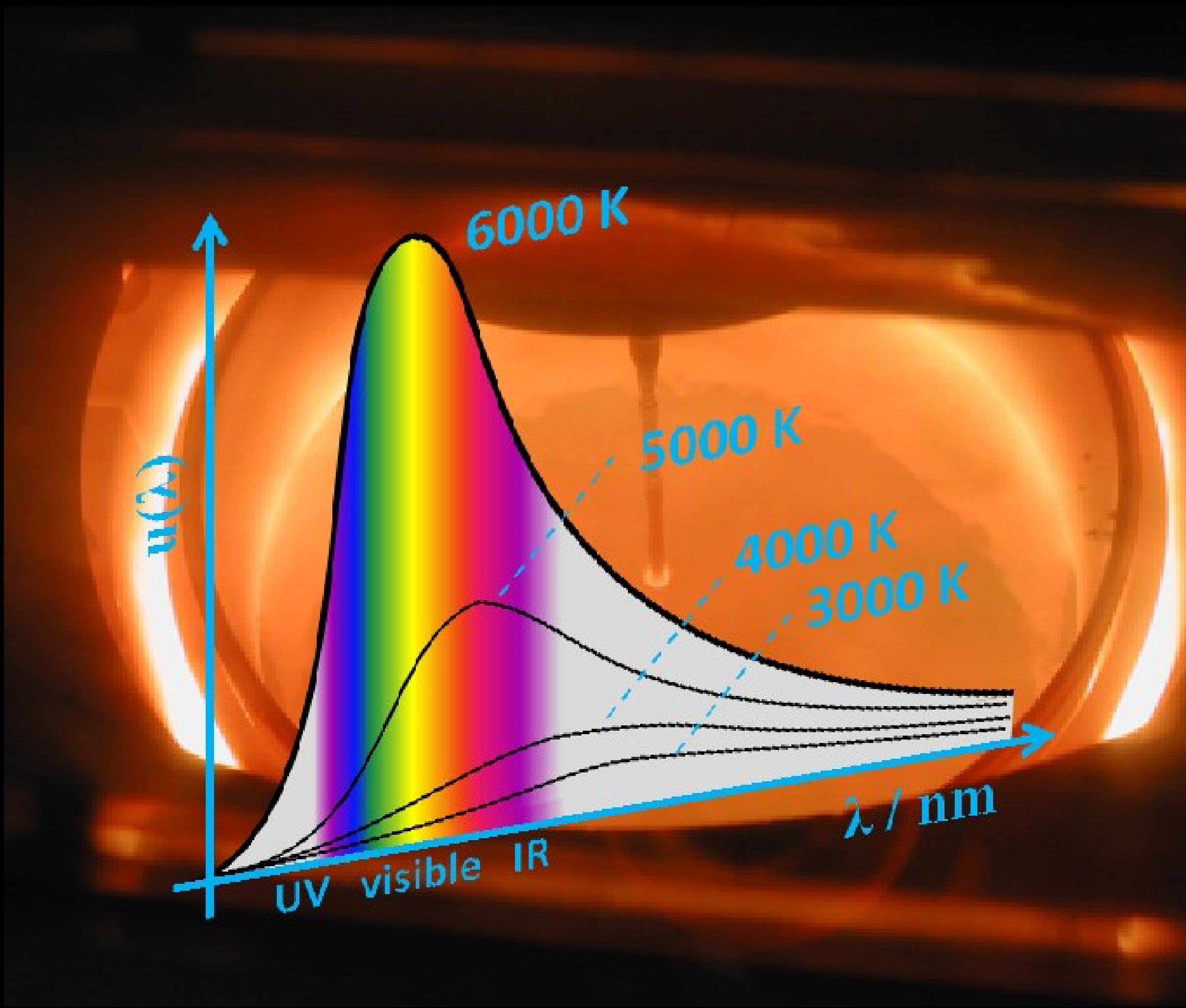
University of Glasgow | School of Physics & Astronomy



PHYS4030 Thermal Physics

Course Information Guide 2023-24

1 Course Details

Lecturer:	Dr. Jörg Götte	Schedule:	18 lectures, Mon 10am, Wed 10am
SCQF Credits:	10	ECTS Credits:	5
Assessment:	Examination (100%)	Co-requisites:	PHYS4025,PHYS4011, PHYS4031
Level:	Honours		
Typically Offered:	Semester 2	Prerequisites:	Physics 2

2 Course Aims

This course is compulsory for all third BSc (Honours) and MSci students and an elective for the designated degree programme in the School of Physics & Astronomy. It aims to provide students with an opportunity to develop their knowledge and understanding of the key principles and applications of thermal physics, and their relevance to current developments in physics. In particular, it will provide a working knowledge of:

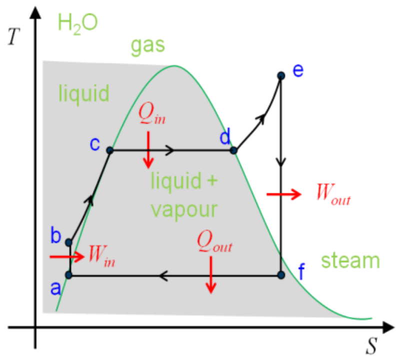


Figure 1: The Rankine cycle summarises the operation of steam engines.

- Revision of the zeroth and first laws of thermodynamics;
- The second law of thermodynamics;
- Entropy;
- Thermodynamic potentials and Maxwell's relations;
- Statistical thermodynamics;
- Bose-Einstein and Fermi-Dirac distributions.

3 Intended Learning Outcomes

By the end of the course students will be able to:

- Demonstrate knowledge and a broad understanding of thermal physics;
- Describe qualitatively and quantitatively process, relationships and techniques relevant to the topics included in the course outline, and apply these techniques to solve general classes of problems;
- Write down and, where appropriate, either prove or explain the underlying basis of physical laws relevant to the course topics, discussing their applications and appreciating their relation to the topics of other courses taken.

4 Course Outline

Revision of Zeroth and First Laws of Thermodynamics: The Zeroth Law of Thermodynamics and property of temperature. The equation of state of a thermal system. Extensive and intensive quantities. First Law of Thermodynamics, conservation of energy for processes in which there is exchange of heat energy and internal energy. Heat capacity and its dependence on the nature of the process operating on a thermal system. The concept of a quasistatic process.

Second Law of Thermodynamics: The Kelvin and Clausius forms of the Second Law of Thermodynamics. Concepts of reversible and irreversible thermodynamic cycles, the Carnot cycle and efficiency. The equivalence of the Kelvin and Clausius forms of the Second Law. Carnot's theorem. The thermodynamic (absolute) temperature scale and its equivalence to the ideal gas scale. Efficiency of engines and heat pumps using the Carnot cycle.

Entropy: The Clausius inequality and how it leads to the concept of entropy as a property of a thermal system. The Second Law and the principle of increasing entropy. The entropy of an ideal gas and examples of the calculation of entropy change for systems.

Thermodynamic potentials and Maxwell's relations: The thermodynamic potentials: internal energy, enthalpy, Helmholtz free energy and the Gibbs of the potentials. Application to Joule-Kelvin expansion: the Joule-Kelvin function. The Maxwell relations. The interpretation and general applications coefficient for ideal and real gases, van der Waal's equation of state, and the liquefaction of gases. Application to phase changes: PVT surfaces, Gibbs function and thermodynamic equilibrium, the Clausius-Clapeyron relation for a phase boundary and its use, and first and second order phase transitions.

Statistical Thermodynamics: Macroscopic and microscopic thermodynamic systems. The Boltzmann distribution and partition function. Ensemble averages for energy and pressure and comparison with the macroscopic thermodynamic expressions to obtain relations for entropy and Helmholtz free energy. Mean energy of a quantum linear oscillator and its quantum and classical limits. Classical treatment of black-body radiation as a gas in a cavity. The Stefan-Boltzmann law. Quantum-mechanical treatment of black-body radiation as photons in a cavity with the Plank energy distribution. The heat capacity of solids from consideration of atomic lattice oscillators, and the high and low temperature limits for heat capacities.

Bose-Einstein and Fermi-Dirac distributions: Introduction to the thermal properties and distributions of Bosons and Fermions.

5 Further Information

Further information can be found on the course Moodle page and also using the links below:

- [Course specification]
- [Reading list]

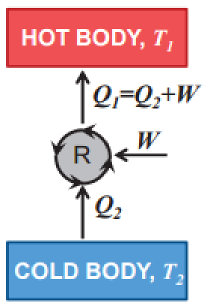


Figure 2: Schematic diagram of the operation of a refrigerator.