

# FC091

## Applications of Mathematics

<b>Module Title:</b>	<b>Mathematics for Science and Engineering</b>
<b>Module Code:</b>	<b>FC091</b>
<b>Deadline:</b>	<b>TBC</b>
<b>Hand in to Grey Box outside the LIC Hub</b>	

READ THESE INSTRUCTIONS CAREFULLY BEFORE COMMENCING THE ASSIGNMENT:

- This assignment is worth 25% of your FC091 module total. (An additional 5% comes from a Viva which takes place after submission).
- You may use theories which you may have studied in prior courses and any pre-existing knowledge which is appropriately referenced.
- Late submission/plagiarism will incur penalties up to a maximum of your work being awarded zero marks.
- Poor English will not reduce your mark unless your meaning can not be understood from what is presented.
- An appropriate cover sheet, which is available on the VLE, must be attached to your work.
- The project contains both mathematics and sentences. The mathematics sections must be hand written. The sentences must be typed and then printed out.

## Project Brief

The railway system in the United Kingdom is the oldest in world, with the first inter-city passenger service, between Liverpool and Manchester, opening in 1830. Many of these railways have not changed since that time. Improvements have been made, but only so that single trains can travel between, for example, Liverpool and London instead of passengers needing several different trains.

In 2009 the UK Government, afraid that investment would move to Europe because they have a faster railway network, started a project called High Speed 2 (HS2).

The first part of the work will start building a line between London and Birmingham in 2017 and this line will be 225 kilometres in length.

## Problem One

A tunnel is to be constructed underneath part of the Chilterns, which is an area of outstanding natural beauty. A tunnel must be built to preserve the beauty of the area by hiding the railway line.

The tunnel will be a straight line, of length 7.5 kilometres. There are three designs of tunnel that could be used, shown in Figures 1, 2 and 3 (below).

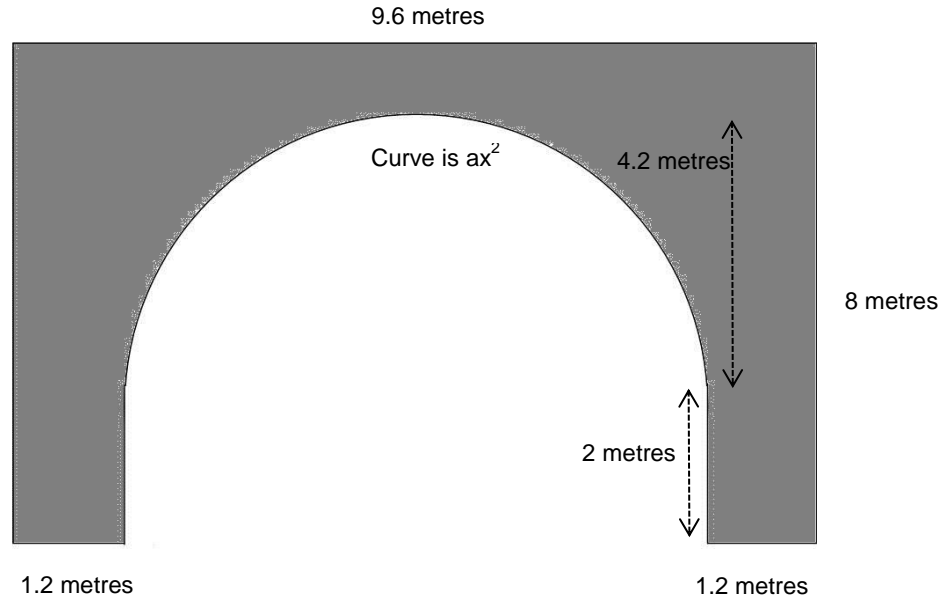


Figure 1

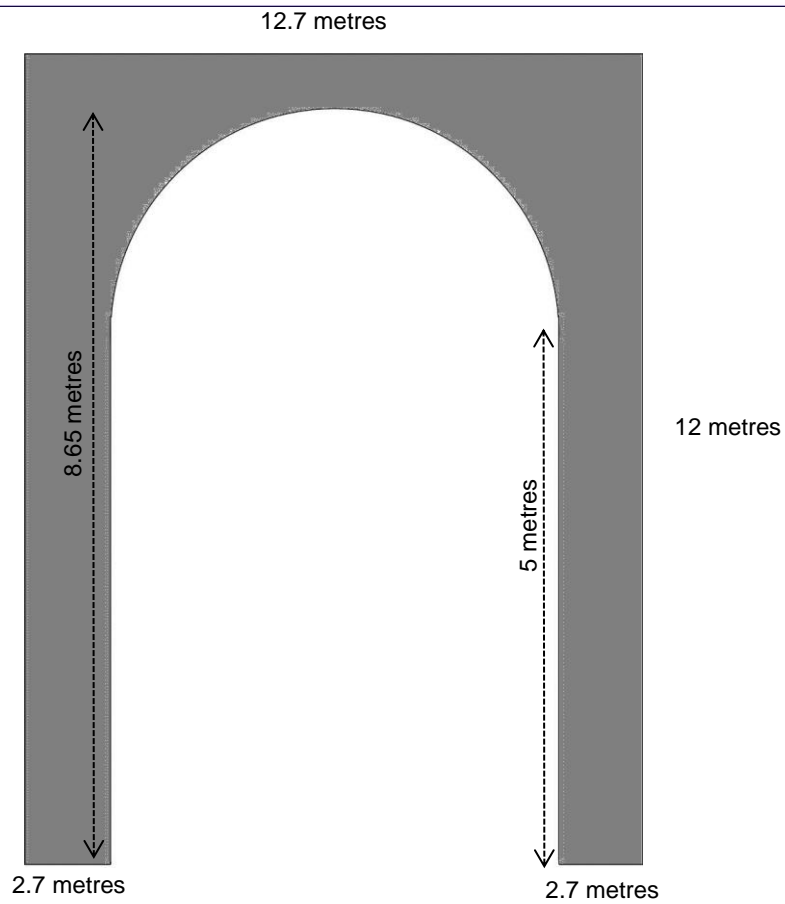


Figure 2

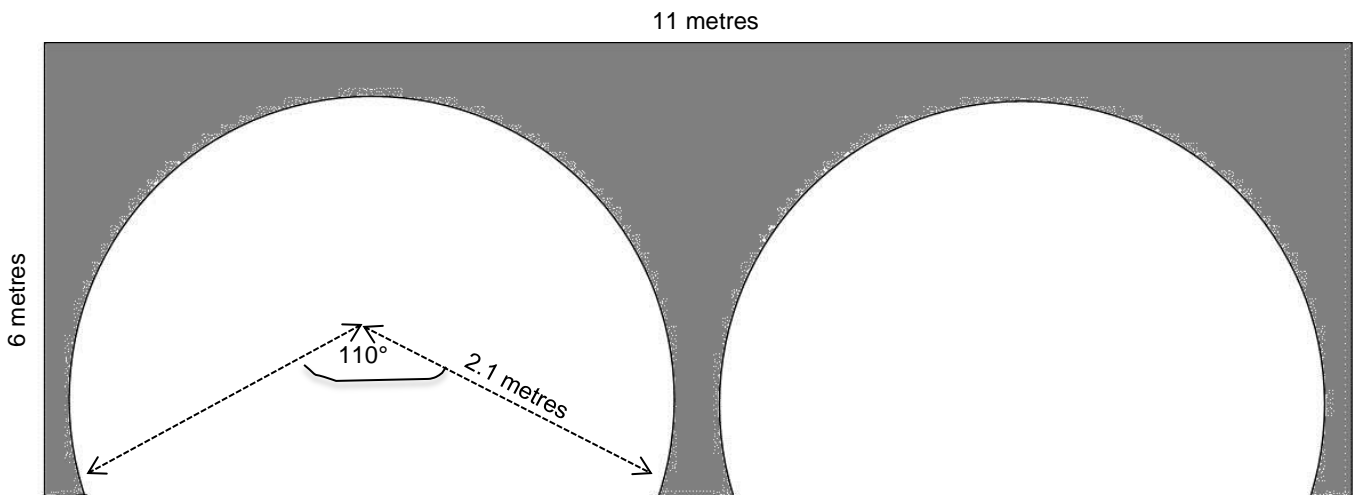


Figure 3

**Task**

- a) For each design of tunnel, work out the volume of concrete that will be needed to fill in the shaded part in each diagram. You must submit a **detailed** and **annotated** set of

mathematical calculations for each tunnel which **clearly** shows all your working. This must be hand written.

- b) Concrete costs £120 per m<sup>3</sup>. Work out how much each tunnel will cost to construct. This must be hand written.
- c) Write a **brief** statement, maximum 300 words, outlining which one tunnel you would choose to construct and why. You must make reference to several sources to support your work and your finished words must be typed. Be careful to include as much detail as possible to support your answer.

### Problem Two

All trains need to run to a timetable so that passengers may find the train they want to use easily and conveniently. When the line is opened a timetable must be produced.

The government have stated that they require three trains per hour to run between London and Birmingham and also three per hour to run between Birmingham and London. The government have stated that

- the journey time will be 49 minutes,
- it takes 6 minutes to empty the train,
- it takes 12 minutes to clean and prepare the train,
- it takes 19 minutes to perform ticket checks and let passengers board the train.

Train services start at 07:01 in London and finish at about 22:00.

Train services start at 07:00 in Birmingham and finish at about 22:00.

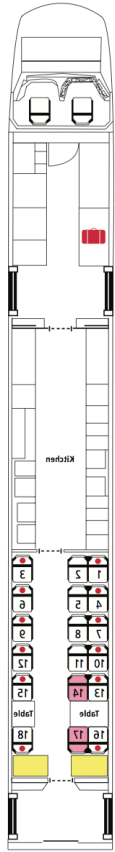
### Task

- a) Using this information, create a train timetable for a single day for Birmingham station and another for London station. Your timetable will show the times each train departs and arrives as well as the times the train is emptied, cleaned, ready to be boarded, etc. Each train that arrives or departs must be shown and care must be taken to show that your timetable actually works, ideally by labelling each train with a number. The timetables can be produced in Excel, but any supporting mathematics you wish to submit must be hand written.
- b) Your timetable has been created by making decisions. These decisions are important. You need to write a maximum of 500 words detailing what decisions you have made and what your thoughts were when you created the timetable. Your sentences must clearly show how you arrived at your solution. Marks are awarded for reference to your own research as well as your own thoughts on the subject. Your sentences must be typed.

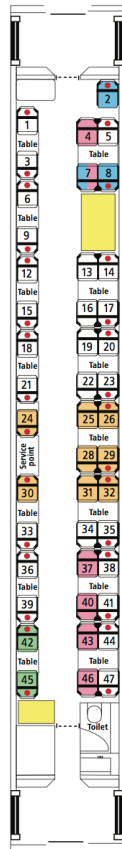
### Problem Three

The stations on the line all have a maximum length, so a train also has a maximum length. The trains on this line can have a maximum length of 11 carriages – this is made up of two engines (one at each end) and between 0 and 9 passenger carriages. Each train will have both first and standard class seating. The train company can decide how many first class carriages it has on the train, but the train length must not be more than 11 carriages long.

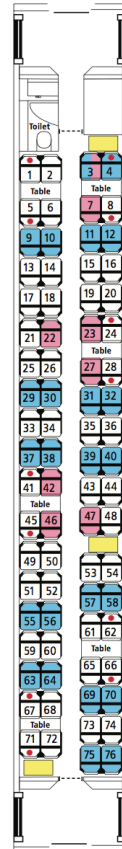
Each First Class seat generates £8.20 of profit for the train company, while each Standard Class seat only generates £5 of profit. However, there are more seats in a Standard Class carriage than in a First Class one, as is shown in the diagrams below.



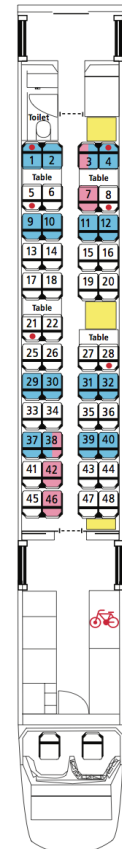
First Class Engine Carriage (18 Seats).



First Class Carriage (47 seats)



Standard Class Carriage (76 seats)



Standard Class Engine Carriage (48 seats)

Each train must have one standard class engine and one first class engine. Each train must be a maximum of 11 cars long, including the two engine cars.

### Task

- Work out a length of train that maximises profit. You must provide detailed, hand written, working out that proves that your arrangement really does provide maximum profit.
- Write a maximum of 500 words stating **either** why the arrangement in part a) is the perfect solution to use in real life, with referenced reasons, **or** what different arrangement you would use, if you feel the maximum profit arrangement would not be suitable in the real world. The sentences here must be typed and marks are awarded for references.

### Problem Four

Health and Safety is an important part of any project, and both building and using Railways include a large emphasis on Health and Safety. A train carriage (or an engine) has many moving parts all of which could, without proper care and maintenance, break - sometimes with dangerous consequences.

A train wheel has a hard tyre around it that will wear down over time, as it rubs on the rail it travels across. Due to the friction between the tyre and the rail, both will grind down as particles from the two pieces break off. This grinding effect happens more to the tyre than the rail. This is because the tyre touches the track all the time, but it touches a different part of the track each time.

In order to decide at what point a tyre will wear down to a level that is deemed unsafe, various calculations are carried out by a train operator.

A tyre

- starts with a size of 844mm
- must be scrapped when it reaches a size of 838mm.
- loses 1mm every 3,120,000 km.

Produce an equation that will model the size of the wheel against the distance travelled, illustrated with a graph where the  $x$ -axis shows kilometres.

The distance between London and Birmingham, on the proposed route of HS2 Phase 1, is 225 kilometres. Work out how many journeys a single train can make before the tyres need to be changed.

Full marks are only awarded for detailed working out, showing your equation works and for a comment on your answer.