

Introduction

What is thermal physics?

Thermal physics is a general term encompassing thermodynamics, kinetic theory and statistical physics. It is basically the study of heat. In this course we will cover thermodynamics and kinetic theory: statistical physics will be introduced next year.

Much of the early part of this course, up to Topic 4, is material you should have met at A level, although we may go into more detail or have a more mathematical approach. We revisit this material because it is important as a foundation for later work.

Why is thermal physics important?

Thermal physics is relevant to most of science, engineering and much of technology. Thermodynamics covers macroscopic systems from the nanometre to cosmic scales. Thermal physics is also important at quantum length scales, but the thermal physics we will study in this introductory course will be nanoscale upwards. Microscopic systems are considered in statistical physics, which is beyond the scope of this course.

Industrialised society relies on thermal physics: classical thermodynamics was originally developed to understand and improve the working of heat engines, in particular steam engines. Our lives and lifestyles require energy, and all commercial energy generation relies on applications of thermal physics. Today, and in the future, climate change is a global crisis requiring new thinking and new technologies. A knowledge and understanding of thermal physics has an essential role to play in modelling and solving our climate change problems.

Thermal physics underlies chemistry, from chemical reactions to the chemical and pharmaceutical industries. It is also crucial to biology. Living systems are thermal systems and thermal energy is of fundamental importance to life.

Astrophysics is another area that relies extensively on thermal physics, from star formation to cosmology.

What is thermodynamics?

Thermodynamics is the study of heat and related concepts of temperature and energy from a macroscopic perspective. Thermodynamics considers the properties and behaviour of whole objects/systems. We know that objects are made up of many atoms, so thermodynamic properties are averages over many atoms; indeed, some thermodynamic properties such as temperature only make sense as averages. The microscopic level of individual atoms/molecules is studied using statistical physics, which you will not meet until next year.

There are a set of famous *laws of thermodynamics*. We will study these laws in this course.

What will you learn in this course?

At the end of this course you should be able to:

1. define temperature in both thermodynamic and kinetic senses;
2. define and use the linear and volume coefficients of thermal expansion, and explain the relationship between them;
3. explain what is meant by heat and the ways heat is transferred, and do calculations relating to this;
4. quote the First Law of Thermodynamics and explain its meaning;

5. explain what is meant by isobaric, isochoric, isothermal and adiabatic pathways on a PV diagram, and use these to do calculations relating to heat engines;
6. quote the Clausius and Kelvin statements of the Second Law of Thermodynamics, and show that they are equivalent;
7. define (in the thermodynamic sense) and use entropy, and relate it to the Second Law of Thermodynamics.

Some of these you may already be able to do from A level. The rest are best learned through *practice*: do not just read over the notes again and again—try problems. There are worked examples throughout the notes to help you get started.

Where does this course fit in your degree?

There is an explicit “Thermal Physics” strand in your degree programme. This course leads on to the Thermal Physics section of the second year core course, which builds on what we do here and also introduces you to statistical mechanics, which in turn brings in ideas from quantum mechanics. In third year you may go on to study statistical physics in more details, although this is not core for all degree programmes.

As mentioned above, thermal physics is also applied in many branches of physics. particularly (of course) those relating to heat and pressure. Thermal physics is an essential input into the physics of stellar interiors, which those of you doing Astrophysics will study in second year. It is also a key ingredient in energy generation and atmospheric physics, so anyone who is interested in a career in climate science or sustainable energy should develop a good understanding of this material.