1. Using the classical Maxwell-Boltzmann distribution function from HW3, let us derive the classical quantum conductances (both electrical and thermal).
   a) Assuming there is only one channel with perfect transmission, what is the thermal conductance of classical particles? Is it constant and how does it compare to the experimentally verified value of \( K = \frac{\pi^2 k_B T}{3h} \).
   b) Where is the “quantumness” coming from if we used a classical distribution? 
   c) Repeat the calculation for electrical conductance using the classical Maxwell-Boltzmann distribution \( f(\omega, T) = \exp\left(-\frac{E - E_F}{k_B T}\right) \) assuming only one channel with perfect transmission above \( E=0 \) and none below it (in other words \( M(E) = \Theta(E) \) is a step function which is zero below \( E=0 \) and 1 above it. The degeneracy of electrons is still 2 because there is one spin up and one spin down so throw in a factor of 2 to account for spin. Your answer is going to depend on the Fermi level explicitly. How does your answer compare to the constant “quantum conductance” we derived in class \( G = \frac{2e^2}{h} \).
   d) Does the Wiedemann-Franz law hold? Remember that the WF law says that the ratio of thermal over electrical conductance and temperature is a constant \( L = \frac{\kappa}{\sigma T} \).

2. Let’s find a general expression for the channel number \( M(E) \) for our general dispersion \( E(k) = \alpha |k|^\beta \) in 3D.
   a) Compare your answer to the sketch in class for electrons (\( \beta = 2 \)) and the density of states for this same type of dispersion (HW2 Problem 3).

3. What is the channel number \( M(\omega) \) of phonons with a linear dispersion \( \omega(k) = \alpha |k| \)?
   a) In 1D? (remember that in 1D we only have points instead of contours at a given frequency)
   b) In 2D? (remember that the channel number \( M(E) \) is equal to the length of the constant frequency contour, which is circular in 2D with a radius equal to the magnitude of wavevector)
   c) In 3D? (use your answer to question 2)
   d) Draw a table of sketches where you show the density of states \( D(\omega) \) for phonons with a linear dispersion along with the channel number \( M(\omega) \) for 1D, 2D, and 3D phonons from parts a), b), and c) of this question.