UNIVERSITY OF CAMBRIDGE
Department of Pure Mathematics and Mathematical Statistics

Posters

Marj Batchelor
Summer 2013

Before you start

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- The purpose: transfer of understanding

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- The principle of layout: maximum information at a glance

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- The principle of layout: maximum information at a glance
- Templates: using LaTeX templates

The purpose

Wednesday, 14 August 2013

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- I will be using these to beg for funds for next year. This is probably the most important consequence, even if it is not its purpose.
- Choose something that has attractive visual representation if possible.
- Choose something that can be related to something more basic that people might be familiar with.
- Keep your focus small.

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  - You don't have to say everything you know.

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The mock-up

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- Choose your focus, decide what needs to be explained.
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- Mock-up: arrange the page layout.
  - One piece of paper for the introduction, one each for separate boxes, containing separate ideas, arrange to suit on a big table top.

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How Many Holes are there in my Doughnut?

Telling shapes apart

If a doughnut and a coffee cup can have the same shape to a topologist, it might seem quite hard to tell whether two shapes are topologically the same or not. So, mathematicians have worked out many ways to assign numbers to shapes in such a way that two shapes that are topologically the same have the same number. One of the most famous of these is called the *Euler number*, after the 18th century Swiss mathematician, Leonhard Euler.

Polyhedra

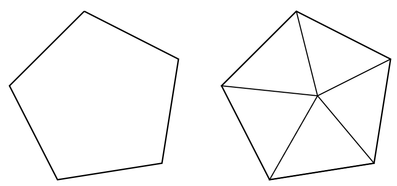
Euler noticed a remarkable fact: if you take any ordinary polyhedron (i.e. one without any holes), and add together the number of faces and the number of corners, and subtract the number of edges, you always get the answer two:

$$\text{corners} - \text{edges} + \text{faces} = 2.$$

Try this yourself with some of the model polyhedra on display!

The reason this happens is that all these polyhedra are topologically just the same as a sphere: they're all surfaces without any holes. If you try the same with the doughnut-shaped polyhedron on display, which is topologically different from a sphere, you'll find that the answer you get this time is zero.

In fact, any surface can be turned into a polyhedron, and because we're only interested in their topology, the faces don't even need to be flat — we can just draw lines connecting points on the surface until we've covered the whole thing. This way, we can talk about the Euler number of any surface, and it doesn't depend on how you choose the faces! Look at what happens if we add a new 'corner' in the middle of, say, a pentagon:

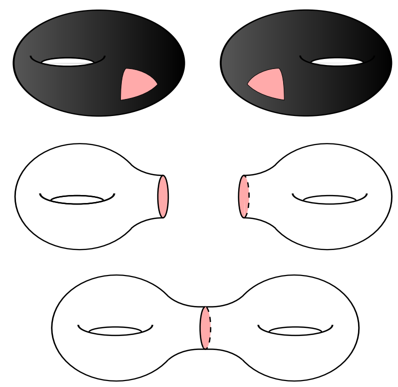


We change what was one face into five, so we add four to the Euler number, we add five edges, so then we subtract five, and finally add one for the new corner, which then doesn't change the Euler number at all. To *prove* that the Euler number is the same however you divide your surface up, mathematicians show that the same thing happens in general when you add new corners and edges, which is not too hard. However, the difficult bit is showing that if you divide your surface up in two different ways, there's always a way of adding corners and edges to each one in such a way that they become the same.

Every polygon can be divided into triangles like the pentagon above, so we only need to think about covering our surfaces with triangles. If we've found a way of covering a surface with triangular faces, we call it a *triangulation*.

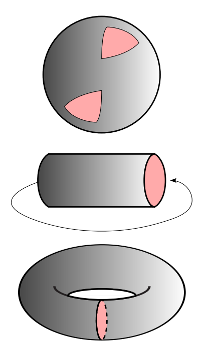
How many holes are there in my doughnut?

It turns out that this 'Euler number', at least for surfaces of shapes in ordinary space, only depends on the number of holes — every extra hole reduces this number by two, and we can see why this is. Imagine what happens when you take two triangulated surfaces, remove a face from each, and then glue them together like this:



You've taken away two faces, three edges and three corners, so that makes the Euler number two less than the sum of the Euler number of the two surfaces you started with — the changes to the numbers of edges and corners cancel one another out. Glueing a doughnut like this to another surface then reduces the Euler number by two because the doughnut itself has Euler number zero, and this is the same thing as adding a hole to the surface.

In fact, we can see why the doughnut has Euler number zero in the same way. If we cut two faces out of a triangulated sphere, we get a cylinder, and if we glue its ends together we get a doughnut:



In doing this, we've lost two faces, three edges and three corners, so the Euler number of the doughnut is two less than that of the sphere, as we expected.

Leonhard Euler (1707-1783)

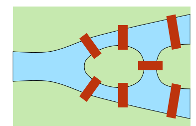
Although he was born and brought up in Switzerland, Leonhard Euler spent most of his life in Russia, at the Imperial Russian Academy of Sciences in St Petersburg, and later also at the Berlin academy.

Euler pictured on a Swiss stamp with his formula for polyhedra

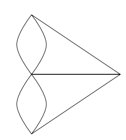
He is one of the most prolific mathematicians ever to have lived, and his collected works fill many volumes. He made important contributions to number theory, including the properties of prime numbers, the theory of infinite series — he was the first to discover that

$$\frac{1}{1^2}+\frac{1}{2^2}+\frac{1}{3^2}+\frac{1}{4^2}+\ldots=\frac{\pi^2}{6}$$

— as well, of course, as the early ideas that led to the development of topology. One problem he is particularly famous for solving is that of the bridges of Königsberg, a city that was then part of Germany but now lies in Russia and is called Kaliningrad. The city is built on a river at a point where there are two islands, connected to the shores on either side by seven bridges arranged like this:



The problem was whether it was possible to find a route through the city which crossed over each bridge just once; no-one had been able to find a way to do this, but Euler proved that no such path could exist. This is a kind of topological problem too, as it only depends on how the islands are connected, not on their precise shape or size. The problem is the same as trying to find a path through the following picture which traces out every edge exactly once, or to draw it without taking your pen off the paper and without retracing any lines:



A picture like this, which just consists of points joined by lines, is called a *graph*. Euler showed that a graph can be drawn without taking your pen off the paper like this precisely when either two or none of the points are attached to an odd number of lines. This is because a path through it must enter *and* leave each point by a different edge unless that point is the start or end point. The Königsberg graph doesn't have this property, because all four points are attached to an odd number of lines.

Wednesday, 14 August 2013

Things I like about this poster:

- The banner stands out well, is simple, catches attention.
- Good use of figures.

Things I might have done differently:

- Explanations of figures in larger type.
- Text in paragraph form rarely gets read.

Transferable Skills Training at CMS
The Practical Component

UNIVERSITY OF CAMBRIDGE

Marjorie Batchelor
Graduate Education Officer DPMMS

Exercising transferable skills

Aims:

- Involve all students in projects run within the department which exercise their skills in communication, teamwork and mentoring.
- Give as many students as possible the experience of directing a project, including handling logistics, recruiting co-workers, and leading the review process to ensure optimal evolution of the project.
- Get all students in the habit of continuing evaluation of the effectiveness of their working group and their role within it.
- Ensure that students have sufficient experience of responsibility within the department that they both think creatively about what might improve the functioning of the department and have the confidence to implement their ideas.

Projects run within the Centre for Mathematical Sciences

- The Part III Cafe PhD students serve free tea and coffee for the Part III students three afternoons a week, and are available to answer questions on coursework and life in Cambridge in general.
- The Part III Seminar Series At the end of the Michaelmas and Lent terms, PhD students run a three day conferenceïn which Part III students have the chance to present talks on subjects arising from their courses and their essay topics.
- The Graduate Mathematics Society This society runs the various projects that the PhD students undertake on behalf of the Part III students as well as the social side of CMS.
- Young Researchers in Mathematics This group runs full scale conferences for research students in mathematics in the UK. This started as part of the 800 celebrations, is now in its third year and is acquiring a national profile.
- The Linyi Summer School Project. Now in it's third year, a team of students go to Shandong Province, PRC, to run a summer school at Linyi Normal University.

The Linyi Project

Linyi Normal University Party Secretary Dr. Xu Tong Wen, and participants in the 2010 summer school in front of the bridge built in honour of the 2010 summer school.

Linyi Normal University

Linyi City, Shandong Province, China, is a university of 30,000 students is the premier academic institution in a city roughly the size of London. The city is in a largely agricultural region, and many of its students come from farming villages. The university serves its local people well, providing an opportunity even for the most impoverished students to attain a level of education that enables them to continue for a higher degree should they wish to.

Aims of the Cambridge Linyi Summer School

1. Introduce small group teaching, encourage questions and conjecture.
2. Introduce informal research seminars.
3. Develop research links.

Teaching and learning in Linyi

Teaching in Cambridge is too easy.

Cambridge students, placed in the general vicinity of knowledge will learn. The double challenge of langauage and differences in mathematical background demanded ingenuity and careful thought and planning.

Linyi - the structure of the project - Training - Execution - Review

- Training phase
  - Teaching theory. Dr. Toni Beardon spent an evening training students planning to teach at the summer school classroom teaching techniques.
  - Teaching practice. Using undergraduates and fellow Linyi participants as guinea pigs, students spent three days practising their teaching techniques.
  - Language. All students travelling on the 2010 summer school trip had at least two terms of Chinese language training.
- Execution Living together for three weeks in challenging circumstances ensured the cohesion of the group. Time not spent teaching was spent discussing how best to teach.
- Review The review process included two days of discussions with Linyi students, Linyi mathematicians and higher Linyi management.


Matthew Tointon and his class at Linyi. We discovered that when the teacher steps off the podium, there is little difficulty eliciting questions from the students.


Basketball outside the classroom assists learning within. Discussion based learning is a new experience for our Chinese students, requiring a considerable degree of courage. Recreation during free time contributed to easy discussion between teachers and students.

Outcomes

Real projects - real results

- About 75 students taking on director level responsibilities over the last 5 years
- 309 Part III seminar talks over 3 years.
- 74 students leading seminar groups over 3 years
- Over 75 students involved in running the Part III Cafe over the last 3 years.
- 2 YRM conferences with attendance over 200 students at each one. A third is planned for this spring at Warwick University.
- YRM engaged in discussions with London Mathematical Society, the British Mathematics Colloquium and the British Applied Mathematics Colloquium for enlarging the scope of the YRM.
- 26 PhD and past Part III students teaching in the Cambridge-Linyi summer school.
- Linyi Normal University will achieve full university status on 8 December 2010.

DPMMS November 2010
mb139@cam.ac.uk

- Space draws attention.
- Illustrations, figures, pictures lead eyes to surrounding text.
- Omit needless words.
- Ideas in paragraphs will be the last to be read.

Inescapable fact: Pictures, graphs, diagrams bring a poster alive. They also eat time.
- Think very hard about what illustrations you use.
- LaTeX drawing packages are not for the faint-hearted. Do your drawing elsewhere, import as .pdf.
- Make quite sure you are going to use an illustration before you embark on the problem of creating it electronically; you really (!) do not want to waste time on an figure you do not intend using. Same can be said about the more complicated equations.

Templates and help

- Stephen Eglen's home page:
  - http://www.damtp.cam.ac.uk/user/sje30/damtp/cuposter/index.html
- Help:
  - Guilherme Lima gfl21@cam.ac.uk
  - Dimitry Tonkonog dt385@cam.ac.uk
  - Tom Begley tcb33@cam.ac.uk
- Printing: send .pdf to Julia Blackwell, J.L.Blackwell@statslab.cam.ac.uk

I will have this talk, Alex's template and other material on my website by tomorrow, I hope.

Time scale

- Focus by Monday 19 August, so you can start worrying about mock-ups and LaTeX.
- Printing: see Julia Blackwell by Thursday 22 August.