18.354J Nonlinear dynamics II: Continuum systems

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Mondays and Wednesdays 3.00-4.30pm

Office Hours
Mondays 4.30-5.30pm (E17-412)

Prerequisites: 18.353J or permission from instructor

Q: What is Physical Applied Maths?

A: PAM is like cooking...

Often the ingredients (*physical principles*) are already known but not the way (*mathematics/equations/couplings*) to turn them into a nice dinner

With some creativity, many new dishes (*novel phenomena*) can be created (*discovered/understood*)

Why study Applied Maths?

- intellectual challenge

- obtain general understanding of physical phenomena and the world around us

- be able to make prediction about physical processes

- development of general tools to be applied to other fields
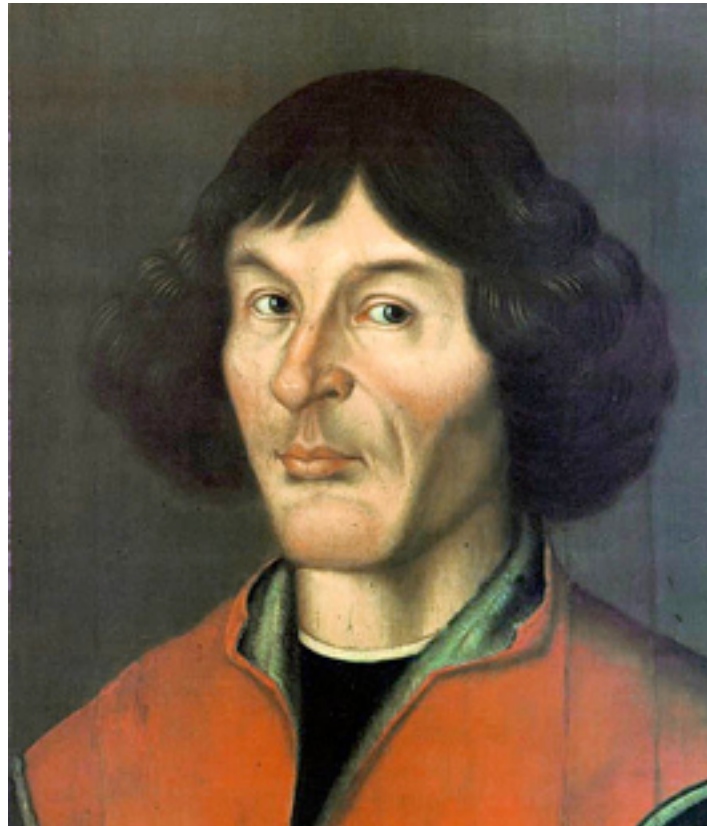
Some famous thoughts on Applied Maths

'Eureka, Eureka'
(Archimedes)

c. 287 BC - c. 212 BC

Some famous thoughts on Applied Maths

'Mathematic is written for mathematicians'
(Nicolaus Copernicus)

19 February 1473 – 24 May 1543

Some famous thoughts on Applied Maths?

'*It would be better for the true physics if there were no mathematicians on earth*'
(Daniel Bernoulli)

8 February 1700 – 17 March 1782

Some famous thoughts on Applied Maths

'Now I will have less distraction'
(Leonhard Euler, upon losing the use of his right eye)
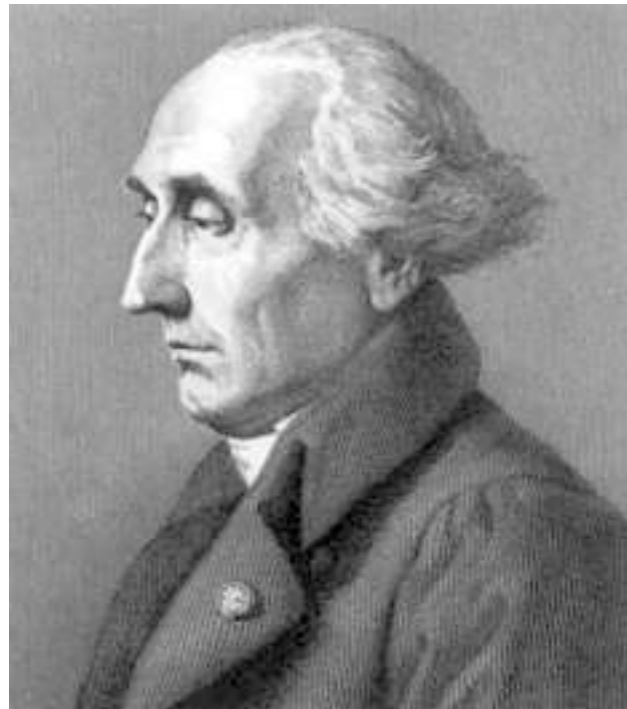

15 April 1707 – 18 September 1783

Some famous thoughts on Applied Maths

'I do not know'
(Joseph-Louis Lagrange, summarizing his life's work)

25 January 1736 - 10 April 1813

Some famous thoughts on Applied Maths

'*Nature laughs at the difficulties of integration*'
(Pierre-Simon Laplace)

23 March 1749 – 5 March 1827

Some famous thoughts on Applied Maths?

'*Mathematicians are born, not made*'
(Henri Poincaré)

29 April 1854 – 17 July 1912

Some famous thoughts on Applied Maths?

'Prediction is very difficult, especially about the future'
(Niels Bohr)

7 October 1885 – 18 November 1962

Some famous thoughts on Applied Maths?

'*It is more important to have beauty in one's equations than to have them fit experiment*' and '*This result is too beautiful to be false*'
(Paul Dirac)

8 August 1902 – 20 October 1984

Some famous thoughts on Applied Maths?

'To those who do not know mathematics it is difficult to get across a real feeling as to the beauty, the deepest beauty, of nature'
(Richard Feynman)
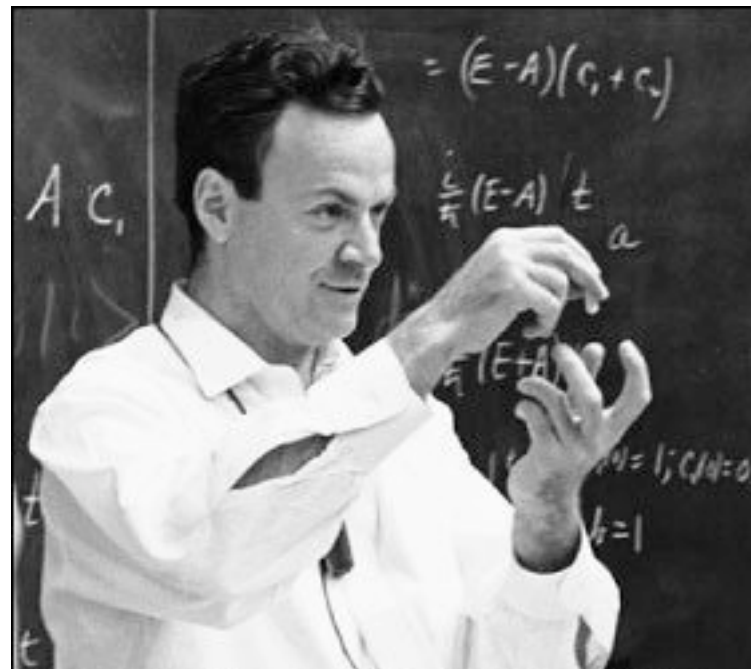
May 11, 1918 – February 15, 1988

BSc 1939

Our course

1.	W	Feb	5	Introduction & Kepler's Laws		**1. Diffusion:**
2.	M	Feb	10	Random walkers		From Micro to Macro
3.	W	Feb	12	Diffusion equation: Fourier method		
	M	Feb	17	— PRESIDENTS DAY —		
4.	W	Feb	19	Diffusion equation: Green's function method		
5.	M	Feb	24	Towards hydrodynamics	**PS1 due**	
6.	W	Feb	26	Navier-Stokes equations		**2. Hydrodynamics,**
7.	M	Mar	3	Impulsively moved boundary (Stokes' 1st probl.)		Navier-Stokes Eqns.
8.	W	Mar	5	The coffee cup		
9.	M	Mar	10	Dimensional analysis	**PS2 due**	**3. Dimensional analysis**
10.	W	Mar	12	Scalings		
11.	M	Mar	17	Calculus of variations		**4. Calculus of Variations:**
12.	W	Mar	19	Surface tension		Surface tension
	MW	Mar	24-28	— SPRING VACATION —		Elasticity
13.	M	Mar	31	Elasticity	**Proposal & PS3 due**	
14.	W	Apr	2	Deformation of a thin beam		
15.	M	Apr	7	Singular perturbations	**PS4 due**	**5. Singular perturbations:**
16.	W	Apr	9	Towards airplane flight		Theory of flight
17.	M	Apr	14	Classical airfoil theory I		Boundary-Layers
18.	W	Apr	16	Classical airfoil theory II	**Mid-term Posted**	
	M	Apr	21	— MIT HOLIDAY (PATRIOTS DAY) —		
19.	W	Apr	23	Classical airfoil theory III	**Mid-term due**	
20.	M	Apr	28	Boundary layers		
21.	W	Apr	30	Rotating flows		**6. Rotating Flows**
22.	M	May	5	Ekman layer and spin-down		
23.	W	May	7	Hydrodynamic instabilities (overview)		**7. Instabilities**
24.	M	May	12	Final projects: student presentations		**7. Final Projects**
25.	W	May	14	Final projects: student presentations	**Project report due**	

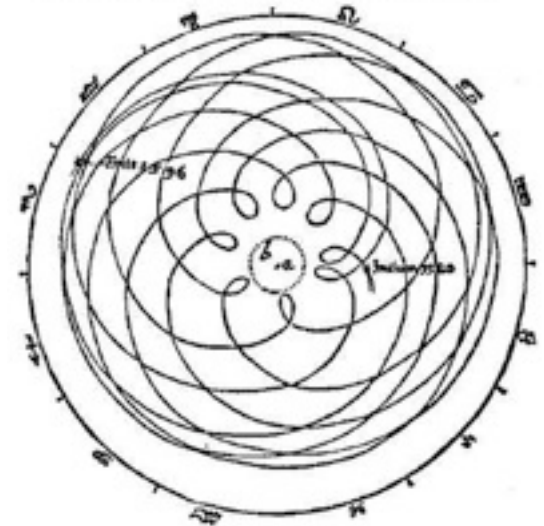# Ptolemy
circa.85 (Egypt) -165 (Alexandria)
Greek geocentric view of the universe
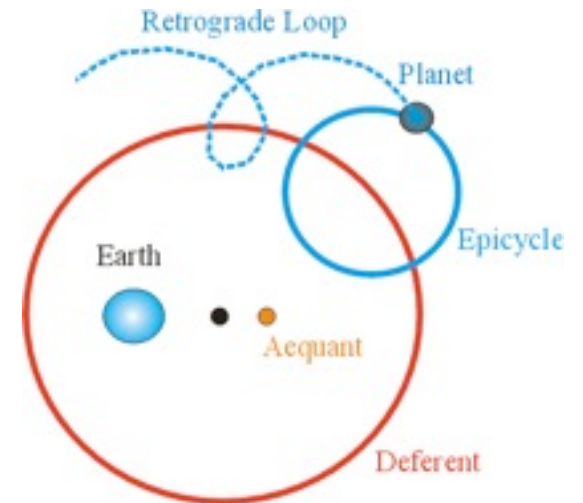
Tycho Brahe
1546 (Denmark) - 1601 (Prague)

"geo-heliocentric" system

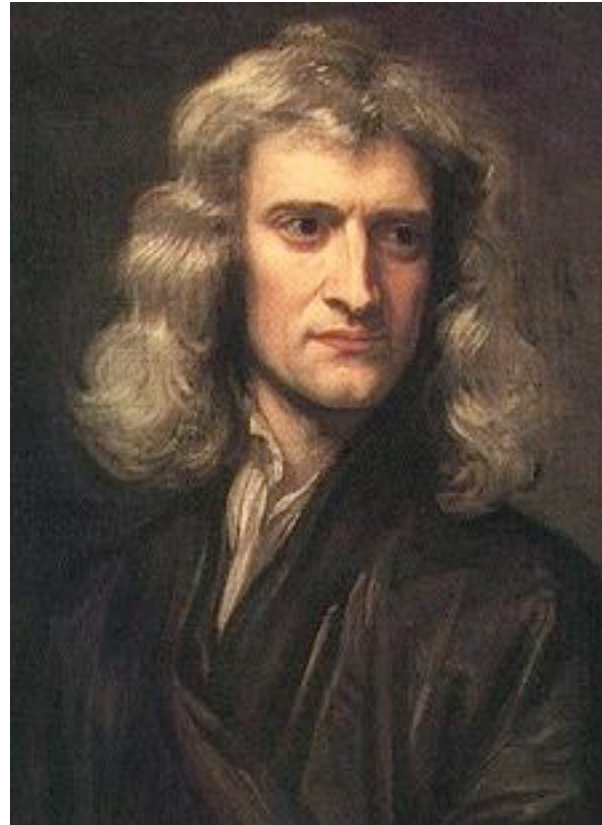last of the major naked eye astronomers

Johannes Kepler
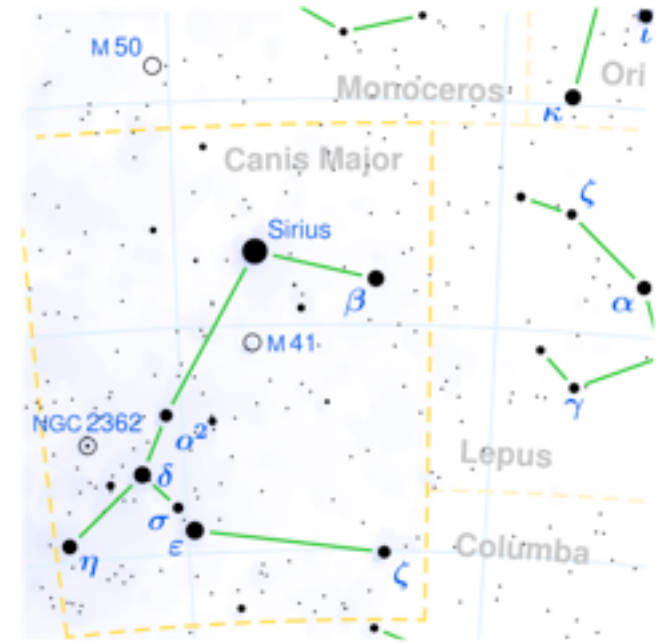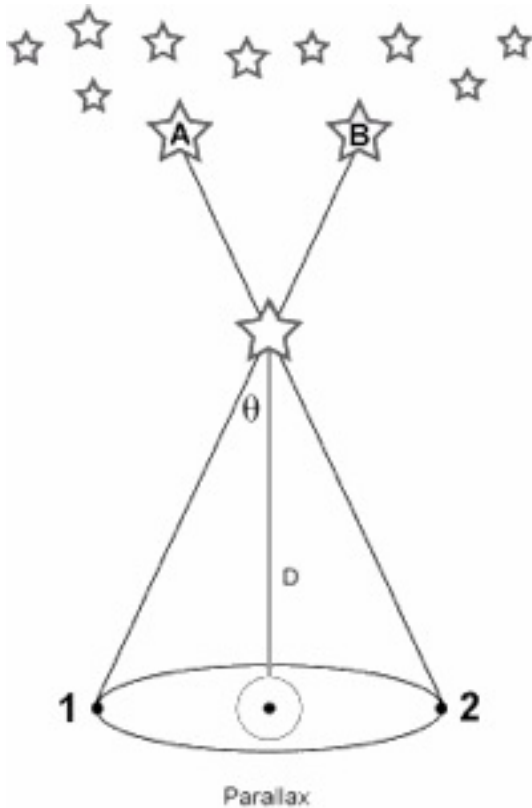## 1571 - 1630 (Germany)

Kepler's 3 laws

Isaac Newton
1643 - 1727 (England)

$$|\mathbf{F}_{12}| = G\frac{m_1 m_2}{r^2}$$

Friedrich Bessel

1784 (Germany) - 1846 (Prussia)

Cygni 61
d~10.3 ly

gravitational many-body problem:
prediction of Sirius B, Bessel functions