OTS Masterclass - Curve Stitching

Session Leader Notes

Inspiration:

The parabola shape is a very common one in a number of everyday contexts. It is the shape made by water travelling initially upwards from fountains, and the shape traced by a ball between bounces. The workshop will explore ways to use straight lines to make the parabola curve.

A parabola is also the shape of the graph $y = x^2$. This workshop may provide a good opportunity to introduce this if your students are ready, but the activities have been designed so that this is optional.

Overview of Activities:

- Thought experiment: Throwing a ball (parabola)
- Folding a parabola
- Ruling a parabola
- Stitching a parabola

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
- Blank A4 paper and pencils/whiteboards for workings
- 2 different coloured post it note pads
- Drinks and biscuits

Specific resources needed (printable worksheets in worksheet folder):

- Balls for throwing (football, tennis, sponge, ping pong - suitable for the space you're in)
- Video of a ball being thrown - https://youtu.be/1PyjLXIYMzI
- 30cm rulers, one per student, and coloured pencils
- Parabola drawing grid worksheet (for students that need one)
- Parabolas in shapes worksheet (one per student)
- Drawing pins, A6 card and foam boards to lean on/push pins through (a foam camping mat can be cut into around 30 pieces large enough for A6)
- (Optional: different colours of A5 card to be folded into greetings cards, C6 envelopes and glue)
- Sewing needles (medium sized) and threaders if needed
- Coloured thread, in contrasting colours to the card - embroidery thread is a good thickness
- Tape, to stick down the ends

Support resources:

- Helper notes: An overview of the Masterclass content and activities
- Supporting notes: Extra information and background on the content of this Masterclass
- Session script: Suggested wording for each section of the session

Things to prepare in advance

- Print worksheets and resources as detailed above
- Gather general Masterclass resources

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
Slide 1 5 minutes (5)	Introduction Instructions on screen. Helper and Speaker circulating and chatting with students	Settling activity - thinking about curves. If I throw a ball across the room, what shape will it draw in the air? Put up slide with the question, and allow students to discuss amongst themselves. Encourage them to think about it without trying to throw anything. Suggest they try to draw the shape they think it will make.
Slides 2-5 5 minutes (10)	Introduction to the Ri *[Only include these slides for the first session in the series – otherwise remember to hide the slides before you start the Masterclass]*	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: • 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).
Slide 8 5 mins (15)	Discussion of introductory task	Put up the slide with various options, and ask the students to vote by hands up which shape they think the ball will make in the air. Some can be ruled out easily - by thinking about how balls move when they are thrown, and what you have observed - but others are more difficult. The ball would continue to move in a straight line if you threw it in space, but because we're standing on the surface of a planet, gravity will pull it down towards the ground. It won't change direction suddenly, so it needs to be a gradual curve. But what shape of curve? A semicircle is a smooth curve, but will the ball make that shape? Don't give away what the answer is, but invite the students to try it for themselves.

Slide 9 5 mins (20)	Ball – throwing video	Watch the video of ball being thrown – you can pause and stepping through frame by frame to see the shape of the curve. It should look curved, but not a semicircle. Explain that this shape is called a **parabola**.
Slides 10-13 5 minutes (25)	Parabola examples	Show the slides with examples of parabola shapes - water fountains and dolphins jumping, and architectural. Explain that this shape occurs when things are thrown and gravity pulls them down, and that architects use it for arches because its shape means it's good at distributing weight across a span, like a bridge
Slides 14-17 15 min. (40)	Folding a parabola activity	Explain that this next activity involves making a curved line using straight lines - there's a nice way to make a parabola by folding paper, and if you fold paper you get a straight line. These lines can be combined to create a parabola. Give each student a blank piece of A4 paper. Ask them to fold it in half length-ways and make a crease down the middle. Ask them to draw a dot on the crease in the middle of the page, about 3cm up from bottom of the page. The students may need a bit of time and help to understand this concept. The slides in this section are designed to step them through the activity and help them understand what's being asked of them. Instruction 1: **fold the paper so that the bottom edge of the paper lies exactly on the dot**. Crease the paper in this position to create a line. You can draw a pencil line along the fold to see it more easily if you like. (Most students will do this fold horizontally, but you could point out if anyone does it differently that your instruction wasn't precise, and that there are many ways to do this. In fact, the fold you wanted the students to do was… all of them!) Instruction 2: Ask them to turn the page over and mark 8 'blobs' on the bottom edge of the page (as shown on slide) Instruction 3: Turn paper back over. Fold up bottom edge so one blob meets original dot on front (paper will be at an angle as shown on slide). In this position, crease the paper to create a second line. Again, you can score this line with a pencil to make it more visible if you like. Instruction 4: Complete instruction 3 for all 8 'blobs'. You see a curve appear on your page. Feel free to let them do folds at more angles if they do the first ones quickly. As you go through this activity, make sure everyone has kept up with instructions and has folded the paper correctly
Slides 18-19 5 minutes (45)	Annotating the folded parabola	Show the first slide of this section – their paper should look a little like this. The lines have created a curve on the sheet. This curve is a parabola. To complete the folded paper parabola, we can annotate it [Skip if doing a short Masterclass, just point out some features quickly, especially the focus point]:

		1. The students can chose a brightly coloured pen and try to draw a line to show the parabola. Don't worry about being exact with this – encourage them to have a go and not worry if it turns out a little wonky. 2. The students can annotate their parabola with all the features shown here. Explain each feature to them: Focus: this is the dot they originally drew on axis of symmetry (has very useful applications in science) Axis of symmetry: The crease they created down middle of page. Parabola has mirror symmetry around this. Vertex: Point where the parabola curve intersects the axis of symmetry (this is at the 'lowest' point of the parabola) Directrix: (quite a difficult concept!) This is the edge of the paper below the parabola that we used to create it. Any point on the parabola curve is the same distance from the focus as it is from the directrix (drawn perpendicular to directrix).
Slide 20 5 min. (50)	Parabolas in science (this slide has animation to add images sequentially)	To show applications of parabolas, talk through this slide. Start by discussing the special properties of a parabola that has a mirror coated internal surface. All light reflected off the surface travels to the focus point, as shown in the diagram. This special property is used in 3-D paraboloids, such as satellite dishes to capture all sorts of weak signals from space etc. (normally other types of radiating signals, not light). A satellite dish has a detector placed at the focus position (as can be seen in some of these pictures). For the last listening 'mirror', people would stand at the focus point and listen to hear the noise that enemy aircraft approaching from afar would make, reflected in the dish.
Slides 21-26 15 min. (65)	Ruling a parabola activity Hand out **Parabola Drawing Grid worksheet** Hand out **Parabolas in Shapes worksheet**	Next we will try a more structured way to make a parabola. Hand out Drawing Grid Worksheet or give blank sheet of paper and get students to mark out X and Y axes themselves. Next, students should use a coloured pencil to rule a line from the top mark to the first mark along on the bottom; then one from the second-to-top mark to the second mark along on the bottom, as shown on the slides, and so on. This should create a parabola. With the Parabolas in Shapes Worksheet, the students have time to explore these ideas - what happens if they change the angle of the lines, or construct more than one parabola? If their two lines are joined to another two lines to make a square, what happens if you make different parabolas on different pairs of lines? What if the shape has a different number of sides? A printable worksheet is available with notched polygons which can be used for this.
10 mins (75)	BREAK	Drinks and biscuits and comfort break
Slides 27-28 30 mins (105)	Curve stitching activity	Having explored different ways to make parabolae using shapes, the students should decide on what they would like to make using stitching. If they want to finish in time, they should choose a design that's not too complicated - only involving 6-10 pairs of holes, and ideally not combining multiple parabolae. If you provide each student with an A6 piece of card, a foam mat, a drawing pin, and a needle and thread, they should be able to draw

		their axes, make holes using the drawing pin at each of the marks (pushing it carefully through into the foam mat) and then use the thread to stitch the lines - starting off on the back, and making sure only the lines they want visible can be seen from the front. You might find it useful to tape down the ends on the back of the piece, if it's difficult to tie a knot. Once completed, they can tie the thread off on the back, trim the edges of their design by a few millimetres and glue their card onto the left hand side of an A5 piece of card, which can be folded and put into an envelope to make a greetings card.
	Extension activities	Many students, having mastered the construction of parabolas from straight lines, enjoy investigating their uses for creating nice designs. For stitched designs, combining several parabolae is a natural development. There are a variety of avenues this can follow. For hand-drawn or stitched parabolae, colouring in the quadrilaterals made by the crossing lines/threads with a checkerboard pattern can create interesting effects, as can experimenting with different colours to draw the lines themselves. Looking beyond parabolae, students may be interested in finding out about creating different types of curves from other groups of lines. Questions beginning 'What would happen if I..' tend to come up during this activity, and with a little encouragement, can lead to greater understanding.
Slides 29-32 5 minutes (110)	Feedback, tidy up, questions time Ask the Ri	Recap of session contents. Don't forget to collect any questions and feedback on post-it notes, and email them to the Masterclass team at the Royal Institution: masterclasses@ri.ac.uk
Slides 33 -37	Further links related to this session – use as extension activities or for them to do at home	https://www.mathsisfun.com/geometry/parabola.html - Maths is Fun website: uses interactive mathematical equations to create parabolas https://nrich.maths.org/8287 - Curve Spotting https://nrich.maths.org/7010 - Straight to Curves bit.ly/parabolic-curves - Math Craft activity with some nice extensions https://mrchads.weebly.com/parabolic-curve.html - teacher blog, sharing some more complex artworks his students made using this technique https://youtu.be/v-pyuaThp-c - Vi Hart: Connecting Dots bit.ly/solvingforxmas - Guardian article about making mathematical Christmas cards using this technique