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## 1 Bosons and Fermions

An $N$ particle quantum system is described by a wavefunction of $N$ arguments $\Psi(\mathbf{r}_1, \ldots, \mathbf{r}_N)$. The starting point of many body quantum mechanics is that:

> Systems of indistinguishable particles are described by **totally symmetric** or **totally antisymmetric** wavefunctions.

Just to be clear, *totally symmetric* means the wavefunction is unchanged by exchanging any two coordinates, whereas *totally antisymmetric* means that it changes sign.

A good fraction of this course is devoted to exploring the ramifications of this fact. Perhaps we should therefore give a *very* quick summary of why it appears to be true.

The first question is: what *are* indistinguishable particles? I'll give a theorist's answer. Indistinguishable particles are those described by Hamiltonians that are invariant under permuting the particle's labels. Thus the sum of single particle Hamiltonians

$$H = \sum_{i=1}^{N} \left[ -\frac{\nabla_i^2}{2m} + V(\mathbf{r_i}) \right]$$

*[did you remember that $\hbar = 1$?]* describes indistinguishable particles while