Blackbody Radiation

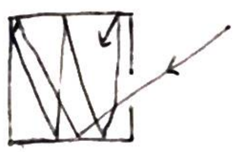
All matter absorbs and emits electromagnetic radiation over a large frequency spectrum. Since energy is released through this mechanism, we have to take this radiation into account when we look at thermodynamic applications.

One way of doing this is by looking at the "spectral flux" of an object. This is a measure of irradiance or emission intensity, with units $Wm^{-2}Hz^{-1}$ and denoted by $\phi(f)$. So if we are trying to describe a body with area A emitting radiation within a frequency range $f \to f+\Delta f$, over a time period Δt, we can give total energy:

$$\boxed{E = \phi(f) A \Delta t \Delta f}$$

When we measure the spectral flux of various bodies, it seems to depend on the material and temperature of the object. However, in the case of a perfect absorbing object, a "blackbody," it is only dependent on temperature.

One way to imagine a blackbody is as a hollow object with a very small hole. If incident radiation passes through the hole, it will bounce around inside and never escape, since the hole is so small. The radiation is 100% absorbed.



The ray will never escape and thus has been perfectly absorbed.

Wien's Law

For a blackbody, the spectral flux depends only on temperature. There will be a peak in spectral flux (and thus a peak in frequency of emitted radiation) at some temperature. For a perfect blackbody, the curves showing intensity emitted against frequency emitted are called Planck's curves.

It can be shown that the peak frequency occurs at:

$$\boxed{f_{max} = 2.8214 \times \frac{k_B T}{h} \approx 5.88 \times 10^{10} \times T}$$

This can be translated to wavelength as well using $f\lambda = c$:

$$\boxed{\lambda_{max} = 0.2014 \times \frac{hc}{k_B T} \approx \frac{2.898 \times 10^{-3}}{T}}$$

Stefan's Law

The power emitted per unit area is called the Flux and is given by:

$$\boxed{F = \sigma T^4}$$

This is called Stefan's Law

σ is the Stefan-Boltzmann constant $\sigma \approx 5.67 \times 10^{-8}$.
The power emitted is in the form of heat, so we can work out the heat flow of an object using:

$$\boxed{\frac{dq}{dt} = F \cdot A}$$