Math 142-1, Group work 1

Problem 1

The Schrödinger equation is

$$i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\Psi + U\Psi$$

where m is its mass and i is the imaginary number. Deduce the units of the other variables (Ψ, $\hbar$, U). Based on the units of U, what do you think it represents?

Problem 2

Maxwell's equations are

$$\begin{aligned}
\nabla \cdot \mathbf{E} &= \frac{\rho}{\varepsilon_0} \\
\nabla \cdot \mathbf{B} &= 0 \\
\nabla \times \mathbf{E} &= -\frac{\partial \mathbf{B}}{\partial t} \\
\nabla \times \mathbf{B} &= \mu_0\left(\mathbf{J} + \varepsilon_0\frac{\partial \mathbf{E}}{\partial t}\right)
\end{aligned}$$

A particle with charge q and velocity $\mathbf{v}$ in this field will experience a Lorentz force

$$\mathbf{f} = q(\mathbf{E} + (\mathbf{v} \times \mathbf{B}))$$

Additionally, the total charge Q in some volume of space Ω is

$$Q = \int_\Omega \rho \, dV$$

If $q = [C]$ and $Q = [C]$ both have units of charge (the unit C is the Coulomb), deduce the units of the quantities in the table below. You may assume units for $\mathbf{f}$ and $\mathbf{v}$.

var	meaning
$\mathbf{E}$	electric field
$\mathbf{B}$	magnetic field
ρ	charge density
$\mathbf{J}$	current density
ε_0	permittivity of free space
μ_0	permeability of free space
Q	total charge
q	particle charge
$\mathbf{v}$	particle velocity
$\mathbf{f}$	force on particle