SSP Exercise 6

To be handed in by 4pm, Thursday 9th February.

1. The Fermi-Dirac distribution function, as a function of energy ε, for a system at temperature T is

$$f(\varepsilon) = 1/\{\exp[(\varepsilon-\varepsilon_F)/k_B T] + 1\},$$

where ε_F is the Fermi energy of the system. Derive expressions for the hole and electron densities, p **[5]** and n **[5]**, in an intrinsic semiconductor using the free electron densities of states per unit energy per volume of real space, $D_c(\varepsilon)$ and $D_v(\varepsilon)$ for holes and electrons, respectively.

2. The carrier density, n_i, for an intrinsic semiconductor is given by

$$n_i = W^{\frac{1}{2}} \times T^{\frac{3}{2}} \times e^{-\frac{\varepsilon_g}{2k_B T}},$$

where W is a constant, T is temperature, and ε_g is the band gap energy. A sample of intrinsic Si (ε_g =1.1 eV) is at 300 K. ***Estimate*** the change in temperature required to increase its electrical conductivity by 10 per cent. (Hint: consider the free electron expression for electrical conductivity.) **[5]**