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4-Total Geometric Mean Cordial Labelling of Some Disconnected Graphs

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Abstract:

Let G be a (p, q) graph. Let f : V(G) □ {1, 2, 3,…, k} be a function where k□N and k□1. For each edge uv, assign the label f (uv) = $\left\lceil \sqrt{f(u)f(v)} \right\rceil$. f is called k-Total geometric mean cordial labeling of G if □ $t_{mf}(i) - t_{mf}(j)$ □ ≤ 1, for all i, j□{1, 2, 3,…, k} where $t_{mf}(x)$ denotes the total number of vertices and edges labeled with x, x□{1, 2, 3,…, k}. A graph that admits the ktotal geometric mean cordial labeling is called k-total geometric mean cordial graph.

In this paper we investigate 4- Total geometric mean cordiality of graphs like P_n □ C_n, P_n □ K1,n , Pn □ Bn,n , Cn □ Cn , Cn □ K1,n , Cn □ Bn,n , Pn □ Yn, Pn □ Pn Θ K1, Cn □ Pn Θ K1.

Keywords: path, cycle, star, bistar, Y_n-tree and comb graph.
AMS subject classification (2010) : 05C78

1. Introduction

Finite, simple and undirected graphs are considered here. Graph labeling we refer to Gallian [1]. We pursue [2] for symbols and phrases. Cordial labeling was introduced by Cahit [3]. Geometric mean cordial labeling of graphs was introduced in [4]. k- total mean cordial labeling of graphs was introduced in [5]. 4-total mean cordial labeling of some graphs derived from path and cycle was introduced in [6]. The notation of k-total geometric mean cordial labeling of some graphs was introduced in [7]. 4-total geometric mean cordial graphs was introduced in [8].

2. k-Total Geometric Mean Cordial Graph

Definition 2.1.

Let G be a (p, q) graph. Let f : V(G) □ {1, 2, 3,…, k} be a function where k□N and k□1. For each edge uv, assign the label f (uv) = $\left\lceil \sqrt{f(u)f(v)} \right\rceil$. f is called k-Total geometric mean cordial labeling of G if □ $t_{mf}(i) - t_{mf}(j)$ □ ≤ 1, for all i, j□{1, 2, 3,…, k} where $t_{mf}(x)$ denotes the total number of vertices and edges labeled with x, x□{1, 2, 3,…, k}. A graph that admits the k-total geometric mean cordial labeling is called k-total geometric mean cordial graph.

3. Preliminaries

Definition 3.1.

The union of two graphs G_1 and G_2 is the graph $G_1 \cup G_2$ with $V(G_1 \cup G_2) = V(G_1) \cup V(G_2)$ and $E(G_1 \cup G_2) = E(G_1) \cup E(G_2)$.

Definition 3.2.

A walk in which all the vertices say $u_1, u_2, \ldots u_n$ are distinct is called a path. A path is denoted by P_n. The path P_n has n vertices and n-1 edges.

Definition 3.3.

A cycle is a closed walk in which all the vertices are distinct, except the last and the first.

Definition 3.4.

The graph obtained by joining a single pendant edge to each vertex of a path is called a Comb.

Definition 3.5.

The complete bipartite graph $K_{1,n}$ is called a star.

Definition 3.6.

The Bistar $B_{m,n}$ is the graph obtained by joining the two central vertices of $K_{1,m}$ and $K_{1,n}$.

Definition 3.7.

A Y_n - tree is obtained from a path P_n by attaching a pendant vertex to the $(n-1)^{th}$ vertex of P_n.

A tree on n+1vertices is denoted by Y_n.

4. Main Results

Theorem 4.1.

The union of path P_n and cycle C_n, $P_n \cup C_n$ is 4-total geometric mean cordial graph .

Proof:

Let $x_1, x_2, x_3, \ldots, x_n$ be the vertices of the path P_n. Let $y_1, y_2, y_3, \ldots, y_n y_1$ be the vertices of the cycle C_n.

Clearly $|V(P_n \cup C_n)| + |E(P_n \cup C_n)| = 4n - 1$.

The $f: V(P_n \cup C_n) \rightarrow \{1, 2, 3, 4\}$ function defined by

Case 1: n is odd

$$f(x_1) = f(x_2) = \ldots\ldots\ldots = f\left(x_{\frac{n+1}{2}}\right) = 1;$$

$$f\left(x_{\frac{n+3}{2}}\right) = f\left(x_{\frac{n+5}{2}}\right) = f\left(x_{\frac{n+7}{2}}\right) = \ldots\ldots\ldots = f(x_n) = 2;$$

$$f(y_1) = f(y_2) = f(y_3) = \ldots\ldots\ldots = f\left(y_{\frac{n+1}{2}}\right) = 3;$$

$$f\left(y_{\frac{n+3}{2}}\right) = f\left(y_{\frac{n+5}{2}}\right) = f\left(y_{\frac{n+7}{2}}\right) = \ldots\ldots\ldots = f(y_n) = 4.$$

Case 2: n is even

$$f(x_1) = f(x_2) = f(\ x_3) = \ldots\ldots\ldots = f\left(x_{\frac{n}{2}}\right) = 1;$$
$$f\left(x_{\frac{n+2}{2}}\right) = f\left(x_{\frac{n+4}{2}}\right) = f\left(x_{\frac{n+6}{2}}\right) = \ldots\ldots\ldots = f(x_n) = 3;$$
$$f(y_1) = f(y_2) = f(y_3) = \ldots\ldots\ldots = f\left(y_{\frac{n}{2}}\right) = 4;$$
$$f\left(y_{\frac{n+2}{2}}\right) = f\left(y_{\frac{n+4}{2}}\right) = f\left(y_{\frac{n+6}{2}}\right) = \ldots\ldots\ldots = f(y_{n-1}) = 2;$$
$$f(y_n) = 1.$$

Hence the function f is 4-total geometric mean cordial labeling and P_n□C_n is 4-total geometric mean cordial graph .

Theorem 4.2.

The graph P_n□ $K_{1,n}$ is 4-total geometric mean cordial graph.

Proof:

Let $x_1\ x_2\ x_3 \ldots\ldots\ldots x_n$ be the path P_n. Let y be the centre vertex and $y_1, y_2, y_3, \ldots, y_n$ be the pendant vertices of the star $K_{1,n}$.

$$|V(P_n \cup K_{1,n})| + |E(P_n \cup K_{1,n})| = 4n$$ Clearly .

Define $f : V\left(P_n \cup K_{1,n}\right) \to \{1,2,3,4\}$ by

Case 1: n is odd

$$f(x_1) = f(x_2) = \ldots\ldots\ldots = f\left(x_{\frac{n+1}{2}}\right) = 1;$$
$$f\left(x_{\frac{n+3}{2}}\right) = f\left(x_{\frac{n+5}{2}}\right) = f\left(x_{\frac{n+7}{2}}\right) = \ldots\ldots\ldots = f(x_n) = 2;$$
$$f(y) = 2;$$
$$f(y_1) = f(y_2) = f(y_3) = \ldots\ldots\ldots = f(y_n) = 4.$$

Case 2: n is even

$$f(x_1) = f(x_2) = f(\ x_3) = \ldots\ldots\ldots = f\left(x_{\frac{n}{2}}\right) = 3;$$
$$f\left(x_{\frac{n+2}{2}}\right) = f\left(x_{\frac{n+4}{2}}\right) = f\left(x_{\frac{n+6}{2}}\right) = \ldots\ldots\ldots = f(x_n) = 4;$$
$$f(y) = 3;$$
$$f(y_1) = f(y_2) = f(y_3) = \ldots\ldots\ldots = f(y_n) = 1.$$

Hence f is 4-total geometric mean cordial labeling and P_n□ $K_{1,n}$ is 4-total geometric mean cordial graph .

Theorem 4.3.

The graph P_n□ $B_{n,n}$ is 4-total geometric mean cordial graph . Proof:

Let $x_1\ x_2\ x_3 \ldots\ldots\ldots x_n$ be the path. Let $y_1, y_2, y_3, \ldots, y_n$, $z_1, z_2, z_3, \ldots, z_n$ be the pendant vertices and y, z be the centre vertices of $B_{n,n}$.

Clearly

$$|V(P_n \cup B_{n,n})| + |E(P_n \cup B_{n,n})| = 6n + 2.$$

Define $f : V\left(P_n \cup B_{n,n}\right) \to \{1,2,3,4\}$ by

Case 1: n is odd

$$f(x_1) = f(x_2) = f(\,x_3) = .\dots\dots. = f\left(x_{\frac{n+1}{2}}\right) = 3;$$
$$f\left(x_{\frac{n+3}{2}}\right) = f\left(x_{\frac{n+5}{2}}\right) = f\left(x_{\frac{n+7}{2}}\right) = .\dots\dots.. = f(x_n) = 4;$$
$$f(y) = 3;$$
$$f(z) = 4;$$
$$f(y_1) = f(y_2) = f(y_3) = .\dots\dots. = f(y_n) = 1;$$
$$f(z_1) = f(z_2) = f(z_3) = .\dots\dots. = f\left(z_{\frac{n+1}{2}}\right) = 1;$$
$$f\left(z_{\frac{n+3}{2}}\right) = f\left(z_{\frac{n+5}{2}}\right) = f\left(z_{\frac{n+7}{2}}\right) = .\dots\dots. = f(z_n) = 3.$$

Case 2: n is even

$$f(x_1) = f(x_2) = f(\,x_3) = .\dots\dots.. = f\left(x_{\frac{n+2}{2}}\right) = 3;$$
$$f\left(x_{\frac{n+4}{2}}\right) = f\left(x_{\frac{n+6}{2}}\right) = .\dots\dots. = f(x_n) = 4;$$
$$f(y) = f(z) = 4;$$
$$f(y_1) = f(y_2) = f(y_3) = .\dots\dots. = f(y_n) = 1;$$
$$f(z_1) = f(z_2) = f(z_3) = .\dots\dots. = f\left(z_{\frac{n}{2}}\right) = 1;$$
$$f\left(z_{\frac{n+2}{2}}\right) = f\left(z_{\frac{n+4}{2}}\right) = .\dots\dots.. = f(z_n) = 3.$$

Hence f is 4-total geometric mean cordial labeling and P_n□ $B_{n,n}$ is 4-total geometric mean cordial graph .

Theorem 4.4.

The graph C_n□ C_n is a 4-total geometric mean cordial graph.

Proof:

$x_1, x_2, x_3, \dots, x_n$ and $y_1, y_2, y_3, \dots, y_n$ Let be the vertices of two copies of cycle C_n.

$|V(C_n \cup C_n)| + |E(C_n \cup C_n)| = 4n.$ Clearly

Define $f : V(C_n \cup C_n) \rightarrow \{1, 2, 3, 4\}$ by

Case 1: n is odd

$$f(x_1) = f(x_2) = \dots\dots\dots = f\left(x_{\frac{n+1}{2}}\right) = 1;$$
$$f\left(x_{\frac{n+3}{2}}\right) = f\left(x_{\frac{n+5}{2}}\right) = .\dots\dots. = f(x_n) = 2;$$
$$f(y_1) = f(y_2) = .\dots\dots. = f\left(y_{\frac{n+1}{2}}\right) = 3;$$
$$f\left(y_{\frac{n+3}{2}}\right) = f\left(y_{\frac{n+5}{2}}\right) = .\dots\dots. = f(y_n) = 4.$$

Case 2: n is even

Subcase (i): n = 4

$$f(x_1) = f(x_2) = f(\,y_1) = 1;$$
$$f(x_3) = f(x_4) = f(\,y_2) = 3;$$
$$f(y_3) = f(y_4) = 4.$$

Subcase (ii): n ≥ 6

$$f(x_1) = f(x_2) = f(x_3) = \dots\dots = f\left(x_{\frac{n}{2}}\right) = 1;$$
$$f(x_{n-1}) = 1;$$
$$f(x_n) = 3;$$
$$f\left(x_{\frac{n+2}{2}}\right) = f\left(x_{\frac{n+4}{2}}\right) = f\left(x_{\frac{n+6}{2}}\right) = \dots\dots = f(x_{n-2}) = 2;$$
$$f(y_1) = f(y_2) = f(y_3) = \dots\dots = f\left(y_{\frac{n}{2}}\right) = 4;$$
$$f\left(y_{\frac{n+2}{2}}\right) = f\left(y_{\frac{n+4}{2}}\right) = f\left(y_{\frac{n+6}{2}}\right) = \dots\dots = f(y_{n-1}) = 3;$$
$$f(y_n) = 2.$$

Hence f is 4-total geometric mean cordial labeling and C_n□ C_n is a 4-total geometric mean cordial graph.

Theorem4.5.

The graph C_n□ $K_{1,n}$ is a 4-total geometric mean cordial graph .

Proof:

Let $x_1\, x_2\, x_3 \dots\dots x_n x_1$ be the cycle C_n. Let y be the centre vertex and $y_1, y_2, y_3, \dots, y_n$ be the pendant vertices of the star $K_{1,n}$.

Clearly $|V(C_n \cup K_{1,n})| + |E(C_n \cup K_{1,n})| = 4n + 1$

Define $f : V\left(C_n \cup K_{1,n}\right) \to \{1, 2, 3, 4\}$ by

$$f(y) = 3;$$
$$f(y_1) = f(y_2) = f(y_3) = \dots\dots = f(y_n) = 1.$$

Case 1: n is odd

$$f(x_1) = f(x_2) = f(x_3) = \dots\dots = f\left(x_{\frac{n+1}{2}}\right) = 3;$$
$$f\left(x_{\frac{n+3}{2}}\right) = f\left(x_{\frac{n+5}{2}}\right) = f\left(x_{\frac{n+7}{2}}\right) = \dots\dots = f(x_n) = 4.$$

Case 2: n is even

$$f(x_1) = f(x_2) = f(x_3) = \dots\dots = f\left(x_{\frac{n}{2}}\right) = 3;$$
$$f\left(x_{\frac{n+2}{2}}\right) = f\left(x_{\frac{n+4}{2}}\right) = f\left(x_{\frac{n+6}{2}}\right) = \dots\dots = f(x_n) = 4.$$

Hence f is 4-total geometric mean cordial labeling and C_n□ $K_{1,n}$ is a 4-total geometric mean cordial graph.

Theorem 4.6.

The graph C_n□ $B_{n,n}$ is 4-total geometric mean cordial graph .

Proof:

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Let $x_1\ x_2\ x_3 \dots \dots . x_n x_1$ be the cycle C_n. Let $y_1, y_2, y_3, \dots, y_n$, $z_1, z_2, z_3, \dots, z_n$ be the pendant vertices and y, z be the centre vertices of $B_{n,n}$.

Clearly $|V(C_n \cup B_{n,n})| + |E(C_n \cup B_{n,n})| = 6n + 3$.

Define $f: V(C_n \cup B_{n,n}) \rightarrow \{1,2,3,4\}$ by

Case 1: n is odd

$f(x_1) = f(x_2) = f(x_3) = \dots \dots . = f\left(x_{\frac{n+1}{2}}\right) = 3;$
$f\left(x_{\frac{n+3}{2}}\right) = f\left(x_{\frac{n+5}{2}}\right) = f\left(x_{\frac{n+7}{2}}\right) = . \dots \dots . . = f(x_n) = 4;$
$f(y) = 3;$
$f(z) = 4;$
$f(y_1) = f(y_2) = f(y_3) = . \dots \dots . = f(y_n) = 1;$
$f(z_1) = f(z_2) = f(z_3) = . \dots \dots . = f\left(z_{\frac{n+1}{2}}\right) = 1;$
$f\left(z_{\frac{n+3}{2}}\right) = f\left(z_{\frac{n+5}{2}}\right) = f\left(z_{\frac{n+7}{2}}\right) = . \dots \dots . = f(z_n) = 3.$

Case 2: n is even

$f(x_1) = f(x_2) = f(x_3) = . \dots \dots . . = f\left(x_{\frac{n+2}{2}}\right) = 3;$
$f\left(x_{\frac{n+4}{2}}\right) = f\left(x_{\frac{n+6}{2}}\right) = f\left(x_{\frac{n+8}{2}}\right) = . \dots \dots . . = f(x_n) = 4;$
$f(y) = 3;$
$f(z) = 4;$
$f(y_1) = f(y_2) = f(y_3) = . \dots \dots . . = f(y_n) = 1;$
$f(z_1) = f(z_2) = f(z_3) = . \dots \dots . = f\left(z_{\frac{n+2}{2}}\right) = 1;$
$f\left(z_{\frac{n+4}{2}}\right) = f\left(z_{\frac{n+6}{2}}\right) = . \dots \dots . . = f(z_n) = 3.$

Hence f is 4-total geometric mean cordial labeling.

Theorem 4.7.

The graph $P_n \cup Y_n$ is 4-total geometric mean cordial graph.

Proof:

Let $x_1\ x_2\ x_3 \dots \dots . x_n$ be the path P_n. Let $y_1, y_2, y_3, \dots, y_n$ be the vertices of the path in the Y graph and z_1 be the pendant vertex adjacent to y_2

Clearly $|V(P_n \cup Y_n)| + |E(P_n \cup Y_n)| = 4n$.

Define $f: V(P_n \cup Y_n) \rightarrow \{1,2,3,4\}$ by

Case 1: n is odd

$$f(x_1) = f(x_2) = f(x_3) = . \dots \dots . . = f\left(x_{\frac{n-1}{2}}\right) = 3;$$

$$f\left(x_{\frac{n+1}{2}}\right) = f\left(x_{\frac{n+3}{2}}\right) = f\left(x_{\frac{n+5}{2}}\right) =. \dots\dots.. = f(x_{n-1}) = 4;$$
$$f(x_n) = 3;$$
$$f(y_1) = f(y_2) = f(y_3) =. \dots\dots.. = f\left(y_{\frac{n+1}{2}}\right) = 1;$$
$$f\left(y_{\frac{n+3}{2}}\right) = f\left(y_{\frac{n+5}{2}}\right) = f\left(y_{\frac{n+7}{2}}\right) =. \dots\dots. = f(y_n) = 2;$$
$$f(z_1) = 3.$$

Case 2: n is even

$$f(x_1) = 1;$$
$$f(x_2) = f(x_3) =. \dots\dots. = f\left(x_{\frac{n+2}{2}}\right) = 4;$$
$$f\left(x_{\frac{n+4}{2}}\right) = f\left(x_{\frac{n+6}{2}}\right) =. \dots\dots. = f(x_n) = 3;$$
$$f\left(y_{\frac{n+2}{2}}\right) = f\left(y_{\frac{n+4}{2}}\right) =. \dots\dots. = f(y_{n-1}) = 2;$$
$$f(y_n) = 3;$$
$$f(z_1) = 3.$$

Hence f is 4-total geometric mean cordial labeling and P_n □ Y_n is 4-total geometric mean cordial graph.

Theorem 4.8.

P_n □ $P_n \odot K_1$ is 4-total geometric mean cordial graph for n≥2.

Proof:

$u_1, u_2, u_3, \dots, u_n$

$y_1, y_2, y_3, \dots, y_n$

$f: V(P_n \cup P_n \odot K_1) \rightarrow \{1, 2, 3, 4\}$

Let be the vertices of the path. Let $x_1, x_2, x_3, \dots, x_n$ be the vertices of the path and be the pendant vertices of the comb graph.

Define by

Case1: n is odd

$$f(u_1) = f(u_2) =. \dots\dots.. = f\left(u_{\frac{n+1}{2}}\right) = 1;$$
$$f\left(u_{\frac{n+3}{2}}\right) = f\left(u_{\frac{n+5}{2}}\right) =. \dots\dots.. = f(u_n) = 3;$$
$$f(x_1) = f(x_2) =. \dots\dots. = f\left(x_{\frac{n-1}{2}}\right) = 2;$$
$$f\left(x_{\frac{n+1}{2}}\right) = f\left(x_{\frac{n+3}{2}}\right) =. \dots\dots. = f(x_n) = 4;$$
$$f(y_1) = f(y_2) =. \dots\dots.. = f\left(y_{\frac{n-1}{2}}\right) = 1;$$
$$f\left(y_{\frac{n+1}{2}}\right) = f\left(y_{\frac{n+3}{2}}\right) =. \dots\dots. = f(y_{n-1}) = 3;$$
$$f(y_n) = 2.$$

Case2: n is even

$$f(u_1) = f(u_2) = f(u_3) =. \dots \dots. . = f\left(u_{\frac{n}{2}}\right) = 1;$$
$$f\left(u_{\frac{n+2}{2}}\right) = f\left(u_{\frac{n+4}{2}}\right) =. \dots \dots. . = f(u_n) = 3;$$

$$f(x_1) = f(x_2) = f(\,x_3) =. \dots \dots. . = f\left(x_{\frac{n}{2}}\right) = 2;$$
$$f\left(x_{\frac{n+2}{2}}\right) = f\left(x_{\frac{n+4}{2}}\right) =. \dots \dots. = f(x_n) = 4;$$
$$f(y_1) = f(y_2) = f(\,y_3) =. \dots \dots. = f\left(y_{\frac{n}{2}}\right) = 1;$$
$$f\left(y_{\frac{n+2}{2}}\right) = f\left(y_{\frac{n+4}{2}}\right) =. \dots \dots. = f(y_n) = 3.$$

Hence f is 4- total geometric mean cordial labeling.

Theorem 4.9.
C_n□ $P_n \Theta K_1$ is 4-total geometric mean cordial graph.

Proof:

$u_1, u_2, u_3, \dots, u_n u_1$
$y_1, y_2, y_3, \dots, y_n$
$f : V(C_n \cup P_n \odot K_1) \rightarrow \{1, 2, 3, 4\}$

Let be the vertices of the cycle. Let $x_1, x_2, x_3, \dots, x_n$ be the vertices of the path and be the pendant vertices of the comb graph.
Define by

Case 1: n is odd

$$f(u_1) = f(u_2) =. \dots \dots. . = f\left(u_{\frac{n+1}{2}}\right) = 1;$$
$$f\left(u_{\frac{n+3}{2}}\right) = f\left(u_{\frac{n+5}{2}}\right) =. \dots \dots. . = f(u_n) = 4;$$
$$f(x_1) = f(x_2) = . \dots \dots. . = f\left(x_{\frac{n+1}{2}}\right) = 3;$$
$$f\left(x_{\frac{n+3}{2}}\right) = f\left(x_{\frac{n+5}{2}}\right) = . \dots \dots. . = f(x_n) = 2;$$
$$f(y_1) = f(y_2) = . \dots \dots. = f\left(y_{\frac{n-1}{2}}\right) = 1;$$
$$f\left(y_{\frac{n+1}{2}}\right) = f\left(y_{\frac{n+3}{2}}\right) = . \dots \dots. . = f(y_n) = 4.$$

Case 2: n is even

$$f(u_1) = f(u_2) = \ldots\ldots.. = f\left(u_{\frac{n+2}{2}}\right) = 1;$$
$$f\left(u_{\frac{n+4}{2}}\right) = f\left(y_{\frac{n+6}{2}}\right) = \ldots\ldots.. = f(u_n) = 4;$$
$$f(x_1) = f(x_2) = \ldots\ldots.. = f\left(x_{\frac{n}{2}}\right) = 3;$$
$$f\left(x_{\frac{n+2}{2}}\right) = f\left(x_{\frac{n+4}{2}}\right) = \ldots\ldots.. = f(x_n) = 2;$$
$$f(y_1) = f(y_2) = \ldots\ldots.. = f\left(y_{\frac{n-2}{2}}\right) = 1;$$
$$f\left(y_{\frac{n}{2}}\right) = f\left(y_{\frac{n+2}{2}}\right) = \ldots\ldots.. = f(y_n) = 4.$$

Hence f is 4- total geometric mean cordial labeling and C_n □ $P_n \odot K_1$ is 4-total geometric mean cordial graph.

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