

The Special Number Pi Masterclass

Thank you very much for leading this Masterclass. We hope that you enjoy working with this material as much as we enjoyed putting the activities together. We do appreciate all the effort that our volunteers put into bringing inspirational Mathematics Masterclasses to children around the country. Don't forget that we'd love to know your thoughts on the Masterclass – more detail at the end of this section.

Inspiration for this topic:

The properties of pi has long fascinated people the world over. We have evidence that the concept of pi has been known about for millennia, yet it was only named in the 17th century. It appears in the most unexpected of places in mathematics, as well as the expected ones! It is both useful and beautiful, and the search for patterns within pi is both satisfying and frustrating. Detailed examination of the digits of pi is an excellent introduction to randomness and probability too.

Overview of Activities:

- This Masterclass begins with a challenge to construct quadrilaterals within a circle. (This is not directly related but gets students thinking about shape, and is a nice low threshold, high ceiling settling task)
- Students are challenged to find the locus of a point a fixed distance from a fixed point, thus introducing circles
- A circle vocabulary challenge provides vital definitions for the next task
- Pi is derived by measuring the diameter and circumference of circular objects and entering data in a spreadsheet
- Numberphile video "Mile of pi"
- Brief history of pi
- Examination of the randomness of pi's digits
- Search for birthday within pi
- (Extension activity) Write a mnemonic to memorise the first few digits of pi

General Masterclass resources needed:

- Register of children
- Consent forms and emergency information to hand
- Stickers and markers for name badges
- Adult register
- Ri child protection policy
- Paper and pencils/whiteboards for workings
- 2 different coloured post it note pads
- Settling activity if not included in specific Masterclass (this one has the "Where are they" activity nrich1058)
- Drinks and biscuits

Specific resources needed:

- Counters, beads or blocks (e.g. multilink) for locus activity OR use "people maths" (see below) – *about 20 per pair, including one white counter or equivalent*
- Collection of circular/cylindrical objects. Ideally ranging from small circles through to larger circles (e.g. paper plates, cups, hula hoops, bicycle wheel, Frisbee, containers, tins, coasters, waste bin etc. Encourage children to look for further examples in the classroom) – *enough for one per pair*
- For measuring larger circular objects:
 - Tape measures OR lengths of string about 60/70cm – *one per pair*
 - Several metre rulers
 - A few longer lengths of string/tape measures for larger circles, if needed
- 30cm rulers – *one each if possible; if not, one per pair and enough 15cm rulers for a class set*

- Highlighters or coloured pencils/pens – *enough for one or two each*
- Access to internet and projector to show numberphile video and use “my piday” website
- **Downloads:**
 01. Starter activity quadrilaterals (*print two pages per pupil, double sided if possible*). *This worksheet is an NRICH activity (activity 962)*
 02. Excel spreadsheet for calculation of pi (*running on a computer which can be displayed, ideally*)
 03. Circles vocabulary (*2 per sheet: print, cut in half and give one sheet per pupil*)
 04. Measuring circles worksheet (*2 per sheet: print, cut in half and give one sheet per pair of pupils*)
 05. First 2000 digits of pi (*print one per pupil*)
 06. Randomness of pi (*2 per sheet: print, cut in half and give one sheet per pair of pupils*)
 07. OPTIONAL Additional nrich activities connected to this Masterclass. *Show on-screen or print from links shown below and on last slide of PPT.*

Things to prepare in advance

- Print and cut worksheets and gather resources as detailed above
- Gather general Masterclass resources
- Check that you can access and run YouTube or numberphile video
- Check excel spreadsheet is running, and you know how it works.

Ask the Ri

Don't forget to collect any questions which arise, and email them to the Masterclass team at the Royal Institution: masterclasses@ri.ac.uk

Feedback

We would very much welcome your feedback on this session. If you have time, please collect feedback from the students at the end of the Masterclass and send it through to us. We would also appreciate feedback on how you have used the session, what you think worked well and what improvements would be useful.

Time plan of Masterclass:

Slides & Time	Overview	Activity
Slides 1,2,3 10 minutes (10)	Introductory activity Instructions on screen. Helpers and Speaker circulating and chatting with students	<p>*GIVE OUT STARTER "QUADRILATERALS" SHEET (01) AND PENCILS AND RULERS*</p> <p>Check that the students understand the problem, and what a quadrilateral is. (This activity is only very loosely linked to the rest of the MC, but should give a chance to use some circle vocabulary and all can have a go)</p> <p>Suggest that students work systematically to ensure they have unique quadrilaterals. A discussion may well be needed about what is and isn't considered to be "the same".</p> <p>Encourage them to have a go by themselves first, and then to compare notes.</p> <p>If anyone thinks they have finished they should be able to convince you that they are certain that there are no more solutions.</p> <p>When you think most people have had time to have a go, show slide 3 (solutions) then break to introduce the Ri, if appropriate, or jump to slide 13</p>

Slides & Time	Overview	Activity
Slides 4-10 5 minutes (15)	Introduction to the Ri <i>[Only include these slides for the first session in the series – otherwise remember to hide the slides before you start the Masterclass]</i>	Use these slides to introduce the students to the work of the Ri and other ways they can get involved – see notes on the slides for more detail. In particular: <ul style="list-style-type: none"> • The Ri is a science communication charity which has been around since 1799. We've got a huge amount of history and lots of famous scientists lived and worked at the Ri. Most importantly, we've always been about communicating science to the general public – and that's something we still do today. We do talks and activities for the public as well as with schools all across the UK. • There are lots of family events at our building in London, including family fun days and holiday workshops just like the Masterclasses. • The CHRISTMAS LECTURES are for young people and are on television at Christmas time, looking at a different topic every year. We've got an archive on our website of all of the recent series plus many of the older ones. The CHRISTMAS LECTURES are what started the Masterclass programme. See slide notes for links. • We have a YouTube channel with lots of videos for people interested in science (and maths engineering, computer science...), especially our ExpeRimental series which is all about doing experiments at home. • Students are part of a big family of Masterclass attendees – we have been running Masterclasses since 1981. • Students at series running within reach of London will be invited to a Celebration Event at the Ri in June/July. • You can become an Ri Member to get more involved with what we do (and enter the ballot to buy tickets to the CHRISTMAS LECTURES filming).
Slides 11,12	Repeat of intro slides.	See notes on slides 1-3 Can start from here if more convenient.
Slides 13 10 minutes (25)	Locus Activity Activity to establish a circle, and the rule to draw a circle	<p>*GIVE OUT COUNTERS/BEADS/BLOCKS, ENSURING EACH PAIR HAS AT LEAST ONE WHITE ONE, AND ENSURE EACH PAIR HAS A RULER*</p> <p>Students should ideally work in pairs. They are given some counters* and a ruler and the instruction to place one counter as a fixed point (it will be the centre of the circle) They are then asked to take it in turns to place another counter 10cm from the fixed point. This should result in a circle around the fixed point, radius 10cm.</p> <p>*This could be beads, blocks or counters, as described in the resource list above. The PPT slide refers to "counters".</p> <p>Alternatively use some "people maths": ask a student to be the fixed point. Ask another student to stand 1m from the first one. And continue. Gradually a circle radius 1m should emerge. Encourage them to imagine a bird's eye view. Hopefully they will say a circle!</p>

Slides & Time	Overview	Activity
Slide 14-16 15 mins (40)	Focus on circle vocabulary. Most of this will be new. The important words are diameter and circumference	<p>*GIVE OUT CIRCLE VOCABULARY SHEET (03) *</p> <p>Emphasise that they won't know all these words, but to fill in what they can and then to talk on their tables.</p> <p>Slide 15 is the question</p> <p>Slide 16 has all the answers in red, they all appear at once.</p> <p>If time match the vocabulary to the part of the circle.</p>
Slides 17,18 15 minutes (55)	Circle measuring activity (to find pi by experiment)	<p>*GIVE OUT CIRCLE MEASURING SHEET (04), RULERS AND STRING/TAPE MEASURES. HAVE A SELECTION OF CIRCULAR AND CYLINDRICAL OBJECTS LAID OUT FOR THE STUDENTS TO CHOOSE FROM. A FEW METER RULERS MIGHT BE USEFUL TOO *</p> <p>Demonstrate how to measure the diameter and circumference of one of the objects, and record it on the excel spreadsheet. Measurements should be made as carefully as possible, to the nearest mm</p> <p>Invite the students to select an object each, carry out the measurements and record on their sheet. Then they should bring the sheet forward to you/a helper, who will input the data into the spreadsheet. They should return the object and repeat with another. Allow them to do at least 1 or 2 each.</p>
10 mins (65)	BREAK	Drinks and biscuits and comfort break
Slides 20,21 10 mins (75)	Introducing pi	<p>Look at the spreadsheet and hopefully they will see that the relationship between the diameter and circumference is a ratio of 3.14...</p> <p>If time add a little on the history of pi</p>
Slides 22-25 15 minutes (90)	How random is pi?	<p>*GIVE OUT FIRST 2000 DIGITS OF PI (05) AND RANDOMNESS OF PI SHEET (06) AND IF POSSIBLE SOME MARKERS OR HIGHLIGHTERS *</p> <p>The slides explain the process of looking for 2 digit numbers. It should be found that each pair arises about 20 times in the 2000 digits</p>
Slide 26 10 minutes (100)	Mile of pi video	<p>Show numberphile video: it is great to see this level of enthusiasm for pi!</p> <p>Discuss any questions arising</p>
Slide 27,28 10 mins (110)	Find your pi day	<p>Fabulous website to find where your birthday occurs in the digits of pi. This really emphasises just how infinite and random pi is.</p>

Slides & Time	Overview	Activity
Slide 29 10 minutes (120)	Feedback, tidy up, questions time Ask the Ri	<p>Don't forget to collect any questions which arise, and email them to the Masterclass team at the Royal Institution: masterclasses@ri.ac.uk</p> <p>We will send you answers as soon as possible. Then these can be reported back to the children at their next Masterclass session. In this way you cannot be "caught out" by a question. It also demonstrates the point that not everything in maths is known, but some questions need time and research to find answers sometimes, and sometimes the answer has not been found by anyone yet, of course! Maybe our Masterclass students will be the ones who solve the problem when they are older?</p>
Slide 30	Further activities	<p>Possible NRIC problems related to the special number pi – use as extension activities or for them to do at home:</p> <p>https://nrich.maths.org/2490 Article about π https://www.math.hmc.edu/funfacts/ffiles/10001.2-8.shtml Write your own mnemonic https://www.youtube.com/watch?v=ZNiRzZ66YN0 Watch a video about measuring pi with pies http://www.mypiday.com/ Find your piday!</p> <p>This slide could be printed and given out as a nice "take home" activity suggestion.</p>