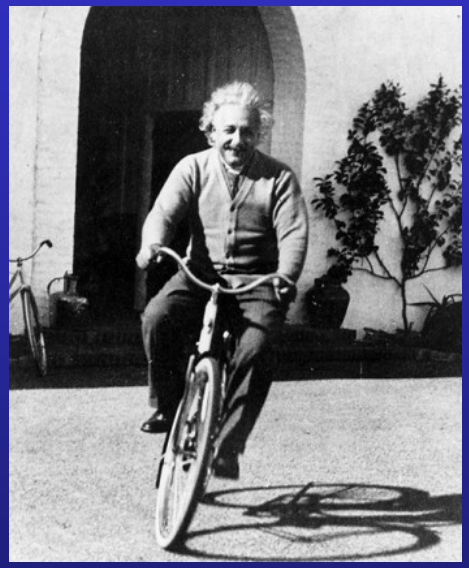
UNIVERSITY OF
Southampton
School of Physics
and Astronomy

Classical Mechanics

PHYS2006

Tim Freegarde



Helicopter dynamics

- You are James Bond / Lara Croft / …

- … and have seized a convenient helicopter in which to pursue your foe …
- You push forward the control column to tilt the rotor forward and accelerate the aircraft

www.robinsonheli.com

- What happens next ?

Bicycle dynamics

- You are Victoria Pendleton / Chris Froome / …

- Approaching a curve after a long straight run, you turn the handlebars a little to the right (clockwise when viewed from above)

- Which way does the road curve?

Inclined planes

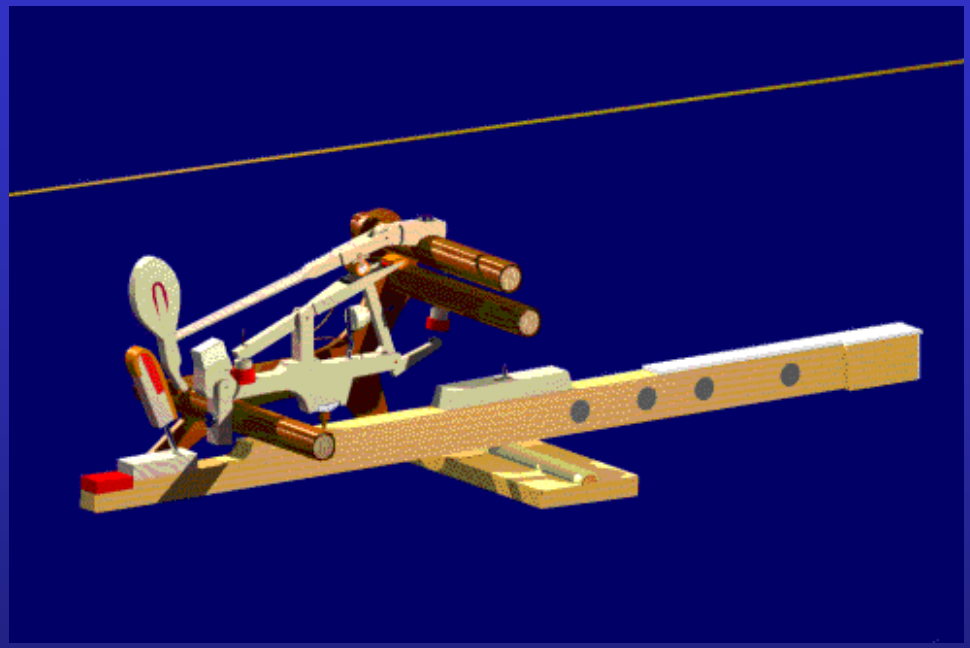
- You have two identical basketballs…

- You place them side-by-side at the top of a smoothly sloping inclined plane.
- One is placed directly on the inclined plane, the other is carried by a toy truck.
- The two basketballs are released at the same instant.

- Do they reach the bottom of the slope at the same time?

Pianoforte

- The piano has two or three strings for each note
- When a key is pressed, the hammer strikes these strings simultaneously



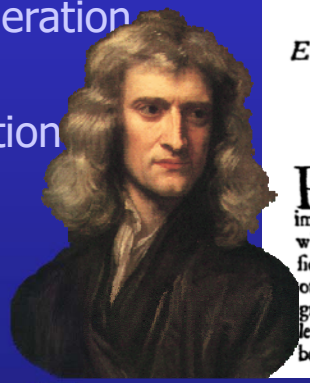
K Wayne Land www.musicresourcesusa.com

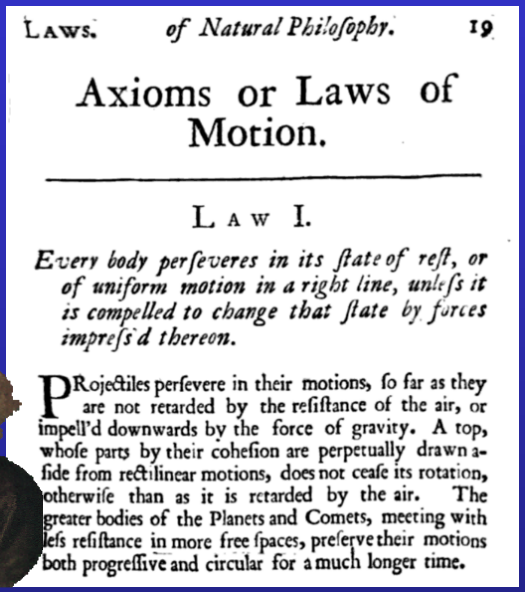
- How does this give the instrument its characteristic sound?

Principles of Classical Mechanics

- Newton's laws of motion (in an inertial frame)
  1. a body continues in constant motion unless acted upon by an external force
  2. an external force causes a proportional acceleration in inverse relation to the body's mass
  3. every action has an equal and opposite reaction

G Galilei, Discorsi e Dimostrazioni Matematiche Intorno a Due Nuove Scienze (1638)





Laws. *of Natural Philoſophy.* 19

Axioms or Laws of Motion.

Law I.

Every body perſeveres in its ſtate of reſt, or of uniform motion in a right line, unleſs it is compelled to change that ſtate by forces impreſs'd thereon.

Projectiles perſevere in their motions, ſo far as they are not retarded by the reſiſtance of the air, or impell'd downwards by the force of gravity. A top, whoſe parts by their cohesion are perpetually drawn aſide from rectilinear motions, does not ceaſe its rotation, otherwiſe than as it is retarded by the air. The greater bodies of the Planets and Comets, meeting with leſs reſiſtance in more free ſpaces, preſerve their motions both progreſſive and circular for a much longer time.

I S Newton, Philosophiæ Naturalis Principia Mathematica (1687)

- Principle of conservation of energy

Émilie du Châtelet, Principes mathématiques de la philosophie naturelle (1759)

- Properties of Euclidean space

Euclid of Alexandria, Στοιχεῖα (c300 BC)

R Decartes, La Géométrie (1637)

Classical Mechanics

LINEAR MOTION OF SYSTEMS OF PARTICLES	centre of mass
	Newton's 2nd law for bodies (internal forces cancel)
	rocket motion
ANGULAR MOTION	rotations and infinitessimal rotations
	angular velocity vector, angular momentum, torque
	parallel and perpendicular axis theorems
	rigid body rotation, moment of inertia, precession
GRAVITATION & KEPLER'S LAWS	conservative forces, law of universal gravitation
	2-body problem, reduced mass
	planetary orbits, Kepler's laws
	energy, effective potential
NON-INERTIAL REFERENCE FRAMES	centrifugal and Coriolis terms
	Foucault's pendulum, weather patterns
NORMAL MODES	coupled oscillators, normal modes
	boundary conditions, Eigenfrequencies

Classical Mechanics

LECTURES	1 single + 1 double lecture each week lecture notes and directed reading	
CLASSES	once a week (Friday 4pm) identify difficulties beforehand!	
COURSEWORK	weekly sheets of exercises hand in on level 3	20%
EXAMINATION	a: 5 short questions b: 2 longer questions	80%

- formal analysis of rigid body dynamics
- rockets, planets, plate tectonics, cricket bats, bicycles, weather, gyrocompass, piano
- Newton's laws, Kepler's laws, gravitation, Coriolis, Foucault
- normal modes, Eigen-frequencies, Hamiltonian, Lagrangian

MPhys/BSc second year

more independent approach to study:

- weekly coursework with longer, structured questions
- formal working and derivations expected – care with vectors, units etc.
- hand-written solutions and hand-drawn diagrams expected
- weekly problem classes replace tutorials
- variety of sources: lectures, notes, directed reading, own literature research
- coursework sample marked; full model solutions provided

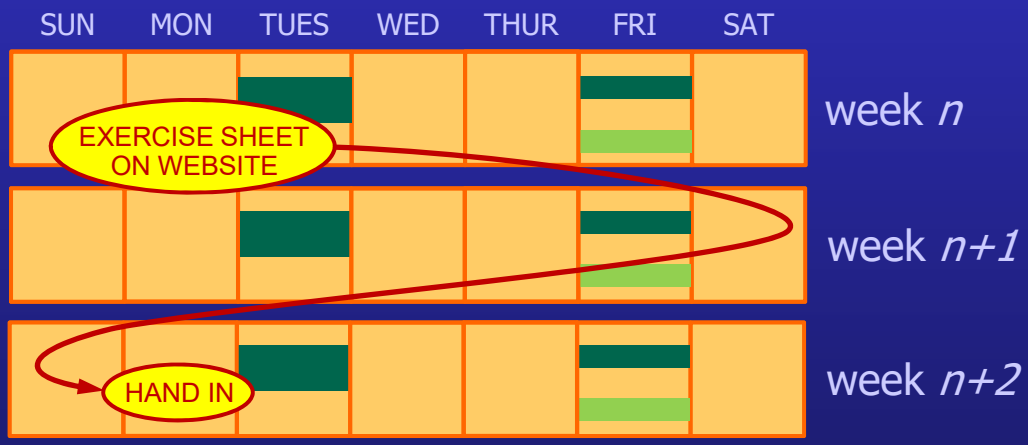
PHYS2006 Classical Mechanics Name Albert Ross
2019-20 Student no. 2718282

exercise sheet	structure /layout	diagrams	assumptions	rigour /logic	commentary /discussion	care /legibility	precision /uncertainty	general comments	initials
1	✓	✓	✗	✗	✗	✓	+	More formal derivations, please	fi
2	✓	✓	✓	✗	✗	✓	✓	Assumptions much better!	Pts
3									

Classical Mechanics resources

You should expect to make use of:

- lectures, hand-outs and your own lecture notes
- textbooks - some suggestions in following slide
- exercises and classes:



- for handouts, links and other material, see http://phyweb.phys.soton.ac.uk/quantum/phys2006.htm

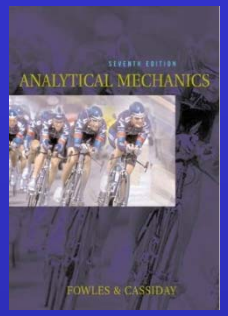
Classical Mechanics 'feedback'

To help you assess your progress and improve:

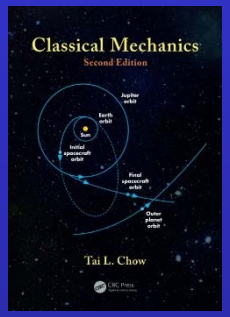
- weekly coursework will be returned with marks and comments
- weekly problems classes offer individual help
- tutors can give additional help
- some past exam papers have model answers
- lecturer 'at home': Tuesdays 4:00-5:00
- email me!

- for handouts, links and other material, see http://phyweb.phys.soton.ac.uk/quantum/phys2006.htm

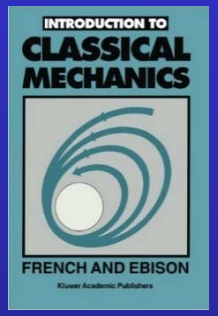
Textbooks



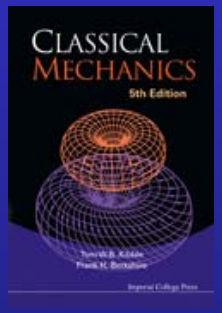
Fowles & Cassiday *Analytical Mechanics*
- ► good: right level comprehensive on rigid-body dynamics; fine examples



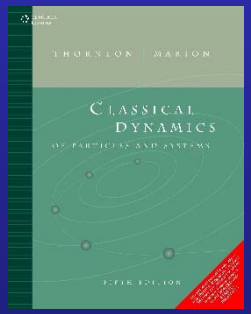
Chow *Classical Mechanics*
- ► good: right approach; concise



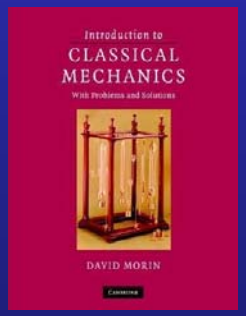
French & Ebison *Introduction to Classical Mechanics*
- ► quite good: right level, well paced



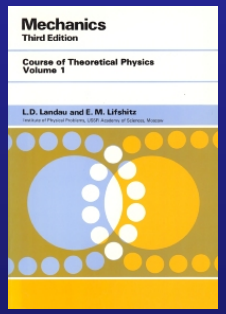
Kibble & Berkshire *Classical Mechanics*
- ► good, concise



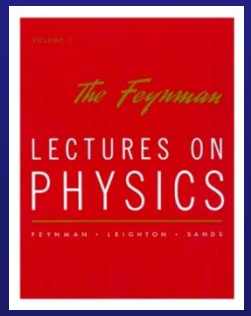
Marion & Thornton *Classical Dynamics*
- ► looks good, concise



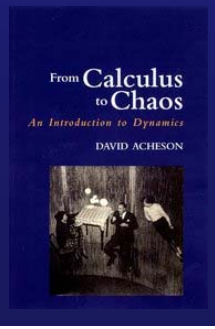
Morin *Intro to Class Mech*
- ► more advanced



Landau & Lifshitz *Mechanics*
- ► classic theoretical approach

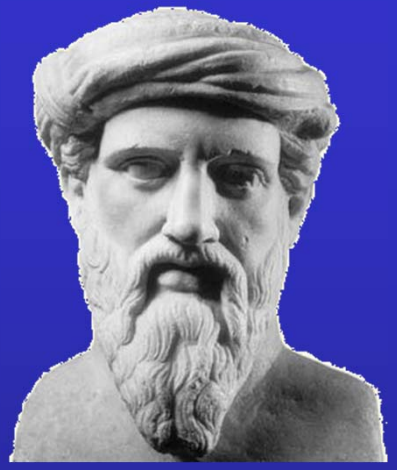


Feynman *Lectures on Physics*
- ► excellent introduction: put on your Christmas list!

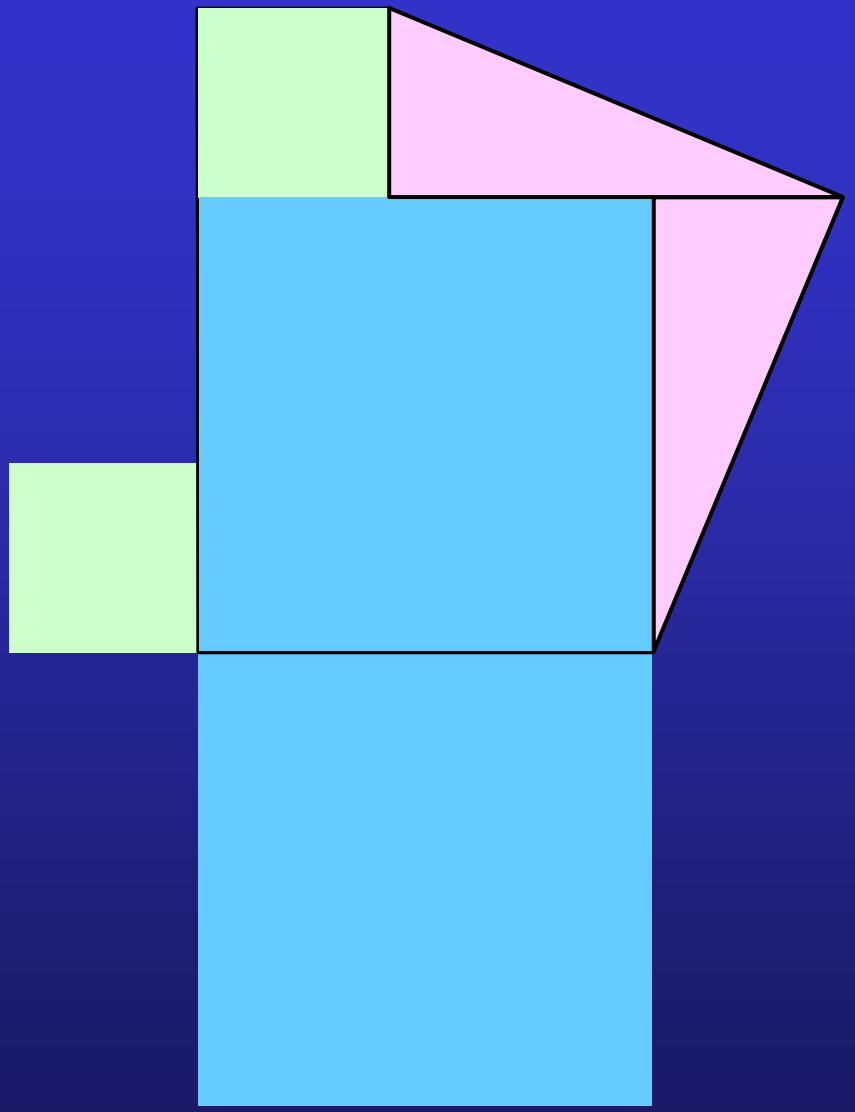


Acheson *From Calculus to Chaos*
- ► inspiring, supplementary reading

Pythagoras' theorem



Pythagoras of Samos (c570-495 BC)



- Relies upon properties of Euclidean space

Join flagship programme: MPhys with year in experimental research

Positions are still open for experimental projects to start in October 2020 (or later)

Projects are hosted by the QLM group at P&A and research topics include:

- Single photons and squeezed light
- Quantum theory
- Solid-state theory
- Polaritonics
- Nanomaterials for biomedical applications
- X-ray diffraction and imaging
- Cold atoms
- Nano-optics and plasmonics
- Optomechanics
- THz spectroscopy and semiconductor lasers
- Raman and ultra-fast spectroscopy
- 2d materials
- Liquid crystal materials and analysis
- Matterwave interferometry
- Fundamental physics on the table top

Who can join?

You are excited about experimental or theoretical research within the Quantum, Light and Matter research group. You have an average mark of not less than 70.

Research project condition:

You will spend the entire 4th year of studies on an exclusive Physics research project.

Please get in contact asap:

Professor Hendrik Ulbricht
Quantum, Light and Matter
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