MAGICNESS IN EXTENDED DUPLICATE GRAPHS

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Abstract -*A graph labeling is a mapping that carries a set of graph elements onto a set of numbers called labels(usually the set of integers). In this paper we prove the existence of graph labeling such as Z_3- vertex magic total,Z_3- edge magic total labeling and total magic cordial labeling for extended duplicate graph of comb graph and middle graph of extended duplicate graph of path graph. We also provide an algorithm to obtain n- edge magic labeling for extended duplicate graph of comb graph .*

Keywords: Graph labeling, Comb graph , Path graph, Middle graph, Duplicate graph.

1 . Introduction

Rosa introduced the notion of Graph labeling in 1967 [1]. In 1970 Kotzig and Rosa defined the concept of edge magic total labeling [2]. A detailed study on graph labeling has been done by Gallian [3]. MacDougall et. al introduced the notion of vertex magic total labeling in 1999 [4].

Thirusangu et., al introduced the concept of Extended Duplicate graph [5]. They proved that the Extended duplicate graph of twig graph admits Z_3 – vertex magic total , edge magic total and total magic cordial labeling. In [6] they also proved some results on Extended duplicate graph of comb graph.

In 2012 Jeyapriya and Thirusangu introduced 0- Edge magic labeling and shown the existence of this labeling for some class of graphs [7].Neelam Kumari and Seema Mehra establish the concept of 1- Edge magic and n – Edge magic labeling [8].They proved P_t ,C_t(t is even) and sun graph S_t(t is even) are n- Edge magic.

Hamada et. ,al introduced Middle graph [9] and they proved middle graph of the complete graph (K_n) has (n-1) forest coloring. Arundhadi and Thirusangu proved some colorings on middle graph of some class of graphs [10].

Definition: 1.1

Let P_{m+1} be a path graph .Comb graph is defined as $P_{m+1}\odot$ (m+1)K_1. It has 2m+2 vertices and 2m+1 edges.

Definition :1.2

The middle graph M(G) of a graph G(V,E) is defined with the vertex set as V$\cup$E and two vertices u, v in M(G) are adjacent if they are incident in G or they are adjacent edges in G.

.Definition : 1.3

Let G(V,E) be a Comb graph. A Duplicate graph of G is DG=(V_1,E_1) where the vertex set V_1 = V$\cup$V' and V$\cap$V'=φ and f: V→V' is bijective (for v $\in$ V, we write f(v) = v' for convenience) and the edge set E_1 of DG is defined as follows: The edge v_iv_j is in E if and only if both v_iv_j' and $v_i'v_j$ are edges in E_1.The extended duplicate graph of G is the graph DG $\cup$\{ v_iv_i'\}, for some `i'.

Definition : 1.4

A labeling function f : V$\cup$E → Z_3 -\{0\} is said to be a Z_3 – vertex magic total labeling in G(V,E) if there exist a function f*: V → N$\cup$\{0\} such that f*(v_i) = \{f(v_i) +$\sum$ f(e)\} (mod 3) , is a constant where e is the edge incident at v_i .

Definition : 1.5

A labeling function f : V$\cup$E → Z_3 -\{0\} is said to be a Z_3– edge magic total labeling in G(V,E) if there exist a function f*: E → N$\cup$\{0\} such that f*(v_iv_j) =\{f(v_i+f(v_j)+f(v_iv_j)\}(mod3) is a constant for all edges $v_iv_j \in$ E .

Definition : 1.6

A graph G(V,E) is said to admit total magic cordial labeling if f : V$\cup$ E → \{0,1\} such that (i). f(x) + f(y)+f(xy)\} (mod 2) is constant for all edges xy $\in$ E. (ii) for all i,j $\in$ \{0,1\} , \{ m_i(f) + n_i(f) \} – \{ m_j(f) + n_j(f) \} ≤ 1, (i ≠ j) where m_i(f) = \{e $\in$ E / f(e) = i\} and n_i(f) = \{v $\in$ V/ f(v) = i\}

Definition : 1.7

Let G = (V,E) be a graph. Let $f : V \rightarrow \{-1,1\}$ and $f^* : E \rightarrow \{0\}$ such that for all uv ∈ E, $f^*(uv) = f(u) + f(v) = 0$ then the labeling is called 0 – Edge magic labeling.

Definition : 1.8

Let G = (V,E) be a graph. Let $f : V \rightarrow \{-1,n+1\}$ and $f^* : E \rightarrow \{n\}$ such that for all uv ∈ E, $f^*(uv) = f(u) + f(v) = n$ then the labeling is called n – Edge magic labeling.

In this paper, we prove that, the extended duplicate graph of Comb graph admits Z_3 – vertex magic total ,Z_3-edge magic total ,total magic cordial and n – edge magic labeling. We show that the middle graph of extended duplicate graph of path graph is Z_3 – vertex magic total ,Z_3-edge magic total and total magic cordial graph.

2. MAIN RESULT

In this section we present the structures of the extended duplicate graph of a comb graph and the middle graph of extended duplicate graph of path graph. We obtain labelings such as Z_3 – vertex magic total , Z_3 -edge magic total ,total magic cordial and n – edge magic labeling .

Definition: (Structure of the extended duplicate graph of a comb graph)

Let G(V,E) be a comb graph. The duplicate graph of comb graph DG(comb)= (V_1,E_1) has 4m+4 vertices and 4m+2 edges.

Denote the vertex set as $V_1= \{v_1,v_2,\ldots\ldots v_{2m+2},v_1',v_2'\ldots\ldots v_{2m+2}'\}$ and the edge set as $E_1= \{(v_iv_{i+1}' \cup v_i'v_{i+1}$ for $1 \le i \le m)$ $\cup$ $(v_i'v_{m+i+1} \cup v_iv_{m+i+1}'$ for $1 \le i \le m+1)\}$. The extended duplicate graph of comb EDG(Comb) is obtained from DG(comb) by adding the edges (i) v_1v_{m+1} and $v_{m+2}'v_{2m+2}'$ if $m \equiv 1 (\mathrm{mod}\ 2)$.(ii) v_1v_{m+1}' and $v_{m+2}'v_{2m+2}$ if $m \equiv 0(\mathrm{mod}\ 2)$.

Thus the extended duplicate graph of comb graph has 4m+4 vertices and 4m+4 edges.

Definition: (Structure of Middle graph of Extended Duplicate graph of Path(P_m)).

Let EDG(P_m) be a graph with 2m+2 vertices $\{v_1,v_2,\ldots\ldots v_{m+1},v_1',v_2',\ldots\ldots v_{m+1}'\}$ and 2m+1 edges where `m' represents the length of the path P_m. The middle graph of EDG(P_m) is obtained by introducing a new vertex w_i on each edge as follows:

$v_iv_{i+1}' \rightarrow w_i$; $1 \le i \le m$, $v_iv_{i-1}' \rightarrow w_{i+m-1}$; $2 \le i \le m+1$; $v_2v_2' \rightarrow w_{2m+1.}$

Thus the middle graph of EDG(P_m) is a (V,E) graph where

$V=\{v_i \cup v_i' \cup w_k \ /\ \ 1 \le i \le m+1$ and $1 \le k \le 2m+1\}$

E= $\{v_iw_i ; w_iv_{i+1}'$ for $1 \le i \le m \}$ $\cup$ $\{v_iw_{i+m-1} ;\ w_{i+m-1}\, v_{i-1}'$ for $2 \le i \le m+1\}$ $\cup$ $\{v_2w_{2m+1} ; w_{2m+1}v_2'\}$ $\cup$ $\{w_iw_{i+m+1}$ for $1 \le i < m \}$ $\cup$ $\{w_iw_{im+1}$ for $m < i < 2m\}$ $\cup$ $\{w_iw_{2m+1}$ for $1 \le i \le 2$ and i=m+1 and i=m+2 }. Thus MEDG(P_m) has 4m+3 vertices and 6m+4 edges.

Algorithm: 1

Procedure :Z_3-vertex magic total labeling for EDG(comb)graph.)
//assignment of labels to the vertices and edges

$v_1 ,v_{m+1} , v_{m+1}' ,v_{m+2}' , v_1'v_2 \leftarrow 1$

$v_2 \leftarrow 2$

for i = 3 to m-1 ,

$\{ v_i \} \leftarrow 1$

for i = 1 to m-1,

$\{ v_i' \leftarrow 1 ,\ v_iv_{i+1}' \leftarrow 2 \}$

for i = 1 to m ,

$\{ v_{m+i+1} \leftarrow 2 \}$

for i = 2 to m ,

$\{ v_{m+i+1}' \leftarrow 2\}$

for i =2 to m-1 ,

$\{ v_i'v_{i+1} \leftarrow 2 \}$

for i = 1 to m+1 ,

$\{ v_iv_{m+i+1}' ,\ v_i'v_{m+i+1} \leftarrow 1\}$

end for
if $m \equiv 1 \pmod 2$
$v_m' ,\ v_{2m+2}' ,\ v_mv_{m+1}' ,\ v_{m+2}'v_{2m+2}' \leftarrow 1 :\ v_m ,\ v_{m+2}$
$v_1v_{m+1} ,\ v_m'v_{m+1} \leftarrow 2$

if $m \equiv 0 \pmod 2$

v_m , v_{m+2} , $v_m'v_{m+1}$, $v_{m+2}'v_{2m+2}$ ← 1 : v_m' , v_{2m+2}' , v_1v_{m+1}' , v_mv_{m+1}' ← 2
end procedure

output : Labeled EDG(comb) graph.

Theorem : 2.1

Extended duplicate graph of Comb graph admits Z_3 – vertex magic total labeling.

Proof :

EDG(comb) (V,E) graph has 4m+4 vertices and 4m+4 edges. The vertices and edges of EDG(comb) graph are labeled by defining a function $f : V \cup E \rightarrow \{1,2\}$ as given in algorithm 1. The induced function is defined by $f^* : V \rightarrow N \cup \{0\}$ such that $f^*(v) = (f(v) + \sum f(uv)) \pmod 3$.
Clearly the induced function yields the labels for the vertices as follows:
$f^*(v) = (f(v) + f(uv)) \pmod 3 = 3 \text{ (or } 6) \pmod 3 = 0$, a constant.
Hence EDG(comb) graph admits Z_3- vertex magic total labeling.

Example : 2.1

Z_3 - vertex magic total labeling of EDG(comb) graph for m = 5 and m = 6 are given in figure 1 and figure 2 respectively.

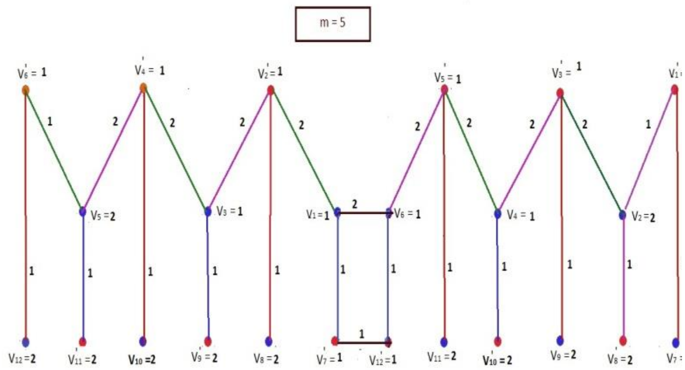

Fig . 1: Z_3 - vertex magic total labeling of EDG(comb) graph for m = 5

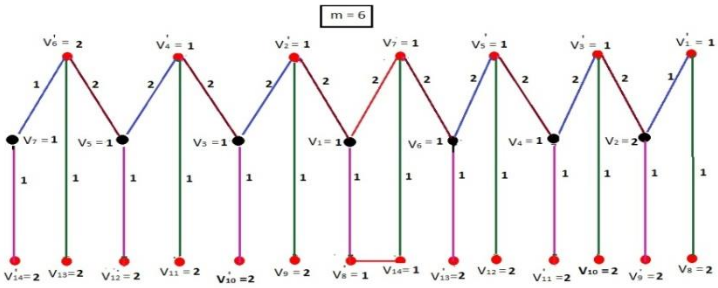

Fig.2: Z_3 - vertex magic total labeling of EDG(comb) graph for m = 6

Algorithm : 2

Procedure :(Z_3 – vertex magic total labeling for MEDG(P_m), m ≥ 2)

// assignment of labels to the vertices and edges

$w_1, w_2, w_{m+1}, w_{m+2}, w_2w_{2m+1}, w_{m+2}w_{2m+1}$ ← 1

$v_1, v_2, v_1', v_2', w_{2m+1}, w_1w_{2m+1}, w_{m+1}w_{2m+1}, v_2w_{2m+1}, v_2'w_{2m+1}, v_{m+1}w_{2m}, v_{m+1}'w_m$ ← 2

for i= 3 to m+1

{v_i , v_i' ← 1 }

for i = 3to m

{w_i ,w_{m+i} ←2}

for i = 1 to m

{v_iw_i , $v_i'w_{m+i}$ ← 1 }

for i = 1 to m-1

{w_iw_{m+i+1} ← 1}

for i = 2 to m

{v_iw_{m+i-1} , $v_i'w_{i-1}$, w_iw_{m+i+1} ← 1 }

end for

end procedure

Output : labeled MEDG(P_m).

Theorem : 2.2

Middle graph of extended duplicate graph of path P_m , MEDG(P_m) admits Z_3 – vertex magic total labeling , where m represents the length of the path.

Proof :

MEDG(P_m) be a graph with 4m+3 vertices and 6m+4 edges. The vertices and edges are labeled by defining a function $f : V \cup E \rightarrow \{1,2\}$ as given in algorithm 2. Thus all the 4m+3 vertices and 6m+4 edges are labeled .

The induced function is defined by $f^* : V \rightarrow N \cup \{0\}$, such that $f^*(v)=f(v)+\sum f(uv))(\text{mod}3)=k$, a constant for all edges $uv \in E$.

The total weight of each vertex is ,

$f^*(v) = (f(v) + \sum f(uv)) \ (\text{mod } 3) = 3 \text{ (or 6) } (\text{mod } 3) = 0$, a constant for all edges $uv \in E$.

Thus the induced function yields the weight `0' to all the vertices.Therefore `f ' is a Z_3- vertex magic total labeling.

Hence the middle graph of extended duplicate graph of path (P_m) , m ≥ 2 is Z_3 – vertex magic total graph.

Example : 2.2

Z_3 – vertex magic total labeling for MEDG(P_5) is given in figure 3.

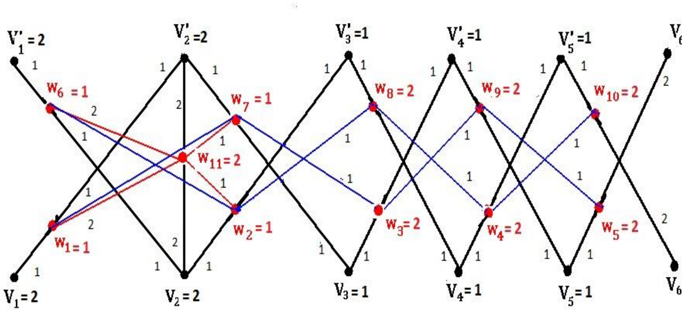

Fig.3: Z_3 – vertex magic total labeling for MEDG(P_5)

Algorithm : 3

Procedure : (Z_3-edge magic total labeling for EDG(comb)graph.)

//assignment of labels to the vertices and edges

$v_{m+2} \leftarrow 2$, $v_{m+2}' \leftarrow 1$, $v_1v_{m+2}' \leftarrow 2$

for i = 1 to m+1

{ v_i , $v_i' \leftarrow 1$ }

for i =2 to m

{ v_{m+i+1} , $v_{m+i+1}' \leftarrow 2$; $v_iv_{m+i+1}' \leftarrow 1$}

for i =1 to m

{ v_iv_{i+1}' , $v_i'v_{i+1} \leftarrow 2$; $v_i'v_{m+i+1} \leftarrow 1$}

end for

if m ≡ 1 (mod 2)

$v_{2m+2} \leftarrow 2$,$v_{2m+2}' \leftarrow 1$, $v_{m+1}'v_{2m+2} \leftarrow 1$: v_1v_{m+1} , $v_{m+2}'v_{2m+2}'$,$v_{m+1}v_{2m+2}' \leftarrow 2$

if m ≡ 0(mod 2)

$v_{2m+2} \leftarrow 1$,$v_{2m+2}' \leftarrow 2$, $v_{m+1}v_{2m+2}' \leftarrow 1$: v_1v_{m+1}' , $v_{m+2}'v_{2m+2}$,$v_{m+1}'v_{2m+2} \leftarrow 2$

end procedure

output : Labeled EDG(comb) graph.

Theorem : 2.3

Extended duplicate graph of Comb graph admits Z_3 – edge magic total labeling.

Proof :

EDG(comb)(V,E) graph has 4m+4 vertices and 4m+4 edges. The vertices and edges of EDG(comb) graph are labeled by defining a function $f : V \cup E \rightarrow \{1 ,2\}$ as given in algorithm 3. The induced function is defined by $f^* : E \rightarrow N \cup \{0\}$ such that

$f^*(uv) = (f(u) + f(v) + f(uv)) \ (\text{mod } 3)$.

The induced function yields the labels for edges as follows:

$f^*(uv) = (f(u) + f(v) + f(uv)) = 1+2+1 \text{ (or) } 1+1+2 = 4 \ (\text{mod } 3) = 1$.

Thus the induced function yields Z_3 – edge magic total labeling with magic constant `1'.

Hence EDG(comb) graph admits Z_3 – edge magic total labeling.

Example : 2.3

Z_3 - edge magic total labeling of EDG(comb) graph for m = 5 and m = 6 are given in figure 4 and figure 5 respectively.

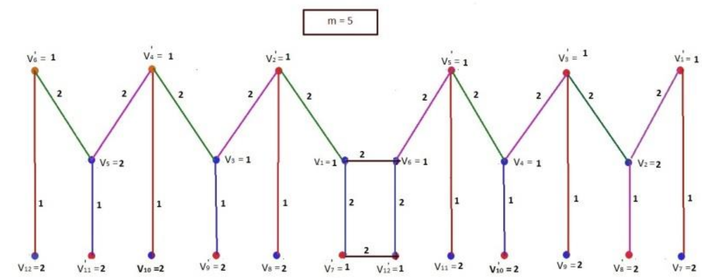

Fig . 4: Z_3 - edge magic total labeling of EDG(comb) graph for m = 5

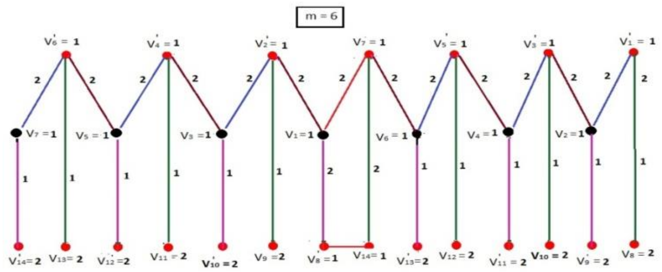

Fig.5: Z_3 - edge magic total labeling of EDG(comb) graph for m = 6.

Algorithm : 4

Procedure : (Z_3 – edge magic total labeling for MEDG(P_m), m ≥ 2)

//assignment of labels to the vertices and edges

v_2w_{2m+1} , $v_2'w_{2m+1}$, w_1w_{2m+1} ,w_2w_{2m+1} ,$w_{m+1}w_{2m+1}$, $w_{m+2}w_{2m+1}$ ← 2 : w_{2m+1} ← 1

for i = 1 to m+1

{v_i' , v_i ← 1 }

for i = 1 to m

{w_i , w_{m+I} ← 1}

for i = 2 to m

{w_iw_{m+i-1} ← 2 }

for i = 1 to m-1

{w_iw_{m+i+1} ← 2}

for i = 2 to m+1

{v_iw_{m+i-1} , v_i' wi_{-1} ← 2}

endfor

end procedure

Output : labeled MEDG (P_m).

Theorem : 2.4

Middle graph of extended duplicate graph of path P_m , MEDG(P_m) admits Z_3 – edge magic total labeling , where m represents the length of the path.

Proof :

MEDG(P_m) be a graph with 4m+3 vertices and 6m+4 edges. The vertices and edges are labeled by defining a function f : V ∪ E → {1,2} as given in algorithm 4.Thus all the 4m+3 vertices and 6m+4 edges are labeled .

The induced function is defined by f* : E → N ∪ {0}, such that f*(uv) = (f(u) + f(v) + f(uv)) (mod 3) = k , a constant for all the edges uv ∈ E.

We have f*(uv) = (f(u) + f(v) + f(uv)) (mod 3) = 1 , a constant. Thus the induced function yields the weight `1' to all the edges. Therefore `f' is a Z_3 – edge magic total labeling .

Hence the middle graph of extended duplicate graph of path (P_m) , m ≥ 2 admits Z_3 – edge magic total labeling.

Example : 2.4

Z_3 – edge magic total labeling for MEDG(P_5) is given in figure 6.

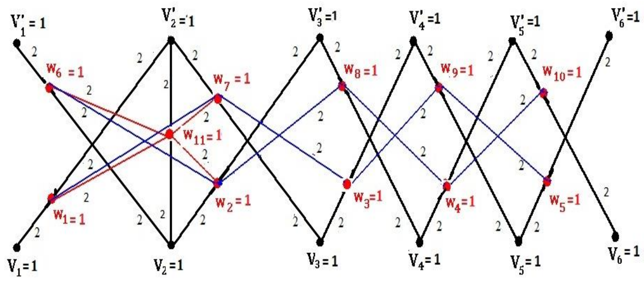

Fig.6: Z_3 – edge magic total labeling for MEDG(P_5).

Algorithm: 5

Procedure:(Total magic cordial labeling for EDG(comb) graph , m ≥ 2)

//assignment of labels to the vertices and edges

for i = 1to m

{v_iv_{i+1}' , $v_i'v_{i+1}$ ← 1 }

for i = 1 to m+1

{v_iv_{m+i+1}' , $v_i'v_{m+i+1}$ ← 0}

end for

if m ≡ 0 (mod 2)

v_1v_{m+1}' , $v_{m+2}'v_{2m+2}$ ← 1

for i = 1to m+1

{v_i , v_{m+i+1}' ← 0 ; v_i' , v_{m+i+1} ← 0} end for

if $m \equiv 1 \pmod 2$

v_1v_{m+1} , $v_{m+2}'v_{2m+2}'$ $\leftarrow 1$

for i = 1 to m+1

{v_i , v_i' , v_{m+i+1} , v_{m+i+1}' $\leftarrow$ 1 if $i \equiv 0 \pmod 2$

} 0 otherwise.

end for

end procedure.

Output : labeled EDG (comb) graph.

Theorem : 2.5

Extended duplicate graph of Comb graph, EDG(comb) graph admits total magic cordial labeling.

Proof :

EDG(comb) be a graph with 4m+4 vertices and 4m+4 edges. The vertices and edges are labeled by defining a function $f : V \cup E \rightarrow \{0,1\}$ as given in algorithm 5.

Clearly , the number of edges labeled with `0' is 2m+2 and `1' is m+m+2 =2m+2 and the number of vertices labeled with `0' is m+1+m+1 =2m+2 and `1' is m+1+m+1 =2m+2

Thus all the 4m+4 vertices and 4m+4 edges are labeled such that the number of vertices labeled with ` 0' and `1'differ by atmost one . The number of edges labeled with `0' and `1' are also differ by atmost one.

The induced function is defined by $f^* : E \rightarrow \{0,1\}$ such that $f^*(uv) = (f(u) + f(v) + f(uv)) \pmod 2$.

Thus the induced function yields , $f^*(uv)=(f(u)+f(v)+f(uv)) = 0+0+0$ (or) $1+0+1 \pmod 2 = 0$ which is a constant `0'.Hence the extended duplicate graph of comb graph is total magic cordial graph.

Example : 2.5

Total magic cordial labeling of EDG(comb) graph for m=5 and m = 6 are given in figure 7 and figure 8 respectively.

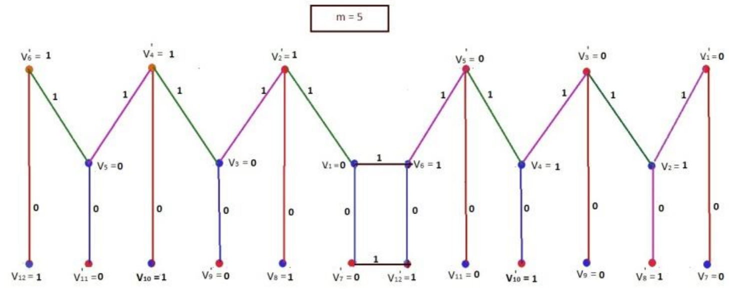

Fig . 7: Total magic cordial labeling of EDG(comb) graph for m = 5

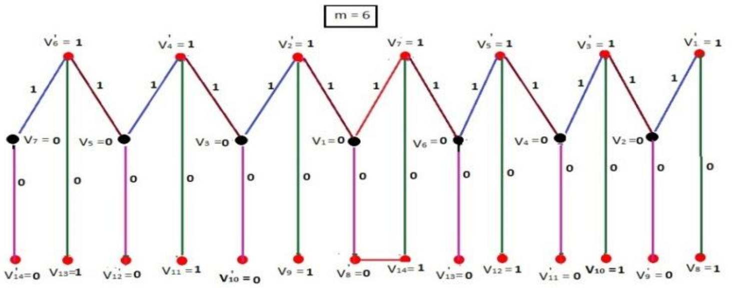

Fig.8: Total magic cordial labeling of EDG(comb) graph for m = 6.

Algorithm : 6

Procedure: Total magic cordial labeling for MEDG(P_m) , $m \geq 2$)

//assignment of labels to the vertices and edges

v_{m+1}' , w_2w_{2m+1} , $w_{m+1}w_{2m+1}$, $w_{m+2}w_{2m+1}$ $\leftarrow 1$.

w_{2m+1} ,w_1w_{2m+1} , v_2w_{2m+1} , $v_2'w_{2m+1}$ $\leftarrow$ 0.
$v_{m+1}'w_m \leftarrow$ 0 if $m \equiv 0 \pmod 2$

1 otherwise.

for i = 2 to m

{ $v_i'w_{i-1}$ $\leftarrow$ 0 , w_iw_{m+i-1} $\leftarrow$ 0 if $i \equiv 0 \pmod 2$

} 1 otherwise.

for i = 1 to m+1

{v_i $\leftarrow$ 0 }

for i = 1 to m

{w_{m+i} $\leftarrow$ 1 , v_i' $\leftarrow$ 0 if $i \equiv 0 \pmod 2$

} 1 otherwise.

for i = 1 to m

{ w_i , v_iw_i , $v_i'w_{m+i}$ ← 1 if i ≡ 0(mod 2)

} 0 otherwise.

for i = 2 to m+1

{v_iw_{m+i-1} ← 1}

for i = 1 to m-1

{w_iw_{m+i+1} ← 1 if i ≡ 1(mod 2)

} 0 otherwise.

Output :labeled MEDG (P_m).

Theorem : 2.6

Middle graph of extended duplicate graph of path P_m , MEDG(P_m) admits total magic cordial labeling , where m represents the length of the path.

Proof :

The graph MEDG(P_m) has 4m+3 vertices and 6m+4 edges. The vertices and edges are labeled by defining a function f : V ∪ E → {0,1} as given in algorithm 6.

Clearly, the number of vertices labeled with 0 is 2m+2 and 1 is 2m+1 and the number of edges labeled with 0 is 3m+2 and 1 is also 3m+2.

Thus all the 4m+3 vertices and 6m+4 edges are labeled such that the number of vertices labeled with ` 0' and `1'differ by atmost one . The number of edges labeled with `0' and `1' are also differ by atmost one.

The induced function is defined by f* : E →N ∪ {0} , such that f*(uv) = (f(u) + f(v) + f(uv)) (mod 2).

Thus we have f*(uv) = (f(u) + f(v) + f(uv)) (mod 2) = 1+1+0 = 2(mod 2) = 0 , a constant. Hence the middle graph of extended duplicate graph of path (P_m) , m ≥ 2 is total magic cordial graph.

Example : 2.6

Total magic cordial labeling for MEDG(P_5) is given in figure 9.

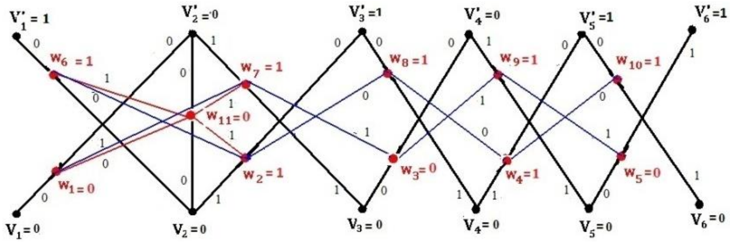

Fig.9: Total magic cordial labeling for MEDG(P_5)

Algorithm :7

Procedure : (n- Edge magic labeling for EDG(comb) graph , m ≥ 2).

// assignment of labels to the vertices

If m ≡ 1(mod 2)

for i = 1 to m+1

{v_i , v_i' ← -1 if i ≡ 1(mod 2)

} n+1 other wise.

for i = 2 to m+2

{v_{m+i} , v_{m+i}' ← -1 if i ≡ 1(mod 2)

} n+1 other wise.

If m ≡ 0 (mod 2)

for i = 1 to 2m+2

{v_i ← n+1 , v_i' ← -1}

end for

Output : Labeled EDG(comb) graph .

Theorem : 2.7

Extended duplicate graph of Comb graph admits n-Edge magic labeling.

Proof :

EDG(comb) graph has 4m+4 vertices and 4m+4 edges.The vertices are labeled by defining a function f :V → {-1 , n+1 / n ϵ N } as given in algorithm 7.The induced function is defined as f* : E → N such that f* (uv) = f(u) + f(v) .

Thus we have f*(uv) = f(u) + f(v) = -1+n+1= n , a constant for all uv ∈ E.

Thus EDG(comb) graph admits n – Edge magic labeling.

Example : 2.7

n - Edge magic labeling of EDG(comb) graph for m = 5 and m = 6 are given in figure 10 and figure 11 respectively.

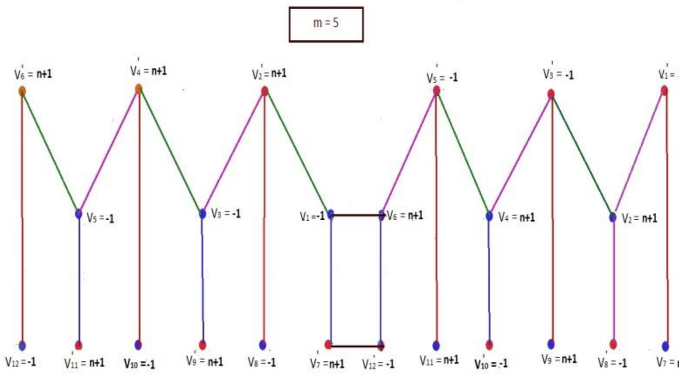

Fig . 10: n - Edge magic labeling of EDG(comb) graph for m = 5

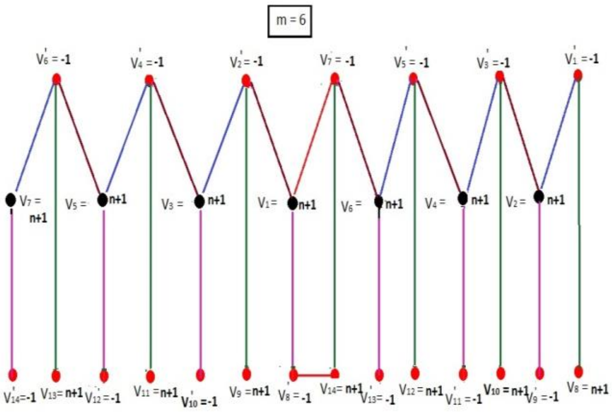

Fig. 11: n -Edge magic labeling of EDG(comb) graph for m = 6

CONCLUSION :

In this paper we proved the existence of Z_3 – vertex magic total ,Z_3- edge magic total ,total magic cordial , n – edge magic labeling for the extended duplicate graph of comb graph and Z_3 – vertex magic total ,Z_3- edge magic total ,total magic cordial labeling for the middle graph of extended duplicate graph of path graph by presenting algorithms.

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