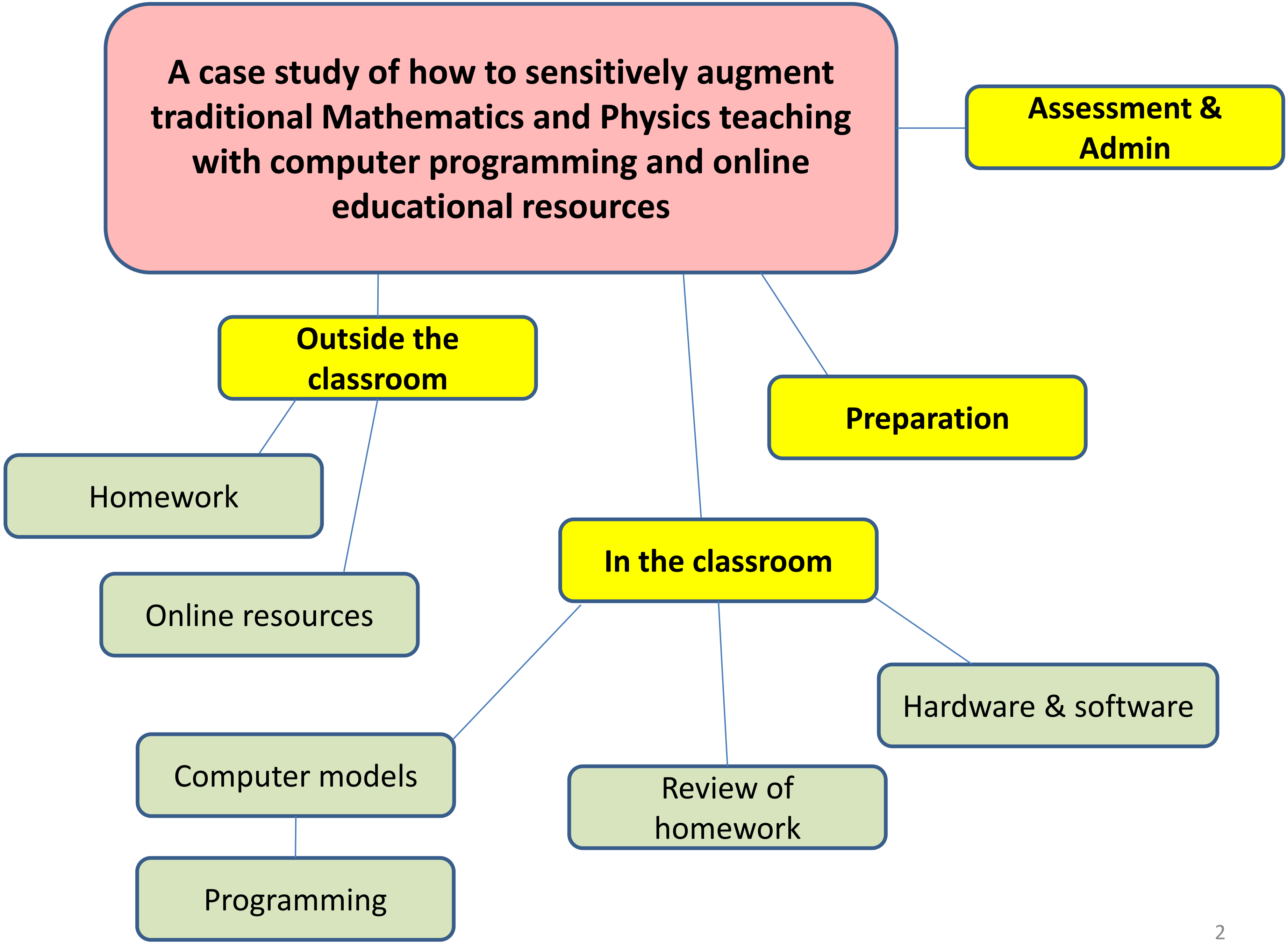
WLSA Conference 2015
14-15 July 2015 – Amsterdam, The Netherlands

Neither Chalk and Talk or Death by PowerPoint

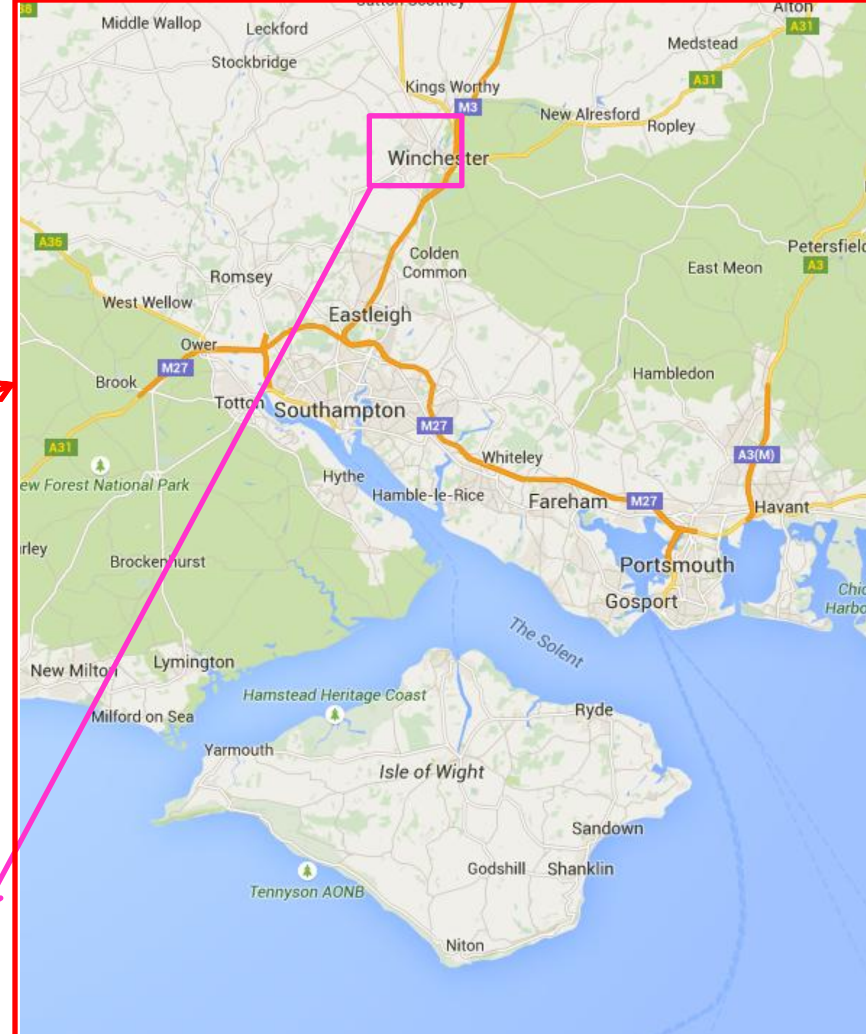
A case study of how to sensitively augment traditional Mathematics and Physics teaching with computer programming and online educational resources

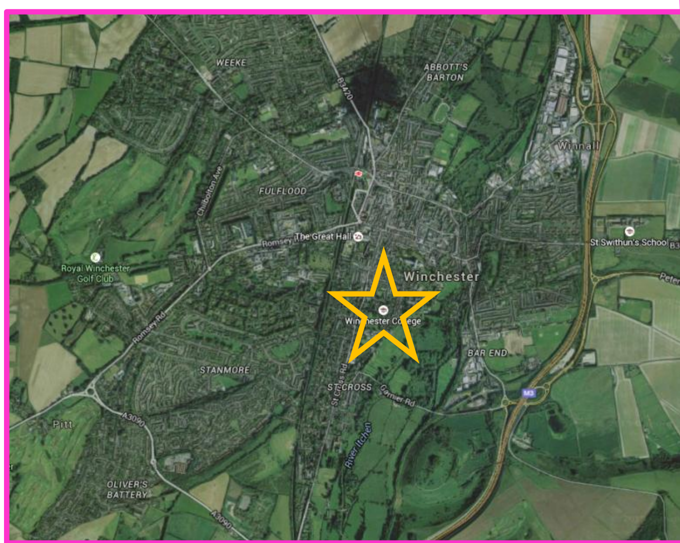
Dr Andrew French

Winchester College, UK


A case study of how to sensitively augment traditional Mathematics and Physics teaching with computer programming and online educational resources
Assessment & Admin
Outside the classroom
Preparation
Homework
Online resources
In the classroom
Hardware & software
Computer models
Review of homework
Programming

Where is my classroom?





I teach at **Winchester College**

- A UK Independent Boarding School
- Founded 1382
- 700 boys : 100 teachers

http://www.winchestercollege.org

Meads

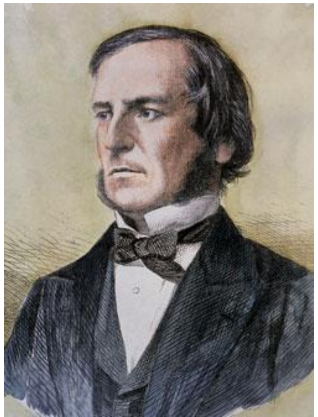
Bethesda

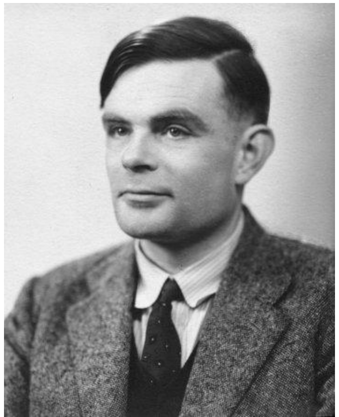
Chapel & School

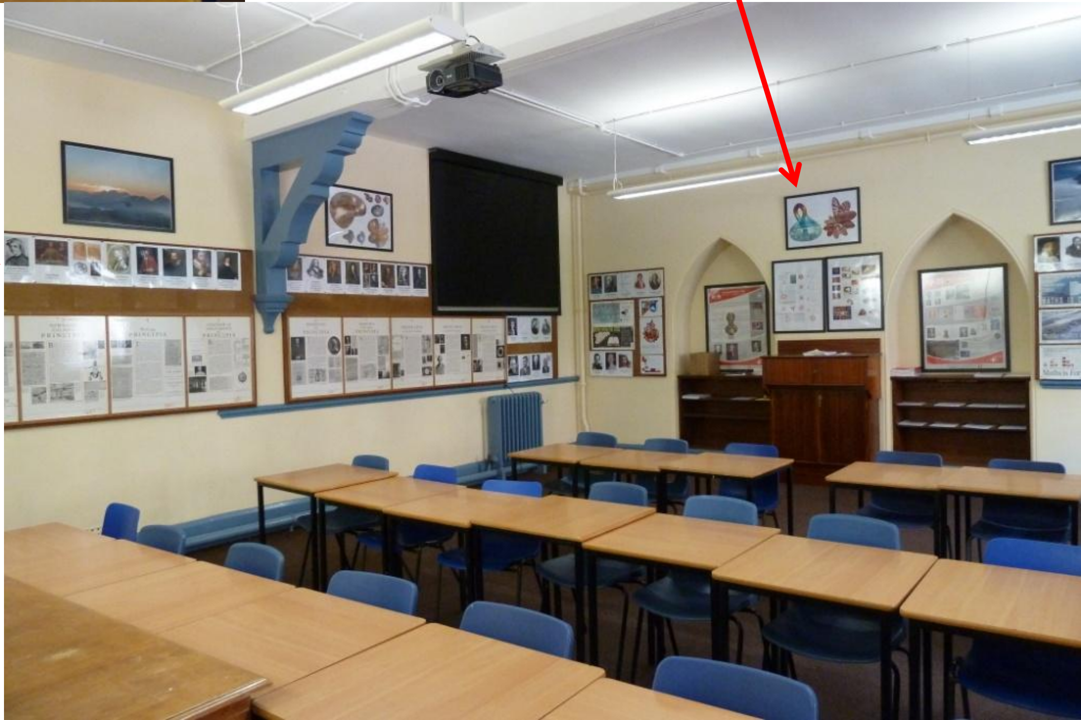
Flint court

B2, Flint Court. Max students = 22

‘Faces of Mathematics’







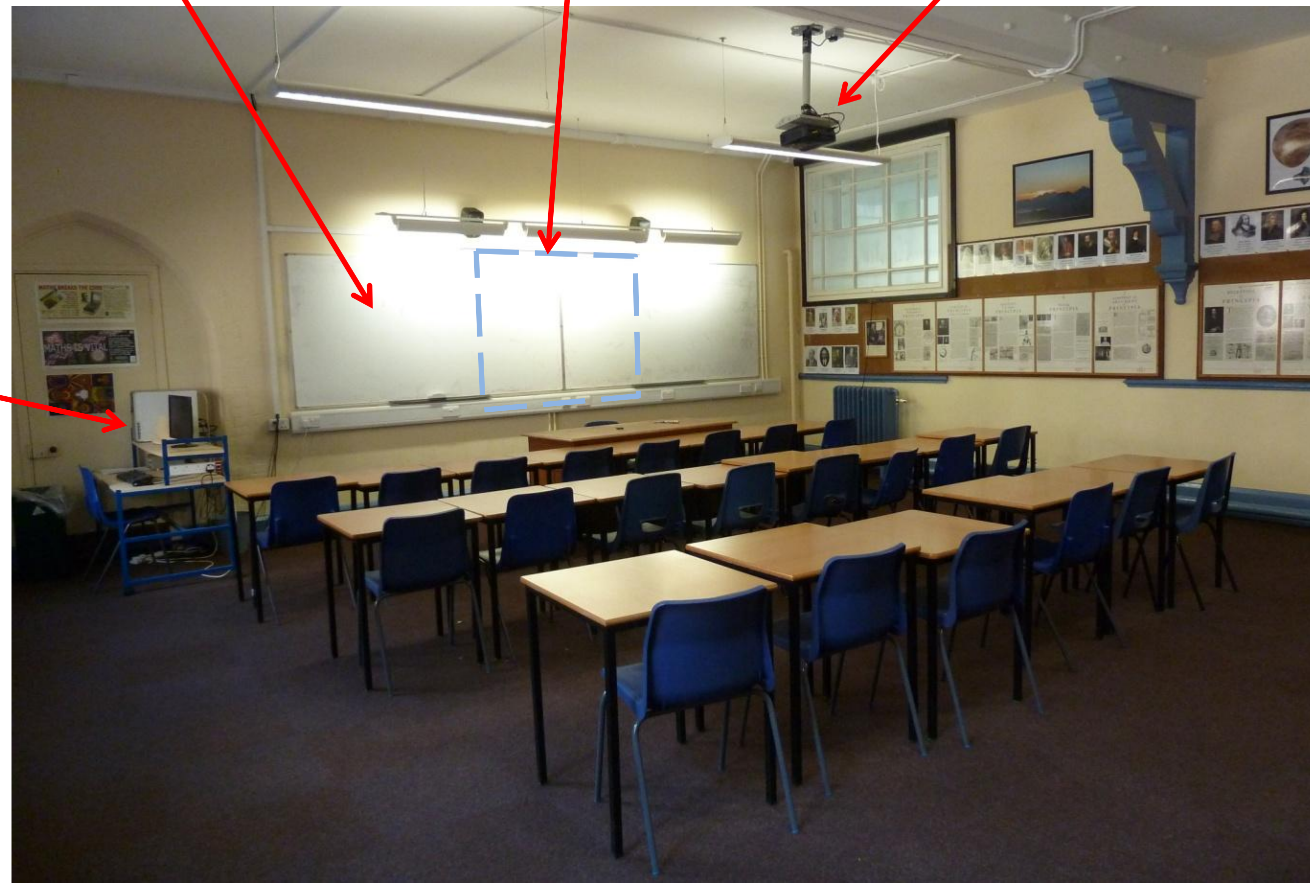
In the classroom

Hardware & software

Double-width white board

Pull down projector screen

Overhead projector linked to computer



Desktop Windows PC linked to College network
- Network drives for students (Y) and staff (Z)
- Internet access
- SIMS

What are my **requirements** for IT equipment? – ***To enable me to teach more effectively***

But what do I do in the classroom most often?

- **Model what the students do**, which is *almost always using pen and paper*

Hence emphasis on a **large whiteboard** and *not* a tiny, hard-to-read 'Smartboard'

But 'inspiratia' (hard to draw figures, accurately plotted graphs, simulations etc) are *difficult (i.e. time consuming) to create without the use of IT*

Software

In the Winchester Mathematics department we typically use **Microsoft Word** (with **Mathtype** for equations) to prepare worksheets and exams

FxGraph and **FxDraw** are used for graphs and illustrations

We also use **Autograph** and **Microsoft Excel** for analysis and graph plotting

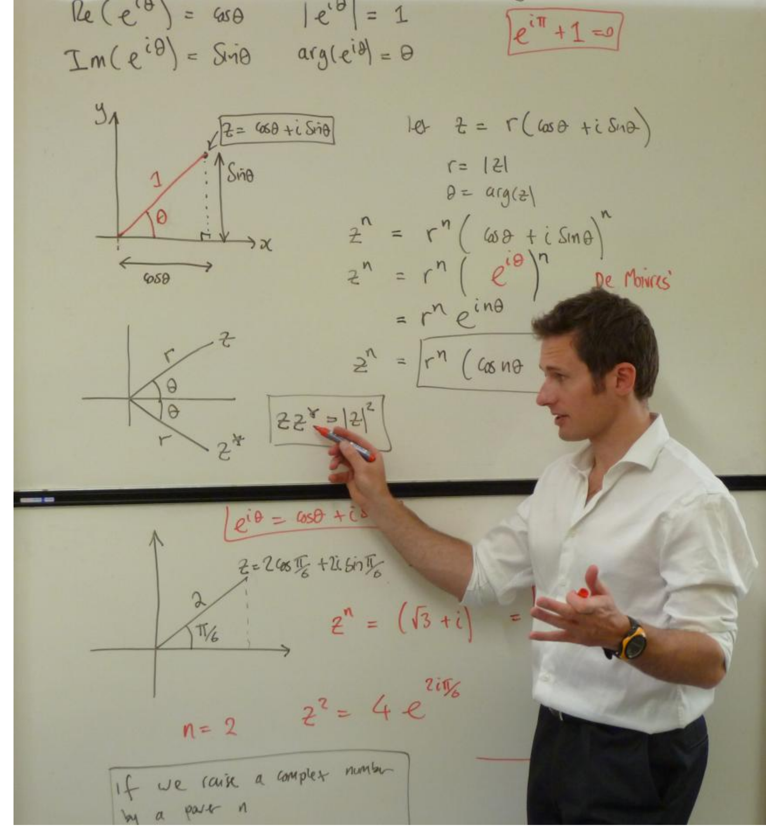
I tend to use **PowerPoint** for handouts as well as presentations

I also use **MATLAB** for simulations and **Xara Designer** for complex illustrations and website design

Occasionally I will use **Scientific Word** (LaTeX) for mathematical documents

I use **Adobe Acrobat** for PDF display and **IrfanView** for graphics display

Most of my IT usage is *not* ‘cutting edge.’ My students are typically **most engaged when they experience Mathematics being done *live***, with a pen or pencil. i.e. *just like how I expect them to do it.*



There is *infinite creative freedom* with a pen, and no ‘boot up time’ !

However, there *are* many occasions when an IT based solution *is* preferable. **Examples** to follow ....

My Golden Rule for IT usage

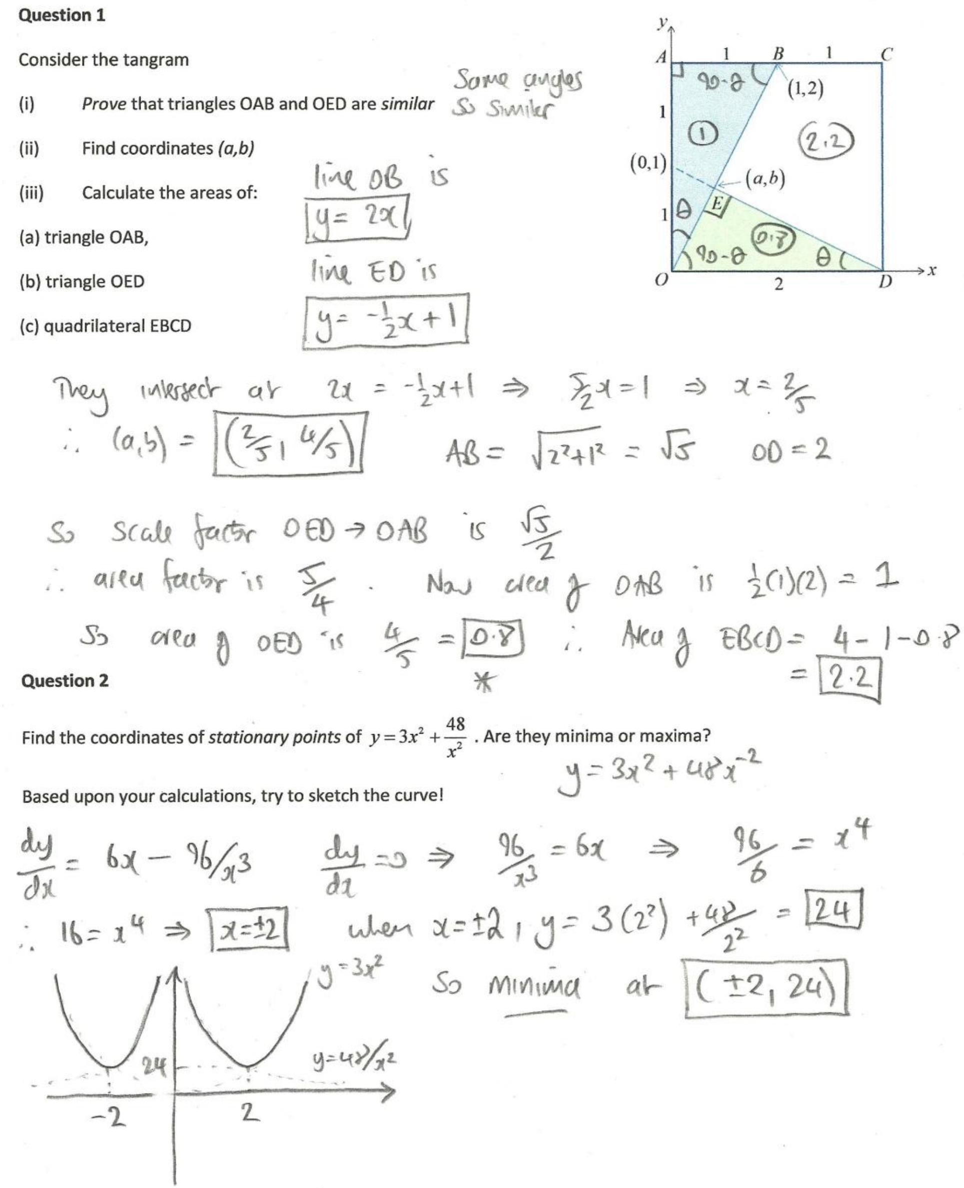
Does it offer tangible **benefits** over simple, traditional write-on-a board teaching techniques, compared to the **cost** in terms of boot-up-time, reliance on network infrastructure etc?

Example 1: Projection of homework PDFs to facilitate feedback

"Middle Part" (Year 10, i.e. 14-15 year olds) Mathematics:
5 lessons + 3 x 30min homework per week

Homework problems, regularly bespoke and always varied, form the backbone of the Winchester Mathematics experience.

Homework feedback is therefore of paramount importance. To make this process *efficient*, I typically **display** PDF copies of my *handwritten* solutions using the projector.


Question 1

Consider the tangram

(i) *Prove* that triangles OAB and OED are *similar*

(ii) Find coordinates *(a,b)*

(iii) Calculate the areas of:

(a) triangle OAB,

(b) triangle OED

(c) quadrilateral EBCD

Same angles So Similar

line OB is $y = 2x$

line ED is $y = -\frac{1}{2}x + 1$

They intersect at $2x = -\frac{1}{2}x + 1 \Rightarrow \frac{5}{2}x = 1 \Rightarrow x = \frac{2}{5}$

$\therefore (a,b) = \left(\frac{2}{5}, \frac{4}{5}\right)$ $AB = \sqrt{2^2+1^2} = \sqrt{5}$ $OD = 2$

So scale factor OED → OAB is $\frac{\sqrt{5}}{2}$

$\therefore$ area factor is $\frac{5}{4}$. Now area of OAB is $\frac{1}{2}(1)(2) = 1$

So area of OED is $\frac{4}{5} = 0.8$ $\therefore$ Area of EBCD $= 4 - 1 - 0.8 = 2.2$

Question 2

Find the coordinates of *stationary points* of $y = 3x^2 + \frac{48}{x^2}$. Are they minima or maxima?

$y = 3x^2 + 48x^{-2}$

Based upon your calculations, try to sketch the curve!

$\frac{dy}{dx} = 6x - 96/x^3$ $\frac{dy}{dx} = 0 \Rightarrow \frac{96}{x^3} = 6x \Rightarrow \frac{96}{6} = x^4$

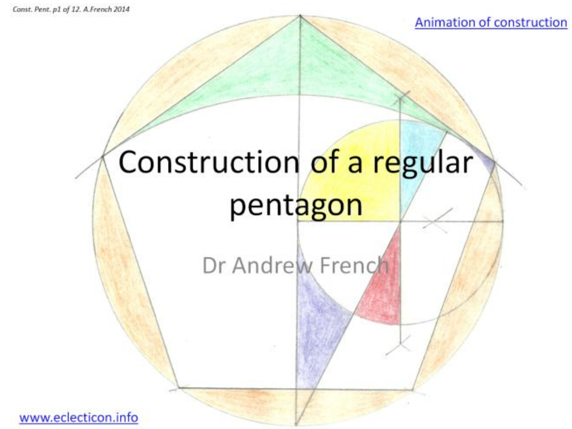
$\therefore 16 = x^4 \Rightarrow x = \pm 2$ when $x = \pm 2$, $y = 3(2^2) + \frac{48}{2^2} = 24$

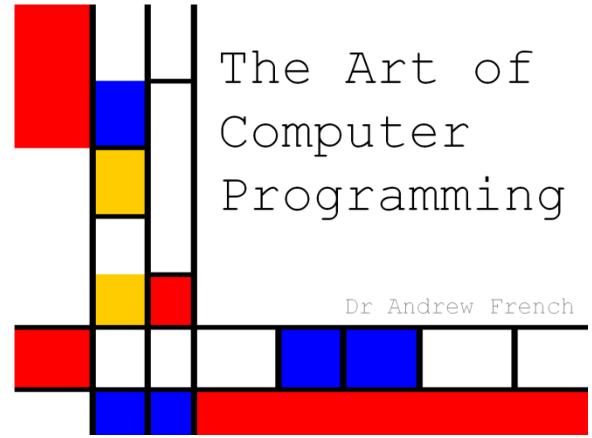
So minima at $(\pm 2, 24)$

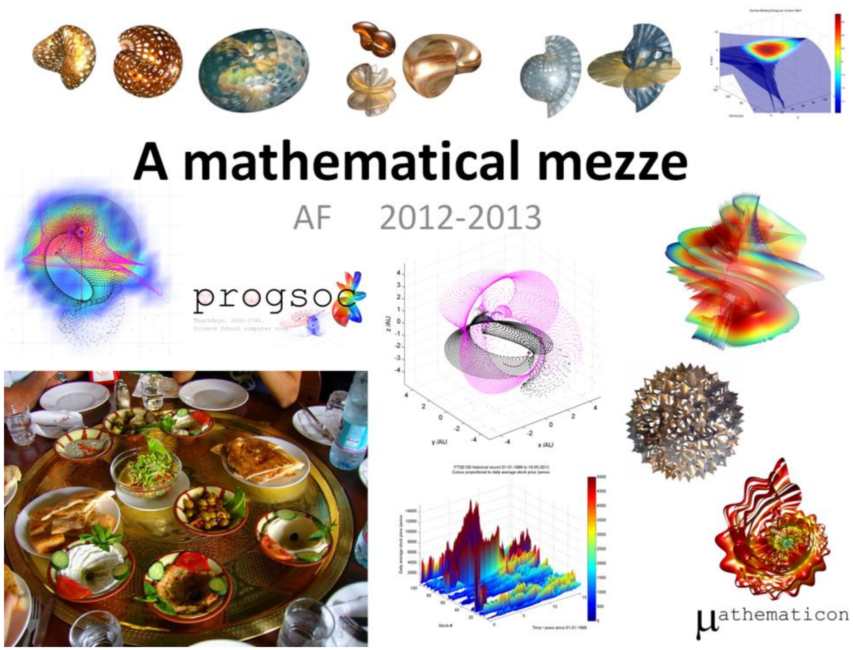
Benefits

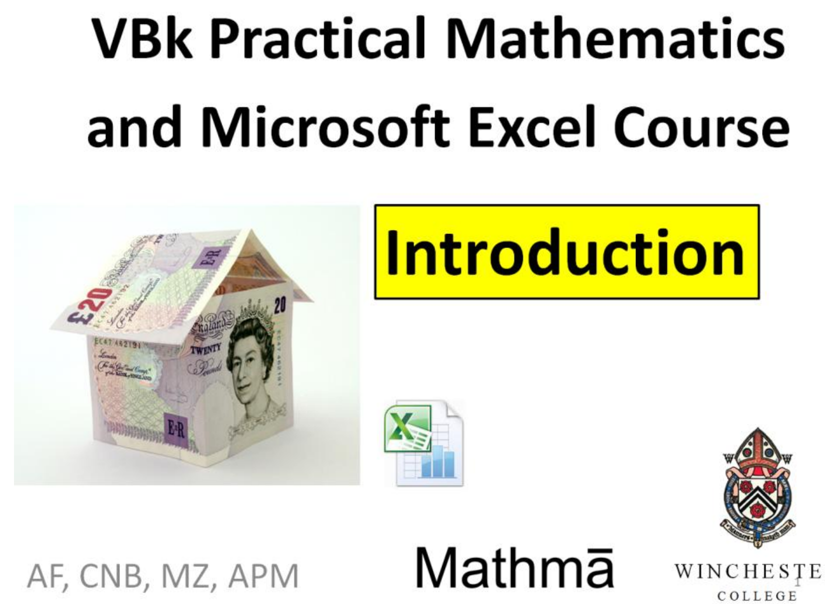
- I can face the class and discuss the problems with them
- Students annotate their work via direct visual comparison. It is what their homework ideally should look like.
- Essence of lesson stored for future use. Minimum subsequent preparation.

Example 2: Use *PowerPoint* when you *really need* to give a proper lecture!

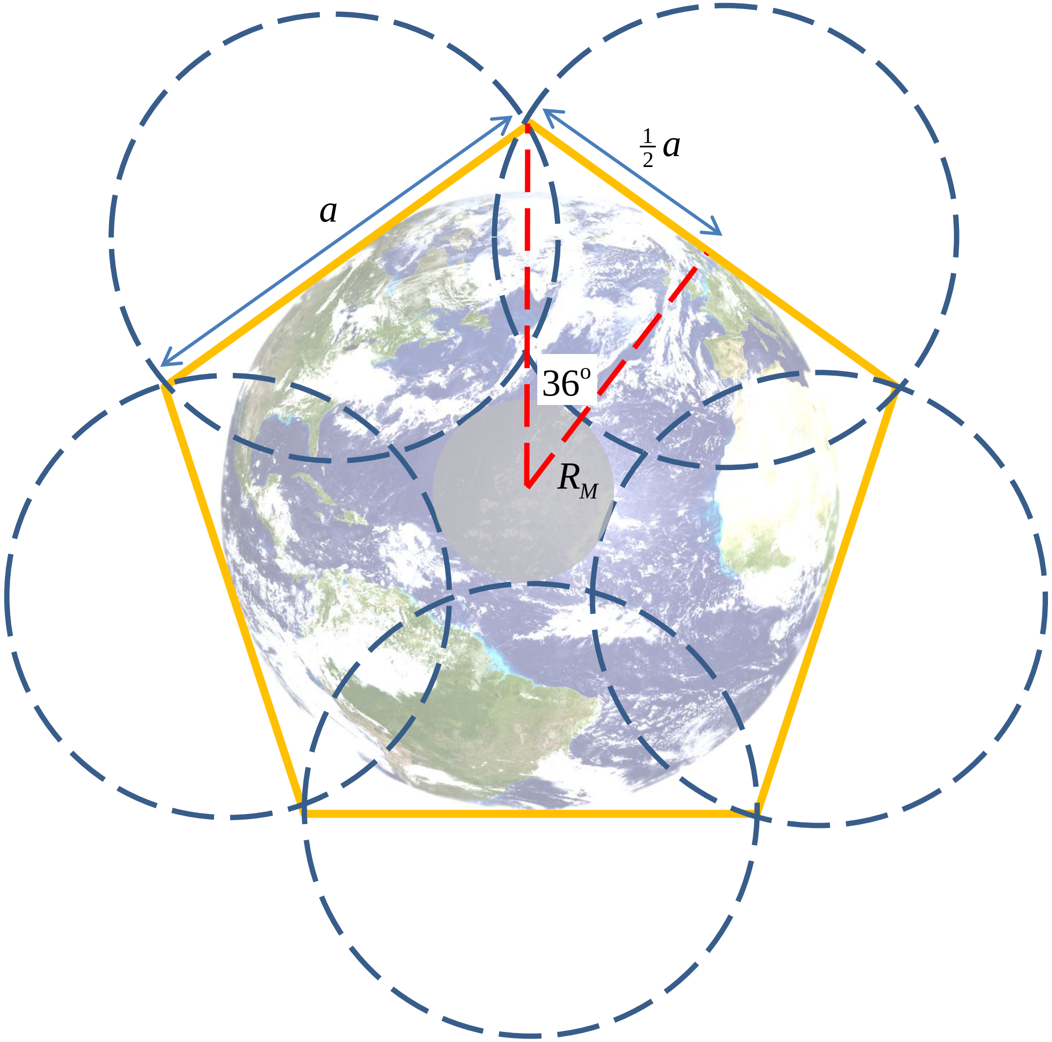








The ratio of Moon and Earth radii is approximately $\frac{R_\oplus}{R_M} \approx \frac{6353\text{km}}{1737\text{km}} = 3.66$



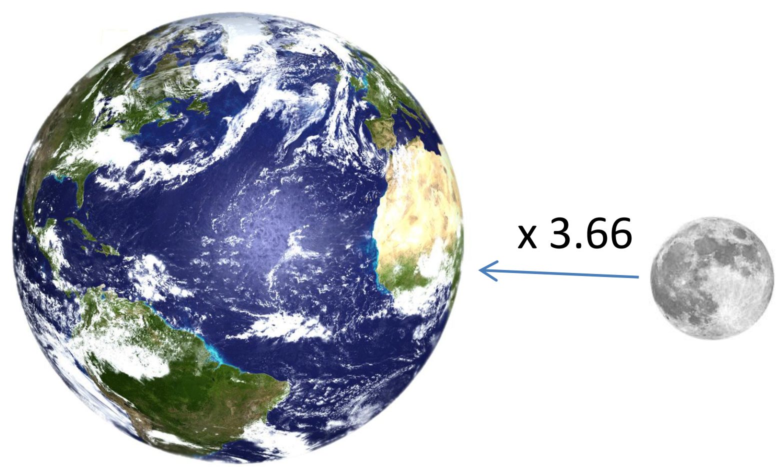
By the construction on the left:

$$R_M = R_\oplus - \tfrac{1}{2}a$$

$$\tfrac{1}{2}a = R_\oplus \tan 36^{\circ}$$

$$\therefore R_M = R_\oplus - R_\oplus \tan 36^{\circ}$$

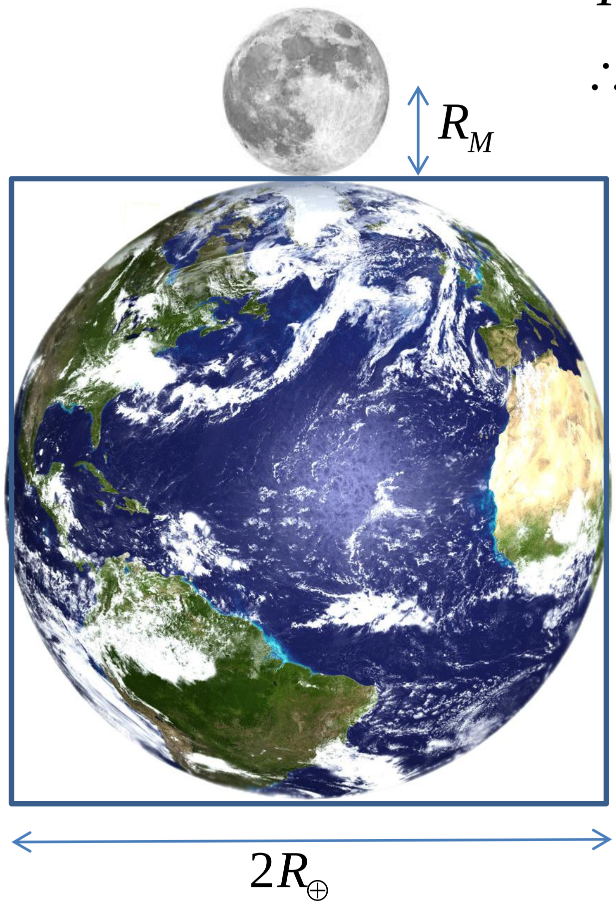
$$\frac{R_\oplus}{R_M} = \frac{1}{1 - \tan 36^{\circ}} \approx 3.66$$



$$\frac{R_\oplus}{R_M} \approx 3\tfrac{2}{3} = \tfrac{11}{3}$$

$$\therefore R_\oplus = \tfrac{11}{3} R_M$$

This amazing coincidence also shows that 'the Moon and the Earth square the circle'



The circumference of the Earth plus the circumference of the Moon is given by:

$$C = 2\pi R_\oplus + 2\pi R_M$$

$$C = 2\pi R_M \left(\tfrac{11}{3} + 1\right)$$

$$C = 2\pi R_M \left(\tfrac{11}{3} + \tfrac{3}{3}\right) = 2\pi R_M \times \tfrac{14}{3}$$

$$C = \tfrac{4\times 7}{3} \pi R_M$$

The perimeter of a square bounding the Earth is

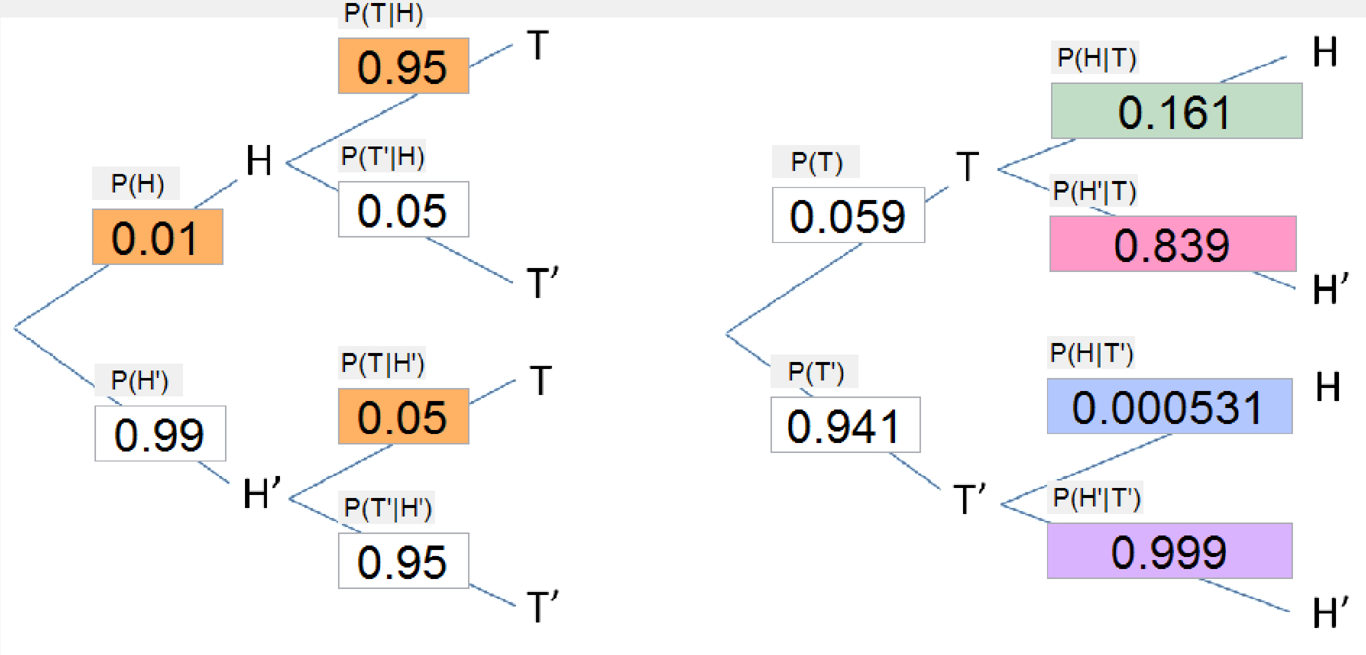
$$P = 4 \times 2R_\oplus = 4 \times \tfrac{22}{3} R_M$$

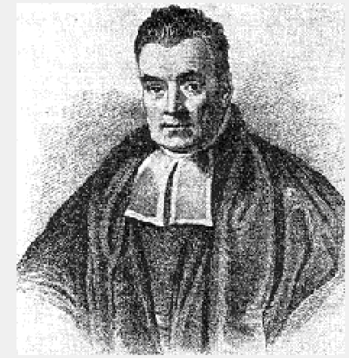
$$\therefore \quad \frac{P}{C} = \frac{4 \times \frac{22}{3} R_M}{\frac{4\times 7}{3} \pi R_M} = \tfrac{22}{7} \times \tfrac{1}{\pi} = 1.000402\ldots$$

i.e. $P = C$ to a very good approximation!

Note this is perhaps where the popular approximation $\pi \approx \frac{22}{7}$ *might* have originated....

Example 3: What if? analysis using automated calculation





BAYES-O-METER

A. French. February 2014.

Probability of hypothesis true given pass of test P(H|T) = **0.161**

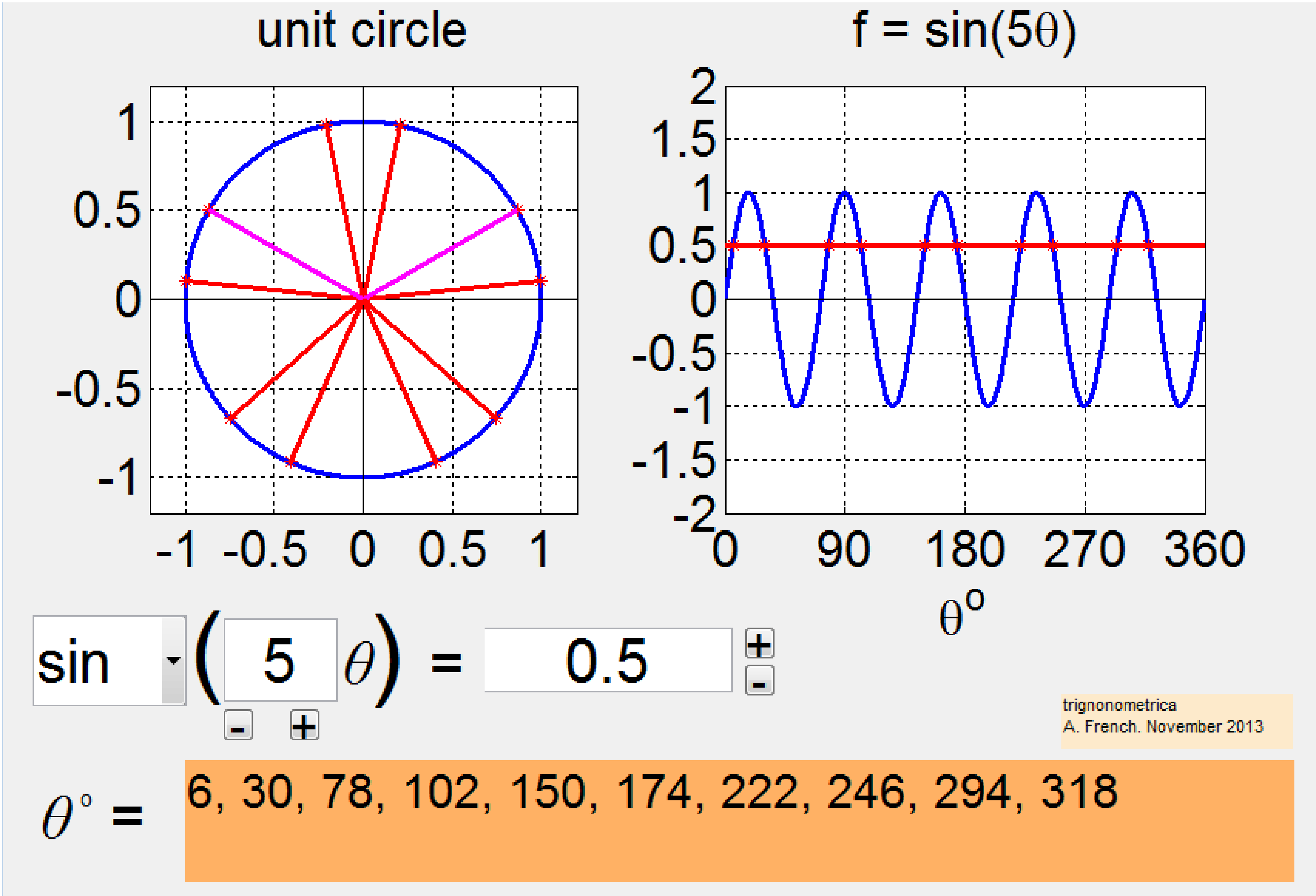
Probability of hypothesis false given pass of test P(H'|T) = **0.839**
(False positive)

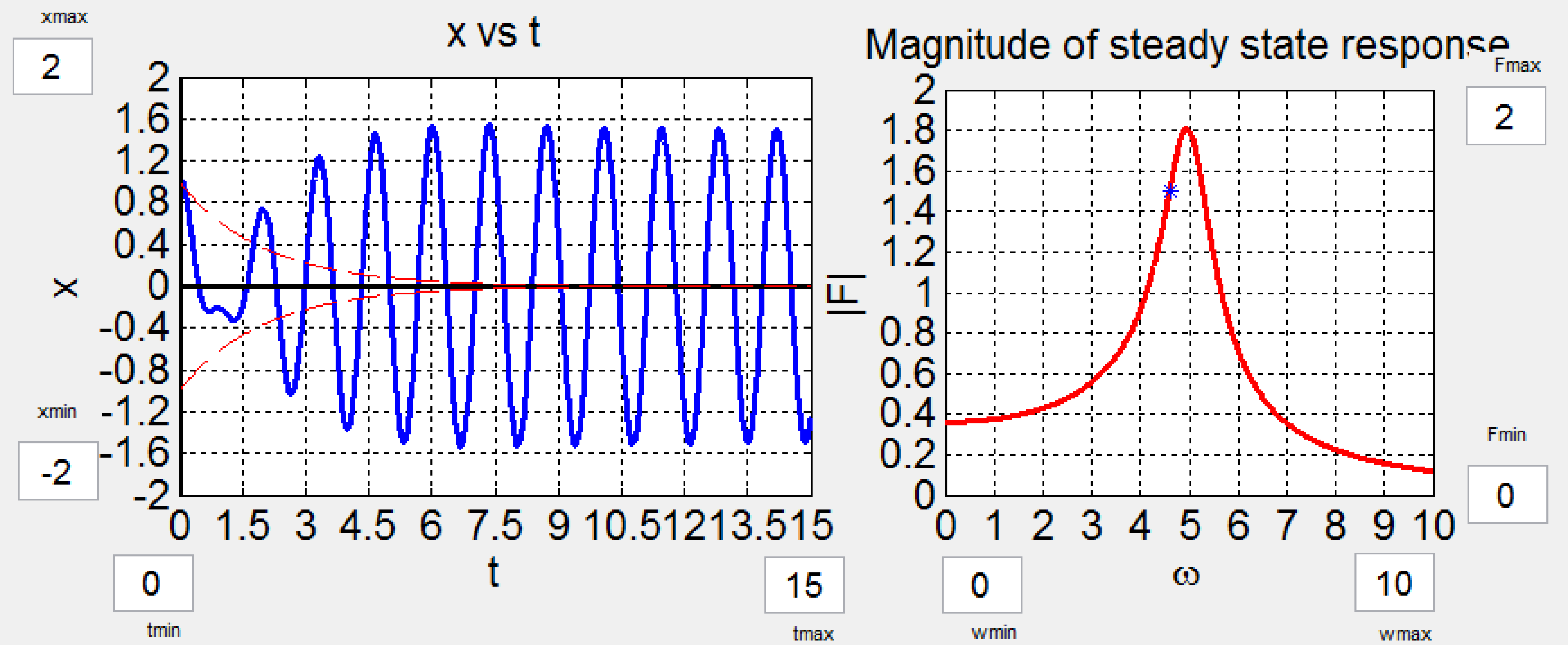
Probability of hypothesis true given fail of test P(H|T') = **0.000531**
(False negative)

Probability of hypothesis false given fail of test P(H'|T') = **0.999**

It is really hard to describe a 'mathematical landscape' if each elevation has to be painstakingly constructed! Once the basic technique is accepted, automation can enable exploration. In this case, a *bespoke* 'app' is often needed to *make your point clearly*

Example 3:   What if? analysis using automated calculation

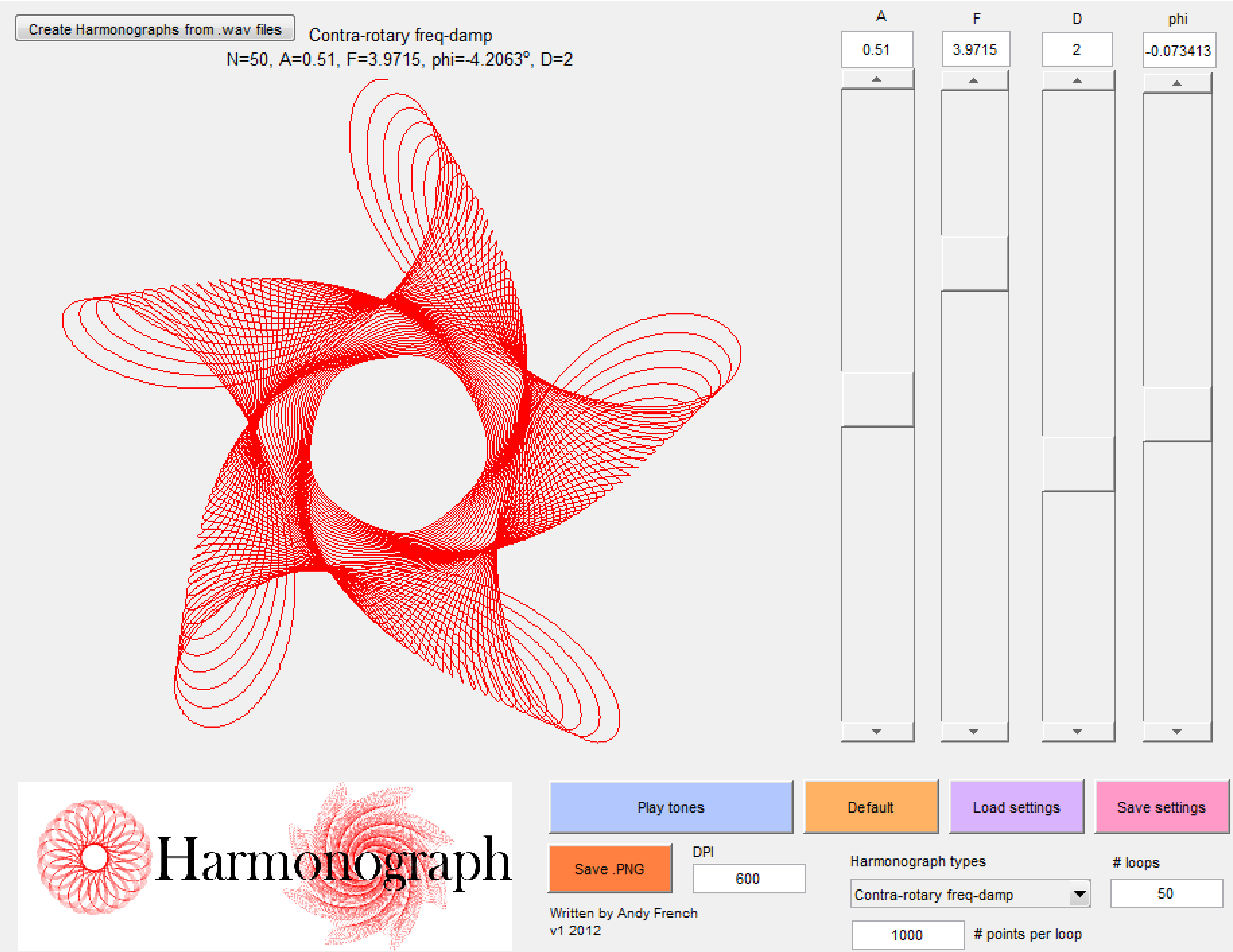




$$\frac{d^2x}{dt^2} + 2\gamma\frac{dx}{dt} + \omega_0^2 x = F_0 \sin \omega t$$

Forced Simple Harmonic Equation solution explorer
Andy French. November 2013.

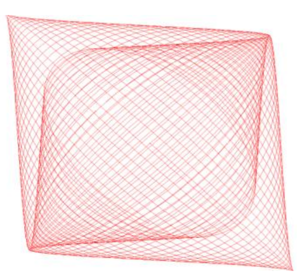
γ	ω_0	F_0	ω	x_0	v_0
0.5	5	9	4.6	1	1
- +	- +	- +	- +	- +	- +

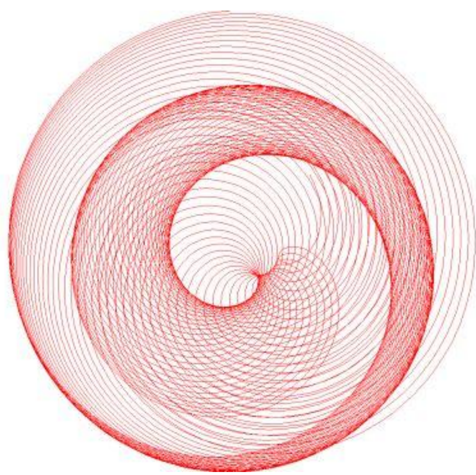

Create Harmonographs from .wav files
Contra-rotary freq-damp
N=50, A=0.51, F=3.9715, phi=-4.2063°, D=2
A
0.51
F
3.9715
D
2
phi
-0.073413
Harmonograph
Play tones
Default
Load settings
Save settings
Save .PNG
DPI
600
Harmonograph types
Contra-rotary freq-damp
loops
50
1000
points per loop
Written by Andy French
v1 2012

harmonograph

- The Harmonograph was a Victorian curiosity attributed to Professor Blackburn in 1844

- Use two or three pendulums to create strange and beautiful patterns





Example of a *lateral* harmonograph

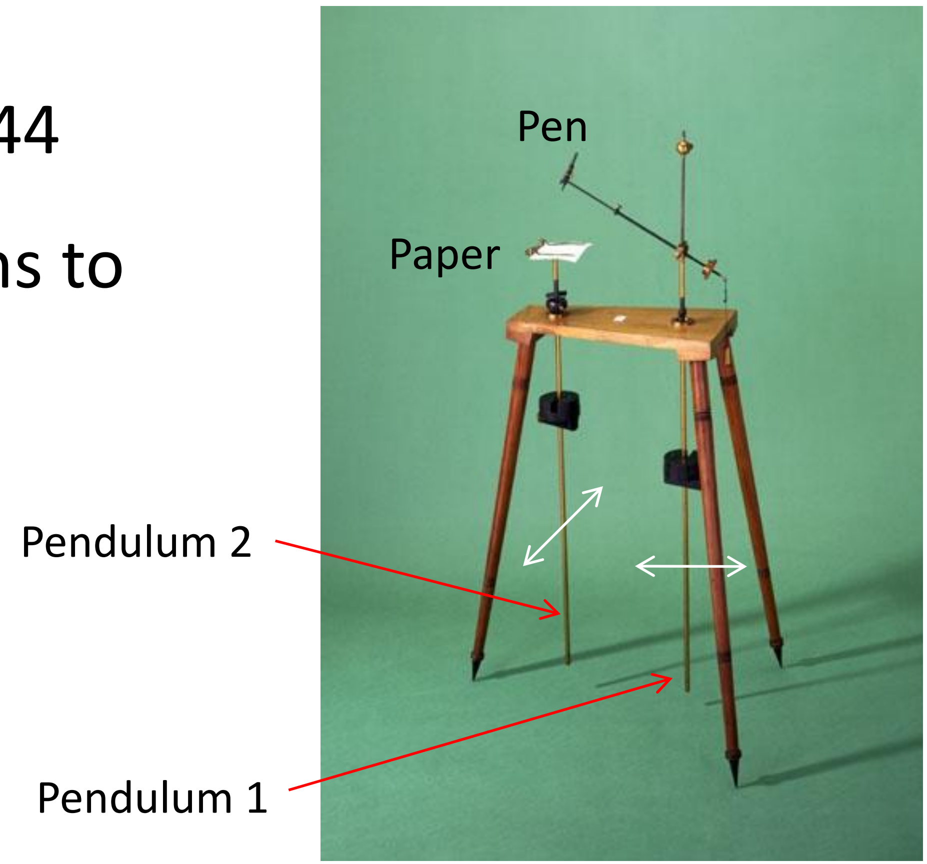
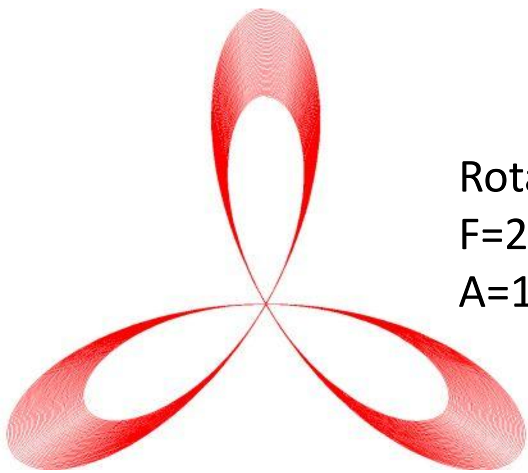
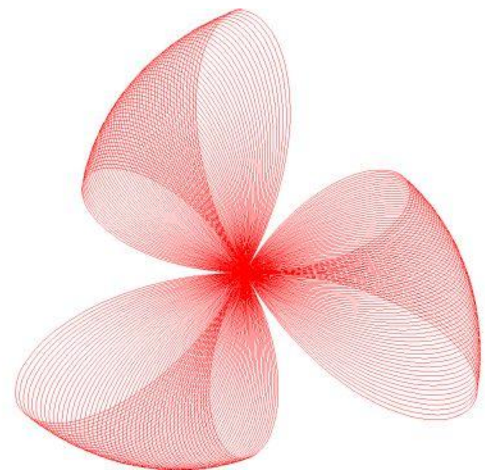


Photo from The Science Museum

Represent musical harmonies visually with the harmonograph!

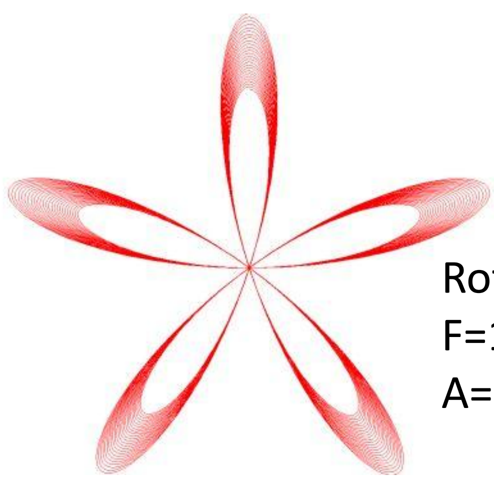


Rotary
F=2, D=0.7,
A=1, phi=0

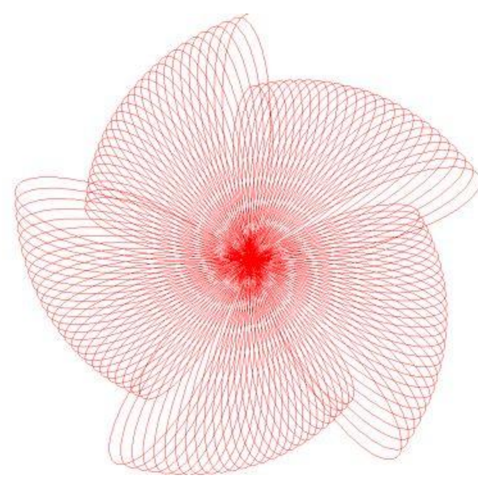


Rotary
F=2.01, D=0.7,
A=1, phi=0

Note the difference a small change in F makes....



Rotary
F=1.5, D=0.7,
A=1, phi=0



Rotary
F=1.51, D=0.7,
A=1, phi=0

Gravity simulator using Excel

Binary system gravity simulation.
Dr Andrew French. June 2015.

Mass of star1 (solar masses)	6
Mass of star2 (solar masses)	2
Mass of planet (Earth masses)	1
Semi-major axis of initial star orbit /AU	1
Semi-major axis of initial planet orbit /AU about star1	2.12345
Orbital eccentricity of initial star orbit	0.3
Orbital eccentricity of initial planet orbit about star 1	0
Initial polar angle /degrees of initial star orbit	0
Initial polar angle /degrees of initial planet orbit about star 1	0
timestep /years	0.000072

theta0 (stars) /radians	0
theta0 (planet) /radians	0
delta_t /s	2270.592
mass 0 (planet) /kg	5.97E+24
mass 1 (star1) /kg	1.1934E+31
mass 2 (star2) /kg	3.978E+30
Mass of Sun /kg	1.989E+30
Mass of Earth /kg	5.97E+24
G	6.67E-11
AU /m	1.496E+11

Initial conditions based upon Keplerian orbits

Planet

	AU	AU	AU	ms^-1	ms^-1
theta	r	x0	y0	vx0	vy0
0	2.123	1.94845	0	0	50057.50806

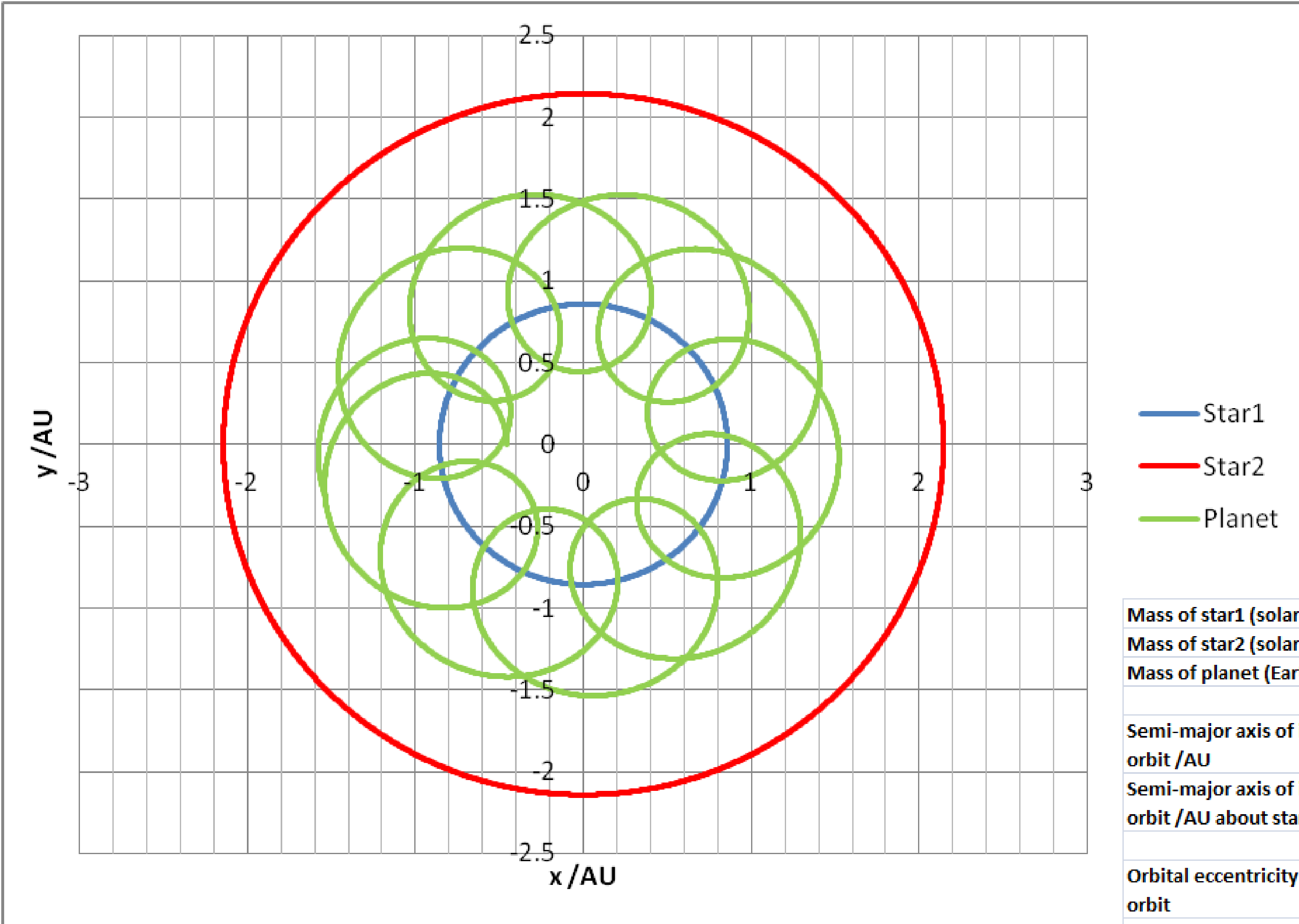
Star 1

	AU	AU	AU	ms^-1	ms^-1	ms^-1
theta	r	x1	y1	vx1	vy1	v1
0	0.7	-0.175	0	0	-28696.05328	28696.05328

Star 2

	AU	AU	AU	ms^-1	ms^-1	ms^-1
theta	r	x1	y1	vx1	vy1	v2
0	0.7	0.525	0	0	86088.15985	86088.15985

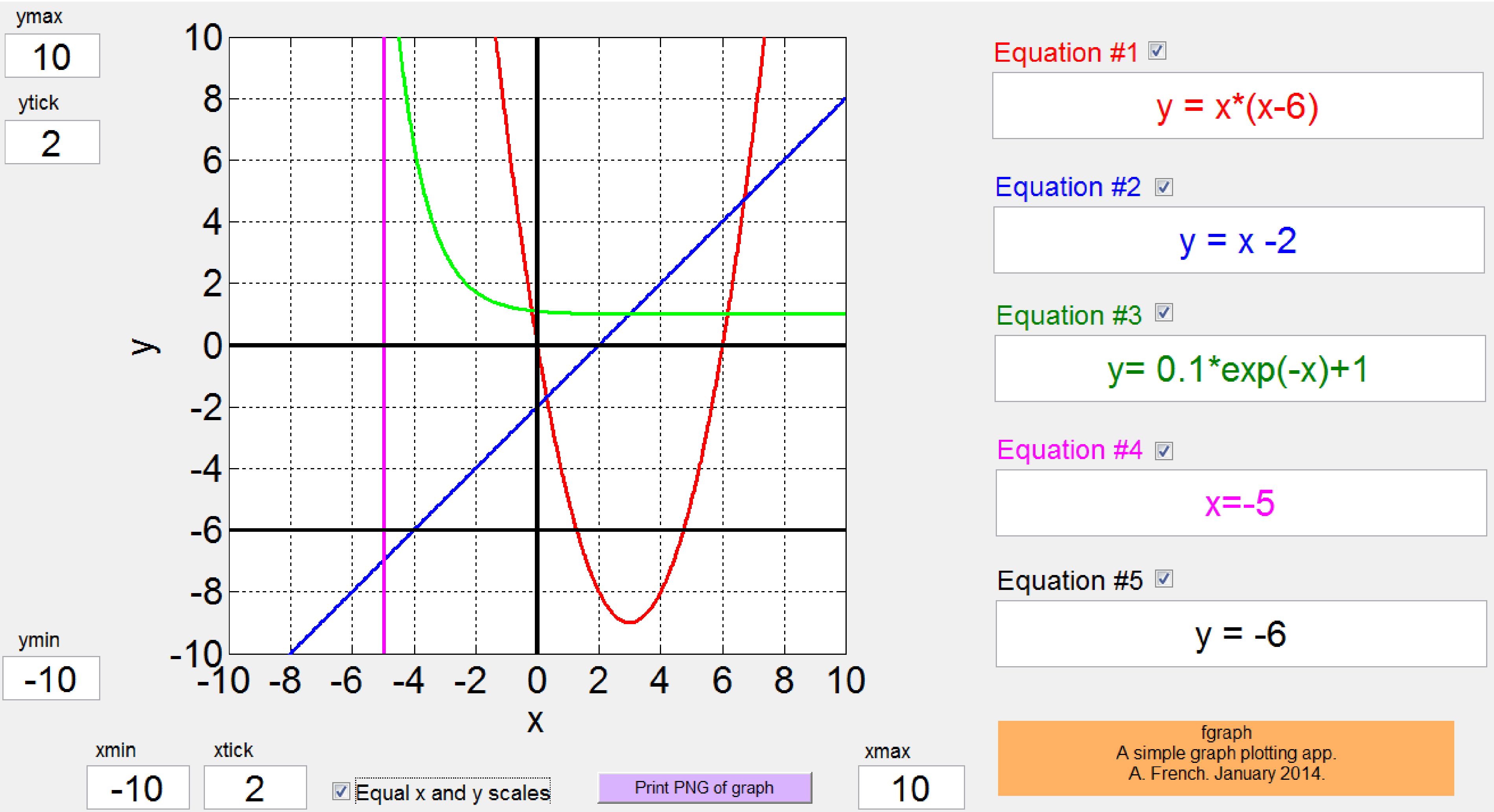
	Planet					
years	AU	ms^-1	ms^-2	AU	ms^-1	ms^-2
t	x0	vx0	ax0	y0	vy0	ay0
0	1.94845	0	-0.013175634	0	50057.51	0
0.000072	1.9484498	-23.9134	-0.007887959	0.00076	50057.5	-4.44018E-06
0.000144	1.9484493	-41.8238	-0.007887961	0.00152	50057.49	-8.88036E-06
0.000216	1.9484485	-59.7341	-0.007887963	0.002279	50057.46	-1.33205E-05
0.000288	1.9484475	-77.6444	-0.007887967	0.003039	50057.43	-1.77607E-05
0.00036	1.9484461	-95.5548	-0.007887971	0.003799	50057.38	-2.22009E-05
0.000432	1.9484446	-113.465	-0.007887975	0.004559	50057.33	-2.66411E-05
0.000504	1.9484427	-131.376	-0.007887981	0.005318	50057.26	-3.10813E-05
0.000576	1.9484406	-149.286	-0.007887987	0.006078	50057.19	-3.55215E-05
0.000648	1.9484382	-167.196	-0.007887993	0.006838	50057.1	-3.99616E-05
0.00072	1.9484355	-185.107	-0.007888001	0.007598	50057	-4.44018E-05
0.000792	1.9484326	-203.017	-0.007888009	0.008357	50056.9	-4.8842E-05
0.000864	1.9484293	-220.928	-0.007888018	0.009117	50056.78	-5.32822E-05
0.000936	1.9484258	-238.838	-0.007888028	0.009877	50056.66	-5.77224E-05
0.001008	1.9484221	-256.749	-0.007888038	0.010637	50056.52	-6.21625E-05
0.00108	1.9484181	-274.659	-0.007888049	0.011396	50056.37	-6.66027E-05
0.001152	1.9484137	-292.57	-0.007888061	0.012156	50056.22	-7.10429E-05
0.001224	1.9484092	-310.48	-0.007888073	0.012916	50056.05	-7.54831E-05
0.001296	1.9484043	-328.391	-0.007888086	0.013676	50055.87	-7.99233E-05
0.001368	1.9483992	-346.302	-0.0078881	0.014435	50055.69	-8.43634E-05
0.00144	1.9483938	-364.212	-0.007888115	0.015195	50055.49	-8.88036E-05
0.001512	1.9483881	-382.123	-0.00788813	0.015955	50055.29	-9.32438E-05
0.001584	1.9483822	-400.034	-0.007888146	0.016714	50055.07	-9.7684E-05
0.001656	1.948376	-417.944	-0.007888163	0.017474	50054.84	-0.000102124
0.001728	1.9483695	-435.855	-0.00788818	0.018234	50054.6	-0.000106564
0.0018	1.9483628	-453.766	-0.007888199	0.018994	50054.36	-0.000111004
0.001872	1.9483557	-471.677	-0.007888218	0.019753	50054.1	-0.000115445
0.001944	1.9483485	-489.588	-0.007888237	0.020513	50053.83	-0.000119885
0.002016	1.9483409	-507.499	-0.007888257	0.021273	50053.56	-0.000124325
0.002088	1.948333	-525.41	-0.007888278	0.022032	50053.27	-0.000128765
0.00216	1.9483249	-543.321	-0.0078883	0.022792	50052.97	-0.000133205
0.002232	1.9483166	-561.232	-0.007888323	0.023552	50052.66	-0.000137645
0.002304	1.9483079	-579.143	-0.007888346	0.024312	50052.35	-0.000142086
0.002376	1.948299	-597.055	-0.00788837	0.025071	50052.02	-0.000146526
0.002448	1.9482898	-614.966	-0.007888394	0.025831	50051.68	-0.000150966
0.00252	1.9482803	-632.877	-0.007888419	0.026591	50051.33	-0.000155406
0.002592	1.9482706	-650.789	-0.007888445	0.02735	50050.98	-0.000159846
0.002664	1.9482606	-668.7	-0.007888472	0.02811	50050.61	-0.000164286
0.002736	1.9482503	-686.612	-0.007888499	0.02887	50050.23	-0.000168726



Mass of star1 (solar masses)	5
Mass of star2 (solar masses)	2
Mass of planet (Earth masses)	1
Semi-major axis of initial star orbit /AU	3
Semi-major axis of initial planet orbit /AU about star1	0.4
Orbital eccentricity of initial star orbit	0
Orbital eccentricity of initial planet orbit about star 1	0
Initial polar angle /degrees of initial star orbit	0
Initial polar angle /degrees of initial planet orbit about star 1	0
timestep /years	0.0001

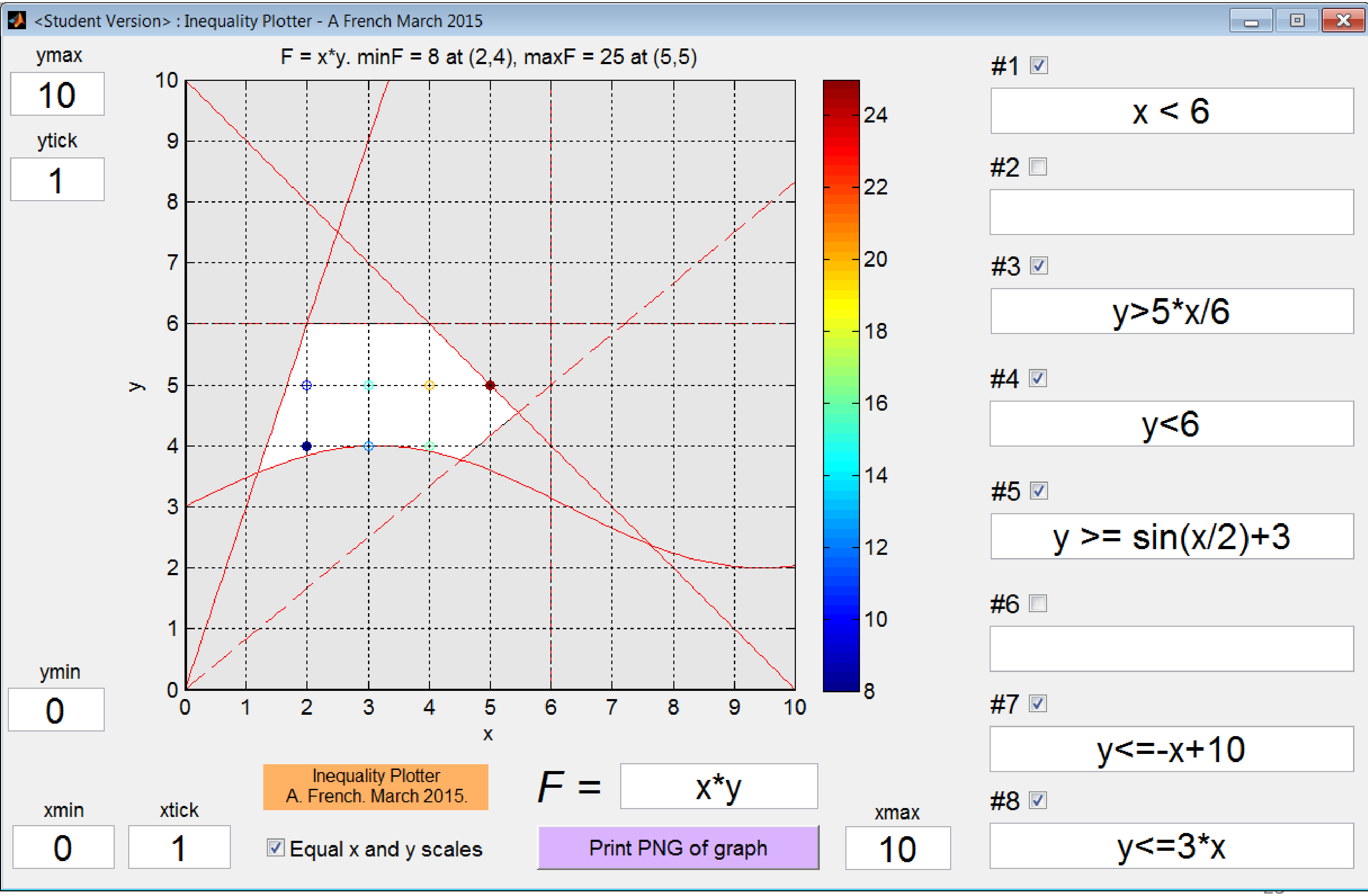
Using the Verlet method to ‘solve’ a three-body problem i.e. the motion of a planet within the mutual orbits of a binary star system

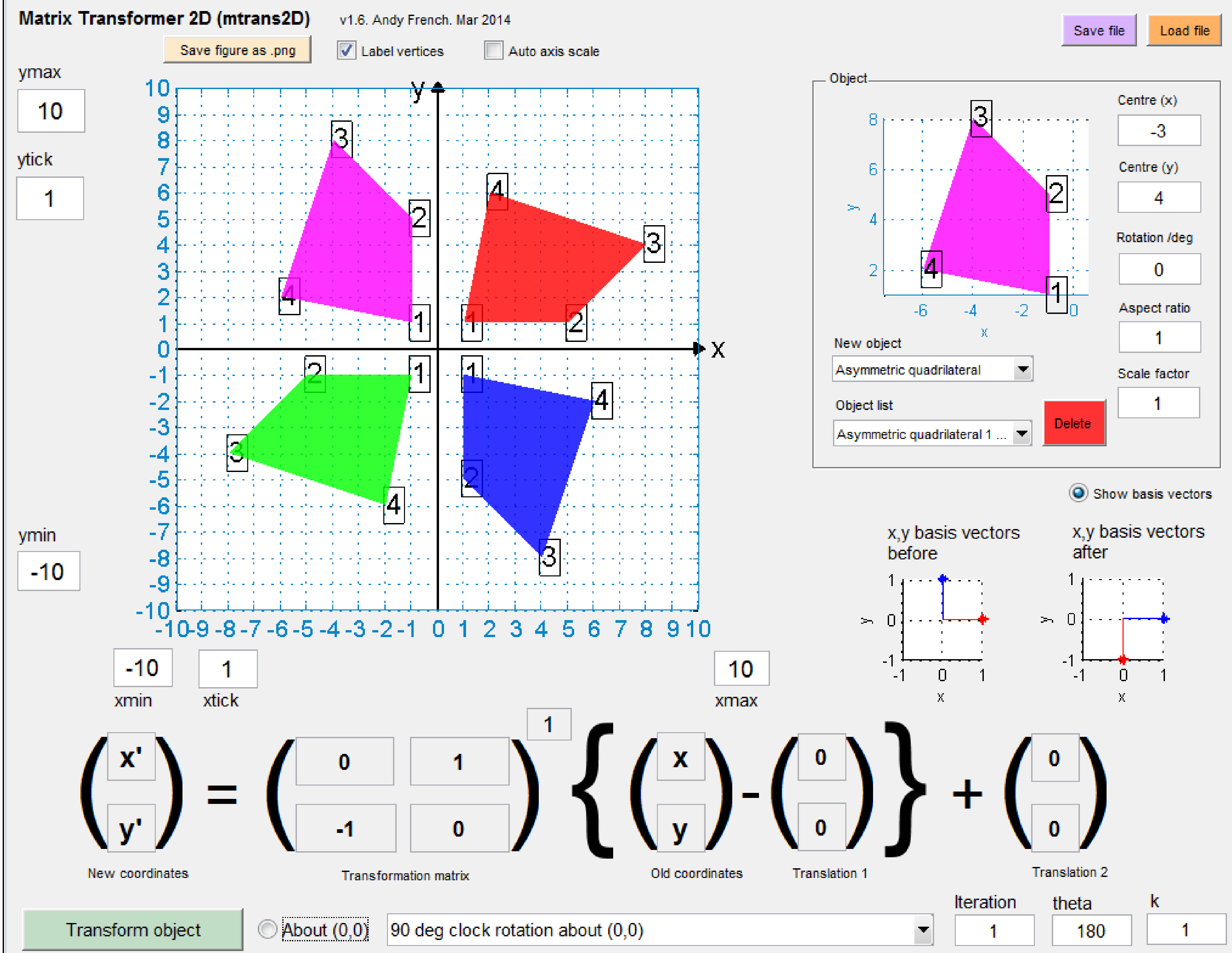
Example 4: Accurate plotting of graphs and geometry and their inter-relationships



Note: Learning to curve sketch a mathematical function *by hand* is one of the best methods for becoming adept at the subject and appreciating its interconnectedness. I *only* use IT for graph plotting when accuracy, or rapid variation, is required.

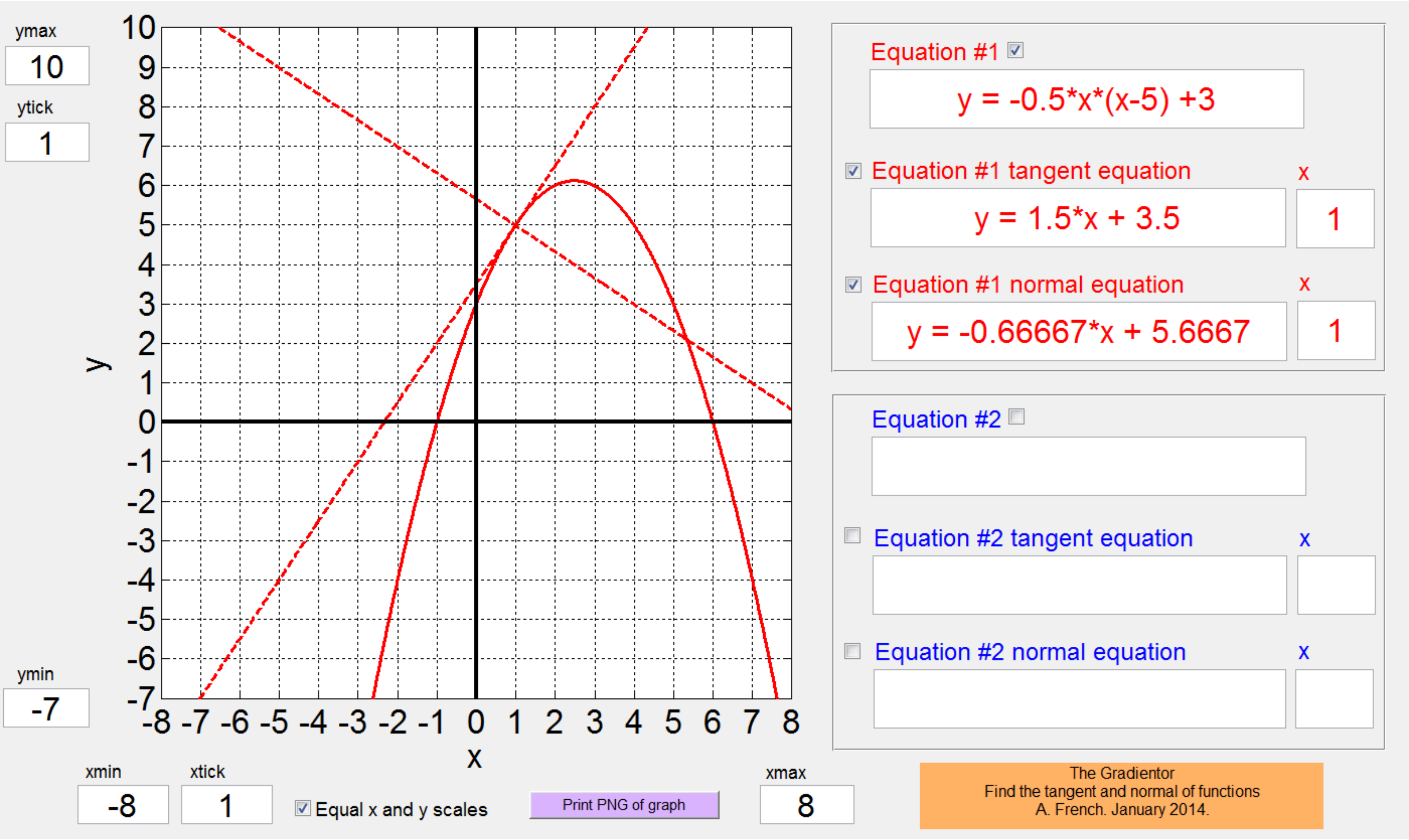
Example 4: Accurate plotting of graphs and geometry and their inter-relationships




Matrix Transformer 2D (mtrans2D)
v1.6. Andy French. Mar 2014
Save figure as .png
Label vertices
Auto axis scale
Save file
Load file
ymax
10
ytick
1
ymin
-10
-10
xmin
1
xtick
10
xmax
Object
Centre (x)
-3
Centre (y)
4
Rotation /deg
0
Aspect ratio
1
Scale factor
1
New object
Asymmetric quadrilateral
Object list
Asymmetric quadrilateral 1 ...
Delete
Show basis vectors
x,y basis vectors before
x,y basis vectors after
New coordinates
Transformation matrix
Old coordinates
Translation 1
Translation 2
Transform object
About (0,0)
90 deg clock rotation about (0,0)
Iteration
1
theta
180
k
1

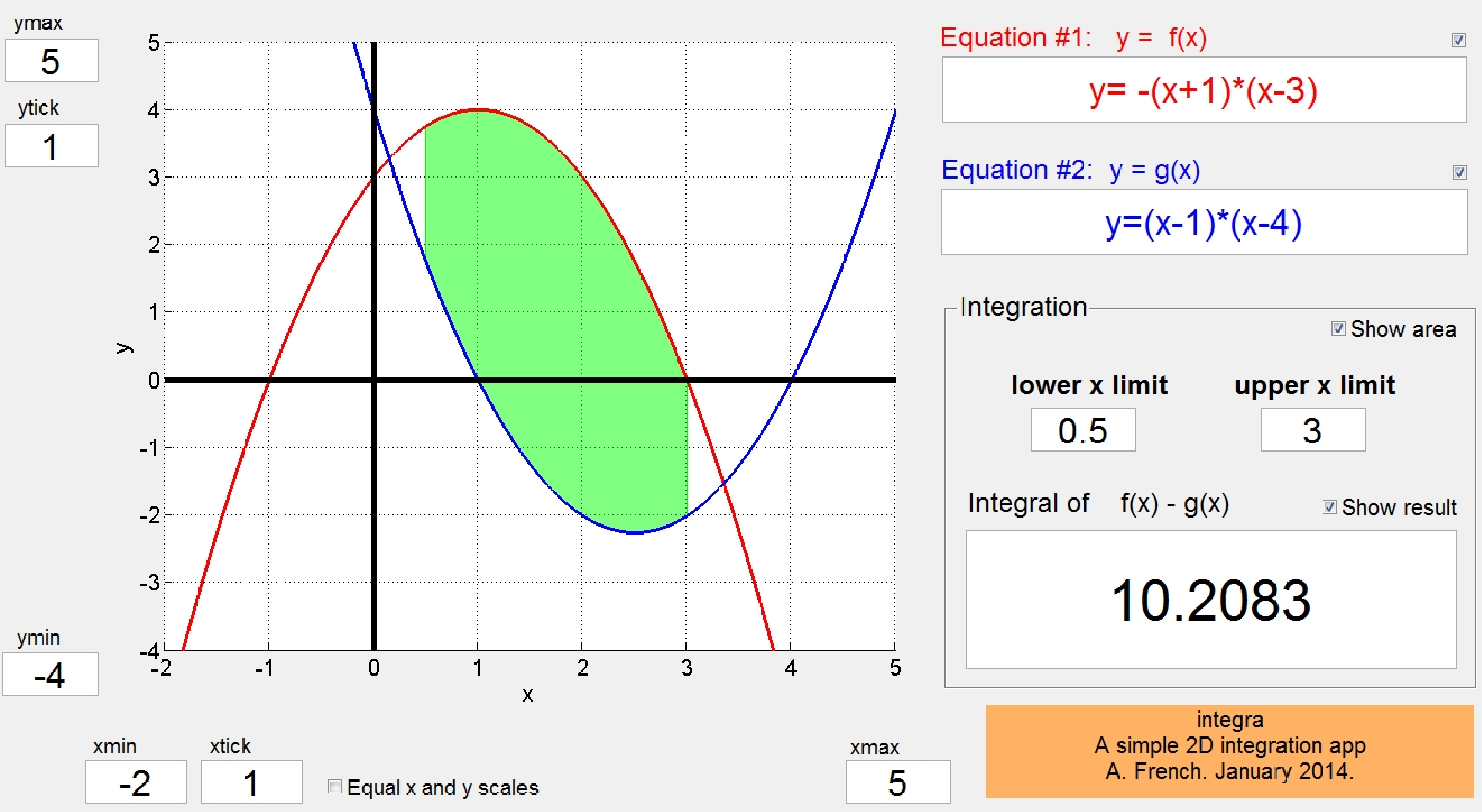
Example 5: Confirming that you are correct!

Accurate drawing of *normals* to scale is often tricky. A tool can help to confirm whether your sketch is correct, and build confidence and precision into a lesson!

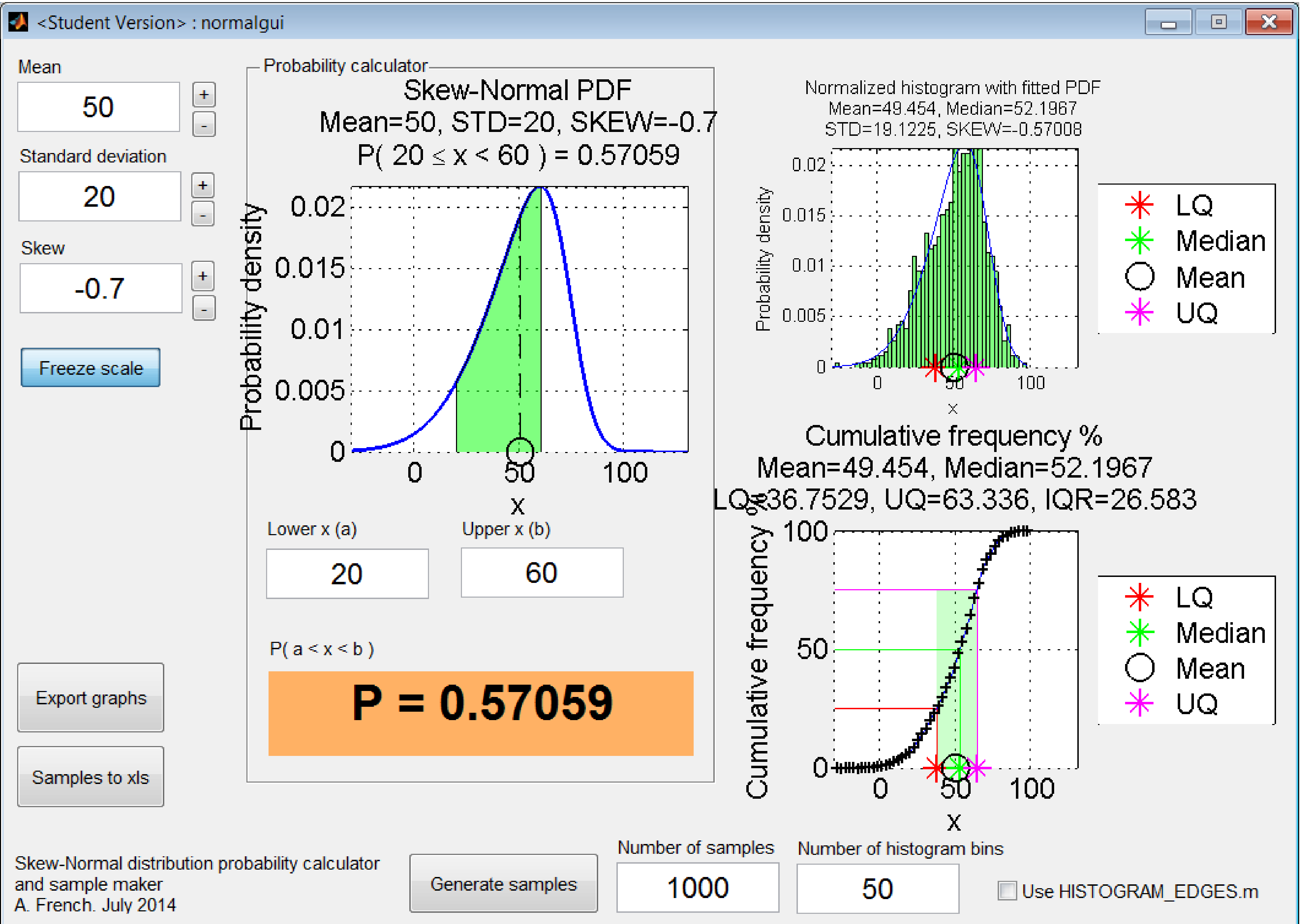


Example 5: Confirming that you are correct!

It is important that students can obtain satisfaction that an extended calculation is correct and also, *why* the answer is what it is. It is *not* always expedient to go through every question from scratch. An informative *automated* display of a solution can solve this problem.



Example 6: Using a tool to generate the ‘right’ numbers to make your point



A tool which generates statistical data can facilitate the creation of *interesting* and *realistic* resources. This would normally be very time consuming!

Half Marathon Statistics

NAME: Dr French **HOUSE:** ....

DATE: ....

ABP SOUTHAMPTON HALF MARATHON & 10K

Table 1 is a frequency table corresponding to athletes who participated in the inaugural *Southampton Half Marathon* (13.1 miles or 21.1km) in April 2015.

Question 1 How many athletes were there in total? 4258

Question 2 Use the formula below to calculate *frequency density* in Table 1

$$\text{frequency density} = \frac{\text{frequency}}{\text{time range}}$$

Time range /hours	Frequency	Frequency density
$x < 1.3$	10	33.3
$1.3 \le x < 1.4$	33	330
$1.4 \le x < 1.5$	110	1100
$1.5 \le x < 1.6$	234	2340
$1.6 \le x < 1.7$	384	3840
$1.7 \le x < 1.8$	533	5330
$1.8 \le x < 1.9$	537	5370
$1.9 \le x < 2.0$	521	5210
$2.0 \le x < 2.1$	462	4620
$2.1 \le x < 2.2$	401	4010
$2.2 \le x < 2.4$	543	2715
$2.4 \le x < 2.6$	290	1450
$2.6 \le x < 2.8$	127	635
$2.8 \le x < 3.0$	47	235
$x \ge 3.0$	26	52

TABLE 1: Number of athletes with half marathon time (in hours) between values stated

← Time range might sensibly be $1 \le x < 1.3$

← $3.0 \le x < 3.5$

Question 3 *Estimate* the *mean* time using Table 1. State your assumption when performing this calculation.

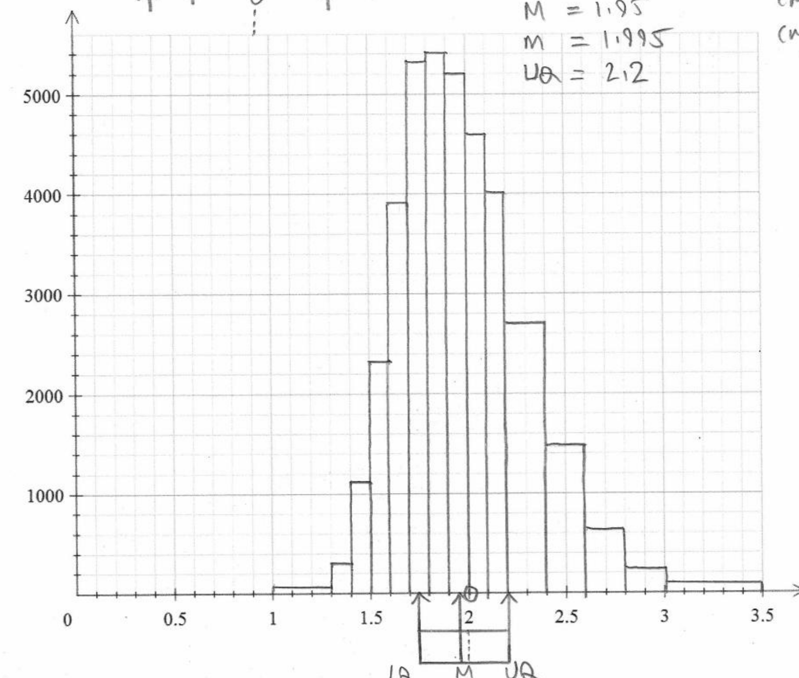
Assume all times are in the middle of the intervals stated

$$\bar{t} \approx \frac{1}{4258}\Big(0.65\times10 + 1.35\times33 + 1.45\times110 + 1.55\times234 + 1.65\times384 + \ldots + 1.75\times533 + 1.85\times537 + 1.95\times521 + 2.05\times462 + \ldots + 2.15\times401 + 2.3\times543 + 2.5\times290 + 2.7\times127 + \ldots + 2.9\times47 + 3.25\times26\Big)$$

$$= \frac{8495.85}{4258} = \boxed{1.995} \text{ hours}$$

Question 6 Using the axes below, draw a *histogram* for the data in Table 1. Mark on the times corresponding to the LQ, Median, Mean and UQ times.

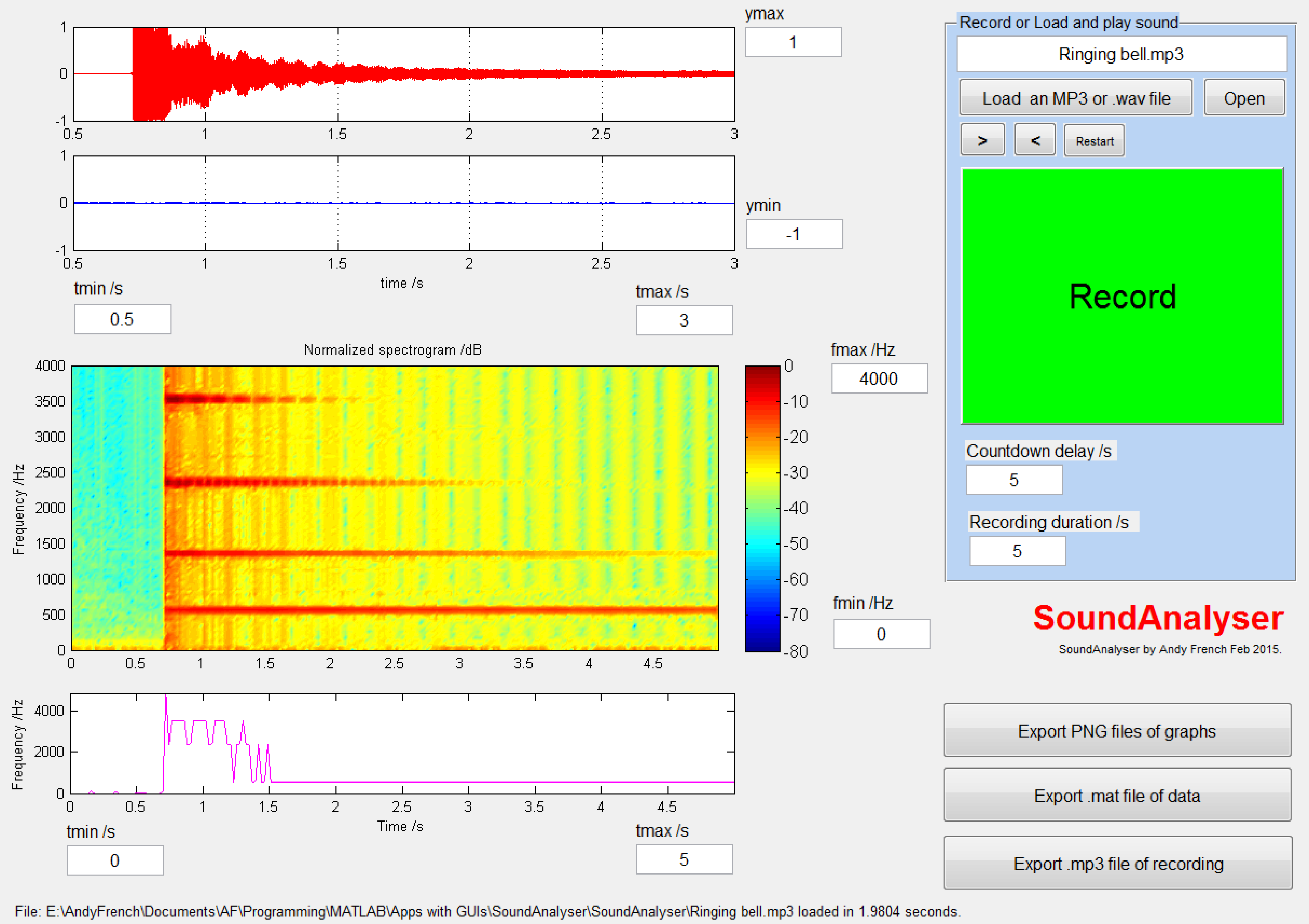
LQ = 1.75
M = 1.95 (Median)
M = 1.995 (mean)
UQ = 2.2



Question 7 (i) What proportion of athletes ran under two hours?

From cumulative frequency graph, 2 hours corresponds to ≈ 56%

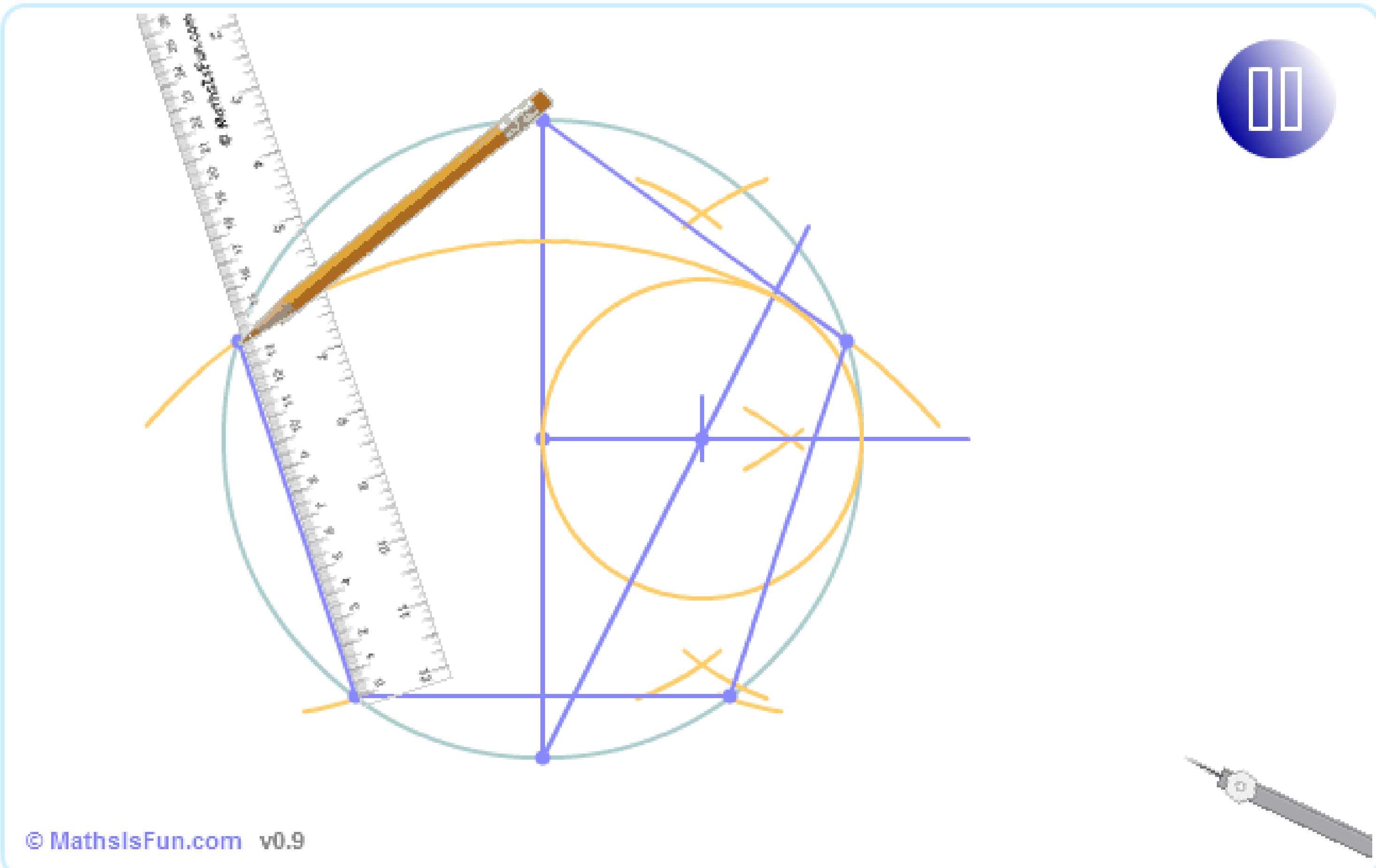
Example 7: (Physics) Live visual analysis of experimental data

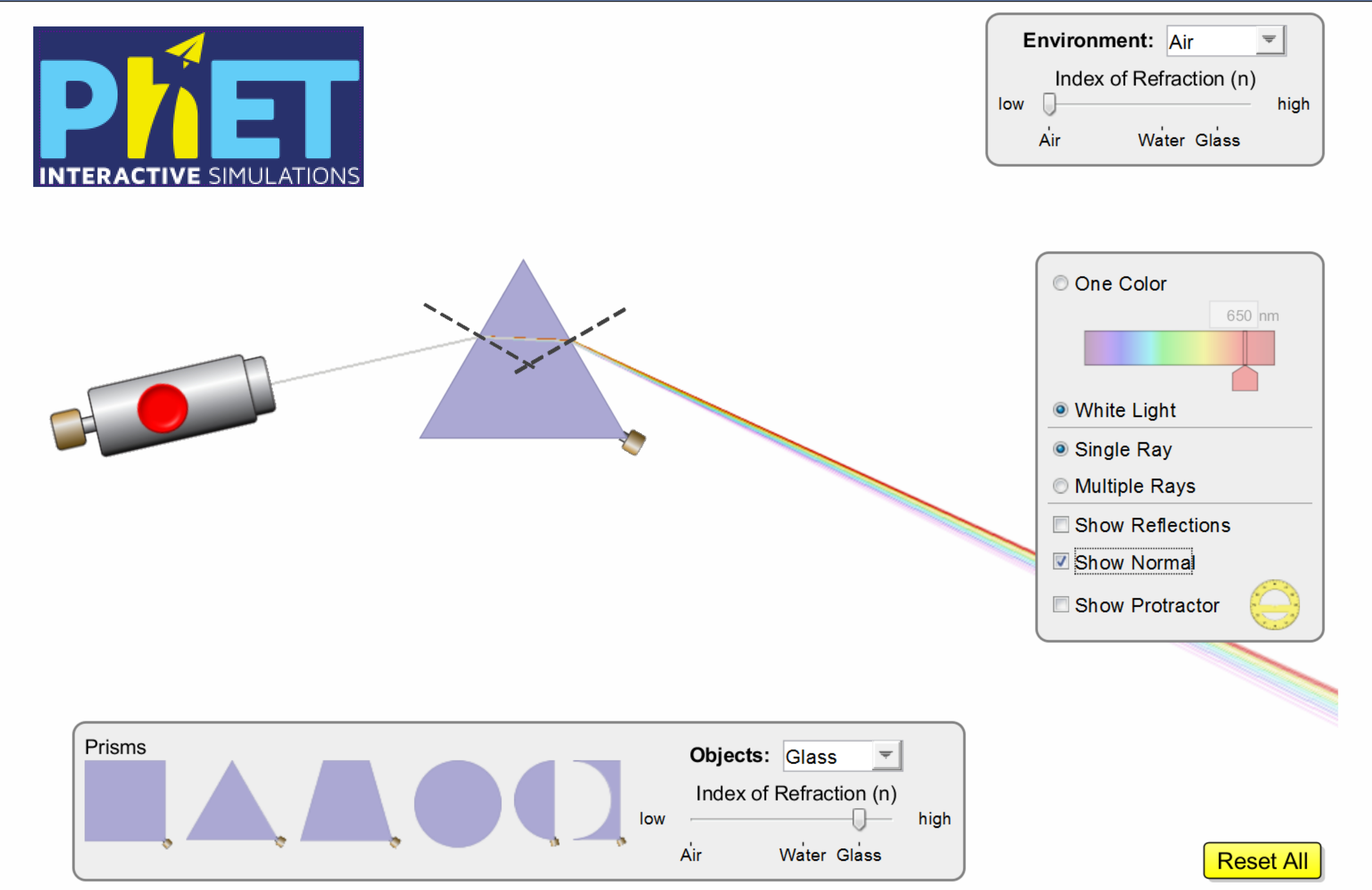


Example 8: When you really need an animated demo!

Pentagon

How to construct a Pentagon
using just a compass and a straightedge

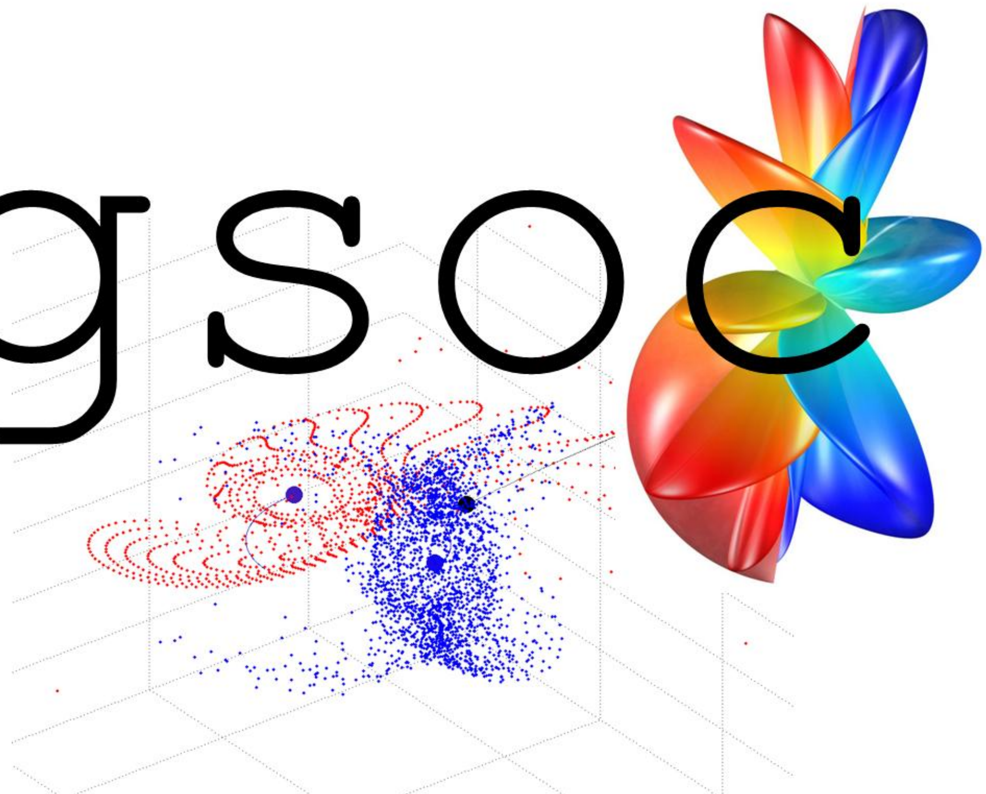



INTERACTIVE SIMULATIONS
Environment: Air
Index of Refraction (n)
low
high
Air
Water Glass
One Color
650 nm
White Light
Single Ray
Multiple Rays
Show Reflections
Show Normal
Show Protractor
Prisms
Objects: Glass
Index of Refraction (n)
low
high
Air
Water Glass
Reset All

In the classroom

Programming

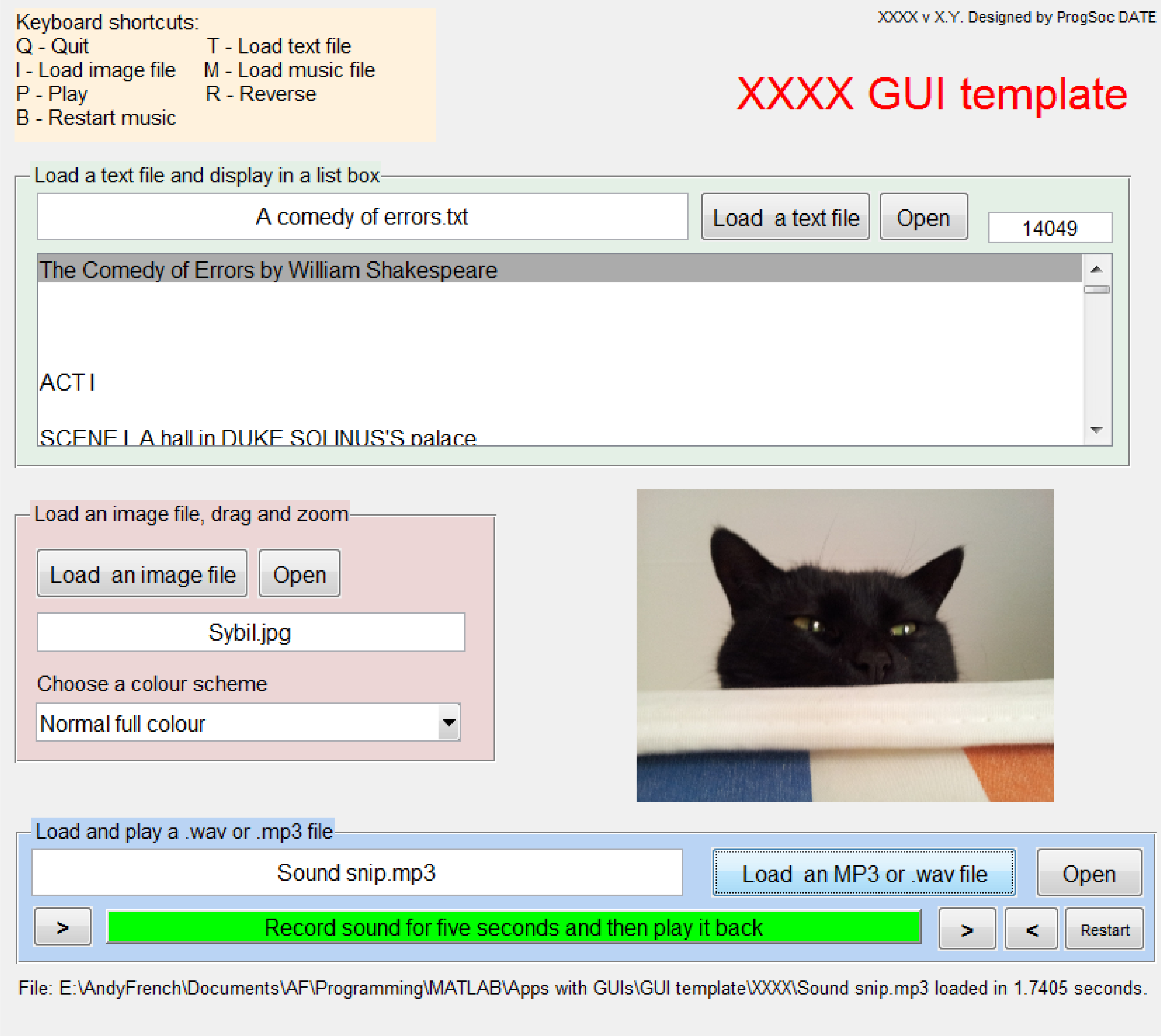
progsoc



Thursdays. 1600-1745.

Mill or Science School

IT suites


Keyboard shortcuts:
Q - Quit
T - Load text file
I - Load image file
M - Load music file
P - Play
R - Reverse
B - Restart music
XXXX v X.Y. Designed by ProgSoc DATE
XXXX GUI template
Load a text file and display in a list box
A comedy of errors.txt
Load a text file
Open
14049
The Comedy of Errors by William Shakespeare
ACT I
SCENE I. A hall in DUKE SOLINUS'S palace
Load an image file, drag and zoom
Load an image file
Open
Sybil.jpg
Choose a colour scheme
Normal full colour
Load and play a .wav or .mp3 file
Sound snip.mp3
Load an MP3 or .wav file
Open
>
Record sound for five seconds and then play it back
>
<
Restart
File: E:\AndyFrench\Documents\AF\Programming\MATLAB\Apps with GUIs\GUI template\XXXX\Sound snip.mp3 loaded in 1.7405 seconds.

E:\AndyFrench\Documents\AF\Programming\MATLAB\Apps\GUI template\XXXX.m

```matlab
%%

%List box which displays the loaded text
function LISTtext_Callback(hObject, eventdata, handles) ...

%%

%%% IMAGE %%%

% Load image file (e.g .jpg, .png etc) pushbutton
function PUSHloadimage_Callback(hObject, eventdata, handles)
global d

%Bring up a windows file browser
[filename, pathname] = uigetfile( {'*.jpg;*.png;*.bmp'}, 'Choose image file to load');

%Only proceed if file selected ...
if filename ~=0

    %Delete any previous image
    delete( d.image.image_handle );

    %Store the filename in the GUI data
    d.image.filename = [pathname,filename];

    %Update the edit box with the filename only
    set( d.h.EDITloadimage, 'string', filename );

    %Load the image
    d.image.image = flipdim( imread( d.image.filename ), 1 );

    %Apply desired basic image procesing
    RGB_output = basic_image_processing( d.image.image , d.image.colour_scheme );
```

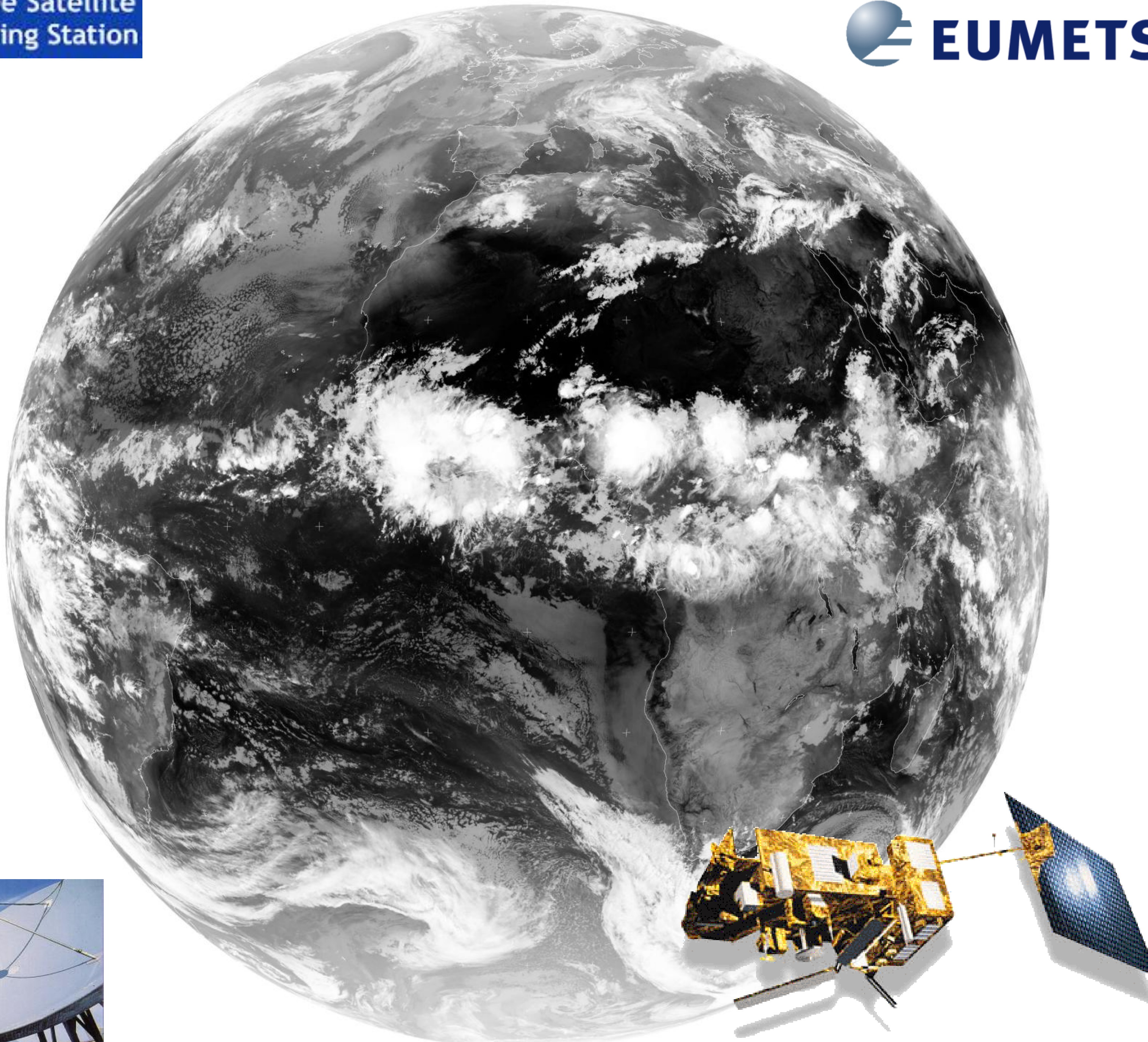
What is the difference between these images? The one on the left *also contains the entire works of Shakespeare.*

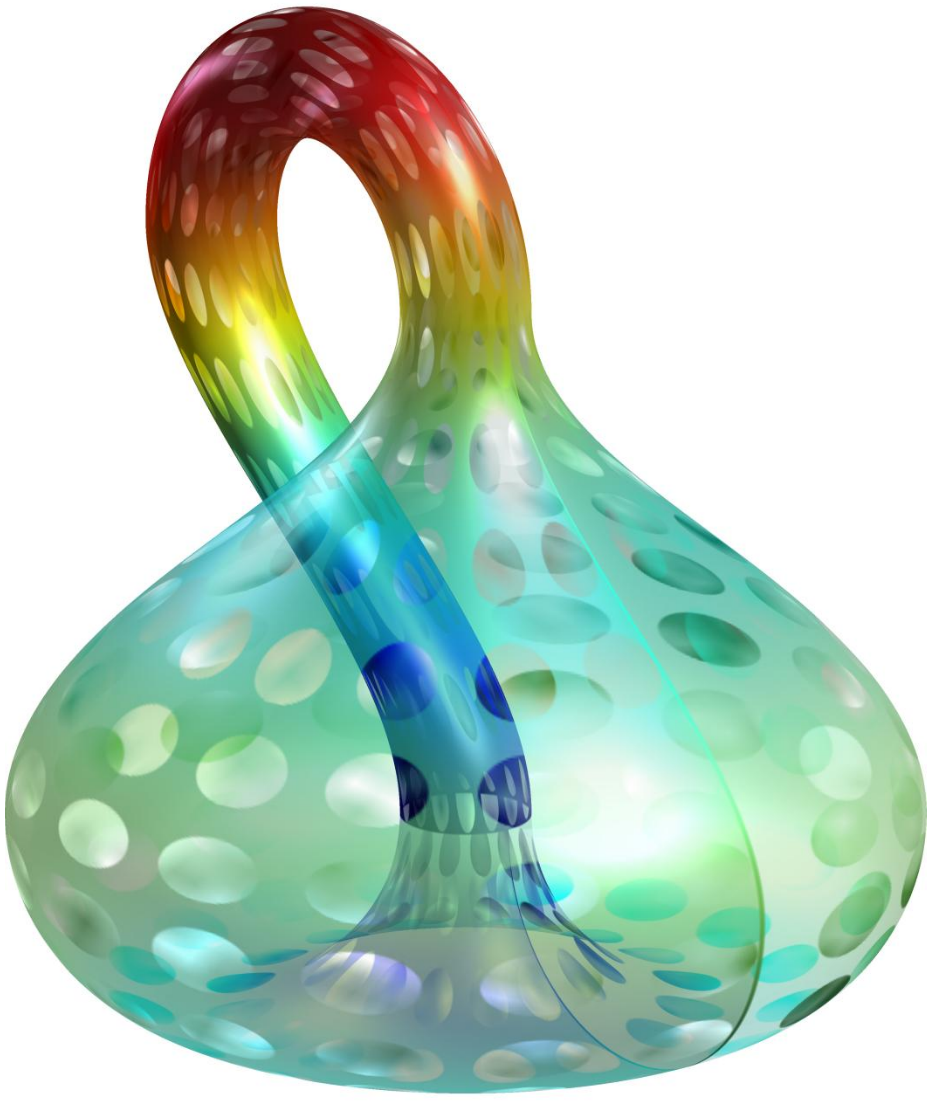
Find out how to do this, and much more, at **ProgSoc.** Mill, Thursdays 1600-1800.

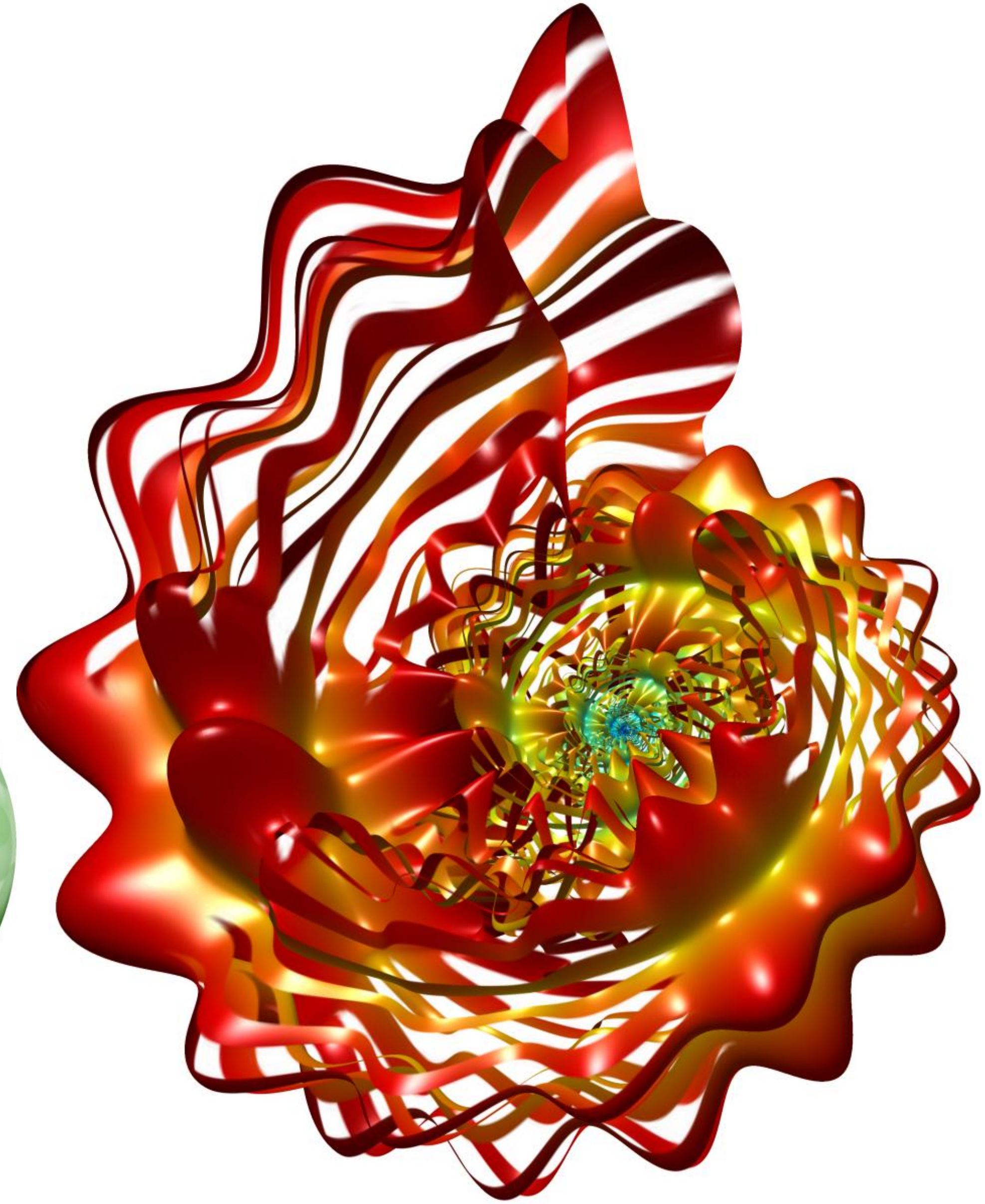
Dundee Satellite Receiving Station

EUMETSAT

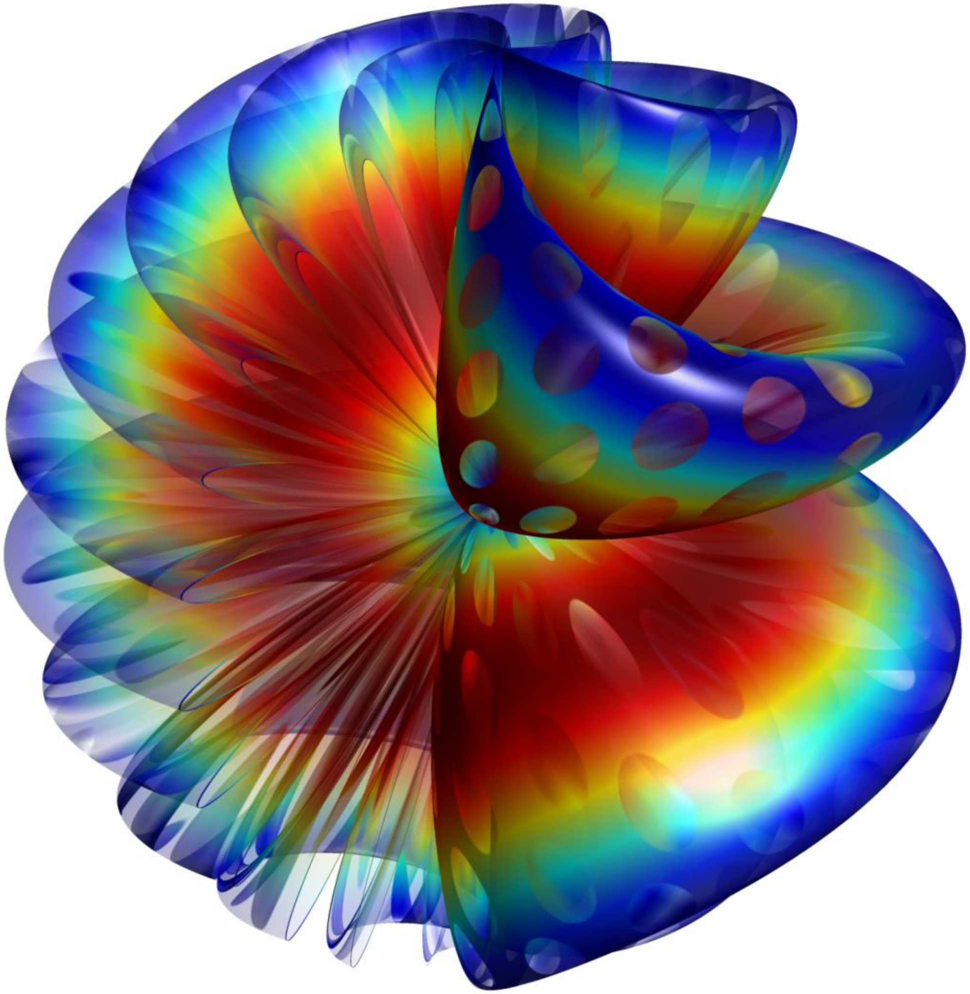
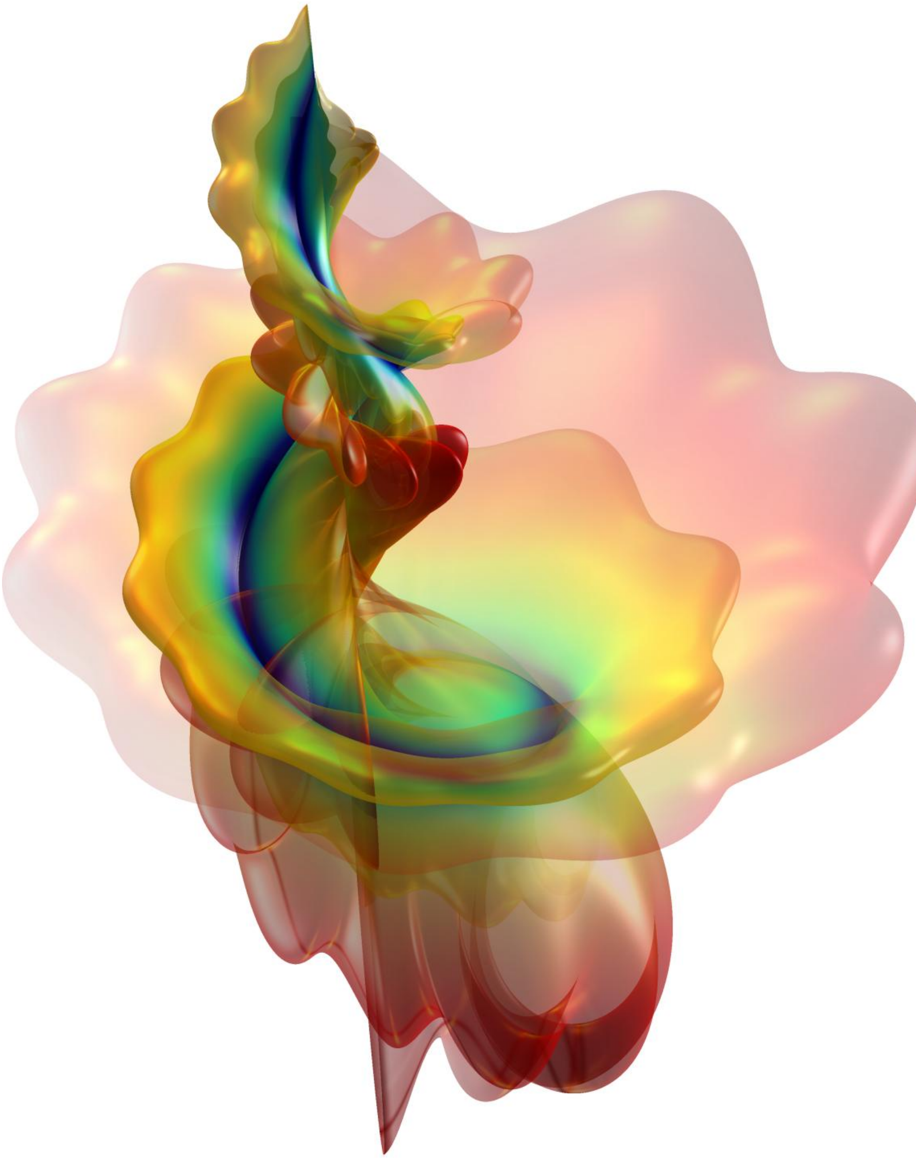
UNIVERSITY OF DUNDEE

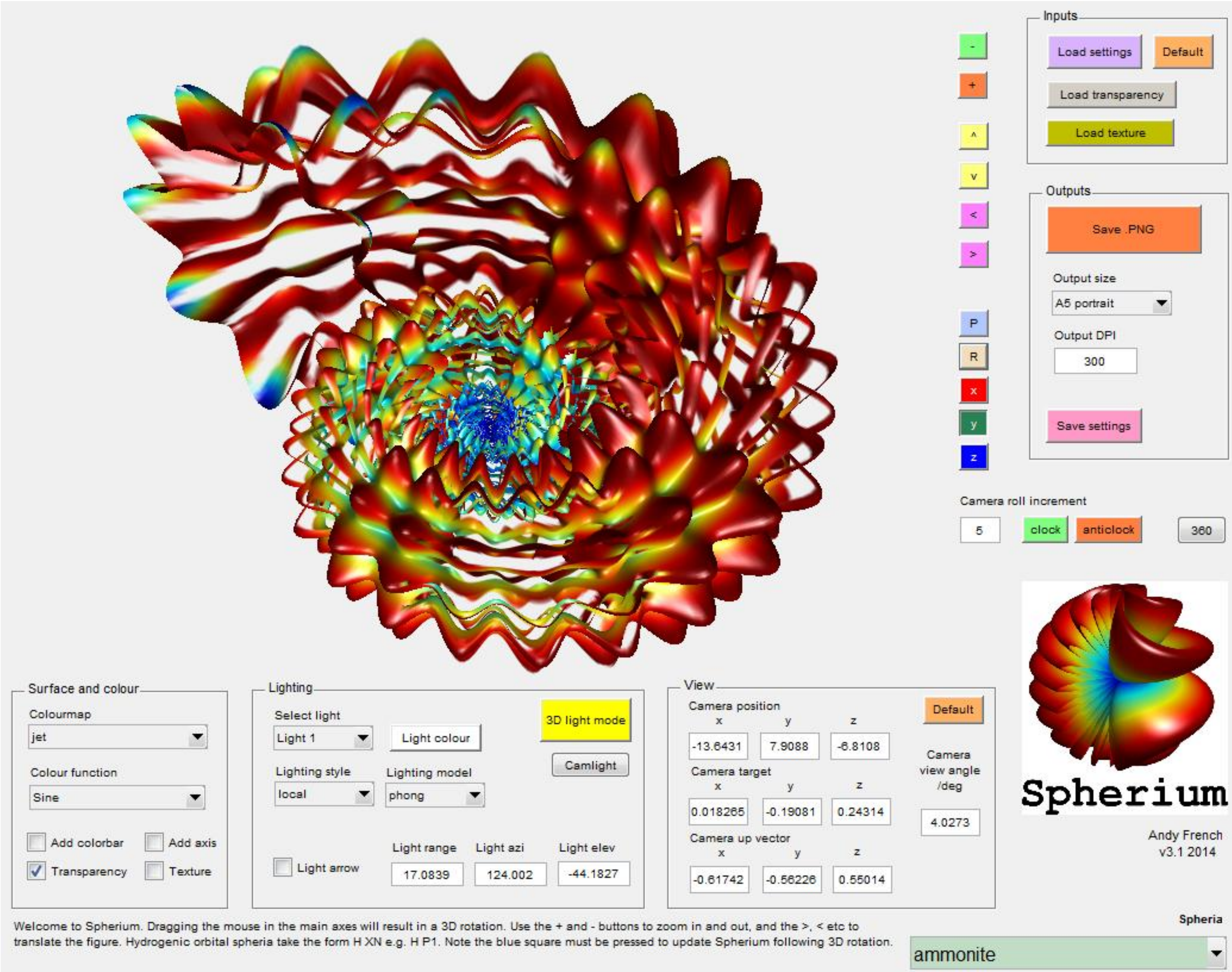


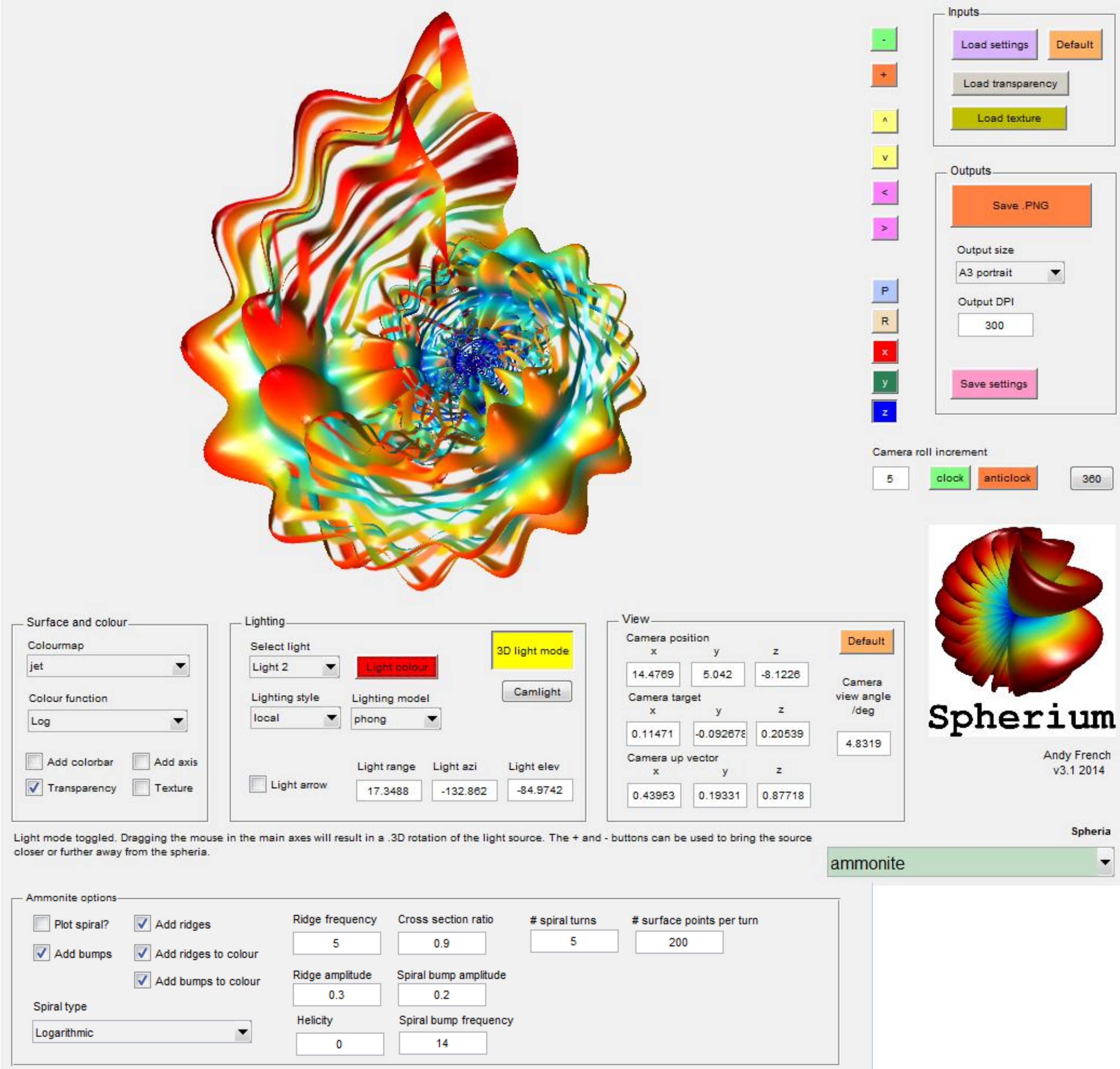


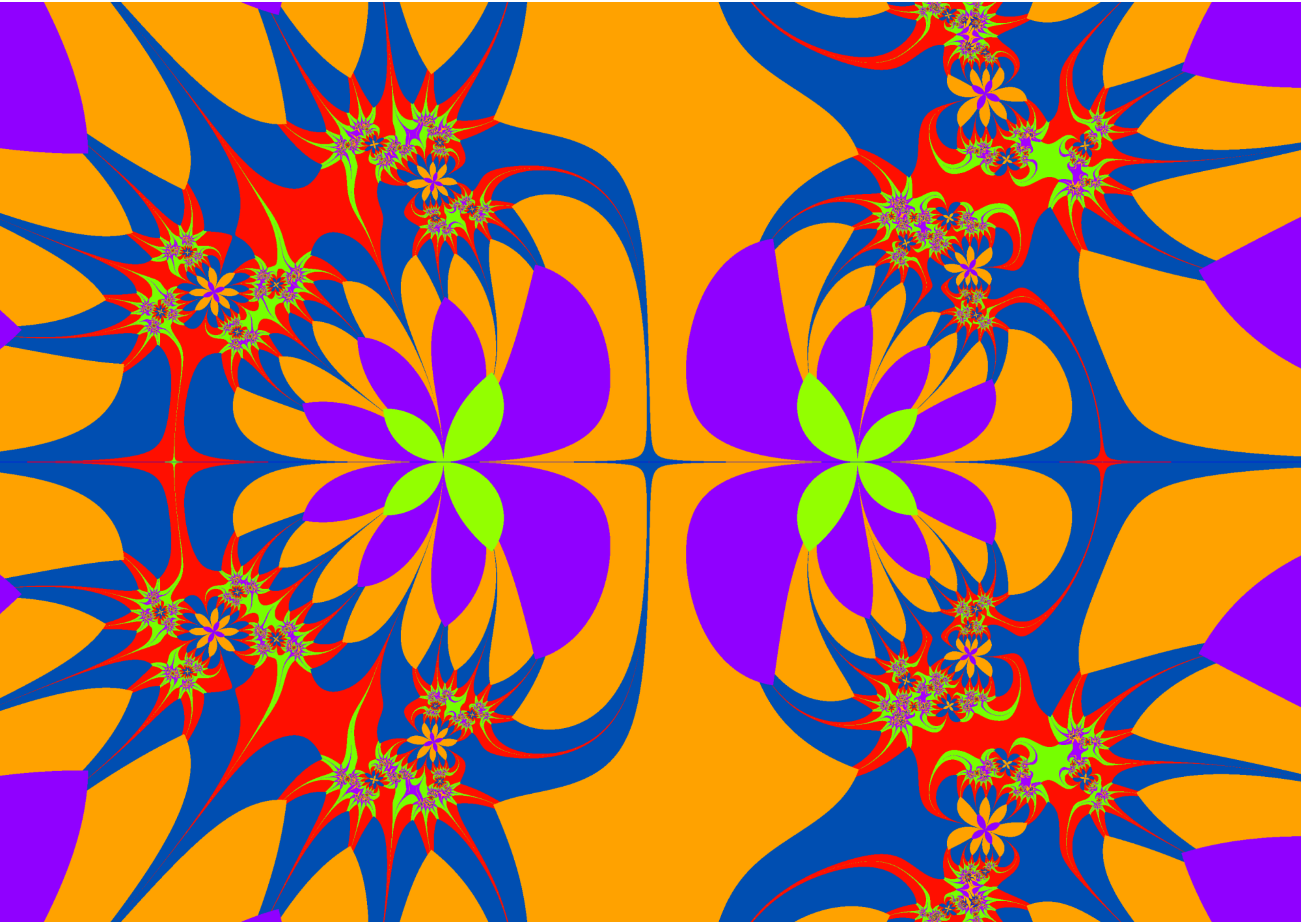


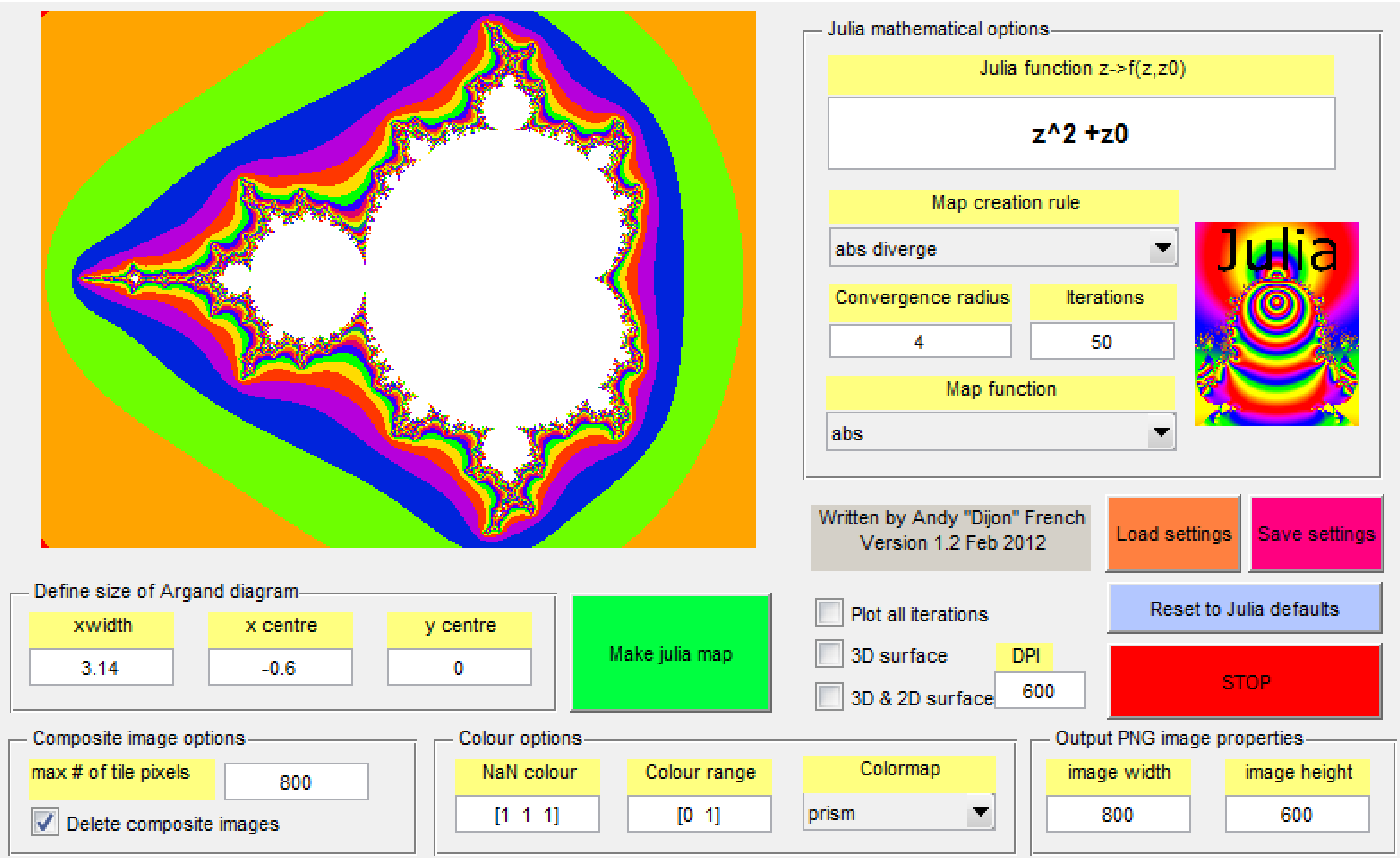
mathematicon


Inputs
Load settings
Default
Load transparency
Load texture
Outputs
Save .PNG
Output size
A5 portrait
Output DPI
300
Save settings
-
+
^
v
<
>
P
R
x
y
z
Camera roll increment
5
clock
anticlock
360
Spherium
Andy French
v3.1 2014
Surface and colour
Colourmap
jet
Colour function
Sine
Add colorbar
Add axis
Transparency
Texture
Lighting
Select light
Light 1
Light colour
3D light mode
Camlight
Lighting style
local
Lighting model
phong
Light arrow
Light range
17.0839
Light azi
124.002
Light elev
-44.1827
View
Camera position
x
y
z
-13.6431
7.9088
-6.8108
Default
Camera target
x
y
z
0.018265
-0.19081
0.24314
Camera view angle /deg
4.0273
Camera up vector
x
y
z
-0.61742
-0.56226
0.55014
Welcome to Spherium. Dragging the mouse in the main axes will result in a 3D rotation. Use the + and - buttons to zoom in and out, and the >, < etc to translate the figure. Hydrogenic orbital spheria take the form H XN e.g. H P1. Note the blue square must be pressed to update Spherium following 3D rotation.
Spheria
ammonite

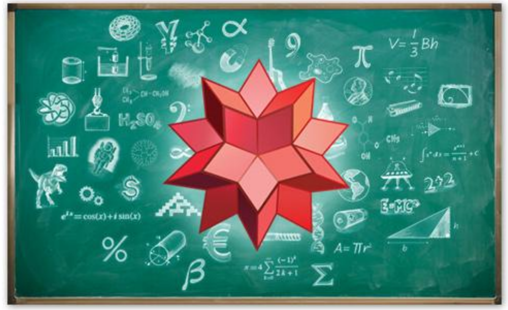

Inputs
Load settings
Default
Load transparency
Load texture
Outputs
Save .PNG
Output size
A3 portrait
Output DPI
300
Save settings
Camera roll increment
5
clock
anticlock
360
Spherium
Andy French
v3.1 2014
Surface and colour
Colourmap
jet
Colour function
Log
Add colorbar
Add axis
Transparency
Texture
Lighting
Select light
Light 2
Light colour
3D light mode
Camlight
Lighting style
local
Lighting model
phong
Light arrow
Light range
17.3488
Light azi
-132.862
Light elev
-84.9742
View
Camera position
14.4769
5.042
-8.1226
Default
Camera view angle /deg
4.8319
Camera target
0.11471
-0.092678
0.20539
Camera up vector
0.43953
0.19331
0.87718
Light mode toggled. Dragging the mouse in the main axes will result in a .3D rotation of the light source. The + and - buttons can be used to bring the source closer or further away from the spheria.
Spheria
ammonite
Ammonite options
Plot spiral?
Add ridges
Add bumps
Add ridges to colour
Add bumps to colour
Spiral type
Logarithmic
Ridge frequency
5
Cross section ratio
0.9
spiral turns
5
surface points per turn
200
Ridge amplitude
0.3
Spiral bump amplitude
0.2
Helicity
0
Spiral bump frequency
14




Julia mathematical options
Julia function z->f(z,z0)
z^2 +z0
Map creation rule
abs diverge
Convergence radius
4
Iterations
50
Map function
abs
Julia
Written by Andy "Dijon" French
Version 1.2 Feb 2012
Load settings
Save settings
Define size of Argand diagram
xwidth
3.14
x centre
-0.6
y centre
0
Make julia map
Plot all iterations
3D surface
3D & 2D surface
DPI
600
Reset to Julia defaults
STOP
Composite image options
max # of tile pixels
800
Delete composite images
Colour options
NaN colour
[1 1 1]
Colour range
[0 1]
Colormap
prism
Output PNG image properties
image width
800
image height
600

Outside the classroom

Online resources



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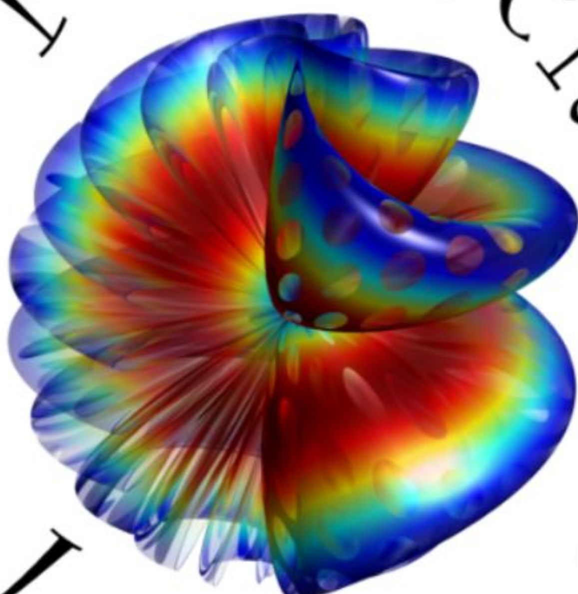
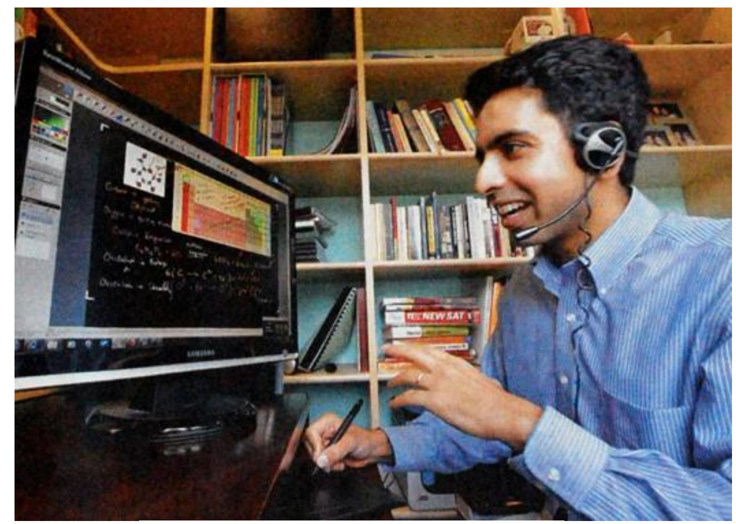
Dr French's Eclecticon



WIKIPEDIA
The Free Encyclopedia

MITOPENCOURSEWARE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Google



KHANACADEMY

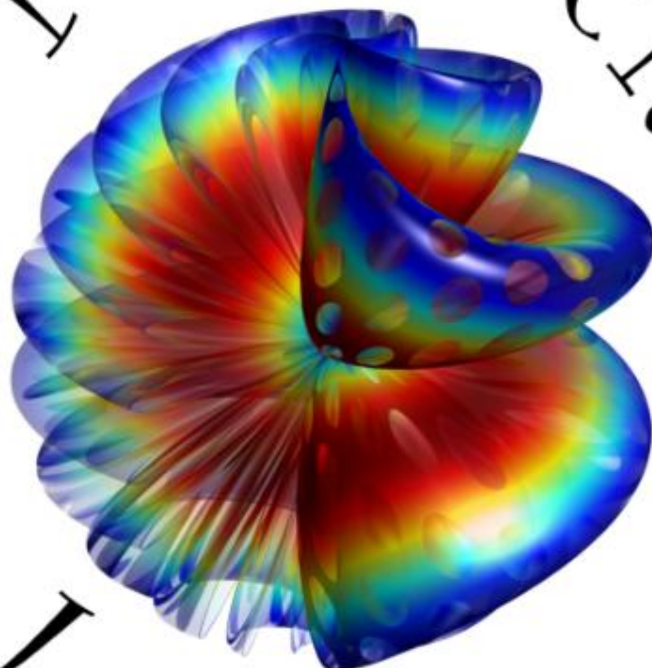
Art | Books | Comedy | Films | Fitness | Gastronomy | Maths

First created Jul 2012

Last updated Jun 2015

Web Counter

Dr French's Eclecticon



Mountaineering | Music | Philosophy | Photography | Physics | Programming | Writing

tes
Schools resources

Numberphile

Math is Fun

nrich

Maths helper

STEMNET

WolframAlpha

theguardian DATABLOG Facts are sacred

Wolfram MathWorld the web's most extensive mathematics resource

Numbers Algebra Geometry Calculus

Trigonometry Mechanics Probability & Statistics

IGCSE Maths mindmaps

STEP

Note topic handouts under construction!
Download PowerPoint files for all handouts (50MB)

Faces of mathematics

Excel Course
(Practical Mathematics
& Computing)

Geometry

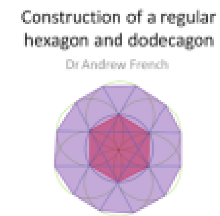
Areas of basic shapes
Arcs, sectors, radians
Argand diagram complex loci
Cartesian equation of a circle
Circle theorems
Coordinate transformations
Lines and angles
Loci & constructions
Lorentz transform
Polygons
Symmetry
Transformations using matrices: Intro
Transformations using matrices: Rotations
Transformations using matrices: Not about the origin
Transformations using matrices: Invariant lines
Vectors
Vector equations of lines and planes
Volumes of basic solids

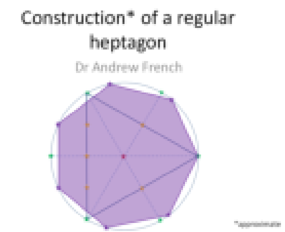
Geometric transformations using matrices

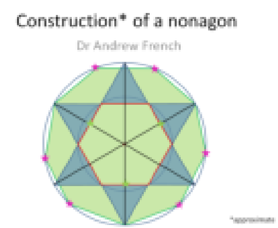
IGCSE trigonometry proofs
First 86 Pythagorean triples
Special triangles
Proof of circle theorems

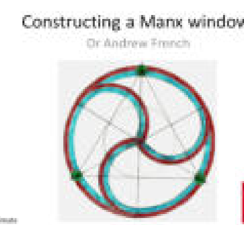
Basic geometry notes
Chimborazo

Maths is Fun: Geometric Construction animations





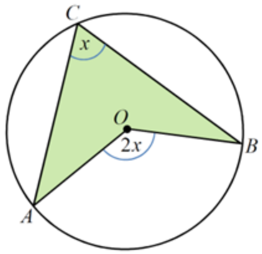




All construction presentations

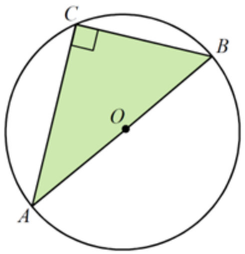
Circle theorems

There are five main circle theorems, which relate to triangles or quadrilaterals drawn inside the circumference of a circle.



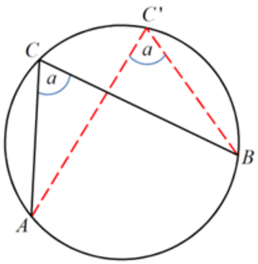
'Arrowhead' theorem

An angle at the **centre** of a circle is **twice** (the size of) the **angle on the circumference** if they are both **subtended** by the same **arc**.



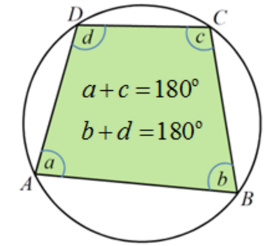
'Right-angle diameter' theorem

Any angle (**inscribed**) in a **semicircle** is a **right angle.**



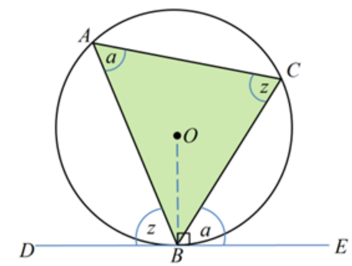
'Mountain' or 'bow-tie' theorem

The angles in the **same segment** (**subtended** by **the same arc or arcs of the same size**) are equal.



'Cyclic quadrilateral' theorem

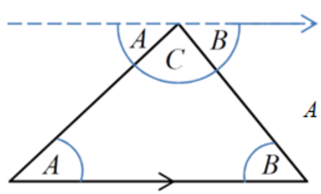
A quadrilateral ABCD is **cyclic** if and only if (it is convex and) **both pairs of opposite angles are supplementary**



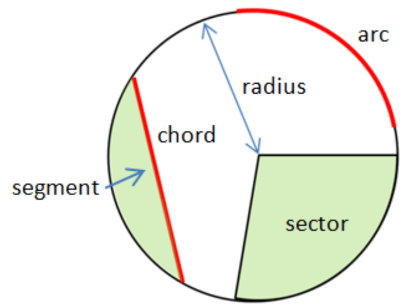
Chord-tangent or Alternate segment theorem

If a line drawn through the end point of a **chord** forms an angle equal to the angle subtended by the chord in the **alternate segment** then the line is a **tangent** (chord-tangent or alternate segment theorem)

Internal angles of any triangle sum to 180°



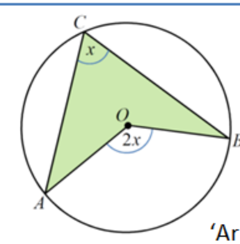
$$A + B + C = 180^\circ$$



Proof of 'Right-angle diameter' theorem

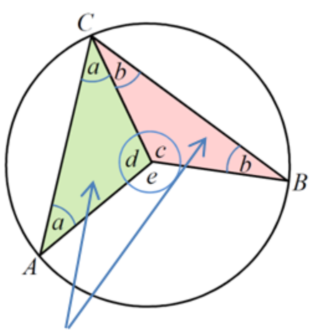
This is a special case of the 'Arrowhead' theorem:

When $2x = 180^\circ$
this means the arrowhead angle x is half this, i.e. $x = 90^\circ$.



'Arrowhead' theorem

Proof of the 'Arrowhead' theorem



$2a + d = 180^\circ$
$2b + c = 180^\circ$ } Add these together ...

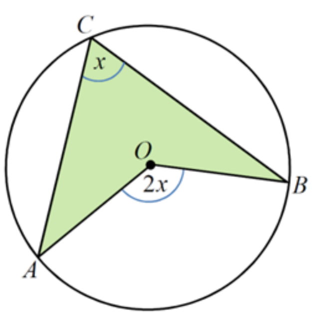
$\therefore 2(a+b) + d + c = 360^\circ$

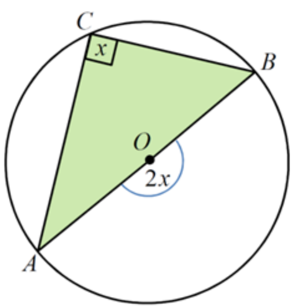
$d + c + e = 360^\circ$

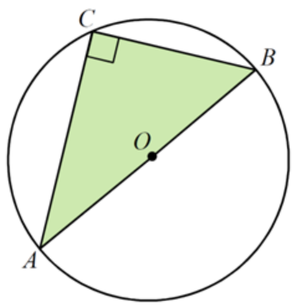
$\therefore d + c + e = 2(a+b) + d + c$

$\therefore$ $e = 2(a+b)$

These are *isosceles triangles* since they both meet at the *origin* of the circle, and therefore two edges of each triangle are circle radii.







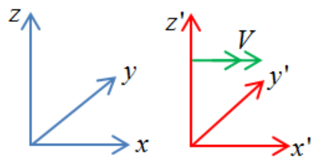
Special Relativity is a theory of dynamics proposed by **Albert Einstein** in 1905. The key mathematical element is the use of the ***Lorentz Transform.*** This extends the equations of *Galilean Relativity*, which relate the Cartesian *x,y,z* coordinates of an object to coordinates of the same object as viewed in a frame of reference moving at velocity *V* in the positive *x* direction relative to the *x,y,z* system. Let *S* denote the *x,y,z* coordinate system and *S'* denote the *x',y',z'* coordinates of the moving frame.

The Lorentz transform incorporates the strange (but seeming true!) fact that the speed of light is the **same** for both S and S' frames. In other words, if a torch is shone from frame *S*, the speed of the light observed by *S'* would be the same speed as in *S*, and *not* the speed of light minus *V*.

The consequence of this effect is *profound*. It results in *length contraction*, *time dilation* and *time synchronisation* changes between the *S* and *S'* frames.

Galilean relativity

$$x = x' + Vt$$
$$x' = x - Vt$$
$$y = y'$$
$$z = z'$$
$$t = t'$$



Galilean relativity appears to work just fine in normal scenarios on Earth, i.e. when $V \ll c$ where the speed of light $c = 2.998 \times 10^8 \text{ms}^{-1}$
The effects of Special relativity are *only significant* when *V* is close to *c*.

Consider the following candidates for the Lorentz transform of the spatial coordinates between the *S* and *S'* frames:

$$x = \gamma(x' + Vt')$$
$$x' = \gamma(x - Vt)$$
$$y = y'$$
$$z = z'$$

γ is a function of *V*. In order to be consistent with Galilean relativity, it must be *unity* when $V \ll c$

Hence:

$$x = \gamma(x' + Vt')$$
$$\frac{x}{\gamma} = x' + Vt'$$
$$t' = \frac{x}{\gamma V} - \frac{x'}{V}$$
$$t' = \frac{x}{\gamma V} - \frac{\gamma(x - Vt)}{V}$$
$$\therefore t' = \gamma\left(t - \frac{x}{V}\left(1 - \frac{1}{\gamma^2}\right)\right)$$

$$x' = \gamma(x - Vt)$$
$$\frac{x'}{\gamma} = x - Vt$$
$$t = \frac{x}{V} - \frac{x'}{\gamma V}$$
$$t = \frac{\gamma(x' + Vt')}{V} - \frac{x'}{\gamma V}$$
$$\therefore t = \gamma\left(t' + \frac{x'}{V}\left(1 - \frac{1}{\gamma^2}\right)\right)$$

Now consider a *spherical light pulse* emitted when *x' = x*. Since it radiates out at speed *c* in ***both*** *S* and *S'* from their (respective) origins, we can compare the radii *r,r'* of the pulse as observed from *S* and *S'*

$$r'^2 = c^2t'^2 = x'^2 + y'^2 + z'^2$$
$$r^2 = c^2t^2 = x^2 + y^2 + z^2$$

Since $y = y', \; z = z'$ this means $c^2t'^2 - x'^2 = c^2t^2 - x^2$

Now when $x' = 0, \quad x = Vt$

Hence $c^2t'^2 = c^2t^2 - V^2t^2$

$$\Rightarrow t' = t\sqrt{1 - \frac{V^2}{c^2}}$$

Now using $t = \gamma\left(t' + \frac{x'}{V}\left(1 - \frac{1}{\gamma^2}\right)\right)$ when $x' = 0 \quad \Rightarrow t = \gamma t\sqrt{1 - \frac{V^2}{c^2}}$

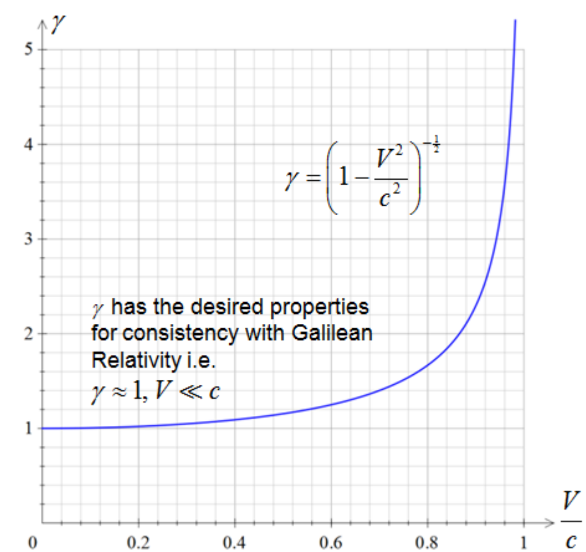
$$\therefore \gamma = \left(1 - \frac{V^2}{c^2}\right)^{-\frac{1}{2}}$$

$$\therefore 1 - \frac{1}{\gamma^2} = 1 - 1 - \frac{V^2}{c^2} = \frac{V^2}{c^2}$$
$$\therefore \frac{1}{V}\left(1 - \frac{1}{\gamma^2}\right) = \frac{V}{c^2}$$

The **Lorentz Transform** is now revealed!

$$x = \gamma(x' + Vt') \qquad x' = \gamma(x - Vt)$$
$$y = y' \qquad y = y'$$
$$z = z' \qquad z = z'$$
$$t = \gamma\left(t' + \frac{Vx'}{c^2}\right) \qquad t' = \gamma\left(t - \frac{Vx}{c^2}\right)$$

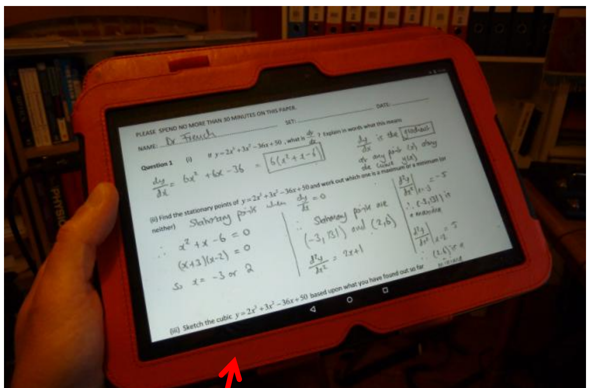
So ***lengths contract*** and ***time dilates*** **and *shifts*** when *V* becomes close to *c*



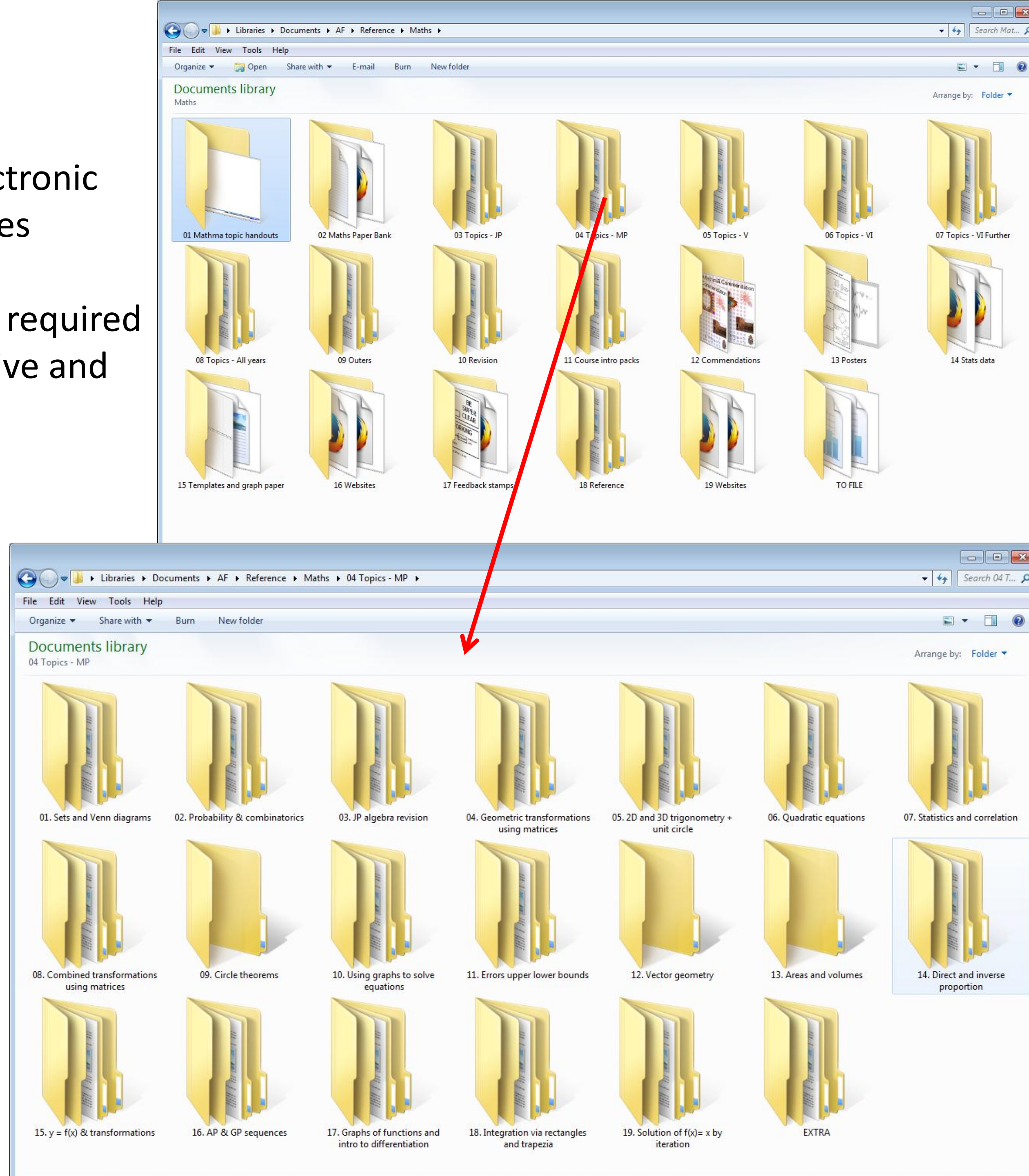
Preparation

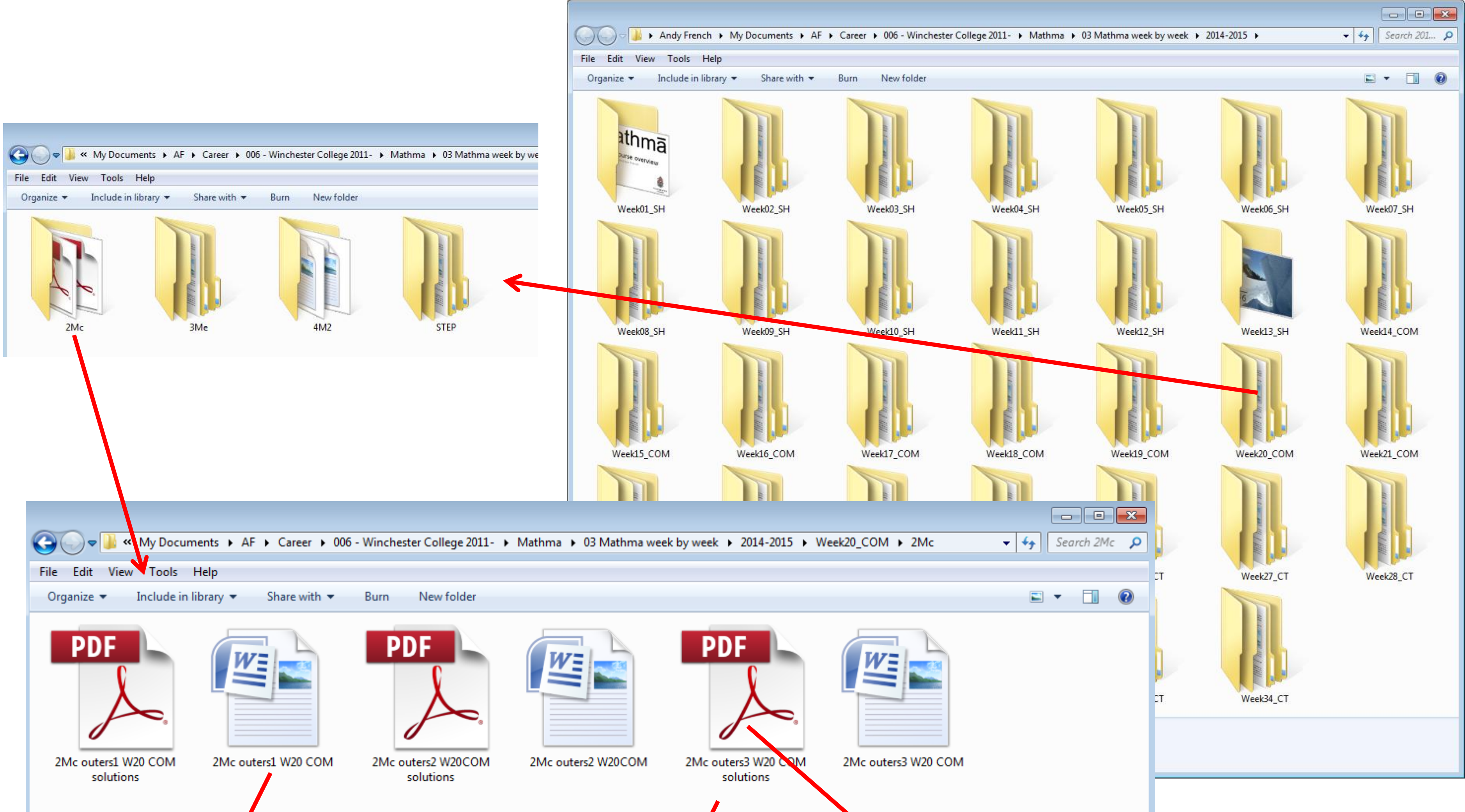
I make extensive use of an electronic filing system for all my resources

I prepare **weekly** and copy the required files to the College network drive and my **tablet**



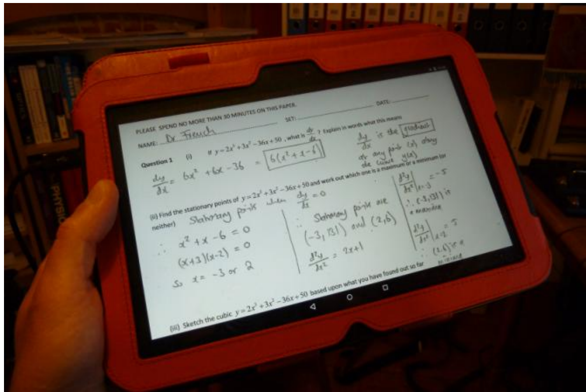
This is very useful for my teaching notes, and for helping students during workshop-style lessons





Printed worksheet

Classroom projector screen



Assessment & Admin

An Excel spreadsheet for continuous, quantitative assessment

A simple colour coding system is useful when briefing parents

W10 MP Topics exam	W10 MP Algebra exam	W11SH TT#1	W11SH TT#2	W12SH TT#1	W14COM TT#1 - Proof stuff	W15COM TT#1	Circle Theorems test	W15COM TT#2	W15COM TT#3	W16COM TT#1	W16COM TT#2	W16COM TT#3	Intermediates Jan 2015	W17COM TT#1	W17COM TT#2	W17COM TT#3	W18COM TT#1	W18COM TT#2	W18COM TT#3	W19COM TT#1	W19COM TT#2
	Y	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N
45%	65%	3	3	2.5	2		45%	2	2	2	2.5	3	3.0	3	3	3	2.5	3	2	3	3
58%	43%	3.5	3		2.5	3	100%	1.5	3	3	2.5	3	3.0		3	3.5	3.5	2.5	2	2.5	2.5
55%	35%	2	2.5	2	3	1.5	100%	1	2	2	1	2	2.0	2.5	2	3	1.5	2.5	1	2	2
48%	85%	3	4	2.5	2.5	3	83%	3	3	4	4	3	3.0	4	3	2.5	3	4	2.5	Play	3
50%	65%	2	3	3.5	3	4	100%	2.5	3	3	4	3	3.0	3	3	3	4	3	3	2.5	2
50%	83%	III	III	III	2.5	2	100%	2.5	3	3	2	2	2.0	3	3	3.5	3.5	2	2	2	3
58%	68%	2.5	3	3	3	2	100%	2	1	3	3	2	3.0	3	2	2.5	2.5	2.5	1.5	4	2
70%	58%	2	2	2	2		100%	1	2	4		2	2.0	4	1.5	3	2	3.5	1.5	3	1
63%	70%	2.5	3	3.5	2.5	3	100%	2	2	3	2.5	3	3.0	1.5	2.5	2	3.5	4		3	3
55%	55%	2.5	2.5	2	2	2.5	100%	2.5	2	2	1	2	2.0	2.5	2.5	2.5	2	2	2	3	3
50%	43%	2.5	4.5		2		83%	2	3			2	3.0	3.5	4	3	3.5	2.5	4	2.5	3
38%	50%	3	4	3	2.5	3	94%	2.5	2	2	3	2	2.0	3	3	4	5	4	3	4	4
55%	93%	2.5	2.5	1.5	2	2	100%	2.5	2	3	2	2	2.0	2	2	2	3	3	2	3	2.5
63%	55%	1.5	2.5	3	3	4	78%	2	III		2.5	3	3.0	3.5	2.5	2.5	2.5	2.5	2	3	2
63%	28%	2.5	2.5	2	2		89%	1	3	3	2		3.0	2.5	2.5	2	2	2.5	1.5	2.5	2.5
50%	48%	1.5	2	3	3	3	94%	1	2	3	1.5	2	2.0	2	2.5	2.5	2	2	1.5	III	III
55%	55%	2	2.5	2	4	2.5	94%	1.5	3	2	2	2	2.0	3	2.5	3.5	2.5	3	2	III	III
73%	85%	1.5	2	1.5	2	1	100%	1	2	2	1	2	1.0	1.5	1	2	2	1.5	1	2.5	2.5
55%	63%	2.5	2.5	3.5	2	3.5	78%	1	3	2	3	3	3.0	2.5	2	3.5	2.5	3	3	III	III
55%	38%	2	3	3	3	3.5	100%	2	2	3	lost!	2	2.0	3	2.5	2.5	3	3	2.5	3	3
55%	40%	III		3	3	3	100%	2.5	2	4	3.5		4.0		2.5	4	3	4	2	4	3
63%	68%	1.5	2	2.5	3	2.5	100%	1.5	3	2	2	2	2.0	3	2	2	2.5	2.5	2	3.5	2
57%	59%						93%														

W20COM TT#1	W20COM TT#2	W20COM TT#3	W21COM TT#1	W22COM TT#1	W22COM TT#2	W22COM TT#3	W23COM TT#1	W23COM TT#2	W24COM TT#1	W24COM TT#2	W25COM TT#1	W25COM TT#2	W25COM TT#3	W26COM TT#1	W26COM TT#2	W26COM TT#3	Intermediates May 2015	W28CT TT#2	MP Summer Exam 1	MP Summer Exam 1
N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y
2.5	1	3	3		2.5	2.0	2.0	2.5	4	4	4	3	3	4	2.5		3	3	53%	55%
2.5	2	2.5	5	3	3	3.0	2.0		3.5	3	3.5	2	2.5	3	4		3		50%	65%
1	1	2	1	2	2.5	1.0	1.5	1.0	1	1	1	2	2.5	2	1.5	2	1	2	83%	58%
3.5	2.5	3		3	2	2.0	2.0	2.0	3	4	4	3.5	3	3	3	3	3	3	68%	35%
3	4	3	3.5	3	2.5	3.0	2.0	2.0	2.5	3	4	2.5	4.5	4.5	2.5	3	3	3	55%	45%
ill	ill	ill	2	4	4	ill	ill	4.0	2	2.5	3	2.5		2.5	3	4	2	3.5	65%	75%
1	2.5	2.5	3.5	2	2.5	3.0	2.0	3.0	2.5	2.5	2.5	2.5	2	3	3	2	2	3	68%	58%
1	1	2.5	2	1.5		2.0	2.0	1.5	2	2	2	2	3	3	1	2	2	2	63%	63%
2	2	2.5	2	3		3.5	3.0	5.0	III	3	3	2	2.5	2	2.5	2	2	3	75%	78%
3	2.5	2.5	2	2.5	2	2.5	2.0	2.0	3	3	3	2	2	3	2.5	2.5	2	3	58%	63%
4	3	3	4	3.5		1.5	3.5	2.0	4.5	2.5	2.5	2.5	3	4	3	2	4	3	68%	53%
3	3	3	3.5	3.5	3.5	5.5	3.5		4	3	3	3.5	4	4.5	3.5	4	3	4	65%	43%
2.5	3	2.5	2	2	1.5	2.5	2.0	2.0	2	3.5	2.5	3	3	3	2.5	2.5	3	2	75%	53%
3	ill	ill	2	ill	ill	3.0	2.0	2.0	3	2.5	away	away	2.5	2.5	3	2.5	3	2	70%	68%
1.5	1	2	2.5	3	3	2.5	2.0	2.0	2	3	2.5	2.5	5	4.5	4	2.5	3	3	65%	60%
1	1.5	2		3	2		2.0	3.0	3	3	2	2	2	2.5	2	1.5	2	2.5	68%	65%
2	2	3	III	2.5	3.5	2.0	2.0	away	2	2	4	3	2	2.5	2	3	2	2.5	50%	68%
1	1	2	1	1.5	2	1.0	1.5	2.0	1	1	1.5	2	2	2	1.5	2	1	1.5	65%	50%
3	2.5	3	2	3	3	1.5	2.0	3.0	2.5	2.5	3	3.5	3	4	3	3	3	3	40%	50%
3	3	3.5	4	3	3.5	2.0	2.0	1.5	2.5	3	2.5	3.5	3	3	3	3	3	3.5	55%	45%
	2	2					3.0	4.0	4	3.5	4.5	2.5	4.5	4.5	4.5	5	4	3	65%	55%
2	2	3	3	3	3	2.5	2.0	2.0	3	2.5	3	2.5	3	2.5	2	3	3		58%	55%
																			63%	57%

Microsoft Word documents for **School Reports**

SIMS

Summary & opinions!

Neither Chalk and Talk or Death by PowerPoint

A case study of how to sensitively augment traditional Mathematics and Physics teaching with computer programming and online educational resources

IT is perhaps *most useful for teachers, not students* in terms of resource creation, storage and dissemination, and assessment and administration

Bespoke apps / computer models can offer an enriched Mathematical experience that cannot be easily achieved without IT

Online resources can help augment learning, but inspiration starts in the classroom, *from* the teacher

Teacher led, largely ‘traditional’ lessons can be very effective!

Model good Mathematics by *doing it live*, *with a pen*

IT can often be a distraction. The cost often outweighs the benefit

I don’t like Smartboards!
Keep it simple. Use a projector *if needed*, but otherwise write on a huge whiteboard!

Sybil’s opinions

Stop the madness for constant group work. Just stop it. And I want to be clear about what I'm saying, because I deeply believe our offices should be encouraging casual, chatty cafe-style types of interactions - you know, the kind where people come together and serendipitously have an exchange of ideas. That is great. It's great for introverts and it's great for extroverts. But we need much more privacy and much more freedom and much more autonomy at work. **School, same thing.** We need to be teaching kids to work together, for sure, but we also need to be **teaching them how to work on their own.** This is especially important for extroverted children too. They need to work on their own because that is where deep thought comes from in part.

TED
Ideas worth spreading

TED talk "The Power of Introverts"

Susan Cain
Author of *Quiet*

Dr French's

Eclecticon

www.eclecticon.info