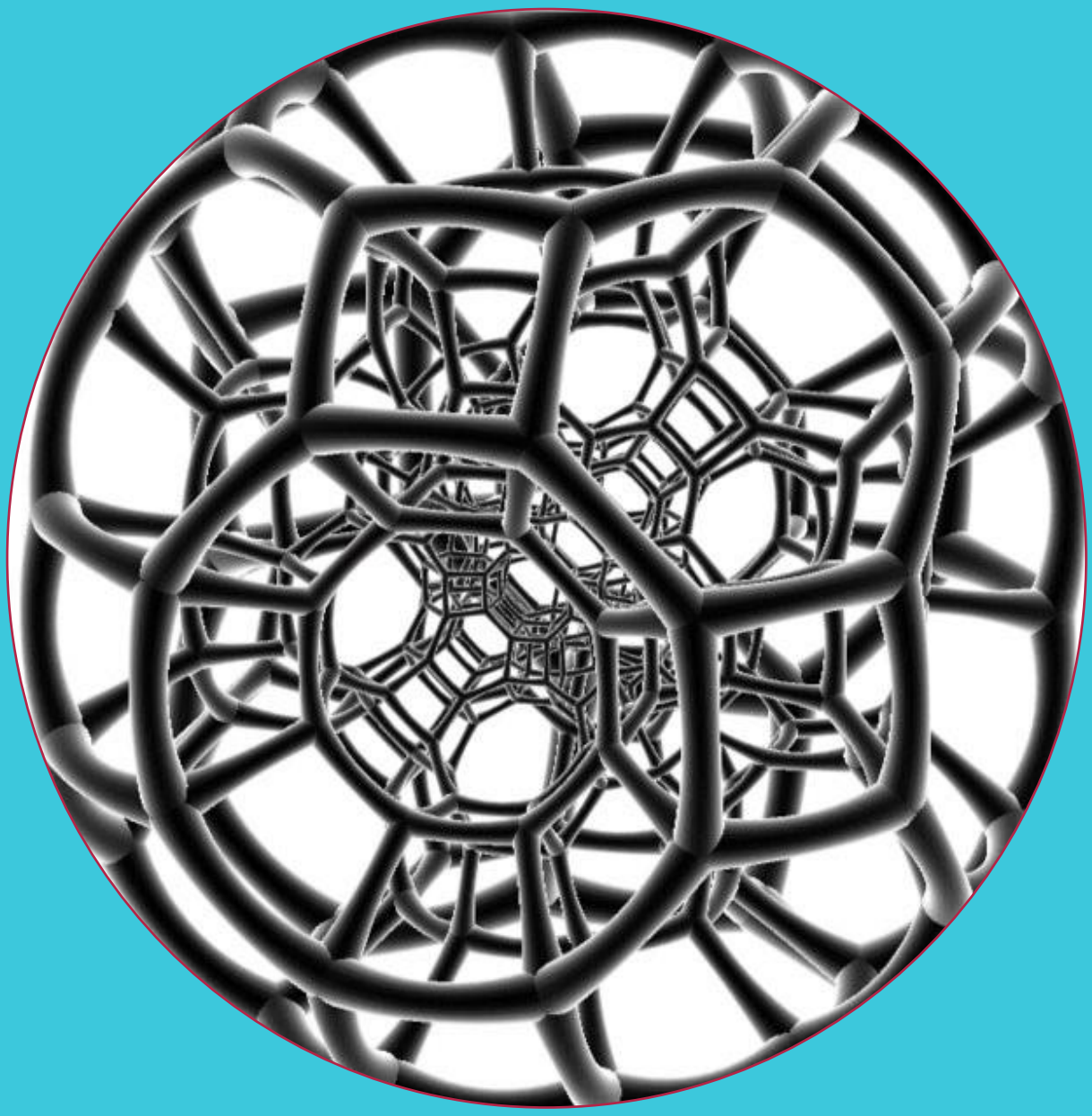

Catch the thief

Key Stage 4 Programme

Pupil Name	Name
Handbook Designed by	Dr Cyriac Grigorious

Timetable and Assignment Submission

Timetable – Tutorials

1			
2			
3			
4			
5			
6 (Feedback)			

Timetable – Homework Assignments

Tutorial 1		
Tutorial 2		
Tutorial 3		
Tutorial 4		
Tutorial 5		

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after midnight on 9th August	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

The Brilliant Club KS4 Programme – Pupil Feedback Report

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at AS-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Name of PhD Tutor			
Title of Assignment			
Name of Pupil			
Name of School			
ORIGINAL MARK / 100		FINAL MARK / 100	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the PhD tutor should give an explanation in this section:

Learning Feedback Comment 1 - ***Enter Key Learning Priority Here***	
What you did in relation to this Key Learning Priority *Enter feedback here*	How you could improve in the future *Enter feedback here*
Learning Feedback Comment 2 – ***Enter Key Learning Priority Here***	
What you did in relation to this Key Learning Priority *Enter feedback here*	How you could improve in the future *Enter feedback here*
Learning Feedback Comment 3 – ***Enter Key Learning Priority Here***	
What you did in relation to this Key Learning Priority *Enter feedback here*	How you could improve in the future *Enter feedback here*
Resilience Comment	
How you showed learning resilience during the course *Enter feedback here*	How you could build learning resilience in the future *Enter feedback here*

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Course Rationale

Graph theory is an established modelling method used in a variety of disciplines to describe relationships between objects. A graph consists of a finite set of vertices (points, nodes), a finite set of edges (lines, linkages) and a rule that defines which edge joins which pair of vertices. It is customary to represent a graph by means of a diagram and refer to the diagram as the graph. Unlike Euclidean graphs with horizontal and vertical axes, graph theory graphs portray topological quantities, patterns and relationships. Structures that can be represented as graphs exist in nature and many problems of practical interest can be represented by graph.

Many real-world situations can conveniently be described by means of a diagram consisting of a set of points together with lines joining certain pairs of these points. For example, the points could be the different cities in a country and the lines could be the roads connecting them; or the points might be communication centres, with lines representing communication links between the centres. Note that we are interested mainly in whether or not two given points are joined by a line; the manner in which they are joined is immaterial. A mathematical abstraction of situations of this type gives rise to the concept of graph. Graph theory is the study of graphs.

In these tutorials, we are going to look into the interesting field of mathematics called graph theory and learn few basic definitions and theorems along with few applications of graph theory. We shall also consider some of the challenging research problems in graph theory. Graphs can be used to model many types of relations and processes in physical, biological, social and information systems. Many practical problems can be represented by graphs. Emphasizing their application to real-world systems, the term *network* is sometimes defined to mean a graph in which attributes (e.g. names) are associated with the nodes and/or edges. In computer science, graphs are used to represent networks of communication, data organization, computational devices, the flow of computation, etc. For instance, the link structure of a website can be represented by a directed graph, in which the vertices represent web pages and directed edges represent links from one page to another. A similar approach can be taken to problems in social media, travel, biology, computer chip design, and many other fields. The wide variety of applications has increased the popularity of graph theory in many fields like natural sciences, engineering, genetics and even in soft sciences like psychology and sociology.

Mark Scheme Table

	Skills	1st (70-100)	2:1 (60-69)	2:2 (50-59)
Subject knowledge	Knowledge and Understanding	○ All content included is relevant to the general topic and to the specific question/title ○ Good understanding of all the relevant topics. ○ Scientific terms are defined and used accurately throughout ○ Clear justification on how the content included is related to the specific issues that are the focus of the assignment	○ Most of the content included is relevant to the general topic and to the specific question/title ○ Good understanding of most the relevant topics ○ Scientific terms are used accurately but not always clearly defined. ○ Adequate justification on how the content included is related to the specific issues that are the focus of the assignment	○ Some of the content included is relevant to the general topic and to the specific question/title ○ Good understanding on some of the relevant topics but occasional confusion on others. ○ Scientific terms are used mostly accurately with occasional confusion and often not defined. ○ Some justification on how the content included is related to the specific issues that are the focus of the assignment
Critical thinking	Research and Evidence	○ Inclusion of rich sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas ○ Use evidence/calculations to support claims/assertions/ideas, consistently clearly and convincingly ○ Evidence of further reading beyond materials provided which were used in an appropriate context	○ Inclusion of adequate sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas ○ Use evidence/calculations to support claims/assertions/ideas, mostly clearly and convincingly ○ Evidence of further reading beyond materials provided	○ Inclusion of some sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas ○ Use evidence/calculations to support claims/assertions/ideas, at times clearly and convincingly ○ Limited evidence of further reading beyond materials provided ○
	Developing an Argument	○ A point of view or position in relation to the title or question is consistently clear ○ Argument/proof exceptionally well-developed and well-justified ○ A position is clearly established in relation to the question, and is developed effectively and consistently	○ A point of view or position in relation to the title or question is adequately clear ○ Argument/proof clear and well-developed and position justified ○ A position is established in relation to the question, and is well-developed in most of the essay ○ Some evidence of linking subjects that have not previously been associated	○ A point of view or position in relation to the title or question is somewhat clear ○ Argument/proof clear but not well-developed ○ A position is established in relation to the question, and is well-developed in parts of the essay ○ Limited evidence of linking subjects that have not previously been associated

		throughout the essay ○ Makes links effectively between subjects that have not previously been associated ○ Uses concepts from the tutorials in an unfamiliar context, and does so accurately and confidently.	○ Use some concepts from the tutorials in an unfamiliar context, but not always accurate	○ Limited use of concepts from the tutorials in other contexts
	Critical Evaluation	○ Moved beyond description to an assessment of the value or significance of what is described ○ Evaluative points are consistently explicit/systematic/reasoned/justified ○ Effective critiques on the reliability of sources provided	○ Mostly description but some assessment of the value or significance of what is described ○ Evaluative points are mostly explicit/systematic/reasoned/justified ○ Some evidence of critiques on the reliability of sources provided	○ Only description with minimal assessment of the value or significance of what is described ○ Evaluative points are at times explicit/systematic/reasoned/justified ○ Limited evidence of critiques on the reliability of sources provided
Written communication	Structure and Presentation	○ Ideas are presented in paragraphs and arranged in a logical structure that is appropriate for the assignment ○ The introduction clearly outlines how the essay/report will deal with the issues ○ The conclusion summarizes all the main points clearly and concisely ○ All calculations, formulas and methods are clearly structured, clear to follow and correct ○ Tables and graphs are effectively constructed including appropriate headings, units and scales. ○ All sources are referenced correctly in an agreed format	○ Ideas are presented in paragraphs and arranged in a structure that is mostly appropriate for the assignment ○ The introduction adequately describes how the essay/report will deal with the issues ○ The conclusion summarizes most of the main points clearly ○ Calculations, formulas and methods are mostly structured, clear to follow and correct ○ Most tables and graphs are well constructed ○ Most sources are referenced correctly in an agreed format	○ Ideas are presented in paragraphs and arranged in a structure ○ The introduction mentions how the essay/report will deal with the issues ○ The conclusion summarizes some of the main points clearly ○ Calculations, formulas and methods are not always structured, clear to follow and correct. ○ Some tables and graphs are well constructed but contains some errors ○ Some sources are referenced correctly in the agreed format with occasional errors

	Language and Style	○ No spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout ○ Writing style consistently clear, appropriate for scientific documents and easy to follow ○ Accurate and consistent use of technical language and vocabulary	○ Minimal spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout ○ Writing style mostly clear, appropriate for scientific documents and easy to follow ○ Some attempts of using technical language and vocab alary, but not always accurate	○ Some spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout with occasional errors ○ Writing style moderately clear, appropriate for scientific documents and easy to follow ○ Use of simple language and vocabulary effectively but struggles to use technical language

Glossary of Keywords

Word	Definition
Graph	A **graph** is an ordered pair *G* = (*V*, *E*) comprising a set *V* of *vertices* or *nodes* or *points* together with a set *E* of *edges* or *arcs* or *lines*, which are 2-element subsets of *V* (i.e. an edge is associated with two vertices, and that association takes the form of the unordered pair comprising those two vertices).
Degree of a vertex	The number of edges incident on a vertex
Distance $d(u;\ v)$	between two vertices u and v in a graph G is the length of the shortest path between u and v.
Connected graph	A graph G is connected if every two of its vertices are connected
Component of a graph G	A component of a graph $\boldsymbol{G}$ is a connected subgraph H such that no subgraph of G that properly contains H is connected.

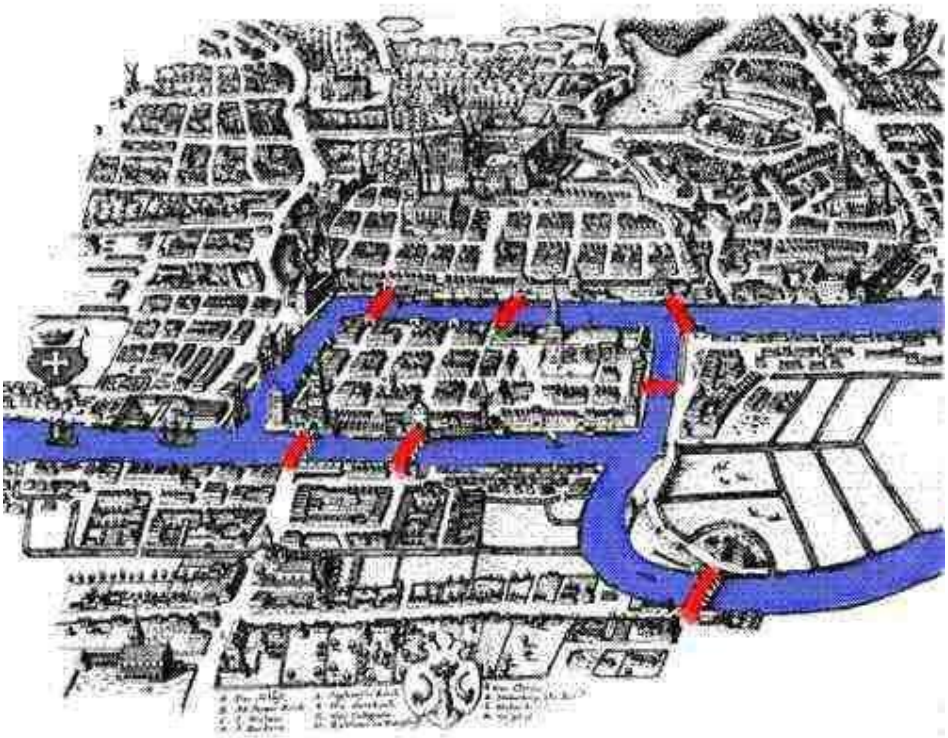
Tutorial 1 – History of graphs

What is the Purpose of Tutorial 1?

- Introduction to graph theory
- Basic definitions
- Applications of graph theory

Many real world situations can conveniently be described by means of a diagram consisting of a set of points together with lines joining certain pairs of these points. For example, the points could be the different cities in a country and the lines could be the roads connecting them; or the points might be communication centres, with lines representing communication links between the centres. Note that we are interested mainly in whether or not two given points are joined by a line; the manner in which they are joined is immaterial. A mathematical abstraction of situations of this type gives rise to the concept of graph. Graph theory is the study of graphs. The wide variety of applications has increased the popularity of graph theory in many fields like natural sciences, engineering, genetics and even in soft sciences like psychology and sociology.
Graphs are so named because they can be represented graphically, and it is this graphical representation which helps us understand many of their properties. Each vertex is indicated by a point, and each edge by a line joining the points which represents its ends.

Konigsberg bridge problem



As the river flowed around Kneiphof, literally meaning pub yard, and another island, it divided the city into four distinct regions. The seven bridges were called Blacksmith's bridge, Connecting Bridge, Green Bridge, Merchant's Bridge, Wooden Bridge, High Bridge, and Honey Bridge. According to lore, the citizens of Königsberg used to spend Sunday afternoons walking around their beautiful city. While walking, the people of the city decided to create a game for themselves, their goal being to devise a way in which they could walk around the city, crossing each of the seven bridges only once. Even though none of the citizens of Königsberg could invent a route that would allow them to cross each of the bridges only once,

Basic definitions

- Graphs
- Degree of vertices
- Distance, path, walk, complete graph

Assignment 1

1. Find some applications of graph theory in real life and explain in your own words.
2. Draw three different examples of simple graphs with 6 vertices each and write the degree of each of the vertices

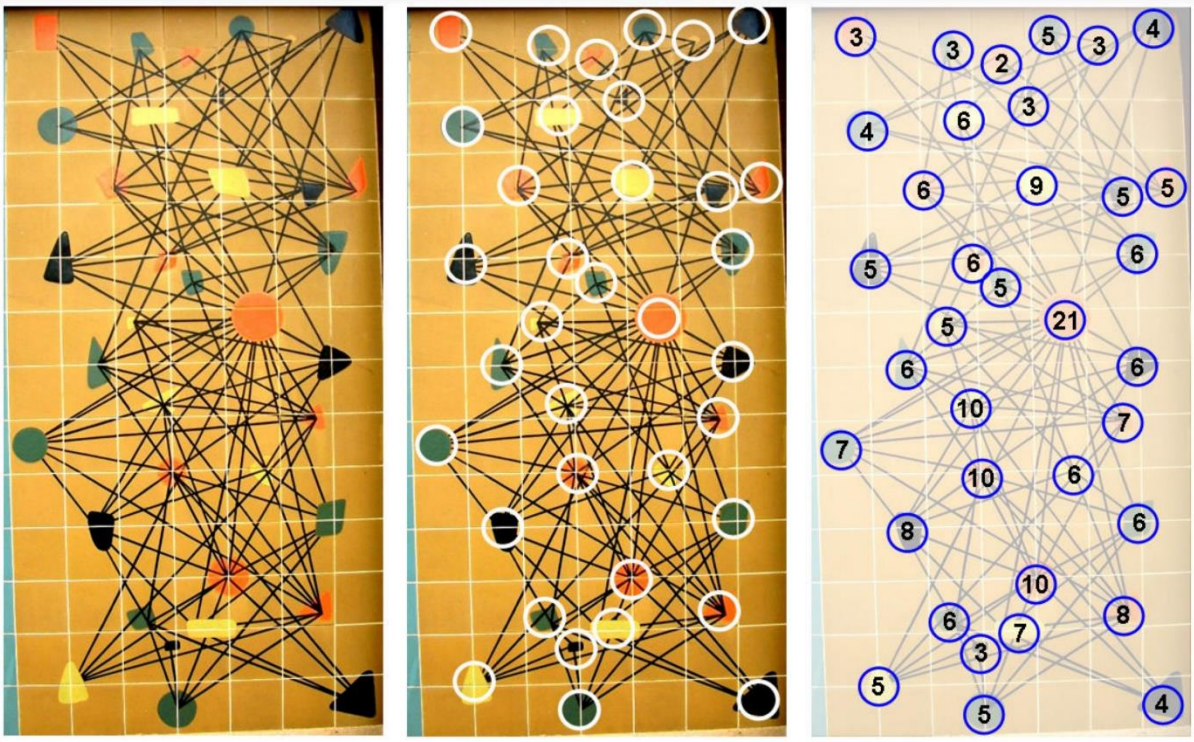
Tutorial 2 – Basic Definitions

What is the Purpose of Tutorial 2?

In this tutorial, we are going to learn about some very basis theorems in graph theory and various ways of representing a graphs.

- Handshake Lemma

  Activity 1 : Try to prove the handshake lemma with an activity. Make the students do hand shakes between themselves. Find out the total number of handshakes from the number of handshakes each person did.
  Suppose that vertices represent people at a party and an edge indicates that the people who are its end vertices shake hands. If everybody counts how many times they have shaken hands then the grand total will be twice the number of handshakes: there are twice as many hands shaken as handshakes.
  This rather obvious truth is nevertheless a key which unlocks some far from obvious facts. For example, a 3-regular graph, in which every vertex has degree 3, must have an even number of vertices. Not hard to prove, but a triviality given the immediate corollary of the Handshaking Lemma that **the number of odd degree vertices in any graph must be even.**

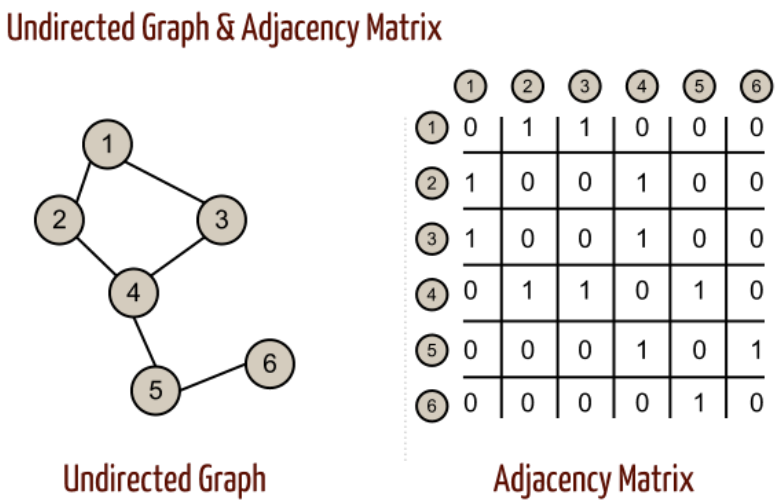


ex is the number of edges incident with it (a *self-loop* joining a vertex to itself contributes 2 to the degree of that vertex)

- Different ways of representing a graph.

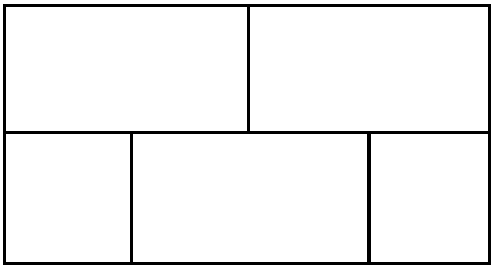
  Graphs and sets theory.

  Matrix representation of graphs



Assignment 2

1. Draw a graph and write its adjacency matrix.
2. The object of the puzzle is to cross each "wall" of the diagram with a continuous line only once

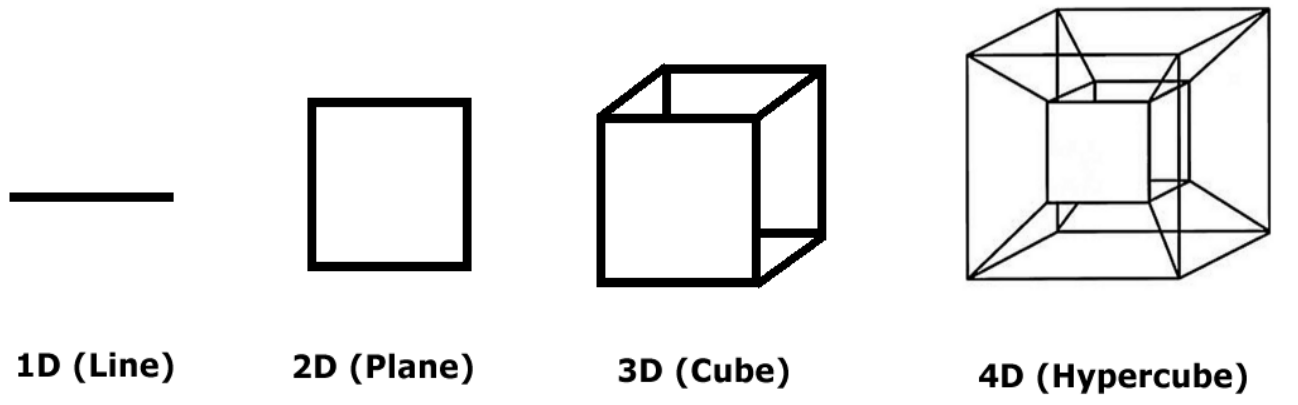


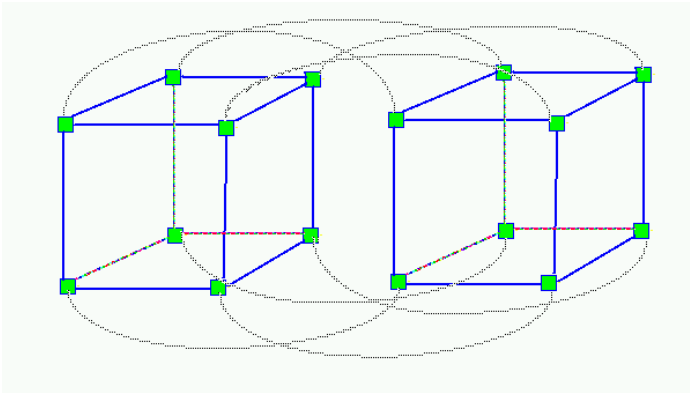
Tutorial 3 – More interesting graphs

What is the Purpose of Tutorial 3?

This week, we are going to learn about few more interesting graphs, some with lots of symmetry and some without any.

- Trees, cycles, Grids
- Hypercubes





- Circulant graphs

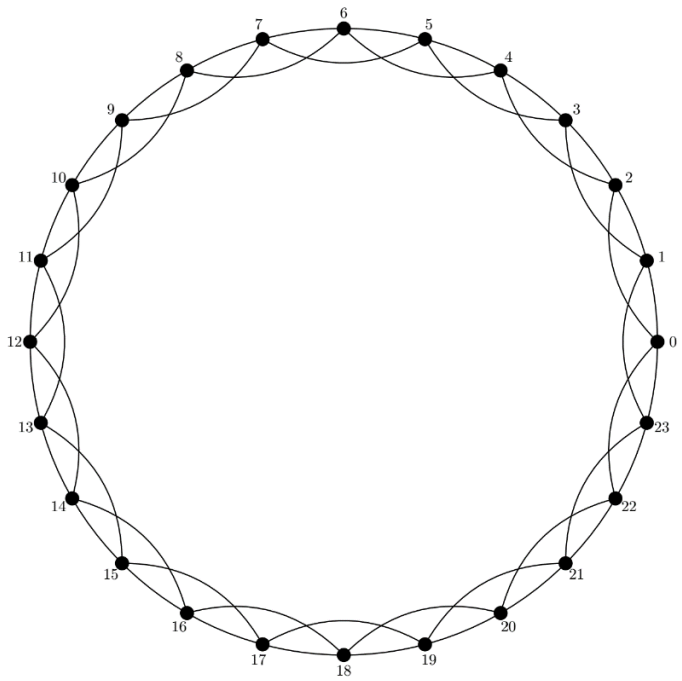


Figure 1: A Circulant graph

Assignment 3

Find the following properties of 6-d hypercube

- Number of vertices
- Number of edges
- Degree of each vertex

Draw the circulant graph $C(12, \{1,2,3\})$. Find the following as well

- Number of edges
- Diameter of the graph.

Tutorial 4 – Catching the thief

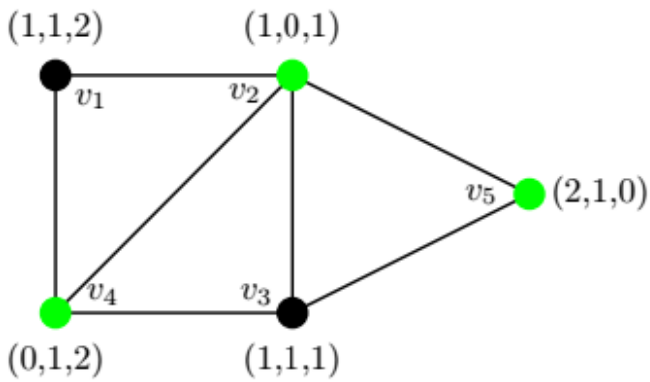
What is the Purpose of Tutorial 4?

In this tutorial, we are going to learning about a problem that has lots of real life applications:

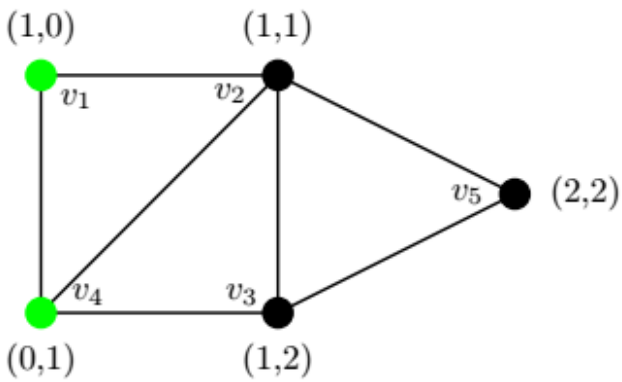
- Metric dimension and applications
- Metric dimension of paths and complete graphs

Metric dimension

A metric basis for a connected graph G is a smallest set W of points of G such that no two points have the same distances to all points of W.



(A) A resolving set



(B) A minimum resolving set

Applications of metric dimension

Safety Alarms (Fire/Burgler): For safeguards analysis of a facility, such as a fire protection study of nuclear power plants, the facility can be modelled by a graph $G = (V; E)$, where each vertex can represent a room, a hallway, a staircase, etc., and an edge connects two vertices representing locations that are physically adjacent or perhaps within sight or sound of each other. With the objective of being able to precisely locate an intruder (fire, thief, saboteur, etc.) in the system, a detection device, such as heat-sensing device, is placed at a set S of vertex locations. Each device at a vertex v measure the distance to the intruder from its location. What is required is to have a (smallest possible) collection S of vertices at which to place detection devices so that if an object (or intruder) is placed at any vertex in the graph, then the object can be detected and its position uniquely identified. In graph theoretic terms this set S is a metric basis.

Robot Navigation: Robot is a self-governing, programmable electromechanical device used in industry and in scientific research to perform a task or a limited repetition of tasks. Navigation of a robot can be studied in a graph-structured framework. The navigating agent can be assumed to be a point robot, which moves from node to node of a graph space. For a robot, it is assumed that it can sense the distances to a set of landmarks. Evidently, if the robot knows its distances to a sufficiently large set of landmarks, its position in the graph is uniquely determined.

Consider a robot which is navigating in a space modelled by a graph and which wants to know its current location. It can send a signal to find out how far it is from each among a set of fixed landmarks. This suggests the following problem:

Given a graph what is the smallest number of landmarks needed and where should they be located, so that the distances to the landmarks uniquely determine the robot's position in the graph?

Metric dimension of paths and complete graph:

Theorem 1: A graph G has $dim(G) = 1$ if and only if G is a path.

Theorem 2: A connected graph G of order $n \geq 2$ has dimension $n - 1$ if and only if $G = K_n$.

Assignment 4

1.Find the metric dimension of cycles.

2.Obtain a metric basis for grid graphs.

Tutorial 5 – More problems…

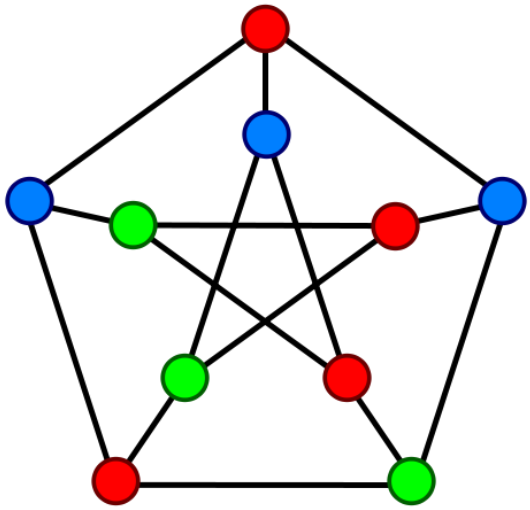
What is the Purpose of Tutorial 5?

In this tutorial we are going to see about some more interesting problems in graph theory as follows:

- Colouring, conditional resolvability
- Domination

Coloring

In graph theory, **graph coloring** is an assignment of labels traditionally called "colors" to elements of a graph subject to certain constraints. In its simplest form, it is a way of coloring the vertices of a graph such that no two adjacent vertices share the same color; this is called a **vertex coloring**. Similarly, an edge coloring assigns a color to each edge so that no two adjacent edges share the same color. For a given graph, chromatic number is the smallest number of colors for which a coloring of the vertices exists such that adjacent vertices receive different colors.

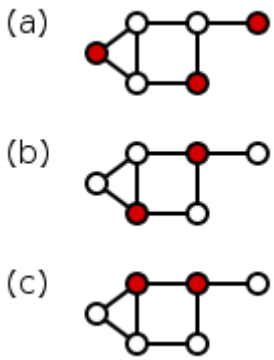


Conditional resolvability

When one or more conditions are imposed on a metric basis, we get conditional resolving sets. For example, path resolving set, star resolving set, independent resolving sets etc.

Domination

In graph theory, a **dominating set** for a graph $G = (V, E)$ is a subset D of V such that every vertex not in D is adjacent to at least one member of D. The **domination number** $\gamma(G)$ is the number of vertices in a smallest dominating set for G.



Final Assignment

Find out more about various conditions that are applied on metric dimension and domination. Define a new condition on metric dimension and obtain the basic results on it.

What is the Purpose of Tutorial 6?

- To receive feedback on final assignments.
- To share examples of best practice with the other pupils in your group.
- To write targets for improvement in school lessons.
- To reflect on the programme including what was enjoyed and what was challenging.

Final assignment feedback

What I did well…	What I could have improved on…
•	•
•	•
•	•

My target for future work is…

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?
• • •

What did you find challenging about the programme?	How did you overcome these challenges?
• • •	• • •

Appendix 1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you to avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

What is a reference?

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

When should I use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important to thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

1. **A marker in your assignment**: After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this is in your text with a number, e.g. [1]. The next time you use a reference you should use the next number, e.g. [2].
2. **Bibliography**: This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used, and include as much information as you have about the reference. The list below gives what should be included for different sources.

    a. **Websites** – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].

    E.g. Dan Snow, 'How did so many soldiers survive the trenches?', http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [11 July 2014].

    b. **Books** – Author, date published, title of book (in italics), pages where the information came from.

    E.g. S. Dubner and S. Levitt, (2006) *Freakonomics*, 7-9.

    c. **Articles** – Author, 'title of the article' (with quotation marks), *where the article comes from* (newspaper, journal etc.), date of the article.

    E.g. Maev Kennedy, 'The lights to go out across the UK to mark First World War's centenary', Guardian, 10 July 2014.

Appendix 2 – Using the VLE

VLE username	
VLE password	

Please remember the following key details...

- You are able log into the VLE either through the link on our website (**www.thebrilliantclub.org**) or going directly to the VLE site at (https://portal.thebrilliantclub.org/sign-in).
- Please update your profile with your full name and email address- this will allow you to retrieve forgotten passwords or usernames
- If you forget your log-in details you can request them to be emailed to you by clicking the link on the VLE home page. (If you are still having problems you can email: **schools@thebrilliantclub.org**)

What is the VLE?

The VLE is a virtual learning environment for all pupils on Uni Pathways it is used for:

- messaging your tutor
- submitting homework
- submitting your final assignment
- accessing resources for your tutorials
- finding out more information about university and careers

How should I use the VLE?

The VLE is a professional academic environment in which pupils are able to message their PhD Tutor. Here are a few things to consider:

- Ensure you keep a professional tone in the messages you send to your tutors.
- Ensure you always reply to your tutors in a timely manner.
- Thank your tutor for the effort they are putting in to give you your feedback etc.
- Submit all homework to your tutor on time.

IMPORTANT: Final assignment

- When you submit your final assignment, please remember that you need to do so through the **'My Activities'** tab and not as an attachment to a message.

Notes

Notes

Notes

Course Title

Key Stage 4 Programme

researchersinschools.org