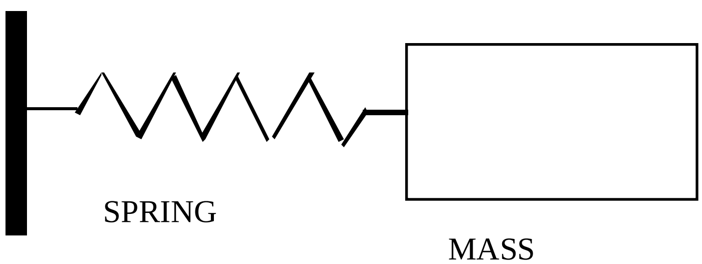
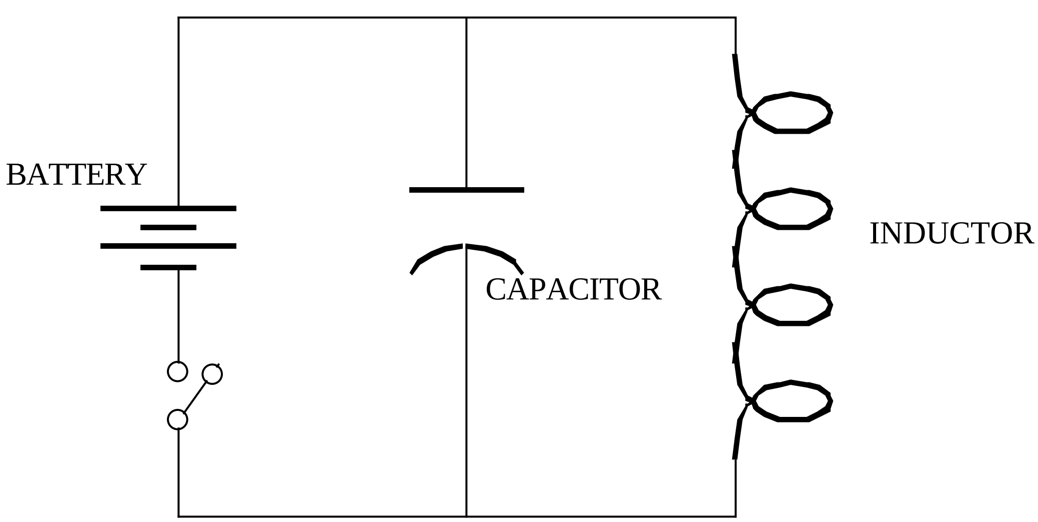
I. INTRODUCTION: What is EA3 all about?

EA3 deals with the *dynamics of systems*. By *dynamics* we mean that something is changing with time, and by *systems* we mean collections of interconnected elements. The elements or components of the system can be from mechanical, electromagnetic, thermal, biological, economic, or social domains etc, and these elements are somehow interconnected to perform some task. Of course, we will restrict attention here to *physical* systems that are of interest to engineers, but the basic idea is that complex systems in many domains can be modeled using essentially the same strategies. Surprisingly, we often find underlying similarities in the resulting mathematical models of systems from various domains. Essentially, what this means is that if we understand the dynamics of one particular system in one domain, we can relatively easily leverage that understanding to figure out the dynamics of an *analogous* system in another domain.

Shown below are two models of systems, one mechanical and the other electrical.





We will see in this course that the two systems are *mathematically* analogous. In the mechanical domain that you are already familiar with from EA2, there are concepts such as force, velocity and displacement, and they have their analog in the electrical domain in the concepts of voltage, current and charge. I would like to emphasize that you should not take the fact that there are mathematical analogs between systems from various domains to mean that the two systems (or worse, the two domains) are physically the same! They are not. It is very important to get a good grasp of the *physical* concepts in each domain, and you will work on that in the various courses you take in your major. Remember that even if I later tell you that mechanical force is analogous to electrical voltage, or mechanical velocity is analogous to electrical current, physically force is not the same as voltage, and velocity is not the same as current. In fact, current is the rate of flow of charge, and charges can move with a certain velocity as you understand it from mechanics! Thus, do not take the analogy too far! Learn the physics of things as you go along. In the long run, it pays! Having said that, however, the similarities between various domains is something that we can make very good use of. Besides it might lead us to philosophize about the underlying unity of nature, or at least the underlying unity of our attempts to understand (model) nature.

In this course, we will start off with the dynamics of mechanical systems. This will be a continuation of what you started in EA2, and therefore the physical concepts in this domain are already familiar to you. We will revisit the topic of motion of particles, but we will now also develop *numerical* methods to solve the equations of motion of particles. This will involve MATLAB coding, so you must have your computers (and coffee makers) loaded and ready! We will look into such problems as the motion of an electron in an electromagnetic field, the motion of a projectile in the presence of air drag, and orbital motion of satellites and planets.

Staying within the mechanical domain, I will next introduce the concepts of conservation of energy and momentum, and we will apply these to solve various problems such as impact of particles etc., and possibly even see how rockets fly. Along the way, we will look into oscillatory behavior of an ideal spring-block system. We will also introduce energy dissipative mechanisms (friction and dampers).

At this point, I will recast our approach to mechanical systems using the language of *systems dynamics*. I will restrict attention to what are called one-dimensional, lumped parameter, translational mechanical systems, and we will develop the pertinent equations of motion, and analytically or numerically obtain their solutions. We will analyze systems of springs, masses, and dampers, and see how we can model the dynamics of bungee jumping.

With the systems approach to mechanical systems under our belt, we will transition to the electrical domain. Those of you who have already taken Physics A35-2 will be familiar with the concepts in this domain, but we will briefly revisit them in any case. We will then look into the dynamics of several simple circuits, taking advantage of the analogy between the electrical and the mechanical domains. Specifically, we will look into a simple graphics equalizer (tone control), and explore the dynamics of transmission lines (such as the cable that brings your TV or data transmissions to you).

Time permitting, we will explore either the hydraulic or the thermal domain, just so you get to see how easily you can export the expertise you acquire in one domain into another.