



Research Article

DOMINATION PARAMETERS OF MONGOLIAN TENT

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ABSTRACT

The domination parameters of a graph G of order n has been already introduced. It is defined as D ⊆ V(G) is a dominating set of G, if every vertex v ∈ V - D is adjacent to atleast one vertex in D. In this paper, we have established various domination parameters of Mongolian Tent, also we have studied the relation between this parameters and illustrated with an examples.

Key words:

Graph, Domination, Mongolian Tent, Path and null graph

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INTRODUCTION

A graph G = (V, E), where V is a finite set of elements, called vertices and E is a set of unordered pairs of distinct vertices of G called edges. The degree of a vertex v in G is the number of edges incident on it. Every pair of its vertices are adjacent in G is said to be complete, the complete graph on 'n' vertices is denoted by Kn.

Let u and v be the vertices of a graph G, a u - v walk of G is an alternating sequences u = u0, e, u1, e2, u2, ..., un-1, en, vn = v of vertices and edges beginning with vertex u and ending with vertex v such that ei = ui-1ui for all i = 1, 2, ..., n. The number of edges in a walk is called its length. A walk in which all the vertices are distance in called a path. A path on 'n' vertices is denoted by Pn. A closed path is called a cycle, a cycle on 'n' vertices is denoted by Cn. Let G = (V, E) be a simple connected graph, for any vertex v ∈ V, the open neighborhood is the set N(v) = {u ∈ V / uv ∈ E} and the closed neighborhood of v is the set N[v] = N(v) ∪ {u}. For a set S ⊂ V, the open neighborhood of S is N(S) = ∪ N(v), v ∈ S and the closed neighborhood of S is N[s] = N(S) ∪ S.

Definition 1.1

A set D ⊆ V is a dominating set of G if every vertex v ∈ V - D is adjacent to at least one vertex of D. We call a dominating set D is a minimal if there is no dominating set D' ⊆ V (G) with D' ⊂ D and D' ≠ D. Further we call a dominating set D is minimum if these is no dominating set D ⊆ V(G) with |D'| < |D|.

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The cardinality of a minimum dominating set is called the domination number denoted by γ(G) and the minimum dominating set D of G is also called a γ- set.

Definition 1.2

A dominating set D is said to be a total dominating set if every vertex in V is adjacent to some vertex in D. The total domination number of G denoted by γt(G) is the minimum cardinality of a total dominating set.

Definition 1.3

A dominating set D of a graph G is an independent dominating set, if the induced sub graph <D> has no edges. The independent domination number γi(G) is the minimum cardinality of an independent dominating set.

Definition 1.4

A dominating Set D is said to be connected dominating set, if the induced sub graph <D> is connected. The connected domination number γc(G) is the minimum cardinality of a connected dominating set.

Definition 1.5

A dominating Set D of a graph G is said to be a paired dominating set if the induced sub graph <D> contains at least one perfect matching, paired domination number γp(G) is the minimum cardinality of a paired dominating set.

Definition 1.6

A dominating Set D of G is a split dominating set if the induced sub graph <V - D> disconnected Split domination number γs(G) is the minimum cardinality of a split dominating set.

Definition 1.7

A dominating Set D of G is a non split dominating set, if the induced sub graph $\langle V - D \rangle$ is connected. Non split domination number $\gamma_{ns}(G)$ is the minimum cardinality of a non split dominating set.

Definition 1.8

A dominating set D of a graph G is called a global dominating set, if D is also a dominating set of \overline{G} . The global domination number $\gamma_g(G)$ is the minimum cardinality of a global dominating set.

Definition 1.9

A dominating set D is called a perfect dominating set, if every vertex in $V - D$ is adjacent to exactly one vertex in D . The perfect domination number $\gamma_{pr}(G)$ is the minimum cardinality of a perfect dominating set.

n -Centipede graph is a tree on $2n$ vertices obtained by joining the bottom of n -copies of the path graph P_2 laid in a row with edges and is denoted by C_n .

Definition 1.10

The Harary graph $H_{n,k}$ is a graph on the n vertices $\{v_1, v_2, \dots, v_n\}$ defined by the following construction: • If k is even, then each vertex v_i is adjacent to $v_{i\pm 1}, v_{i\pm 2}, \dots, v_{i\pm k/2}$, where the indices are subjected to the wraparound convention that $v_i \equiv v_{i+n}$ (e.g. v_{n+3} represents v_3). • If k is odd and n is even, then $H_{n,k}$ is $H_{n,k-1}$ with additional adjacencies between each v_i and $v_{i+n/2}$ for each i . • If k and n are both odd, then $H_{n,k}$ is $H_{n,k-1}$ with additional adjacencies

$$\{v_1, v_{1+n/2}\}, \{v_1, v_{1+n/2+1}\}, \{v_2, v_{2+n/2}\}, \{v_3, v_{3+n/2}\}, \dots, \{v_{n/2}, v_n\}$$

Definition 1.11

Let x be any real value, then its upper sealing of x is denoted as $\lceil x \rceil$ and is defined

$$\lceil x \rceil = \begin{cases} x & \text{if } x \text{ is an integer} \\ k, & \text{where } k \text{ is an integer lies in the interval } x < k < x + 1 \end{cases}$$

the lower sealing of x is denoted as $\lfloor x \rfloor$ and is defined by

$$\lfloor x \rfloor = \begin{cases} x & \text{if } x \text{ is an integer} \\ k, & \text{where } k \text{ is an integer lies in the interval } x - 1 < k < x \end{cases}$$

Definition 1.12

The k^{th} power of a graph G is a graph with the same set of vertices of G and an edge between two vertices if there is a path of length almost k between them. G^2 is called the square of G , G^3 is called the cube of G etc.

Lemma 2.1

Let G be a connected graph with $\delta(G) \geq 2$, then $\gamma(G) + \gamma'(G) = n$ if and only if $G = P_4$ or C_4 .

Lemma 2.2

Let G be a connected graph with $\delta = 1$ and $\Delta = n$ then $\gamma(G) + \gamma'(G) = n + 1$ if and only if $G = K_{1,n}$.

Lemma 2.3

For any tree with $n \geq 2$ with more than two pendent vertices then there exists a vertex $v \in V$ such that $\gamma(T - v) = \gamma(T)$.

Theorem 2.4

G be a Mongolian tent with $m n + 1$ vertices then $\gamma(G) \leq (m - 1) \lfloor \frac{n}{4} \rfloor + 2$.

Proof: The Mongolian Tent with $2n+1$ vertices is represented in figure 1.1 as follows

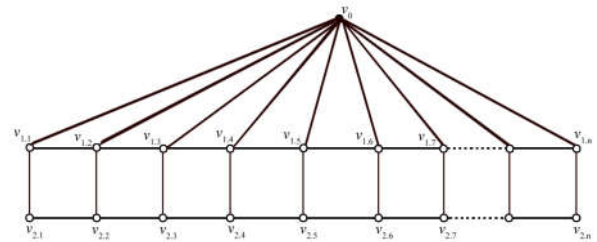


Figure 1.1

The vertex set of G is denoted by $V = \{v_0, v_{ij}/i = 1, 2; j = 1 \dots n\}$

Case (i) $n \equiv 0(mod 3)$ then

$D = \{v_0, v_{2,3i-1}/i = 1, 2, \dots, k\}$ is the minimum dominating set of G and its cardinality is

$$|D| = \lfloor \frac{n}{3} \rfloor + 1 = \lfloor \frac{n}{3} \rfloor + 1 \quad \{ \text{Since } n \equiv 0(mod 3) \Rightarrow \lfloor \frac{n}{3} \rfloor = \lfloor \frac{n}{3} \rfloor \}$$

Case (ii) $n \not\equiv 0(mod 3)$ then

$D = \{v_0, v_{2,3i-1}, v_{2,n}/i = 1, 2, \dots, \lfloor \frac{n}{3} \rfloor\}$ is the minimum dominating set with cardinality is

$$|D| = \lfloor \frac{n}{3} \rfloor + 2 = \lfloor \frac{n}{3} \rfloor + 1 \quad \left[\text{Since } n \not\equiv 0(mod 3) \Rightarrow \lfloor \frac{n}{3} \rfloor \right] = \lfloor \frac{n}{3} \rfloor + 1$$

Therefore, $\gamma(G) = \lfloor \frac{n}{3} \rfloor + 1$

Mongolian tent with $3n + 1$ vertices then G is represented figure 1.2 follows

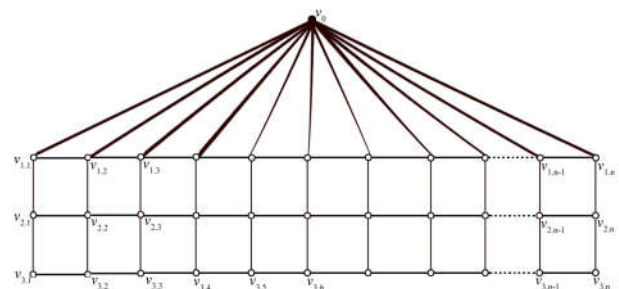


Figure 1.2

Now the vertex set of G are denoted by $= \{v_0; v_{i,j}/i = 1,2,3 \text{ and } j = 1,2,\dots,n\}$

Case (i)

$n \equiv 0(mod4)$ then
 $D = \{v_0; v_{2,4j-3}; v_{3,4j-1}; v_{2n}/j = 1,2,\dots, \lfloor n/4 \rfloor\}$ is the required minimum dominating set of G and its cardinality is $|D| = 2 \lfloor \frac{n}{4} \rfloor + 2$

$$= 2 \lfloor \frac{n}{4} \rfloor + 2$$

$$\{\because n = 4k \Rightarrow \lfloor \frac{n}{4} \rfloor = \lfloor \frac{n}{4} \rfloor\} \tag{i}$$

Case (ii)

$n \equiv 1(mod4)$ Then select the vertices of D as
 $D = \{v_0; v_{2,4j-3}; v_{3,4j-1}; /j = 1,2,\dots, \lfloor n/4 \rfloor\}$ is the required minimum dominating set of G
 Therefore, $|D| = \lfloor \frac{n}{4} \rfloor + \lfloor \frac{n}{4} \rfloor + 1 + 1$

$$\lfloor \frac{n}{4} \rfloor 2 \tag{ii}$$

Case (iii)

$n \equiv 2(mod4)$ then select the vertices of D as
 $D = \{v_0; v_{3,3}; v_{2,4j-3}; \frac{v_{3,4j+2}}{j} = 1,2,\dots, \lfloor \frac{n}{4} \rfloor\}$ is the minimum dominating sets and its cardinality is $|D| =$

$$\lfloor \frac{n}{4} \rfloor + \lfloor \frac{n}{4} \rfloor + 2 =$$

$$\lfloor \frac{n}{4} \rfloor + \lfloor \frac{n}{4} \rfloor 2 \lfloor \frac{n}{4} \rfloor \tag{iii}$$

Case (iv)

If $n \equiv 3(mod4)$ Collect the vertices of D as
 $D = \{v_0; v_{2,4j-3}; v_{3,4j-1}/j = 1,2,\dots, \lfloor n/4 \rfloor\}$ is the required minimum dominating set of G and its cardinality is $|D| = 2 \lfloor n/4 \rfloor + 1$

$$\text{Therefore, } \gamma(G) = \begin{cases} 2 \lfloor \frac{n}{4} \rfloor + 2 & \text{if } n \equiv 0,1(mod4) \\ 2 \lfloor \frac{n}{4} \rfloor & \text{if } n \equiv 2(mod4) \\ 2 \lfloor \frac{n}{4} \rfloor + 1 & \text{if } n \equiv 3(mod4) \end{cases}$$

If G is a Mongolian Tent with $4n+1$ vertices is given in figure 1.3 as follows

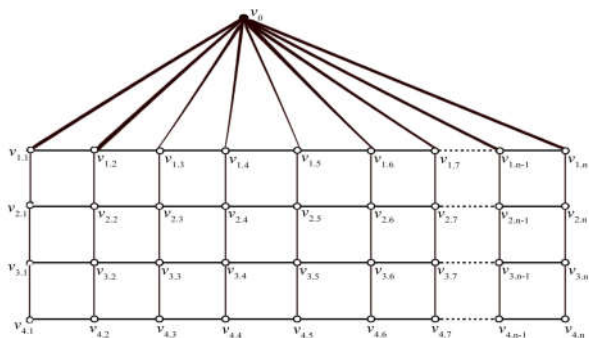


Figure 1.3

Let the vertices set of G are denoted by

$$V = \{v_0, v_{ij}/i = 1, \dots, 4; j = 1,2, \dots, n\}$$

Case (i)

$n \equiv 0(mod4)$ then
 $D = \{v_0; v_{2,4j-1}; v_{3,4j-3}; v_{3,n}; v_{4,4j-1}/j = 1, \dots, \lfloor n/4 \rfloor\}$ is the dominating set with minimum cardinality and $|D| = 2 \lfloor \frac{n}{4} \rfloor + \lfloor \frac{n}{4} \rfloor + 2 = 3 \lfloor \frac{n}{4} \rfloor + 2$

$$= 3 \lfloor \frac{n}{4} \rfloor + 2 \quad \{\because n = 4k \Rightarrow \lfloor \frac{n}{4} \rfloor = \lfloor \frac{n}{4} \rfloor\} \tag{i}$$

Case (ii)

$n \equiv 1(mod4)$ then $D = \{v_0; v_{2,4j-1}; v_{3,4j-2}; v_{4,4j-1}; /j = 1,2, \dots, \lfloor \frac{n}{4} \rfloor\}$ is the minimum dominating set of G and its cardinality is $|D| = 2 \lfloor \frac{n}{4} \rfloor + \lfloor \frac{n}{4} \rfloor + 1$

Case (iii)

If $n \equiv 2(mod4)$ then
 $D = \{v_0; v_{2,4j-1}; v_{3,4j-1}; v_{3,n}; v_{4,4j-1}/j = 1, \dots, \lfloor n/4 \rfloor\}$ is the minimum dominating set and its cardinality is $|D| = 2 \lfloor \frac{n}{4} \rfloor + \lfloor \frac{n}{4} \rfloor + 2 = 2 \lfloor \frac{n}{4} \rfloor + 2 + \lfloor \frac{n}{4} \rfloor = 2 \lfloor \frac{n}{4} \rfloor + \lfloor \frac{n}{4} \rfloor = 3 \lfloor \frac{n}{4} \rfloor$

Case (iv)

$n \equiv 3(mod4)$ then
 $D = \{v_0; v_{2,4j-1}; v_{3,4j-3}; v_{4,4j-1}/i = 1,2, \dots, \lfloor \frac{n}{4} \rfloor\}$

is the required minimum dominating set of G and

$$|D| = 3 \lfloor \frac{n}{4} \rfloor + 1$$

$$\text{Therefore, } \gamma(G) = \begin{cases} 3 \lfloor \frac{n}{4} \rfloor + 2 & \text{if } n \equiv 0(mod4) \\ 2 \lfloor \frac{n}{4} \rfloor + \lfloor \frac{n}{4} \rfloor + 1 & \text{if } n \equiv 1(mod4) \\ 3 \lfloor \frac{n}{4} \rfloor & \text{if } n \equiv 2(mod4) \\ 3 \lfloor \frac{n}{4} \rfloor + 1 & \text{if } n \equiv 3(mod4) \end{cases}$$

III If G is Mongolian tent with $5n + 1$ vertices

Case (i)

$n \equiv 0(mod4)$ then
 $D = \{v_0; v_{2,4j-1}; v_{3,4j-3}; v_{4,4j-1}; v_{4n}; v_{5,4j-3}/j = 1, \dots, \lfloor n/4 \rfloor\}$ is the minimum dominating set and its cordiality is $|D| = 4 \lfloor \frac{n}{4} \rfloor + 1 + 1 = 4 \lfloor \frac{n}{4} \rfloor + 2$

$$\{\because n = 4k \Rightarrow \lfloor \frac{n}{4} \rfloor = \lfloor \frac{n}{4} \rfloor\}$$

Case (ii)

If $n \equiv 1(mod4)$ then
 $D = \{v_0; v_{2,4j-1}; v_{3,4j-3}; v_{4,4j-1}; v_{5,4j-1}/j = 1, \dots, \lfloor \frac{n}{4} \rfloor\}$ is the required minimum dominating set of G and

$$2 \left\lfloor \frac{n}{4} \right\rfloor + 2 \left\lfloor \frac{n}{4} \right\rfloor + 1 = |D| \tag{ii}$$

Case (iii)

If $n \equiv 2 \pmod{4}$ then

$$D = \{v_0; v_{2,4j-1}; v_{3,4j-3}; v_{3,n}; v_{4,4j-1}; v_{5,4j-3}/i = 1, 2, \dots, \left\lfloor \frac{n}{4} \right\rfloor\}$$

is the minimum dominating set and its cardinality is

$$|D| = 2 \left\lfloor \frac{n}{4} \right\rfloor + 2 \left\lfloor \frac{n}{4} \right\rfloor + 2 = 2 \left\lfloor \frac{n}{4} \right\rfloor + 2 \left\lfloor \frac{n}{4} \right\rfloor = 4 \left\lfloor \frac{n}{4} \right\rfloor \tag{iii}$$

$$\left[\because \left\lfloor \frac{n}{4} \right\rfloor = \left\lfloor \frac{n}{4} \right\rfloor + 1 \right]$$

Case (iv)

If $n \equiv 3 \pmod{4}$ then

$$D = \{v_0; v_{2,4j-1}; v_{3,4j-3}; v_{4,4j-1}; v_{5,4j-3}/j = 1, \dots, \left\lfloor \frac{n}{4} \right\rfloor\}$$

if the minimum dominating set of G and its cardinality is

$$|D| = 4 \left\lfloor \frac{n}{4} \right\rfloor + 1 \tag{iv}$$

Then,

$$\gamma(G) = \begin{cases} 4 \left\lfloor \frac{n}{4} \right\rfloor + 2 & \text{if } n \equiv 0 \pmod{4} \\ 2 \left\lfloor \frac{n}{4} \right\rfloor + 2 \left\lfloor \frac{n}{4} \right\rfloor + 1 & \text{if } n \equiv 1 \pmod{4} \\ 4 \left\lfloor \frac{n}{4} \right\rfloor & \text{if } n \equiv 2 \pmod{4} \\ 4 \left\lfloor \frac{n}{4} \right\rfloor + 1 & \text{if } n \equiv 3 \pmod{4} \end{cases}$$

(V) In similar G having $6n + 1$ vertices then its minimum dominating sets and its cardinality is as follows.

Let the vertices set of G are denoted by $V = \{v_0; v_{ij}/i = 1, 2, 3, \dots, 6; j = 1, 2, \dots, n\}$

Cases (i)

If $n \equiv 0 \pmod{4}$ then

$$D = \{v_0; v_{2,4j-1}; v_{3,4j-3}; v_{4,4j-1}; v_{4,n}; v_{5,4j-3}; v_{6,4j-1}/j = 1, 2, \dots, \left\lfloor \frac{n}{4} \right\rfloor\}$$

is the minimum dominating set of G and its cardinality is

$$|D| = 5 \left\lfloor \frac{n}{4} \right\rfloor + 2 = 5 \left\lfloor \frac{n}{4} \right\rfloor + 2 \tag{i}$$

$$\left[\text{Since } \left\lfloor \frac{n}{4} \right\rfloor = \left\lfloor \frac{n}{4} \right\rfloor \text{ if } n \equiv 0 \pmod{4} \right]$$

Case (ii)

If $n \equiv 1 \pmod{4}$ then choose the elements of D as

$$D = \{v_0; v_{2,4j-1}; v_{3,4j-3}; v_{4,4j-1}; v_{5,4j-3}; v_{6,4j-1}/j = 1, 2, \dots, \left\lfloor \frac{n}{4} \right\rfloor\}$$

is the minimum dominating set of G and its cardinality is $|D| = 3 \left\lfloor \frac{n}{4} \right\rfloor + 2 \left\lfloor \frac{n}{4} \right\rfloor + 1 \tag{ii}$

Case (iii)

If $n \equiv 2 \pmod{4}$ choose

$$D = \{v_0; v_{2,4j-1}; v_{3,4j-3}; v_{3,n}; v_{4,4j-1}; v_{5,4j-3}; v_{5,n}; v_{6,4j-1}/j = 1, 2, \dots, \left\lfloor \frac{n}{4} \right\rfloor\}$$

is the required dominating set of G and its cardinality is

$$|D| = 3 \left\lfloor \frac{n}{4} \right\rfloor + 2 \left\lfloor \frac{n}{4} \right\rfloor + 3$$

$$= 3 \left\lfloor \frac{n}{4} \right\rfloor + 3 + 2 \left\lfloor \frac{n}{4} \right\rfloor = 3 \left\lfloor \frac{n}{4} \right\rfloor + 2 \left\lfloor \frac{n}{4} \right\rfloor$$

$$\left[\text{some } n \equiv 2 \pmod{4} \right] \left\lfloor \frac{n}{4} \right\rfloor \equiv \left\lfloor \frac{n}{4} \right\rfloor + 1$$

$$= 5 \left\lfloor \frac{n}{4} \right\rfloor \tag{iii}$$

Case (iv)

If $n \equiv 3 \pmod{4}$ then

$$D = \{v_0; v_{2,4j-1}; v_{3,4j-3}; v_{4,4j-1}; v_{5,4j-3}; v_{6,4j-3}/j = 1, 2, \dots, \left\lfloor \frac{n}{4} \right\rfloor\}$$

is the required minimum dominating set of G and $|D| = 5 \left\lfloor \frac{n}{4} \right\rfloor + 1$

Therefore,

$$\gamma(G) = \begin{cases} 5 \left\lfloor \frac{n}{4} \right\rfloor + 2 & \text{if } n \equiv 0 \pmod{4} \\ 3 \left\lfloor \frac{n}{4} \right\rfloor + 2 \left\lfloor \frac{n}{4} \right\rfloor + 1 & \text{if } n \equiv 1 \pmod{4} \\ 5 \left\lfloor \frac{n}{4} \right\rfloor & \text{if } n \equiv 2 \pmod{4} \\ 5 \left\lfloor \frac{n}{4} \right\rfloor + 1 & \text{if } n \equiv 3 \pmod{4} \end{cases}$$

from the above we have

$\frac{n}{m}$	$n \equiv 0 \pmod{4}$	$n \equiv 1 \pmod{4}$	$n \equiv 2 \pmod{4}$	$n \equiv 3 \pmod{4}$	γ
$m = 3$	$2 \left\lfloor \frac{n}{4} \right\rfloor + 2$	$\left\lfloor \frac{n}{4} \right\rfloor + \left\lfloor \frac{n}{4} \right\rfloor + 1$	$2 \left\lfloor \frac{n}{4} \right\rfloor$	$2 \left\lfloor \frac{n}{4} \right\rfloor + 1$	$\gamma \leq 2 \left\lfloor \frac{n}{4} \right\rfloor + 2$
$m = 4$	$3 \left\lfloor \frac{n}{4} \right\rfloor + 2$	$2 \left\lfloor \frac{n}{4} \right\rfloor + \left\lfloor \frac{n}{4} \right\rfloor + 1$	$3 \left\lfloor \frac{n}{4} \right\rfloor$	$3 \left\lfloor \frac{n}{4} \right\rfloor + 1$	$\gamma \leq 3 \left\lfloor \frac{n}{4} \right\rfloor + 2$
$m = 5$	$4 \left\lfloor \frac{n}{4} \right\rfloor + 2$	$2 \left\lfloor \frac{n}{4} \right\rfloor + \left\lfloor \frac{n}{4} \right\rfloor + 1$	$4 \left\lfloor \frac{n}{4} \right\rfloor$	$4 \left\lfloor \frac{n}{4} \right\rfloor + 1$	$\gamma \leq 4 \left\lfloor \frac{n}{4} \right\rfloor + 2$
$m = 6$	$5 \left\lfloor \frac{n}{4} \right\rfloor + 2$	$3 \left\lfloor \frac{n}{4} \right\rfloor + \left\lfloor \frac{n}{4} \right\rfloor + 1$	$5 \left\lfloor \frac{n}{4} \right\rfloor$	$5 \left\lfloor \frac{n}{4} \right\rfloor + 1$	$\gamma \leq 5 \left\lfloor \frac{n}{4} \right\rfloor + 2$

Corollary 2.5

G be a Mongolian tent with $mn + 1$ vertices then

$$\gamma(G) \leq (m - 1) \left\lfloor \frac{n}{4} \right\rfloor + 2.$$

Lemma 2.6

Let G be a Mongolian tent with $mn + 1$ vertices then $\gamma(G) =$

$$\begin{cases} (m - 1) \left\lfloor \frac{n}{4} \right\rfloor + 2 & \text{if } n \equiv 0 \pmod{4} \\ \left\lfloor \frac{m}{2} \right\rfloor \left\lfloor \frac{n}{4} \right\rfloor + \left\lfloor \frac{m-1}{2} \right\rfloor \left\lfloor \frac{n}{4} \right\rfloor + 1 & \text{if } n \equiv 1 \pmod{4} \\ (m - 1) \left\lfloor \frac{n}{4} \right\rfloor & \text{if } n \equiv 2 \pmod{4} \\ (m - 1) \left\lfloor \frac{n}{4} \right\rfloor + 1 & \text{if } n \equiv 3 \pmod{4} \end{cases}$$

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