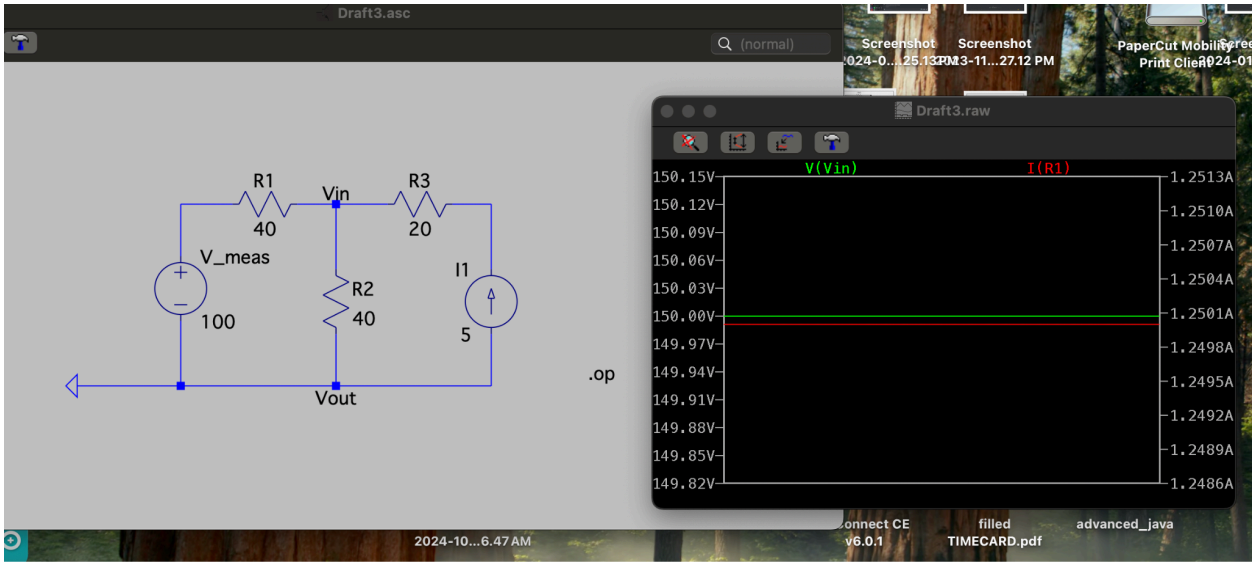

Lab Report Week 3:

One of the interesting things we found when learning about how circuit modeling softwares calculate voltage and current values is how each component can effectively be uniquely modeled by a single equation. The equation is often differential when you are talking about alternating current and components such as capacitors or inductors. Drawing from what we learned in Physics 207B, the voltage in an inductor leads the current through the component by 90 degrees, and a capacitor lags by 90 degrees. This is important information for circuit modeling software because these relationships are characterized by differential equations. $V_L = L(di/dt)$ and $V_C = (1/\omega C)dq/dt$. V_R can be easily modeled using Ohm's law, $V = IR$. According to an electrical engineer and researcher, Thomas Russel on stack exchange explains how there are really three fundamental types of analyses, and thus, three different algorithms are necessary for running each type of analysis (DC operating point, AC analysis, Transient analysis). DC operating point is the easiest because it is just a linear circuit, so nodal analysis is sufficient to solve such a circuit (I would presume this is done with clever uses of linear algebra). For nonlinear circuits, "additional tricks have to be used". What this means is that modeling softwares derived from LTspice use Newton's method modified for multiple equations to "guess" and then successive iterations are run to converge to a specific value. Other tricks are used for transient analysis, like Euler's method (where you use the derivative at a point and multiply by the Δx to approximate the increment in y).

Citation:

Thomas Russell 1, et al. “How Do Circuit Simulators Actually Work?” *Electrical Engineering Stack Exchange*, 1 Nov. 1958, electronics.stackexchange.com/questions/91416/how-do-circuit-simulators-actually-work#:~:text=Circuit%20simulation%20programs%2C%20of%20which,into%20equations%20to%20be%20solved.