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STRONGLY CHROMATIC METRO DOMINATION OF P_n, C_n AND ${P_n}^2$

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ABSTRACT
A dominating set *D* of a graph *G(V,E)* is called metro dominating set *G* if for every pair of vertices *u,v*, there exists a vertex *w* in *D* such that $d(u,w) \neq d(v,w)$. A metro dominating set *D* is called strongly chromatic metro dominating set if for every vertex $v \in D$ is from the same color class. The minimum cardinality strongly chromatic metro dominating set is called strongly chromatic metro domination number and is denoted by $SC\gamma_\beta$. In this paper we find strongly chromatic metro domination number of path, cycles and square of a path.

Keywords: *metric dimension, metro domination, strongly chromatic metro domination, power graph.*
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I. INTRODUCTION

Let *G(V,E)* be a simple, non-trivial, undirected and non-null graphs. A graph *G* is k-colorable if there exists a k-coloring of *G*. One of the fastest growing areas within graph theory is the study of domination and related problem. A subset *D* of *V* is said to be a dominating set of *G* if every vertex in *V-D* is adjacent to a vertex in *D*.
The minimum cardinality of a dominating set is called the domination number of *G* and is denoted by $\gamma(G)$. A subset *D*of *V* is said to be a dom-chromatic set if*D* is a dominating set and $\chi(<D>) = \chi(G)$.The dom-chromatic number $\gamma_{ch}(G)$ of *G* is the minimum cardinality of a dom-chromatic set.

In 1976 F.Harary and R.A.Melter [1] introduced the notation of metric dimension. A vertex $x \in V(G)$ resolves a pair of vertices $u,w \in V(G)$ if $d(v,x) \neq d(w,x)$. A set of vertices $S \subseteq V(G)$ resolves *G* and *S* is a resolving set of *G*, if every pair of distinct vertices of *G* are resolved by same vertex in *S*. A resolving set *S* of *G* with minimum cardinality is a metric dimension of *G* denoted by $\beta(G)$.

A dominating set *D* of *V(G)* having a property that for each pair of vertices *u,v* there exist a vertex *w* in *D* such that $d(u,w) \neq d(v,w)$ is called metro dominating set of *G* or simply MD-set. The minimum cardinality of a metro dominating set of *G* is called metro domination number of *G* and is denoted by $\gamma_\beta(G)$.

II. DEFINITIONS

2.1 Metric dimension:
The metric dimension of a graph *G* is the minimum cardinality of a subset *S* of vertices such that all other vertices are uniquely determined by their distances to the vertices in *S*. It is denoted by $\beta(G)$.

2.2 Domination:
Let *G(V,E)* be a graph. A subset of vertices $D \subseteq V$ is called a dominating set (γ-set) if every vertex in *V-D* adjacent to atleast one vertex in *D*. The minimum cardinality of a dominating set is called the domination number of the graph *G* and is denoted by $\gamma(G)$.

2.3 Locating domination:
A dominating set *D* is called a locating dominating set or simply LD-set if for each pair of vertices $u,v \in V-D$, $ND(u) \neq ND(v)$ where $ND(u) = N(u) \cap D$. The minimum cardinality of an LD-set of the graph *G* is called the locating domination number of *G* denoted by $\gamma_L(G)$.

2.4 Metro domination:
A dominating set *D* of *V(G)* having the property that for each pair of vertices *u,v* there exists a vertex *w* in *D* such that $d(u,w) \neq d(v,w)$ is called metro dominating set of *G* or simply MD-set. The minimum cardinality of a metro dominating set of *G* is called metro domination number of *G* and is denoted by $\gamma_\beta(G)$.

2.5 Chromatic number:
The minimum number of colors required for a proper coloring of *G* is called chromatic number of *G* and is denoted by $\chi(G)$.

2.6 Chromatic domination:
A subset *D* of *V* is said to be a dom-chromatic set if *D* is a dominating set and $\chi(\langle D\rangle) = \chi(G)$. The dom-chromatic number $\gamma_{ch}(G)$ of *G* is the minimum cardinality of a dom-chromatic set.

III. SOME KNOWN RESULTS

In this section we mention some of the known result on metric dimension, domination, metro domination.

Theorem 3.1. (Harary and Melter [1]) The metric dimension of a non trivial complete graph of order n is n-1.

Theorem 3.2. (Khuller, Raghavachari, Rosenfeld [4]) The metric dimension of a graph *G* is 1 if and only if *G* is a path.

Theorem 3.3. (Harary and Melter [1]) The metric dimension of a complete bipartite graph $K_{m,n}$ is $m+n-2$.

Theorem 3.4.[5] The metro domination number of a graph *G* is $\left\lceil \frac{n}{5} \right\rceil$ if and only if *G* is a cycle.

Theorem 3.5.[5] Let *G* be a graph on n vertices. Then $\gamma_\beta(G) = n-1$ if and only if *G* is K_n or $K_{1,n-1}$ for $n \geq 1$.

Theorem 3.6. [5] For any integer n, $\gamma_\beta(P_n) = \left\lceil \frac{n}{3} \right\rceil$.

Remark 3.7. For any connected graph *G*, $\gamma_\beta(G) \geq \max\{\gamma(G), \beta(G)\}$.

Remark 3.8. For any integer $n>3$, $\chi(C_n) = \begin{cases} 3 & \text{for } n \text{ odd} \\ 2 & \text{for } n \text{ even} \end{cases}$

Remark 3.9. For any integer $n > 1$, $\chi(P_n) = 2$.

Lemma 3.10. [9] Let $G = P_n^2$, $n > 3$. Then $dim(G) = 2$.

Theorem 3.11. [7] For every $n \geq 1$, $\gamma_\beta(P_n^2) = \left\lceil \frac{n}{5} \right\rceil$.

Theorem 3.12. [2] For any integer $n \geq 3$, $\gamma_\beta(P_n^2) = \begin{cases} 2 & \text{if } 3 \geq n \geq 7 \\ 3 & \text{if } 8 \geq n \geq 10 \\ \left\lceil \frac{n}{5} \right\rceil & \text{if } n \geq 11 \end{cases}$

Remark 3.13. For any integer $n \geq 3$, $\chi(P_n^2) = 3$.

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IV. MAIN RESULTS

Theorem 4.1. For any integer $n \geq 4$, $SC\gamma_\beta(P_n) = \left\lceil \frac{n-1}{2} \right\rceil$.

Proof: By theorem 3.2 $\beta(P_n) = 1$ and by remark 3.9 $\chi(P_n) = 2$, clearly we have $\left\lceil \frac{n}{2} \right\rceil$ vertices of one color class and remaining $\left\lfloor \frac{n}{2} \right\rfloor$ vertices of other color class. Hence we have choice of either $\left\lceil \frac{n}{2} \right\rceil$ or $\left\lfloor \frac{n}{2} \right\rfloor$ vertices for dominating set D whose vertices are from the same color class.For even n, $\frac{n}{2}$ vertices of same color class dominates the remaining $\frac{n}{2}$ vertices. For odd n, $\frac{n-1}{2}$ vertices of same color class will dominates the remaining vertices and hence $SC\gamma_\beta(P_n) \geq \left\lceil \frac{n-1}{2} \right\rceil$ (1)

To prove the reverse inequality, we define a strongly chromatic dominating set $D = \left\{ v_{2i} \,/\, 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor \right\}$ of cardinality $\left\lceil \frac{n-1}{2} \right\rceil$. We note that D acts as a dominating set also as a resolving set and each $v_i \in D$ is from the same color class and hence $SC\gamma_\beta(P_n) \leq \left\lceil \frac{n-1}{2} \right\rceil$ (2)

from(1) and (2)
$SC\gamma_\beta(P_n) = \left\lceil \frac{n-1}{2} \right\rceil$.

Theorem 4.2. For any integer $n \geq 5$, $SC\gamma_\beta(C_n) = \left\lceil \frac{n-1}{2} \right\rceil$.

Proof: By the result $\beta(C_n) = 2$ and by remark 3.8, $\chi(C_n) = \begin{cases} 3 & \text{for } n \text{ odd} \\ 2 & \text{for } n \text{ even} \end{cases}$, clearly we have $\frac{n}{2}$ vertices of one color class and remaining $\frac{n}{2}$ vertices of other color class for even n and $\left\lfloor \frac{n}{2} \right\rfloor$ vertices of one color class and other $\left\lfloor \frac{n}{2} \right\rfloor$ vertices of second color class and remaining one vertex of third color class for odd n. Hence we have choice of $\frac{n}{2}$ vertices for dominating set D such that each $v_i \in D$ are from the same color class.For even cycle, $\frac{n}{2}$ vertices of same color class dominate the remaining $\frac{n}{2}$ vertices. For odd cycle, $\frac{n-1}{2}$ vertices of same color class will dominate the remaining vertices and hence $SC\gamma_\beta(C_n) \geq \left\lceil \frac{n-1}{2} \right\rceil$ (1)

To prove the reverse inequality, we define a strongly chromatic dominating set $D = \left\{ v_{2i-1} \,/\, 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor \right\}$ of cardinality $\left\lceil \frac{n-1}{2} \right\rceil$, which also acts as a resolving set and each $v_i \in D$ is from the same color class and hence $SC\gamma_\beta(C_n) \leq \left\lceil \frac{n-1}{2} \right\rceil$ (2)

from(1) and (2)
$SC\gamma_\beta(C_n) = \left\lceil \frac{n-1}{2} \right\rceil$.

Theorem 4.3. For any integer $n \leq 9$, $SC\gamma_\beta(P_n^2) = \left\lfloor \frac{n}{3} \right\rfloor$.

Proof: By lemma 3.10, $dim(P_n^2) = 2$ for $n > 3$. Also by Theorem 3.11 $\gamma_\beta(P_n^2) = \left\lceil \frac{n}{5} \right\rceil$, $n \geq 11$ here each $\left\lceil \frac{n}{5} \right\rceil$ vertices of metro dominating set are not from the same color class. By remark 3.13, $\chi(P_n^2) = 3$, $n \geq 3$ if we label v_1 of P_n^2 by color 1 and v_2 by color 2 and v_3 by color 3 and continuing the coloring, we get $\left\lceil \frac{n}{3} \right\rceil$ vertices of color class 1, $\left\lfloor \frac{n+1}{3} \right\rfloor$

vertices of color class 2 and $\left\lfloor \frac{n}{3} \right\rfloor$ vertices of color class 3. Hence we have a choice of $\left\lceil \frac{n}{3} \right\rceil$ or $\left\lfloor \frac{n+1}{3} \right\rfloor$ or $\left\lfloor \frac{n}{3} \right\rfloor$ vertices for strongly chromatic metro dominating set minimum among these $\left\lfloor \frac{n}{3} \right\rfloor$is minimum and hence

$$SC\gamma_{\beta}(P_n^2) \geq \left\lfloor \frac{n}{3} \right\rfloor \qquad (1)$$

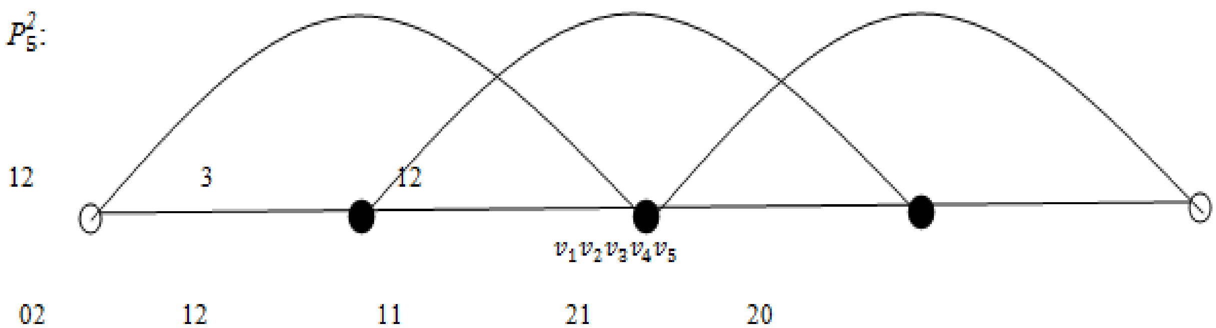
To prove the reverse inequality, we defined the strongly chromatic metro dominating set as$D = \left\{v_{3i} \,/\, 1 \leq i \leq \left\lfloor \frac{n}{3} \right\rfloor\right\}$ of cardinality$\left\lfloor \frac{n}{3} \right\rfloor$. We note that D is a dominating set also acts as a resolving set and each $v_i \in D$ are all from the same color class and hence $SC\gamma_{\beta}(P_n^2) \leq \left\lfloor \frac{n}{3} \right\rfloor$(2)

from(1) and (2)

$SC\gamma_{\beta}(P_n^2) = \left\lfloor \frac{n}{3} \right\rfloor$.

EXAMPLE:

P_5^2:



$D_1 = \{v_3\}$

$D_1$is a dominating set but not resolving set.

$D_2 = \{v_1, v_5\}$

$D_2$is a dominating set also resolving set but both vertices are not from same color class. Hence it is not a strongly chromatic metro domination.

Hence P_5^2 is not a strongly chromatic metro domination.

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