Among the largest success stories in applied materials science of the last two decade are the introduction of spin valves (GMR heads) in magnetic recording heads and the development of compact semiconductor lasers in all kind of different colors. Both devices are based on nanotechnology and contain structures that have atomistic dimensions in at least one dimension. Spin valves have thin non-magnetic layers that are sandwiched between to magnetic layers and some semiconductor lasers contain a multilayer that confine the electrons in 2D thin layers. Other materials have been developed that have small sizes in two (nano-wires) or three (quantum dots) of the dimensions. Materials based on nanotechnology have different properties than its bulk materials. In this problem you will explore the effect the dimension will make on the phonon density of states.

1. In class we derived expressions for the phonon density of states (i.e. number of modes) for the 1D and 3D case. Use a similar approach to derive an expression for D(ω) for a 2D system. Please assume that the dispersion relation is given by:

    $$\omega = vK$$

    Where v is the velocity of sound. This equation is similar as assuming that the phonon speed is constant and equal to the speed of sound in the material. You might first want to derive an equation for D(K) and then convert that in D(ω) using one of the two methods shown in the text (bottom of page 111 and top of page 112, or the technique used at the bottom of page 110).

2. Now use the result of 1 to calculate the total internal energy U of the 2D system. See also expression (8) and (9) in the text.
3. Now use the U you found in (2) to determine the heat capacity of the material, i.e. dU/dt (see also equation (10) in the text).

4. Work problem 1 at the end of the chapter.