

On the Locating Chromatic Number of Certain Barbell Graphs

By Asmiati Asmiati

Research Article

On the Locating Chromatic Number of Certain Barbell Graphs

Asmiati ¹, I. Ketut Sadha Gunce Yana,¹ and Lyra Yulianti²

¹Mathematics Department, Faculty of Mathematics and Natural Sciences, Lampung University,
 Jl. Brodjonegoro No.1 Bandar Lampung, Indonesia

²Mathematics Department, Faculty of Mathematics and Natural Sciences, Andalas University,
 Kampus UNAND Limau Manis, Padang 25163, Indonesia

Correspondence should be addressed to Asmiati; asmiati308@yahoo.com





Received 27 March 2018; Revised 26 June 2018; Accepted 22 July 2018; Published 5 August 2018






Academic Editor: Dalibor Froncek


Copyright © 2018 Asmiati et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.


The locating chromatic number of a graph G is defined as the cardinality of a minimum resolving partition of the vertex set $V(G)$ such that all vertices have distinct coordinates with respect to this partition and every two adjacent vertices in G are not contained in the same partition class. In this case, the coordinate of a vertex v in G is expressed in terms of the distances of v to all partition classes. This concept is a special case of the graph partition dimension notion. In this paper we investigate the locating chromatic number for two families of barbell graphs.




1. Introduction


The partition dimension  was introduced by Chartrand et al. [1] as the development of the concept of metric dimension. The application of metric dimension plays a role in robotic navigation [2], the optimization of threat detecting sensors [3], and chemical data classification [4]. The concept of locating chromatic number is a marriage between the partition dimension and coloring  of a graph, first introduced by Chartrand et al in 2002 [5]. The locating chromatic number of a graph is a newly interesting topic  study because there is no general theorem for determining the locating chromatic number  of any graph.


Let $G = (V, E)$ be a connected graph. We  the distance as the minimum length of path connecting  vertices u and v in G , denoted by $d(u, v)$. A k -coloring of G is a function $c : V(G) \rightarrow \{1, 2, \dots, k\}$, where $c(u) \neq c(v)$ for any two adjacent vertices u and v in G . Thus, the coloring c induces a partition Π of $V(G)$ into k color classes (independent sets) C_1, C_2, \dots, C_k , where C_i is the set of all vertices  colored by the color i for $1 \leq i \leq k$. The  code $c_{11}(v)$ of a vertex v in G is defined as the k -vector $(d(v, C_1), d(v, C_2), \dots, d(v, C_k))$, where $d(v, C_i) = \min\{d(v, x) : x \in C_i\}$ for $1 \leq i \leq k$. The k -coloring c of G such that all vertices have different  color codes is called a locating coloring of G . The locating chromatic


number of G , denoted by $\chi_L(G)$, is the minimum k such that G has a locating coloring. 

The following theorem is a basic theorem proved by Chartrand et al.  The neighborhood of vertex u in a connected graph G , denoted by $N(u)$, is the set of vertices adjacent to u .

Theorem 1 (see ). Let c be a locating coloring in a connected graph G . If u and v  distinct vertices of G such that $d(u, t) = d(v, t)$ for all $t \in V(G) - \{u, v\}$, then $c(u) \neq c(v)$. In particular, if u and v are non-adjacent vertices of G such that $N(u) = N(v)$, then $c(u) \neq c(v)$. 

The following corollary gives the lower bound  of the locating chromatic number for every connected graph G .

Corollary 2 (see ). If G is a connected graph and there is a vertex adjacent to k leaves, then $\chi_L(G) \geq k + 1$.

There are some interesting results related to the determination of the locating chromatic number of some graphs. The results are obtained by focusing on certain  families of graphs. Chartrand et al. in [5] have determined all graphs of order n with locating chromatic number n , namely, a complete multipartite graph of n vertices. Moreover, Chartrand et

al. [6] have succeeded in constructing tree on n vertices, $n \geq 5$, with locating chromatic numbers varying from 3 to n , except for $(n - 1)$. Then Behtoei and Omoomi [7] have obtained the locating chromatic number of the Kneser graphs. Recently, Asri [24] et al. [8] obtained the locating chromatic number of the generalized Petersen graph $P(n, 1)$ for $n \geq 3$. Baskoro and Asmiati [9] have characterized all trees with locating chromatic number 3. In [10] all trees of order n with locating chromatic number $n - 1$ were characterized, for any integers n and t , where $n > t + 3$ and $2 \leq t < n$. [35] Asmiati et al. in [11] have succeeded in determining the locating chromatic number of homogeneous amalgamation of stars and their monotonicity properties and in [12] for firecracker graphs. Next, Wellyyanti et al. [13] determined the locating chromatic number for complete n -ary [5] es.

The generalized Petersen graph $P(n, m)$, $n \geq 3$ and $1 \leq m \leq \lfloor (n - 1)/2 \rfloor$, consists of an outer n -cycle y_1, y_2, \dots, y_n , a set of n spokes $y_i x_i$, $1 \leq i \leq n$, and n edges $x_i x_{i+m}$, $1 \leq i \leq n$, with indices taken modulo n . The generalized Petersen graph was introduced by Watkins in [14]. Let us note that the generalized Petersen graph $P(n, 1)$ is a prism defined as Cartesian product of a cycle C_n and a path P_2 .

Next theorems give the locating chromatic numbers for complete graph K_n and generalized Petersen graph $P(n, 1)$.

Theorem 3 (see [6]). For $n \geq 2$, the locating chromatic number of complete graph K_n is n . [38]

Theorem 4 (see [8]). The locating chromatic number of generalized Petersen graph $P(n, 1)$ is 4 for odd $n \geq 3$ or 5 for even $n \geq 4$.

The barbell graph is constructed by connecting two arbitrary connected graphs G and H by a bridge. In this paper, firstly we discuss the locating chromatic number for barbell graph $B_{m,n}$ for $m, n \geq 3$, where G and H are complete graphs on m and n vertices, respectively. Secondly, we determine the locating chromatic number of barbell graph $B_{P(n,1)}$ for $n \geq 3$, where G and H are two isomorphic copies of the generalized Petersen graph $P(n, 1)$.

2. Results and Discussion

Next theorem proves the exact value of the locating chromatic number for barbell graph $B_{m,n}$.

Theorem 5. Let $B_{m,n}$ be a barbell graph for $n \geq 3$. Then the locating chromatic number of $B_{m,n}$ is $\chi_L(B_{m,n}) = n + 1$. [8]

Proof. Let $B_{m,n}$, $n \geq 3$, be a barbell graph with the vertex set $V(B_{m,n}) = \{u_i, v_i : 1 \leq i \leq n\}$ and the edge set $E(B_{m,n}) = \bigcup_{i=1}^{n-1} \{u_i, u_{i+1}\} \cup \bigcup_{i=1}^{n-1} \{v_i, v_{i+1}\} \cup \{u_n, v_n\}$.

First, we determine the lower bound of the locating chromatic number for barbell graph $B_{m,n}$ for $n \geq 3$. Since the barbell graph $B_{m,n}$ contains two isomorphic copies of a complete graph K_n , then with respect to Theorem 3 we have $\chi_L(B_{m,n}) \geq n$. Next, suppose that c is a locating coloring

using n colors. It is easy to see that the barbell graph $B_{m,n}$ contains two vertices with the same color codes, which is a contradiction. Thus, we have that $\chi_L(B_{m,n}) \geq n + 1$. [29]

To show that $n + 1$ is an upper bound for the locating chromatic number of barbell graph $B_{m,n}$ it suffices to prove the existence of an optimal locating coloring $c : V(B_{m,n}) \rightarrow \{1, 2, \dots, n + 1\}$. For $n \geq 3$ we construct the function c in the following way:

$$c(u_i) = i, \quad 1 \leq i \leq n$$

$$c(v_i) = \begin{cases} n, & \text{for } i = 1 \\ i, & \text{for } 2 \leq i \leq n - 1 \\ n + 1, & \text{otherwise.} \end{cases} \quad (1)$$

By using the coloring c , we obtain the color codes of $V(B_{m,n})$ as follows:

$$c_{\Pi}(u_i) = \begin{cases} 0, & \text{for } i^{\text{th}} \text{ component, } 1 \leq i \leq n \\ 2, & \text{for } (n + 1)^{\text{th}} \text{ component, } 1 \leq i \leq n - 1 \\ 1, & \text{otherwise,} \end{cases}$$

$$c_{\Pi}(v_i) = \begin{cases} 0, & \text{for } i^{\text{th}} \text{ component, } 2 \leq i \leq n - 1 \\ & \text{for } n^{\text{th}} \text{ component, } i = 1, \text{ and} \\ & \text{for } (n + 1)^{\text{th}} \text{ component, } i = n, \\ 3, & \text{for } 1^{\text{st}} \text{ component, } 1 \leq i \leq n - 1 \\ 2, & \text{for } 1^{\text{st}} \text{ component, } i = n \\ 1, & \text{otherwise.} \end{cases} \quad (2)$$

Since all vertices in $V(B_{m,n})$ have distinct color codes, then the coloring c is desired locating coloring. Thus, $\chi_L(B_{m,n}) = n + 1$. \square

Corollary 6. For $n, m \geq 3$, and $m \neq n$, the locating chromatic number of barbell graph $B_{m,n}$ is

$$\chi_L(B_{m,n}) = \max\{m, n\}. \quad (3)$$

Next theorem provides the exact value of the locating chromatic number for barbell graph $B_{P(n,1)}$.

Theorem 7. Let $B_{P(n,1)}$ be a barbell graph for $n \geq 3$. Then the locating chromatic number of $B_{P(n,1)}$ is

$$\chi_L(B_{P(n,1)}) = \begin{cases} 4, & \text{for odd } n \\ 5, & \text{for even } n. \end{cases} \quad (4)$$

8 Proof. Let $B_{P(n,1)}$, $n \geq 3$, be the barbell graph with **12** the vertex set $V(B_{P(n,1)}) = \{u_i, u_{n+i}, w_i, w_{n+i} : 1 \leq i \leq n\}$ and the edge set $E(B_{P(n,1)}) = \{u_i u_{i+1}, u_{n+i} u_{n+i+1}, w_i w_{i+1}, w_{n+i} w_{n+i+1} : 1 \leq i \leq n-1\} \cup \{u_n u_1, u_{2n} u_{n+1}, w_n w_1, w_{2n} w_{n+1}\} \cup \{u_i u_{n+i}, w_i w_{n+i} : 1 \leq i \leq n\} \cup \{u_n w_n\}$.

Let us distinguish two cases.

27 Case 1 (n odd). According to Theor. **4** for n odd we have $\chi_L(B_{P(n,1)}) \geq 4$. To show that 4 is an upper bound for the locating chromatic number of the barbell graph $B_{P(n,1)}$ we describe an locating coloring c using 4 colors as follows:

$$c(u_i) = \begin{cases} 1, & \text{for } i-1 \\ 3, & \text{for even } i, i \geq 2 \\ 4, & \text{for odd } i, i \geq 3. \end{cases}$$

$$c(u_{n+i}) = \begin{cases} 2, & \text{for } i-1 \\ 3, & \text{for odd } i, i \geq 3 \\ 4, & \text{for even } i, i \geq 2. \end{cases}$$

$$c(w_i) = \begin{cases} 1, & \text{for odd } i, i \leq n-2 \\ 2, & \text{for even } i, i \leq n-1 \\ 3, & \text{for } i = n. \end{cases}$$

$$c(w_{n+i}) = \begin{cases} 1, & \text{for even } i, i \leq n-1 \\ 2, & \text{for odd } i, i \leq n-2 \\ 4, & \text{for } i = n. \end{cases}$$

For n odd the color codes of $V(B_{P(n,1)})$ are

$$c_{\Pi}(u_i) = \begin{cases} i, & \text{for } 2^{nd} \text{ component, } i \leq \frac{n+1}{2} \\ i-1, & \text{for } 1^{st} \text{ component, } i \leq \frac{n+1}{2} \\ n-i+1, & \text{for } 1^{st} \text{ component, } i > \frac{n+1}{2} \\ n-i+2, & \text{for } 2^{nd} \text{ component, } i > \frac{n+1}{2} \\ 0, & \text{for } 3^{th} \text{ component, } i \text{ even, } i \geq 2 \\ & \text{for } 4^{th} \text{ component, } i \text{ odd, } i \geq 3 \\ 1, & \text{otherwise.} \end{cases}$$

$$c_{\Pi}(u_{n+i}) = \begin{cases} i, & \text{for } 1^{st} \text{ component, } i \leq \frac{n+1}{2} \\ i-1, & \text{for } 2^{nd} \text{ component, } i \leq \frac{n+1}{2} \\ n-i+1, & \text{for } 2^{nd} \text{ component, } i > \frac{n+1}{2} \\ n-i+2, & \text{for } 1^{st} \text{ component, } i > \frac{n+1}{2} \\ 0, & \text{for } 4^{th} \text{ component, } i \text{ even, } i \geq 2 \\ & \text{for } 3^{th} \text{ component, } i \text{ odd, } i \geq 3 \\ 1, & \text{otherwise.} \end{cases}$$

$$c_{\Pi}(w_i) = \begin{cases} i, & \text{for } 3^{th} \text{ component, } i \leq \frac{n-1}{2} \\ i+1, & \text{for } 4^{th} \text{ component, } i \leq \frac{n-1}{2} \\ n-i, & \text{for } 3^{th} \text{ component, } i \geq \frac{n+1}{2} \\ n-i+1, & \text{for } 4^{th} \text{ component, } i \geq \frac{n+1}{2} \\ 0, & \text{for } 2^{nd} \text{ component, } i \text{ even, } i \leq n-1 \\ & \text{for } 1^{st} \text{ component, } i \text{ odd, } i \leq n-2 \\ 1, & \text{otherwise.} \end{cases}$$

$$c_{\Pi}(w_{n+i}) = \begin{cases} i, & \text{for } 4^{th} \text{ component, } i \leq \frac{n-1}{2} \\ i+1, & \text{for } 3^{th} \text{ component, } i \leq \frac{n-1}{2} \\ n-i, & \text{for } 4^{th} \text{ component, } i \geq \frac{n+1}{2} \\ n-i+1, & \text{for } 3^{th} \text{ component, } i \geq \frac{n+1}{2} \\ 0, & \text{for } 1^{st} \text{ component, } i \text{ even, } i \leq n-1 \\ & \text{for } 2^{nd} \text{ component, } i \text{ odd, } i \leq n-2 \\ 1, & \text{otherwise.} \end{cases}$$

(6)

Since all vertices in $B_{P(n,1)}$ have distinct color codes, then the coloring c with 4 colors is an optimal locating coloring and it proves that $\chi_L(B_{P(n,1)}) \leq 4$.

Case 2 (n even). In view of the lower bound from Theorem 7 it suffices to prove the existence of a locating coloring $c : V(B_{P(n,1)}) \rightarrow \{1, 2, \dots, 5\}$ such that all vertices in $B_{P(n,1)}$ have distinct color codes. For n even, $n \geq 4$, we describe the locating coloring in the following way:

$$c(u_i) = \begin{cases} 1, & \text{for } i = 1 \\ 3, & \text{for even } i, 2 \leq i \leq n-2 \\ 4, & \text{for odd } i, 3 \leq i \leq n-1 \\ 5, & \text{for } i = n. \end{cases}$$

$$\begin{aligned}
 c(u_{n+i}) &= \begin{cases} 2, & \text{for } i = 1 \\ 3, & \text{for odd } i, i \geq 3 \\ 4, & \text{for even } i, i \geq 2. \end{cases} \\
 c(w_i) &= \begin{cases} 1, & \text{for odd } i, i \leq n-3 \\ 2, & \text{for even } i, i \leq n-2 \\ 3, & \text{for } i = n-1 \\ 4, & \text{for } i = n. \end{cases} \\
 c(w_{n+i}) &= \begin{cases} 1, & \text{for even } i, i \leq n-2 \\ 2, & \text{for odd } i, i \leq n-1 \\ 5, & \text{for } i = n. \end{cases}
 \end{aligned} \tag{7}$$

In fact, our locating coloring of $B_{P(n,1)}$, n even, has been chosen in such a way that the color codes are

$$\begin{aligned}
 c_{\Pi}(u_i) &= \begin{cases} i, & \text{for } 2^{nd} \text{ and } 5^{th} \text{ components, } i \leq \frac{n}{2} \\ i-1, & \text{for } 1^{st} \text{ component, } i \leq \frac{n}{2} \\ n-i, & \text{for } 5^{th} \text{ component, } i > \frac{n}{2} \\ n-i+1, & \text{for } 1^{st} \text{ component, } i > \frac{n}{2} \\ n-i+2, & \text{for } 2^{nd} \text{ component, } i > \frac{n}{2} \\ 0, & \text{for } 3^{th} \text{ component, } i \text{ even, } 2 \leq i \leq n-2 \\ & \text{for } 4^{th} \text{ component, } i \text{ odd, } 3 \leq i \leq n-1 \\ 2, & \text{for } 4^{th} \text{ component, } i = 1 \\ & \text{for } 3^{th} \text{ component, } i = n \\ 1, & \text{otherwise.} \end{cases}
 \end{aligned}$$

$$\begin{aligned}
 c_{\Pi}(u_{n+i}) &= \begin{cases} i, & \text{for } 1^{st} \text{ component, } i \leq \frac{n}{2} \\ i-1, & \text{for } 2^{nd} \text{ component, } i \leq \frac{n}{2} \\ n+i, & \text{for } 5^{th} \text{ component, } i \leq \frac{n}{2} \\ n-i+1, & \text{for } 2^{nd} \text{ and } 5^{th} \text{ components, } i > \frac{n}{2} \\ n-i+2, & \text{for } 1^{th} \text{ component, } i > \frac{n}{2} \\ 0, & \text{for } 3^{th} \text{ component, } i \text{ odd, } 3 \leq i \leq n-1 \\ & \text{for } 4^{th} \text{ component, } i \text{ even, } 2 \leq i \leq n \\ 2, & \text{for } 3^{th} \text{ component, } i = 1 \\ 1, & \text{otherwise.} \end{cases}
 \end{aligned}$$

$$\begin{aligned}
 c_{\Pi}(w_i) &= \begin{cases} i, & \text{for } 4^{th} \text{ component, } i < \frac{n}{2} \\ i+1, & \text{for } 5^{th} \text{ component, } i \leq \frac{n}{2} \\ & \text{for } 3^{th} \text{ component, } i < \frac{n}{2} - 1 \\ n-i, & \text{for } 4^{th} \text{ component, } i > \frac{n}{2} \\ n-i+1, & \text{for } 5^{th} \text{ component, } i > \frac{n}{2} \\ n-i-1, & \text{for } 3^{th} \text{ component, } \frac{n}{2} \leq i \leq n-1 \\ 0, & \text{for } 1^{st} \text{ component, } i \text{ odd, } i = n-3 \\ & \text{for } 2^{nd} \text{ component, } i \text{ even, } i \leq n-2 \\ 2, & \text{for } 1^{st} \text{ component, } i = n-1 \\ & \text{for } 2^{nd} \text{ component, } i = n \\ 1, & \text{otherwise.} \end{cases}
 \end{aligned}$$

$$\begin{aligned}
 c_{\Pi}(w_{n+i}) &= \begin{cases} i, & \text{for } 5^{th} \text{ component, } i \leq \frac{n}{2} \\ i+1, & \text{for } 4^{th} \text{ component, } i \leq \frac{n}{2} \\ i+2, & \text{for } 3^{th} \text{ component, } i \leq \frac{n}{2} - 1 \\ n-i, & \text{for } 3^{th} \text{ component, } \frac{n}{2} \leq i \leq n-1 \\ & \text{for } 5^{th} \text{ component, } i > \frac{n}{2} \\ n-i+1, & \text{for } 4^{th} \text{ component, } i > \frac{n}{2} \\ 0, & \text{for } 1^{st} \text{ component, } i \text{ even, } i \leq n-2 \\ & \text{for } 2^{nd} \text{ component, } i \text{ odd, } i \leq n-1 \\ 2, & \text{for } 1^{st} \text{ and } 3^{th} \text{ components, } i = n \\ 1, & \text{otherwise.} \end{cases} \tag{8}
 \end{aligned}$$

Since for n even all vertices of $B_{P(n,1)}$ have distinct color codes then our locating coloring has the required properties and $\chi_L(B_{P(n,1)}) \leq 5$. This concludes the proof. \square

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

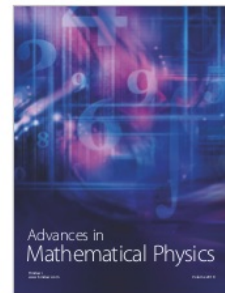
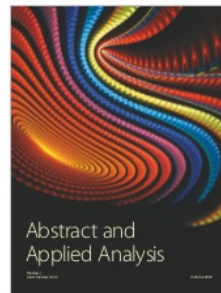
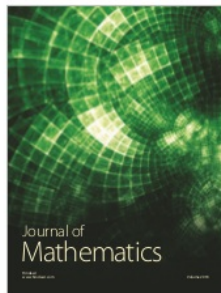
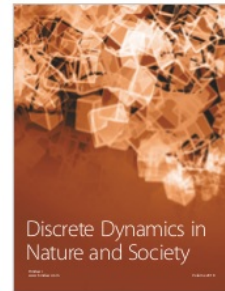
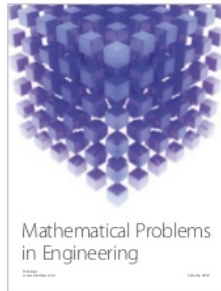
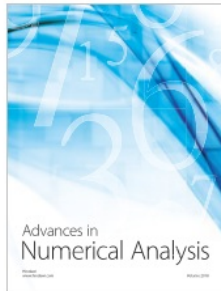
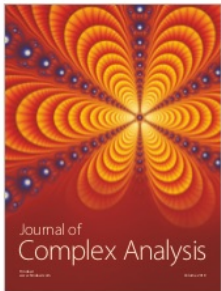
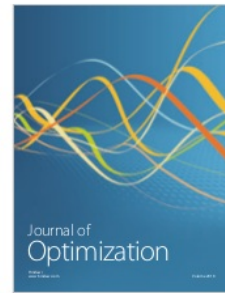
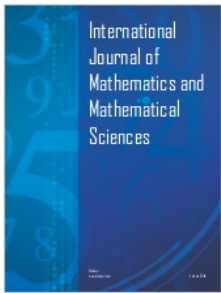
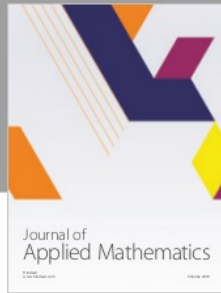
22 authors declare that they have no conflicts of interest.

Acknowledgments

The authors are thankful to DRPM Dikti for the Fundamental Grant 2018.

References

- [1] G. Chartrand, P. Zhang, and E. Salehi, "On the partition dimension of a graph," *Congressus Numerantium*, vol. 130, pp. 157–168, 1998.
- [2] V. Saenpholphat and P. Zhang, "Conditional resolvability: a survey," *International Journal of Mathematics and Mathematical Sciences*, vol. 38, pp. 1997–2017, 2004.
- [3] M. Johnson, "Structure-activity maps for visualizing the graph variables arising in drug design," *Journal of Biopharmaceutical Statistics*, vol. 3, no. 2, pp. 203–236, 1993.
- [4] G. Chartrand and P. Zhang, "THE theory and applications of resolvability in graphs. A survey," vol. 160, pp. 47–68.
- [5] G. Chartrand, D. Erwin, M. A. Henning, P. J. Slater, and P. Zhang, "The locating-chromatic number of a graph," *Bulletin of the Institute of Combinatorics and Its Applications*, vol. 36, pp. 89–101, 2002.
- [6] G. Chartrand, D. Erwin, M. A. Henning, P. J. Slater, and P. Zhang, "Graphs of order $n-1$," *Discrete Mathematics*, vol. 269, no. 1-3, pp. 65–79, 2003.
- [7] A. Behtoei and B. Omoomi, "On the locating chromatic number of Kneser graphs," *Discrete Applied Mathematics: The Journal of Combinatorial Algorithms, Informatics and Computational Sciences*, vol. 159, no. 18, pp. 2214–2221, 2011.
- [8] Asmiati, Wamiliana, Devriyadi, and L. Yulianti, "On some Petersen graphs having locating chromatic number four or five," *Far East Journal of Mathematical Sciences*, vol. 102, no. 4, pp. 769–778, 2017.
- [9] E. T. Baskoro and Asmiati, "Characterizing all trees with locating-chromatic number 3," *Electronic Journal of Graph Theory and Applications. EJGTA*, vol. 1, no. 2, pp. 109–117, 2013.
- [10] D. K. Syofyan, E. T. Baskoro, and H. Assiyatun, "Trees with certain locating-chromatic number," *Journal of Mathematical and Fundamental Sciences*, vol. 48, no. 1, pp. 39–47, 2016.
- [11] Asmiati, H. Assiyatun, and E. T. Baskoro, "Locating-chromatic number of amalgamation of stars," *ITB Journal of Science*, vol. 43A, no. 1, pp. 1–8, 2011.
- [12] Asmiati, H. Assiyatun, E. T. Baskoro, D. Suprijanto, R. Simanjuntak, and S. Uttunggadewa, "The locating-chromatic number of firecracker graphs," *Far East Journal of Mathematical Sciences (FJMS)*, vol. 63, no. 1, pp. 11–23, 2012.
- [13] D. Welyyanti, E. T. Baskoro, R. Simanjuntak, and S. Uttunggadewa, "On locating-chromatic number of complete n -ary tree," *AKCE International Journal of Graphs and Combinatorics*, vol. 10, no. 3, pp. 309–315, 2013.
- [14] M. E. Watkins, "A theorem on tait colorings with an application to the generalized Petersen graphs," *Journal of Combinatorial Theory*, vol. 6, no. 2, pp. 152–164, 1969.



On the Locating Chromatic Number of Certain Barbell Graphs

ORIGINALITY REPORT

24%

SIMILARITY INDEX

PRIMARY SOURCES

- 1 **María Teresa Signes Pont, Juan Manuel García Chamizo, Higinio Mora Mora, Gregorio de Miguel Casado.** "Calculation Scheme Based on a Weighted Primitive: Application to Image Processing Transforms", *EURASIP Journal on Advances in Signal Processing*, 2007
46 words — 2%
Crossref
- 2 **Carmen Hernando, Mercè Mora, Ignacio M. Pelayo, Liliana Alcón, Marisa Gutierrez.** "Neighbor-locating coloring: graph operations and extremal cardinalities", *Electronic Notes in Discrete Mathematics*, 2018
36 words — 1%
Crossref
- 3 **journals.itb.ac.id**
35 words — 1%
Internet
- 4 **INDRA RAJASINGH, M. AROCKIARAJ, BHARATI RAJAN, PAUL MANUEL.** "CIRCULAR WIRELENGTH OF GENERALIZED PETERSEN GRAPHS", *Journal of Interconnection Networks*, 2012
34 words — 1%
Crossref
- 5 **Indra Rajasingh.** "Feedback Arc Set in Oriented Graphs", 2009 International Conference on Computer Technology and Development, 11/2009
28 words — 1%
Crossref
- 6 **Dereniowski, D..** "Vertex rankings of chordal graphs and weighted trees", *Information Processing Letters*, 20060516
28 words — 1%
Crossref
- 7 **Martin Bača, Mirka Miller, Joe Ryan, Andrea Semaničová-**

Feňovčíková. "Chapter 3 Vertex-Magic Total Labelings", Springer Science and Business Media LLC, 2019 25 words — 1 %
Crossref

8 Martin Bača, Mirka Miller, Oudone Phanalasy, Andrea Semaničová-Feňovčíková. "Super d-antimagic labelings of disconnected plane graphs", Acta Mathematica Sinica, English Series, 2010 23 words — 1 %
Crossref

9 Le Gao, N. K. Govil. "Annular Bounds for the Zeros of a Polynomial", International Journal of Mathematics and Mathematical Sciences, 2018 23 words — 1 %
Crossref

10 jmua.fmipa.unand.ac.id 21 words — 1 %
Internet

11 Mehar Chand, Hanaa Hachimi, Rekha Rani. "New Extension of Beta Function and Its Applications", International Journal of Mathematics and Mathematical Sciences, 2018 20 words — 1 %
Crossref

12 Ming-Chien Yang. "Super Connectivity of Component-Composition Networks", 2015 3rd International Conference on Applied Computing and Information Technology/2nd International Conference on Computational Science and Intelligence, 2015 20 words — 1 %
Crossref

13 Sara Bitan. "The last packing number of quadruples, and cyclic SQS", Designs Codes and Cryptography, 10/1993 18 words — 1 %
Crossref

14 hdl.handle.net 16 words — 1 %
Internet

15 Enqiang Zhu, Fei Jiang, Zepeng Li, Zehui Shao, Jin Xu. "On Adjacent Vertex-Distinguishing Total Chromatic Number of Generalized Petersen Graphs", 2016 IEEE First 14 words — 1 %

-
- 16 Y. T. Yau, W. Z. Jiang, K. I. Hwu. "Bidirectional Operation of High Step-Down Converter", IEEE Transactions on Power Electronics, 2015
13 words — 1%
Crossref
-
- 17 www.discuss.wmie.uz.zgora.pl
Internet
13 words — 1%
-
- 18 link.springer.com
Internet
13 words — 1%
-
- 19 "Rarefied Gas Dynamics", Springer Nature, 1985
Crossref
12 words — < 1%
-
- 20 Xu, B.. "Decreasing solutions and convex solutions of the polynomial-like iterative equation", Journal of Mathematical Analysis and Applications, 20070501
Crossref
12 words — < 1%
-
- 21 ANDRÉ E. KÉZDY, HUNTER S. SNEVILY. "Distinct Sums Modulo and Tree Embeddings ", Combinatorics, Probability and Computing, 2002
Crossref
11 words — < 1%
-
- 22 Shiyong Wang, Mujiangshan Wang. " The Edge Connectivity of Expanded -Ary -Cubes ", Discrete Dynamics in Nature and Society, 2018
Crossref
10 words — < 1%
-
- 23 Saeid Alikhani, Yee-Hock Peng. "Dominating Sets and Domination Polynomials of Paths", International Journal of Mathematics and Mathematical Sciences, 2009
Crossref
10 words — < 1%
-
- 24 S. Ghosh, P. De, K. Basu, S.K. Das. "PeterNet: an emergent technology based radio access network architecture for next generation cellular wireless systems", First International Conference on Broadband Networks, 2004
Crossref
10 words — < 1%

25	Rahman, M.S.. "On Hamiltonian cycles and Hamiltonian paths", Information Processing Letters, 20050415 Crossref	10 words — < 1%
26	S.-i. KAWANO. "Generating All Series-Parallel Graphs", IEICE Transactions on Fundamentals of Electronics Communications and Computer Sciences, 05/01/2005 Crossref	9 words — < 1%
27	www.wisdom.weizmann.ac.il Internet	9 words — < 1%
28	S. SEN SARMA, S. K. BANDYOPADHYAY. "Some sequential graph colouring algorithms", International Journal of Electronics, 1989 Crossref	9 words — < 1%
29	prh.hec.gov.pk Internet	9 words — < 1%
30	export.arxiv.org Internet	9 words — < 1%
31	Gabriel A. Barragán-Ramírez, Juan A. Rodríguez-Velázquez. "The Local Metric Dimension of Strong Product Graphs", Graphs and Combinatorics, 2015 Crossref	9 words — < 1%
32	vita.bu.edu Internet	8 words — < 1%
33	Shlomo Gelaki, Sara Westreich. " On the Quasitriangularity of $(sl)'$ ", Journal of the London Mathematical Society, 1998 Crossref	8 words — < 1%
34	fmipa.itb.ac.id Internet	8 words — < 1%
35	jurnal.unpad.ac.id Internet	8 words — < 1%

8 words — < 1%

36 Cyriac Grigorious, Paul Manuel, Mirka Miller, Bharati Rajan, Sudeep Stephen. "On the metric dimension of circulant and Harary graphs", Applied Mathematics and Computation, 2014 8 words — < 1%
Crossref

37 matematika-racunalnistvo.fnm.uni-mb.si 8 words — < 1%
Internet

38 Szekely, L.A.. "A successful concept for measuring non-planarity of graphs: the crossing number", Discrete Mathematics, 20040206 7 words — < 1%
Crossref

39 S. Latifi, M. Hegde, M. Naraghi-Pour. "Conditional connectivity measures for large multiprocessor systems", IEEE Transactions on Computers, 1994 6 words — < 1%
Crossref

EXCLUDE QUOTES ON

EXCLUDE BIBLIOGRAPHY ON

EXCLUDE MATCHES OFF