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Introduction to Year 1
Lectures, problems classes….

Bradley Cheal
Year 1 Coordinator

Who am I?

- Coordinator for the first year of your studies
- Senior Academic Advisor
- Module Leader for Maths in your first semester

- I also teach Quantum & Atomic Physics in Year 3
- My research is to study the size and shape of radioactive nuclei using lasers

https://www.youtube.com/watch?v=LbDfyctlBSE

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Who am I?

- Went to school in Cheltenham, Gloucestershire
- University of Warwick, Physics and Maths degree,
- University of Birmingham, PhD Nuclear Physics
- University of Manchester, Research Fellow
- University of Liverpool, since 2013

- Office is Room 410 of the Oliver Lodge Building
- More usefully: bradley.cheal@liverpool.ac.uk

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What's coming up in your first year

Semester 1	Semester 2
PHYS101: Dynamics and Relativity	PHYS103: Wave Phenomena
PHYS102: Thermal Physics and Properties of Matter	PHYS104: Foundations of Quantum Physics
PHYS105: Introduction to Computational Physics	One of { PHYS115: Introduction to Medical Physics PHYS135: … Nuclear Science PHYS155: … Astrophysics
PHYS106: Practical Physics I →	
PHYS107: Maths for Physicists I	PHYS108: Maths for Physicists II

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What's coming up in your first year

Semester 1

PHYS101: Dynamics and Relativity

PHYS102: Thermal Physics and Properties of Matter

PHYS105: Introduction to Computational Physics

PHYS106: Practical Physics I

PHYS107: Maths for Physicists I

Prof. Tara Shears

Dr Kostas Mavrokoridis

Prof. Tim Veal

Prof. Tim Greenshaw

Dr Frank Jaeckel

(Thursday at 10am)

Prof. Bradley Cheal

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When will teaching take place?

- Each semester is 12 weeks, starting next week!
- Unusually, we will have 10 weeks of teaching

  …then Christmas (2 weeks)

  …then 2 more weeks of teaching

  …then a 3 week assessment period

➠ Semester 2 starts

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How will lectures be delivered?

- There will be two approaches.
- In PHYS105 and PHYS107…
  lectures will be given live via Teams.
- In PHYS101 and PHYS102…
  pre-recorded lectures will be available online
  then the lecture slot used for discussion via Teams

What happens in workshops?

- These are weekly "problems classes" for PHYS101, PHYS102, PHYS107

  (and PHYS103, PHYS104, PHYS108 in S2)

- Each class is a "bubble" of 20 students
- Each bubble has a 1 hour slot per module per week

- These contribute to your mark for the module
- More importantly, they are there to help you learn

What happens in workshops?

For each week…

- Problem sheets will be available online on Mondays (9am)
- Please make a start and try as many problems as you can.
- Use the workshop to the full…
  - Try and team up in groups of 4 (but respect social distancing)
  - Discuss with your classmates and help each other
  - Ask if you need help! (we don't bite)
  - Ask if an answer needs checking
- Submit your work for marking

  (by Friday 5pm - but remember labs!)

NB.: Attendance will be recorded to make sure you are OK!

What happens when in workshops?

One big workshop for each module

Seven bubble groups (at different times)

Unusually, workshop sessions are <u>before</u> lectures in the week

➜ A topic from lectures in Week 1, is covered in workshops in Week 2

…   ⋱   ⋱

a topic from lectures in Week 10, is covered in workshops in Week 11

➜ So PHYS101, PHYS102, PHYS107 will each have 10 workshops <u>for assessments</u>

The workshops in Week 1 and Week 12 will not be for assessed work.

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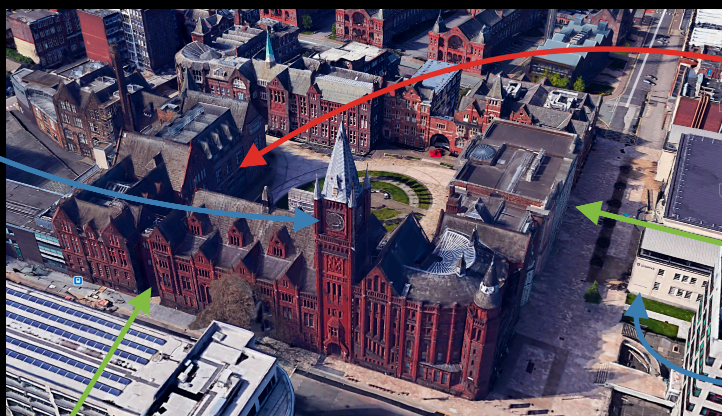
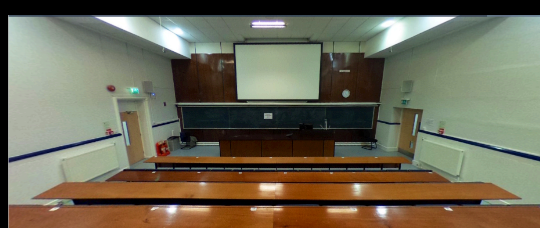
Where are the workshops?

ENG-WLT — Walker Lecture Theatre (Engineering)



Harrison Hughes Building

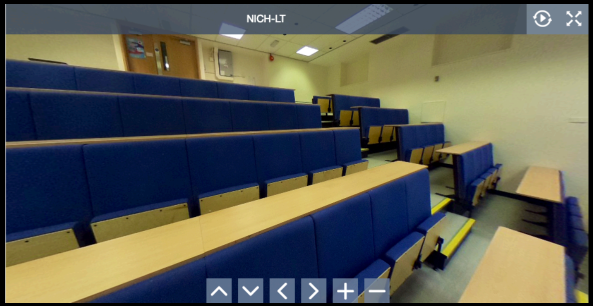

Walker Lecture Theatre

Where are the workshops?

NICH-LT — Nicholson Building Lecture Theatre

Big clock

Nicholson Building



Lecture Theatre

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What happens in workshops in Week 1?

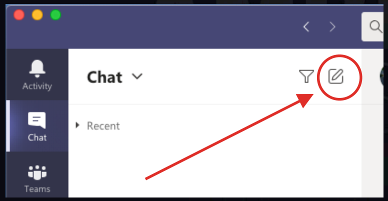
- Find the room ✔
- Find a place to sit ✔
- Say hello to your "bubble tutor" (or tutors) ✔
- Get to know your classmates ✔
- Try and "group up"… ✔

  ➜ exchange names

  ➜ prepare to learn together

  ➜ make your own private chat space on Teams

  …. so you can discuss with each other during online (and offline) activities



- Upload [something] as your first (dummy run) assignment ✔

But what if something goes wrong?

- Your lecturer's internet drops out?
  - ➜ Please be patient and they'll come back
- We have a second lockdown?
  - ➜ Workshops will move online with help to hand

(we wont have disappeared! 😉)

- You miss an assignment deadline?
  - ➜ You must do your best to stay up to date, but if there is a problem then please speak with your Module Leader ASAP

(and remember that assignments are more valuable in helping you learn than for marks!)

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A look ahead…

Semester 1

PHYS101: Dynamics and Relativity

Prof. Tara Shears

Dr Kostas Mavrokoridis

PHYS102: Thermal Physics and Properties of Matter

Prof. Tim Veal

PHYS105: Introduction to Computational Physics

Prof. Tim Greenshaw

PHYS106: Practical Physics I

Dr Frank Jaeckel

(Thursday at 10am)

PHYS107: Maths for Physicists I

Prof. Bradley Cheal

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PHYS107
Mathematics for Physicists I

Bradley Cheal
Module Coordinator

UNIVERSITY OF LIVERPOOL

PHYS107 : Mathematics for Physicists I

Staff teaching

Bradley Cheal  Module leader (lecturer), Bubble (workshop) tutor

Tessa Charles  Bubble (workshop) tutor

David Joss  Bubble (workshop) tutor

Postgraduate students


Charlie


Hannah


Dominic


Abbie


Annie

PHYS107 : Mathematics for Physicists I

Module outline

- Week 1: Statistics
- Week 2: Vectors
- Week 3: Differentiation 1
- Week 4: Differentiation 2
- Week 5: Partial differentiation
- Week 6: Integration 1
- Week 7: Integration 2
- Week 8: Multiple integration
- Week 9: Coordinate systems
- Week 10: Complex numbers
- Week 11&12: Revision and further practice

(Weeks 3–5) Start from scratch, recap, then to new methods

(Weeks 6–9) Start from scratch, recap, then to new methods

PHYS107 : Mathematics for Physicists I

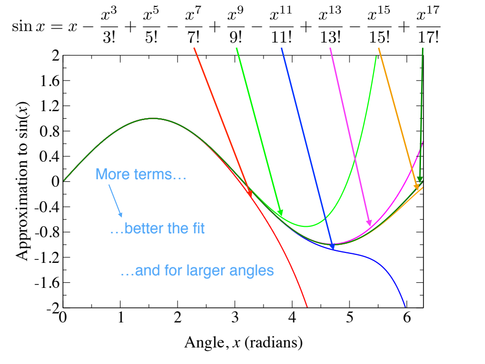
Differentiation

Start from “first principles”

➜ Recap from A-level

➜ Discover new techniques

$$E = -\frac{d\phi}{dx}$$



PHYS107 — Problem Sheet 3: Differentiation — 17/10/2019

This is the first problem sheet for differentiation. You will now have reminded yourself of the chain, product and quotient rules. Remember the procedure involved for each, so that you can use a combination of them if need be. You are learning that implicit differentiation is a useful tool, that logarithmic differentiation speeds things up for some messy functions, and finally, that L’Hospital’s rule tells you what happens when we divide zero by zero.

1) Given the function: $f(x) = x^3 + 2x^2 + x + 1$,
What is the equation of the straight line that is tangential to the curve at $x = 2$?

2) Using the chain, product and/or quotient rules, differentiate:-
   - i) $x^3 \cos x$
   - ii) $x^2 / \sin x$
   - iii) $\sin(x^2)$
   - iv) $(x^2 + 3x + 4)^4$
   - v) $\ln(x^2 + \cos x)$
   - vi) $e^{\cos 3x}$
   - vii) $\tan x = \sin x / \cos x$
   - viii) $e^x \tan x$
   - ix) $\sqrt{e^x \tan x}$
   - x) $e^x \sin(x^2)$
   - xi) $(1 - x^2)/\sqrt{1 + x^2}$ ← You will be able to tidy up your answer quite a bit here

   (vii–x) You should be happy to tackle any such function — go step by step

3) Using implicit differentiation, differentiate with respect to x and find $\frac{dy}{dx}$ for:-
   - i) $x^2 + y + y^2 + \sin(xy) = 7$
   - ii) $\cos y = x$
   - iii) $\tan y = x$

   Afterwards, use the identity $\sin^2\theta + \cos^2\theta = 1$, to express your answers in terms of *x*.
   What helpful derivatives have you just found?
   Hint: For (iii), divide the above identity through by $\cos^2\theta$…

4) Use logarithmic differentiation to differentiate:-
   - i) $y = x^2 \sin x$
   - ii) $y = e^{\sin x}$
   - iii) $y = \frac{x^3 e^x \sin x}{\cos(x^2)}$

   NB.: Remember that $\ln(e) = 1$ whereas $\ln(e^x) = x\ln(e) = x$ — which is to be expected as one is the inverse of the other

5) Use L’Hospital’s rule to find:-
   - i) The value of $y = \frac{\tan x}{x}$ as $x \to 0$,
   - ii) and use this to write an approximation for $\tan x$ for small angles.
   - iii) The value of $y = \frac{\sin^3 x}{x^2}$ as $x \to 0$. (Same problem? Use L’Hospital again…)

6) If a mass on a spring oscillates according to $x(t) = A\cos(\omega t + \phi)$, where A, ω, ϕ are constants, what is the acceleration, in terms of x?
(This is called Simple Harmonic Motion.)

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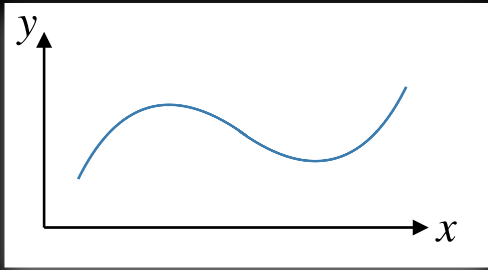
PHYS107 : Mathematics for Physicists I

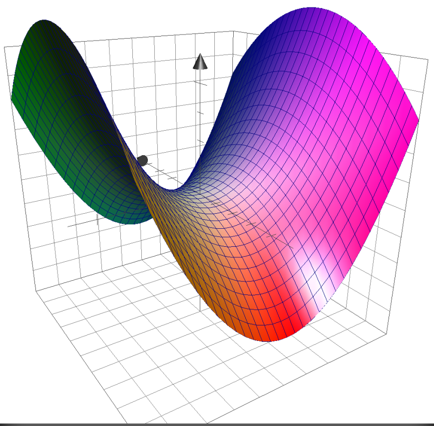
Partial Differentiation



$$y = f(x) \rightarrow \frac{dy}{dx}$$

…the “gradient”
…the “rate of change”

…but what about functions of two variables?



$z = f(x, y)$?

…or of three dimensions?

$f(x, y, z)$?

$\phi(x, y, z)$?

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PHYS107 : Mathematics for Physicists I

Integration

Just as before…

Start from “first principles”

➜ Revise from A-level

➜ Then move on to learn some new techniques

Integrating functions of x

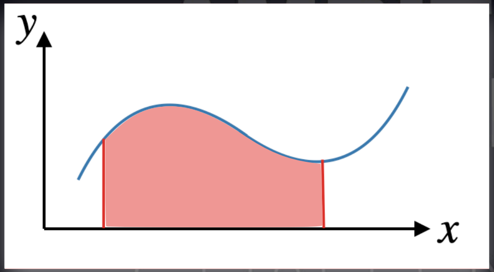
What method would you use to integrate these functions?

$\int x^4 + 3x^2 + 4\, dx$	$\int x \sin x\, dx$
$\int \cos x\, dx$	$\int x^2 \sin x\, dx$
$\int \frac{1}{1+x^2}\, dx$	$\int e^x \sin x\, dx$
$\int \frac{2x+1}{x^2+x+4}\, dx$	$\int x \sin(x^2)\, dx$
$\int \frac{4x+1}{x^2+x-12}\, dx$	$\int \sin^5 x\, dx$
$\int \tan x\, dx$	$\int \sin^4 x\, dx$

PHYS107 : Mathematics for Physicists I

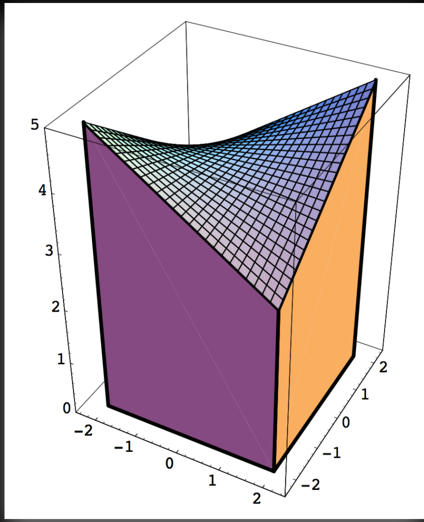
Multiple integration

We can "find the area under a graph"…

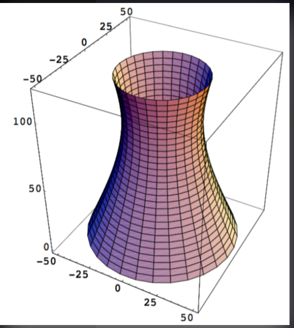


$$y = f(x) \quad \rightarrow \quad y = \int f(x)\, dx$$

What about "the volume under a surface"?



Or integrating over 3 dimensional space?



$$\iiint f(x,y,z)\, dx\, dy\, dz$$

$$\iiint g(r,\theta,z)\, dr\, d\theta\, dz$$

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PHYS107 : Mathematics for Physicists I

Vectors…

Which would we use?

$F = ma$ or $\underline{\mathbf{F}} = m\underline{\mathbf{a}}$?

$F = Bqv\sin\theta$ or $\underline{\mathbf{F}} = q\underline{\mathbf{v}} \times \underline{\mathbf{B}}$?

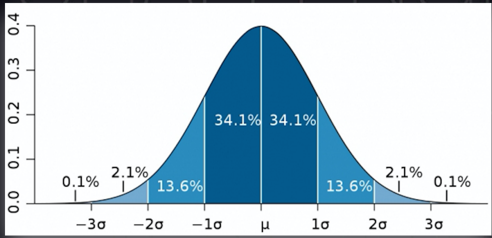
Statistics…

What is a “probability distribution”?

Do we always measure the “correct value”?

Do we always measure the *same* value?

What is the error?



Complex numbers…

What is $\sqrt{-1}$?

Is that “a thing”?

Can we use it?

https://www.bbc.co.uk/programmes/b00tt6b2

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PHYS102 Thermal Physics and Properties of Matter

Tim Veal
Module Coordinator

Who am I?

- Module Coordinator for Thermal Physics module
- An academic advisor
- Department Director of Equality and Diversity
- Director of Postgraduate Research for the School of Physical Sciences (Chemistry, Maths and Physics)
- My research is on semiconductor physics for renewable energy applications

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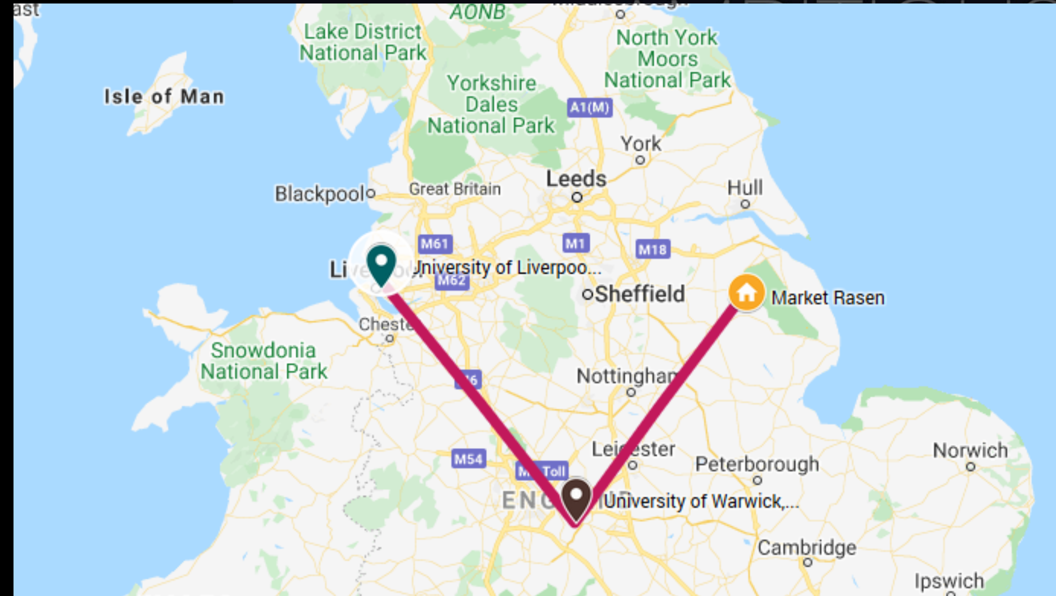

Who am I?

- Went to school in Market Rasen, Lincolnshire
- University of Warwick, Maths and Physics degree
- University of Warwick, PhD Condensed Matter Physics
- University of Warwick, Research Fellow
- University of Liverpool, since 2012

- Office is G17, Chadwick Building
- More usefully: timveal@liverpool.ac.uk

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PHYS102: Thermal Physics and Properties of Matter

Staff teaching

Tim Veal  Module coordinator (lecturer)
Bubble (workshop) tutor

Ronan McGrath  Bubble (workshop) tutor

Max Klein  Bubble (workshop) tutor

Postgraduate students


Leanne


Luke


Pruthvi


Kieran


Antony

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PHYS102: Thermal Physics and Properties of Matter

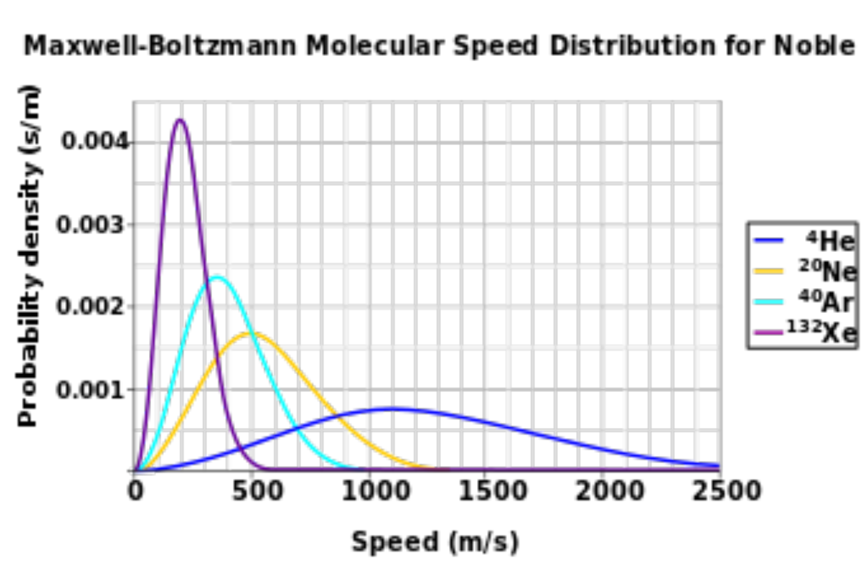
Module Outline:

- Week 1: Zeroth law, Heat Transfer and Cooling
- Week 2: Gas laws and kinetic theory of gases
- Week 3: Equipartition principle, heat capacity, first law
- Week 4: Heat engines, second law, Carnot's theorem
- Week 5: Equivalence of second law formulations, real engines
- Week 6: Mechanical Properties of Materials
- Week 7: Mathematics for Thermodynamics
- Week 8: Entropy, Central Equation of Thermodynamics
- Week 9: Thermodynamic potentials, Maxwell's relations and applications
- Week 10: Free and throttling expansions, phase transitions
- Week 11: Partition function, third law and its consequences
- Week 12: Revision

PHYS102: Thermal Physics and Properties of Matter

Applications of Maths!

Finding the most probable molecular speed in the Maxwell-Boltzmann distribution function. Differentiate function, set to zero and solve for speed.



Partial differentiation is essential to thermal physics, particularly Maxwell's relations which are related to thermodynamic potentials – quantities that are conserved in different thermodynamic processes.

Maxwell's relations

	From
$\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial p}{\partial S}\right)_V$	From $dU = TdS - pdV$ Internal Energy
$\left(\frac{\partial T}{\partial p}\right)_S = \left(\frac{\partial V}{\partial S}\right)_p$	From $dH = TdS + Vdp$ Enthalpy
$\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial p}{\partial T}\right)_V$	From $dF = -SdT - pdV$ Helmholtz Free Energy
$\left(\frac{\partial S}{\partial p}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_p$	From $dG = -SdT + Vdp$ Gibbs Free Energy

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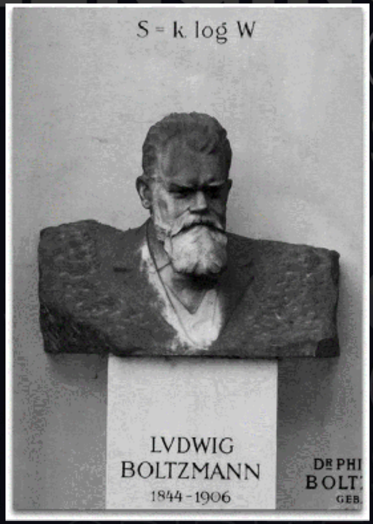
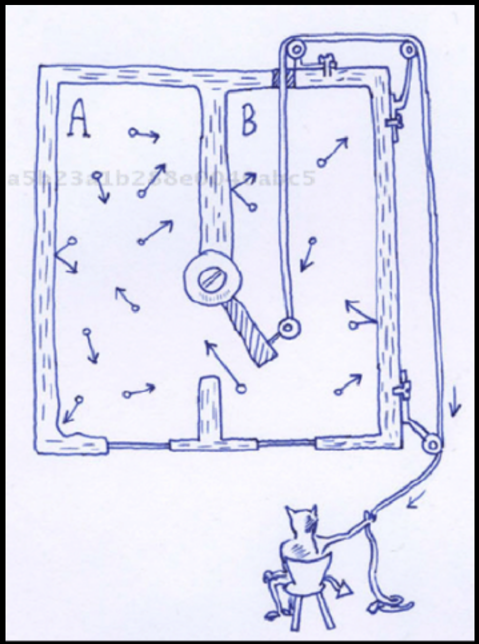
PHYS102: Thermal Physics and Properties of Matter

Entropy as dispersal of energy

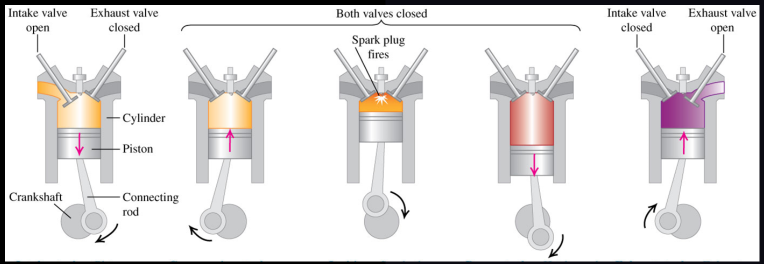
Initial gravitational potential energy
→ kinetic energy of the ball
→ heat energy in the air and floor
→ sound energy throughout the room

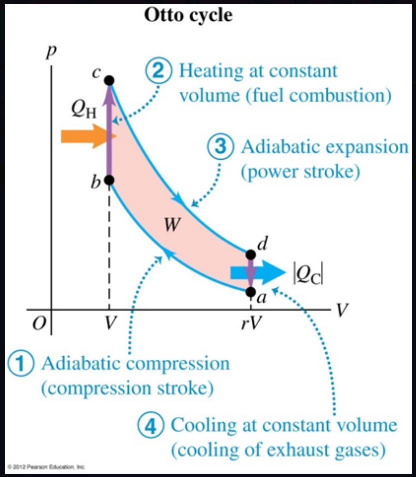




Can Maxwell's demon overcome the second law of thermodynamics?

Thermodynamics of engines





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PHYS101
Dynamics and Relativity

Tara Shears (Dynamics)
Module Coordinator
Kostas Mavrokoridis (Relativity)

PHYS101: Dynamics and Relativity

Module coordinator and Dynamics lecturer: Tara Shears
Special Relativity lecturer: Kostas Mavrokoridis
Tutors: TS, KM, Nikos Rompotis, David Martin

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PART A: Dynamics (weeks 1 – 6)

How do things move? How do forces influence motion?

Tara Shears

- Explanations and concepts are **online**.
- Watch these each week before the lecture
- We'll recap and discuss each week's material in the lecture slot (via Teams)
- Also … online problem sets each week for practise
- And weekly (assessed) problem sheets to do
- Tutorials will help you each week

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Course Overview: Dynamics

- Wk1: Forces, Motion, Newton's laws
- Wk2: Resistance to Motion; friction and drag
- Wk3: Work, energy, momentum

- Wk4: Circular motion, moment of inertia, torque
- Wk5: Angular momentum, rolling, precession

- Wk 6: Gravity, orbits, Kepler's laws

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PART B: Special Relativity

What happens when things go *really fast*?

Kostas Mavrokoridis

Lectures will be interactive and will be delivered during the allocated lecture slot via Teams. Make sure you connect!

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Course Overview: Special Relativity

- Wk7: In search for the Ultimate reference system
  - Aether and the beginnings of relativity
  - The principle of relativity
  - Simultaneity of events
- Wk8: Consequences of the relativity principle
  - Time dilation, length contraction and visualisation
- Wk9: The Lorenz transformation
  - Velocity transformation
- Wk10: Spacetime and Paradoxes
  - Spacetime intervals; light cones

Christmas Break

- Wk11: Relativistic energy and momentum
  - $E=mc^2$
- Wk12: Revision

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PHYS105 Introduction to Computational Physics

Tim Greenshaw

Module Coordinator

What will we do this year?

- Using CoCalc and Jupyter Notebooks.
- Installing Python on your own computer.
- Fitting laboratory data.
- Python data and control structures.
- Matplotlib and Numpy.
- Random numbers and Monte Carlo methods.
- Numerical solution of equations.
- Image analysis.
- Introduction to computer algebra.s

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Who will we do it with?

Staff

- Tim Greenshaw

- Carl Gwilliam

- Jan Kretzschmar

- Joe Price

Who will we do it with?

Postgraduate demonstrators

- Daniel Bromley

- Barney Ellis

- Selina Dhinsey

- Ondrej Sedlacek

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And how will we do it?

- Online lectures.
  - We will use Teams – make sure you have this on your computer!
- Computer classes.
  - These will be face-to-face, in “bubbles” of about 20.
  - Demonstrators will be on hand to help you with any difficulties you have working through the course’s Jupyter Notebooks.
  - We will use CoCalc, which means we can move completely online if there is another lockdown.

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Computer classes

- Will be held in the MOTC PC centre.
- This is on room 101, on the first floor of Maths.
- Building 206 on the Campus Map.

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INSPIRING
SPIRITED
CHALLENGING
INSPIRING
AMBITIOUS
SPIRITED
INSPIRING

Computer classes

MOTC

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Jupyter Notebooks

Phys105-Week01-Student

January 31, 2020

1 Introduction to Computational Physics - Week 1

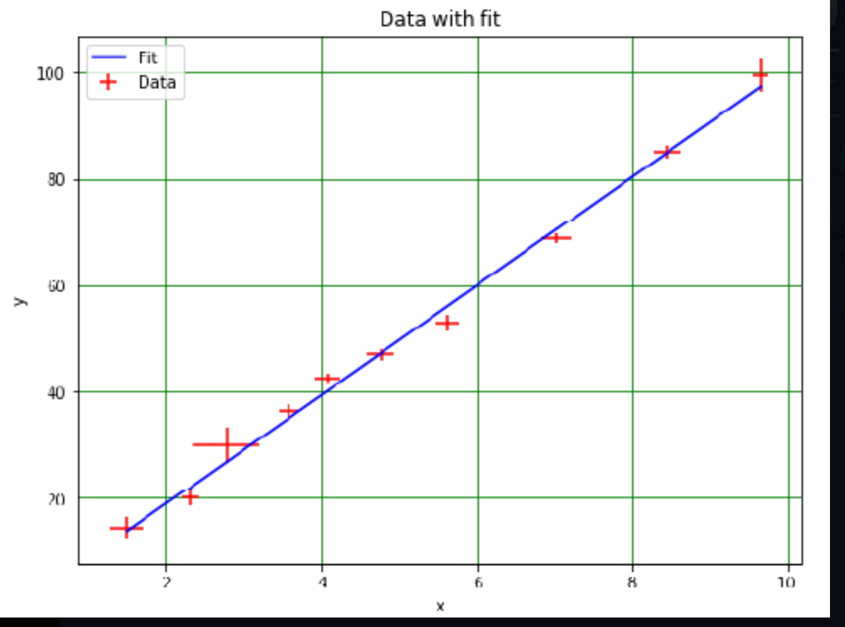
1.1 Table of contents week 1

1.2 Introduction to week 1

The aim of the Introduction to Computational Physics (Phys105) module is to provide a practical introduction to programming in Python for Physics students and students on related courses. It takes a "bottom-up" approach: from day one we use examples to develop an understanding of how Python programs can be used to tackle physics problems, rather than first learning a lot of general principles and then trying to apply them. There are two reasons for this. Firstly, you will be using Python in your practical and some other modules soon, so need to be in a position to do some things quite quickly. Secondly, most people learn more effectively by actually doing things than by just hearing how they can be done.

$$\int_0^\pi \sin x dx = (-\cos x)_0^\pi \quad (1)$$
$$= -(\cos(\pi) - cos(0)) \quad (2)$$
$$= -(-1-1) \quad (3)$$
$$= 2. \quad (4)$$

```
#
def fitLineDiff(p, x):
    '''
    Differential of straight line
    '''
    df = p[1]
    return df
#
def fitChi(p, x, y, xerr, yerr):
    '''
    Cost function
    '''
    e = (y - fitLine(p, x))/(np.sqrt(yerr**2 + fitLineDiff(p, x)**2*xerr**2))
    return e
```



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CoCalc

- The Physics Department has bought the CoCalc package to make sure teaching is as interactive as possible, whatever Covid throws at us.
- Allows us to run Jupyter Notebooks online.
- Demonstrators can edit and run your code with you “live”, while talking/chatting using Teams.
- We will spend the first week learning how to sign in to CoCalc and use this new tool!
- Looking forward to working with to make PHYS105 a success!

Semester 2: A quick peek

Bradley Cheal

Year 1 Coordinator

A peek beyond…

Semester 1	Semester 2
PHYS101: Dynamics and Relativity	PHYS103: Wave Phenomena
PHYS102: Thermal Physics and Properties of Matter	PHYS104: Foundations of Quantum Physics
PHYS105: Introduction to Computational Physics	One of { PHYS115: Introduction to Medical Physics; PHYS135: … Nuclear Science; PHYS155: … Astrophysics
PHYS106: Practical Physics I →	→
PHYS107: Maths for Physicists I	PHYS108: Maths for Physicists II

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A peek beyond…

Semester 1

Dr David Martin

Prof David Joss

Dr Frank Jaeckel

(Thursday at 10am)

Prof Ronan McGrath

Semester 2

PHYS103: Wave Phenomena

PHYS104: Foundations of Quantum Physics

One of {
- PHYS115: Introduction to Medical Physics
- PHYS135: … Nuclear Science
- PHYS155: … Astrophysics

PHYS106: Practical Physics I →

PHYS108: Maths for Physicists II

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PHYS115/135/155

PHYS115 Medical Physics

Dr Helen Boston

PHYS135 Nuclear Science

Prof Andy Boston

PHYS155 Astrophysics

Dr Stacey Habergham-Mawson

➜ Seminar on Friday

"Supernova Science"

F350 BSc with Medical Physics ➜ PHYS115

F390 BSc with Nuclear Science ➜ PHYS135

F521/F3F5 Astrophysics programmes ➜ PHYS155

F303/F300 Physics programmes ➜ Choose any one of these (later in this semester)

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