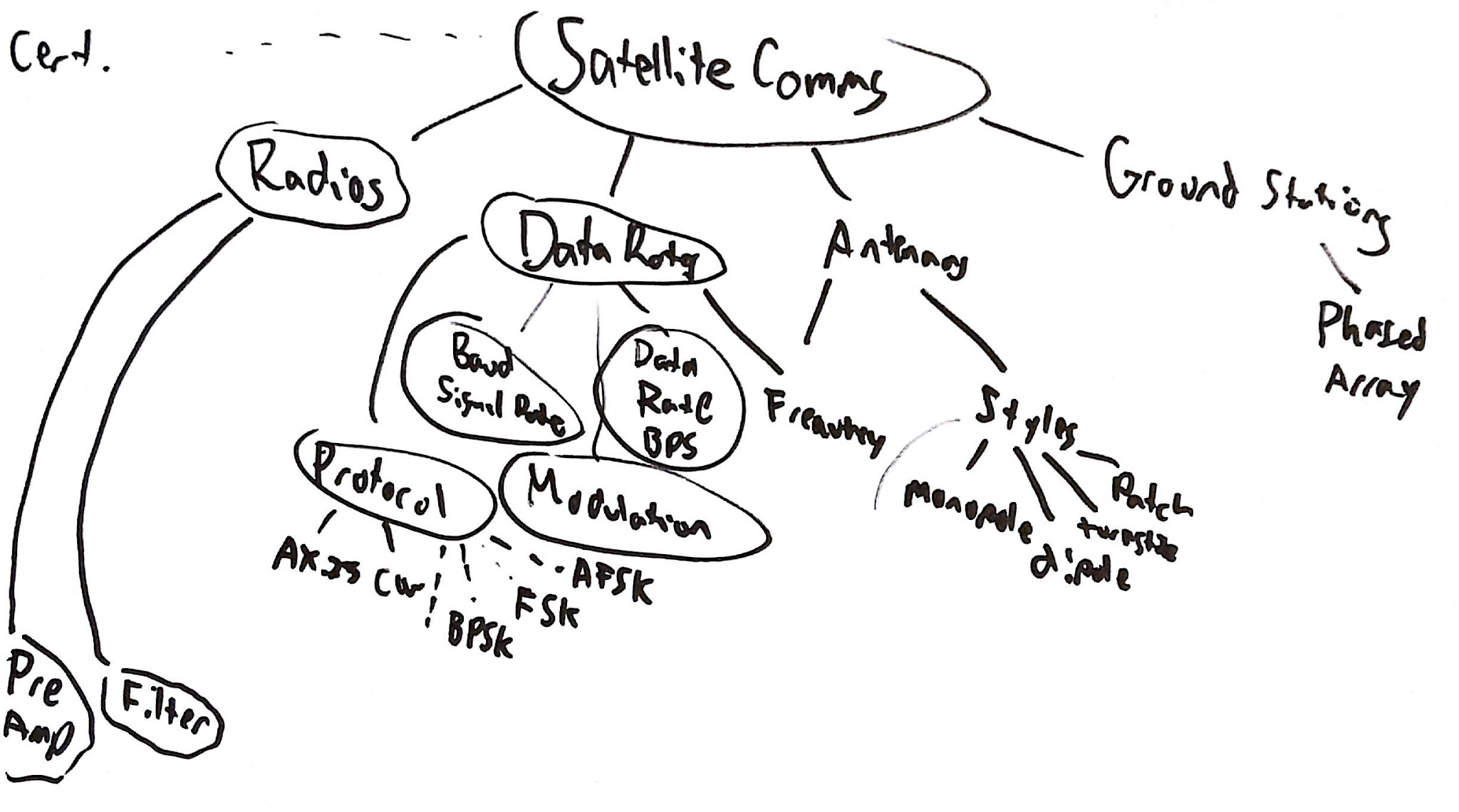
# Notes and Reflections

I’m glad that we as a class were given this assignment as review. It was good for me to look back over my old work, and fun to try some of the old problems again. There were a few places I opted not to solve the assigned problems (some iSIM stuff and Difference Equations) because I didn’t think that would be the optimal use of my time. **This is a new thing for me**, and I’m still trying to find the right balance. Bear with me as I figure that out.

# Concept breakdown: Communications Systems



## Key concepts:

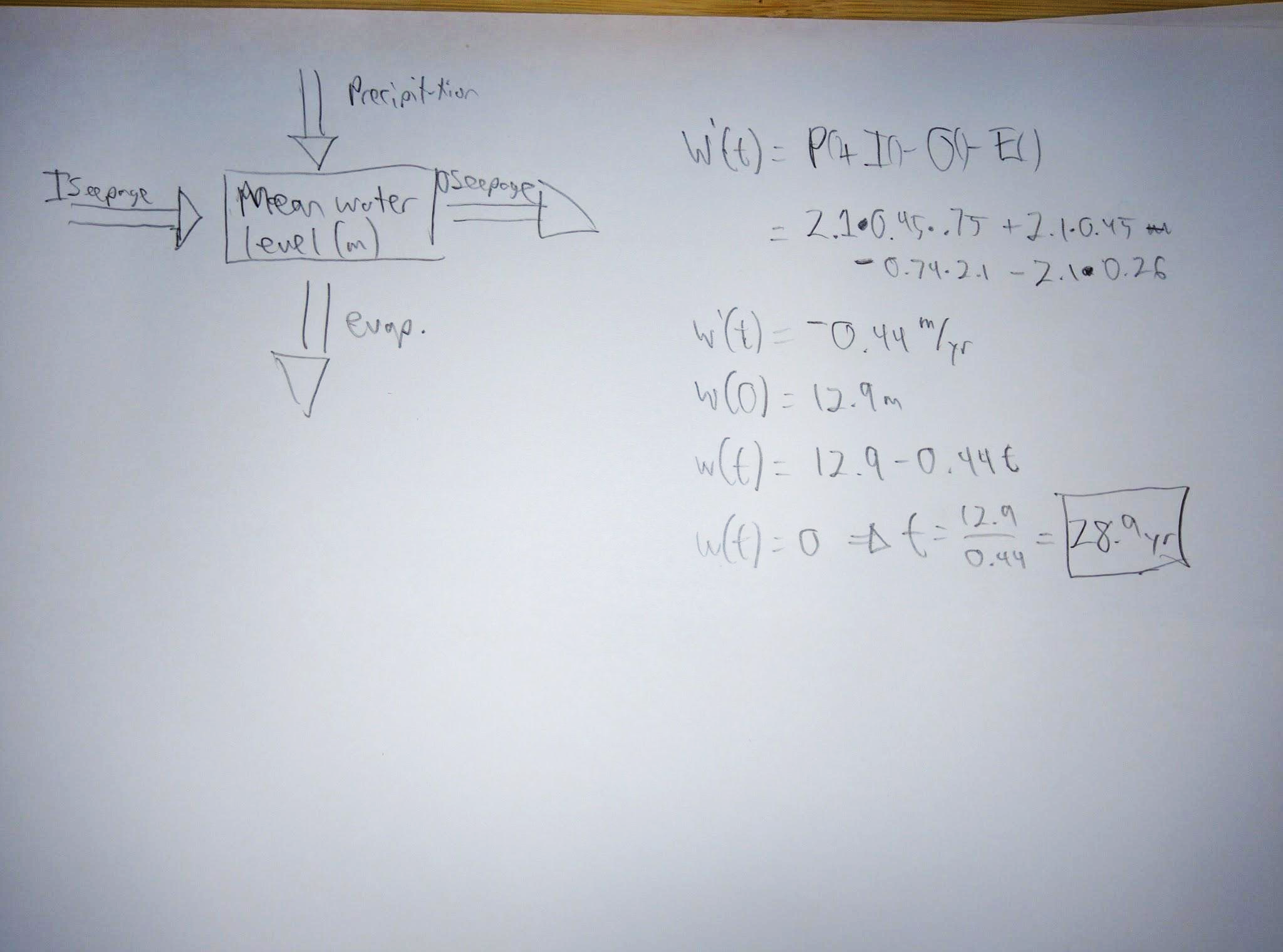
* Frequency
* Modulation
* Protocol
* Data/Baud rate
* Gain
* Filtering

Antenna design

# Review of ModSim

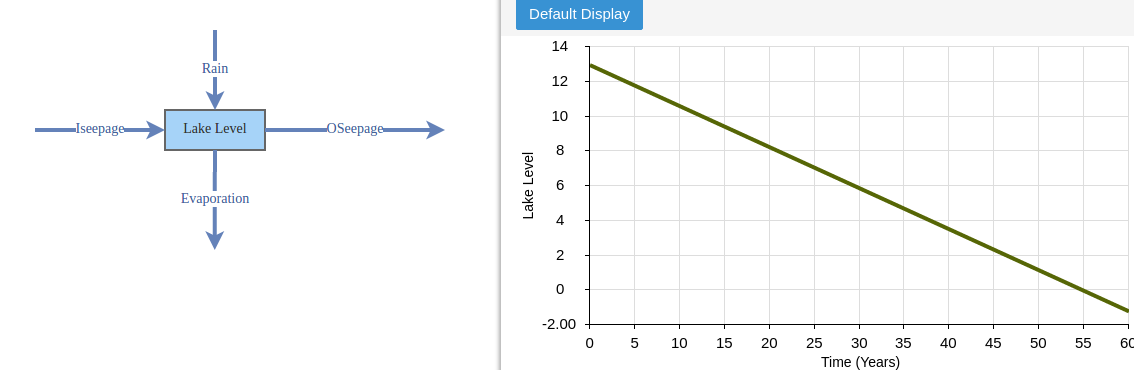
## 1. Walden Pond

I implemented the model analytically because it is simple enough.



Result: 54.6 years.

Also: InsightMaker practice



I object to this model because it assumes no dependence of evaporation on lake level. It produces garbage results (negative levels) after the lake empties, and since the time of emptying is an important moment for the model to work, I’d like it to behave nicer around there. This would be enabled by using a better stock than “lake level in meters”.

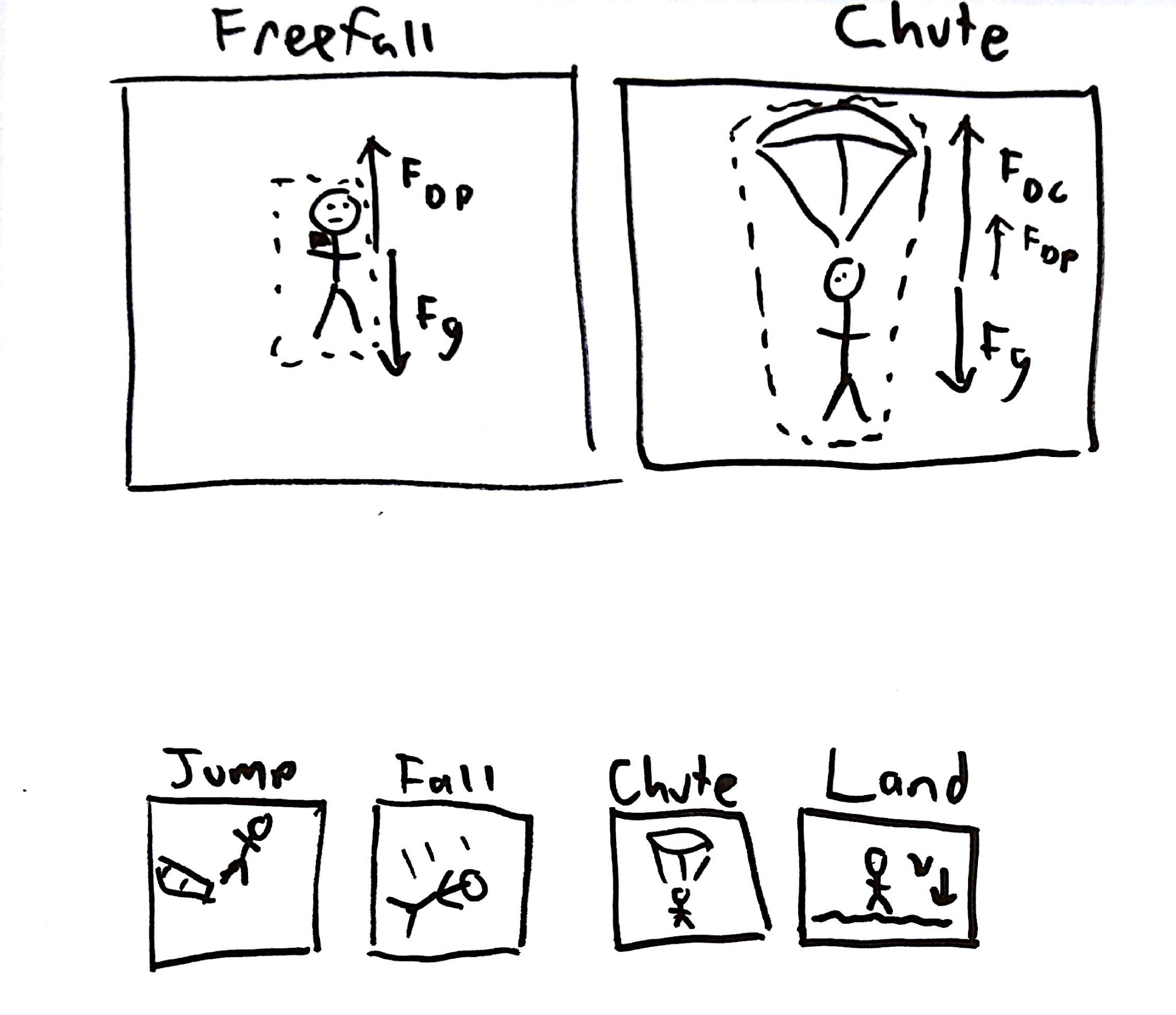
## 2. HALO jumps

### Punchline Graph



### 

### First-pass modelXrUPrCEUa9tNhgd3rJd5YaHT.jpg

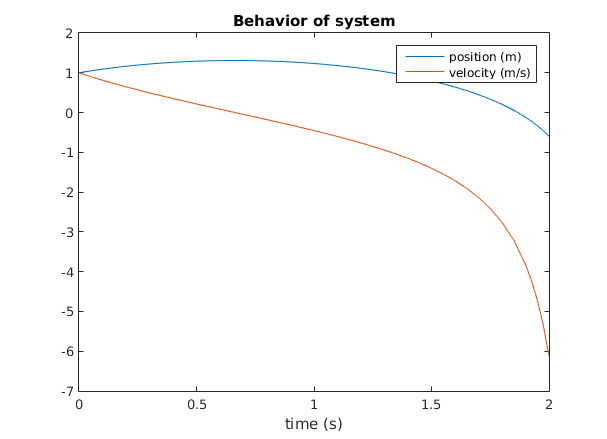


Where k and A represent drag coeffs. And g is gravity.

## 

## 3. Crank a model

a. Assuming SI units, has units of , has units of .

b. Using MatLab:

|  |
| --- |
| **function** [dy] = DEs(~, y)  %DES Summary of this function goes here  % Detailed explanation goes here  x = y(1);  v = y(2);  %% setup params  p.alpha = 1;  p.beta = 1;  %% Calculate derivatives  xdot = v;  vdot = - p.alpha \* x - p.beta \* v ^ 2;  dy = [xdot; vdot];  **end** |
| % Main simulation script  y0 = [1, 1]; % Initial conditions for [x(t), v(t)]  [T, Y] = ode45(@DEs, [0, 2], y0);  plot(T, Y);  title('Behavior of system');  xlabel('time (s)');  legend('position (m)', 'velocity (m/s)'); |

## 4. Teacup

|  |  |  |
| --- | --- | --- |
| **State Variables** | **Control parameters** | **Equations** |
| Temp(t) : tea temperature | - temp of room  - Thermal mass of tea  - R-value of cup walls  - Area of cup walls  - convective coefficient |  |

I could generate units if required.

# Review of iSIM

<https://www.khanacademy.org/science/electrical-engineering/ee-circuit-analysis-topic/ee-ac-analysis/v/ee-impedance>

## 1. Resistor math

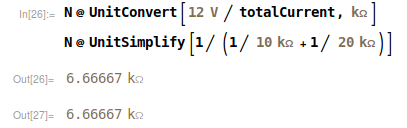
Resistors in series behave as one resistor with the sum of resistances.



Total current is the sum of individual currents in case 2

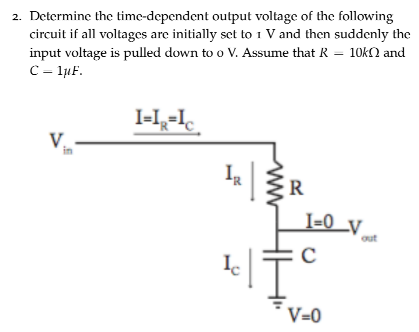


Equivalent resistance is thus:

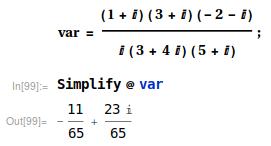


As expected, this is the reciprocal of the sums of the reciprocals.

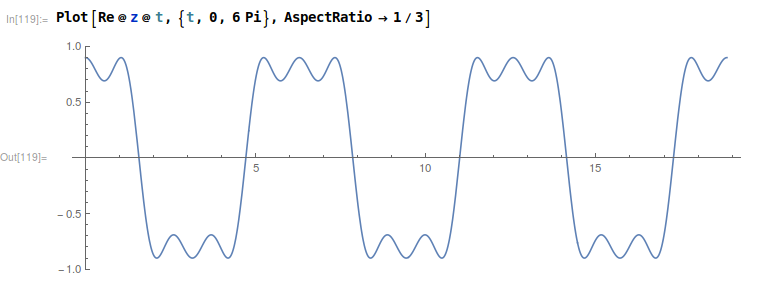
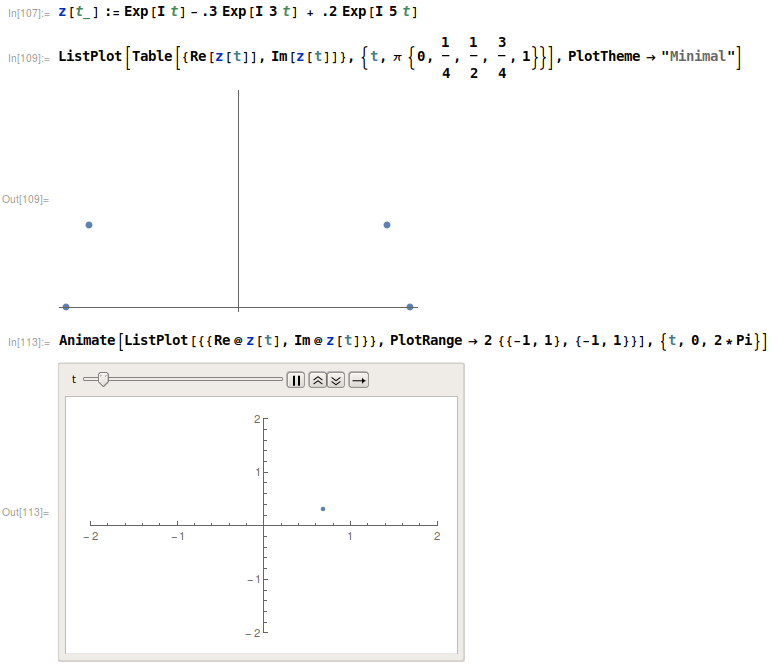
## 2. Time dependence



## 3. Complex #s



## 4. Plotting



I feel confident in my ability to design lowpass and bandpass filters based on the review of my old labs I conducted, so am not duplicating that effort here.

# QEA Concepts

* Many engineering problems cannot be efficiently solved with trial and error, instead they require quantitative analysis tools drawn from math and science.
* Free body diagrams are an important tool for reasoning about forces passing across the boundary of a well-defined system.
* Many forces are distributed forces, but can be modelled as a point force with magnitude equal to the surface or volume integral associated with their true form. That point force should be applied at their “center of pressure” as determined through another vector integral.
* Buoyancy forces are equal in magnitude to the weight of the displaced fluid, and are applied at the center of mass of that displaced fluid volume.
* The dot product operation takes two vectors and returns a scalar quantity defined as whereis the angle between the two vectors.
* The cross product operations takes two 3-dimensional vectors and returns a vector with magnitude and perpendicular to both A and B.
* Torques are vector quantities, and are defined to be where R is the vector from the center of rotation to the point of application of the force and F represents the magnitude and direction of the force.
* For an object to be statically at rest, and .
* Boats boats boats boats boats. Boats.
* Matrices can be thought of as operators that transform one vector into another. In this formulation, rotation matrices, scaling matrices, and skew matrices all perform meaningful geometric operations on position vectors.
* When acted upon by a square matrix, certain vectors can be transformed into a version of themselves scaled by some constant factor. That vector is referred to as an eigenvector of the matrix, and the scaling factor is its corresponding eigenvalue.
* Most square matrices can be decomposed into LU form as a product of a lower-triangular matrix L and an upper-triangular matrix U. This is useful for finding the inverse of a matrix (that which when multiplied by the matrix produces an identity matrix)
* Square matrices can also be decomposed into an Eigenvalue decomposition or the closely related SVD, which takes the form where U and V are formed from the eigenvectors of the matrix, and D is a diagonal matrix containing the eigenvalues. This is useful for calculating matrix powers, among other things.
* The principal eigenvectors of a set of images represent the axes of most variability between the faces, and can be used to efficiently match images to the nearest training image available, particularly useful in face recognition.

# Sample Problem

*This is a hard problem, so spend some time working on it, then give up.*

A container is filled with a layer of water (density 1 g/cm^3) and a layer of mineral oil (density 0.85 g/cm^3). Defining y=0 to be at the boundary of the two liquids, what is the net force experienced by a uniform ice ball of density 0.92 g/cm^3 and radius 5cm positioned with its center at y=0? If released to float freely, what height would it stabilize at?

# Difference Equations

I’ve seen this stuff before, skipping for greener pastures. The eigenvalue formulation is cool, though, and good to be reminded of.