |f(u) − f(v)|. f is called a **cordial labeling** if the number of vertices labeled 0 and the the number of vertices labeled 1 differ by atmost 1 and also the number of edges labeled 0 and the the number of edges labeled 1 differ by atmost 1. A graph is called **Cordial** if it has a cordial labeling.

Definition 2.2:

Let $< A , *>$ be any abelian group. A graph G = (V(G), E(G)) is said to be A-cordial[6,9] if there is a mapping f: V(G) →A which satisfies the following two conditions with each edge e= uv is labeled as f(u)*f(v).

(i)$\left|v_f(a) - v_f(b)\right| \leq 1, \forall$ a,b∈A
(ii)$\left|e_f(a) - e_f(b)\right| \leq 1, \forall$ a,b∈A
where $v_f(a)$= the number of vertices with label a
$v_f(b)$= the number of vertices with label b

$e_f(a)$= the number of edges with label a
$e_f(b)$= the number of edges with label b
We note that if A = < V_4 , *> is a multiplicative group. Then the labeling is known as
V_4 Cordial Labeling. A graph is called a **V_4 Cordial graph** if it admits a V_4 Cordial Labeling.

Definition 2.3:

G^+ is a graph obtained from G by attaching a pendant vertex from each vertex of the graph G.

3.Main Results:

Theorem 3.1.

F_n^+ is a V_4 Cordial graph.

Proof:

Let V(F_n^+) ={$u, v, u_i: 1 \le i \le n, v_i: 1 \le i \le n$}.
Let E (F_n^+)= {$(uu_i) : 1 \le i \le n$}∪ {$(u_iu_{i+1}) : 1 \le i \le n-1$} ∪{$uv$}∪{$u_iv_i: 1 \le i \le n$ }.
Define f : V(F_n^+) → V_4 by
Let f(u) = 1 , f(v) = i

$$f(u_i) = \begin{cases} -i & if\ i \equiv 0(mod\ 4) \\ -1 & if\ i \equiv 1(mod\ 4) \\ i & if\ i \equiv 2(mod\ 4) \\ 1 & if\ i \equiv 3(mod\ 4) \end{cases}, \quad 1 \le i \le n$$

$$f(v_i) = \begin{cases} i & if\ i \equiv 0(mod\ 4) \\ 1 & if\ i \equiv 1(mod\ 4) \\ -i & if\ i \equiv 2(mod\ 4) \\ -1 & if\ i \equiv 3(mod\ 4) \end{cases}, \quad 1 \le i \le n$$

Case (i) : when n is even

The induced edge labelings are
f(u)* f(v) = i

$$f(u)*f(u_i) = \begin{cases} -i & if\ i \equiv 0(mod\ 4) \\ -1 & if\ i \equiv 1(mod\ 4) \\ i & if\ i \equiv 2(mod\ 4) \\ 1 & if\ i \equiv 3(mod\ 4) \end{cases}, \quad 1 \le i \le n$$

$$f(u_i)*f(u_{i+1}) = \begin{cases} -i & if\ i \equiv 1(mod\ 2) \\ i & if\ i \equiv 0(mod\ 2) \end{cases}, \quad 1 \le i \le n-1$$

$$f(u_i)*f(v_i) = \begin{cases} -1 & if\ i \equiv 1(mod\ 2) \\ 1 & if\ i \equiv 0(mod\ 2) \end{cases}, \quad 1 \le i \le n$$

Vertex Conditions:

$v_f(1)$=$v_f(i) = \frac{n}{2} + 1$ and $v_f(-i)$ =$v_f(-1) = \frac{n}{2}$
Hence, $|v_f(a) - v_f(b)| \le 1$, ∀ a,b∈ V_4.

Edge Conditions:

Let n=4k , k∈ *N*

$e_f(1) = e_f(i) = e_f(-1) = e_f(-i) = n - k$.

Let n=4k+2, k∈ *N*

$e_f(1) = e_f(-i) = n - k - 1$ and $e_f(-1) = e_f(i) = n - k$.
Hence, $|e_f(a) - e_f(b)| \le 1$, ∀ a,b∈ V_4.
Hence, F_n^+ is a V_4Cordial Graph .
For example, the V_4Cordial Labeling of F_6^+ and F_8^+ are shown in Figures 3.1.1 and 3.1.2.

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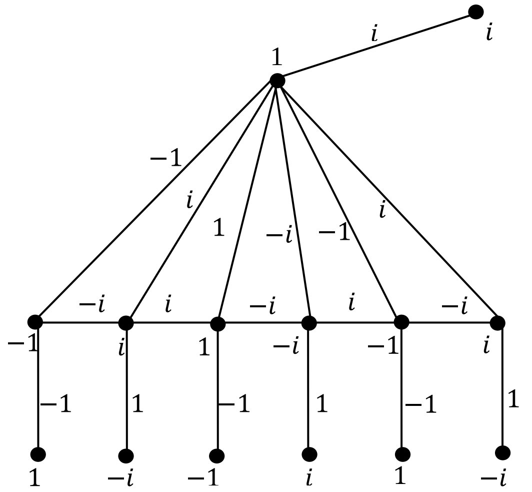

Figure3.1.1

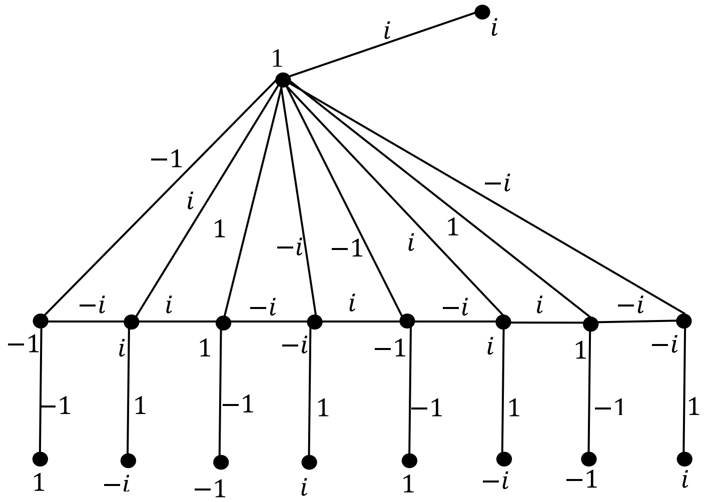

Figure3.1.2

Case (ii) : when n is odd

The induced edge labelings are

$f(u) * f(v) = 1$

$$f(u) * f(u_i) = \begin{cases} 1 & if\ i \equiv 0(mod\ 4) \\ -i & if\ i \equiv 1(mod\ 4) \\ -1 & if\ i \equiv 2(mod\ 4) \\ i & if\ i \equiv 3(mod\ 4) \end{cases} \quad , \ 1 \le i \le n$$

$$f(u_i) * f(u_{i+1}) = \begin{cases} -i & if\ i \equiv 1(mod\ 2) \\ i & if\ i \equiv 0(mod\ 2) \end{cases} \quad , \ 1 \le i \le n-1$$

$$f(u_i) * f(v_i) = \begin{cases} -1 & if\ i \equiv 1(mod\ 2) \\ 1 & if\ i \equiv 0(mod\ 2) \end{cases} \quad , \ 1 \le i \le n$$

Vertex Conditions:

$v_f(1) = v_f(i) = v_f(-i) = v_f(-1) = \frac{n+1}{2}$

Hence, $|v_f(a) - v_f(b)| \le 1$, $\forall$ a,b$\in$ V_4.

Edge Conditions:

Let n=4k +1, k$\in$ *N*

$e_f(1) = e_f(-1) = e_f(-i) = n - k$ and $e_f(i) = n - k - 1$.

Let n=4k+3, k∈ N

$e_f(1) = e_f(-i) = e_f(i) = n-k-1$ and $e_f(-1) = n-k$.

Hence, $|e_f(a) - e_f(b)| \leq 1$, ∀ a,b∈ V_4.

Hence, F_n^+ is a V_4Cordial Graph .

For example, the V_4Cordial Labeling of $F_5^+$and $F_7^+$are shown in Figures 3.1.3 and 3.1.4.

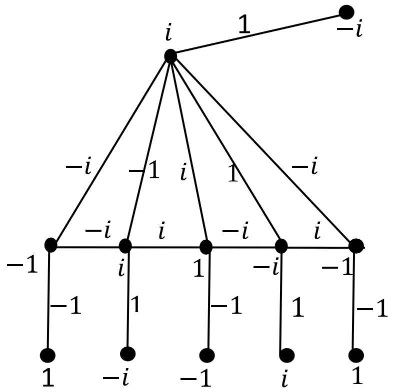

Figure3.1.3

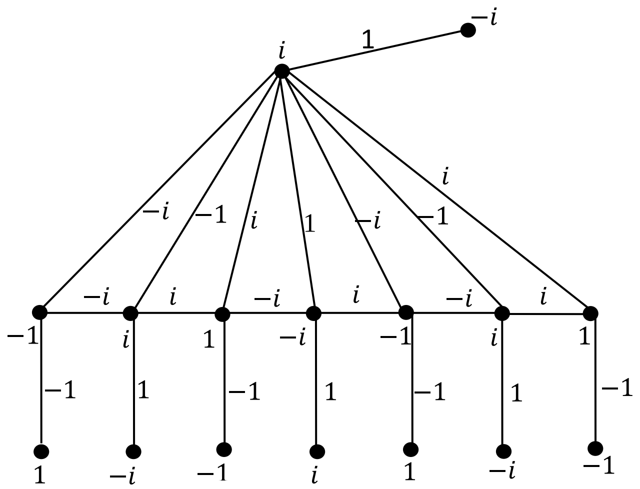

Figure3.1.4

Theorem 3.2.

C_n^+ is a V_4 Cordial graph.

Proof:

Let V(C_n^+) $=\{u_i : 1 \leq i \leq n \ , v_i : 1 \leq i \leq n\}$.

Let E (C_n^+) = $\{(u_i u_{i+1}) : 1 \leq i \leq n-1\} \cup \{u_n u_1\} \cup \{(u_i v_i) : 1 \leq i \leq n\}$.

Case(i): when n ≡ 0,1 (mod 4)

Define f : V(C_n^+) → V_4 by

$$f(u_i) = \begin{cases} -i & if\ i \equiv 0 (mod\ 4) \\ -1 & if\ i \equiv 1 (mod\ 4) \\ i & if\ i \equiv 2 (mod\ 4) \\ 1 & if\ i \equiv 3 (mod\ 4) \end{cases} \quad , \ 1 \leq i \leq n$$

$$f(v_i) = \begin{cases} i & if\ i \equiv 0(mod\ 4) \\ 1 & if\ i \equiv 1(mod\ 4) \\ -i & if\ i \equiv 2(mod\ 4) \\ -1 & if\ i \equiv 3(mod\ 4) \end{cases} ,1 \le i \le n$$

Subcase(i): when n ≡ 0(mod 4)

The induced edge labelings are

$$f(u_i) * f(u_{i+1}) = \begin{cases} -i & if\ i \equiv 1(mod\ 2) \\ i & if\ i \equiv 0(mod\ 2) \end{cases} , 1 \le i \le n$$

$$f(u_i) * f(v_i) = \begin{cases} -1 & if\ i \equiv 1(mod\ 2) \\ 1 & if\ i \equiv 0(mod\ 2) \end{cases} , 1 \le i \le n$$

Vertex Conditions:

Here, $v_f(1) = v_f(i) = v_f(-i) = v_f(-1) = \frac{n}{2}$

Hence, $|v_f(a) - v_f(b)| \le 1$, ∀ a,b∈ V_4.

Edge Conditions:

Here, $e_f(1) = e_f(i) = e_f(-1) = e_f(-i) = \frac{n}{2}$

Hence, $|e_f(a) - e_f(b)| \le 1$, ∀ a,b∈ V_4.

Hence, C_n^+ is a V_4Cordial graph.

For example, the V_4Cordial Labeling of C_8^+ is shown in the Figure 3.2.1.

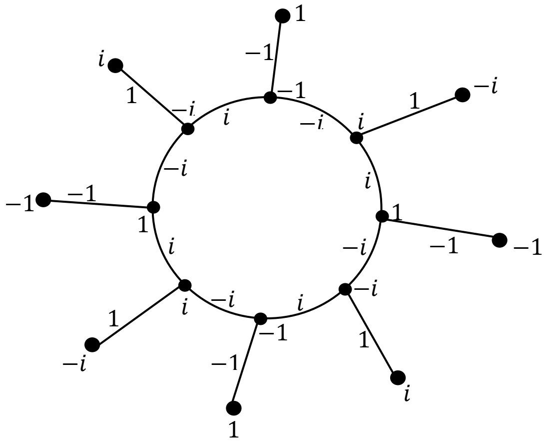

Figure 3.2.1

Subcase(ii): when n ≡ 1(mod 4)

The induced edge labelings are

$$f(u_i) * f(u_{i+1}) = \begin{cases} -i & if\ i \equiv 1(mod\ 2) \\ i & if\ i \equiv 0(mod\ 2) \end{cases} , 1 \le i \le n-1$$

$f(u_n) * f(u_1) = 1$

$$f(u_i) * f(v_i) = \begin{cases} -1 & if\ i \equiv 1(mod\ 2) \\ 1 & if\ i \equiv 0(mod\ 2) \end{cases} ,1 \le i \le n$$

Vertex Conditions:

Here, $v_f(1) = v_f(-1) = \frac{n+1}{2}$ and $v_f(i) = v_f(-i) = \frac{n-1}{2}$.

Hence, $|v_f(a) - v_f(b)| \le 1$, ∀ a,b∈ V_4.

Edge Conditions:

Here, $e_f(1) = e_f(-1) = \frac{n+1}{2}$ and $e_f(i) = e_f(-i) = \frac{n-1}{2}$.

Hence, $|e_f(a) - e_f(b)| \le 1$, ∀ a,b∈ V_4.

Hence, C_n^+ is a V_4Cordial graph.

For example, the V_4Cordial Labeling of C_9^+ is shown in the Figure 3.2.2.

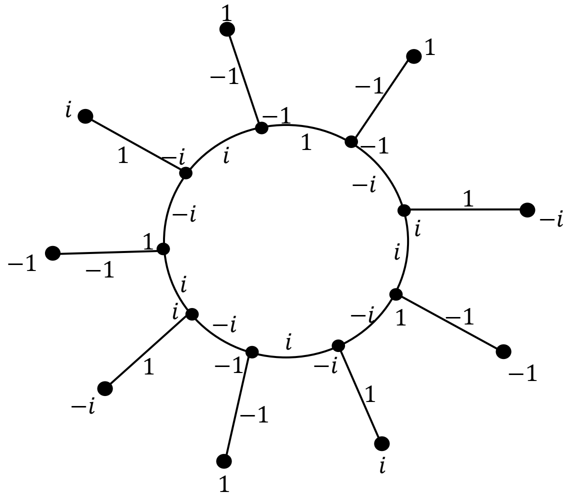

Figure 3.2.2

Case(ii): when n ≡ 2(mod 4)

Define f : V(C_n^+) → V_4 by

$$f(u_i) = \begin{cases} -i & if\ i \equiv 0(mod\ 4) \\ -1 & if\ i \equiv 1(mod\ 4) \\ i & if\ i \equiv 2(mod\ 4) \\ 1 & if\ i \equiv 3(mod\ 4) \end{cases}, 1 \le i \le n-2$$

$f(u_{n-1}) = 1$, $f(u_n) = -1$

$$f(v_i) = \begin{cases} i & if\ i \equiv 0(mod\ 4) \\ 1 & if\ i \equiv 1(mod\ 4) \\ -i & if\ i \equiv 2(mod\ 4) \\ -1 & if\ i \equiv 3(mod\ 4) \end{cases}, 1 \le i \le n-2$$

$f(v_{n-1}) = i$, $f(v_n) = -i$

The induced edge labelings are

$$f(u_i) * f(u_{i+1}) = \begin{cases} -i & if\ i \equiv 1(mod\ 2) \\ i & if\ i \equiv 0(mod\ 2) \end{cases}, 1 \le i \le n-3$$

$f(u_{n-2}) * f(u_{n-1}) = -i$, $f(u_{n-1}) * f(u_n) = -1$, $f(u_n) * f(u_1) = 1$

$$f(u_i) * f(v_i) = \begin{cases} -1 & if\ i \equiv 1(mod\ 2) \\ 1 & if\ i \equiv 0(mod\ 2) \end{cases}, 1 \le i \le n-2$$

$f(u_{n-1}) * f(v_{n-1}) = f(u_n) * f(v_n) = i$

Vertex Conditions:

Here, $v_f(1) = v_f(i) = v_f(-i) = v_f(-1) = \frac{n}{2}$

Hence, $|v_f(a) - v_f(b)| \le 1$, ∀ a,b∈ V_4.

Edge Conditions:

Here, $e_f(1) = e_f(i) = e_f(-1) = e_f(-i) = \frac{n}{2}$

Hence, $|e_f(a) - e_f(b)| \le 1$, ∀ a,b∈ V_4.

Hence, C_n^+ is a V_4Cordial graph.

For example, the V_4Cordial Labeling of C_{10}^+ is shown in the Figure 3.2.3.

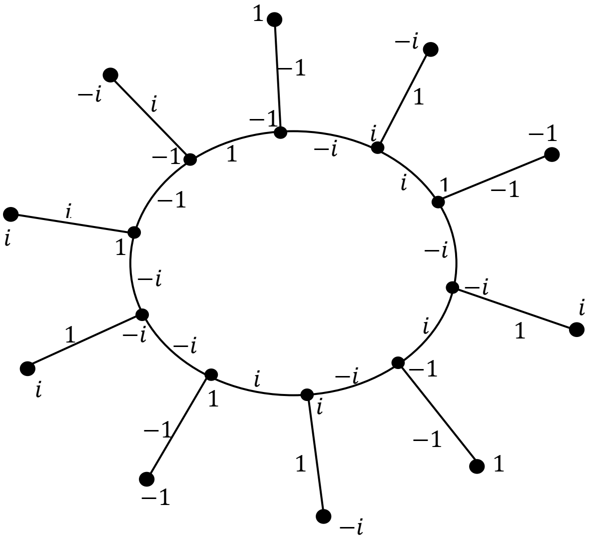

Figure 3.2.3

Case(ii): when n ≡ 3(mod 4)

Define f : V(C_n^+) → V_4 by

$$f(u_i) = \begin{cases} -i & if\ i\ \equiv\ 0(mod\ 4) \\ -1 & if\ i\ \equiv\ 1(mod\ 4) \\ i & if\ i\ \equiv\ 2(mod\ 4) \\ 1 & if\ i\ \equiv\ 3(mod\ 4) \end{cases} ,1 \le i \le n-2$$

$f(u_{n-1}) = i$, $f(u_n) = 1$

$$f(v_i) = \begin{cases} i & if\ i\ \equiv\ 0(mod\ 4) \\ 1 & if\ i\ \equiv\ 1(mod\ 4) \\ -i & if\ i\ \equiv\ 2(mod\ 4) \\ -1 & if\ i\ \equiv\ 3(mod\ 4) \end{cases} ,1 \le i \le n-2$$

$f(v_{n-1}) = f(v_n) = -i$

The induced edge labelings are

$$f(u_i) * f(u_{i+1}) = \begin{cases} -i & if\ i\ \equiv\ 1(mod\ 2) \\ i & if\ i\ \equiv\ 0(mod\ 2) \end{cases} ,1 \le i \le n-1$$

$f(u_n) * f(u_1) = -1$

$$f(u_i) * f(v_i) = \begin{cases} -1 & if\ i\ \equiv\ 1(mod\ 2) \\ 1 & if\ i\ \equiv\ 0(mod\ 2) \end{cases} ,1 \le i \le n-1$$

$f(u_n) * f(v_n) = -i$

Vertex Conditions:

Here, $v_f(1) = v_f(-i) = \frac{n+1}{2}$ and $v_f(-1) = v_f(i) = \frac{n-1}{2}$

Hence, $|v_f(a) - v_f(b)| \le 1$, ∀ a,b∈ V_4.

Edge Conditions:

Here, $e_f(1) = e_f(i) = \frac{n-1}{2}$ and $e_f(-1) = e_f(-i) = \frac{n+1}{2}$

Hence, $|e_f(a) - e_f(b)| \le 1$, ∀ a,b∈ V_4.

Hence, C_n^+ is a V_4Cordial graph.

For example, the V_4Cordial Labeling of C_{11}^+ is shown in the Figure 3.2.4 .

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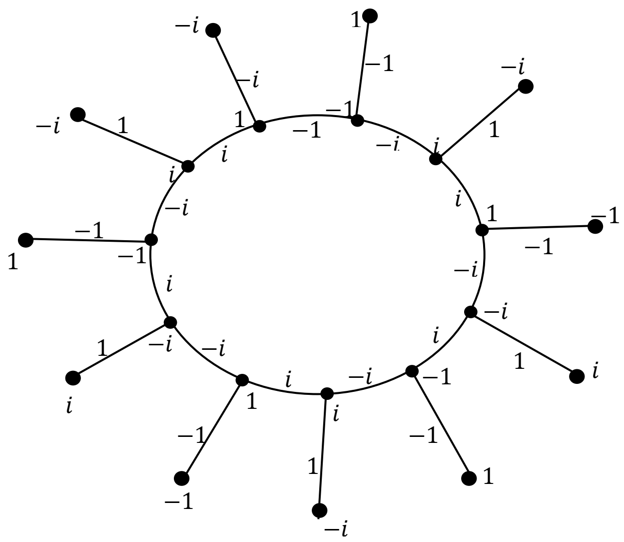

Figure 3.2.4

Theorem 3.3.

H_n^+ is a V_4 Cordial graph(when n is odd).

Proof:

Let $V(H_n^+) = \{u_i, v_i : 1 \le i \le n, u_i', v_i' : 1 \le i \le n\}$.

Let $E(H_n^+) = \{(u_iu_{i+1}), (v_iv_{i+1}) : 1 \le i \le n-1\} \cup \{u_iu_i', v_iv_i' : 1 \le i \le n\} \cup \{u_{\left(\frac{n+1}{2}\right)}v_{\left(\frac{n+1}{2}\right)}\}$.

Define f : $V(H_n^+) \to V_4$ by

$$f(u_i) = \begin{cases} -i & if\ i \equiv 0(mod\ 4) \\ -1 & if\ i \equiv 1(mod\ 4) \\ i & if\ i \equiv 2(mod\ 4) \\ 1 & if\ i \equiv 3(mod\ 4) \end{cases}, 1 \le i \le n$$

$$f(u_i') = \begin{cases} i & if\ i \equiv 0(mod\ 4) \\ 1 & if\ i \equiv 1(mod\ 4) \\ -i & if\ i \equiv 2(mod\ 4) \\ -1 & if\ i \equiv 3(mod\ 4) \end{cases}, 1 \le i \le n$$

$$f(v_i) = \begin{cases} 1 & if\ i \equiv 0(mod\ 4) \\ i & if\ i \equiv 1(mod\ 4) \\ -1 & if\ i \equiv 2(mod\ 4) \\ -i & if\ i \equiv 3(mod\ 4) \end{cases}, 1 \le i \le n$$

$$f(v_i') = \begin{cases} -1 & if\ i \equiv 0(mod\ 4) \\ -i & if\ i \equiv 1(mod\ 4) \\ 1 & if\ i \equiv 2(mod\ 4) \\ i & if\ i \equiv 3(mod\ 4) \end{cases}, 1 \le i \le n$$

The induced edge labelings are

$$f(u_i) * f(u_{i+1}) = \begin{cases} -i & if\ i \equiv 1(mod\ 2) \\ i & if\ i \equiv 0(mod\ 2) \end{cases}, 1 \le i \le n-1$$

$$f(v_i) * f(v_{i+1}) = \begin{cases} -i & if\ i \equiv 1(mod\ 2) \\ i & if\ i \equiv 0(mod\ 2) \end{cases}, 1 \le i \le n-1$$

$$f(u_i) * f(u_i') = \begin{cases} -1 & if\ i \equiv 1(mod\ 2) \\ 1 & if\ i \equiv 0(mod\ 2) \end{cases}, 1 \le i \le n-1$$

$$f(v_i) * f(v_{i+1}') = \begin{cases} 1 & if\ i \equiv 1(mod\ 2) \\ -1 & if\ i \equiv 0(mod\ 2) \end{cases}, 1 \le i \le n-1$$

$$f(u_{\left(\frac{n+1}{2}\right)}) * f(v_{\left(\frac{n+1}{2}\right)}) = -i$$

Vertex Conditions:

Here, $v_f(1) = v_f(i) = v_f(-i) = v_f(-1) = n$

Hence, $|v_f(a) - v_f(b)| \leq 1$, ∀ a,b∈ V_4.

Edge Conditions:

Here, $e_f(1) = e_f(-1) = e_f(-i) = n$ and $e_f(i) = n-1$.

Hence, $|e_f(a) - e_f(b)| \leq 1$, ∀ a,b∈ V_4.

Hence, H_n^+ is a V_4Cordial graph.

For example, the V_4Cordial Labeling of H_5^+ and H_7^+ are shown in Figures3.3.1 and 3.3.2.

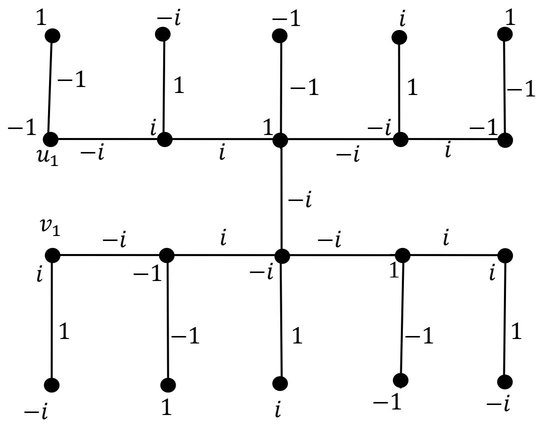

Figure 3.3.1

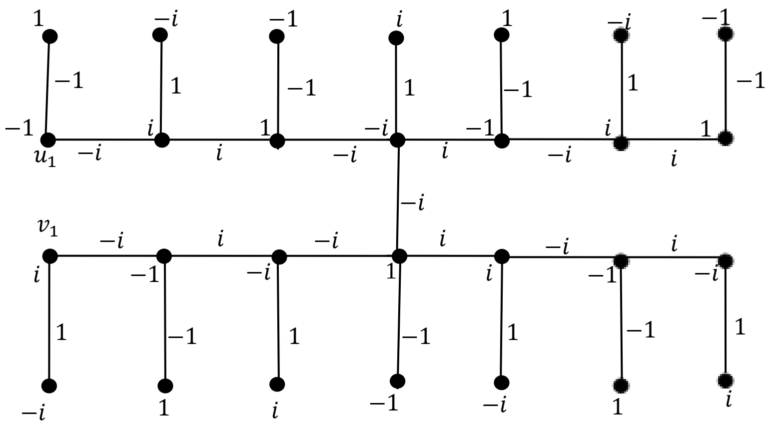

Figure 3.3.2

Theorem 3.4.

H_n^+ is a V_4 Cordial graph(when n is even).

Proof:

Let $V(H_n^+) = \{u_i, v_i : 1 \leq i \leq n, u_i', v_i' : 1 \leq i \leq n\}$.

Let $E(H_n^+) = \{(u_i u_{i+1}), (v_i v_{i+1}) : 1 \leq i \leq n-1\} \cup \{u_i u_i', v_i v_i' : 1 \leq i \leq n\} \cup \{u_{(\frac{n}{2}+1)} v_{(\frac{n}{2})}\}$.

Define f : $V(H_n^+) \rightarrow V_4$ by

$$f(u_i) = \begin{cases} -i & if\ i \equiv 0 (mod\ 4) \\ -1 & if\ i \equiv 1 (mod\ 4) \\ i & if\ i \equiv 2 (mod\ 4) \\ 1 & if\ i \equiv 3 (mod\ 4) \end{cases}, 1 \leq i \leq n$$

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$$f(u_i') = \begin{cases} i & if\ i \equiv 0(mod\ 4) \\ 1 & if\ i \equiv 1(mod\ 4) \\ -i & if\ i \equiv 2(mod\ 4) \\ -1 & if\ i \equiv 3(mod\ 4) \end{cases}, 1 \le i \le n$$

$$f(v_i) = \begin{cases} -i & if\ i \equiv 0(mod\ 4) \\ 1 & if\ i \equiv 1(mod\ 4) \\ i & if\ i \equiv 2(mod\ 4) \\ -1 & if\ i \equiv 3(mod\ 4) \end{cases}, 1 \le i \le n$$

$$f(v_i') = \begin{cases} i & if\ i \equiv 0(mod\ 4) \\ -1 & if\ i \equiv 1(mod\ 4) \\ -i & if\ i \equiv 2(mod\ 4) \\ 1 & if\ i \equiv 3(mod\ 4) \end{cases}, 1 \le i \le n$$

The induced edge labelings are

$$f(u_i) * f(u_{i+1}) = \begin{cases} -i & if\ i \equiv 1(mod\ 2) \\ i & if\ i \equiv 0(mod\ 2) \end{cases}, 1 \le i \le n-1$$

$$f(v_i) * f(v_{i+1}) = \begin{cases} i & if\ i \equiv 1(mod\ 2) \\ -i & if\ i \equiv 0(mod\ 2) \end{cases}, 1 \le i \le n-1$$

$$f(u_i) * f(u_i') = \begin{cases} -1 & if\ i \equiv 1(mod\ 2) \\ 1 & if\ i \equiv 0(mod\ 2) \end{cases}, 1 \le i \le n-1$$

$$f(v_i) * f(v_{i+1}') = \begin{cases} -1 & if\ i \equiv 1(mod\ 2) \\ 1 & if\ i \equiv 0(mod\ 2) \end{cases}, 1 \le i \le n-1$$

$$f(u_{\left(\frac{n}{2}+1\right)}) * f(v_{\left(\frac{n}{2}\right)}) = i$$

Vertex Conditions:

Here, $v_f(1) = v_f(i) = v_f(-i) = v_f(-1) = n$

Hence, $|v_f(a) - v_f(b)| \le 1$, ∀ a,b∈ V_4.

Edge Conditions:

Here, $e_f(1) = e_f(-1) = e_f(-i) = n$ and $e_f(i) = n-1$.

Hence, $|e_f(a) - e_f(b)| \le 1$, ∀ a,b∈ V_4.

Hence, H_n^+ is a V_4Cordial graph.

For example, the V_4Cordial Labeling of H_6^+ and H_8^+ are shown in Figures 3.4.1 and 3.4.2 .

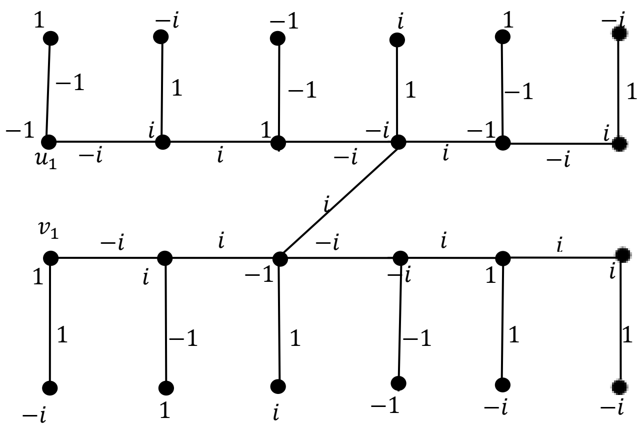

Figure 3.4.1

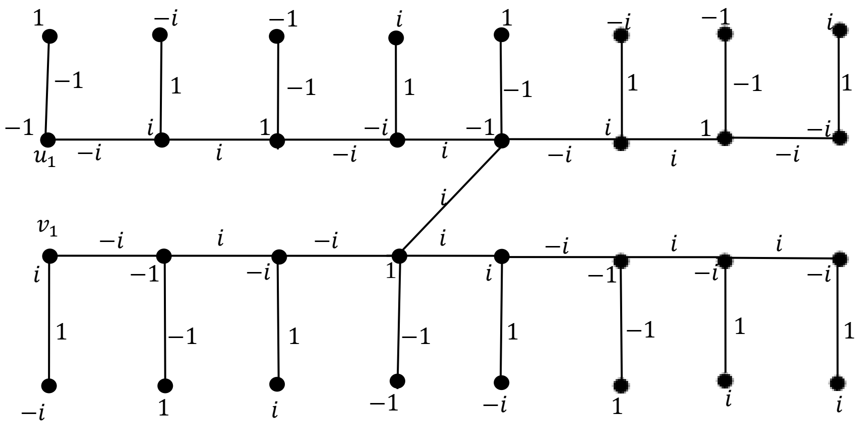

Figure 3.4.2

4. Conclusion

Group Theory plays a crucial role in the field of Mathematics. Combining group theory and the labelling of a graph by defining edge labelling induced by composition of mapping will definitely a significant aspect. It may bring wider applications.

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