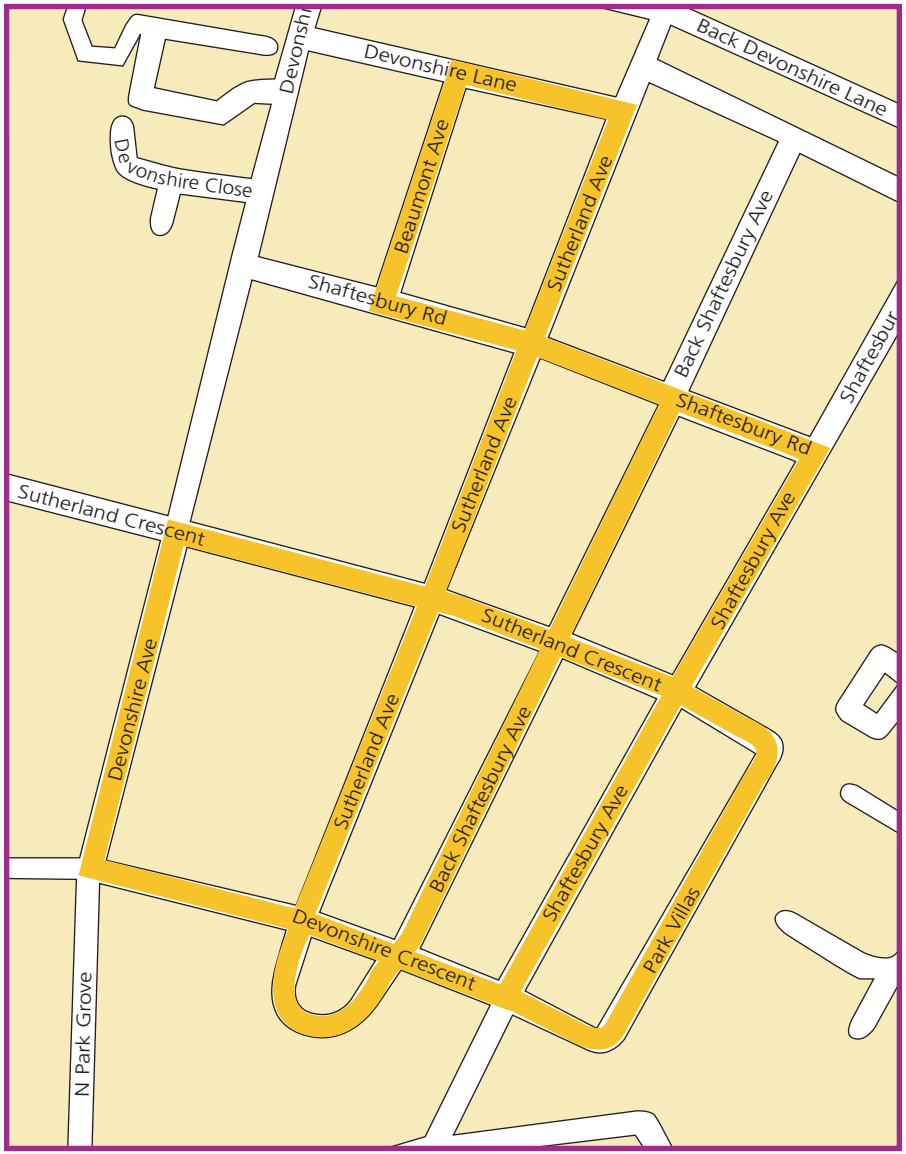
paper rounds

The **mathematics** here is often used at work.
It solves a variety of networking problems.

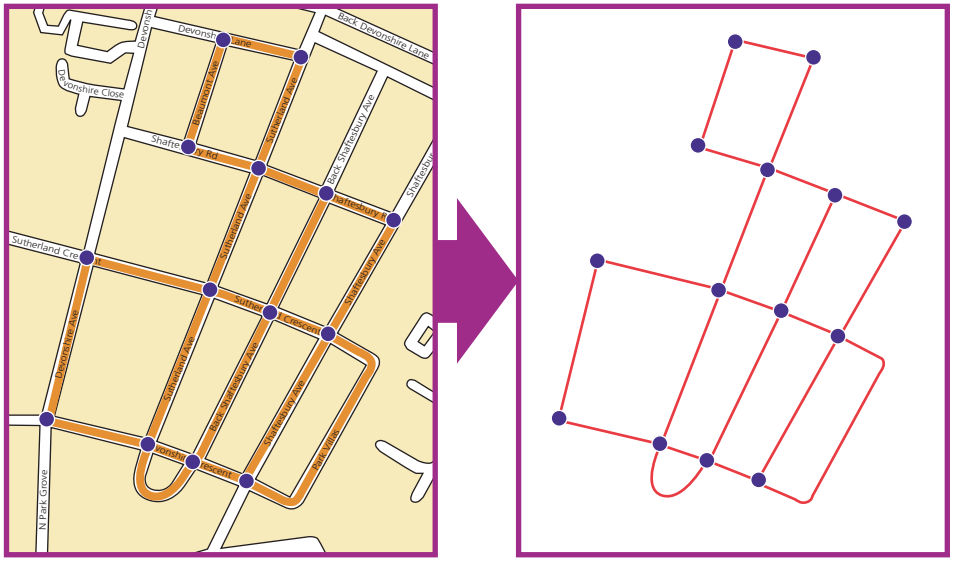
create maths

Getting there

Can you find the best route to deliver to every street?



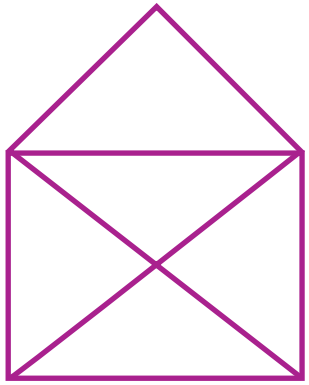
- The roads marked show Pat's paper round.
- The round is some way from Pat's home so the newsagent drops Pat off in her van.
- She also collects her at the end of her delivery.

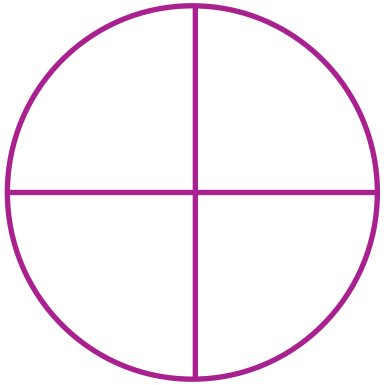


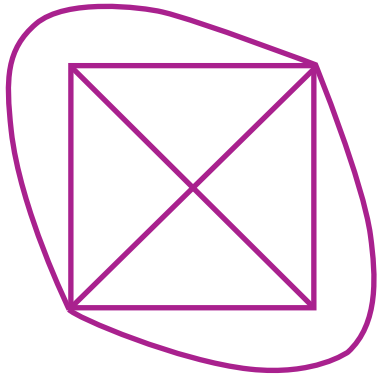
- Pat can save time if she can find a route where she only walks along each road once.
- Where should Pat be dropped off by the newsagent and where should she be picked up at the end of her round?

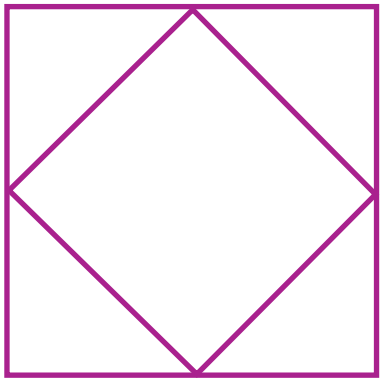
Five of these networks can be traced without taking your pencil off the page.

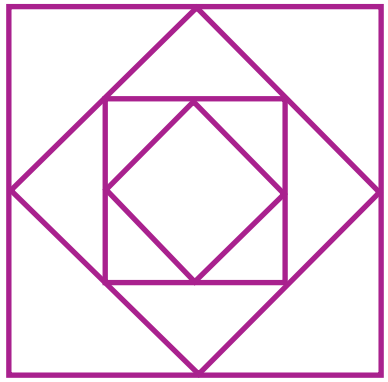
Which ones?

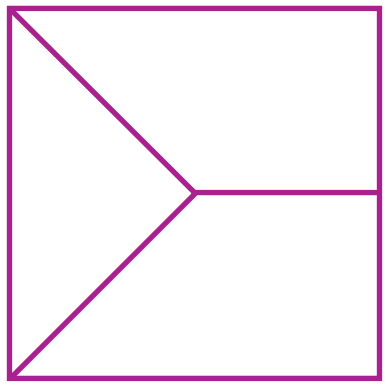






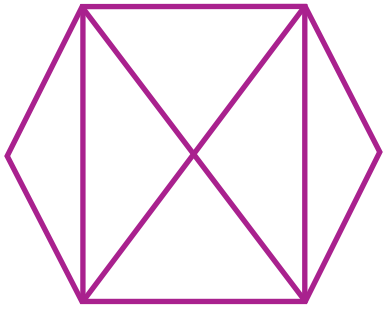


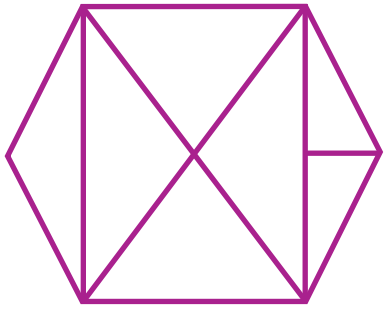


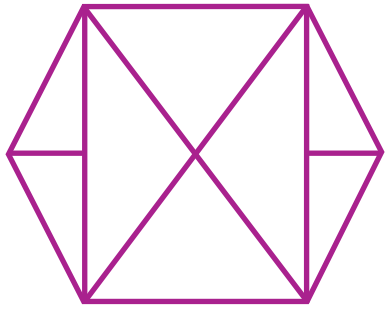


Find a rule which predicts which networks are traceable.

Test your rule with some networks of your own.







create maths

Getting there

cable connections

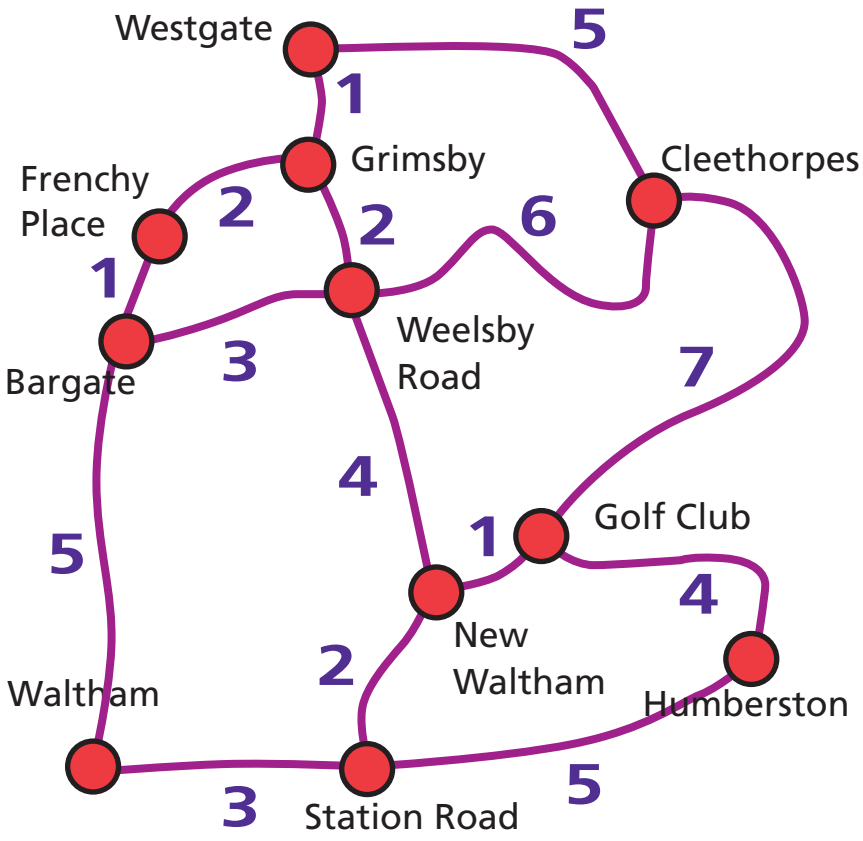
The **mathematics** here is often used at work.
It solves a variety of networking problems.

create maths

Getting there

Can you link these places using the shortest length of cable?

- **Your task** is to plan how to lay cables for a cable TV service between all the places on the map.
- **Laying cable** is very expensive so you need to keep the total length of cable as short as possible.



Distances in kilometres

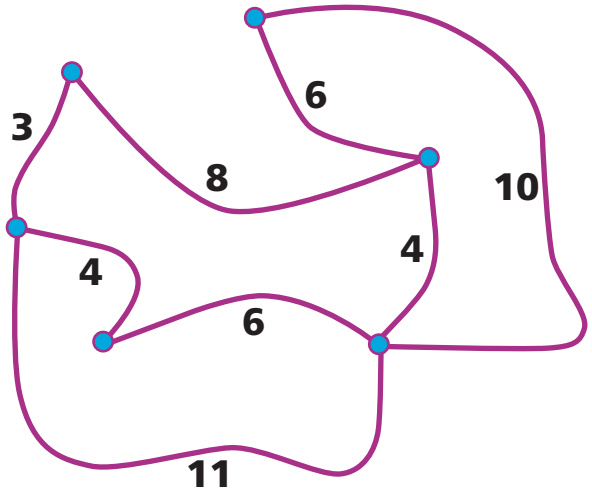
- Make sure all the locations are **connected**. They do not have to be connected directly, as the signals travel along the cables at the **speed of light**!
- You discover that due to planned engineering works it will not be possible to lay cable directly between Weelsby Road and New Waltham.
- What is the **shortest length of cable** required now?

Find the minimum length of cable required to connect all the locations in each of these networks:

create maths

Getting there

1



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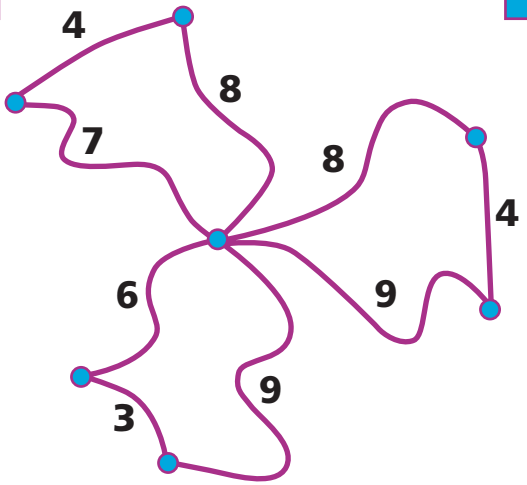

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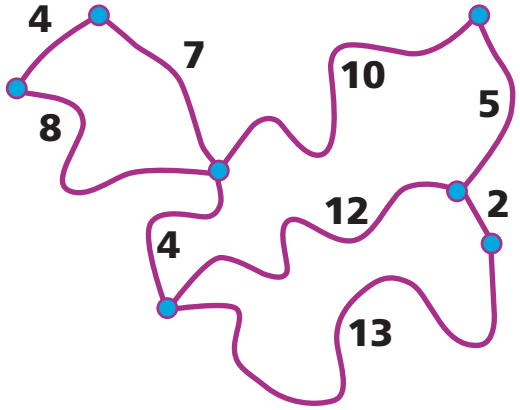

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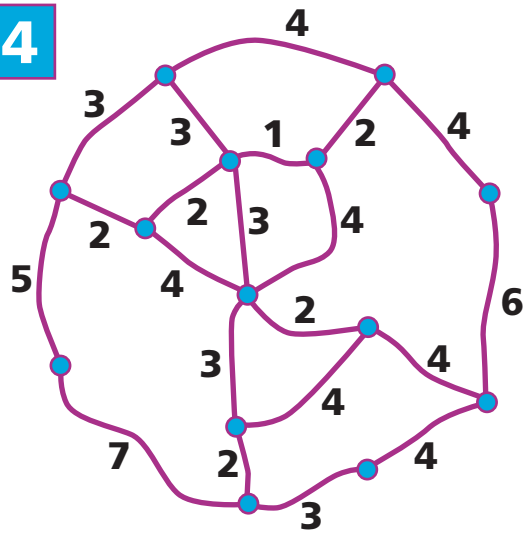

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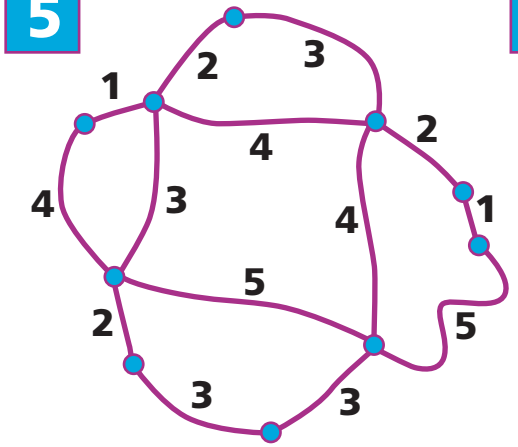

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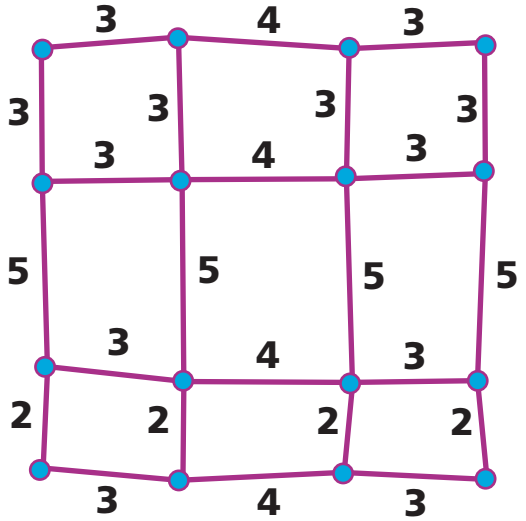


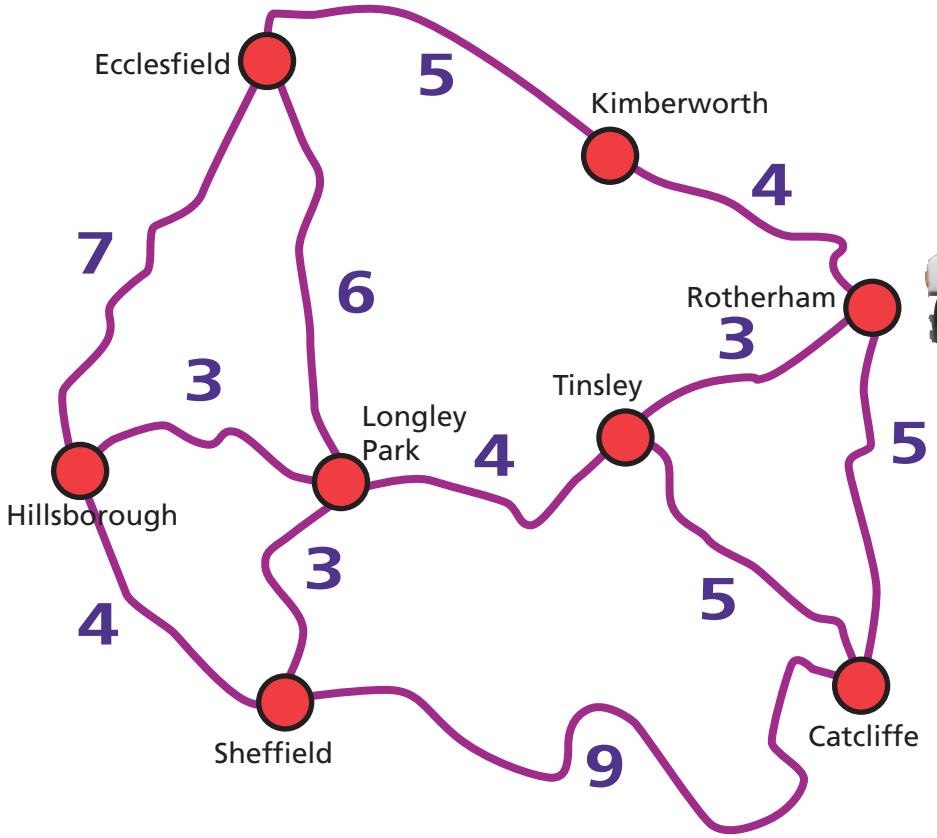
deliveries

The **mathematics** here is often used at work.
It solves a variety of networking problems.

create maths

Can you find the best route to deliver to every town?

- You have to make deliveries to all the places marked in the map, starting from your company's warehouse in Sheffield.



Distances in kilometres

- The numbers beside the roads tell you the distances between the places.
- Your task is to find the shortest route to all the drop-off points, ending up back at the warehouse in Sheffield.

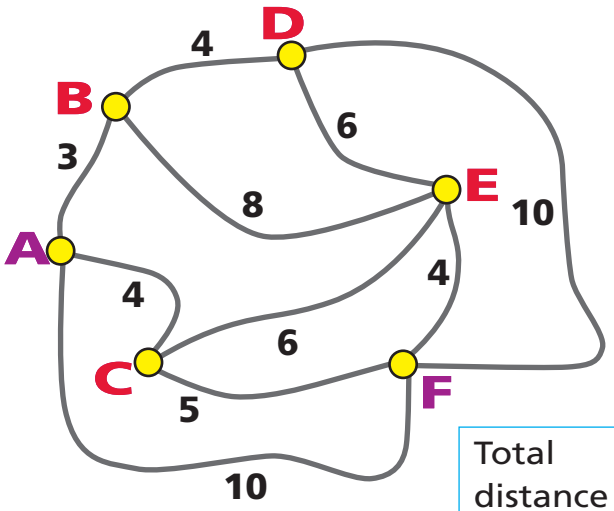
Getting there

In each case, find the shortest route which visits every place.

create maths

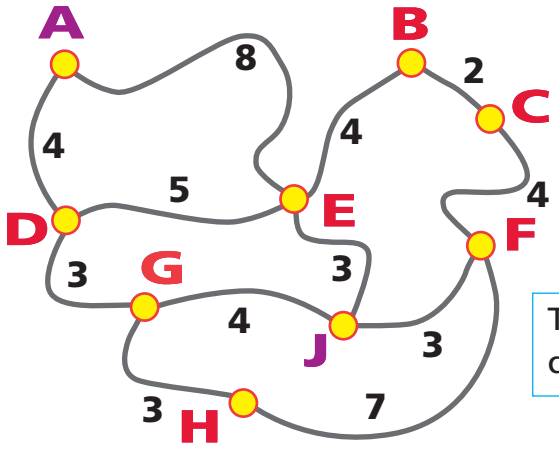
Getting there

1 Start at **A** and end at **F**



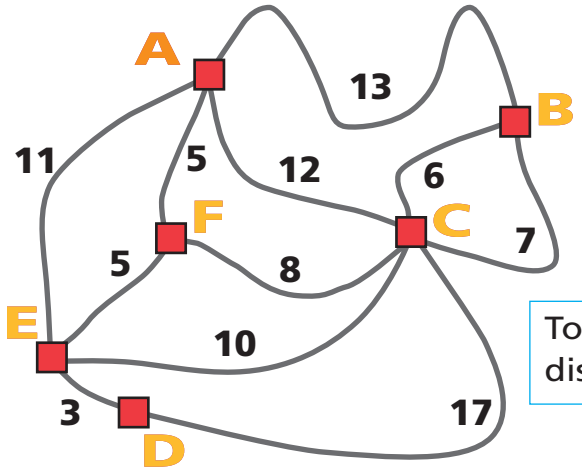
Total distance = _____

2 Start at **A** and end at **J**



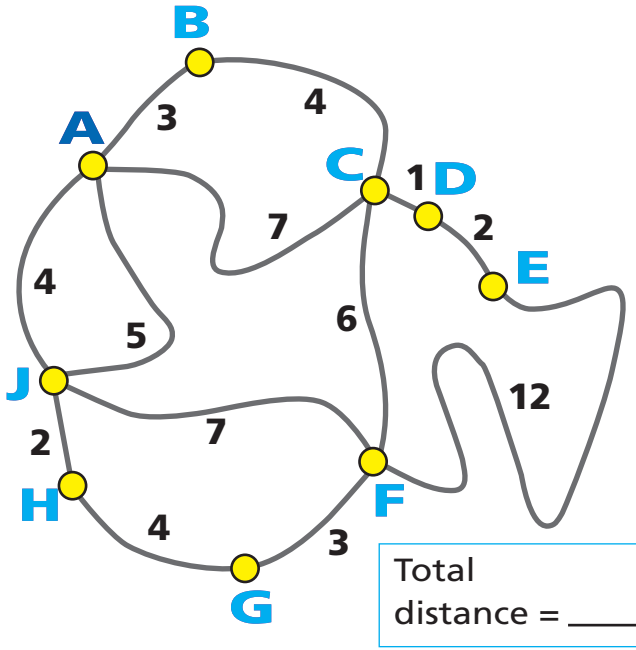
Total distance = _____

3 Start and end at **A**



Total distance = _____

4 Start and end at **A**



Total distance = _____

Teacher notes

Getting there : Working for efficiency

Description

This topic looks at simplified versions of three different network problems that are encountered in practical logistical planning.

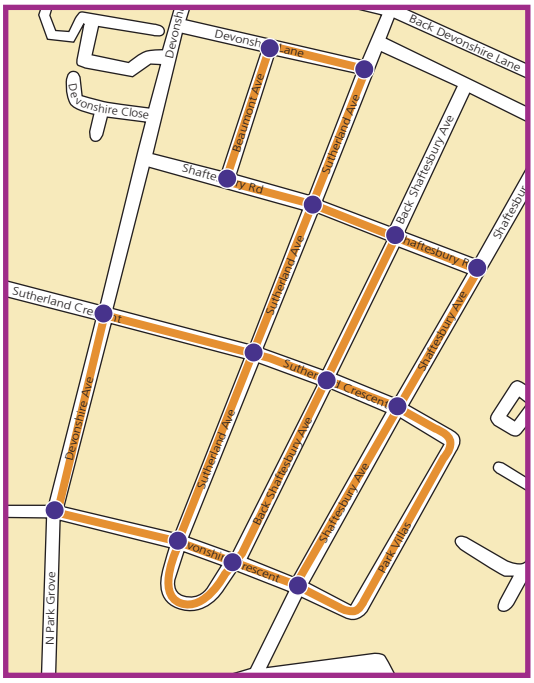
Activity 1: Paper rounds
Activity 2: Cable connections
Activity 3: Deliveries

Edge-traceable graphs are explored in Paper rounds. The starter activity offers a simple version of a practical context in which to explore the concept. The famous mathematician Euler noticed that, to be edge-traceable, a network must have at most two odd nodes.

The worksheet offers opportunities for further exploration and then asks the pupils to search for a rule and to prove their results. At some point it is worth asking: *can you have just one odd node?*

Using tracing paper supports experimenting. For lower attaining pupils, slipping the worksheet into a plastic wallet will allow experimentation using felt tip pens, wiping off incorrect attempts, which may be easier.

Encourage pupils to look for what the edge-traceable networks have in common. Which graphs can be traced whatever starting point is chosen? Which graphs can be traced only if you start, and end, at particular points? Pupils will test out their theories better if they work together.



Cable connections provides a practical example of a minimum connector problem. It is quite possible to find a good or even an optimal solution using trial and improvement methods but the task provides the opportunity to introduce pupils to the key mathematical idea of an algorithm. Prim's algorithm, to find this minimum spanning tree, is quite within the grasp of many pupils, even at key stage 3.

For some of the problems on the worksheet, there is more than one optimum solution.

Prim's algorithm works as follows:

Step 1: *Choose an arbitrary location, say Grimsby, and connect it to the nearest place, in this case, Westgate.* ***Note the distance****.*

Step 2: *Find the nearest place not yet in the solution, in this case either Frenchy place or Wheelsby Road. Whenever you get a choice of connections of equal length, choose either one. Here we have arbitrarily chosen Frenchy place.*

Continue this process until all the locations are connected.

Getting there : Working for efficiency

Deliveries illustrates a very familiar problem in logistics. Finding the shortest route to a set of delivery points will save on both time and money. For a relatively small network like the problem offered here, the shortest route may be found by trial and improvement methods, or by considering all the possible routes. Pupils will develop helpful strategies, for example, they might decide to try to avoid longer stages, like the road which goes directly from Sheffield to Catcliffe.

You can extend this activity for pupils who solve the initial problem by making one or two of the roads one-way, or by making one of the roads impassable. Both of these variations do, of course, represent real features of shortest route problems as applied to road systems.

In this type of problem, the number of calculations needed to exhaust every possibility increases very fast. Because of the very large number of computations required to be sure of the best solution, mathematicians have developed algorithms which give good solutions for problems that are too large to test for every possible solution. Pupils may be intrigued to find out that, to date, there is no known algorithm which can guarantee a best solution for a large number of locations – an unsolved problem in mathematics. If they have derived some helpful strategies, can they find networks where their approach fails to provide the optimal solution?

The mathematics

Paper rounds offers the opportunity for reasoning and proof as the arguments needed to establish Euler's theorem are within their grasp. It also, along with Cable connections and Deliveries, offers opportunities for the mathematical skills of planning, being systematic, recording and logical experiment. The algorithmic thinking developed is picked up in key stage 5 in the decision maths curriculum.