Olympic Cycling
Teacher Notes

Introduction

With the Olympics being held in London in 2012 it seemed appropriate to make some TI-Nspire documents based around sport. Since I have some experience of competitive cycling I choose this as a topic. This file was produced after I asked myself “where's the maths in that?”
The TI-Nspire document is split into 4 different activities.

Activity 1 – Frame Geometry

Are all cycle frames the same? Students use TI-Nspire to make measurements of images of cycles gathered from the web and to compare angles and ratios of lengths.

Activity 2 – Track Statistics

Are all cycle tracks the same? Compare the features of 25 tracks around the world using data provided. Then add more data to reach more reliable conclusions.

Activity 3 – Track Dimensions

The lengths of the straights and the radii of the ends of cycle tracks vary. Build a model track so that it has a particular overall length.

Activity 4 – Fermi Problems and gear ratios

How many times do a bike’s pedals rotate during one lap of a cycle track?

Resources

A class set of TI-Nspire handhelds. For Activity 1, CX versions are required and the use of a suite of laptops or computer. Navigator is also required to make best use of most of the activities.

Skills required

Activity 1 – Frame Geometry

Moving between pages
Changing lengths of line segments
Search Google Images
Enter data into a Lists & Spreadsheet page
Create graphs on a Data & Statistics page

Activity 2 – Track Statistics

Use a Data & Statistics page to create graphs from a Lists & Spreadsheeet page
Answer questions in a TI-Nspire document.

Activity 3 – Track Dimensions

On a TI-Nspire Geometry page:

- draw segments, circles and Circle arcs,
- use the Construction menu,
- measure lengths, assign variables and calculate with them.

Activity 4 – Fermi Problems and gear ratios

Using a Notes page to document and carry out calculations.

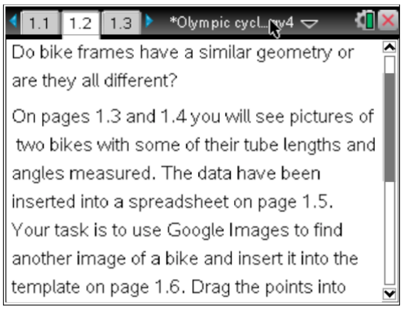
The activities

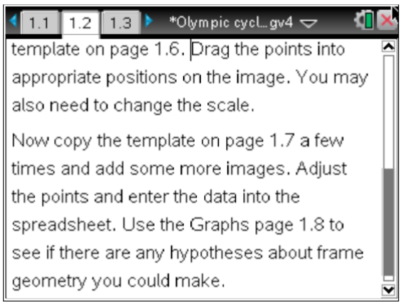
Activity 1 – Frame Geometry

Cycling is a highly technological sport: millions of pounds are spent by Olympic teams to give their cycles that extra edge during a race. Both materials and shape are continuously developing and over the years there have been several controversies surrounding bicycle design. One of the most famous involved the “superman position” used by Graham Obree in 1995 to enable a lower air resistance. Cycling's governing body, the Union Cycliste International (UCI), banned this position and has many rules governing the size and shape of a frame.

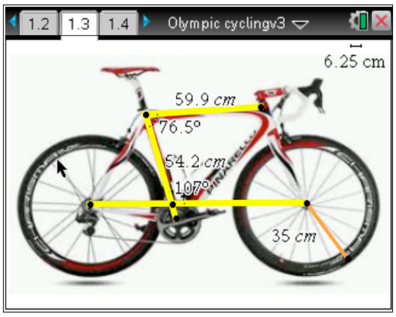
The key question for this activity is “are all bike frames the same?” This could be used to prompt a pupil discussion. Obviously there are different sized bikes for different sizes of rider: they differ in size but what about shape? Pupils should be steered towards looking at the angles between different tubes of a bike frame or possibly the ratios of lengths of different tubes. Both of these measures are likely to be independent of bike size.

Page 1.2 in the .tns file has a summary of the instructions.



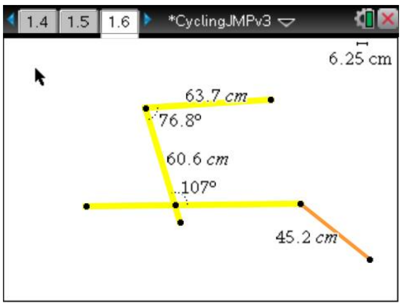


Pages 1.3 and 1.4 are Geometry pages with two images of bikes on which various line segments have been drawn and measurements made. The ends of the line segments can all be dragged to fit the image of the bike.



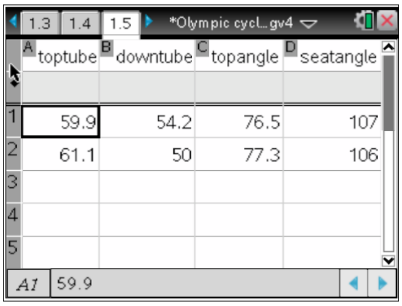
To turn this into an investigation more images will need to be gathered and measured. Pupils can be asked to find these themselves on Google Images, either as a classwork task using laptops or a computer room or as a homework task.

If pupils are confident with using the computer software version of TI-Nspire they can insert the images into the template on page 1.6, then use the template on page 1.6 to measure them.



Alternatively pupils could send the images to you to be gathered together into the .tns file and redistributed to the class via TI-Connect or Navigator.

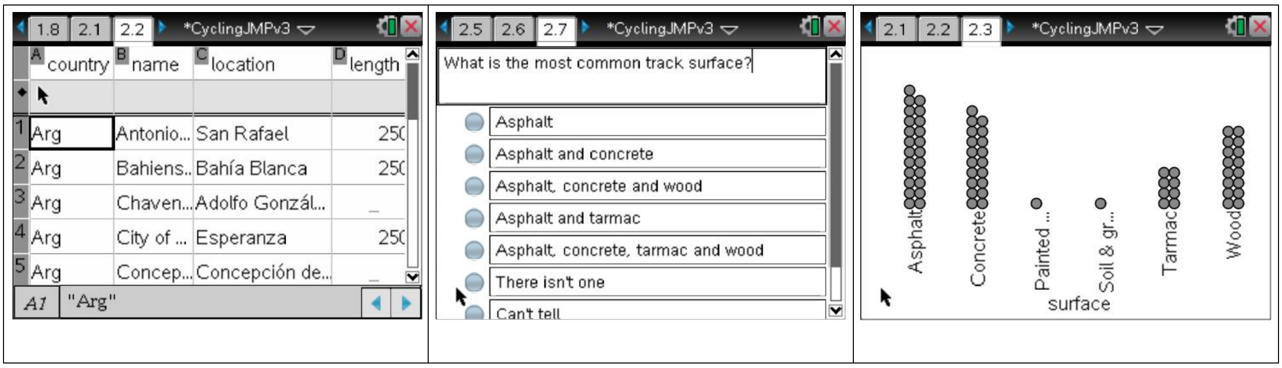
Pupils can than gather their data into the spreadsheet on page 1.5. A useful way of allowing pupils to share the data they have in their spreadsheets is to make a screen capture in Navigator, freeze your projector screen and then simply allow pupils to copy data from the board onto their own handheld. Once they have sufficient data they can use a Data & Statistics page to draw graphs and reach conclusions.



Activity 2 – Track Statistics

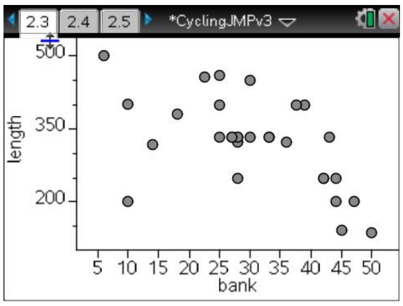
One form of cycle racing takes place on tracks. The obvious question to ask is: are all tracks around the world the same? If not, is there a more common length or surface? Many of the questions have slightly ambiguous answers. Rather than being a disadvantage, this creates a perfect opportunity for student discussion – *real* data handling is like this!

On Page 2.2 pupils are presented with a table of statistics about tracks around the world. On the following few pages they are asked to answer some questions. For example, the screen shot shows the question on page 2.7: what is the most common track surface? Pupils should decide themselves what is the best graph to draw on page 2.3 to answer this question. See for example the screen shot below right. Once the pupils in the class have answered the questions, the teacher can use Navigator to collect the files back in from the class. Then in the Navigator software the Class Analysis tool can be used to review the question responses. The Screen Capture tool could also be used to view pupils' graphs to use as a talking point.



The last question should promote some discussion about the reliability of data: is there a correlation between the length of the track and the angle of the banking?

It appears that there might be but the data provided only has the angles and lengths for around 25 tracks. More research would be required to answer this question thoroughly!



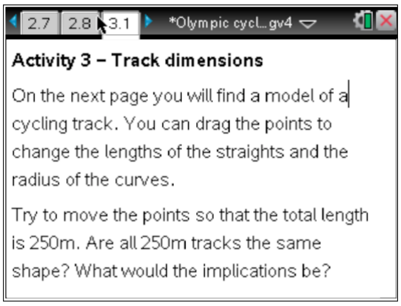
Activity 3 – Track Dimensions

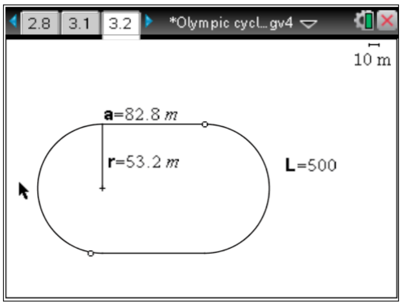
From analysis of the data in Activity 2 it appears that tracks differ in length but 250m is the most common. A few more questions can now be asked.

- Are all tracks the same shape, or are some more circular than others?
- If you cycle one metre to the right of another cyclist, how much further do you travel in one lap?

This last question has very important implications for track cyclists since their bikes have no brakes! One of the ways they can slow down is by taking a larger circle.

In this activity pupils are challenged to construct a model of a track on a Geometry page, such as the example shown in the screen shot below. Ask students to make a track of length 250m but leave the other dimensions up to them. It is an ideal opportunity for them to get to grips with lines, segments, perpendiculars and arcs. Then the Screen Capture tool on Navigator can be used to display all the different shapes of tracks, comparing the radius of the circle to the length of the straights. Or if this is too advanced, pupils could simply use the model provided on Pages 3.1 and 3.2 to experiment with different dimensions.



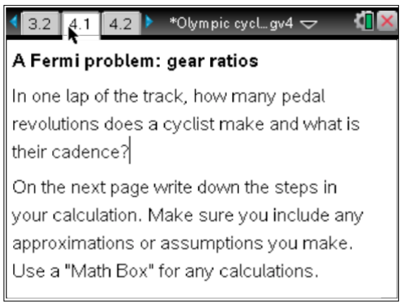


Activity 4 – Fermi Problems and gear ratios

Enrico Fermi was an American physicist who developed the idea of a problem that involved limited information and would require justified guesses to approximate an answer. His most famous problem is: how many piano tuners are there in Chicago?

A track bike is very different from a normal bike designed for the road: it has no brakes and only one gear. This gear has a fixed link to the pedals and there is no freewheeling. If the rider stops pedalling, the rear wheel stops moving and this can lead to some heart-stopping moments for first time velodromists! However, it does make it easier to estimate, for example the number of pedal revolutions a cyclist makes during one circuit of a track. This is an example of a Fermi problem. Its solution would require a number of assumptions: length of the track, the cyclist's position on the track, the gear ratio on the bike (this depends on the particular event), the size of the wheel, etc. A track bike has a small gear on the rear wheel linked by a chain to a larger gear on the pedal shaft. The gear ratio is defined as the number of times the smaller gear revolves for a single revolution of the larger gear. For example, a typical larger gear would have 53 teeth and a typical small gear would have 12 teeth giving a ratio of 53/12, a bit bigger than 4. Cyclists define their cadence to be the number of revolutions of their pedals per minute. For a track bike, because its gear ratio is fixed, a higher cadence would give a higher speed.

In this activity pupils can be asked to document their solutions to this problem on a TI-Nspire Notes page alongside their calculations. Navigator can then be used to allow every member of the class to see what everyone else has done.



An example of a possible solution is shown in the screen shot to the right.