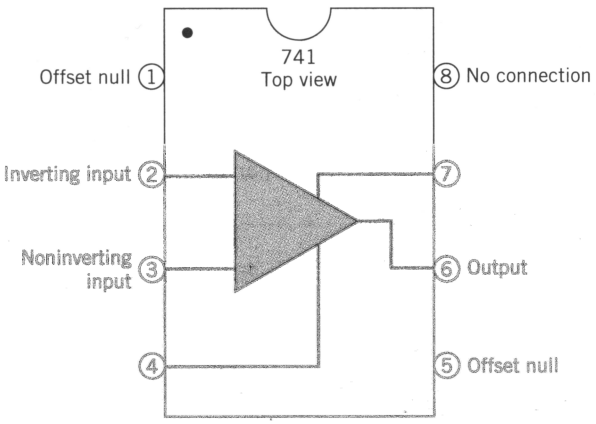
Final Exam

December 12, 2003

1. (16) The figure on the right shows a standard op-amp, with the same pin arrangement as a TL081. Mark each of the statements below as:

A – True (or possible) only in an ideal op-amp
B – True for real op-amps and ideal op-amps
C – False for properly functioning op-amp



_____ $v_2 = v_3$

_____ $v_7 < v_6 < v_4$

_____ $v_7 = v_4$

_____ $i_2 = 0$

_____ $i_3 = 10$ mA

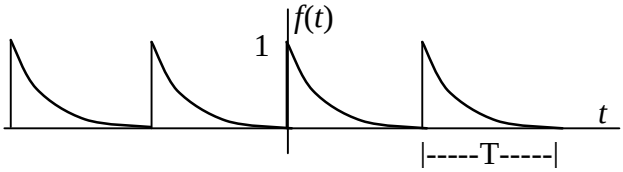
_____ i_6 is independent of R_L (a load resistor connected from pin 6 to ground)

_____ v_6 is independent of R_L

_____ $v_2 > v_3$ and $v_6 = v_7$

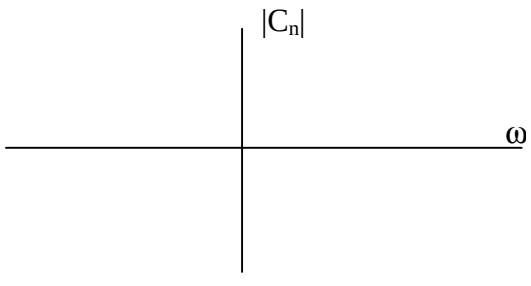
2. (14) Assume that we grow cells on a surface that includes a flat, metal electrode that is about the same size as a cell. The ground electrode is some distance away in the growth medium. We wish to use the potential difference between these electrodes to measure the membrane potential of the cell.
What factors would affect or degrade the electrical signal measured by the electrode? Explain briefly how or why each factor affects the reading.

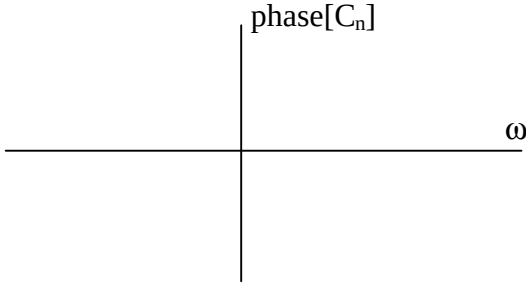
3. (25) Let $f(t)$ be an infinite train of exponential functions, such that $f(t-nT) = e^{-at}$.
The function $f(t)$ can be represented by a Fourier series with complex coefficients, as shown below.



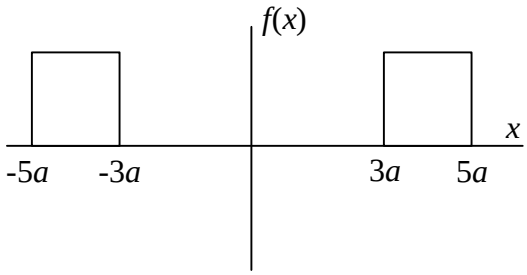
$$f(t) = C_0 + \sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} C_n e^{jnw_0 t}$$

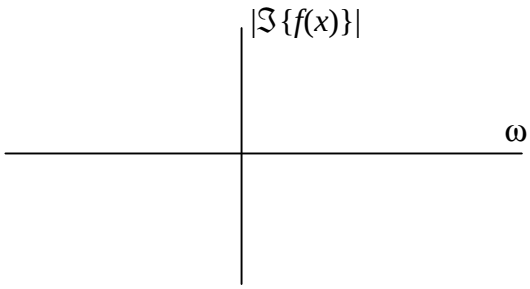
A. Determine the complex coefficients C_0 and C_n for the Fourier series representation of $f(t)$.
B. Plot the approximate magnitude and phase of C_0 and C_n for $f(t)$.



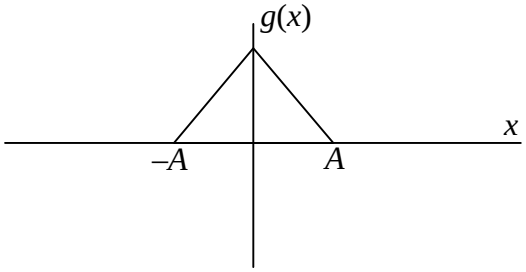


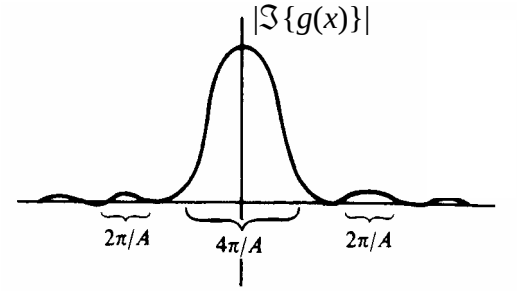
4.A (10) Let $f(x)$ be a function consisting of two pulses of height 1. Find its Fourier transform, $\Im\{f(x)\}$, using the convolution property. Draw an approximate plot of $|\Im\{f(x)\}|$.



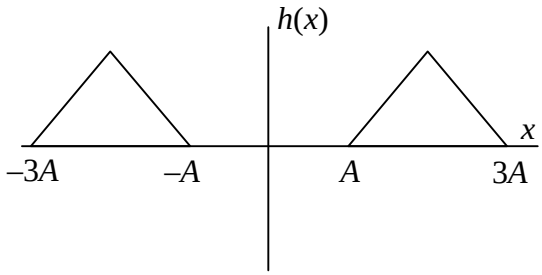


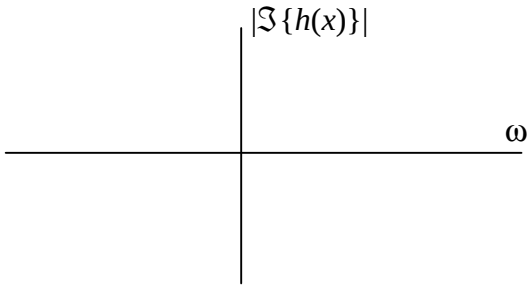
4.B (10) Given the Fourier transform of the single-triangle function $g(x)$,





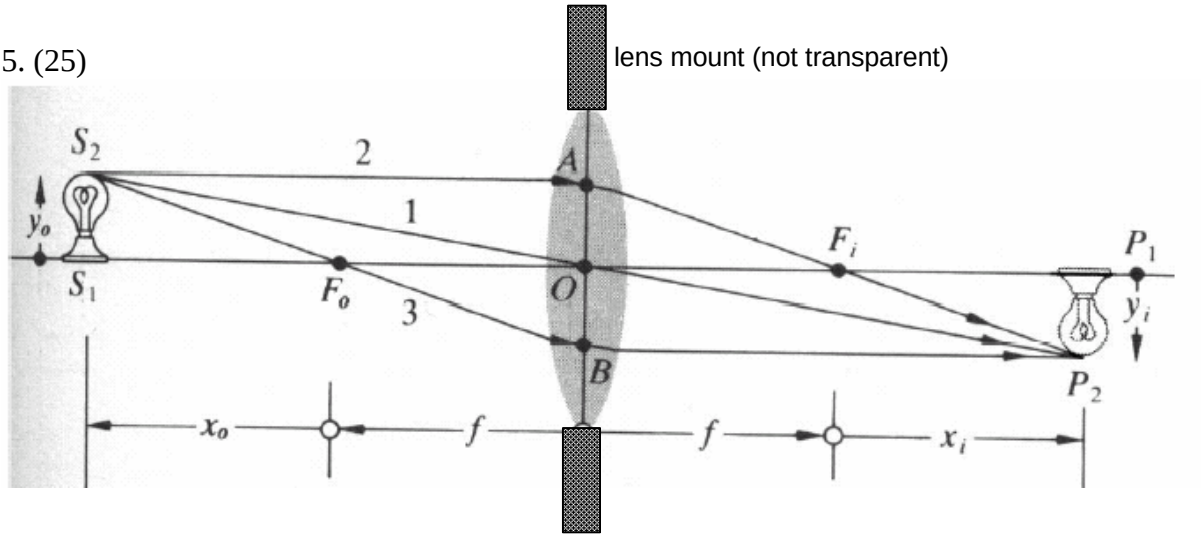
draw the Fourier spectrum of the double-triangle function $h(x)$.





What is the form of the mathematical expression for the <u>first</u> Fourier spectrum, $|\Im\{g(x)\}|$?

5. (25)



In the projection of an object through a circular lens,

- Using concepts of Fourier analysis, discuss what we mean when we say that the lens aperture acts as an “optical filter”.
- Discuss whether the lens passes mainly low, high, or a band of spatial frequencies.
- Discuss the implications that this filtering has on the ultimate resolving capability that an instrument based on this lens can achieve.