ST. GREGORIOS COLLEGE KOTTARAKARA

Student's Project-UG

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A COMPARATIVE STUDY OF

PROTEIN CASEIN AND LACTIC ACID CONTENT IN FIVE DIFFERENT MILK SAMPLES

PROJECT WORK

SUBMITTED TO THE UNIVERSITY OF KERALA IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF BACHELOR OF SCIENCE IN CHEMISTRY

2020 ADMISSION
[SEMESTER SYSTEM]

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GREEN SYNTHESIS OF GOLD NANOPARTICLES

Project Report Submitted To the University Of Kerala in Partial Fulfilment for the Requirement for the Award of the Degree Of

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ANALYSING MOLLYWOOD'S DEPICTION OF MEN: A CRITIQUE OF PATRIARCHAL REPRESENTATION

First Degree Programme in Career related 2(a)

English and Communicative English under CBCS System

Year 2020-2023

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"MORPHOLOGICAL AND ANATOMICAL STUDIES OF DASAPUSHPANGAL"

DISSERTATION WORK

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A dissertation submitted to Kerala University in partial fulfilment of the requirements

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PREVALENCE OF BLACK MAGIC, EXORCISM AND SUPERSTITIONS IN KERALA SOCIETY

Dissertation submitted to the University of Kerala in partial fulfilment of the requirements for the award of Bachelor of Arts Degree in Political Science

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A STUDY ON RAMSEY NUMBERS

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CONTENTS

Introduction

All of the work in this paper falls under a category of Mathematics known as Ramsey Numbers. The work does not have a strong likelihood of producing some new development in the field of Ramsey theory and more likely serves as an overview of work done in past. As such, the content of this paper instead aim to create a discussion of Ramsey theory that is accessible to individuals with different mathematical backgrounds. Whether through the use of visuals, aggregation of proofs and examples that I believe to be understandable or relatable, or the creation of a very general computational method for Ramsey Numbers.

The definition of Ramsey Numbers was first proposed by British mathematician Ramsey in 1928. Since 1930, a large number of scholars made a thorough study of the Ramsey Number, having been developed by people remains low. It is described in any discrete structure as long as the "structure" is sufficiently large, there must be a particular sub-section. This definition was subsequently developed into Ramsey theory by Graham Rothschild, and Spencer. Ramsey number of graphs is the promotion of Ramsey number theory.

There are two general definitions of Ramsey theory that provide a good context into what will be discussed in this paper. The basic idea is that "Ramsey theory with finding order amongst apparent chaos". It is based on that "any structure will necessarily contain an orderly substructure".

In this paper we mainly go through three chapters. In chapter 1 we will go over some basic definitions of terms used in this paper. This will help to understand the paper in an easy way. At the same time chapter 2 deeply explains "what is Ramsey theory and Ramsey Numbers" and its properties. In the last chapter we can go through applications of Ramsey Numbers. This shows the importance of Ramsey Numbers even in the daily life situations. Ramsey theory is the study that a limited number of exceptions is found from the infinite case, Ramsey number corresponds to the minimum ground-breaking number of mathematical induction. As a whole the project is a brief explanation of Ramsey theory and its acceptance.

CHAPTER-1

PRELIMINARIES

Introduction

Given that graph theory representations of Ramsey theory is going to be the most prevalent aspect of this paper, we will go over some basic definitions of some frequently used terms. Additionally, a brief explanation of the relevance of definitions will accompany each definition.

Definition 1.1. *A* ***graph*** $G = (V, E)$ *is a set of vertices and edges, where* $V(G)$ *and* $E(G)$ *are the sets of vertices and edges in* G*, respectively.*

Definition 1.2. *A* ***complete graph*** *on* n *vertices, denoted* K_n*, is a graph in which every vertex is adjacent, or connected by an edge, to every other vertex in* G*.*

Definition 1.3. *A* ***clique*** *is a subset of vertices such that there exists an edge between any pair of vertices in that subset of vertices. This is equivalent to having a complete subgraph.*

Definition 1.4. *An* ***independent set*** *of a graph is a subset of vertices such that there exists no edges between any pair of vertices in that subset.*

Definition 1.5. *Let C be a set of colors $\{c_1, c_2, \ldots, c_m\}$ and $E(G)$ be the edges of a graph G. An **edge coloring** $f : E \to C$ assigns each edge in $E(G)$ to a color in C. If an edge coloring uses k colors on a graph, then it is known as a k-colored graph.*

The Ramsey Number $R(m, n)$ gives the solution to the party problem, which asks the minimum number of guests $R(m, n)$ that must be invited so that atleast m will know each other or atleast n will not know each other.

CHAPTER-2

RAMSEY NUMBER

Introduction

Now that we are armed with at least a tentative understanding of what Ramsey theory is and have been provided with some basic definitions, it's time to work talk about some specific work in Ramsey theory. To start, we'll delve into a discussion of some of the key figures in early Ramsey theory and their work.

2.1 Van der Waerden's Theorem

One of the first mathematical theorems classified as part of Ramsey theory was produced by Dutch mathematician Bartel Leendert van der Waerden, who in 1927 published a paper that established the following theorem.

Theorem 2.1 (Van der Waerden's Theorem).*For any p,s* $\in \mathbb{N}$,*there is an* $N \in \mathbb{N}$ *such that for any partition of the set* $\{1, 2, \ldots, N\}$ *into p sets there will be an arithmetic sequence of s terms.*

While this theorem will be offered without proof, it's worth taking some time to run through an example of what this theorem implies. We note that the van der Waerden number $W(p,s)$ is the smallest N value satisfying van der Waerden's Theorem for the given p,s. With this in mind, we consider the known case $W(2,3) = 9$. To to see how this works, consider the set $\{1, 2, 3, 4, 5, 6, 7, 8, 9\}$ randomly partitioned it into two sets. Because $W(2,3) = 9$, one of our two subsets will be guaranteed to contain three terms that form an arithmetic sequence. For example, in the partition

$$\{1, 2, 3, 4, 5, 6, 7, 8, 9\} \to \{1, 3, 4, 6, 9\}\ ,\ \{2, 5, 7, 8\}\ ,$$

the subset $\{1, 3, 4, 6, 9\}$ contains the arithmetic sequence 3,6,9.

2.2 Ramsey's Theorem

The naming fame of Ramsey theory goes to British mathematician Frank Plumpton Ramsey, who published a paper in 1928 with proof of what we now call Ramsey's Theorem and other work which would be most easily classified as a part of Ramsey theory. Interestingly, Ramsey was involved in a variety of other disciplines, most notably economics. He worked with famous economist John Maynard Keynes and produced multiple papers which were still cited into the 1990s.However, Ramsey sadly died in 1930 at the age of 26 after an illness and "complications from abdominal surgery."

The main contribution Ramsey made was Ramsey Theorem, which has a variety of definitions depending on the context in which the theorem is intended to be used. For our purposes, we're going to focus in on a specific version of Ramsey's Theorem that is based on coloring a complete graph.

Theorem 2.2 (Ramsey's Theorem (2-color version)).*Let r* $\in \mathbb{N}$.*Then there exists an* $n \in \mathbb{N}$ *such that any 2-colored* K_n *graph contains a monochromatic (1-colored) subgraph* K_r *of* K_n.

So in reference to our second definition of Ramsey theory provided in Section 1.1, if there is an orderly substructure (i.e. a complete monochromatic subgraph K_r) then there must be some larger 2-colored structure in which that orderly substructure exists (i.e K_n). From this, we also develop the idea of Ramsey numbers for a 2-colored graph.

Definition 2.1 (Ramsey number (2-color definition)).*A Ramsey Number, written as n = R(r,b), is the smallest integer n such that the 2-colored graph* K_n, *using the colors red and blue for edges, implies a red monochromatic subgraph* K_r *or a blue monochromatic subgraph* K_b.

There are a couple things to note about this definition. First, there are definitions of Ramsey theory and Ramsey numbers that address graphs with edge colorings using more than two colors. However, relations in 2-colored graphs are much easier to analyze and thus more progress has been made in the study of 2-colored Ramsey numbers than any other. Secondly, the choice of colors is completely arbitrary, but seems to be a convention in a few journals so this paper will do the same.

2.3 Contributions of Erdös

The last mathematician we will choose to discuss is the esteemed Hungarian mathematician Paul Erdös. In 1933, Erdös and George Szekeres were posed the following question by fellow mathematics student Esther Klein:

"Is it true that for all n, there is a least integer g(n) so that any set of g(n) points in the plane in general position must alwyas contain the vertices of a convex n-gon?"

This problem is now known as the Happy End Problem, a nod to the fact Szekeres and Klein ended up getting married after the production of a paper on the question that showed that $2^{n-2}+1 \leq g(n) \leq \binom{2n-4}{n-2}+1$. But the most pertinent detail for Ramsey theory was that the work for this problem caused Erdös to discover Ramsey's 1928 paper. This in turn led Erdös to begin working on identifying Ramsey numbers and sparked the beginning of major interest in Ramsey theory problems. Erdös is also well-remembered in Ramsey theory for providing the two of the most fre- quently cited stories about the theory. The first is a canonical example known as the Party Problem. In this problem, we assume that there are n people at a party where any two people either know each other or do not know each other. It can be shown that if there are six people at the party, then there will be a subgroup of at least three people that all know each other or all do not know each other. This is also another way of stating that $R(3,3) = 6$, something that will be proven explicitly in another section.

2.4 Ramsey Numbers

Of all divisions of Ramsey theory, one of the most researched and well-known is that of Ramsey numbers. Although previously defined in Section 1.1, it's worth reestablishing a formal definition as the following subsections will rely heavily on an understanding of Ramsey numbers, which are derived from an interpretation of Ramsey's Theorem provided in Section 2.2.

Definition 2.2 (Ramsey number(2-color definition)).*A Ramsey Number, written as* $n = R(r, b)$*, is the smallest integer* *n such that the 2-colored graph K_n, using the colors red and blue for edges, implies a red monochromatic subgraph K_r or a blue monochromatic subgraph K_b.*

Once again, we note that the colors red and blue are arbitrary choices for the two different colors in the 2-colored K_n. Moreover, we specifically refer to this definition of Ramsey numbers as the "2-colored definition" because there are other ways in which Ramsey numbers are defined and analyzed. For example, it's quite common for mathematicians to look at all graphs on n vertices and look for the existence of cliques or complete sets of specified orders. These still fit the general intent of Ramsey numbers, as if you consider the existence of an edge between two vertices as a "red" colored edge and the lack of an edge as a "blue" colored edge, you notice strong similarities between these two interpretations.

2.4.1 Important Properties of Ramsey Numbers

Now we can discuss some useful relationships between different Ramsey numbers, known values and range of values for different Ramsey numbers, then conclude with some proofs of important Ramsey numbers with known numbers. The first important property is that Ramsey numbers are symmetric with respect to their r and b values.

Theorem 2.3. *For all r,b $\in \mathbb{N}$, the relationship R(r,b) = R(b,r) holds.*

Proof. This result is a natural consequence of the symmetry of graphs. From the standpoint of edge colorings, consider that a 2-colored complete graph G will have an inversely 2-colored complete graph G', where any red edge in G will be colored blue in G' and vice versa. We know that $R(r, b)$ requires that any edge coloration of $K_{R(r,b)}$ will have a red monochromatic subgraph K_r or a blue monochromatic subgraph K_b - that also means that the inversely 2-colored graph $K'_{R(r,b)}$ will have a blue monochromatic subgraph K_r or a red monochromatic subgraph K_b. Thus, since the inverses of all edge colorings are just all edge colorings, we have the equivalent conditions for $R(b, r)$.

The next relationship was proved in 1955 by Greenwood and Gleason, which is extremely useful recursive bound for Ramsey numbers which is used in a few proofs of specific Ramsey numbers.

Theorem 2.4. *For all* $r,b \in \mathbb{N}$*, the inequality* $R(r,b) \leq R(r-1,b) + R(r,b-1)$ *holds.*

Proof. Let G be a 2-colored graph on $R(r-1,b) + R(r,b-1)$ edges (see Figure 1(a) for an example). Consider vertex $v \in G$. We denote n_r as the number of vertices adjacent to v via a red edge and denote n_b as the number of vertices adjacent to v via a blue edge. Moreover, we let the n_r vertices adjacent to v by a red edge form a set S_r (see Figure 1(b)) and similarly the n_b vertices adjacent to v by a blue edge form the set S_b.

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Figure 1: A visualization of an edge coloring of $K_1$8 (a), the vertices in this edge coloring that would be in the set S_r (b), and the corresponding subgraph of $K_1$8 using the vertices in S_r (c).

Since v is connected to every other vertex in G, we have

$$n_r + n_b + 1 = \text{R(r-1,b)} + \text{R(r,b-1)}.$$

From this we have two cases. If $n_r < R(r-1, b)$, then $n_b \geq$ R(r,b-1) and we consider the vertices in S_b. Because $n_b \geq$ R(r,b-1), then in the complete subgraph of G formed from the vertices of S_b and all edges between them there is a complete monochromatic subgraph M on r vertices or $s-1$ vertices. Additionally, since we established that the vertices in S_b were all connected to v by a blue edge, we can say that the complete subgraph of G formed from the vertices of $S_b + v$ and all edges between them will contain a blue complete monochromatic subgraph on b vertices. Thus, G has a blue monochromatic subgraph of size b, and the inequality holds in this case.
In the other case, we have $n_r \geq R(r-1, b)$ and consider the vertices in S_r. Because $n_r \geq R(r-1, b)$, then in the complete subgraph of G formed from the vertices of S_r and all edges between them (see Figure 1(c) for a visual) there is a complete monochromatic subgraph N on $r-1$ vertices or b vertices. Additionally, since all vertices in S_r are connected to v by a red edge, we can say that the complete subgraph of G formed from the vertices of $S_r + v$ and all edges between them will contain a re complete monochromatic graph on r edges. Thus, G has a

red monochromatic subgraph of size r, and the inequality also holds, meaning that the theorem is valid in all cases.

The value of Theorem 2.4 is its ability to establish a general upper bound for all Ramsey numbers. While the difference between $R(r, b)$ and $R(r, b-1) + R(r-1, b)$ tends to increase as r and b increase (and therefore lessen the value of this upper limit), it's an excellent starting point for setting up the bounds of a given $R(r, b)$. The last theorem we will spend time discussing is one that sets another upper bound for $R(r, b)$, but this time in relation to combinations as opposed to other Ramsey numbers.

Theorem 2.5.

$$R(r, b) \leq \binom{r+b-2}{r-1}$$

Proof. We will prove by induction on r, b. First, we establish the following base case $r = b = 2$:

$$R(2,2) = 2 \leq 2 = \binom{2+2-2}{2-1}.$$

Now assume that the relation holds for all $r = x-1, b = y$ and $r = x, b = y-1$ cases - we demonstrate that the $r = x, b = y$ case holds using Theorem 2.3 and Pascal's Rule (which is not defined but is a well-known combinatorial relationship):

$$
\begin{aligned}
R(r,b) &\leq R(r-1,b) + R(r,b-1) \\
&\leq \begin{pmatrix} (r-1)+b-2 \\ (r-1)-1 \end{pmatrix} + \begin{pmatrix} r+(b-1)-2 \\ r-1 \end{pmatrix} \\
&= \begin{pmatrix} r+b-2 \\ r-1 \end{pmatrix} \\
R(r,b) &\leq \begin{pmatrix} r+b-2 \\ r-1 \end{pmatrix}.
\end{aligned}
$$

CHAPTER-3

APPLICATION OF RAMSEY NUMBERS

3.1 The Problem of Eccentric Hosts(Party Problem)

A man and his wife are planning a dinner party,but they each have certain peculiarities.The man likes to have everyone at the dinner table know one another,for he feels this creates more harmony during the meal.On the other hand ,his wife thinks that no two people at the dinner table should know each other, for she believes one important aspect of dinner parties is the opportunity it gives people for making new acquaintance. Despite this difference of opinion between husband and wife,they are a happily married couple and both will be happy if either's wishes are fulfilled. Hence, several tables are set, two of which are designated A and B . At table A , the man's table, all guests are to know one another, while at table B , the wife table, no two guests are to know each other.We may now state our problem.
Suppose table A is to seat 'm' people and table B is to seat 'n' people. All guests at table A are to know one another, while

no two people seated at table B are to know each other. What is the least number of people that may attend a dinner party, so that atleast one of the two tables can be filled according to these rules?

For each collection of p people present at the party, we can represent their situation by a graph G of order p whose vertices correspond to the people, and much that two vertices of G are adjacent of and only of the corresponding people know each other. Here we need G and G_1 to state the problem of the Eccentric Hosts in Mathematical terms.

Let F_1 and F_2 be any two graphs we define the Ramsey number x (F_1, F_2) to be the least integer p such that for every graph G of order P, either G contains F_1 as a subgraph or G_1 contains F_2 as a subgraph.
These numbers are named after Frank Ramsey who proved that for every complete graphs K_m and K_n the Ramsey number r(K_m, K_n) unfortunately for $m \geq 3$ and $n \geq 3$ very few Ramsey numbers have been found. Hence the problem is unsolved.

Let us look into an another problem .

3.2 Among any six people, there are three any two of whom are friends, or there are three such that no two of them are friends.

This is not a sociological claim, but a very simple graph-theoretic statement: in other words, in any graph on 6 vertices, there is a triangle or three vertices with no edges between them.

Let G = (V,E) be a graph and $|V| = 6$. Fix a vertex $v \epsilon$ V We consider two cases .

(i) If the degree of v atleast 3, then consider three neighbors of v, call them to x, y, z. If any two among $\{x, y, z\}$ are friends, we are done because they form a triangle together with If not,no two of $\{x, y, z\}$ are friends and we are done as well.

(ii) If the degree of v is at most 2, then there are at least three other vertices which are not. neighbors of v, call them x, y, z. In this case, the argument is complementary to the previous one. Either $\{x, y, z\}$ are mutual friends, in which case we are done. Or there are two among $\{x, y, z\}$ who are not friends, for example x and y, and then no two of $\{v, x, y\}$ are friends.

3.3 The Dancing Problem

Suppose we have a group of men and women at a party, with atleast as many men present as there are women. Under what conditions is it possible to have all women dance with equally many men so that each dancing couple is compatible?

As before, we explore this problem by setting up a mathematical model using graphs. Let G be a graph whose vertex set represents the people at the party, and such that two vertices are adjacent if and only if the corresponding people are compatible dancing partners. It is possible for all women to be dancing at the same time if and only if G contains a 1-regular subgraph F such that the number of edges in F equals the number of women.

A few new graphical definitions will make this problem easier to discuss. A graph G is called *bipartite* if it is possible to partition the vertex set of G into two subsets, say V_1 and V_2, so that every edge of G joins a vertex of V_1 with a vertex of V_2, and no vertex joins another vertex of its own set. In Figure, we have redrawn a graph G to illustrate its bipartite property. Thus, for this graph, we could let V_1=$\{v_1, v_3, v_5, v_7\}$ and V_2= $\{v_2, v_4, v_6, v_8, v_9\}$

Let G be a bipartite graph whose vertex set is partitioned into subsets V_1 and V_2, as just described. Let U_1 be a subset of V_1. We say that U_1 is *matched* to a subset U_2 of V_2 if G contains a 1- regular subgraph F whose vertex set is $U_1 \cup U_2$. If U_1 is matched to then we must have $|U_1| = |U_2|$. The subgraph F is referred to as a *matching* , for it matches (or pairs off) one set of vertices, namely U_1, with another set of vertices, namely U_2.

We illustrate this concept with the bipartite graph G of Figure .Here we let $V_1 = \{v_1, v_2, v_3, v_4\}$,$V_2 = \{w_1, w_2, w_3, w_4, w_5\}$,and U_1=$\{v_1, v_3, v_4\}$.If we let $U_2 = \{w_1, w_2, w_5\}$, then we see that G contains the 1- regular subgraph F with vertex set $U_1 \cup U_2$. Hence,U_1 is matched to U_2. Note that V_1 itself can be matched to a subset V_2.

Again,let us assume G to be a bipartite graph with its vertex set partitioned into V_1 and V_2. If $W_1 \subseteq V_1$,then we denote W_1^*.

those vertices of V_2 adjacent with atleast one vertex in W_1.The *deficiency* def(W_1) of W_1 in G is defined by

$$\text{def}(W_1) = |W_1| - |W_1^*|.$$

The set $U_1 \subseteq V_1$ is said to be *nondeficient* in G if no (nonempty) subset of U_1 has positive deficiency. We note that positive deficiency for a subset W_1 of U_1 means that there are more vertices in W_1 than there are vertices adjacent to the elements in W_1; hence,it would be hopeless to attempt matching W_1 to a subset of V_2 .

Every subset of V_1 in the graph G of Figure has negative or zero deficiency : that is, no subset of V_1 has positive deficiency. Hence,

(1) V_1 is nondeficient.

We have already observed that

(2) V_1 is matched to a subset of V_2.

We shall soon see that observations (1) and (2) are synonymous.

Returning to the Dancing Problem, we can now see that we have represented the situation by a bipartite graph G .If we denote by V_1 the vertices corresponding to the women , and by V_2 those vertices corresponding to the men, then we are asking conditions under which V_1 can be matched to a subset of V_2.We now give such conditions.

CONCLUSION

This project consist of three chapters which discuss about **Ramsey Numbers**.An understanding of the most basic concepts such as definitions of different terms in Ramsey Numbers, explanation of Ramsey theory and Ramsey Numbers and application of Ramsey Numbers. This study help us to get well information on Ramsey Numbers and help us to find out general applications in daily life situations.

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