- (a) Assuming that $f(x, 0) = \delta(x)$, find f(x, t). (Your answer should depend on t).
- (b) Find the mean and the variance of f(x, t) (with respect to x).
- (c) From his calculations, Einstein found that the diffusion constant is given by

$$D = \frac{kT}{6\pi\eta R} \,,$$

where k is Boltzmann's constant, T is the temperature, η is the viscosity of the fluid, and R is the size of the particles. Given your results from part (b), what can you say about the diffusion of the particles (their evolution over time) as a function of their size and of the temperature?

5. (20 points) Voice scrambling/descrambling A simple scrambling circuit for voice communications works as follows. Consider the frequency band from 0 to 4 kHz. It is a known fact that the overwhelming majority of the power spectrum of human voice is concentrated in this frequency band. One way of scrambling this frequency band is to subdivide it into 4 equal sub-bands and interchange the sub-bands according to some pre-determined key. For example, let sub-band A correspond to frequencies between 0 and 1 kHz. Then, sub-band B corresponds to frequencies between 1 and 2 kHz, sub-band C corresponds to frequencies between 2 and 3 kHz, and sub-band D corresponds to frequencies between 3 and 4 kHz. The original order of the sub-bands is ABCD. A simple scrambling technique is to interchange this order, i.e. reorder the sub-bands to BCDA or DCBA or CABD or any other pre-determined order. Call the resulting signal the scrambled signal. This scrambled signal is not comprehensible unless you know the key and can rearrange the sub-bands back into the original order.

The goal of this problem is for you to design a MATLAB program that will descramble a given voice signal. You may obtain the scrambled signal ('scramble.wav') from the course web site,

http://see.stanford.edu/materials/lsoftaee261/PS-4-scramble.wav

in the 'Problem Sets' section of the Handouts. It has been scrambled in the above-described fashion by rearranging the bands ABCD into CBDA. Descramble this signal and transcribe the first and last 5 words. **Turn in your code as well as your transcription.** (No, this is not a test of your transcribing skills, we just want to make sure that your code works.)

