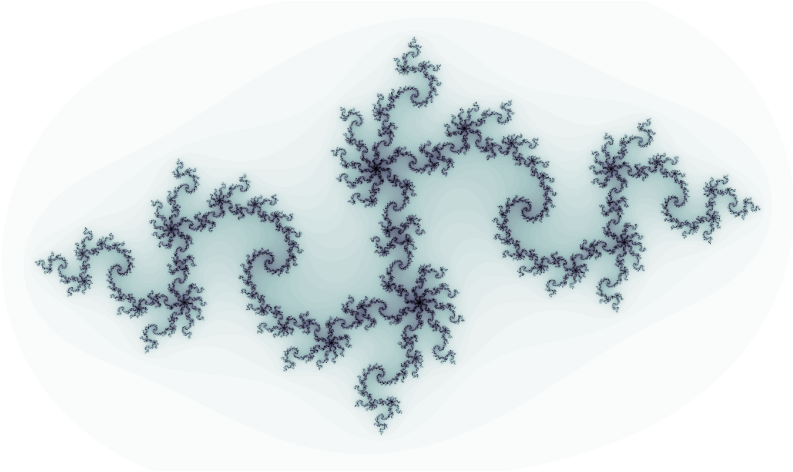
MAX: A Preview of Coming Attractions

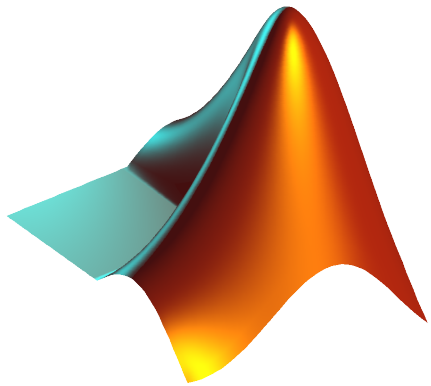


Paddy and Peter, MAX Lecturers

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

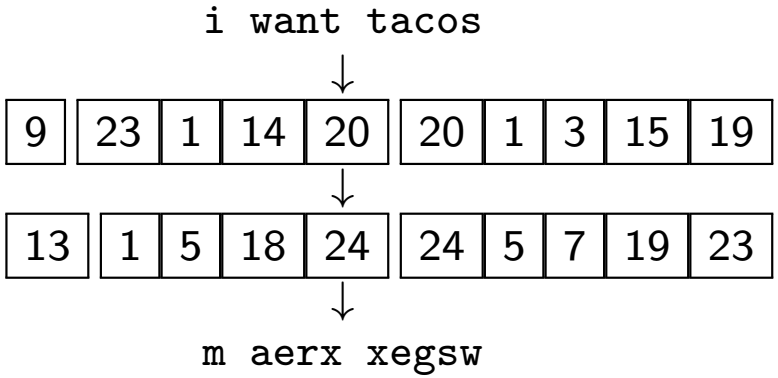
Weeks 1-4: MATLAB and Cryptography

- MAX is a course that will teach you how to use MATLAB, a programming language + numerical computing environment.
- MATLAB can do some remarkably beautiful things!
- We're not assuming that you know how to program entering this class; we're going to build these skills from scratch.
- If you do know how to program, however, we'll have plenty of things to keep you engaged :D



Weeks 1-4: MATLAB and Cryptography

- **Cryptography** is the art of communicating securely . . . and also the art of breaking into those secure communications!
- An example: the **Caesar cipher**.
- Suppose your message is "i want tacos," and your secret key is 4.
- Translate your message into numbers.
- Then, add your key to each number!



a	b	c	d	e	f	g	h	i	j	k	l	m
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
1	2	3	4	5	6	7	8	9	10	11	12	13

n	o	p	q	r	s	t	u	v	w	x	y	z
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
14	15	16	17	18	19	20	21	22	23	24	25	26

Weeks 1-4: MATLAB and Cryptography

- The Caesar cipher can be broken.
- But what about more sophisticated ciphers?

a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
f	j	o	r	d	b	a	n	k	v	e	x	t	c	w	m	g	l	y	p	h	s	q	u	i	z

or

	j	a	m	i	s	d	e	l	i	c	i	o	u	s
	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	k	e	y	k	e	y	k	e	y	k	e	y	k	e
=	t	e	k	s	w	b	o	p	g	m	m	m	e	w

- Are there encryption methods that are *immune* to attacks?

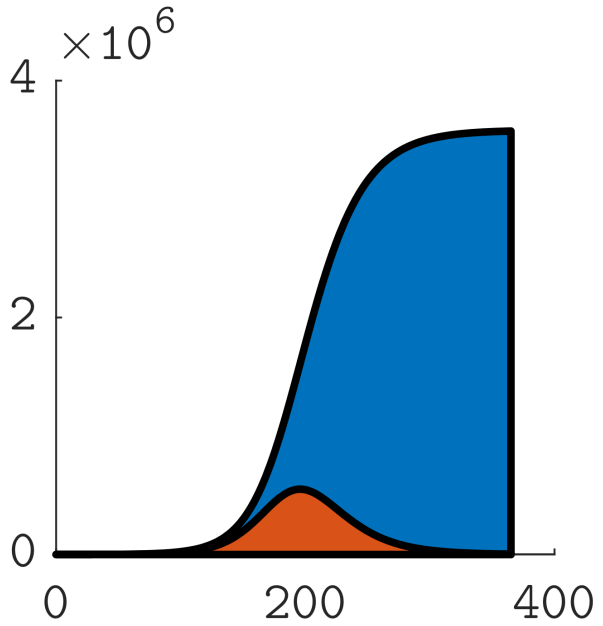
Weeks 5-8: Modelling, Fractals and Chaos

- In the middle third of the course, you're going to turn your MATLAB skills towards the field of **mathematical modelling**!
- Here, you'll study the equations used by the MoH in NZ to model COVID-19:

$$S_{n+1} = S_n - e \cdot t \cdot \frac{I_n}{P} \cdot S_n$$

$$I_{n+1} = I_n + e \cdot t \cdot \frac{I_n}{P} \cdot S_n - \gamma I_n$$

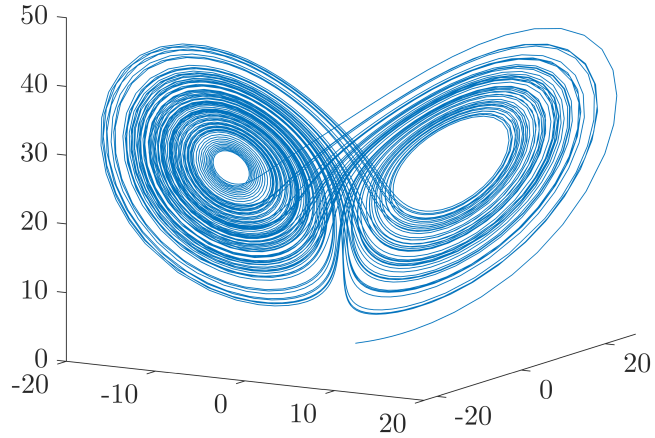
$$R_{n+1} = R_n + \gamma I_n$$



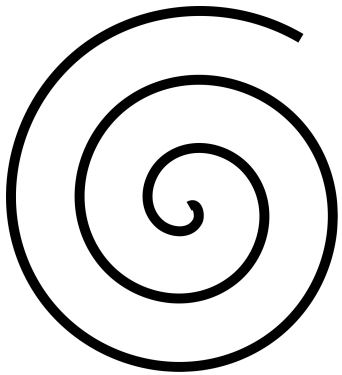
Weeks 5-8: Modelling, Fractals and Chaos

- You'll also encounter **chaos**, in the **butterfly effect**

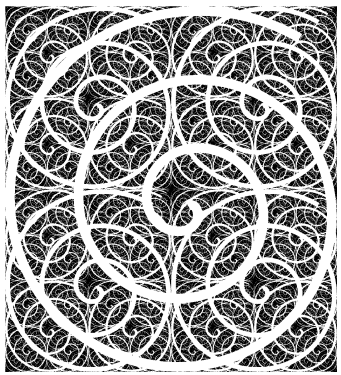
$$
\begin{aligned}
x'(t) &= \sigma(y(t) - x(t)),\\
y'(t) &= x(t)(\rho - z(t)) - y(t),\\
z'(t) &= x(t)y(t) - \beta z(t)
\end{aligned}
$$



- and the **chaos game**:

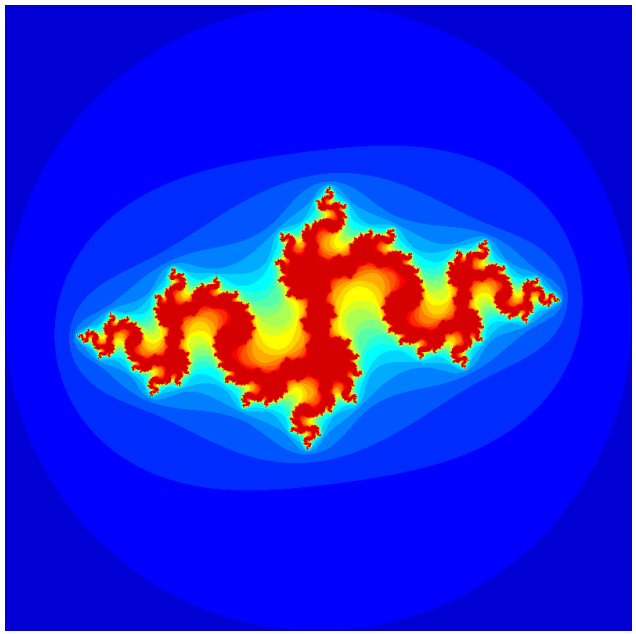


$\longrightarrow$



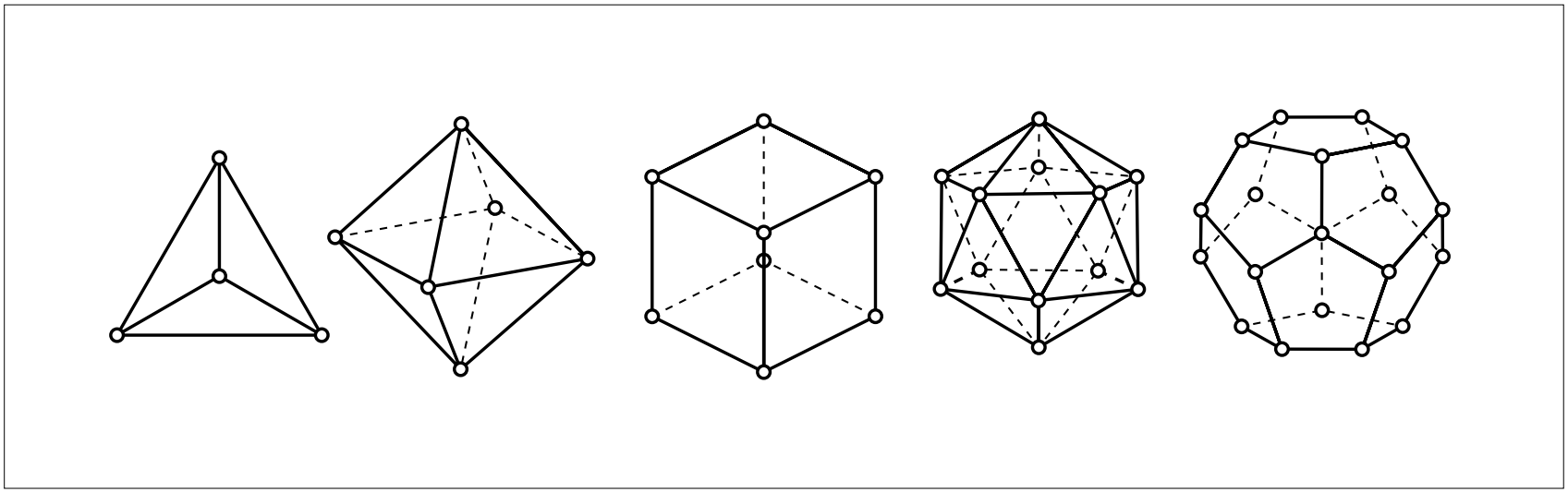
Weeks 5-8: Modelling, Fractals and Chaos

- Finally, you'll encounter **fractals**, and see how an outwardly simple function like $f_c(z) = z^2 + c$ can yield images like the following:



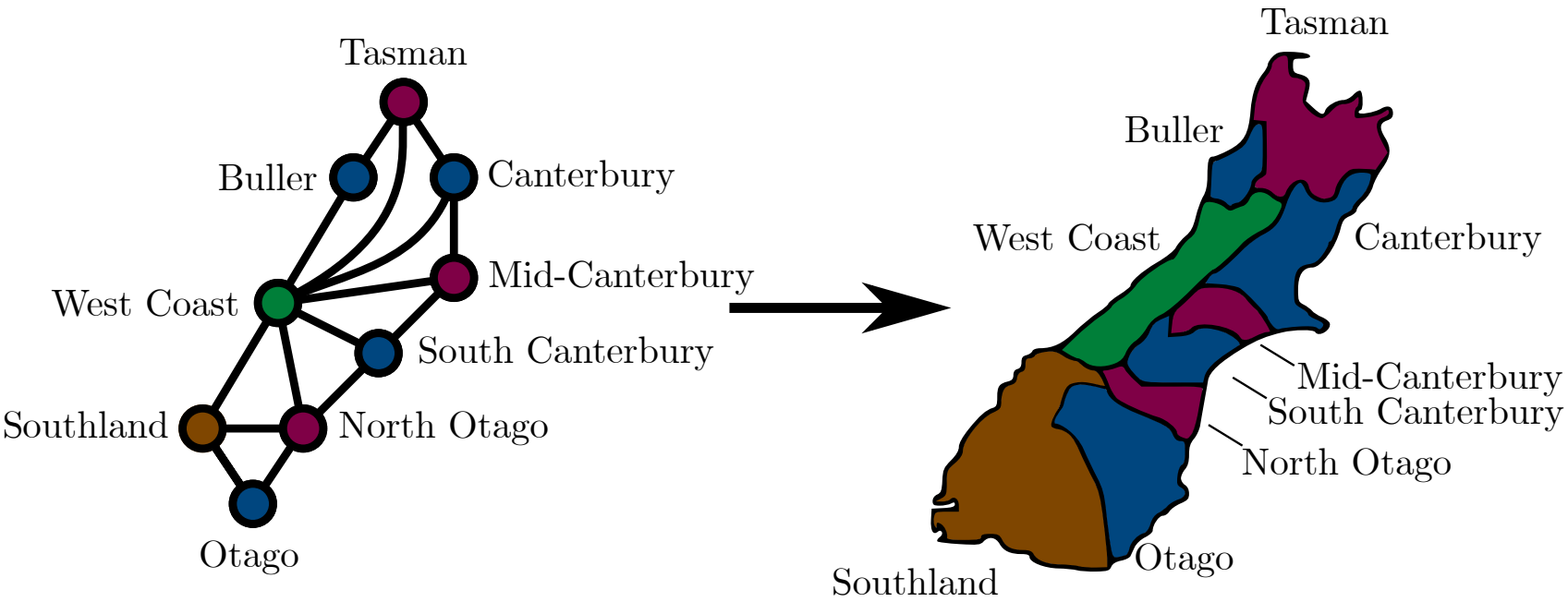
Weeks 9-12: Graph Theory

- The last third of this course is centered on **graph theory!**
- With this tool, we'll prove that there are only 5 platonic solids:



Weeks 9-12: Graph Theory

- Then, we'll prove that any map can be colored with at most four colors:



Weeks 9-12: Graph Theory

- To finish, we'll study **random walk** problems by using (of all things) **circuits**: