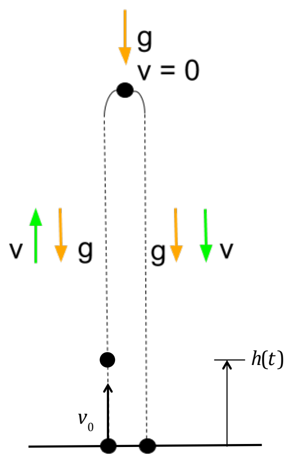
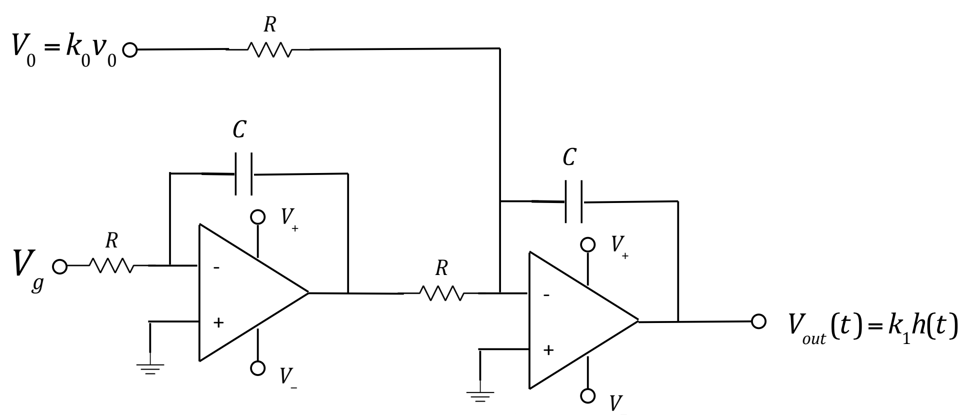
P116B Homework 1

Due 1/18/2019

1. Analog Computing. Consider an object thrown straight upward with an initial vertical velocity v_0 from an initial height $h(0) = 0$



We will use the circuit below to do an analog calculation of the altitude as a function of time.



V_0 is fixed at $V_0 = k_0 v_0$, where v_0 is the initial upward velocity. All Rs are equal and all Cs are equal. Assume all capacitors are initially discharged.

(a) Write an expression for the output $V_{out}(t)$, in terms of k_0,V_0, R,C, and V_g.

(b) Based on this, write expressions for k_1 and V_g, such that $V_{out} = k_1 h(t)$, in terms of k_0, R, C, and g, where g is the (positive) deceleration of gravity, as shown. Be careful with signs!

(c) Sketch a modified circuit with *one component replaced* (i.e. swap an R with a C or a C with an R), such that $V_{out} = k_1 v(t)$, where $v(t)$ is the vertical velocity as a function of time, rather than height. Write and expression for k_1 in terms of k_0, R, and C. Again, be careful with signs.

2. Non-linear analog computing. In class, we discussed the design of an analog multiplication circuit. Based on this design, design a circuit for which

$$v_{out} \propto v_{in}^2$$

Include the correction for any linear terms. Design this using four ideal op-amps, and several diodes and resistors. Express all resistances in terms of a fundamental resistance R.

3. H&H 7.2