A SUMMARY OF TOPICS THAT WILL BE HELPFUL WHEN TAKING BIOEN 316

PART 1: MATHEMATICS AND PROGRAMMING

Programming

MATLAB

General topic	Example functions	
Array generation	`ones, zeros, linspace, logspace,` `x = [1 1 2 3 5]; t = 1:0.5:10; y = 5*t;`	
Array indexing	`x2 = x(2:5); x3 = x(3:end); size, length`	
Array arithmetic	`+ - / * .* ./ ^ .^` `A .* B` *versus* `A * B`	
Plotting	`plot, plot3, polar, bar, figure, subplot` `hold on/off, axis`	
Programming	`While` and `for` loops. `If / else` statements. Object-oriented programming is optional.	
Other math	`abs, imag, real, angle, sqrt, mean` `sin, cos, tan, sind, cosd, tand, atan, atand`	

Mathematics

Algebra

Basic equation manipulation and solution methods, especially the quadratic formula.

Trigonometry

Radians vs. degrees, definition of sine, cosine, tangent, and their inverses.
Conversion between rectangular (Cartesian) and polar coordinates.
Addition, dot product, and cross product of 2-D vectors.

Calculus

Definite integrals of sine, cosine, and exponential functions.
Integration by parts.

Summations

Notation for finite and infinite series and summations, for example

$$f(x) = \sum_{n=0}^{\infty} a_n x^n = a_0 + a_1 x^1 + a_2 x^2 \ldots$$

Logarithms

Let $\log(x) \equiv \log_{10}(x)$. Convert each of the following expressions to the form $k \log(x)$, if possible:

$\log(100x)$ $\log(x/\sqrt{10})$

$\log(100+x)$ $20 \log(x^2)$

$20 \log(x) - 10 \log(1/x)$

Natural log and e are defined such that $\ln(e^x) = e^{\ln(x)} = x$; $\ln(x) = \log_{10}(x)/\log_{10}(e)$.

Log(x) is defined only for positive x, where x is simply a number (no units). It <u>is</u> legitimate to calculate the logarithm of a ratio of two numbers with the same units; this is done when converting sound pressure level to decibels: Loudness in dB = 10 log(I / I_0) where I and I_0 are both sound intensities in Watts/m^2.

Complex numbers

Let $j^2 = -1$. Label each of the following as real, imaginary, complex, or none of these.

27	$\sqrt{-6}$	$\sqrt{j}$ Hint: what is j in terms of e?
$4 + 5j$	$2e^{2j}$	
$7e^{\pi j}$	e^{-j}	
$2e^{-j\pi/2}$	$2e^{\pi/4}$	
$e^{3j} + e^{-3j}$	$e^{2}\, e^{-5j} - e^{5j+2}$	

In the following questions let z^* be the complex conjugate of the complex number z. That is, $(a+jb)^* = (a-jb)$. Write an equivalent form for each of the following expressions.

$(3 - 2j)^*$

$(3 - 2j)^*(3 - 2j)$ i.e. the product of z and z^*.

$(x + 3 - 2j)^2$

Is $(x + 3 - 2j)^*(x + 3 - 2j)$ ….

a) Real b) Imaginary

c) Complex d) Depends on x

Add the following by converting to rectangular coordinates and back to polar.

$6e^{j\pi/6} + 2e^{-j\pi/6}$

Divide the following by converting to polar form and back.

$$\frac{2-3j}{7+4j} \qquad \frac{14+8j}{2} \qquad \frac{12j}{3-2j}$$

L'Hopital's rule

The limit of a ratio of two functions is equal to the ratio of the derivatives of the numerator and denominator, each taken to the same limit. This can be used to determine the value of the ratio of some functions that would otherwise be undefined (tend toward infinity) as the limit is approached.

$$\lim_{x\to\infty}\left(\frac{f(x)}{g(x)}\right)=\frac{\lim_{x\to\infty}\left(\frac{df(x)}{dx}\right)}{\lim_{x\to\infty}\left(\frac{dg(x)}{dx}\right)}$$

Statistics

Definition of mean, standard deviation, variance, and median.

Biology

Terminology

Cardio = heart; myo = muscle; cephalo = head; oculo = eye;

Anatomy

Basic layout of the heart: atria, ventricles, septum, apex, aorta, valves.

Neurophysiology

Action potential: how an electrochemical impulse travels along a neuron.

Physics

Electromagnetics

Definition of electric charge (Q), voltage (V or v), and current (I or i).

Concept of electrical potential: voltage (joules/coulomb) and electric field (volts/meter)

Waves

Let x, y and z define the Cartesian coordinate system.

Traveling wave: $p = A\cos(kx - \omega t + \varphi)$, crests moving in the +$x$ direction

Stationary wave: $p = A\cos(kx + \varphi)$

Stationary oscillation: $p = A\cos(\omega t + \varphi)$

ω is in radians/second, $\omega = 2\pi f = 2\pi/T$, where f is frequency in Hz and T is period.

k is in radians/meter, $k = 2\pi/\lambda$, where λ is spatial period (wavelength).