

## Highway Link: Lesson Plans

The Highway Link case study challenges pupils to plan and optimise the route of a bypass for a small village, while ensuring that the proposed route conforms to the mathematical conditions laid down by the Highways Agency. The realities of road geometry and cost minimisation mean pupils engage in the mathematics, but the real-life setting ensures that the mathematics is a means to an end, rather than an end in itself.

Pupils will consider all the issues that need to be taken into account (**Lesson 1**) and then propose, measure and refine routes for the bypass (**Lessons 2 and 3**). Then (**Lesson 4**) groups will share their proposals and a class vote will decide the winner.

During the case study pupils will need to work with ratios and proportions; read tables and graphs; use the relationship between time, length and speed; convert units; represent percentages as decimal numbers (and *vice versa*). Spreadsheet calculators and converters are provided for pupils. Consider your pupils' prior knowledge and skills in these areas, and how they might be learnt and developed within the context of a real-world problem.

The **National Curriculum** links are as follows,

<b>1 Key Concepts</b>	2 <i>Creativity</i>	a Combining understanding, experiences, imagination and reasoning to construct new knowledge. b Using existing mathematical knowledge to create solutions to unfamiliar problems. c Posing questions and developing convincing arguments.
	3 <i>Applications</i>	b Understanding that mathematics is used as a tool in a wide range of contexts
<b>2 Key Processes</b>	1 <i>Representing</i>	a identify the mathematical aspects of a situation or problem b choose between representations d select mathematical information, methods and tools to use
	3 <i>Interpreting and evaluating</i>	b consider the assumptions made and the appropriateness and accuracy of results and conclusions e relate findings to the original context, identifying whether they support or refute conjectures f engage with someone else's mathematical reasoning in the context of a problem or particular situation g consider the effectiveness of alternative strategies.
	4 <i>Communicating</i>	b engage in mathematical discussion of results c consider the elegance and efficiency of alternative solutions
<b>3 Content</b>	1 <i>Number</i>	c applications of ratio and proportion d accuracy and rounding
	2 <i>Geometry</i>	g units, compound measures and conversions
<b>4 Curriculum opportunities</b>		a develop confidence in an increasing range of methods and techniques b work on sequences of tasks that involve using the same mathematics in increasingly difficult or unfamiliar contexts, or increasingly demanding mathematics in similar contexts c work on open and closed tasks in a variety of real and abstract contexts that allow them to select the mathematics to use d work on problems that arise in other subjects and in contexts beyond the school e work on tasks that bring together different aspects of concepts, processes and mathematical content f work collaboratively as well as independently in a range of contexts g become familiar with a range of resources, including ICT, so that they can select appropriately.

## Lesson 1: Setting the scene

*Pupils consider the social issues of bypasses. Don't worry if not much maths gets done, it will from Lesson 2 onwards.*

### Whole class introduction (~30 mins)

Introduce the case study with the **ByPass software** on a whiteboard. Initiate a whole class discussion about the problems too much traffic might cause. Make reference to local roads and areas.

Lead discussion towards bypasses, their benefits and drawbacks. Encourage issues of financial costs, safety, health and pollution, traffic flow and impacts on the natural and human environment to arise.

Explain that length, number of **junctions** (Handout HL4) and terrain affect the cost of a bypass; and that curves and junctions slow traffic down. **Costs** and **speed limits** can be considered qualitatively at this stage.

### Notes

**News stories** (Handout HL2) can stimulate debate; controversial bypasses have resulted in public campaigns either for or against a given bypass (see BBC news footage about the Newbury bypass).

**Stakeholders** (Handout HL1) can be used as a prompt sheet.

You might demonstrate an absurd route to stimulate discussion.

Some pupils may be unfamiliar with terms such as bypass and refinery. The **Glossary** (Handout HL3) sheet may help them.

### Group work (~20 mins)

Organise the class into groups.

Each group prioritises the stakeholder issues they consider important. They must come to agreement within their groups, perhaps by producing a priority list of the interests they consider most important.

Each group then drafts a rough route for a bypass, using pencils and printed maps or the **ByPass software**.

Explain they will modify and improve their routes in the next lessons. Make clear that in the final lesson they will present their final route and a vote will be taken.

### Notes

Pupils might express personal views, or role play a **Stakeholder** (Handout HL1) within their groups. They will be used to role-play from Drama and English lessons.

Pupils might be given an A4 copy of the map each, or each group might share a single A3 copy of the map.

### Whole class plenary (~10 mins)

Ask each group to share and explain its priority issues and route suggestion. Offer prompts and questions for whole class discussion.

### Notes

Pupils might hold up printed maps or display their software route on the whiteboard.

### Homework (optional)

The fill-the-blanks versions of the **Glossary** (Handout HL3) sheets can be used for homework. Pupils will need to research some of the answers.

For a short piece of homework, the **Speed Signs** (Handout HL7) sheet can be used as a delete-the-errors activity.

### Notes

Variations can be considered. You might ask pupils to find out about words and concepts that have arisen during the lesson.

## Lesson 2: Designing the bypass

*Pupils work in groups with software and physical resources.  
They propose, measure and refine routes for the bypass.*

### Whole class (~20 mins)

Hand out or display the **Curves and Speed Limits** (Handouts HL8, HL9) and **Costs** (Handout HL5) sheets. Explain the bypass must be safe yet allow traffic to flow freely, and that costs must be kept to a minimum. Stress there is no right answer and the best solution will be decided by vote.

Discuss the **Speed Signs, Speed Limits, Junctions** and **Glossary** sheets (Handouts HL7, HL6, HL4, HL3).

Introduce and demonstrate the **ByPass software** or **pin-boards**, and user guides. Explain each group will review and refine their rough route from last lesson. They will use the resources to make measurements and calculations, and then try variations on their route.

### Notes

Give out all printable resources here, or stagger them over the two lessons.

Pupils won't necessarily have a grasp of typical speed limits, distances, road and junction types and so on. References to local examples will be helpful.

Alternatives to the software can be used, such as pin-boards or printed maps and stationary.

Introduce the spreadsheet **calculators and converters**, if pupils need support with these areas.

### Group work (~35 mins)

Groups work on measuring and refining their routes.

Circulate, asking groups to justify their work in terms of maths and social issues. Make suggestions and set groups and individual pupils subtasks as appropriate (e.g. "*Find out if it would be cheaper to go through the marsh*"). Stress the importance of ensuring routes are realistic ("*How does your speed limit compare with the road outside the school?*").

Tell the groups to record their work on paper or electronically. By the end of the next lesson will need to have produced a poster, *PowerPoint* presentation or other collaborative format for presenting their ideas in **Lesson 4**. This presentation will need to include information about speed limits, cost, safety, social impact and so on.

### Notes

Pupils might start each lesson with a fresh copy of the map and keep a log of how their thinking has developed

Break group work up with short whole class discussions. This is useful to clarify points, give out printed resources, and asking groups to share ideas.

Distribute **Curves and Speed Limits, Costs** and **Junctions** (Handouts HL8, HL9, HL5, HL4). Pupils may also need the **ByPass Guide** or **Pin-boards Guide**. Provide a table of general maths resources including calculators, rulers, compasses, conversion tables, scissors, glue and so on.

### Whole class plenary (~5 mins)

Ask each group to share and explain how they have refined their route, and how they plan to present their ideas to the rest of the class in **Lesson 4**.

### Notes

Pupils might show how they have recorded their decisions and justifications to the rest of the class.

### Homework (optional)

Pupils might be encouraged to prepare some presentation materials for homework. These might be the start of a *PowerPoint* slideshow, or a draft of what they plan to say when presenting their bypass.

### Notes

### Lessons 3: Refining the bypass

*Pupils continue working in groups, producing a final bypass route by the end of the lesson.*

#### Whole class (~10 mins)

Distribute resources and recap the previous lesson. Remind the groups that by the end of this lesson they need to have produced a poster, *PowerPoint* presentation or other collaborative format for presenting their ideas in **Lesson 4**.

#### Notes

Use whole class questioning to recap the lesson and establish where each group is up to.

#### Group work (~40 mins)

Groups continue and complete their work, producing a final route and a presentation summarising their decisions and reasons.

#### Notes

Resources and activities as for the **Group work** session in **Lesson 2**. Pupils will need to consider how they will break up the presentation amongst themselves in **Lesson 4**.

#### Plenary (~10 mins)

Explain that in the next lesson each group will present their bypass route and explain why their route is best in terms of speed limits, cost, safety, social impact and so on.

#### Notes

If time allows, you might plan to allow groups a further 10 mins or so to complete their presentations at the start of the next lesson.

#### Homework (optional)

Each pupil might rehearse his or her part of the presentation at home.

#### Notes

## Lessons 4: Presentations and voting

*Groups present their work and vote to decide the best proposal.*

### Introduction (~10 mins)

Explain that in this lesson groups will vote on each others' routes to select a winner.

### Notes

For the first few minutes, allow pupils some time to continue, complete and check over their group work from **Lesson 3**.

### Review/Presentation (~30 mins)

There are several options as to how the bulk of the lesson can be run. For example...

**Symposium:** Each group can be given five minutes to present their route to the class

**Display:** Posters, pin-boards and other group products can be displayed round the classroom and pupils circulate with scorecards

**Peer review:** Pupils sit in groups and review the other groups' work.

### Notes

Whole class presentation offers a clear structure and can be a refreshing change after two lessons of bustling group work. However, it can get a bit repetitive if the presentations are too many or too long.

Individual and group review allows more scrutiny of bypass proposals. However it offers groups less opportunity to defend and explain ideas.

### Voting (~10 mins)

There is flexibility on how a winner can be decided. Voting is the obvious choice, although inviting an "expert" (e.g. a Geography teacher) to make the final decision is another option.

### Notes

It's probably best not to let pupils vote for themselves. Emphasise the importance of voting for the best bypass, not for their friends.

Interactive voting systems, such as *Promethean's ACTIVote*, should be used if your school possesses one.

### Plenary (~10 mins)

Declare the winner and conclude the case study.

Ask the pupils to reflect on the case study. How was it similar and different to usual maths lessons? What did the pupils feel they learned? What maths was involved?

### Notes

### Homework (optional)

Pupils might find out about and compare two or three voting systems for homework. The voting system can vary from a simple hand count, through to knock out-rounds by secret ballots. Ballots can involve approval voting (vote for all those you like); ranking (number them in order of preference), and a draw (all votes put in a hat and the one pulled out wins).

### Notes

## Lessons 5: Optional extension work

*Pupils use GoogleEarth to create a map of a real bypass, or town in need of one.*

### Introduction (~15 mins)

Tell the pupils they will create their own map of a real bypass, or a design bypass for town or village that arguably needs one. They will then analyse the bypass and estimate its cost and speed limits.

Demonstrate **GoogleEarth** and show the pupils how to create maps for import into *Word* or the **ByPass software**.

### Notes

This lesson can be done after completing the case study, or before so that pupils use their own **GoogleEarth** maps in place of the provided map.

If **GoogleEarth** is not available, a website such as [maps.google.co.uk/maps](https://maps.google.co.uk/maps), or [multimap.co.uk](https://multimap.co.uk), or printed ordnance survey maps, might be used instead.

### Pupil work (~40 mins)

Distribute the **GoogleEarth Guide**. Pupils work individually, in pairs or in their groups to make a bypass map.

If this lesson is taught after completing the case study then the goals, methods and mathematics of the lesson are the same as those outlined in **Lessons 2 and 3**.

If it is taught prior to, or instead of the case study, then the goals and methods are the same as those outlined in **Lesson 1**.

### Notes

Places from the **news** (Handout HL2) such as Newbury or Ormskirk (which has no bypass yet) might be used. Another option is to use local roads.

### Plenary (~5 mins)

Conclude by asking individuals / pairs / groups to feedback their findings to the rest of the class.

### Notes

### Homework (optional)

Pupils might research the true cost and speed limits of the bypass and find out whether these figures match their own.

### Notes