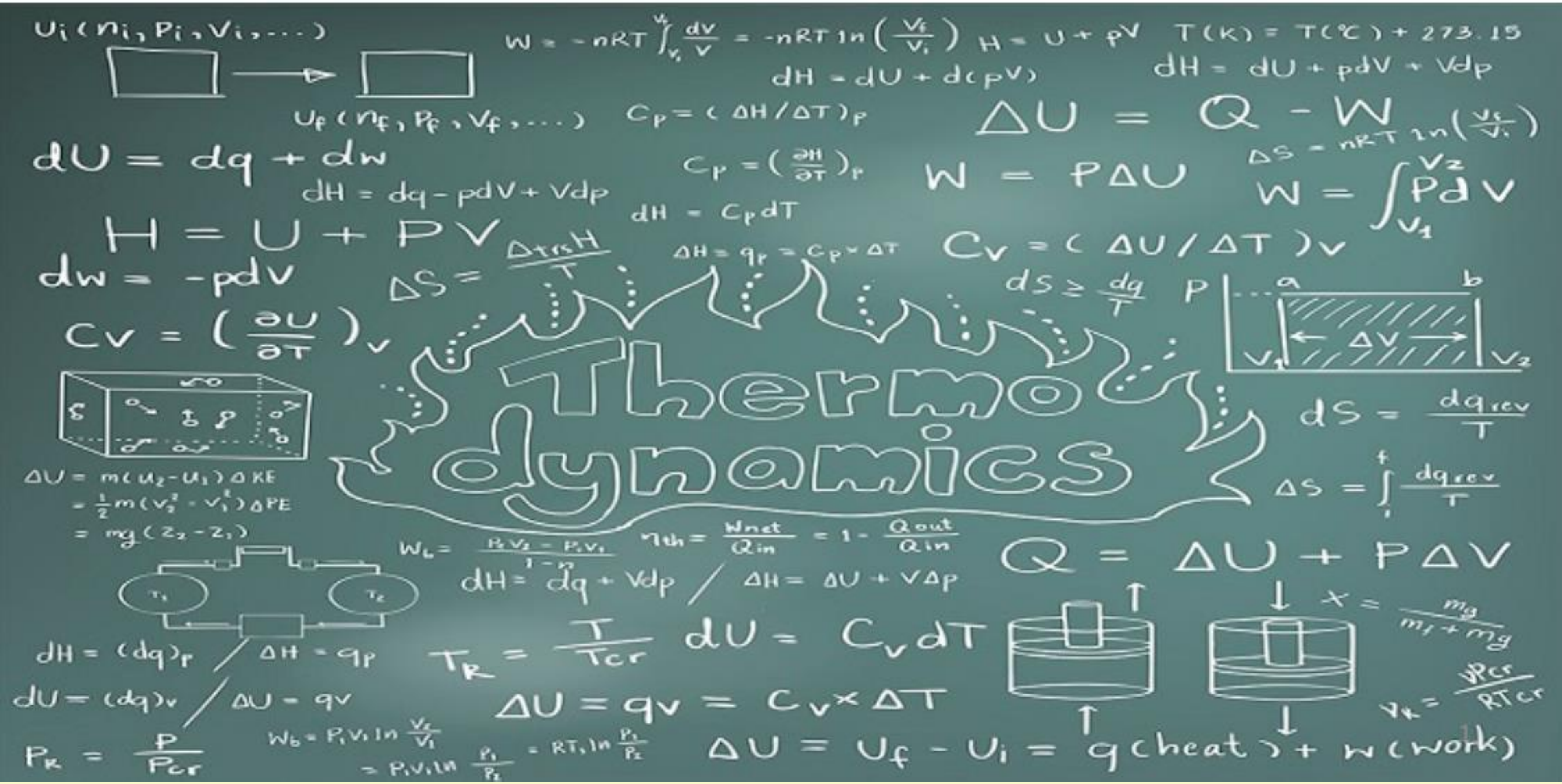
PHYS1013
Energy and Matter



Prof Nick Evans

46/5043

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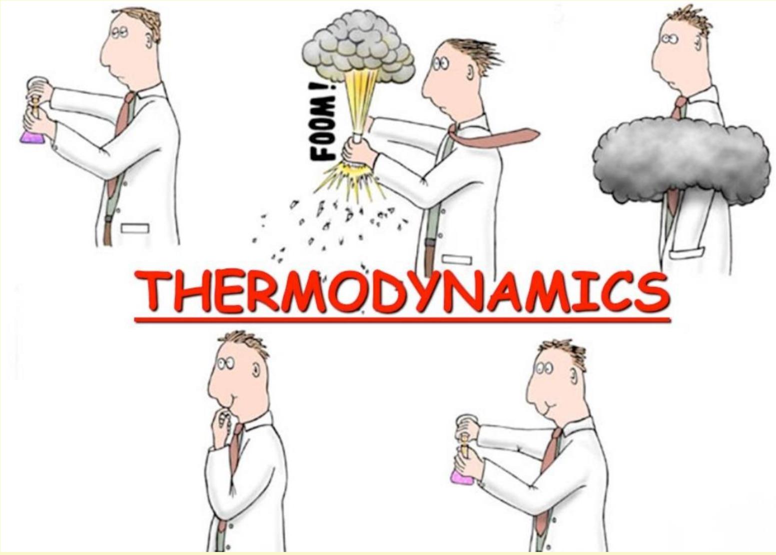
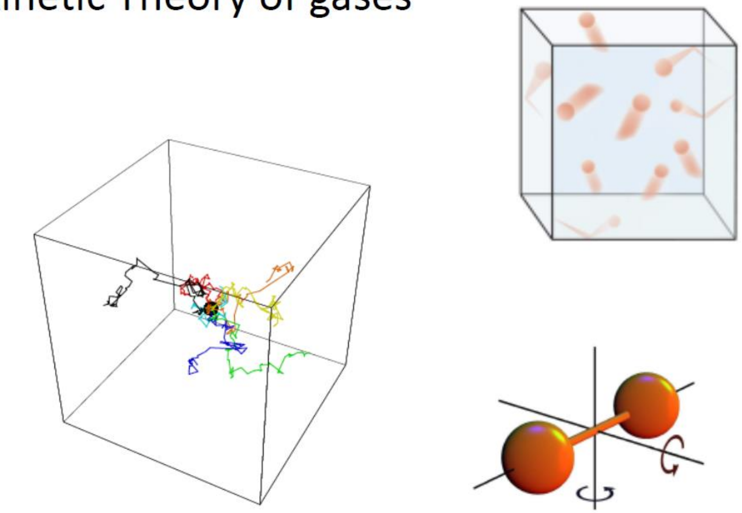
Theoretical particle physicist

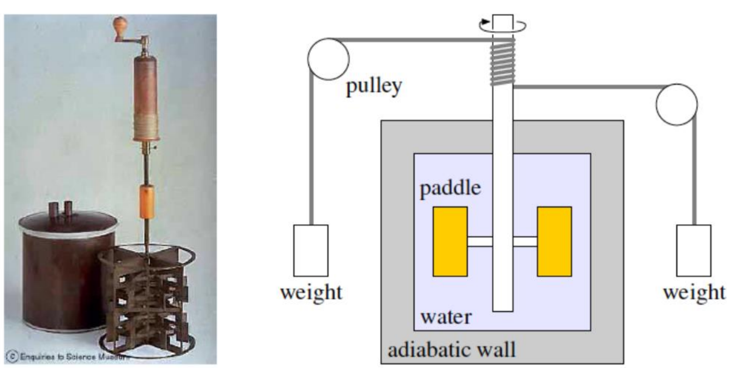
* strong interactions (nuclear force)
* origin of mass
* vacuum structure
* string theory



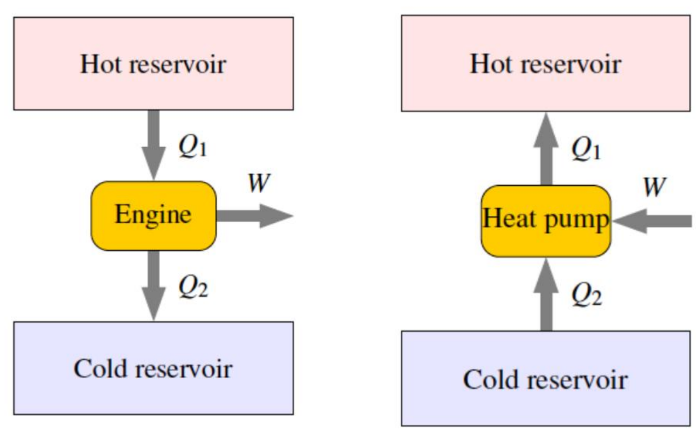
Kinetic Theory of gases



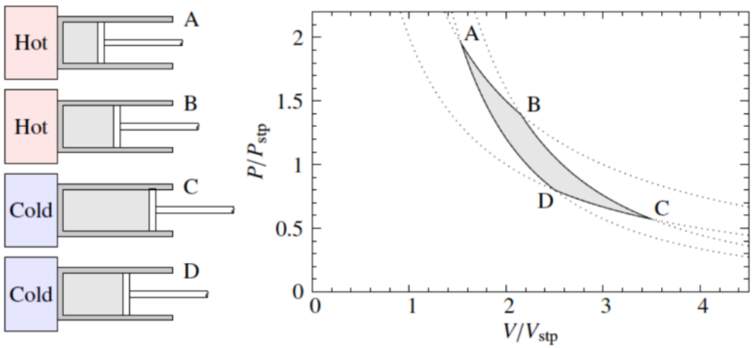
Work, heat, internal energy, heat capacities



Engines and efficiencies

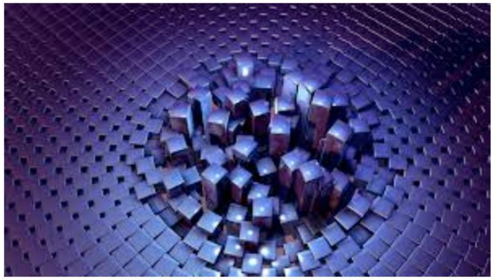


Indicator diagrams

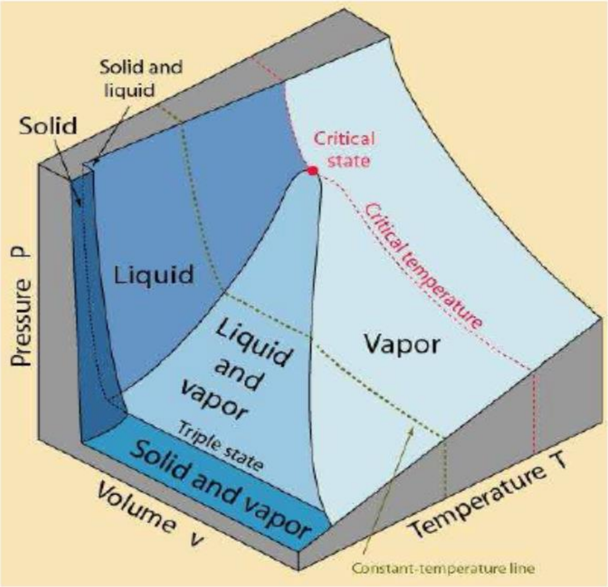


Entropy

Boltzmann's tomb with his definition of entropy engraved on it.



Phase transitions



Energy and Matter

24 lecture sessions across 12 weeks of lecture sessions.

(We will take breaks for the mid-term test in WEEK 6 and when Other duties take me away – but we'll finish with plenty of time to spare before the exam)

9 problem classes starting in WEEK 2

Tutorial sessions weekly

Energy and Matter

Course material is available on blackboard

Printed notes

Lecture notes

Lecture recordings

Problem sheets for tutorials & problem classes
+ solutions one week on

These slides

Course Book

There are a vast number books in the library covering this material – see what you get on with!!

Here are two that I get on with OK

S Blundell and K Blundell, *Concepts in Thermal Physics*. Oxford University Press.

C J Adkins (1984). Equilibrium Thermodynamics. Cambridge University Press.

Hints on Lectures and note-taking

Taking notes is an important skill. The act of writing in a lecture should help fix the material in your memory so that it is easier to recall later. What you record in a lecture gives you a reminder of what to go over later, and understand better. Copies of my hand written notes are on the website.

In lecture:

- Copy the board with annotations from what I say!
- My powerpoint slides are "background"
- Listen to what is said. It is difficult to write and listen.
- Shout at me if I go too fast!
- Underline or highlight important points.
- Use simple diagrams.
- If you don't understand something, make a note of it.

After lecture:

- Read through notes as soon as possible.
- Copy them out again, especially if messy, adding to them from textbook.
- Sort out the points you don't understand, read up, ask me, or tutor.
- Discuss with friends, as this really helps understanding.

Assessed Problem sets will be available online every second week –

Blackboard –> Mastering Physics -> Assignments

These problems must be completed by the set deadline, which will be clearly stated (usually Sunday at 12, midnight).

(* change from 10…. No n-2 rule *)

The unmarked but important introductory exercise is available now and you should do it this week!

They are worth 20% of your course mark. (nerdish analysis shows that students who don't bother fail… no exceptions…)

Tutorial problems sheets will also be distributed online on Monday for Tutorials and Workshop.

They contain conceptual/simple problems to be worked on and discussed in your tutorials.

The main problems will be done in your workshops, where help will be available – look at them before workshops but plan to write out the solutions there…

Workshops for this course start NEXT week… you must attend!

Answers to these problems will be posted on blackboardafter a suitable interval.

Workshop problems are similar to examination problems.

How do I get feedback on progress?

- Mastering Physics gives you real time hints you go.

- Problem sheet solutions will be online the week after you do them.

- I am available after lectures (particularly in the double slot) to answer questions – use me!

- Demonstrators are available to help you in the problem classes – use them!

- I will attend most problem classes by way of office hours – you can grab me to ask questions. This is instead of the online office hours.

- Your tutorial sessions are periods where you can ask anything – go to your tutorials with questions about what you don't understand!

- There will be revision lectures at the end of the semester with free discussion periods too.

COMPONENT	WHEN	MARK
10 Problem sheets	Weekly	
6 Mastering Physics Homeworks	Weekly	20%
Mid-semester exam	Week 6	10%
Final exam	Exam week	70%

Empirical Gas Laws

$$P V = n k T$$

Boyle's law

P proportional to 1/V at constant T

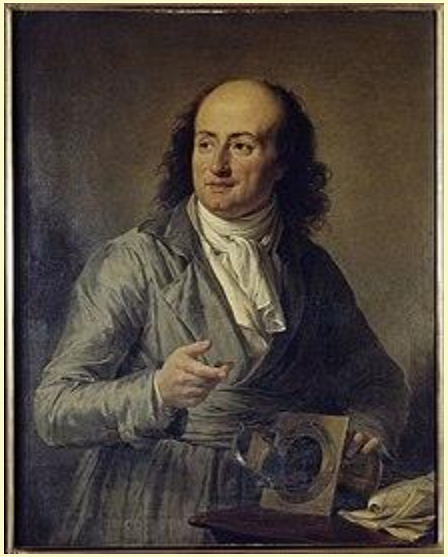
Wikipedia: This relationship between pressure and volume was first noted by Richard Towneley and Henry Power in the 17th century. Robert Boyle confirmed their discovery through experiments and published the results. According to Robert Gunther and other authorities, it was Boyle's assistant, Robert Hooke, who built the experimental apparatus. Boyle's law is based on experiments with air, which he considered to be a fluid of particles at rest in between small invisible springs. At that time, air was still seen as one of the four elements, but Boyle disagreed. Boyle's interest was probably to understand air as an essential element of life; for example, he published works on the growth of plants without air. Boyle used a closed J-shaped tube and after pouring mercury from one side he forced the air on the other side to contract under the pressure of mercury. After repeating the experiment several times and using different amounts of mercury he found that under controlled conditions, the pressure of a gas is inversely proportional to the volume occupied by it.

1627 –1691

Charles' law

V proportional to T   at fixed P

Wikipdeia: The law was named after scientist Jacques Charles, who formulated the original law in his unpublished work from the 1780s.



Jacques Alexandre César Charles (1746 – 1823) was a French inventor, scientist, mathematician, and balloonist. Charles wrote almost nothing about mathematics, and most of what has been credited to him was due to mistaking him with another Jacques Charles. Charles and the Robert brothers launched the world's first unmanned hydrogen-filled gas balloon in August 1783; then in December 1783, Charles and his co-pilot Nicolas-Louis Robert ascended to a height of about 1,800 feet (550 m) in a manned gas balloon. Their pioneering use of hydrogen for lift led to this type of balloon being named a Charlière (as opposed to a Montgolfière which used hot air).

Charles's law, describing how gases tend to expand when heated, was formulated by Joseph Louis Gay-Lussac in 1802, but he credited it to unpublished work by Jacques Charles.

Joseph Louis Gay-Lussac

V proportional to T   at fixed P

Wikipdeia: The law was named after scientist Jacques Charles, who formulated the original law in his unpublished work from the 1780s.

Gay-Lussac (1778-1850) is known mostly for his discovery that water is made of two parts hydrogen and one part oxygen by volume (with Alexander von Humboldt), for two laws related to gases, and for his work on alcohol–water mixtures, which led to the degrees Gay-Lussac used to measure alcoholic beverages in many countries.

He discovered Boron and Iodine

He developed an improved version of the burette that included a side arm, and coined the terms "pipette" and "burette" in an 1824 paper about the standardization of indigo solutions.

Fick

Wikipedia: Adolf Eugen Fick (1829 –1901) was a German-born physician and physiologist. Fick began his work in the formal study of mathematics and physics before realising an aptitude for medicine. He then earned his doctorate in medicine from the University of Marburg in 1851.

In 1855, he introduced Fick's laws of diffusion, which govern the diffusion of a gas across a fluid membrane. In 1870, he was the first to measure cardiac output, using what is now called the Fick principle.

Fick's nephew, Adolf Gaston Eugen Fick, invented the contact lens.

Fourier

Wikipedia: Jean-Baptiste Joseph Fourier (1768 – 1830) was a French mathematician and physicist best known for investigating of Fourier series, and their applications to heat transfer and vibrations.

Fourier was born at Auxerre, the son of a tailor. Orphaned at age nine. Fourier was recommended to the Bishop of Auxerre and he was educated by the Benedictine Order of the Convent of St. Mark. He accepted a military lectureship on mathematics. He was imprisoned briefly during the Terror but, in 1795, was appointed to the École Normale and subsequently the École Polytechnique.

Fourier accompanied Napoleon on his Egyptian expedition in 1798, as scientific adviser, and was appointed secretary of the Institut d'Égypte. Cut off from France by the British fleet, he organized the workshops on which the French army had to rely for their munitions of war.

Viscosity in Strongly Interacting Quantum Field Theories from Black Hole Physics

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Abstract

The ratio of shear viscosity to volume density of entropy can be used to characterize how close a given fluid is to being perfect. Using string theory methods, we show that this ratio is equal to a universal value of $\hbar/4\pi k_B$ for a large class of strongly interacting quantum field theories whose dual description involves black holes in anti–de Sitter space. We provide evidence that this value may serve as a lower bound for a wide class of systems, thus suggesting that black hole horizons are dual to the most ideal fluids.

PACS numbers: 11.10.Wx, 04.70.Dy, 11.25.Tq, 47.75.+f

2870 citations

QR code for questionnaire on S1 courses.

Avagadro’s law

equal volumes of gases under the same conditions of temperature and pressure will contain equal numbers of molecules $PV/T = n\,k$

Wikipedia: Amedeo Avogadro was born in Turin to a noble family of the Kingdom of Sardinia in 1776. He graduated in ecclesiastical law.

In 1811, he published an article with the title "Essay on a manner of Determining the Relative Masses of the Elementary Molecules of Bodies and the Proportions by Which They Enter These Combinations“, which contains Avogadro's hypothesis.

In 1820, he became a professor of physics at the University of Turin. Turin was now the capital of the restored Kingdom of Sardinia. Avogadro was active in the revolutionary movement of March 1821. As a result, he lost his chair in 1823 (or, as the university officially declared, it was "very glad to allow this interesting scientist to take a rest from heavy teaching duties, in order to be able to give better attention to his researches"). Avogadro was recalled to the university in Turin in 1833, where he taught for another twenty years.

Daniel Bernoulli FRS (1700 –1782) was a Swiss mathematician and physicist in the Bernoulli family from Basel. He is particularly remembered for his applications of mathematics to mechanics, especially fluid mechanics, and for his pioneering work in probability and statistics. His name is commemorated in the Bernoulli's principle, a particular example of the conservation of energy, which describes the mathematics of the mechanism underlying the operation of two important technologies of the 20th century: the carburetor and the airplane wing.

In 1738 Daniel Bernoulli published *Hydrodynamica*, which laid the basis for the kinetic theory of gases. In this work, Bernoulli posited the argument, that gases consist of great numbers of molecules moving in all directions, that their impact on a surface causes the pressure of the gas, and that their average kinetic energy determines the temperature of the gas. The theory was not immediately accepted, in part because conservation of energy had not yet been established, and it was not obvious to physicists how the collisions between molecules could be perfectly elastic.

At the beginning of the 20th century, however, atoms were considered by many physicists to be purely hypothetical constructs, rather than real objects. An important turning point was Albert Einstein's (1905)[13] and Marian Smoluchowski's (1906)[14] papers on Brownian motion, which succeeded in making certain accurate quantitative predictions based on the kinetic theory.