# Edge Trimagic Graceful Labeling of Some Disconnected Graphs

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***ABSTRACT:*** *A (p, q) graph G is called an edge trimagic graceful if there exists a bijection $\varphi : V(G) \cup E(G) \rightarrow \{1, 2, 3, \ldots, p + q\}$ such that for each edge xy in E(G), $|\varphi(x) - \varphi(xy) + \varphi(y)| = c_1$ or $c_2$ or $c_3$, where $c_1$, $c_2$ and $c_3$ are constants. In this paper, we proved some disconnected graphs like, $(C_m \odot K_1) \cup P_n$, $nP_3$, $K_{1,l} \cup K_{1,m} \cup K_{1,n}$, $nC_4$ and $(C_m \odot K_1) \cup C_n$ are edge trimagic graceful graphs.*

***Key Words***: *Graph, disconnected graph, trimagic, graceful, trimagic graceful.*
***AMS Subject Classification:*** *05C78*

## 1. INTRODUCTION

Labeling of a graph G is an assignment of labels to either the vertices or the edges or both subject to certain conditions. Graph labeling was first introduced in 1960's. In 1970, Kotzig and Rosa[6] defined, an edge magic labeling of graph G is a bijection f: V∪E →{1, 2, …, p+q} such that, for each edge uv∈ E(G), f(u) + f(uv) + f(v) is a magic constant. A few years later, S. W. Golomb renamed β-labeling as graceful labeling as it is known today [4]. In 2004 J. Baskar Babujee introduced Edge Bimagic labeling [1]. Marimuthu and Balakrishnan [7] introduced the edge magic graceful labeling of a graph. In 2013,C. Jayasekaran, M. Regees and C. Davidraj [8] introduced the edge trimagic total labeling of graphs.

A graph is connected if every pair of points are joined by a path. A graph which is not connected is disconnected. Graphs $G_1$ and $G_2$ have disjoint vertex set $V_1$ and $V_2$ and the edge set $E_1$ and $E_2$ respectively. Their union $G = G_1 \cup G_2$ has, as expected, $V = V_1 \cup V_2$ and $E = E_1 \cup E_2$. A simple graph in which there exists an edge between every pair of vertices is called a complete graph and it is denoted by $K_n$. A bigraph G is a graph whose vertex set V can be partitioned into two subsets $V_1$ and $V_2$ such that every edge of G joins a point of $V_1$ to a point of $V_2$. If G contains every edge joining $V_1$ and $V_2$, then G is a complete bigraph. If $V_1$ and $V_2$ have m and n vertices, we write $G = K_{m,n}$. A star is a complete bigraph $K_{1,n}$. Further reference, we have used the survey on graph labeling by J. A. Gallian (2018) [5].

We can see some Super edge bimagic and trimagic labeling for some disconnected graphs are proved in [2, 3, 9]. In this paper we are going to prove some of the disconnected graphs such as $(C_m \odot K_1) \cup P_n$, $nP_3$, $K_{1,l} \cup K_{1,m} \cup K_{1,n}$, $nC_4$ and $(C_m \odot K_1) \cup C_n$ are edge trimagic graceful graphs.

## 2. EDGE TRIMAGIC GRACEFUL LABELING OF SOME DISCONNECTED GRAPHS

**Theorem 2.1:** The graph $(C_m \odot K_1) \cup P_n$ admits an edge trimagic graceful labeling for all values of $m$ and $n$.

**Proof:** Let $w_1w_2 \ldots w_n$ be the path $P_n$. Let $u_1u_2 \ldots u_mu_1$ be the cycle $C_m$ and let $v_i$ be the vertex which is joined to the vertex $u_i$ of the cycle $C_m$, $1 \le i \le m$, then the resultant graph is $(C_m \odot K_1)$. Then $(C_m \odot K_1) \cup P_n$ is a disconnected graph with $2m + n - 1$ edges and $2m + n$ vertices.

**Case 1**: $n$ is odd

Define a bijection $\varphi$: V∪E → {1, 2, 3, ..., $4m + 2n + 1$} such that

$\varphi(u_i) = i$, $1 \le i \le m - 1$

$\varphi(v_i) = m + i$, $1 \le i \le m - 1$

$\varphi(u_n) = m$; $\varphi(v_n) = 2m$

$$\varphi(w_i) = \begin{cases} 2m + \frac{i+1}{2}, & 1 \le i \le n, \text{ i is odd} \\ 2m + \frac{n+i+1}{2}, & 1 \le i \le n, \text{ i is even} \end{cases}$$

$\varphi(u_iu_{i+1}) = 2m + 2n + 2i$, $1 \le i \le m - 1$

$\varphi(u_iv_i) = 2m + 2n + 2i - 1, 1 \le i \le m$
$\varphi(w_iw_{i+1}) = 2m + n + i, 1 \le i \le n - 1$ and $\varphi(u_nu_1) = 2m + 2n$.

Using this labeling, for each edge $uv \in E[(C_m \odot K_1) \cup P_n]$, $|\varphi(u) - \varphi(uv) + \varphi(v)|$ will form any one of the constants $c_1 = |1 - 2m - 2n|$, $c_2 = |1 - m - 2n|$ and $c_3 = \left|\frac{3-n+4m}{2}\right|$. Therefore, the disconnected graph $(C_m \odot K_1) \cup P_n$ admits an edge trimagic graceful labeling for $n$ is odd.

**Case 2**: $n$ is even
Define a bijection $\varphi$: V∪E → {1, 2, 3, ..., $4m + 2n + 1$} such that
$\varphi(u_i) = i, 1 \le i \le m - 1$
$\varphi(v_i) = m + i, 1 \le i \le m - 1$
$\varphi(u_n) = m$; $\varphi(v_n) = 2m$

$$\varphi(w_i) = \begin{cases} 2m + \frac{i+1}{2}, 1 \le i \le n, \text{i is odd} \\ 2m + \frac{n+i}{2}, 1 \le i \le n, \text{i is even} \end{cases}$$

$\varphi(u_iu_{i+1}) = 2m + 2n + 2i, 1 \le i \le m - 1$
$\varphi(u_iv_i) = 2m + 2n + 2i - 1, 1 \le i \le m$
$\varphi(w_iw_{i+1}) = 2m + n + i, 1 \le i \le n - 1$ and $\varphi(u_nu_1) = 2m + 2n$.
Using this labeling, for each edge $uv \in E[(C_m \odot K_1) \cup P_n]$, $|\varphi(u) - \varphi(uv) + \varphi(v)|$ will form any one of the constants $c_1 = |1 - 2m - 2n|$, $c_2 = |1 - m - 2n|$ and $c_3 = \left|\frac{2-n+4m}{2}\right|$. Therefore, the disconnected graph $(C_m \odot K_1) \cup P_n$ admits an edge trimagic graceful labeling for $n$ is even.

We proved that the disconnected graph $(C_m \odot K_1) \cup P_n$ admits an edge trimagic graceful labeling. Since $(C_m \odot K_1) \cup P_n$ has $4m+2n+1$ vertices and these $4m+2n+1$ vertices have labels 1, 2, ..., $4m+2n+1$ for all values of $n$ and $m$, the graph $(C_m \odot K_1) \cup P_n$ is a super edge trimagic graceful.

**Example 2.2:** An edge trimagic graceful labeling of the graph $(C_5 \odot K_1) \cup P_6$ and the graph $(C_6 \odot K_1) \cup P_7$ are given in figure 1 and figure 2 respectively.

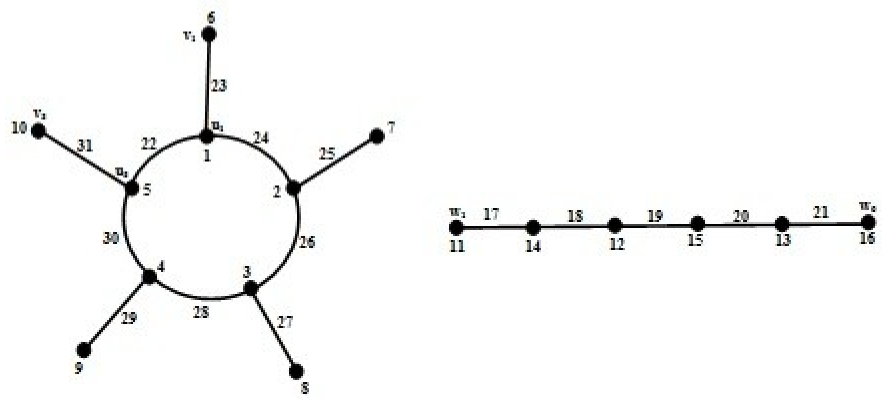

**Figure 1:** $(C_5 \odot K_1) \cup P_6$ with edge trimagic graceful constants $c_1 = 21$, $c_2 = 16$ and $c_3 = 8$

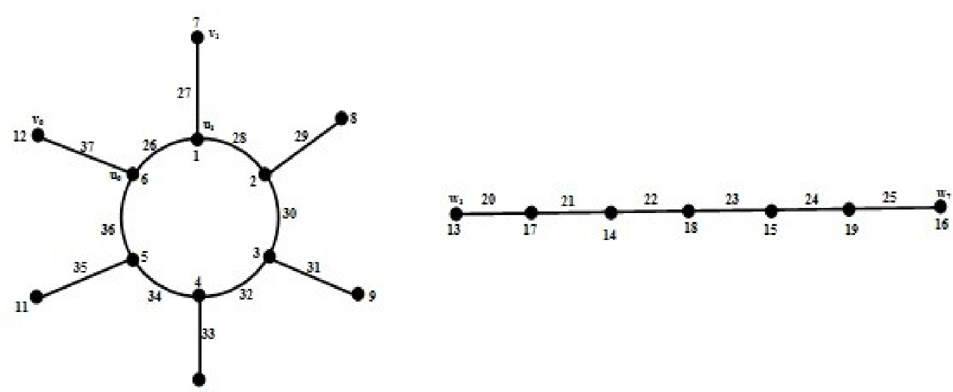

**Figure 2:** $(C_6 \odot K_1) \cup P_7$ with edge trimagic graceful constants $c_1 = 25$, $c_2 = 19$ and $c_3 = 10$

**Theorem 2.3:** The graph $nP_3$admits an edge trimagic graceful labeling for all $n$.

**Proof:** Let V $(nP_3)$ = { $u_i$, $v_i$, $w_i$ / 1 ≤ i ≤ $n$ } be the vertex set ,and E $(nP_3)$ = { $u_iv_i$, $v_iw_i$/ 1 ≤ i ≤ $n$ } be the edge set of the disconnected graph $nP_3$. Then the disconnected graph $nP_3$ has $3n$ vertices and $2n$ edges.

Define a bijection $\varphi$: V∪E → {1, 2, 3, ..., $5n$} such that

$\varphi(u_1) = 1$ ; $\varphi(u_{i+1}) = i + 1, 1 \le i \le n - 1$

$\varphi(v_1) = n + 1$; $\varphi(v_{i+1}) = n + i + 1 , 1 \le i \le n - 1$

$\varphi(w_i) = 2n + i , 1 \le i \le n$ ; $\varphi(u_1v_1) = 5n$ ; $\varphi(v_1w_1) = 5n - 1$

$\varphi(u_{i+1}v_{i+1}) = 3n + 2i - 1 , 1 \le i \le n - 1$ and $\varphi(v_{i+1}w_i) = 3n + 2i, 1 \le i \le n - 1$

Using this labeling, for each edge uv ∈ E($nP_3$), $|\varphi(u) - \varphi(uv) + \varphi(v)|$ will form any one of the constants$c_1$ = $|2 - 4n|$, $c_2$= $|3 - 2n|$ and $c_3$ = $|2|$. Therefore, the disconnected graph $nP_3$ admits an edge trimagic graceful labeling for all $n$.

Since the disconnected graph $nP_3$has $3n$ vertices and these $3n$ vertices have labels 1,2,..., $3n$ for all n, the disconnected graph $nP_3$ is a super edge trimagic graceful graph.

**Example 2.4:** A super edge trimagic graceful labeling of $5P_3$is given in figure 3.

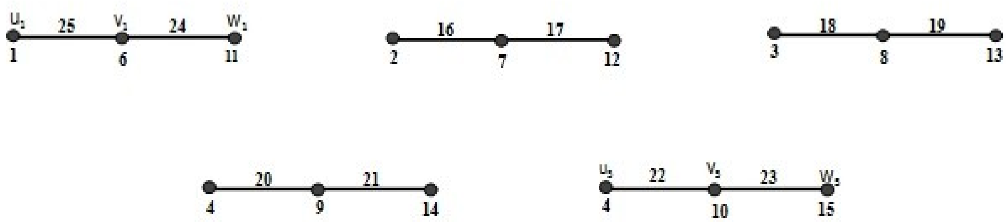


**Figure 3:**$5P_3$ with edge trimagic graceful constants$c_1$= 18, $c_2$ = 7 and $c_3$= 2.

**Theorem 2.5:** The graph $K_{1,l} \cup K_{1,m} \cup K_{1,n}$ admits an edge trimagic graceful labeling for all values of $l$, $m$ and $n$.

**Proof:** Let V($K_{1,l} \cup K_{1,m} \cup K_{1,n}$ ) = { $u_i$, $v_j$, $w_k$ / 1 ≤ i ≤ $l$+1; 1 ≤ i ≤ $m$ +1, 1 ≤ i ≤ $n$ +1 } be the vertex set , and E($K_{1,l} \cup K_{1,m} \cup K_{1,n}$ ) = { $u_1u_i$ , $v_1v_j$, $w_1w_k$ / 2 ≤ i ≤ $l$+1; 2 ≤ i ≤ $m$ +1, 2 ≤ i ≤ $n$ +1 } be the edge set of the disconnected graph $K_{1,l} \cup K_{1,m} \cup K_{1,n}$ . Then the disconnected graph $K_{1,l} \cup K_{1,m} \cup K_{1,n}$ has $l + m + n + 3$ vertices and$l + m + n$ edges.

**Case 1:** $l$, $n$ are odd and $m$ is even.

Define a bijection $\varphi$: V ∪E → {1, 2, 3, ..., $2l + 2m + 2n +3$} such that

$\varphi(u) = 1, \varphi(v) = 2, \varphi(w) = 3$

$\varphi(u_i) = 3 + i , 1 \le i \le l$; $\varphi(uu_i) = l + m + n + i + 3, 1 \le i \le l$

$\varphi(v_j) = m + j + 2, 1 \le j \le m$ ;$\varphi(w_k) = 2n + k, 1 \le k \le n$

$\varphi(vv_j) = l + m + 2n + j + 1, 1 \le j \le m$

and $\varphi(ww_k) = 2l + m + 2n + k + 2, 1 \le k \le n.$

Using this labeling, for each edge uv ∈ E($K_{1,l} \cup K_{1,m} \cup K_{1,n}$ ), $|\varphi(u) - \varphi(uv) + \varphi(v)|$ will form any one of the constants $c_1$ = $|1 - ( l + m + n)|$, $c_2$ = $|3 - ( l + 2n)|$ and$c_3$ = $|1 - ( 2l + m)|$. Therefore, the disconnected graph$K_{1,l} \cup K_{1,m} \cup K_{1,n}$ admits an edge trimagic graceful labeling for $l$, $n$ are odd and $m$ is even.

**Case 2:** $l$, $m$ and $n$ are odd.

Define a bijection $\varphi$: V ∪E → {1, 2, 3, ..., $2l + 2m + 2n +3$} such that

$\varphi(u) = 1, \varphi(v) = 2, \varphi(w) = 3$

$\varphi(u_i) = 3 + i, 1 \le i \le l$ ; $\varphi(v_j) = m + j + 1, 1 \le j \le m$

$\varphi(w_k) = m + n + k - 1, 1 \le k \le n$ ; $\varphi(uu_i) = l + m + n + i + 3 , 1 \le i \le l.$

$\varphi(vv_j) = l + 2m + n + j + 1, 1 \le j \le m$ and $\varphi(ww_k) = l + 2m + 2n + k - 1, 1 \le k \le n.$

Using this labeling, for each edge uv ∈ E($K_{1,l} \cup K_{1,m} \cup K_{1,n}$ ), $|\varphi(u) - \varphi(uv) + \varphi(v)|$ will form any one of the constants $c_1$ = $|1 - ( l + m + n)|$, $c_2$ = $|2 - ( l + m + n)|$ and $c_3$ = $|3 - ( l + m + n)|$. Therefore, the disconnected graph $K_{1,l} \cup K_{1,m} \cup K_{1,n}$ admits an edge trimagic graceful labeling for $l$, $m$ and $n$ are odd.

**Case 3:** $l$, $m$ and $n$ are even.

Define a bijection $\varphi$: V ∪E → {1, 2, 3, ..., $2l + 2m + 2n +3$} such that

$\varphi(u) = 1, \varphi(v) = 2, \varphi(w) = 3$

$\varphi(u_i) = 3 + i, 1 \le i \le l$ ; $\varphi(v_j) = m + j, 1 \le j \le m$

$\varphi(w_k) = l + n + k, 1 \le k \le n$ ; $\varphi(uu_i) = l + m + n + i + 3 , 1 \le i \le l.$

$\varphi(vv_j) = 2l + m + n + j + 3, 1 \le j \le m$ and $\varphi(ww_k) = l + 2m + 2n + k - 1, 1 \le k \le n.$

Using this labeling, for each edge uv ∈ E($K_{1,l} \cup K_{1,m} \cup K_{1,n}$ ), $|\varphi(u) - \varphi(uv) + \varphi(v)|$ will form any one of the constants $c_1 = |1 - (l + m + n)|$, $c_2 = |-2l - n|$ and $c_3 = |5 - 2m - n|$. Therefore, the disconnected graph $K_{1,l} \cup K_{1,m} \cup K_{1,n}$ admits an edge trimagic graceful labeling for *l, m* and *n* are even.

**Case 4:** For all other cases ( *l, m* are even and *n* is odd (or) *m, n* are odd and *l* is even (or) *l, n* are even and *m* is odd (or) *l, m* are odd and *n* is even (or) *l* is odd and *m, n* are even)

Define a bijection $\varphi$: V ∪E → {1, 2, 3, ..., 2*l* + 2*m* + 2*n* +3} such that

$\varphi(u) = 1, \varphi(v) = 2, \varphi(w) = 3$

$\varphi(u_i) = 3 + i, 1 \le i \le l$ ; $\varphi(v_j) = l + j + 3, 1 \le j \le m$

$\varphi(w_k) = l + m + k + 3, 1 \le k \le n$ ; $\varphi(uu_i) = l + m + n + i + 3$ , $1 \le i \le l$.

$\varphi(vv_j) = 2l + m + n + j + 3, 1 \le j \le m$

and $\varphi(ww_k) = 2l + 2m + n + k + 3, 1 \le k \le n$

Using this labeling, for each edge uv ∈E($K_{1,l} \cup K_{1,m} \cup K_{1,n}$ ), $|\varphi(u) - \varphi(uv) + \varphi(v)|$ will form any one of the constants $c_1 = |1 - (l + m + n)|$, $c_2 = |2 - (l + m + n)|$ and $c_3 = |3 - (l + m + n)|$. Therefore, the disconnected graph $K_{1,l} \cup K_{1,m} \cup K_{1,n}$ admits an edge trimagic graceful labeling for all other cases such as *l, m* are even and *n* is odd, *m, n* are odd and *l* is even, *l, n* are even and *m* is odd, *l, m* are odd and *n* is even and *l* is odd and *m, n* are even.Hence the theorem follows from the above all four cases.

We proved the disconnected graph $K_{1,l} \cup K_{1,m} \cup K_{1,n}$ admits an edge trimagic graceful labeling. Since the disconnected graph $K_{1,l} \cup K_{1,m} \cup K_{1,n}$ has *l* + *m* + *n* + 3 vertices and these vertices have labels 1, 2, ..., *l* + *m* + *n* + 3, the disconnected graph $K_{1,l} \cup K_{1,m} \cup K_{1,n}$ is a super edge trimagic graceful graph.

**Example 2.6:** A super edge trimagic graceful labeling of $K_{1,7} \cup K_{1,9} \cup K_{1,11}$ is given in figure 4.

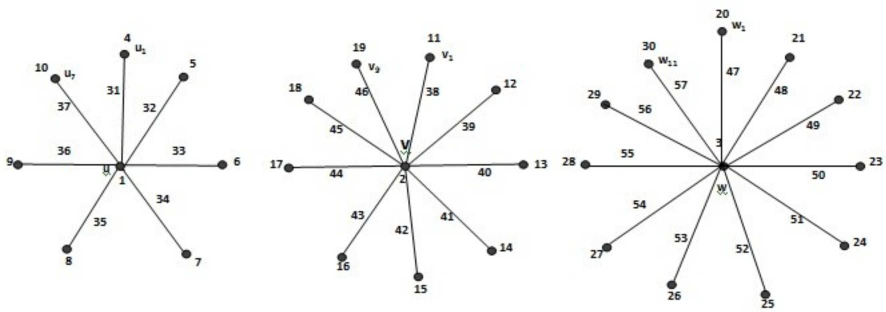


**Figure 4:** $K_{1,7} \cup K_{1,9} \cup K_{1,11}$ with edge trimagic graceful constants $c_1 = 26, c_2 = 25$ and $c_3 = 24$.

**Theorem 2.7:** The graph $nC_4$ admits an edge trimagic graceful labeling for all *n*.

**Proof:** Let V($nC_4$) = {$w_i, x_i, y_i, z_i / 1 \le i \le n$} be the vertex set and E($nC_4$) = {$w_ix_i, x_iz_i, y_iz_i, y_iw_i$ / $1 \le i \le n$ } be the edge set of the disconnected graph $nC_4$. Then the graph $nC_4$ has 4*n* vertices and 4*n* edges.

Define a bijection : V∪E → {1, 2, …, 8*n*} such that

$\varphi(w_i) = i, 1 \le i \le n$ ; $\varphi(x_i) = n + i, 1 \le i \le n$

$\varphi(y_i) = 2n + i, 1 \le i \le n$; $\varphi(z_i) = 3n + i, 1 \le i \le n$.

$\varphi(w_ix_i) = 4n + i - 1, 1 \le i \le n$ ; $\varphi(x_iy_i) = 6n + 2i, 1 \le i \le n$

$\varphi(y_iz_i) = 6n + 2i - 1, 1 \le i \le n$ and $\varphi(z_iw_i) = 4n + 2i, 1 \le i \le n$.

Using this labeling we get, for each edge uv ∈ E($nC_4$), $|\varphi(u) - \varphi(uv) + \varphi(v)|$ will form any one of the constants $c_1 = |1 - 3n|$, $c_2 = |-2n|$ and $c_3 = |1 - n|$ . Hence the graph $nC_4$ is an edge trimagic graceful for all values of *n*.

We proved the graph $nC_4$ admits an edge trimagic graceful labeling. The labeling given in the proof of theorem 2.7, the vertices get labels $\varphi(w_i) = i$, $\varphi(x_i) = n + i$, $\varphi(y_i) = 2n + i$, $\varphi(z_i) = 3n + i$, for all $1 \le i \le n$. Since the graph $nC_4$ has 4*n* vertices and these 4*n* vertices have labels 1, 2, ..., 4*n*. Hence, the graph $nC_4$ is a super edge trimagic graceful graph.

**Example 2.8:** An edge trimagic graceful labeling of $5C_4$ is given in figure 5.

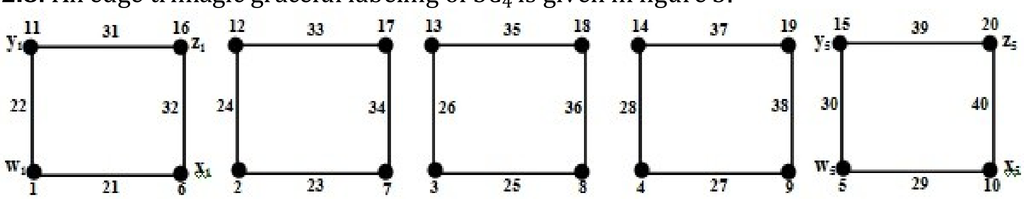


**Figure 5:** $5C_4$ with the edge trimagic graceful constants $c_1 = 14$, $c_2 = 10$ and $c_3 = 4$

**Theorem 2.9:** The disconnected graph $(C_m \odot K_1) \cup C_n$ admits an edge trimagic graceful labeling for all values of $m$ and for odd $n$.

**Proof:** Let V$[(C_m \odot K_1) \cup C_n]$ ={ $u_i, v_i, w_j$, $1 \le i \le m$, $1 \le j \le n$} be the vertex set, and E $[(C_m \odot K_1) \cup C_n]$ = {$u_iv_i$, $u_iu_{i+1}$, $w_jw_{j+1}$ /$1 \le i \le m, 1 \le j \le n$} be the edge set of the graph $(C_m \odot K_1) \cup C_n$. Then the graph $(C_m \odot K_1) \cup C_n$ has $2m + n$ vertices and $2m + n$ edges.

**Case 1:** m is odd

Define a bijection $\varphi$: V ∪ E → {1, 2, 3, ..., $4m + 2n$} such that

$\varphi(u_i) = i, 1 \le i \le m$ ; $\varphi(v_i) = m + i, 1 \le i \le m$

$$\varphi(w_j) = \begin{cases} \frac{2m+2n+j-3}{2}, & 1 \le i \le n, j \text{ is odd} \\ \frac{2m+3n+j-3}{2}, & 1 \le i \le n, j \text{ is even} \end{cases}$$

$\varphi(u_iu_{i+1}) = 2m + 2n + 2i + 1, 1 \le i \le m-1$ ; $\varphi(u_1u_m) = 2m + 2n + 1$

$\varphi(u_iv_i) = 2m + 2n + 2i, 1 \le i \le m$ ; $\varphi(w_1w_n) = 2m + 2n + 2i - 1$

and $\varphi(w_iw_{i+1}) = 2m + n + i + 1, 1 \le j \le n - 1$

Using this labeling, for each edge uv ∈ E $[(C_m \odot K_1) \cup C_n]$, $|\varphi(u) - \varphi(uv) + \varphi(v)|$ will form any one of the constants $c_1 = |-2m - 2n|$, $c_2 = |-2n - m|$ and $c_3 = \left|\frac{3n-7}{2}\right|$. Therefore, the graph $(C_m \odot K_1) \cup C_n$ admits an edge trimagic graceful labeling for odd $m$.

**Case 2:** $m$ is even

Define a bijection $\varphi$: V ∪ E → {1, 2, 3, ..., $4m + 2n$} such that

$\varphi(u_i) = i, 1 \le i \le m$ ; $\varphi(v_i) = m + i, 1 \le i \le m$

$$\varphi(w_j) = \begin{cases} 2m + \frac{i+1}{2}, & 1 \le i \le n, i \text{ is odd} \\ 2m + \frac{n+i+1}{2}, & 1 \le i \le n, i \text{ is even} \end{cases}$$

$\varphi(u_iu_{i+1}) = 2m + 2n + 2i + 1, 1 \le i \le m-1$ ; $\varphi(u_1u_m) = 2m + 2n + 1$

$\varphi(u_iv_i) = 2m + 2n + 2i, 1 \le i \le m$ ; $\varphi(w_1w_n) = 2m + n + 1$

and $\varphi(w_jw_{j+1}) = 2m + n + j + 1, 1 \le j \le n-1$

Using this labeling, for each edge uv ∈ E$[(C_m \odot K_1) \cup C_n]$, $|\varphi(u) - \varphi(uv) + \varphi(v)|$ will form any one of the constants $c_1 = |-2m - 2n|$, $c_2 = |-m - 2n|$ and $c_3 = \left|\frac{4m+1-n}{2}\right|$. Therefore, the graph $(C_m \odot K_1) \cup C_n$ admits an edge trimagic graceful labeling for even $m$.

Hence, the theorem follows from case 1 and case 2.

Since the graph $(C_m \odot K_1) \cup C_n$ has $2m + n$ vertices and these $2m + n$ vertices have labels 1, 2, ...,$2m + n$. Hence, the graph $(C_m \odot K_1) \cup C_n$ is a super edge trimagic graceful graph.

**Example 2.10:** An edge trimagic graceful labeling of $(C_5 \odot K_1) \cup C_7$ and $(C_6 \odot K_1) \cup C_9$ are given in figure 6 and figure 7.

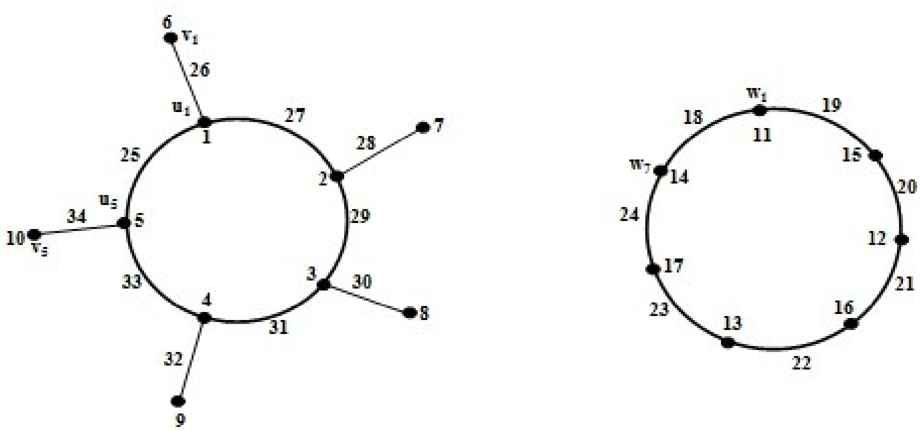


**Figure 6:**$(C_5 \odot K_1) \cup C_7$ withedge trimagic graceful constants $c_1 = 24, c_2 = 19$ and $c_3 = 7$.

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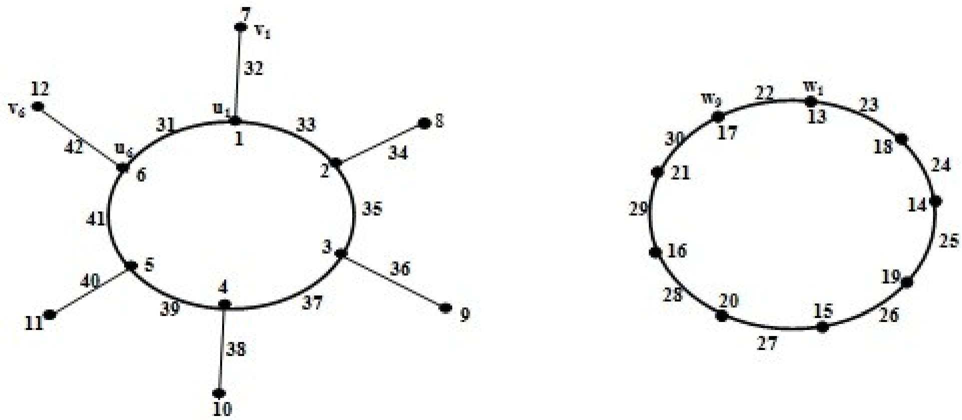


**Figure 7:**$(C_6 \odot K_1) \cup C_9$ with edge trimagic graceful constants $c_1$ = 30, $c_2$= 24 and $c_3$= 8.

**CONCLUSION**

In this paper, we proved that the disconnected graphs $(C_m \odot K_1) \cup P_n$, $nP_3$, $K_{1,l} \cup K_{1,m} \cup K_{1,n}$, $nC_4$ and $(C_m \odot K_1) \cup C_n$ are edge trimagic graceful graphs, using these ideas we can find more Edge Trimagic Graceful labeling of some more disconnected graphs.

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