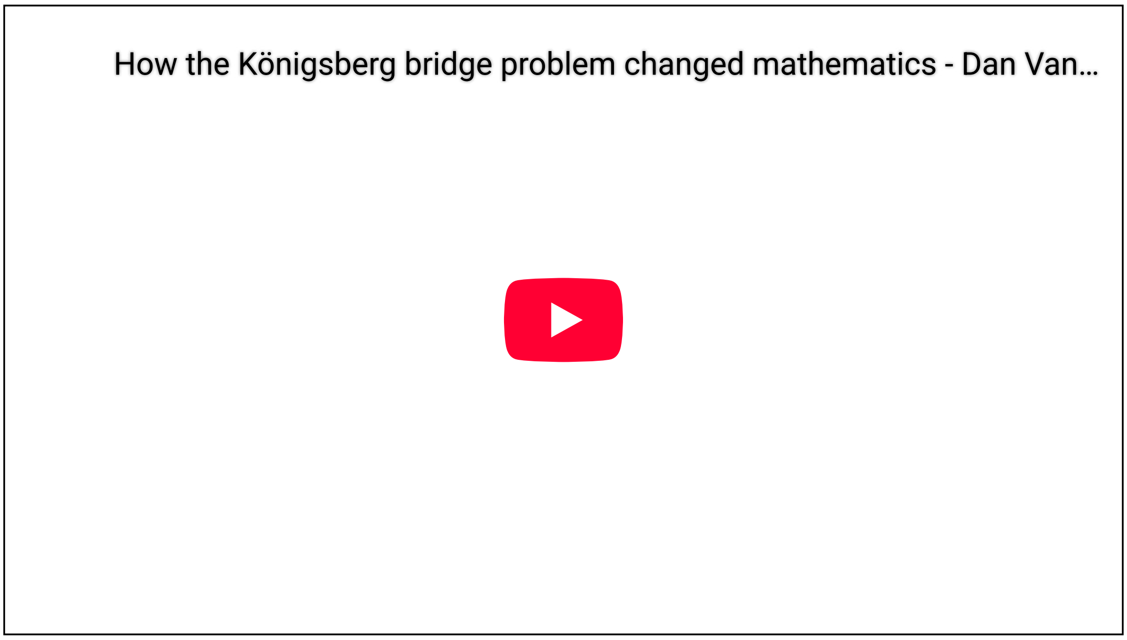
Introduction to graph theory

Index

The big picture

Watch this video to learn how an entire area of mathematics was born from finding the solution to one problem.



Graph theory has grown in importance from being used to solve this one problem to being essential in many areas of life, such as mapping apps and communication networks.

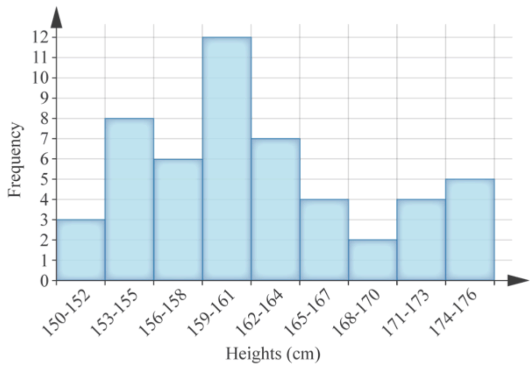
Concept

When searching for solutions to real-world problems, it is often helpful to build a model that only includes the most important information.

Basic graph theory

Definitions

In mathematics, graphs are tools that allow you to visualise relationships, either in real-world or abstract contexts. Consider the two graphs shown below. The graph on the left is called a bar graph. It illustrates the height distribution of a certain group of people. The graph on the right has been plotted on the Cartesian plane and illustrates the relationship between two variables.



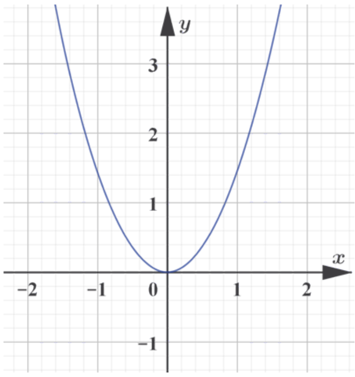
More information

The image is a bar chart that shows the frequency of different height ranges in a group. The X-axis represents heights in centimeters, divided into ranges: 150-152, 153-155, 156-158, 159-161, 162-164, 165-167, 168-170, 171-173, and 174-176 cm. The Y-axis represents the frequency, with values from 0 to 12.

Bar heights: - 150-152 cm: 3 - 153-155 cm: 8 - 156-158 cm: 4 - 159-161 cm: 11 - 162-164 cm: 7 - 165-167 cm: 3 - 168-170 cm: 1 - 171-173 cm: 5 - 174-176 cm: 5

The tallest bar is for the height range 159-161 cm, indicating it is the most common height range in this group. There is a notable peak at this range and a dip in frequency for the range 168-170 cm, which has the lowest frequency.

[Generated by AI]

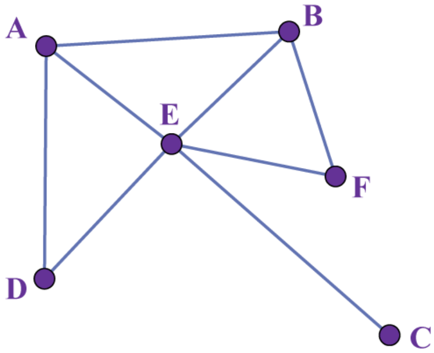


More information

The image is a graph depicting a parabolic curve. The X-axis, labeled as 'x', ranges from approximately -3 to 3. The Y-axis, labeled as 'y', ranges from approximately -1 to 4. The parabola opens upwards and is centered at the origin (0,0). Key points include the vertex at (0,0) and the curve passes mirror symmetrically through the points (-1, 1), (1, 1), and (-2, 4) and (2, 4). The graph is on a grid layout, with major grid lines dividing each unit.

[Generated by AI]

In this section, you will begin to explore a different type of graph, one that is made using vertices and edges. The graph shown below has six vertices labelled with letters A through F. Each of the lines that connect two vertices is called an edge.



Student view

More information

The image is a graph consisting of six vertices labeled A, B, C, D, E, and F. Each vertex is a point, and lines connect certain pairs of vertices, representing edges. Vertex A is connected to vertices B, E, and D. Vertex B connects to A, E, and F. Vertex C connects to F and E. Vertex D connects to A and E. Vertex E, situated centrally, is connected to all other vertices: A, B, C, D, and F. Vertex F connects to B, E, and C, forming a complex network of interconnections among the vertices.

[Generated by AI]

Important

A graph, G, is a figure that contains vertices, V, and edges, E.

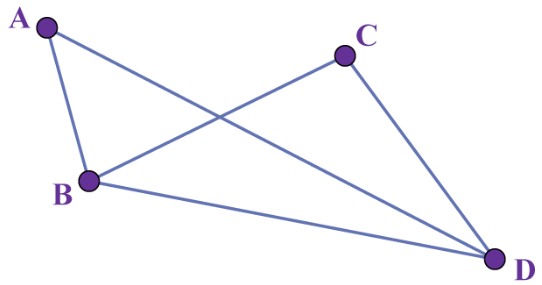
The order of a graph, $|V|$, is defined as the number of vertices in the graph.

The size of the graph, $|E|$, is defined as the number of edges in the graph.

Example 1

★☆☆

State the order and size of the graph shown in the figure below.



Student view

Overview
(/study/ap
ai-
hl/sid-
132-
cid-
761618/ov

More information

The graph shown is a simple connected graph with four nodes labeled A, B, C, and D. There are edges connecting these nodes: A is connected to B and C, B is connected to C and D, and C is connected to D. The layout forms a quadrilateral shape with an intersecting diagonal between nodes B and C, creating a criss-cross pattern. There are no isolated nodes, and each node has a degree of at least two. This forms a complete quadrilateral, showcasing connections between each of the four nodes.

[Generated by AI]

Steps	Explanation
Count the number of vertices to determine the order.	As there are four vertices (A , B , C and D), the order of the graph is 4.
Count the number of edges to determine the size.	As there are five edges (AB , AD , BC , BD and), the size of the graph is 5.

Consider how the edges were labelled in the solution for **Example 1**. The first edge was AB, which means the edge connects vertices A and B. What does this notation tell you about the vertices A and B?

Important

In graph theory, when two vertices are connected by an edge, they are called adjacent vertices.

Similarly, when two edges share a common vertex, they are called adjacent edges.

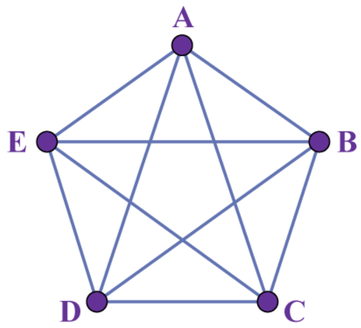
Student view

Example 2

★★☆

Overview
(/study/app/math-ai-hl/sid-132-cid-761618/ov

List all of the edges that are adjacent to the edge AB in the graph shown in the figure below.



More information

The image is a graph diagram with five vertices labeled A, B, C, D, and E, forming a pentagon. The vertices are connected by edges as follows: (AB), (AC), (AD), (AE), (BC), (BD), (BE), (CD), and (DE). The vertices A, B, C, D, and E are arranged in a clockwise manner, starting from A at the top. The problem asks to list all edges adjacent to the edge (AB). These include edges (AE), (AD), and (AC) as they all connect with vertex A, and edges (BE), (BD), and (BC) as they connect with vertex B.

[Generated by AI]

Steps	Explanation
To find the adjacent edges, consider the edges that share a common vertex with AB:	The edges BC, BD and BE are all adjac to edge AB since they share vertex B. The edges AC, AD and AE are all adjac to edge AB since they share vertex A.

Student view

Overview
(/study/app/math-ai-hl/sid-132-cid-761618/ov

Another important feature of the graph is the degree of the vertex. Consider again the graph shown in **Example 1**. How many edges are connected to each vertex? What about the vertices in the graph shown above.

Important

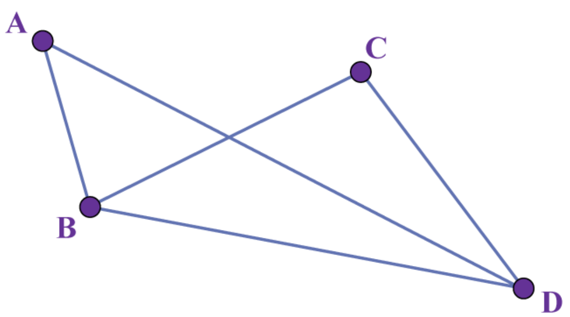
The degree of a vertex is defined as the number of edges that connect to the vertex.

These edges are said to be incident to the vertex.

Example 3

★☆☆

Write down the value of $\deg(\mathrm{A})$, the degree of vertex A.



More information

A graph with four vertices labeled A, B, C, and D. Vertex A is connected by edges to both vertices B and C. Vertex B is connected to D and C. Vertex C is connected directly to D. This forms a network of triangular shapes between the vertices. Each line is a connection or edge between two points. The goal is to determine the degree of vertex A, which is the number of edges connected to it.

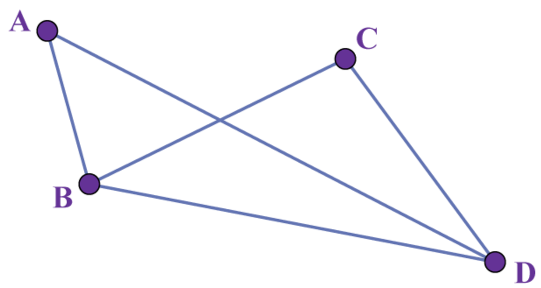
[Generated by AI]

Student view

Overview
(/study/ap
ai-
hl/sid-
132-
cid-
761618/ov

Step	Explanation
Count the number of edges incident to vertex A to determine its degree.	$\deg(\mathrm{A}) = 2$ since there are two edge incident to vertex A.

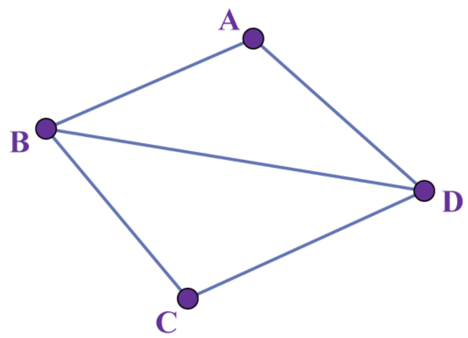
Activity



More information

The image depicts a geometric diagram with four labeled points: A, B, C, and D. These points are connected by straight lines to form a closed shape. Starting from point A, a straight line connects to point B, forming one side. From point B, another line extends to point C, creating the second side. A line is drawn from C to D as the third side. Finally, line D connects back to A, completing the shape. There are also diagonal lines connecting A to C, A to D, and B to D. Each line segment forms different angles, contributing to the overall geometric figure.

[Generated by AI]



Student
view

Overview
(/study/app/math-ai-hl/sid-132-cid-761618/ov

More information

The image depicts a graph illustrating a quadrilateral figure formed by points labeled A, B, C, and D. Point A is located at the top center, point B is placed at the far left, point C is at the bottom left, and point D is at the bottom right. The points are connected by straight lines forming a geometric shape. A line segment connects A to B, another connects A to D. Further, lines connect B to C, B to D, and C to D, creating a network of lines among these points. The structure and connections form a closed geometric shape.

[Generated by AI]

Consider the two graphs shown in the figure above. Let the graph on the left be graph G and the graph on the right be graph H .

1. Compare the two graphs by measuring the following:
   a) The order of the graphs
   b) The size of the graphs
   c) The degree of each vertex within the graphs
   d) Which vertices within the graphs are adjacent to each other
2. What do your findings tell you about these two graphs?

Important

When drawing a graph, the actual positions of the vertices and the lengths of the edges are not important. Rather, it is the connections between the vertices (represented by the edges) that are crucial.

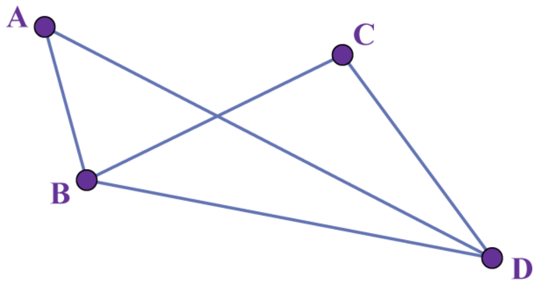
For this reason, it is often beneficial to draw graphs such that vertices are not clumped together and the number of edges that cross each other is minimised. Some graphs can even be drawn or rearranged so that no edges cross.

These graphs are called planar graphs.

Activity

Student view

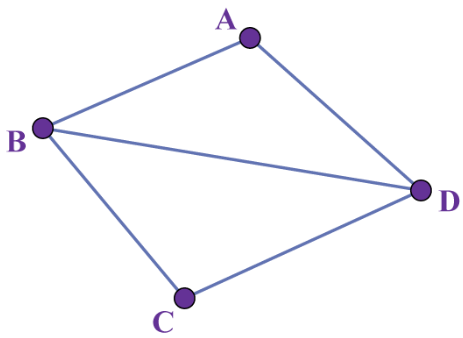
Overview
(/study/app/math-ai-hl/sid-132-cid-761618/ov



More information

The image is a graph consisting of four nodes labeled A, B, C, and D. The nodes are interconnected by lines, forming a network. Node A is connected to nodes B and C. Node B is connected to nodes C and D. Node C is connected to node D. The graph seems to form a geometric shape that resembles a loop with crisscrossed connections in the center. Each connection between nodes is represented by a straight line.

[Generated by AI]



More information

The image is a diagram of a quadrilateral formed by points A, B, C, and D. Points A, B, C, and D represent the vertices of the quadrilateral, each labeled clearly. Lines connect A to B, B to C, C to D, and D back to A, forming the perimeter of the shape. There is an additional line connecting B to D, creating a diagonal within the quadrilateral, dividing it into two triangles. The diagram illustrates the geometric relationships and connectivity between the vertices with a focus on the shape's structure.

[Generated by AI]

Student view

Overview
(/study/app/math-ai-hl/sid-132-cid-761618/ov

1. Consider again the graphs G and H shown above.
   Describe how and which vertices of G can be moved to create graph H.
2. In the applet shown below, drag some of the vertices to transform it into a planar graph.

Interactive 1. Transforming Vertices into a Planar Graph.

More information for interactive 1

This interactive provides an engaging way to explore planar graphs—graphs that can be drawn on a flat surface without any of their edges crossing.
The activity helps users develop a visual and conceptual understanding of graph planarity by allowing them to manipulate vertex positions directly. On the screen, users see five red dots (representing vertices) connected by straight blue lines (representing edges). These dots can be clicked and dragged to new positions on the 2D plane, and as the user moves them, the edges dynamically update, making it easy to experiment with different layouts. The goal is to find a configuration in which no edges intersect. To assist with this, a button labeled “Check solution” at the bottom of the screen provides immediate feedback—displaying “Correct” if the graph is planar or “Try again” if edge crossings remain. An additional feature, “Show intersection points,” highlights all edge crossings with white dots, helping users identify problem areas. A toggle slider offers two difficulty levels: Level 1 presents a simpler graph with five vertices, while Level 2 introduces a more complex structure with seven vertices for advanced exploration.
Users can also click the “New Graph” button to generate a new graph for continued

Student view

practice.

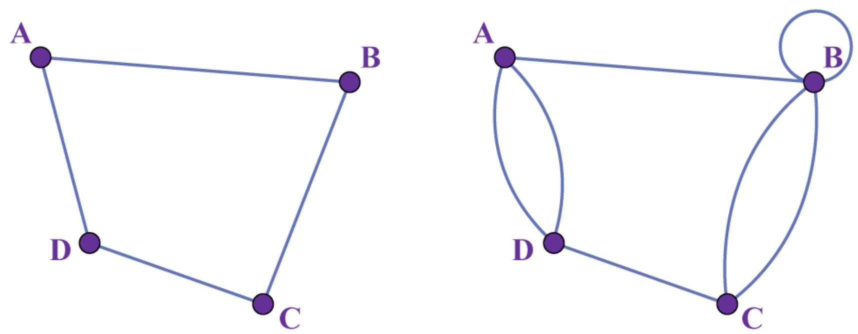
This interactive encourages trial-and-error learning and strengthens spatial reasoning by challenging users to reposition vertices to eliminate edge overlaps. It also builds foundational understanding in discrete mathematics, particularly in areas related to graph theory and algorithm design.

3. When transforming a graph into a planar graph, how can you quickly work out where to place the vertices?

3 section questions

Types of graphs

Simple graphs



More information

The image depicts two graphs with vertices labeled A, B, C, and D. The graph on the left is a simple graph with edges connecting A to B, B to C, C to D, and D to A, forming a quadrilateral. The graph on the right is a multigraph, which includes multiple edges between vertices and a loop. In this graph, A is connected to B, B is connected to C, C to D, and D back to A, forming a similar quadrilateral structure. Additionally, there are two parallel edges between vertices A and D, as well as a loop on vertex B, indicating the presence of multiple connections.

Student view

Overview
(/study/app/math-ai-hl/sid-132-cid-761618/ov

[Generated by AI]

Consider the two graphs shown above. Note that in the graph on the right there are multiple edges between vertices A and D. This type of graph is called a multigraph . Can you think of some real-world applications of graphs in which there are two (or more) edges connecting the same two vertices? (For a hint, think back to the video you watched in section 3.14.0 (/study/app/math-ai-hl/sid-132-cid-761618/book/the-big-picture-id-28226/).)

Now consider the edge that begins and ends at vertex B. This type of edge is called a loop .

Can you think of any examples of how a loop could be used to model a real-world situation?

Important

A simple graph is one that does not contain loops or multiple edges. A simple graph is also unweighted and undirected.

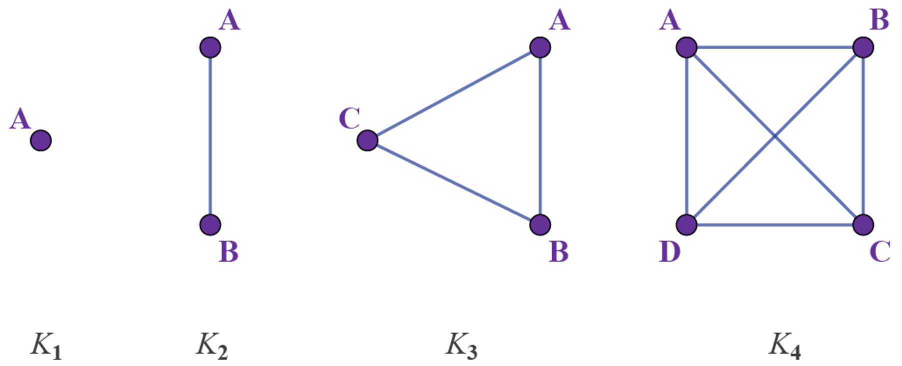
Complete graphs

Look at the four simple graphs below. In each of them, every vertex is connected to every other vertex. These graphs are called complete graphs.

For a complete graph, once the number of vertices is known, then there is a unique way of connecting the vertices with edges. For any number of vertices n, the unique graph is denoted by K_n.

Student view

Overview
(/study/app/math-ai-hl/sid-132-cid-761618/ov



More information

The image displays illustrations of complete graphs, labeled as K1, K2, K3, and K4, from left to right.

- **K1**: A single vertex labeled A.
- **K2**: Two vertices labeled A and B, connected by an edge, forming a simple line.
- **K3**: Three vertices labeled A, B, and C, connected to form a triangle, with each vertex connected to the other two.
- **K4**: Four vertices labeled A, B, C, and D arranged in a square with each vertex connected to every other vertex, including diagonal connections.

[Generated by AI]

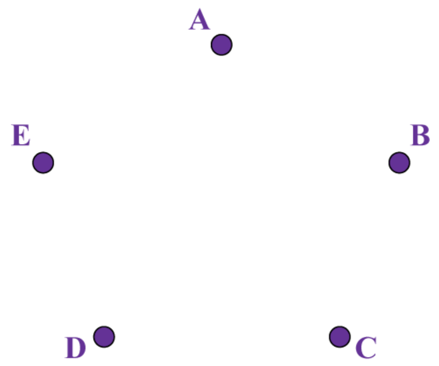
Important

A complete graph, K_n , is a simple graph such that each of its vertices is incident to every other vertex in the graph.

Exam tip

Recall from the activity in section 3.14.1 (/study/app/math-ai-hl/sid-132-cid-761618/book/basic-graph-theory-id-28227/) , that the actual position of the vertices is not important. Therefore, if the vertices in the graphs, shown above, were moved around, they would still represent the same four complete graphs, K_1 to K_4 .

Student view



More information

This is a diagram depicting a graph with five vertices labeled A, B, C, D, and E. The vertices are connected with lines that form a specific path: there is a direct line between A and B, B and C, C and D, D and E, and finally E and A, forming a pentagon shape. There are no crossings or additional connections between non-adjacent vertices. Each vertex represents a node in the graph, and each line represents an edge connecting two nodes.

[Generated by AI]

Activity

1. Copy the five vertices shown above onto a piece of paper, and use them to create the graph K_5 .
2. Compare your final graph to the one in **Example 2** of section 3.14.1 (/study/app/math-ai-hl/sid-132-cid-761618/book/basic-graph-theory-id-28227/).
3. How many edges does the graph K_5 have?
   What is the order of each vertex in the graph K_5 ?
4. Draw the graph K_6 , count the number of edges and determine the order of each of the vertices.
5. Use your results from above and the previous four graphs $K_1 - K_4$ to predict the number of edges that are in the graph K_9 and the order of each of the vertices.
6. What expression can be used to state the number of edges in K_n ?
   What about the order of the vertices in K_n ?
7. How would you arrange the vertices if you were to continue drawing complete graphs for larger values of n ?

Student view

Overview
(/study/app/math-ai-hl/sid-132-cid-761618/ov

Important

For the complete graph K_n , the degree of every vertex is equal to $n-1$ and the total number of edges in the graph, which is the size of the graph, is equal to $\frac{n(n-1)}{2}$.

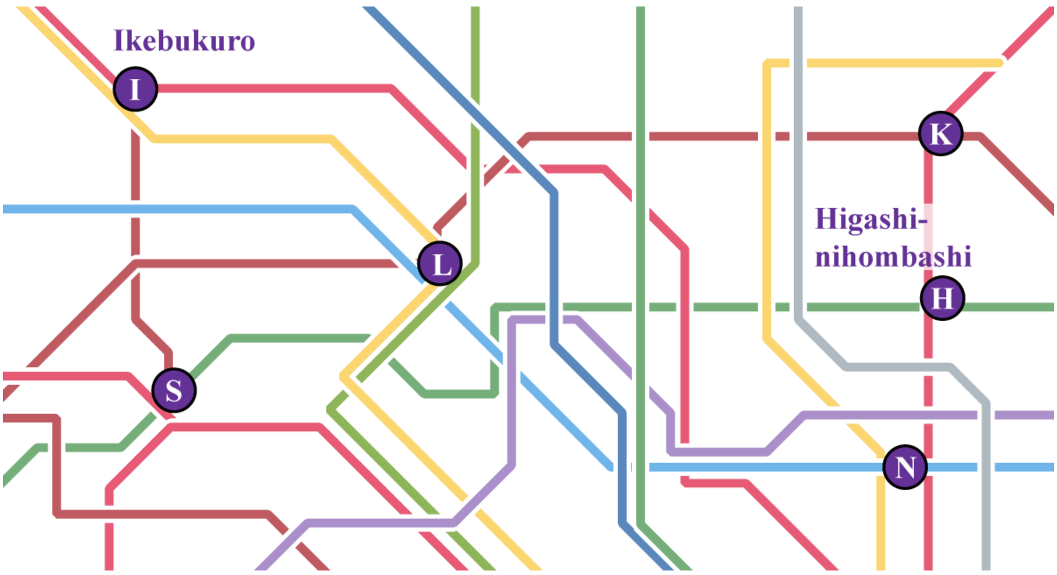
5 section questions

3. Geometry and trigonometry / 3.14 Introduction to graph theory

Weighted and directed graphs

Section Student... (0/0) Feedback Print (/study/app/math-ai-hl/sid-132-cid-761618/book/weighted-and-directed-graphs-id-28229/print/) Assign

Weighted graphs



More information

The image is a partial map of the Tokyo subway network, illustrating routes and connections between several key stations. The background is black with multiple colored lines crisscrossing the map, each representing different train routes. Key stations are marked with bold letters and additional text annotations. The station marked as 'I' is labeled \'Ikebukuro\', and 'H' is labeled \'Higashi-nihombashi\'. Additional noticeable stations include L, S, K, and

Student view

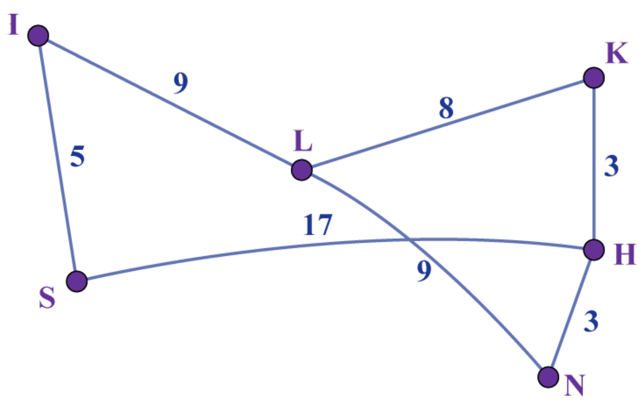
Overview (/study/app/math-ai-hl/sid-132-cid-761618/ov

N. Each station is a node on the map with various colored lines indicating possible routes to other stations. The challenge presented involves figuring out how many different combinations of trains one can use from 'Ikebukuro' to 'Higashi-nihombashi', and determining the quickest route possible.

[Generated by AI]

The illustration above shows a partial map of the subway network in Tokyo, Japan. Imagine that you are currently at the Ikebukuro station (vertex I) and you want to go to the Higashi-nihombashi station (vertex H). How many different combinations of trains can you use to get to the Higashi-nihombashi station? Which combination is the quickest?

You can answer such questions using a graph like the one below. Note that each of the edges has now been given a weight . In this case, each weight represents the length of time (in minutes) that a train takes to travel from one station to another. This type of graph is called a weighted graph .



More information

The image depicts a weighted graph representing a network of train stations. Nodes are labeled with capital letters: A, L, S, K, H, and N. Each node is connected by edges with numerical values indicating the travel time in minutes between the stations. The connections are as follows:

- A is connected to S with a weight of 5.

Student view

Overview
(/study/app/math-ai-hl/sid-132-cid-761618/ov

- A is connected to L with a weight of 9.
- A is connected to K with a weight of 9.
- L is connected to K with a weight of 8.
- L is connected to H with a weight of 17.
- H is connected to N with a weight of 3.
- H is connected to K with a weight of 3.
- L is connected to N with a weight of 9.

This structure forms a network demonstrating how long it takes for a train to travel between each pair of stations.

The graph visually illustrates the connectivity between the stations and the associated travel times.

[Generated by AI]

Exam tip

In the IB examinations, the weights of the edges in a weighted graph could represent time, distance, or cost depending on what is represented by the graph.

To choose the quickest route to get to the Higashi-nihombashi station, you would select the combination of edges with the lowest total weight.

Example 1

★☆☆

Using the graph above determine the quickest route to get from Ikebukuro station (vertex I) to Higashi-nihombashi station (vertex H).

Student view

Overview (/study/app/math-ai-hl/sid-132-cid-761618/ov

Steps	Explanation
To find the best route, find the combination of edges that has the lowest combined weight.	The quickest route according to the graph is IL to L KH. The total weight for this combination of edges i All other combinations have a total weight greater th 20.

As an interesting side note, consider the route IS to SH in the diagram above. Although this has a total weight of 22, it requires only one change of train. Therefore, on some days, this route could be quicker as you may spend less time waiting for a train to arrive at the stations.

Be aware

This simple example demonstrates the concept of weighted graphs. Methods to find solutions to problems involving weighted graphs will be studied in more detail in section 3.16 (/study/app/math-ai-hl/sid-132-cid-761618/book/the-big-picture-id-28238/).

International Mindedness

Google Maps has become very useful for many people all over the world. However, it is interesting to note where its coverage extends to and where it does not. Consider the information that Google provides about its coverage here (https://developers.google.com/maps/coverage). What are the possible factors for each country that could determine whether Google Maps includes all the relevant information for that country?

The street view functionality of Google Maps is also interesting. The information here (https://en.wikipedia.org/wiki/Coverage_of_Google_Street_View)details the countries where street view is available and those where it is not. Are there different factors that countries should consider when determining whether to allow the street view functionality?

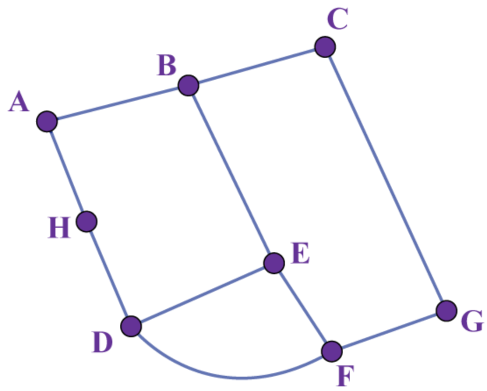
Student view

Overview
(/study/app/math-ai-hl/sid-132-cid-761618/ov

Directed graphs

Making connections

Recall from section 3.14.2 (/study/app/math-ai-hl/sid-132-cid-761618/book/types-of-graphs-id-28228/) that a graph can be used to model the streets in a city.



More information

The image shows a partial map of a London neighborhood alongside a graph that represents the streets in the area. The map on the left features blocks of buildings surrounded by intersecting streets. The graph on the right consists of nodes labeled A through H connected with lines, representing the streets. Each line equates to a street segment that is a one-way path, indicating directionality. The graph serves as a simplified model of the map, allowing for analysis and problem-solving regarding city layout and traffic flow.

[Generated by AI]

A small part of a London neighbourhood is shown above along with a graph that could be used to model the streets shown on the map. It is like the weighted graph discussed in section 3.14.2 (/study/app/math-ai-hl/sid-132-cid-761618/book/types-of-graphs-id-28228/). However, note that the streets in this map are all one-way streets. How can you include this information in the graph?

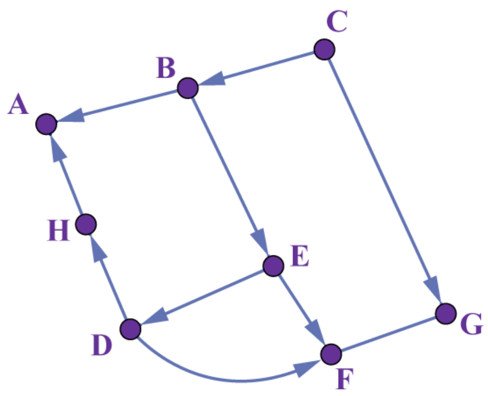
Student view

Overview
(/study/ap
ai-
hl/sid-
132-
cid-
761618/ov

Important

A directed graph, or digraph, is a graph whose edges have a specific direction. The edges are called directed edges.

The diagram below has directed edges to show in which direction cars are allowed to travel between the junctions.



More information

The diagram represents a series of junctions and directed paths. Each junction is labeled with a letter from A to H. The paths include arrows showing the direction of permitted car travel between these junctions. The path sequence is as follows:

- From A, there is a path to H.
- From H, the path goes to D.
- From D, the path moves to E.
- From E, the sequence splits into two separate paths: one leading to F and the other back to C.
- From F, there is a path to G.
- From G, the path goes back to C.
- From C, there is a path back to B.
- Finally, from B, the path leads back to A.

The diagram shows all the allowed directions for cars to travel between these nodes.

Student
view

[Generated by AI]

Important

The in-degree of a vertex in a directed graph is equal to the number of adjacent edges that have a direction **into the vertex** .

The out-degree of a vertex in a directed graph is equal to the number of adjacent edges that have a direction **out of the vertex.**

Example 2

★★☆

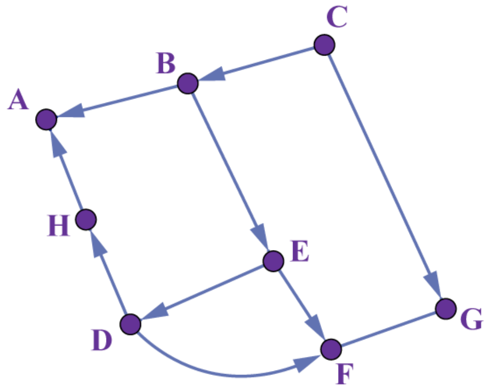
Write down the in-degree and out-degree of vertex E in the graph shown above.

Steps	Explanation
To find the in-degree of a vertex, count the number of adjacent edges that have a direction into the vertex.	Only one edge connected to vertex E h direction into the vertex. Therefore, the degree is 1.
To find the out-degree of a vertex, count the number of adjacent edges that have a direction out of the vertex.	Two edges connected to vertex E have direction out of the vertex. Therefore, th out-degree is 2.

3 section questions

Subgraphs

Consider, once again, the directed graph below.



More information

This image is a directed graph containing nodes labeled from A to H. The arrows between the nodes indicate the direction of movement or flow. The node connections are as follows:

- Node A connects to node B.
- Node B connects to node C.
- Node C connects to node G.
- Node G connects to node F.
- Node F connects to node D and node E.
- Node E connects back to node B.
- Node D connects to node H.
- Node H connects back to node A.

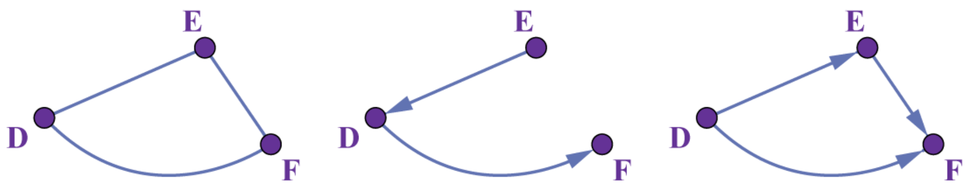
The graph appears to have multiple loops and pathways, showing a complex network of transitions between nodes.

[Generated by AI]

✓ **Important**

A graph is a subgraph if its edges and vertices are contained within another graph. If any edge has a weight or direction, then these must also match those in the other graph for the graph to be a subgraph.

Consider the graphs shown below. Are they all subgraphs of the graph shown above?



More information

The image displays three graph structures. The first graph on the left contains vertices labeled D, E, and F, connected with undirected edges. D is connected to E and F, while E is also connected to F, forming a triangle. The second graph in the middle features the same vertices, but with directed edges: an arrow pointing from D to E, and another from D to F. The third graph on the right displays directed edges from D to F, from E to F, and from E to D. Here, each graph demonstrates various edge orientations that determine subgraph status.

[Generated by AI]

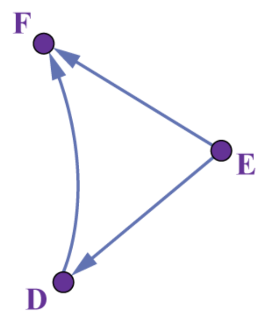
All three of the graphs above have vertices and edges that are in the original graph. However, as you can see, one of the graphs has no directed edges and in another, one of the directed edges is in the opposite direction. For a graph to be a subgraph of a graph, the direction of its edges must match the directions of the edges in the original graph. The only graph that meets that requirement is the one in the middle.

Therefore, the graph in the middle is the only subgraph of the graph given at the start of the section. Note that the middle graph is still considered a subgraph even though it does not include all edges incident between vertices D, E and F in the original graph.

Overview
(/study/app/math-ai-hl/sid-132-cid-761618/ov

Exam tip

Recall from section 3.14.1 (/study/app/math-ai-hl/sid-132-cid-761618/book/basic-graph-theory-id-28227/) that the actual positions of the vertices do not need to be the same for two graphs to be similar. This also applies to subgraphs. The graph below is the same subgraph as those shown above.



More information

The diagram displays a directed triangle with three vertices labeled as D, E, and F. Vertex D is connected to Vertex E by a straight line. Vertex E and Vertex D are both connected to Vertex F by lines with arrows indicating direction. The line from D to F is curved upwards, while the line from E to F is straight. All vertices are marked with purple dots, and the arrows on the lines are blue indicating the direction of connection between the vertices. The diagram demonstrates a subgraph which can be similar to others with different vertex positions but maintaining the same relational structure between the vertices.

[Generated by AI]

3 section questions

3. Geometry and trigonometry / 3.14 Introduction to graph theory

Checklist

Section Student... (0/0) Feedback Print (/study/app/math-ai-hl/sid-132-cid-761618/book/checklist-id-28231/print/) Assign

What you should know

Student view

By the end of this subtopic you should be able to:

Overview
(/study/ap
ai-
hl/sid-
132-
cid-
761618/ov

- describe the basic elements of a graph
- construct a graph with given vertices and edges
- compare the order and size of different graphs
- identify adjacent vertices and adjacent edges
- state the degree of a vertex
- distinguish between simple graphs, weighted graphs, complete graphs and directed graphs
- state the in-degree and out degree of a vertex
- determine whether a graph is a subgraph of another graph.

3. Geometry and trigonometry / 3.14 Introduction to graph theory

Investigation

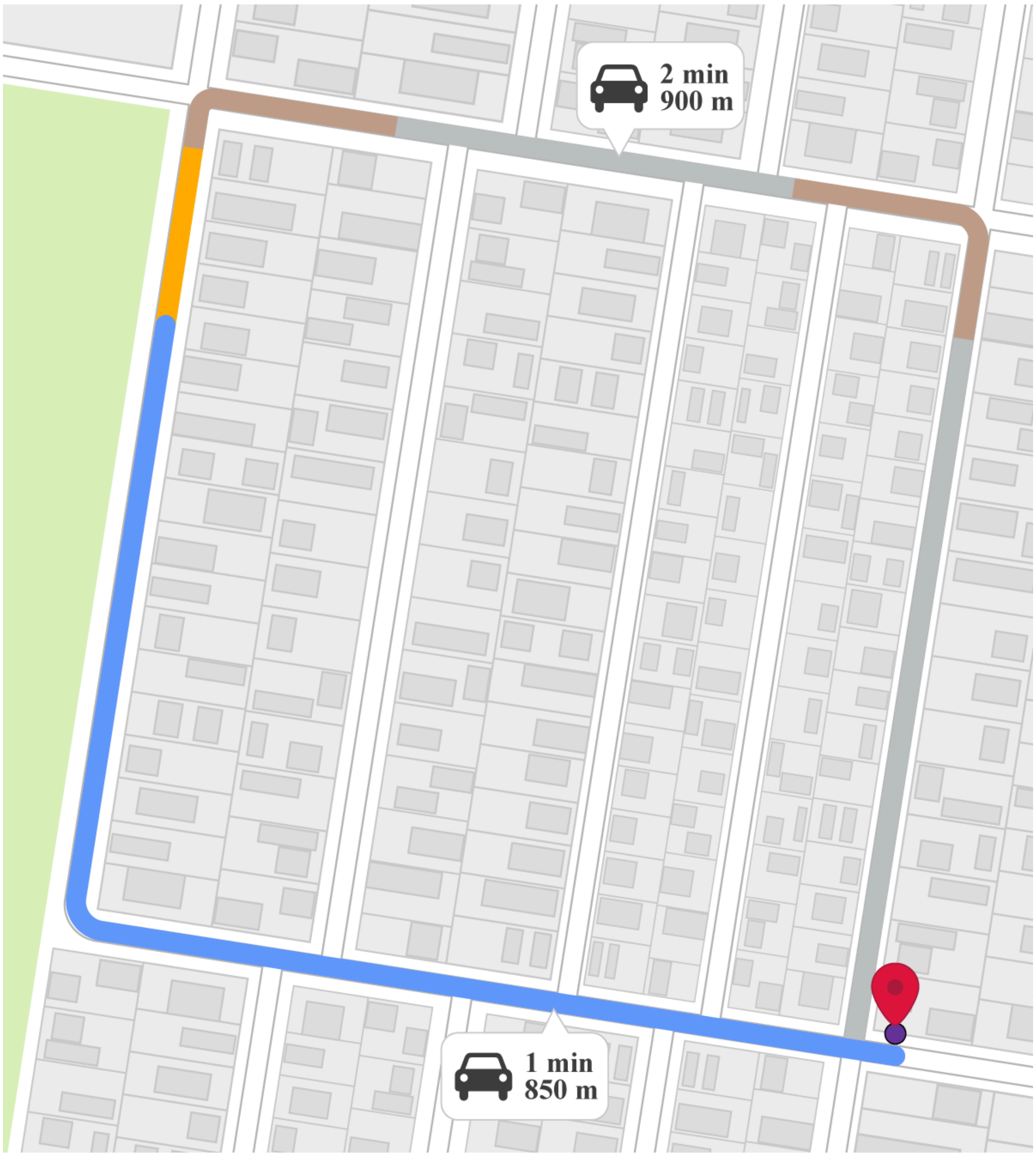
Section Student... (0/0) Feedback Print (/study/app/math-ai-hl/sid-132-cid-761618/book/investigation-id-28232/print/) Assign

A map of a neighbourhood in Sydney, Australia is shown below. Imagine that you are currently at Just Kids Family Day Care Scheme located at the top left of the map and you want to go to Sri Mandir located at the bottom right. How many different combinations of roads can you use to get to Sri Mandir? Which route is the quickest? Which route is the shortest? Does it depend on how you are travelling? What other things might you consider when choosing a route? How would you model this neighbourhood with a graph?

The map shows two suggestions from an online mapping tool. How does it work out the best route between two places?

Student
view

Overview
(/study/ap
ai-
hl/sid-
132-
cid-
761618/ov



More information

The map displays an area with a grid of streets, showing two route suggestions from an online mapping tool. One route is highlighted in blue, indicating a travel time of 1 minute for a distance of 850 meters. The second route is highlighted in orange and brown, indicating a travel time of 2 minutes for a distance of 900 meters. The routes navigate through a residential area with distinct rectangular blocks representing buildings. A significant area on the left of the map is shaded in light green, suggesting a park or open space. Both routes start and end at marked points, with the ending point denoted by a red location pin.

[Generated by AI]

1. Choose a neighbourhood that is familiar to you and find it on an online map.
2. Select a small area of the neighbourhood and model it with a graph.

Student
view

Overview (/study/app/math-ai-hl/sid-132-cid-761618/ov

3. Consider the roads and paths in this area. Why is the traffic slower on some roads? What factors should you consider when working out how long it takes to follow a route?
4. While considering the questions in Step 3, create a weight for each edge (road section) that reflects how long it may take to travel from one end of it the road section to the other. Is the weight the same in both directions? Does it change?
5. Choose two locations on your map and use your graph to determine the best route to get from one location to the other.
6. Ask the online map for the best route and compare it with your answer from Step 5.

The algorithm that online maps use to determine directions is much more complicated than the graphs we have considered in this subtopic. However, this is a basic introduction to graphs and how they are used in navigation systems.

Student view