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Original Article

K^{th} Fibonacci Prime Labeling of Graphs

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Abstract *- In this paper, we introduced k^{th} Fibonacci prime labeling of graphs and prove that path, cycle, $P_n \odot K_1$, Triangular snake, Quadrilateral snake and Tadpole graph are k^{th} Fibonacci prime graphs.*

Keywords *- Prime graph, k-prime graph, Fibonacci number, Fibonacci prime graph, k^{th} Fibonacci prime graph.*

1. Introduction

By a graph, we mean a finite, undirected graph without loops and multiple edges, for terms not defined here, we refer to Bondy and Murthy [1]. For standard terminology and notations related to number theory we refer to Burton [2] and graph labeling, we refer to Gallian [5]. The notion of prime labeling for graphs originated with Roger Entringer and was introduced in a paper by Tout et al. [24] in the early 1980s and since then it is an active field of research for many scholars. In [25], Vaidya et al. introduced the concept of k-prime labeling of graph. A generalization of graceful graphs is the notion of k-graceful graphs introduced independently by Slater [20] in 1982 and by Maheo et al. [8] in 1982. In [21], Sundaram et al. introduced the notion of prime cordial labeling of graphs. Ponraj et al. [18], introduced a new graph labeling called k-prime cordial labeling of graphs. In [15], Ponraj et al. introduced the concept of difference cordial labeling of graphs. Ponraj et al. [17], introduced the concept of k-difference cordial labeling of graphs.

Patel et al. [14] introduce the notion of neighborhood-prime labeling of graphs. In [6], Lawrence et al. introduce the notation of k-neighborhoodprime labeling of labeling of graphs. In [7], Lourdusamy et al. investigated some new construction of SD-prime cordial graph. In [4], Delman et al. introduced the concept of k-SD-prime cordial labeling of graph and discussed k-SD-prime cordial labeling of some standard graphs. The concept of one raised sum prime labeling was introduced by Sunoj and Mathew Varkey in [22]. Muthaiyan et al. introduced the concept of k-one raised sum prime labeling and investigated some new families of k-one raised sum prime graph in [11]. In [23], Sunoj and Mathew Varkey introduced the concept of one raised product prime labeling of graphs. In [10], Muthaiyan et al. introduced the concept of k-one raised product prime labeling of graphs. In [16], Ponraj et al introduced the concept of parity combination cordial labeling of graph. Motivated by the concept of parity combination cordial labeling, Muthaiyan et al. [9] introduced a new concept, which is called k-parity combination cordial labeling of graphs.

Sekar et al. introduced the concept of Fibonacci Prime Labeling of Graphs in [19]. Chandrakala et al. [3] studied various types of cycle related Fibonacci Prime Labeling of Graphs. We introduce k^{th} Fibonacci Prime Labeling of Graphs and k^{th} Fibonacci Prime Labeling of some path related graphs are discussed in [12] and some cycle related graphs are discussed in [13]. In this paper the k^{th} Fibonacci prime labeling of path, cycle, $P_n \odot K_1$, Triangular snake, Quadrilateral snake and Tadpole graph are studied.

Definition :1.1 A graph labeling is the assignment of unique identifiers to the edges and vertices of a graph.

Definition :1.2 Let $G = (V,E)$ be a graph with n vertices. A function $f : V(G) \to \{1,2,3,\dots,n\}$ is said to be a prime labeling, if it is bijective and for every pair of adjacent vertices u and v, $\gcd(f(u),f(v)) = 1$. A graph which admits prime labeling is called a prime graph.

Definition : 1.3 A k-prime labeling of a graph G is an injective function $f : V \to \{k, k+1,\dots, k+|V|-1\}$ for some positive integer k that induces a function $f^+: E(G) \to N$ of the edges of G defined by $f^+(uv) = \gcd(f(u),f(v))$, $\forall e = uv \in E(G)$ such that $\gcd(f(u), f(v)) = 1$, $\forall e = uv \in E(G)$. The graph which admits a k-prime labeling is called a k-prime graph.

Definition : 1.4 The Fibonacci number f_n is defined recursively by the equations $f_1 = 1$, $f_2 = 1$, $f_{n+1} = f_n + f_{n-1}$ $(n \geq 2)$. Then $\gcd(f_n,f_{n-1}) = 1$ and $\gcd(f_n,f_{n+1}) = 1$ for all $n \geq 1$.

Definition : 1.5 The Tadpole graph $T_{m,n}$ also called a dragon graphs obtained by connecting cycle graph C_m and path graph P_n in series with an edge from any vertex of cycle graph to a pendant of path graph for integers $m \geq 3$ and $n \geq 1$.

Definition : 1.6 A Fibonacci prime labeling of a graph G = (V,E) with |V(G)| = n is an injective function $g : V(G) \to \{f_2,f_3,\ldots,f_{n+1}\}$, where f_n is the n^{th} Fibonacci number, that induces a function $g^* : E(G) \to N$ defined by $g^*(uv) = \gcd\{g(u),g(v)\} = 1, \forall\ uv \in E(G)$.

The graph admits a Fibonacci prime labeling and is called a Fibonacci prime graph.

2. Main Results

Definition :2.1 A k^{th} Fibonacci prime labeling of a graph G = (V,E) with |V(G)| = n is an injective function $g : V(G) \to \{f_k,f_{k+1},\ldots,f_{k+n-1}\}$, where f_k is the k^{th} Fibonacci number, that induces a function $g^* : E(G) \to N$ defined by $g^*(uv) = \gcd\{g(u),g(v)\} = 1, \forall\ uv \in E(G)$.

The graph admits a k^{th} Fibonacci prime labeling and is called a k^{th} Fibonacci prime graph.

Remark :2.1 A 2^{nd} Fibonacci prime graph is called Fibonacci prime graph.

Theorem 2.1

Path graph P_n is a k^{th} Fibonacci prime graph.

Proof.

Let G be a path graph P_n with n vertices and n–1 edges.

Let $v_1, v_2, \ldots, v_n$ be the vertices of G. The edge set of G is $E(G) = \{v_iv_{i+1} \mid 1 \le i \le n-1\}$.

Then |V(G)| = n and |E(G)| = n–1.

Define $g : V(G) \to \{ f_k,f_{k+1},\ldots,f_{k+n-1}\}$ as follows $g(v_i) = f_{i+k-1}$, for $1 \le i \le n$.

The induced function $g^* : E(G) \to N$ is defined by $g^*(uv) = \gcd\{g(u),g(v)\}, \forall\ uv\in E(G)$.

Now $\gcd\{f(v_i),f(v_{i+1})\} = \gcd\{f_{i+k-1},f_{i+k}\} = 1$, for $1 \le i \le n-1, \forall\ v_iv_{i+1} \in E(G)$.

Thus G admits a k^{th} Fibonacci prime labeling.

Hence G is a k^{th} Fibonacci prime graph.

Illustration 2.1

The Path P_7 and its 5^{th} Fibonacci prime labeling are shown in figure 2.1

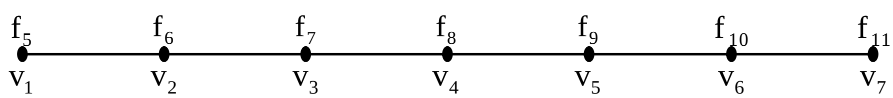

Fig. 1 Path P_7 is 5^{th} fibonacci prime graph

Theorem 2.2

Cycle graph C_n is a k^{th} Fibonacci prime graph for $n \ge 3$.

Proof.

Let G be a cycle graph C_n with n vertices and n edges.

Let $v_1, v_2, \ldots, v_n$ be the vertices of G.

The edge set of G is $E(G) = \{v_iv_{i+1} \mid 1 \le i \le n-1\}\cup\{v_nv_1\}$.

Define $g : V(G) \to \{f_k,f_{k+1},\ldots,f_{k+n-1}\}$ as follows

Case 1 : n is odd.

$$g(v_i) = f_{k+2(i-1)},\ \text{for } 1 \le i \le \frac{n+1}{2}$$

$$g(v_i) = f_{k+2(n+1-i)-1},\ \text{for } \frac{n+3}{2} \le i \le n$$

Then the induced function $g^* : E(G) \to N$ is defined by $g^*(xy) = \gcd\{g(x),g(y)\}\ \forall\ xy \in E(G)$.

Now, $\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k+2(i-1)}, f_{k+2(i-1)+2}\} = 1,\ 1 \le i \le \frac{n-1}{2}$ and

$$\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k+n-1}, f_{k+n-2}\} = 1,\ i = \frac{n+1}{2}$$

$$\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k+2(n+1-i)-1}, f_{k+2(n+1-i)-3}\} = 1,\ \frac{n+3}{2} \le i \le n-1$$

$$\gcd\{g(v_n),g(v_1)\} = \gcd\{f_{k+1}, f_k\} = 1$$

Thus $g^*(xy) = \gcd\{f(x),f(y)\} = 1, \forall\ xy \in E(G)$.

Case 2 : n is even.

$g(v_i) = f_{k+2(i-1)}$, for $1 \le i \le \frac{n}{2}$

$g(v_i) = f_{k+2(n+1-i)-1}$, for $\frac{n+2}{2} \le i \le n$

Then the induced function $g^* : E(G) \to N$ is defined by $g^*(xy) = \gcd\{g(x),g(y)\}$ $\forall$ $xy \in E(G)$.

Now, $\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k+2(i-1)}, f_{k+2(i-1)+2}\} = 1$, $1 \le i \le \frac{n-2}{2}$ and

$\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k+n-2}, f_{k+n-1}\} = 1$, $i = \frac{n}{2}$

$\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k+2(n+1-i)-1}, f_{k+2(n+1-i)-3}\} = 1$, $\frac{n+4}{2} \le i \le n-1$

$\gcd\{g(v_n),g(v_1)\} = \gcd\{f_{k+1}, f_k\} = 1$

Thus $g^*(xy) = \gcd\{f(x),f(y)\} = 1$, $\forall$ $xy \in E(G)$.

Hence C_n is a k^{th} Fibonacci prime graph.

Illustration 2.2

The cycle C_8 and its 7^{th} Fibonacci prime labeling are shown in figure 2.2

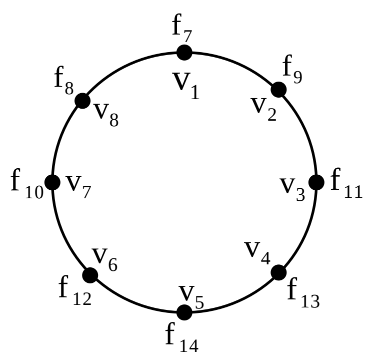

Fig. 2 C_8 is a 7^{th} fibonacci prime graph

Theorem 2.3

The graph $P_n \odot K_1$ is a k^{th} Fibonacci prime graph, for $n \ge 2$.

Proof.

Let G be a $P_n \odot K_1$.

Let G be a comb graph with vertices $v_1, v_2, ..., v_n$ and $u_1, u_2, ..., u_n$.

Then the edge set of G is $E(G) = \{ v_iv_{i+1} \mid 1 \le i \le n-1\} \cup \{ v_iu_i \mid 1 \le i \le n\}$.

Then $|V(G)| = 2n$ and $|E(G)| = 2n-1$.

Define $g : V(G) \to \{f_k, f_{k+1}, \ldots, f_{k+2n-1}\}$ as follows

$g(v_i) = f_{k+2(i-1)}$, for $1 \le i \le n$

$g(u_i) = f_{k+2(i-1)+1}$, for $1 \le i \le n$

Then the induced function $g^* : E(G) \to N$ is defined by $g^*(xy) = \gcd\{g(x),g(y)\}$ $\forall$ $xy \in E(G)$.

Now, $\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k+2(i-1)}, f_{k+2(i-1)+2}\} = 1$, $1 \le i \le n$ and

$\gcd\{g(v_i),g(u_i)\} = \gcd\{f_{k+2(i-1)}, f_{k+2(i-1)+1}\} = 1$, $1 \le i \le n$.

Thus $g^*(xy) = \gcd\{f(x),f(y)\} = 1$, $\forall$ $xy \in E(G)$.

Hence $P_n \odot K_1$ is a k^{th} Fibonacci prime graph.

Illustration 2.3

The graph $P_6 \odot K_1$ and its 6^{th} Fibonacci prime labeling are shown in figure 2.3

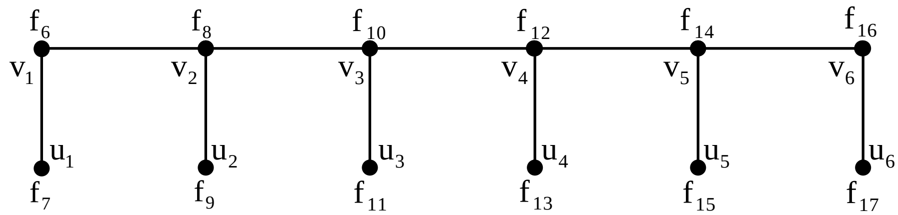

Fig. 3 The graph $P_6 \odot K_1$ is 6^{th} fibonacci prime graph.

Theorem 2.4

Triangular snake T_n is a k^{th} Fibonacci prime graph, for $n \geq 2$.

Proof.

Let G be a Triangular snake T_n.

Let T_n be a Triangular snake with vertices $v_1, v_2, ..., v_n, u_1, u_2, ..., u_{n-1}$.

Then the edge set of G is $E(G) = \{v_iv_{i+1} | 1 \leq i \leq n-1\} \cup \{v_iu_i | 1 \leq i \leq n-1\} \cup \{u_iv_{i+1} | 1 \leq i \leq n-1\}$.

$|V(G)| = 2n-1$ and $|E(G)| = 3n-3$.

Define $g : V(G) \to \{f_k, f_{k+1}, \ldots, f_{k+2n-2}\}$ as follows

$g(v_i) = f_{k+2(i-1)}$, for $1 \leq i \leq n$

$g(u_i) = f_{k+2(i-1)+1}$, for $1 \leq i \leq n-1$

Then the induced function $g^* : E(G) \to N$ is defined by $g^*(xy) = \gcd\{g(x), g(y)\}\ \forall\ xy \in E(G)$.

Now, $\gcd\{g(v_i), g(v_{i+1})\} = \gcd\{f_{k+2(i-1)}, f_{k+2(i-1)+2}\} = 1$, $1 \leq i \leq n$ and

$\gcd\{g(v_i), g(u_i)\} = \gcd\{f_{k+2(i-1)}, f_{k+2(i-1)+1}\} = 1$, $1 \leq i \leq n-1$,

$\gcd\{g(u_i), g(v_{i+1})\} = \gcd\{f_{k+2(i-1)+1}, f_{k+2(i-1)+2}\} = 1$, $1 \leq i \leq n-1$.

Thus $g^*(xy) = \gcd\{f(x), f(y)\} = 1$, $\forall\ xy \in E(G)$.

Hence, the graph T_n is a k^{th} Fibonacci prime graph, for $n \geq 2$.

Illustration 2.4

The triangular snake T_5 and its 7^{th} Fibonacci prime labeling are shown in figure 2.4.

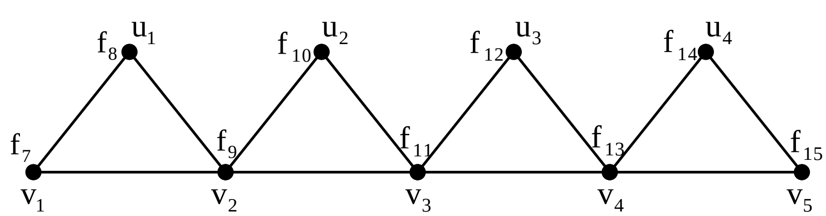

Fig. 4 The triangular snake T_5 is 7^{th} fibonacci prime graph

Theorem 2.5

Quadrilateral snake Q_n is a k^{th} Fibonacci prime graph, for $n \geq 2$.

Proof.

Let G be a Quadrilateral snake Q_n.

Let Q_n be a Quadrilateral snake with vertices $v_1, v_2, ..., v_n, u_1, u_2, ..., u_{n-1}$ and $w_1, w_2, ..., w_{n-1}$

Then the edge set of G is $E(G) = \{v_iv_{i+1} | 1 \leq i \leq n-1\} \cup \{v_iu_i | 1 \leq i \leq n-1\}\} \cup \{u_iw_i | 1 \leq i \leq n-1\} \cup \{w_iv_{i+1} | 1 \leq i \leq n-1\}$.

$|V(G)| = 3n-2$ and $|E(G)| = 4n-4$.

Define $g : V(G) \to \{f_k, f_{k+1}, \ldots, f_{k+3n-3}\}$ as follows

$g(v_i) = f_{k+3(i-1)}$, for $1 \leq i \leq n$

$g(u_i) = f_{k+3(i-1)+1}$, for $1 \leq i \leq n-1$

$g(w_i) = f_{k+3(i-1)+2}$, for $1 \leq i \leq n-1$

Then the induced function $g^* : E(G) \to N$ is defined by $g^*(xy) = \gcd\{g(x), g(y)\}\ \forall\ xy \in E(G)$.

Now, $\gcd\{g(v_i), g(v_{i+1})\} = \gcd\{f_{k+3(i-1)}, f_{k+3(i-1)+3}\} = 1$, $1 \leq i \leq n$ and

$\gcd\{g(v_i), g(u_i)\} = \gcd\{f_{k+3(i-1)}, f_{k+3(i-1)+1}\} = 1$, $1 \leq i \leq n-1$,

$\gcd\{g(u_i),g(w_i)\} = \gcd\{f_{k+3(i-1)+1}, f_{k+3(i-1)+2}\} = 1, 1 \le i \le n-1,$

$\gcd\{g(w_i),g(v_{i+1})\} = \gcd\{f_{k+3(i-1)+2}, f_{k+3(i-1)+3}\} = 1, 1 \le i \le n-1.$

Thus $g^*(xy) = \gcd\{f(x),f(y)\} = 1, \forall\ xy \in E(G)$.

Hence, the graph Q_n is a k^{th} Fibonacci prime graph, for $n \ge 2$.

Illustration 2.5

The Quadrilateral snake Q_4 and its 6^{th} Fibonacci prime labeling are shown in figure 2.5.

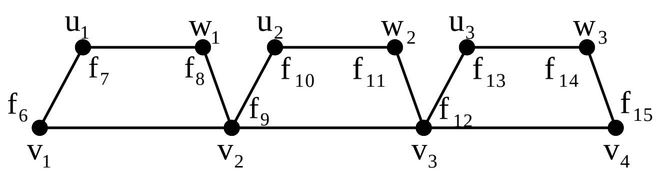

Fig. 5 The quadrilateral snake Q_4 is 6^{th} fibonacci prime graph

Theorem 2.6

The Tadpole graph $T_{m,n}$ is a Fibonacci prime graph for $n \ge 3$, $m \ge 1$.

Proof.

Let G be the Tadpole graph $T_{m,n}$.

Let $v_1,v_2,\ldots,v_m$ be the vertices of the cycle C_m and $u_1,u_2,\ldots,u_n$ be the vertices of the path P_n.

The edge set $E(G) = \{v_iv_{i+1} \mid 1 \le i \le m-1\} \cup \{v_mv_1\} \cup \{v_1u_1\} \cup \{u_iu_{i+1} \mid 1 \le i \le n-1\}$, where v_1u_1 is the bridge joining C_m with P_n.

Then $|V(G)| = m+n$ and $|E(G)| = m+n$.

Define the mapping $g : V(G) \to \{ f_2,f_3,\ldots, f_{k+m+n-1}\}$ as follows

Case 1 : m is odd.

$g(v_i) = f_{k+m-1-2(i-1)}$, for $1 \le i \le \frac{m+1}{2}$

$g(v_i) = f_{k-1+(2i-m-1)}$, for $\frac{m+3}{2} \le i \le m$

$g(u_i) = f_{k+m-1+i}$, for $1 \le i \le n$

Then the induced function $g^* : E(G) \to N$ is defined by $g^*(xy) = \gcd\{g(x),g(y)\}\ \forall\ xy \in E(G)$.

Now, $\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k+m-1-2(i-1)}, f_{k+m-1-2(i-1)-2}\} = 1, 1 \le i \le \frac{m-1}{2}$ and

$\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_k, f_{k+1}\} = 1, i = \frac{m+1}{2}$

$\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k-1+(2i-m-1)}, f_{k-1+(2i-m-1)+2}\} = 1, \frac{m+3}{2} \le i \le m-1$

$\gcd\{g(v_m),g(v_1)\} = \gcd\{f_{k+m-2}, f_{k+m-1}\} = 1$

$\gcd\{g(v_1),g(u_1)\} = \gcd\{f_{k+m-1}, f_{k+m}\} = 1$

$\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k+m-1+i}, f_{k+m+i}\} = 1, 1 \le i \le n-1$

Thus $g^*(xy) = \gcd\{f(x),f(y)\} = 1, \forall\ xy \in E(G)$.

Case 2 : n is even.

$g(v_i) = f_{k+m-1-2(i-1)}$, for $1 \le i \le \frac{m}{2}$

$g(v_i) = f_{k+(2i-m-2)}$, for $\frac{m+2}{2} \le i \le m$

$g(u_i) = f_{k+m-1+i}$, for $1 \le i \le n$

Then the induced function $g^* : E(G) \to N$ is defined by $g^*(xy) = \gcd\{g(x),g(y)\}\ \forall\ xy \in E(G)$.

Now, $\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{ f_{k+m-1-2(i-1)}, f_{k+m-1-2(i-1)-2}\} = 1, 1 \le i \le \frac{m-2}{2}$ and

$\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k+1}, f_k\} = 1, i = \frac{m}{2}$

$\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{ f_{k+2i-m-2}, f_{k+2i-m}\} = 1, \frac{m+2}{2} \le i \le m-1$

$\gcd\{g(v_m),g(v_1)\} = \gcd\{ f_{k+m-2}, f_{k+m-1}\} = 1$
$\gcd\{g(v_1),g(u_1)\} = \gcd\{f_{k+m-1}, f_{k+m}\} = 1$
$\gcd\{g(v_i),g(v_{i+1})\} = \gcd\{f_{k+m-1+i}, f_{k+m+i}\} = 1, 1 \le i \le n-1$

Thus $g^*(xy) = \gcd\{f(x),f(y)\} = 1, \forall\ xy \in E(G)$.

Hence $T_{m,n}$ is a k^{th} Fibonacci prime graph for $n \ge 3$, $m \ge 1$.

Illustration 2.6

The Tadpole graph $T_{8,5}$ and its 5^{th} Fibonacci prime labeling are shown in figure 2.6.

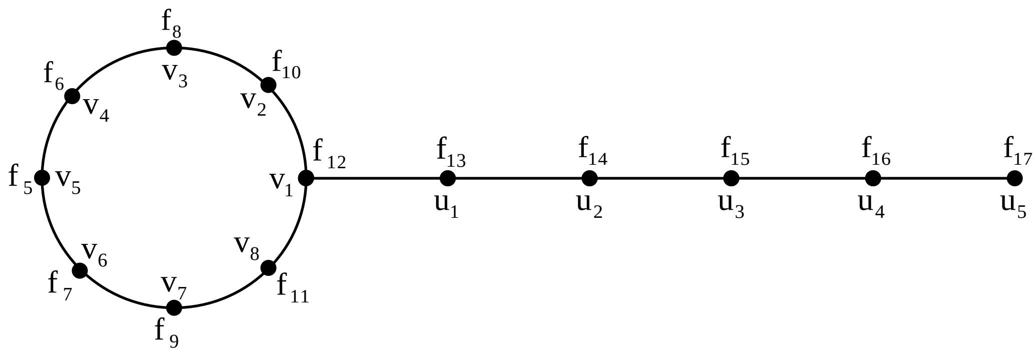

Fig. 6 Tadpole graph $T_{8,5}$ is 5^{th} fibonacci prime graph

3. Conclusion

We have introduced a new labeling namly k^{th} Fibonacci prime labeling of graphs and k^{th} Fibonacci prime labeling of path, cycle, $P_n \odot K_1$, Triangular snake, Quadrilateral snake and Tadpole graph are presented.

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