

Keeping on Track ...

Rollercoasters are a main feature of many theme parks. They are hair-raising rides designed to thrill with high speeds and steep descents.

However, while sending people whizzing around a track is a whole lot of fun, safety is also a major factor. A roller coaster, and its theme park, won't remain open to the public for very long if the thrill-seekers don't live to tell their tale!

What you have to do

There's a new theme park opening in Somerset. The owner has asked you to help design the park's rollercoaster.

The design brief below outlines the various features the owner wants on his rollercoaster.

*Crazy Theme Parks,
Taunton,
Somerset*

Dear Sir/Madam,

Re: Design Brief

We're after a ride which includes an initial drop, at least one loop, and at least one hill. It's up to you whether or not it has any bends. It should also have a particular 'theme'.

The coaster will be lifted to the top of the first drop by an electric motor. After that, no more external force will be applied to the coaster - apart from the force of gravity.

The initial drop must be between 40 and 80 metres high.

The riders should experience no more than 6Gs at any given point (The G-force you experience whenever you accelerate is equal to your acceleration divided by the acceleration due to gravity ($9.8 \text{ metres/second}^2$) and points in the direction opposite to your acceleration). This website describes G-forces on a rollercoaster -

<http://www.glenbrook.k12.il.us/gbssci/phys/mmedia/circmot/rcd.html>

The coaster will operate for up to nine hours a day every day from April to October each year. Annual maintenance must be done in the closed season. All other maintenance should fit around operating times.

How to set about it ...

What exactly do they want?

1. Draw a table like the one below (you may need more rows). Use the first column to list the key **design features** from the **design brief**. In the second column, "Initial thoughts", make a few notes about what you'll have to bear in mind as you begin to come up with possible solutions.

Key design feature	Initial thoughts

2. You can now write your **design specification**. This should explain exactly what's required, and the implications of each design feature.

Generating ideas and shortlisting

3. Using the internet, library and/or resource centre, carry out some research into rollercoaster design. Here are some places you might like to try:

<http://www.learner.org/exhibits/parkphysics/coaster.html> (this site actually has a 'design a roller coaster' section which will help you with the size and shape of your hills and loop the loops)

<http://www.funderstanding.com> (has a section on rollercoasters with a coaster designer and clear explanations of the science).

<http://search.eb.com/coasters/ride.html> (this site tells you about roller coaster physics).

NOTE: Rollercoasters are not driven by motors. They work because, as the coaster is lifted higher, it gains potential energy (PE). When it's released the PE is converted to kinetic energy (KE). When the coaster reaches the bottom of a hill the PE is low but the KE is high. The KE then sends the coaster up the next hill. As it goes up the hill the KE decreases, but the PE increases.
4. Produce a number of **design ideas** using simple freehand sketches to try to visualise them.
5. Shortlist three of your ideas, explaining the decisions behind your choices. Even at this stage you should be pretty sure your design ideas will work; scientific principles will help. For example, you need to know about potential and kinetic energy.

And then there was one ...

6. You must now work out the pros and cons of your three design ideas. There are a number of ways to help you work these out. A few of them are:
 - You could carry out simple tests on scale models of particular components. For example, you could use plastic tubing to mimic the track and a marble to mimic the coaster. If everything's to scale this should give a rough idea if the rollercoaster will work. In some cases you may want to test a scale model of the whole structure.
 - Think about costs. Which of your rollercoasters would be most expensive to manufacture?
 - What's the rough life expectancy of your different designs? Is one much more hard-wearing than another?
 - How much room does your design take up?
 - Could your design or parts of it be modified easily to make a different type of ride for the park? (like a water ride for example).
7. Having weighed up the pros and cons, you've probably got a decent idea which design you think is the best. But the client is the paymaster. So, to help choose a final design solution, you should get feedback (comments and suggestions) from an expert who understands your client's needs.
 - Make 2-D and 3-D drawings and/or scale models of your three design ideas. These should be of good enough quality to allow you (and anybody else for that matter) to visualise exactly what your roller coaster will look like.
 - Present your designs to the expert, and write down their comments and suggestions. (but if you're adamant one design is better than another, make sure you can explain why - you have to give the client what they want, but YOU are the designer!).
 - Consider the expert feedback and decide what modifications you need to make, if any, to make sure your designs meet the client's needs.
8. Choose your final design solution and summarise the reasons behind the choice, including how your **design solution** fulfils the **key design features** in your **design specification** and how you have used expert feedback.

Presenting your solution

9. Decide on a suitable engineering drawing technique to present your final solution. Make 2-D and 3-D engineering design drawings, or use computer aided design (CAD) to produce them. Make sure you stick to engineering standards and conventions.

You've done the design job ...

10. You've successfully produced a **design solution** from a **design brief**. But what now? You've done the job of the designer, so you need to put your engineer's hat on. The design solution has to be turned into a **product specification** - giving the manufacturer the information needed to actually make the product.

A product specification details all the materials needed to make a product; it includes its dimensions, tolerances and details of how the different components will be joined together.

You need to decide which materials will be best to make your roller coaster. To decide which materials are best you should look back at the design brief and your initial research. You should also use databases and other resources to find out properties of materials.

You might also want to try tests for materials, joints and finishes to show how these can vary and influence your choice for the product specification.

COMPARATIVE TESTS