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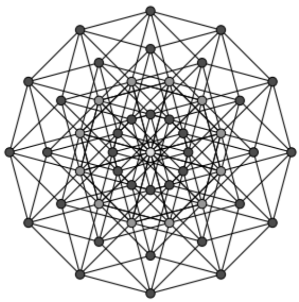

ABSTRACTS

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Department of Mathematics

SSN College of Engineering

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Kalavakkam, Chennai - 603 110

Tamil Nadu, INDIA.

About the conference

Theoretical Computer Science deals with mathematical aspects of computing. The major areas covered under this field include algorithms, data structures, logic, computational geometry, cryptography, computational number theory and algebra, automata theory and the study of randomness. Discrete Mathematics provides the underpinnings of most of the fields in Theoretical Computer Science. Problems in many areas of discrete mathematics such as combinatorics and graph theory, naturally lend themselves to algorithmic techniques. Modern applications of discrete mathematics abound in areas such as business, social and physical sciences. This has fueled much research in discrete mathematics and Theoretical Computer Science.

Invited Talks

On the Skewness of Graphs

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This talk is about planarization of graph by edge deletion. The *skewness* of a graph G is the minimum number of edges in G whose deletion results in a planar graph. As this concept is relatively new in comparison to other existing graph parameters, an introduction along with some recent results on the skewness of graphs is presented.

Coloring Graphs with Forbidden Induced Subgraphs

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A coloring of a graph G is an assignment of colors to the vertices of G such that no two adjacent vertices receive the same color. The minimum number of colors required to color G is called the chromatic number of G, and is denoted by $\chi(G)$. The clique number of G, denoted by $\omega(G)$, is the size of a maximum clique in G. A graph G is perfect if every induced subgraph H of G satisfies $\chi(H) = \omega(H)$. If $\mathcal{F}$ is a family of graphs, a graph G is said to be $\mathcal{F}$-free if it contains no induced subgraph isomorphic to any member of $\mathcal{F}$. It is well-known that for any integer $k \geq 2$, there exists a triangle-free graph with chromatic number equal to k. It follows that for a general class of graphs, there is no upper bound on the chromatic number as a function of its clique number. But for a restricted class of graphs such a function may exist. Following Gyárfás [4] we say that a hereditary class $\mathcal{G}$ of graphs is χ-bounded if there is a function f such that every graph G in $\mathcal{G}$ satisfies $\chi(G) \leq f(\omega(G))$; the function f is called a χ-bounding function of $\mathcal{G}$. If f is a linear function of ω, then we say that $\mathcal{G}$ is linearly χ-bounded. Thus, the class of perfect graphs is linearly χ-bounded with $f(x) = x$.

Many classes of graphs defined by forbidden induced subgraphs are shown to be χ-bounded (see [4, 8]); and linearly χ-bounded (see [2, 4, 5]); see also [8] for a survey. The class of P_t-

free graphs is a subject of extensive research by many authors. It is known that every P_4-free graph is perfect [9]. More generally, for any $t \geq 2$, Gravier, Hoáng and Maffray [3] showed that every P_t-free graph G satisfies $\chi(G) \leq (t-2)^{\omega(G)-1}$. So, for any P_6-free graph G, we have $\chi(G) \leq 4^{\omega(G)-1}$. The problem of reducing this upper bound to a polynomial in $\omega(G)$ seems to be a difficult open problem. In this talk, we present some recent results on linear χ-bounding functions for some classes of P_6-free graphs, and the talk is based on the papers [1, 6, 7].

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Generalized Inverses in the Study of Graphs

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In this talk, we deliberate on the introduction of various generalized inverses of a matrix and their applications in the study of graphs.

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Frames and Design Theory

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In this talk, we discuss Frames and related concepts in Design Theory.

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Recent Developments In Derived Graphs

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Let $G = (V, E)$ be a simple graph of order n and G^c be its complement. If $a(G)$ is a graph parameter, then the lower and upper bounds on the sum $a(G) + a(G^c)$ in terms of n are of prime importance in graph theory. The first of its kind with reference to chromatic number of a graph was studied by Nordhaus and Gaddum on complementary graphs and published in American Mathematical Monthly in 1956.

A set $S \subset V$ is a dominating set of G if each vertex of VS is adjacent to at least one vertex in S. The domination number $g(G)$ of G is the minimum cardinality taken over all dominating sets of G. An induced cycle path partition of G is a partition of V into subsets such that the subsets induce cycles and paths only. The minimum order taken over all induced cycle path partitions is called the induced cycle path number of G and is denoted by $\rho_{cp}(G)$. An ordered subset W of V is said to be a resolving set of G if every vertex is uniquely determined by its vector of distances to the vertices in W. The minimum cardinality of a resolving set is called the resolving number of G and is denoted by $r(G)$. Total resolving number as the minimum cardinality taken over all resolving sets in which $\langle W \rangle$ has no isolates and is denoted by $tr(G)$.

In this talk, we discuss the recent developments with reference to domination number, induced cycle path number and total resolving number for other derived graphs.

Pairwise Compatibility Graphs

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Let T be an edge weighted tree and let d_{min}, d_{max} be two non-negative real numbers where $d_{min} \leq d_{max}$. A *pairwise compatibility graph* (PCG) of T for d_{min} and d_{max}, denoted by $PCG(T, d_{min}, d_{max})$, is a graph $G = (V, E)$ where each vertex $u' \in V$ corresponds to a distinct leaf of T and there is an edge $(u', v') \in E$ if and only if the weighted distance between their corresponding leaves lies within the interval $[d_{min}, d_{max}]$. The tree T is called a *pairwise compatibility tree* (PCT) of G. A given graph is a PCG if there exist suitable T, d_{min}, d_{max} such that $G = PCG(T, d_{min}, d_{max})$. Construction of a PCG is trivial for a given weighted tree T and two real numbers d_{min}, d_{max}. However the reverse problem is difficult. Figure 1(b) illustrates a pairwise compatibility graph G of the edge weighted tree T in Fig. 1(a) for $d_{min} = 4$ and $d_{max} = 5$. For a pairwise compatibility graph G, pairwise compatibility tree T may not be unique. For example, Fig. 1(c) shows another pairwise compatibility tree T' of the graph G in Fig. 1(b) for $d_{min} = 4$ and $d_{max} = 7$.

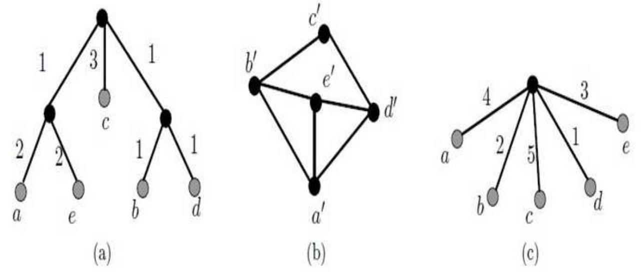

Fig. 1. (a) An edge weighted tree T, (b) a pairwise compatibility graph G of T for $d_{min} = 4$ and $d_{max} = 5$ and (c) another pairwise compatibility tree T' of G for $d_{min} = 4$ and $d_{max} = 7$.

(a) An edge weighted tree T, (b) a pairwise compatibility graph G of T for $d_{min} = 4$ and $d_{max} = 5$ and (c) another pairwise compatibility tree T' of G for $d_{min} = 4$ and $d_{max} = 7$.

PCGs have applications in modeling evolutionary relationship among set of organisms from biological data which is also called phylogeny. Phylogenetic relationships are normally represented as a tree called phylogenetic tree. The *phylogenetic tree reconstruction problem* asks to find a tree which provides the “best” explanation of the data of a set of taxa.

While dealing with a sampling problem from large phylogenetic tree, Kearney *et al.* [7] introduced the concept of PCGs. They also showed that “the clique problem” can be solved in polynomial time for a PCG if a pairwise compatibility tree can be constructed in polynomial time. Since its inception many graph classes are proved to be PCGs [10,13]. Initially, Phillips showed that every graph with at most five vertices is PCG [10] and later Calamoneri *et al.* showed that all graphs with at most seven vertices are PCGs [3]. Since there are exponentially increasing number of tree topologies, Kearney *et* *al.* conjectured that every graph is a PCG [7]. However Yanhaona *et al.* refuted the conjecture by providing an example of a bipartite graph of 15 vertices, as illustrated in Figure 2(a), which is not a PCG [13]. Durocher *et al.* showed a graph of eight vertices, as illustrated in Figure 2(b), and a planar graph of sixteen vertices which are not PCGs [5]. Recently Baiocchi *et al.* showed the graph in Figure 2(c), as the smallest planar graph known which is not a PCG [2].

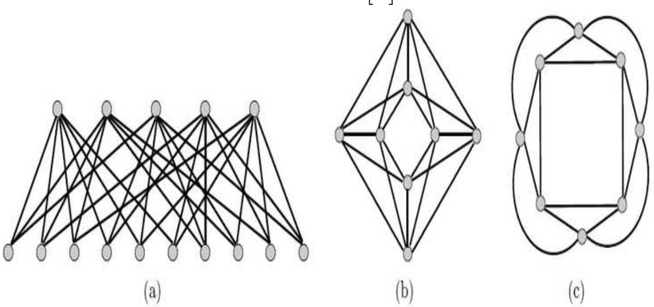

Fig. 2. (a) A bipartite graph with 15 vertices which is not a PCG, (b) a graph with 8 vertices which is not a PCG and (c) the smallest planar graph which is not a PCG.

(a) A bipartite graph with 15 vertices which is not a PCG, (b) a graph with 8 vertices which is not a PCG and (c) the smallest planar graph which is not a PCG.

Researchers have also studied some variants of PCGs. Leaf Power Graphs (LPGs), a subclass of PCGs, are a well-studied class of graphs which is obtained by setting d_{min} to 0 [11,8,9]. A similar but relatively new subclass of PCGs named Min-Leaf Power Graphs (mLPGs) are obtained by setting d_{max} to ∞ [4]. Recently a superclass of PCGs named multi-interval PCGs are introduced where more than one intervals are allowed [1]. If the number of intervals is k then the graphs are called k-

interval PCGs. Since we are allowed to take as many intervals as needed, it is conceivable that every graph is a k-interval PCGs for some k. Ahmed and Rahman showed that wheel graphs with at least 9 vertices, which are proved to be not PCGs [2], are 2-interval PCGs [1]. They also showed that a restricted class of series-parallel graphs, called the SQQ series-parallel graphs, are 2-interval PCGs.

In recent years several researchers are investigating interesting properties of PCGs, and eventually a number of open problems have come out. Some of the open problems are as follows.

- Investigate other graph classes to know which are PCGs and which are not PCGs.
- What is the complexity of PCG recognition problem? Durocher *et al.* proved that a generalized version of PCG recognition problem is NP-hard [5]. However the complexity of the PCG recognition problem is still unknown.
- Obtain a complete characterization of the graph class PCG. Note that Hossain *et al.* gave a necessary condition and a sufficient condition for a graph to be PCG [6]. However, a complete characterization is yet to be known.
- What is the smallest value of k for which every graph is a k-interval PCG?

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On the local antimagic total labeling of graphs

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Let G be a graph with $|V|$ vertices and $|E|$ edges. The *local antimagic total labeling* on G is defined to be an assignment $f : V \cup E \to \{1, 2, \cdots, |V| + |E|\}$ so that the weights of any adjacent vertices or any adjacent edges are distinct. The weight of a vertex v in G is calculated as $w(v) = f(v) + \Sigma_{e \in E(v)} f(e)$ where $E(v)$ is the set of edges incident to v. While the weight of an edge $e_1 = uv$ in G is calculated as $w(e_1) = f(u) + f(e_1) + f(v)$ where u and v are two vertices incident to edge e_1. Therefore, any local antimagic total labeling induces a proper vertex or edge coloring of G where the vertex u or the edge e_1 is assigned the color $w(u)$ or $w(e_1)$, respectively. The local antimagic total chromatic number, denoted by $\chi_{lat}(G)$, is the minimum number of vertex colors taken over all colorings induced by local antimagic total labelings of G. The local antimagic total edge chromatic number, denoted by $\chi_{late}(G)$, is defined analogously. In this talk, we present the local antimagic total chromatic number and local antimagic total edge chromatic number for several family of graphs.

Inequality Chains of Graph Parameters

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In this talk we present several inequality chains of graph parameters using the concepts of domination, independence, irredundance and coloring.

The domination chain is an inequality chain of six parameters given by $ir(G) \leq \gamma(G) \leq i(G) \leq \beta_0(G) \leq \Gamma(G) \leq IR(G)$. This inequality chain has been further extended by using the concept of external irredundance and neighborhood-knockout-with replacement sequence leading to an inequality chain of ten parameters. We also discuss inequality chains arising from covering and equivalence domination.

Generalized Cayley graphs of rings

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Throughout this talk R denotes a commutative ring with identity $1 \neq 0$, $Z(R) = \{a : ab = 0 \text{ for some } b \in R\}$ is the set of all zero-divisors of R and $Z^*(R) = Z(R) \setminus \{0\}$, $Nil(R) \subseteq Z(R)$ is the ideal of all nilpotent elements in R, $Reg(R) = R \setminus Z(R)$ is set of all regular elements in R, $U(R)$ is the set of all units in R. Constructing graphs from commutative rings was initiated by Ivan Berk through his work on zero-divisor graphs and thereafter several graphs constructions were made by several authors. Through the construction of graphs from commutative rings, interplay between algebraic properties of commutative rings and graph theoretical properties of derived graphs are studied. The *unit graph* $G(R)$ of R is the simple graph with vertex set R in which two distinct vertices x and y are adjacent if and only if $x + y \in U(R)$. Unit graphs were introduced in [2] and their properties were investigated by several authors [7,14,15,19]. The *unitary Cayley graph* G_R is the simple graph with vertex set R in which two distinct vertices x and y are adjacent if and only if $x - y \in U(R)$. Unitary Cayley graphs were introduced in [8] and their properties were investigated in [1,10,11,12,13,20,21]. More specifically, the chromatic, clique and independent numbers of G_R are studied in [10].

Khashyarmanesh and Khorsandi [9] provided a generalization of the unit and unitary Cayley graphs as follows: Let G be a multiplicative subgroup of $U(R)$ and S be a non-empty subset of G such that $S^{-1} = \{s^{-1} : s \in S\} \subseteq S$. Then $\Gamma(R, G, S)$

is the simple graph with vertex set R in which two distinct elements $x, y \in R$ are adjacent if and only if there exists $s \in S$ such that $x + sy \in G$. Various properties of $\Gamma(R, G, S)$ were investigated by several authors in [3,4,9,16]. More specifically, Khashyarmanesh et al. [9] obtained a necessary and sufficient condition for $\Gamma(R, G, S)$ to be complete and planar where R is an Artinian ring and $G = U(R)$. Subsequently Asir and Tamizh Chelvam [3,4] obtained a characterization of all commutative Artinian rings whose $\Gamma(R, G, S)$ has one or two.

As a special case of $\Gamma(R, G, S)$, a graph $\Gamma = \Gamma(R, U(R), U(R))$ was first introduced and studied by Ali Reza Naghipour et al. [16]. Hereafter, we denote the graph $\Gamma(R, U(R), U(R))$ by Γ. Also, Ali Reza Naghipour et al. [16] provided a necessary and sufficient condition for Γ to be Hamiltonian. In this talk, we shall discuss several other properties of this graph and construct intersect graph of gamma sets in this graph.

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Structural Parameterization – smooth transition from polynomial time to exponential time.

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There are several problems (like maximum independent set problem) that are NP-hard in general graphs, but polynomial time solvable in specific classes of graphs like forests or bipartite graphs or chordal graphs. We survey two kinds of results in the realm of parameterized complexity.

1. What if the input graph is k vertices (or edges) away from the polynomially solvable instance? Is the problem fixed-parameter tractable? I.e.does it have an algorithm whose running time is $f(k)+$ polynomial where f is some arbitrary (typically exponential) function of k?

2. Can we detect in fixed-parameter tractable time (i.e. $f(k)+$ polynomial) whether the graph is k vertices away from the polynomially solvable instance?

Secure, Upper Secure and Perfect Secure Domination in Graphs

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Let $G = (V, E)$ be a graph. A subset S of V is a dominating set of G if every vertex in $V - S$ is adjacent to a vertex in S. A dominating set S is called a secure dominating set if for each $v \in V - S$ there exists $u \in S$ such that v is adjacent to u and $S_1 = (S - \{u\}) \cup \{v\}$ is a dominating set. If further the vertex $u \in S$ is unique, then S is called a perfect secure dominating set. The minimum cardinality of a secure dominating set of G is called the secure domination number of G and is denoted by $\gamma_s(G)$. The maximum cardinality of a minimal secure dominating set of G is called the upper secure domination number of G and is denoted by $\Gamma_s(G)$. The minimum cardinality of a perfect secure dominating set of G is called the perfect secure domination number of G and is denoted by $\gamma_{ps}(G)$.

In this paper we present a survey of known results on the above three parameters and directions for further research.

The $25,000,000,000 Eigenvector and Google Pageranking

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The usefulness of a search engine depends on the relevance of the result set it gives back. One expects the relevant pages to be displayed within the top 20-30 pages returned by the search engine. When Google went online in the late 1990s, one thing that set it apart from the other search engines was that its search result listings always seemed to deliver the ”good stuff” up front. PageRank algorithm plays an important role in Google’s success. The algorithm ranks the importance of web pages according to an eigenvector of a weighted link matrix. It also involves Markov chains in matrix algebra.

Our goal is to explain one of the core ideas behind how Google calculates web page rankings. This turns out to be a delightful application of standard linear algebra.

On Laplacian spectra of graphs

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Let $G(V, E)$ be a simple graph of order n, size m and having the vertex set $V(G) = \{v_1, v_2, \ldots, v_n\}$ and edge set $E(G) = \{e_1, e_2, \ldots, e_m\}$. The adjacency matrix $A = (a_{ij})$ of G is a $(0, 1)$-square matrix of order n whose (i, j)-entry is equal to 1 if v_i is adjacent to v_j and equal to 0, otherwise. Let $D(G) = diag(d_1, d_2, \ldots, d_n)$ be the diagonal matrix associated to G, where $d_i = \deg(v_i)$, for all $i = 1, 2, \ldots, n$. The matrix $L(G) = D(G) - A(G)$ is called the Laplacian matrix and its spectrum is called the Laplacian spectrum (L-spectrum) of the graph G. We discuss some of the recent developments of Laplacian spectra and Laplacian energy of graphs.

Domination in Graphoidally Covered Graphs: On Characterizing Graphoidally Independent Infinite Graphs

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A graphoidal cover of a graph G (not necessarily finite) is a collection ψ of paths (not necessarily finite or open) satisfying the following axioms: (GC-1) Every vertex of G is an internal vertex of at most one path in ψ, and (GC-2) every edge of G is in exactly one path in ψ. The pair (G, ψ) is called a graphoidally covered graph. In a graphoidally covered graph (G, ψ), two distinct vertices u and v are ψ-adjacent if they are the ends of an open ψ-edge. A graphoidally covered graph (G, ψ) in which no two distinct vertices are ψ-adjacent to each other is called ψ-independent and a graph possessing a graphoidal cover such that G is ψ-independent is called a graphoidally independent graph. The aim of this paper is to discuss graphoidally independent infinite graphs. First we give some properties of a graphoidal cover ψ of a graph G so that G is ψ-independent. Next we provide two necessary conditions for a graph G to possess a graphoidal cover ψ such that G is psi-independent and show that these are sufficient as well for infinite trees and unicyclic graphs. Finally we establish complete characterization of graphoidally independent infinite 2-edge connected graphs.

Decomposition of Graphs into Uniform Subgraphs

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For a graph G, if its edge set $E(G)$ can be partitioned into E_1, E_2, $\ldots$, E_k such that $\langle E_i \rangle \cong H$, for all i, $1 \leq i \leq k$, then we say that H decomposes G. A *k-factor* of G is a k-regular spanning subgraph of it. A *k-factorization* of a graph G is a partition of the edge set of G into E_1, E_2, $\ldots$, E_s such that $\langle E_i \rangle$, $1 \leq i \leq s$, is a k-factor. We say that a k-regular graph G admits a *Hamilton cycle decomposition*, if the edge set of G can be partitioned into Hamilton cycles or Hamilton cycles together with a 1-factor according as k is even or odd, respectively. If H_1, H_2, $\ldots$, H_k are edge disjoint subgraphs of G such that $\bigcup_{i=1}^{k} H_i = G$, then we write $G = H_1 \oplus H_2 \oplus \ldots \oplus H_k$.

In this talk, we discuss some results in decomposition of graphs and product graphs into uniform subgraphs.

Contributed Papers

Odd Harmonious Labeling of Complete Bipartite Graphs

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A graph $G(p,q)$ is said to be odd harmonious if there exists an injection $f : V(G) \to \{0,1,2,\cdots,2q-1\}$ such that the induced function $f^* : E(G) \to \{1,3,\cdots,2q-1\}$ defined by $f^*(uv) = f(u)+f(v)$ is a bijection. In this paper, we prove that path union of r copies of $K_{m,n}$, path union of r copies of K_{m_i,n_i}, $1 \le i \le r$, $K^t_{m,n}$, $K^t_{(m_1,n_1),(m_2,n_2),\cdots,(m_t,n_t)}$, join sum of graph $\langle K_{m,n}; K_{m,n};\cdots, K_{m,n}(t - copies)\rangle$, $\langle K_{m_1,n_1}; K_{m_2,n_2};\cdots; K_{m_t,n_t}\rangle$, circle formation of r copies of $K_{m,n}$ when $r \equiv 0(mod\ 4)$, $S(t.K_{m,n})$ and $P^t_n(t.n.K_{p,q})$ are odd harmonious graphs.

On Group Vertex Magic Graphs

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Let $G = (V(G), E(G))$ be a simple undirected graph and A be an additive abelian group with identity 0. A mapping $l : V(G) \to \mathcal{A} \setminus \{0\}$ is said to be a $\mathcal{A}$-vertex magic labeling of G if there exists an element μ of $\mathcal{A}$ such that $\sum_{u \in N(v)} l(u) = \mu$ for any vertex v of G. A graph G that admits such labeling is called $\mathcal{A}$-vertex magic. If G is $\mathcal{A}$-vertex magic graph for any abelian group $\mathcal{A}$, then G is called a group vertex magic graph. In this paper, we prove few necessary conditions for a graph to be group vertex magic. When $\mathcal{A} \cong \mathbb{Z}_2 \oplus \mathbb{Z}_2$, we give a characterization for the $\mathcal{A}$-vertex magic labeling for any tree T with $diam(T) \leq 5$.

BW-DDoS Attack Detection Using the Maximum Flow Algorithm and Trace out the Source

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The DDoS attack is one of the most threatening factors affecting the internet services. Now days, most of the common attacks are targeting the gaming industry, online shopping websites followed by the software and media sectors. Many of the service providers are available to detect and prevent the DDoS attacks. But their softwares are not updated enough to detect the recent time attacks. In the current IoT trend, available DDoS defences arent sufficient. This work is aimed to propose a novel BW-DDoS attack detection approach based on maximum data flow identification in networks. The proposed method is faster and taking less number of iterations to determine the maximum data flow and also trace out the source of the attacks with minimum time compared with existing approaches.

Graph Partitioning Algorithm for Finding the Minimum Spanning Tree

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Graph partitioning is a technique to split a graph into subgraphs. This can allow one to find the minimum spanning tree of a graph on a number of processors simultaneously. A common approach in graph partitioning is based on a multilevel framework, where the graph is considered as a general graph and then some common factors are found that can be used to partition the graph into a number of subgraphs. In graphs where the edge weights represent distances between vertices and the vertices have geographical coordinates associated with them, we present a graph partitioning algorithm that will make use of the additional location information. Third element L is added to the general definition of the graph which gives the geographical location of each vertex in the graph. The new definition of the graph according to the proposed algorithm is given by $G = (L; V; E)$. We present a method to assemble a minimum spanning trees of all subgraphs to form the general minimum spanning tree for the whole graph. This paper presents also a simple method to find whether the subgraph is sparse or dense allowing to choose a suitable minimum spanning tree algorithm for each subgraph.

Vertices belonging to all or to no minimum vertex-edge dominating sets in trees

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Let G be a simple graph with vertex set $V(G)$ and edge set $E(G)$. A vertex $v \in V(G)$ vertex edge dominates every edge uv incident to v, as well as every edge adjacent to these incident edges. A set $D \subseteq V(G)$ is a vertex-edge dominating set if every edge of $E(G)$ is vertex-edge dominated by a vertex of D. The vertex-edge dominating set of minimum cardinality is called minimum vertex-edge dominating set. In this paper, we characterize the set of vertices that are in all or in no minimum vertex-edge dominating sets in trees.

Group S_3 Cordial Prime labeling of special graphs

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Let $G = (V(G), E(G))$ be a graph. Consider the group S_3. For $u \in S_3$, let $o(u)$ denote the order of u in S_3. Let $g : V(G) \to S_3$ be a function defined in such a way that $xy \in E(G) \Leftrightarrow (o(g(x)), o(g(y))) = 1$. Let $V_j(g)$ denote the number of vertices of G having label j under g. Now g is called a group S_3 cordial prime labeling if $|V_i(g) - V_j(g)| \leq 1$ for every $i, j \in S_3$, $i \neq j$. A graph which admits a group S_3 cordial prime labeling is called a group S_3 cordial prime graph. In this paper, we prove that the Jewel graph, Jelly fish graph, butterfly graph and Hypercube are group S_3 cordial prime. We further characterize Complete bipartite graphs that are group S_3 cordial prime.

On the domination number of a graph and its power graph

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Let $G = (V, E)$ be a connected graph. A subset S of V is called a dominating set of G if every vertex in $V - S$ is adjacent to some vertex in S. The domination number $\gamma(G)$ of G is the minimum cardinality taken over all dominating sets of G. For an integer $k \geq 1$, the k-th power G^k of a graph G, is that graph with $V(G^k) = V(G)$ for which $uv \in E(G^k)$ if and only if $1 \leq d_G(u, v) \leq k$. In this paper, we investigate the lower and upper bounds for the sum $\gamma(G) + \gamma(G^k)$ and characterize the extremal graphs.

K-TUPLE COLOURING ON COMPLEMENTARY GRAPHS

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A k-tuple colouring of a graph G is an assignment of k distinct colours to each vertex of G so that the corresponding set of colours are distinct. The k-tuple chromatic number, $\chi_k(G)$, is the least positive number $'t'$ such that G has a k-tuple colouring using $'t'$ colours. It is known that $2\sqrt{n} \leq \chi + \bar{\chi} \leq n+1$, and $n \leq \chi.\bar{\chi} \leq \frac{(n+1)^2}{4}$, where χ and $\bar{\chi}$ are chromatic numbers of G and $\bar{G}$ respectively. Inspired from this, we find out the extremities of $\chi_k(G) + \chi_k(\bar{G})$ and $\chi_k(G).\chi_k(\bar{G})$ where $\chi_k(G)$ and $\chi_k(\bar{G})$ are k-tuple chromatic numbers of G and $\bar{G}$ respectively. Also, we characterise the graphs that attain the lower bounds and obtain some graph families that attain the upper bounds.

Representation of a lattice by a graph with respect to an ideal and its characterization

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In this paper a graph of a finite lattice L with respect to an ideal I is defined and is denoted by $G_I(L)$.

1. It is proved that,
   - an ideal I of L is prime if and only if I is a strong vertex cut of $G_I(L)$.
   - for a prime ideal I, an element $x \in I$ if and only if $deg(x) = deg(0)$.
   - an ideal I is prime if and only if $G_I(L)$ is ideal symmetric.
2. Let, P be the incidence matrix of $G_I(L)$. Considering P as context table, we obtain corresponding Concept Lattice L_P. We studied the relation between $G_I(L)$ and L_P.

Domination Parameters in Partial Product

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In this paper we discuss about domination number, total domination number and Roman domination number in the partial product of paths. We have obtained the exact values of these parameters for this product.

Dominator Coloring Changing and Stable Graphs upon Vertex Removal

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A dominator coloring of a graph G is a proper coloring of G in which every vertex dominates every vertex of at least one color class. The minimum number of colors required for a dominator coloring of G is called the dominator chromatic number of G and is denoted by $\chi_d(G)$.

On removal of a vertex, the dominator chromatic number may increase or decrease or remain unaltered. For example $\chi_d(K_{1,n-1}) = 2$ and $\chi_d(K_{1,n-1-v}) = n-1$, where v is the central vertex of $K_{1,n-1}$. Also for the corona $G = H \circ K_1$ where H is any nontrivial connected graph, we have $\chi_d(G) = |V(H)| + 1$ and

$$\chi_d(G-v) = \begin{cases} \chi_d(G) - 1, & \text{if } v \text{ is real} \\ \chi_d(G), & \text{otherwise} \end{cases}$$

In this paper, we have characterized the vertices $v \in V^-$ in G. Also, we have characterized nontrivial trees for which dominator coloring is stable.

Impact of Cartesian Product on Double Roman Domination Number

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Given a graph $G = (V, E)$, a function $f : V \to \{0, 1, 2, 3\}$ having the property that if $f(v) = 0$, then there exist $v_1, v_2 \in N(v)$ such that $f(v_1) = f(v_2) = 2$ or there exists $w \in N(v)$ such that $f(w) = 3$, and if $f(v) = 1$, then there exists $w \in N(v)$ such that $f(w) \geq 2$ is called a double Roman dominating function (DRDF). The weight of a DRDF f is the sum $f(V) = \sum_{v \in V} f(v)$, and the minimum weight of a DRDF on G is the double Roman domination number, $\gamma_{dR}(G)$ of G. In this paper, we study the impact of cartesian product on the double Roman domination number.

On Cordial labeling of Double Duplication of Rhombic Grid Graph

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Let f be a function from the vertices of G to $\{0, 1\}$ and for each edge xy, assigns the label $|f(x) - f(y)|$. If the number of vertices labeled 0 and the number of vertices labeled 1 differs by at most 1 and the number of edges labeled 0 and the number of edges labeled 1 differs by at most 1 then f is said to be a cordial labeling. In this paper, we make a detailed study of the existence of cordial labeling of double duplication of all vertices by edges for various values of m and n of a rhombic grid graph $R^n_m, m, n \geq 1$.

Multiple Intruder Locating Dominating Sets in graphs: An algorithmic approach

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A set $S \subseteq V$ of vertices (called codewords) of a graph $G = (V, E)$ is called a Multiple Intruder Locating Dominating set ($MILD$ set) if every non-codeword v is adjacent to at least one codeword u which is not adjacent to any other non-codeword. This enables one to locate intruders at multiple locations of a network and hence the name. The $MILD(G)$ is the minimum cardinality of a $MILD$ set in G. Here, we show that the problem of finding $MILD$ set for general graphs is NP-Complete. Further, we provide an algorithm to find a $MILD$ set for trees through dynamic programming approach and then, the algorithm is extended for unicyclic graphs.

Encrypting Numbers through Labeling techniques

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Cryptography is a part of applied mathematics concerned with flourishing schemes to strengthen the privacy of communications through the use of codes. In this paper, a graph labeling technique is used to encrypt and decrypt five numbers using strong face bimagic labeling of a wheel graph. The proposed method of encrypting and decrypting five numbers, will have a beneficial approach to the existing system.

Local Structure Of Fractals In Zodiac Signs Along With Route Matrix

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The aim of this paper is to explore the Zodiac Signs as a Local Structure of Fractals since they are basically forms a Complex pattern of Dynamical Systems in the Universe. Zodiac signs are an important symbol in the Human's Horoscope; this signs are formed as a Structure and it creates as Fractals. Moreover, the connection among the planets in the Horoscope forms a Route matrix which is also used for the Astrologers to analyze the future of an individual.

Min-Max and Max-Min Graph Saturation Parameters

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Let $G = (V, E)$ be a graph of order n. Let P be a graph theoretic property concerning subsets of the vertex set V, which is either hereditary or super hereditary. We associate with this property P five graph theoretic parameters, namely a minimum parameter, a maximum parameter, a max-min parameter, a min-max parameter and a partition parameter. We initiate a study of these parameters for the properties of independence, domination and irredundance.

Complexity of Roman {2}-Domination and the Double Roman Domination in Graphs

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For a simple, undirected graph $G = (V, E)$, a Roman {2}-dominating function ($R2D$) $f : V(G) \rightarrow \{0, 1, 2\}$ has the property that for every vertex $v \in V(G)$ with $f(v) = 0$, either there exists an adjacent vertex $u \in N(v)$, with $f(u) = 2$, or at least two adjacent vertices $x, y \in N(v)$ with $f(x) = f(y) = 1$. The weight of a $R2D$ is the sum $f(V(G)) = \sum_{v \in V(G)} f(v)$. The minimum weight of a $R2D$ is called the Roman {2}-domination number and is denoted by $\gamma_{\{R_2\}}(G)$. A double Roman dominating function (DRD) on G is a function $f : V(G) \rightarrow \{0, 1, 2, 3\}$ such that for every vertex $v \in V(G)$ if $f(v) = 0$, then v has at least two neighbors $x, y \in N(v)$ with $f(x) = f(y) = 2$ or one neighbor w with $f(w) = 3$, and if $f(v) = 1$, then v must have at least one neighbor w with $f(w) \geq 2$. The weight of a DRD is the value $f(V(G)) = \sum_{v \in V(G)} f(v)$. The minimum weight of a DRD is called the double Roman domination number and is denoted by $\gamma_{dr}(G)$. In this paper, we first show that the decision problem associated with $\gamma_{\{R_2\}}(G)$ is NP-Complete for star (comb) convex bipartite graphs and bisplit graphs. We also show that the problem DRD is NP-Complete for star (comb) convex bipartite graphs. Finally, we prove that, for any connected threshold graph G with at least two vertices, $\gamma_{\{R_2\}}(G) = 2$ and $\gamma_{dr}(G) = 3$.

Equitable edge coloring of Certain Classes of Product of Graphs

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An equitable edge coloring of a graph G is an assignment of colors to all the edges of the graph such that no two adjacent edges receive the same color and any two color classes differ by at most one. The coloring problem is one of the most important problem in the graph theory.

All graphs considered here are finite, simple and undirected. Let $G = (V(G), E(G))$ be a graph with the sets of vertices and edges $V(G)$ and $E(G)$ respectively. An equitable k-edge coloring of G is a mapping $: E(G) \to N$, where N is a set of colors satisfying the following condition

- $f(e) \neq f(e')$ for any two adjacent edges $e, e' \in E(G)$.
- $||f(e_i)| - |f(e_j)|| \leq 1, i, j = 1, 2, \ldots, k$.

The minimum number of colors required for an equitable edge coloring of a graph G is called the Equitable edge chromatic number of G denoted by $\chi'_e(G)$. In this paper we prove some theorem on equitable edge coloring for compound graph of G and H where G and H are any graph.

Exact Solutions of Edge Isopermetric Problem in Chord Graphs and Layout Computation

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One of the prime necessities of a parallel processing system is its ability to implement and simulate parallel algorithms designed for one type of processor on different components of the interconnection network and its efficiency to allocate the data in such a way as to make optimum use of all the available processors. Graph embedding has been found to be the most suitable tool for this purpose.

A graph embedding comprises of an ordered pair of injective maps $\langle f, P_f \rangle$ from a guest graph $G = (V(G), E(G))$ to a host graph $H = (V(H), E(H))$ which is formulated as follows: f is a mapping from $V(G)$ to $V(H)$ and P_f assigns to each edge (a, b) of G, a shortest path $P_f(a, b)$ in H. One of the commonly considered cost criteria to determine the quality of an embedding is the edge congestion. The edge congestion $EC_{\langle f,P_f \rangle}(e)$ of an edge $e \in E(H)$ is the maximum number of edges of G that are embedded on e.

The layout $L_{\langle f,P_f \rangle}(G, H)$ of an embedding is defined as the sum of edge congestion of all the edges of H. The layout of G into H is given by $L(G, H) = minL_{\langle f,P_f \rangle}(G, H)$. The layout problem is to find the embedding that induces $L(G, H)$.

Combinatorial edge isoperimetric problem arises frequently in communication engineering, computer science, physical sciences and mathematics. Two NP-complete versions of the problem have been considered in the literature, one being the maximum induced subgraph problem and the other being the min-cut problem both of which deals with finding an optimal vertex set.

In this paper we develop a pseudo code algorithm to label the chord graph and determine the exact solution for the edge isoperimetric problem of chord graphs. In addition, we use the optimal solution in the computation of minimum layout of embedding the chord graph into a complete cycle on complete graphs.

A Study on Weighted Perfect Secure Domination in Graphs

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Let $G = (V, E)$ be a simple, undirected and connected graph. A set $S \subseteq V(G)$ is a secure dominating set, if for each $u \in V(G) \setminus S$, there exists $v \in S$ such that $(S \setminus \{v\}) \cup \{u\}$ is a dominating set in G. A secure dominating set $S \subseteq V(G)$ is perfect, if for all $u \in V(G) \setminus S$, $|N_G(u) \setminus S| = 1$. In this paper, the concept of perfect secure domination is applied to weighted graphs. The weighted perfect secure domination problem involves finding a PSDS S of G such that the total weight given by $W(S) = \sum\{W(v) : v \in S\} + \sum\{W(u, v) : u \notin S, v \in S\}$ is minimum where W being the weight function, defined as, $W : V(G) \cup E(G) \to R$. In this paper, some basic results of this parameter and a linear algorithm for finding a minimum weight perfect secure dominating set in trees are presented.

On the Total Monophonic Number of a Graph

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For a connected graph G of order at least two, a total monophonic set S of G is called a minimal total monophonic set if no proper subset of S is a total monophonic set of G. The upper total monophonic number of G, denoted by $m_t^+(G)$, is defined as the maximum cardinality of a minimal total monophonic set of G. We determine bounds for it and find the same for certain classes of graphs. It is shown that for any two positive integers a and b such that $4 \leq a \leq b$, there is a connected graph G with $m_t(G) = a$ and $g_t(G) = b$, where $m_t(G)$ is the total monophonic number of a graph and $g_t(G)$ is the total geodetic number of a graph. Also, for any two positive integers a, b with $3 \leq a \leq b$, there is a connected graph G with $m_t(G) = a$ and $m_t^+(G) = b$.

Triangular Difference Mean Graphs

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In this paper, we define a new labeling called triangular difference mean labeling and investigate triangular difference mean behaviors of some standard graphs. A triangular difference mean labeling of a graph $G = (p, q)$ is an injection $f : V \to Z^+$, where Z^+ is a set of positive integers such that for each edge $e = uv$, the edge labels are defined as $f^*(e) = \left\lceil \frac{|f(u)-f(v)|}{2} \right\rceil$ such that the values of the edges are the first q triangular numbers. A graph that admits a triangular difference mean labeling is called a triangular difference mean graph.

All to All Data Broadcasting Using Hamilton Decomposition of Graphs

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Data broadcasting is the process of distributing data sets from one or more nodes to other nodes in the network. The distributing nodes are called source nodes. Data broadcasting has evolved to be a very challenging process due to the fact that data is thriving in volume with every passing instance of time. As a consequence, this process might involve huge time complexity in distributing the data despite a fault tolerant environment. Moreover, the recieving nodes always face a threat of recieving multiple copies of the same data sets making a huge impact on their storing capacity. Thus, a feasible algorithm to broadcast data systematically is required. In the spanning tree model there exists a waiting time if two or more source nodes have to broadcast data simultaneously. Whereas, data broadcasting though node disjoint paths increases the number of copies of data sets at the recieving nodes. Hence, in this paper we propose a method for all to all data broadcasting using hamilton decomposition of graphs under certain edge fault tolerant conditions. The set of edge-disjoint subgraphs $H_1, H_2, ..., H_r$ of a graph G is called a decompostion of that graph G. A decomposition of G can be called a Hamilton decomposition if those edge-disjoints subgraphs are hamiltonian cycles of G.

Modeling Security Problem in Graph Labeling

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Digitalization is quite important in the business world because it contributes to constant change and development. The more we tend to digitalize, more is the concern about data security and privacy. Identity disclosure is divulge of identification of an entity according to the related information and released database. Identity disclosure control on data fascinates an increasing interest in security. We model this problem using graph labeling.

A connected graph $G = (V, E)$ is said to be $S - (a, d)$ antimagic if there exist positive integers a_1, a_2, d_1, d_2 and a bijection $f : E(G) \to \{1, 2, 3, \cdots, |E(G)|\}$ such that the induced mapping $g_f : V' \cup V'' \to W$ is also a bijection, where $W = \{w(v) : v \in V(G)\} = \{a_1, a_1 + d_1, a_1 + 2d_1, \cdots, a_1 + |V'(G) - 1|\, d_1\} \cup \{a_2, a_2 + d_2, a_2 + 2d_2, \cdots, a_2 + |V''(G) - 1|\, d_2\}$. In this paper we have investigated that the Generalized Petersen Graphs $P(n, k)$ is $S - (a, d)$ antimagic.

Navigation of robots on an extended graph space with constant metric dimension

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A network is considered as a graph $G = (V(G), E(G))$, where the components of the network representing the vertices (nodes) and the relationship between the components representing the edges. It is worth investigating whether a network is hacked by any intruder. Generally, robots are placed at the nodes to monitor the activities in the network.

If G is a simple connected graph, $W = \{w_1, w_2, \cdots, w_k\}$ is an ordered set of vertices of G (where the robots are placed uniquely for locating any intrusion) and v is any vertex of G, then the representation $r(v/W)$ of v with respect to W is the k- tuple $(d(v, w_1), d(v, w_2), \cdots, d(v, w_k)$. If distinct vertices of G have distinct representations (co-ordinates) with respect to W, then W is called a resolving set or location set for G. A resolving set of minimum cardinality is called a metric basis for G and this cardinality is called the metric dimension or location number of G and is denoted by $dim(G)$ or $\beta(G)$. In this paper, the concepts of linear algebra are incorporated to extend the graph without altering the metric dimension. Also, we present few results on isomorphism between graphs with same metric dimension.

Characterization of path as a union graph

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A graph $G = (V, E)$ is said to be a union graph on a non empty set X, if there exists a family S of subsets of X and an injective function $f : V(G) \rightarrow S$ such that $U(S) \cong G$ where $U(S)$ is the union graph with vertex set S itself and two vertices S_i and S_j are said to be adjacent if and only if $S_i \cup S_j \in S$ and f is called union labeling of G. In this paper, we present new results on union labeling of join of graphs and path graph.

Domination and Secure Domination Parameters for some Chessboard Graphs

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A set $S \subseteq V(G)$ of a graph $G = (V, E)$ is a dominating set of G if every vertex not in S is adjacent to at least one vertex in S. A dominating set S of G is called a secure dominating set if each vertex $u \in V(G) \setminus S$ is adjacent to a vertex $v \in S$ such that $(S \setminus \{v\}) \cup \{u\}$ is a dominating set. The secure domination number equals the minimum cardinality of a secure dominating set of G and is denoted by $\gamma_s(G)$. In this paper, we initiate the study of independent secure domination in graphs. An independent secure dominating set S is an independent dominating set having the property that for every $u \in V \setminus S$, there exists $v \in S \cap N(u)$ such that $(S \setminus \{v\}) \cup \{u\}$ is a dominating set in G, where $N(u)$ denotes the neighbors of vertex u. The minimum cardinality of an independent secure dominating set is called the independent secure domination number of G and is denoted by $\gamma_{is}(G)$. We determine the total domination, independent domination, secure domination, clique domination and clique secure domination numbers for $n \times n$ rooks graph and the independent secure domination number for $n \times n$ bishops graph.

A New Approach for Finding an Optimal Solution of Fully Interval Transportation Problems

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In this paper, we focus on the solution procedure of the fully interval transportation problem (FITP) where, the cost coefficients of the objective function, the source and destination parameters have been expressed as interval numbers by the decision maker. A method namely, the mid-width method is proposed herein, for finding the optimal interval solution to an interval number.In this paper, by using interval version of Vogel's Approximation Algorithm (IVAM) and interval version of MODI method (IMODI) the mid width method gives the solution for fully interval transportation problem without converting to classical transportation problem has been analyzed. A numerical example is provided to illustrate the solution procedure developed in this paper.

Degree Associated Edge Reconstruction Number of Split Graphs with Biregular Independent Set is one

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A *degree associated edge card* of a graph G is an edge deleted subgraph of G with which the degree of the deleted edge is given. The *degree associated edge reconstruction number* of a graph G (or $dern(G)$) is the size of the smallest collection of the degree associated edge cards of G that uniquely determines G. A *split graph* G is a graph in which the vertices can be partitioned into an independent set and a clique. We prove that the *dern* of all split graphs with biregular independent set is one.

Inclusion relation among permutation representations of S_6

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For a finite group G the most fundamental representation is the regular permutation representation of G. It is the permutation representation of G arising from the action of G on itself by left translation. This representation contains all the irreducible representations of G with multiplicity equal to its degree. There are other natural permutation representations available for all finite groups G. Our focus will be the permutation representations arising from the conjugation action of G on each of its conjugacy classes.

Given a conjugacy class C of a finite group G, there is an action of G on C by conjugation. So this (transitive) action leads to a permutation representation. Given two conjugacy classes C_1 and C_2, we say that C_1 is subordinate to C_2 if the permutation representation corresponding to C_1 is a sub-representation to that of C_2. This relation is reflexive and transitive. Though not antisymmetric it has many desirable properties. The Hasse diagram has a very nice visual symmetry.In this paper we determine which conjugacy classes are subordinate to which for the case of the group $G = S_6$. In fact we give explicit S_6-equivariant maps between the representations.

Parallelization on Regular Languages

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Parallel programming has some advantages that make it attractive as a solution approach for certain types of computing problems that are best suited when multiprocessors are used. Nevertheless, parallel programming also has some disadvantages that must be considered before embarking on this challenging activity.

The main reason behind parallel programming is to execute code efficiently. Parallel programming optimises on time by ensuring the execution of algorithms in a shorter time span. As a consequence, parallel programming often scales with the problem size, and thus can solve larger problems in shorter time. In general, parallel programming is a means of providing concurrency, particularly performing multiple actions simultaneously.

The process of taking a sequential program and dividing it up into processes which can be run in parallel is called parallelisation. It is complex to analyse data dependencies in a sequential program, and therefore, difficult to parallelise efficiently.

In this paper, we parallelize the strings and languages to reduce their length. Parallelized languages have been introduced and their recognition has been studied through parallel regular expression, parallelized finite automaton and parallel regular grammar. Also, we have studied the properties of parallel regular languages.

Decomposition of Product Graphs into Sunlet Graphs of Length Eight

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For any integer $k \geq 3$, we define sunlet graph of order $2k$, denoted by L_{2k}, as the graph consisting of a cycle of length k together with k pendant vertices, each adjacent to exactly one vertex of the cycle. For a graph G, if $E(G)$ can be partitioned into $E_1, E_2, \cdots E_k$ such that the subgraph induced by E_i is H_i, for all $i, 1 \leq i \leq k$, then we say that $H_1, H_2, \cdots, H_k$ decompose G and we write $G = H_1 \oplus H_2 \oplus \cdots \oplus H_k$, since $H_1, H_2, \cdots, H_k$ are edge-disjoint subgraphs of G. For $1 \leq i \leq k$, if $H_i = H$, we say that G has a H-decomposition. In this paper, we give necessary and sufficient conditions for the existence of L_8-decomposition of tensor product and wreath product of complete graphs.

Secure total domination in chain graphs and cographs

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In a graph $G = (V, E)$, a subset D of vertices of G is called a total dominating set of G if for every $u \in V$, there exists a vertex $v \in D$ such that $uv \in E$. A total dominating set D of a graph G is called a secure total dominating set of G if for every $u \in V \setminus D$, there exists a vertex $v \in D$ such that $uv \in E$ and $(D \setminus \{v\}) \cup \{u\}$ is a total dominating set of G. The secure total domination number of G, denoted by $\gamma_{st}(G)$, is the minimum cardinality of a secure total dominating set of G. Given a graph G, the secure total domination problem is to find a secure total dominating set of G with minimum cardinality. In this paper, we first show that the secure total domination problem is linear time solvable on graphs of bounded clique-width. We then present linear time algorithms for computing the secure total domination number of chain graphs and cographs.

Line Graph of Commuting Graph on the Dihedral Group

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Let Γ be a non-abelian group and $\gamma \subseteq \Gamma$. Then the Commuting graph $C(\Gamma, \gamma)$ has γ as its vertex set with two distinct vertices in γ are adjacent if they commute with each other in Γ. Let $G = L(C(\Gamma, \gamma))$ be the Line graph of the Commuting graph. A vertex v_i of G is given by $\{x, y\} = \{y, x\}$ where x and y are the vertices that are adjacent in $C(\Gamma, \gamma)$. In this paper, we discuss certain properties of Line graph of the Commuting graph on the Dihedral group D_{2n}. More specifically, we obtain the chromatic number, clique number and genus of this graph.

Trace Graph Of Matrices With Respect to an Ideal

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Let R be a commutative ring and $M_n(R)$ be the set of all $n \times n$ matrices over R where $n \geq 2$. For a matrix $A \in M_n(R), Tr(A)$ is the trace of A. The trace graph of the matrix ring $Mn_(R)$, denoted by $\Gamma_t(M_n(R))$, is the simple undirected graph with vertex set $\{A \in M_n(R)^* :$ there exists $B \in M_n(R)^*$ such that $Tr(AB) = 0\}$ and two distinct vertices A and B are adjacent if and only if $Tr(AB) = 0$. The trace graph of the matrix ring $M_n(R)$ with respect to an ideal I of R, denoted by $\Gamma_{I^t}(M_n(R))$, is the simple undirected graph with vertex set $M_n(R) \setminus M_n(I)$ and two distinct vertices A and B are adjacent if and only if $Tr(AB) \in I$. In this paper and its sequel, we investigate some properties and structure of $\Gamma_{I^t}(M_n(R))$.

Pseudo Neighbourly Edge Irregular Graphs

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In this paper, pseudo edge regular, pseudo edge irregular and pseudo neighborly edge irregular graphs are introduced. A comparative study between edge irregular graphs and pseudo edge irregular graphs is done. We investigate several problems concerning the existence of these graphs as well as some properties are studied.

Star Super Edge-magic Deficiency of Disjoint Union of Graphs

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A graph $G = (V(G), E(G))$ is called edge-magic if there is a bijection $f : V(G) \cup E(G) \to \{1, 2, \cdots, |V(G)| + |E(G)|\}$ such that for every edge $xy \in E(G)$, $f(x) + f(xy) + f(y) = c$ is a constant. A graph G is said to be super edge-magic if G is edge-magic and the set of labels of all vertices is $\{1, 2, \cdots, |V(G)|\}$. Let G be a graph with p vertices $v_1, v_2, \cdots, v_p$ and S_m be the star with m leaves. If in G, every vertex v_i is identified to the center vertex of S_{mi} for some $m_i \geq 0$, $1 \leq i \leq n$, where $S_0 = K_1$. Then the graph obtained is denoted by $G_{(m_1,m_2,\cdots,m_p)}$. Let

$$M(G) = \{(m_1, m_2, \cdots, m_p) : G_{(m_1,m_2,\cdots,m_p)} \text{ is a super edge magic}\}.$$

The star super edge-magic deficiency $S_{\mu^*(G)}$ is defined as,

$$S_{\mu^*(G)} = \begin{cases} \min\limits_{(m_1,m_2,\cdots,m_p)} \sum\limits_{i=1}^{p} m_i & \text{if } M(G) \neq \phi. \\ +\infty, & \text{if } M(G) = \phi. \end{cases}$$

In this paper, we determine the star super edge-magic deficiency of disjoint union of certain families of trees and 2-regular graphs.

A Study on Pendent Number of Graphs

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A path decomposition of a graph is a collection of its edge disjoint paths whose union is G. The pendent number $\prod_p$ is the minimum number of end vertices of paths in a path decomposition of G. In this paper, we determine the pendent number of corona products and rooted products of paths and cycles and obtain some bounds for the pendent number for some specific derived graphs. Further for any natural number n, the existence of a connected graph with pendent number n has also been established.

On Some Properties of Partial Dominating Sets

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For any graph $G = (V, E)$ and proportion $p \in (0, 1]$, a set $S \subseteq V$ is a p-dominating set if $\frac{|N[S]|}{|V|} \geq p$. The p-domination number $\gamma_p(G)$ equals the minimum cardinality of a p-dominating set in G. We explore some of the properties of p-dominating sets with respect to particular values of p. We consider the cases of $p, q \in (0, 1]$, p is related to the closed neighborhoods of some subsets of V and extension of p dominating sets using the eccentricity. We also find some properties of p-domination analogous to that of classical domination.

Some Results on (1, 2)-Domination in Graphs

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A $(1,2)$-dominating set in a graph $G = (V,E)$ is a set having the property that for every vertex $v \in V - S$, there is at least one vertex in S at a distance 1 from v and a second vertex in S at a distance at most 2 from v. The $(1,2)$-domination number of G, denoted by $\gamma_{1,2}(G)$, is the minimum cardinality of a $(1,2)$-dominating set of G. In this paper, for connected graphs G of order $n \geq 3$, we derive upper bounds for $\gamma_{1,2}(G)$ and $\gamma_{1,2}(\bar{G})$. Moreover, we prove that $\gamma_{1,2}(G)+\gamma_{1,2}(\bar{G}) \leq n+2$. We have also characterized the graphs of order n, for which $\gamma_{1,2}(G) + \gamma_{1,2}(\bar{G}) \leq n + 1, n + 2$.

No-Bend Orthogonally Convex Drawings of Subdivisions of Planar Triconnected Cubic Graphs

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A plane graph is a planar graph with a fixed planar embedding in the plane. In an orthogonal drawing of a plane graph each vertex is drawn as a point and each edge is drawn as a sequence of vertical and horizontal line segments. A bend is a point at which the drawing of an edge changes its direction. In an orthogonal drawing of a plane graph Γ each inner face of Γ is drawn as rectilinear polygon. A rectilinear polygon P is called orthogonally convex if every horizontal or vertical segment connecting two points in P lies totally within P. An orthogonally convex drawing of a plane graph Γ is an orthogonal drawing of Γ where each inner face is drawn as an orthogonally convex polygon. A necessary and sufficient condition for a plane graph to have a no-bend orthogonally convex drawing is known which leads to a linear-time algorithm to find such a drawing of a plane graph, if it exists.

A planar graph G has a no-bend orthogonally convex drawing if any of the plane embeddings of G has a no-bend orthogonally convex drawing. Since a planar graph G may have an exponential number of planar embeddings, determining whether

G has a no-bend orthogonally convex drawing or not using the known algorithm for plane graphs takes exponential time. In this paper we give a linear-time algorithm to determine whether a subdivision of a planar triconnected cubic graph G has a no-bend orthogonally convex drawing or not and to find such a drawing of G, if it exists. We also show that, if such a graph G has a no-bend orthogonal drawing, then G has a no-bend orthogonally convex drawing.

Centrality Betweenness in Some Join of Graphs

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Centrality is an important concept of a connected graph. It measures the status of a vertex in a graph. Centrality betweenness determines how often a vertex comes in between pairs of other vertices. Since shortest paths are considered here, the centrality betweenness of a vertex is proportional to the number of shortest paths passing through it. Join is an important graph operation which interconnects two graphs. Here we present the centrality of some composite graphs generated by this operation.

p-Domatic Number of a Graph

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The domatic number of a graph G is the maximum number of dominating sets into which the vertex set of G can be partitioned. In this paper, we introduce a new parameter called p-domatic number of a graph. The p-domatic number problem is that of partitioning the vertices of a graph into the maximum number of disjoint power dominating sets. In this paper, we initiate the study of p-domatic number of graphs by finding its bounds in terms of domatic number of G. We also compute the p-domatic number of corona of path and cycle, Generalised petersen graph and Jahangir graph.

Local Landmarks of Wheel Related Graphs and $P_{n,1,2}$

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Let $G(V, E)$ be a graph with vertex set V and edge set E. A subset W of V is said to be a local metric basis of G, if for any two adjacent vertices $u, v \in V \setminus W$, there exists a vertex $w \in W$ such that $d(w, u) \neq d(w, v)$. The minimum cardinality of local metric basis is called the local metric dimension of G and is denoted by $\beta_l(G)$. In this paper, we have obtained the local metric dimension of wheel related graphs such as sunflower graphs, closed sunflower graphs and blossom graphs. Also discussed the local metric basis and local metric dimension of dodecahedral other embedding graph $P_{n,1,2}$.

A new look at the concept of domination in hypergraphs

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In this paper we propose a new definition of domination in hypergraphs in such a way that when restricted to graphs it is the usual domination in graphs. Let $H = (V, E)$ be a hypergraph. A subset S of V is called a dominating set of H if for every vertex v in $V - S$, there exists an edge $e \in E$ such that $v \in e$ and $e - \{v\} \subseteq S$. The minimum cardinality of a dominating set of H is called the domination number of H and is denoted by $\gamma(H)$. We determine the domination number for several classes of uniform hypergraphs. We characterize minimal dominating sets and present several results on the upper domination number of a hypergraph.

H-Structure connectivity of Product Graphs

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An efficient inter-connected network must be least vulnerable to disruptions and it is guarded by fault-tolerance. Though connectivity is a prominent aid in the evaluation of fault tolerance, more generalizations are introduced to attain further accuracy. Let H be a connected subgraph of a graph G. A set F of connected subgraphs of G is said to be a subgraph cut of G if $G - F$ is either disconnected or trivial. If each member of F is isomorphic to H then F is called H-structure cut of G. The minimum cardinality of an H-structure cut of G is called H-structure connectivity and it is denoted by $k(G; H)$. In this paper, we have studied the H-structure connectivity of the Cartesian product of graphs.

Decomposition of Complete Tripartite Graphs into Triangles and Claws

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Let $K_{r,s,t}$ be a complete tripartite graph with $r \leq s \leq t$. Let C_k denote a cycle of length k and S_k denote a star with k edges. If $k = 3$, then we call C_3, a triangle and S_3, a claw. In this paper, we obtain necessary and sufficient conditions for the decomposition of $K_{r,s,t}$ into p copies of C_3 and q copies of S_3 for all possible values of $p, q \geq 0$.

Inverse Connective Eccentricity Index and its Applications

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The inverse connective eccentricity index of a connected graph G is defined as $\xi_{ce}^{-1}(G) = \sum\limits_{u \in V(G)} \frac{\epsilon_G(u)}{d_G(u)}$, where $\epsilon_G(u)$ is the eccentricity of the vertex v in G. In this paper, we obtain an upper bounds for inverse connective eccentricity indices for various classes of graphs such as generalized hierarchical product graph and F-sum of graphs.

Further Results on Analytic Odd Mean Labeling of Graphs

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Let $G = (V, E)$ be a graph with p vertices and q edges. A graph G is analytic odd mean if there exist an injective function $f : V \rightarrow \{0, 1, 3, 5 \cdots, 2q - 1\}$ with an induce edge labeling $f^* : E \rightarrow Z$ such that for each edge uv with $f(u) < f(v)$,

$$f^*(\mu) = \begin{cases} \left\lceil \frac{f(v)^2 - (f(u)+1)^2}{2} \right\rceil, & \text{if } f(u) \neq 0. \\ \left\lceil \frac{f(v)^2}{2} \right\rceil, & \text{if } f(u) = 0. \end{cases}$$

is injective. We say that f is an analytic odd mean labeling of G. In this paper we prove that sun graph S_n, prism D_n, helm graph H_n, the graph $C_n \circ P_2$, banana tree, bamboo tree, binary tree, the graph PC_n, unicyclic graph, the caterpillar $P_k(n_0, n_1, \cdots, n_{k-1})$ and spider graph are analytic odd mean graph.

Concatenated Kernel Codes

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Concatenated codes introduced by Forney in 1966 received wide attention. Thereafter, many concatenated codes were constructed on the similar lines and successfully employed in digital communication setup. In this paper, concatenated kernel code is defined. An example concatenated kernel code and its trellis is constructed. For the constructed code, the presence of homomorphism is tested using Blum-Luby-Rubinfeld Linearity test. Further, for the constructed trellis of the example code the properties such as proper, co-proper, biproper, one-to-one, minimal and minimal proper are investigated.

Leech Index of a Tree

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Let $T = (V, E)$ be a tree of order n. Let $f : E \to \{1, 2, 3, ...\}$ be an injective edge labeling of T. The weight of a path P is the sum of the labels of the edges of P and is denoted by $w(P)$. If the set of weights of the $\binom{n}{2}$ paths in T is $\{1, 2, ..., \binom{n}{2}\}$, then f is called a Leech labeling of T and a tree which admits a Leech labeling is called a Leech tree. In this paper we introduce a new parameter called Leech index which gives a measure of how close a tree is towards being a Leech tree. Let $f : E \to \{1, 2, 3, ...\}$ be an edge labeling of T such that both f and w are injective. Let S denote the set of all weights of the paths in T. Let k_f be the positive integer such that $\{1, 2, 3, ..., k_f\} \subset S$ and $k_{f+1} \notin S$. Then $k(T) = maxk_f$, where the maximum is taken over all such edge labellings f is called the Leech index of T. In this paper we determine the Leech index of several families of trees and obtain bounds for this parameter.

The hub number of a graph

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Let $G = (V, E)$ be a connected graph. A subset S of V is called a hub set of G if for any two distinct vertices $u, v \in V - S$, there exists a $u - v$ path P in G such that all the internal vertices of P are in S. The minimum cardinality of a hub set of G is called the hub number of G and is denoted by $h(G)$. In this paper we present several basic results on this parameter. We obtain a characterization of graphs of order n with $h(G) = n - 2$. We also determine $h(G)$ when $G = G_1 + G_2 + ... + G_n$.

Changing and Unchanging of $\mathcal{F}$-domination number of a graph

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Let $G = (V, E)$ be a graph and let $\mathcal{F}$ be a family of subsets of V whose union is V. A dominating set D of G is called a $\mathcal{F}$-dominating set if $D \cap F \neq \emptyset$ for all $F \in \mathcal{F}$. The minimum cardinality of an $\mathcal{F}$-dominatind set of G is called the $\mathcal{F}$-domination number of G and is denoted by $\gamma_{\mathcal{F}}(G)$. In this paper we analyze how the $\mathcal{F}$-domination number changes when a vertex is deleted or an edge is deleted or an edge is added.

Service Quality Assessment in Private Banks: A Study with Special Reference to Karur Vysya Bank Ltd.

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The banking scenario in India is the post liberalization and deregulated environment has witnessed sweeping changes. The tremendous advances in technology and the aggressive imbuement of data technology had gotten an outlook change in banking operations. technology has emerged as a strategic resource for achieving higher efficiency. Another strategic challenge confronting banking establishment today is developing and changing needs and expectation of customers in tandem with increased education levels and developing wealth consumers are became increasingly decreasing and have become more involved in their monetary decisions. Thus, they are demanding a worldly range of items and services at more competitive prices through more efficient and convenient channels. the challenging business process in the budgetary service pressurized banks to introduce alternative delivery channel to pull customers and improve customers perception. customer satisfaction and customer retention are increasingly developing in to key success elements in banking. Technology, specifically has been increasingly employed in service association to enhance customer service quality and delivery, reduced cost and standardize core service offerings.

Local Antimagic Vertex Coloring of Trees

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Let $G = (V, E)$ be a connected graph with $|V| = n$ and $|E| = m$. A bijection $f : E \to \{1, 2, \ldots, m\}$ is called a local antimagic lableing if for any two adjacent vertices u and v, $w(u) \neq w(v)$, where $w(u) = \sum_{e \in E(u)} f(e)$ and $E(u)$ is the set of edges incident to u. Thus any local antimagic labeling induces a proper vertex coloring of G where the vertex v is assigned the color $w(v)$. The local antimagic chromatic number $\chi_{la}(G)$ is the minimum number of colors taken over all colorings induced by local antimagic labelings of G. In this paper we determine the local antimagic chromatic number of several families of trees.

On the Total coloring of Graphs

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A total coloring of a graph $G = (V, E)$ is an assignment of colors to the vertices and edges such that (i) no two adjacent vertices receive same color, (ii) no two adjacent edges receive same color, and (iii) if an edge e is incident on a vertex v, then v and e receive different colors. The total chromatic number of G, denoted as $\chi''(G)$, is the minimum number of colors required for a total coloring of G. The well known total coloring conjecture states that for any graph G with maximum degree $\Delta(G)$, either $\chi''(G) = \Delta(G) + 1$ or $\chi''(G) = \Delta(G) + 2$. A graphs is said to be Type 1 if $\chi''(G) = \Delta(G) + 1$ and is of Type 2 if $\chi''(G) = \Delta(G) + 2$. The classification problem for total coloring is to classify whether a graph G is of Type 1 or Type 2, provided the total coloring conjecture holds for G. However, this classification problem is known to be NP-hard even for bipartite graphs. In this paper, we propose a linear time algorithm to test whether a chain graph is of Type 1 or of Type 2 by providing an optimal total coloring of chain graphs, a proper subclass of bipartite graphs. We also solve the classification problem for certain subclasses of biconvex bipartite graphs, a superclass of chain graphs. The central graph of a graph G, denoted by $C(G)$, is obtained by subdividing each edge of G exactly once and joining all the non-adjacent vertices of G. We prove that the total coloring conjecture holds for the central graph of any graph. In 2001,

Bojarshinov proved that the total coloring conjecture holds for interval graphs by proposing an algorithm, which runs in $O(|V(G)| + |E(G)| + (\Delta(G))^2)$-time, to obtain a total coloring of interval graphs using at most $(\Delta(G) + 2)$ colors. In this paper, we improve this algorithm and shows that the improved algorithm runs in $O(|(V(G)| + |E(G)|)$-time.

Certain Classes of Graphs and Their Binding Numbers

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The binding number of a graph G is defined as the minimum of $|N(S)| / |S|$ taken over all non empty subsets S of the vertex set $V(G)$ of G such that $N(S) \neq V(G)$, where $N(S)$ is the neighbor set of S. In this paper certain classes of graphs are considered and their binding numbers are determined. The binding number of a graph is also related to some graph parameters.

Blockchain Technology And Its Applications-A Survey

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Blockchain Technology is not just about Bitcoin and other cryptocurrencies, there is a wide spectrum of its applications. The different characteristics and efficient consensus algorithms based on which the blockchain works make the blockchain technology an exceptionally secure and safe data sharing system. This paper is focusing to give an introductory idea about blockchain and to have a glimpse at its different applications in various domains.

Recognition and Parsing Algorithms for Probabilistic Conjunctive Grammar

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A conjunctive grammar is a quadruple $G = (\Sigma, N, P, S)$ where Σ and N are disjoint finite nonempty sets of terminal and non-terminal symbols respectively, S is an initial symbol which belongs to N and P is a finite set of rules of the form $A \to \alpha_1 \& \alpha_2 \& .... \& \alpha_n$ where $A \in N$ and $\alpha_1, \alpha_2, ..., \alpha_n \in (\Sigma \cup N)^*$. An object of the form $A \to \alpha_1$ is called a conjunct. If in addition for each rule $A \to B$ a probability $q(A \to B)$ is assigned such that $\sum\limits_{A \to B} q(A \to B) = 1$ for each $A \in N$, then $G_p = (\Sigma, N, P, S, q)$ is called a probabilistic conjunctive grammar. In this paper we propose recognition and parsing algorithms for a probabilistic conjunctive grammar. The algorithm checks whether a given string is in the language set of the grammar and if so, it finds a best possible parsing tree for the string with highest probability.

Token graph of some classes of Graphs

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Let $G = (V, E)$ be a graph of order $n \geq 2$. For an integer $1 \leq k \leq n - 1$, the k-token graph $F_k(G)$ of G is the graph with vertex set all k-subsets of $V(G)$, where two vertices are adjacent in $F_k(G)$ whenever their symmetric difference is a pair of adjacent vertices in G. A graph is called a k-Token graph if it is isomorphic to $F_k(H)$ for some graph H. In this paper, we obtained characterization of 2-token graph of some families of graphs like trees, chordal graph and chordal bipartite graph. We structured 2-token graph of complete bipartite graph. Hamiltonian property of 2-token graphs also noted.

Inverse Domination Number of Circulant Graph

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A set D of vertices in a graph G is a dominating set, if every vertices in $V \setminus D$ is adjacent to atleast one vertex in D. A dominating set is called a minimum dominating set, if D consist of minimum number of vertices among all the dominating set. If $V \setminus D$ contains a dominating set D' of G then D' is called an inverse dominating set with respect to D. An inverse dominating set D' is called a minimum inverse dominating set, if D' consist of minimum number of vertices among all the inverse dominating set. The number of vertices in a minimum inverse dominating set is defined as inverse domination number of a graph G and it is denoted by $\gamma^{-1}(G)$. In this paper we investigate the inverse domination number of a Circulant Graph $G(n; \pm\{1, 2, 3\})$.

Signed and Signed Product Cordial Labelling of Cylinder Graphs and Banana Tree

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A graph $G = (V, E)$ is called signed cordial if it is possible to label the edges with the number from the set $N = \{+1, -1\}$ in such a way that at each vertex v, the algebraic product of the labels of the edges incident with v is either $+1$ or -1 and the inequalities $|v_f(+1) - v_f(-1)| \leq 1$ and $|e_{f^*}(+1) - e_{f^*}(-1)| \leq 1$ are also satisfied, where $v_f(i), i \in \{+1, -1\}$ and $e_{f^*}(j), j \in \{+1, -1\}$ are respectively the number of vertices labeled with i and the number of edges labeled with j. A graph is called signed-cordial if it admits a signed-cordial labeling.

A vertex labeling of graph $G, f : V(G) \to \{-1, +1\}$ with induced edge labeling $f^* : E(G) \to \{+1, -1\}$ defined by $|e_{f^*}(1) - e_{f^*}(-1)| \leq 1$ is signed product cordial labeling if $|v_f(+1) - v_f(-1)| \leq 1$ and $|e_{f^*}(+1) - e_{f^*}(-1)| \leq 1$, where $v_f(i)$ and $e_{f^*}(j)$ are respectively the number of vertices labeled with i and the number of edges labeled with j. A graph G is signed product cordial if it admits signed product cordial labeling. In this paper we investigate signed and signed product cordiality of cylinder graphs and banana tree.

On Graphoidal Length of a Tree in Terms of its Diameter

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A graphoidal cover of a finite graph G is a collection Ψ of (not necessarily open) paths in G satisfying the following conditions:

GC1: Every path in Ψ has at least two vertices;

GC2: Every edge of G is in exactly one path in Ψ;

GC3: Every vertex of G is an internal vertex of at most one path in Ψ.

The set of all graphoidal covers of a graph G is denoted by $\mathcal{G}_G$. For any graphoidal cover Ψ of a graph G, the ordered pair (G, Ψ) is called a graphoidally covered graph and the paths in Ψ are called Ψ-edges of (G, Ψ).

Acharya and Sampathkumar in 1987 first introduced the concept of graphoidal covers as a close variant of another emerging discrete structure called semigraphs. A detailed treatment of graphoidal covers and graphoidally covered graphs are studied by Acharya et al. Arumugam et al. introduced a new graph invariant $gl(G)$, called graphoidal length of a graph G, based on graphoidal covers was introduced and some bounds were obtained for this parameter.

The graphoidal length $gl(G)$ of a graph G is defined as

$$gl(G) = \max_{\Psi \in \mathcal{G}_G} \{\min_{P \in \Psi} l(P)\}.$$

In this paper, we obtain bounds for the graphoidal length of a tree in terms of its diameter. We prove that if G is any tree (excepts paths) of diameter d, then graphoidal length $gl(G)$ is less than equal to $\lfloor 2d/3 \rfloor$. Further, we characterize trees attaining the upper bound. Also, the trees for which $gl(G) = k$ where $\lfloor d/2 \rfloor < k < \lfloor 2d/3 \rfloor$ are characterized.

A computational approach to identify the role of potassium transporter in barley plant

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Potassium ion (K^+) is an essential macro nutrient for plant growth and survival. Since K^+ is involved in several biochemical and physiological pathways, its regulation is essential for normal metabolism and cellular functions. K^+ homeostasis is maintained by many proteins in a coordinated manner. In barley at least fifteen proteins are directly involved in potassium transport. Interaction among these proteins forms a network along with forty nine other proteins. We retrieved the potassium transporter interaction network from STRING and the network was analyzed for centrality measures using Cytoscape. The proteins MLOC_6793.2, MLOC_14891.1, MLOC_16944.1, MLOC_57408.2, and MLOC_63991.1 are found to be most important for the network based on the centalility measures such as Betweenness, Bridging, Centroid, Closeness, Degree, Eccentricity, Eigen Vector, Radiality, and Stress. Moreover

these five proteins interact among them and forms a subgraph. MLOC_63991.1 is found to be the most essential protein as it links other 4 proteins in the network. MLOC_63991.1 is a monomer with 769 amino acid sequences. This protein is predicted and described as Potassium transporter.

Independent Point-Set Dominating Sets in Graphs

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In this paper, we study graphs possessing an independent point-set dominating set (in short, ipsd-set). We first show that girth of a graph possessing an ipsd-set is at most 5 and thereafter characterize ipsd-graphs (graphs possessing an ipsd-set) with girth 5. In our pursuit to study ipsd-graphs of girth 4, we characterize separable ipsd-graphs of girth 4 with at least two non-trivial blocks and also characterize 2-connected C_5-free ipsd-graphs of girth 4. Then we introduce a new graph equivalence relation, duplicated equivalent, to present a class of 2-connected ipsd-graphs with girth $g(G) = 4$ containing C_5 as an induced subgraph.

Local Coloring of Double Vertex Graphs

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A local k-coloring of a graph G is a function $f : V(G) \rightarrow \{1, 2, \ldots, k\}$ such that for each $S \subseteq V(G)$, $2 \leq |S| \leq 3$, there exist u, $v \in S$ with $|f(u) - f(v)|$ at lest the size of the subgraph induced by S. The local chromatic number of G is $\chi_\ell(G) = min\{k : \text{ G has a local k-coloring}\}$.

The double vertex graph $U_2(G)$ is the graph whose vertex set consists of all 2-subsets of V such that two distinct vertices $\{x, y\}$ and $\{u, v\}$ are adjacent if and only if $|\{x, y\} \cap \{u, v\}| = 1$ and if $x = u$, then y and u are adjacent in G.

In this paper, we present some results related to local coloring of double vertex graph.