Conductivity Problems

PROBLEM

Calculate the D.C. conductivity for a Maxwellian gas using the relaxation time approximation. I.e., work out the conductivity just like in class, but use $f \propto e^{-p^2/(2mT)}$ rather than $f \propto \theta(\mu - E_p)$.

PROBLEM

Consider a perfectly *ideal gas* of charged (q) massive (m) particles at a fixed temperature (T) and pressure (P). A parallel plate capacitor, with distance between plates L_0 and plate area A_0, is introduced into the gas and is held at a fixed *potential* v_0. Using the result of the previous problem, and choosing units such that $q^2 = m = \tau = k_B = 1$, calculate the current which flows between the plates for the case of $P = 14$, $T = 2$, $v_0 = 3$, $A_0 = 2$, $L_0 = 1$.

PROBLEM

Linearize the B-Mann Eq. in order to the treat the case of a space- and time-varying electric field $\mathbf{E}(\mathbf{x}, t) = \mathbf{E_0} e^{i\mathbf{k}\cdot\mathbf{x} - i\omega t}$. Use the relaxation time approximation and the ansatz that $g(\mathbf{x}, \mathbf{p}, t) = f(p) + h(\mathbf{x}, \mathbf{p}, t)$ with $h(\mathbf{x}, \mathbf{p}, t) = h(\mathbf{p}) e^{i\mathbf{k}\cdot\mathbf{x} - i\omega t}$. Solve for the frequency- and wavevector-dependent conductivity $\sigma^{ij}(\mathbf{k}, \omega)$ in terms of an integral over the equilibrium distribution function, but don't evaluate the integral.

Answer:

$$\sigma^{ij}(\mathbf{k}, \omega) = -q^2 \int d^3p \frac{\partial f}{\partial E_p} \frac{v_p^i v_p^j}{(-i\omega + 1/\tau + i\mathbf{k}\cdot\mathbf{v_p})} \, .$$