5.11: Wrap up

We began this chapter by developing an approach that enabled us to use conservation of energy to understand and make sense of fluid flow and electric current. In many respects the approach is similar to the approach we developed previously to use energy conservation for understanding all kinds of phenomena by looking at the changes that occurred from before to after an interaction. We called this the energy-interaction model. For steady-state flow phenomena involving fluids and electricity, we needed to make two important modifications to our model. First, instead of focusing on energy, we focused on energy-density. Second, instead of looking at changes from before to after an interaction, we looked at changes in the energy-density as we moved along the flow path. But the general approach and methods are similar in both models. These are very powerful and general models. Energy conservation can be applied to all phenomena. The energy interaction model and the steady-state energy-density model provide us the tools we need to apply conservation of energy.

In the second part of this chapter, we saw how the approach we used in the stead-state energy density model could also be used to make sense of other transport phenomena that didn't even involve energy conservation. The linear transport model applies to any kind of transport that is linearly proportional to a gradient of something. Some of the more interesting cases of transport involve more than one potential gradient. For example, the diffusion of charged particles (ions) across a cell membrane. A cell wall will typically have a voltage, i.e., an electrical potential gradient of the order of 100 mV. In addition there will typically be concentration gradients across the cell wall as well. And there can be active "pumps" that act selectively on certain ions or particles. You should be able to readily make sense of these phenomena when you encounter them in your more advanced courses and lab work by focusing on the underlying transport mechanisms in terms of the general linear transport model.

In the last part of this chapter we looked at a general and universal way systems approach steady state: the exponential change model. We saw that in some cases the flow rate that we discussed so much in this chapter was no longer constant. Instead it depended on the amount of "stuff" that was flowing, whether it was the volume of a liquid or the amount of charge. Mathematically, we saw that this relationship between current and what is flowing resulted in exponential decay phenomena.

One of the difficult things for all of us to do when we are first learning a new subject that is expressed in *quantitative relationships involving symbols* is to get past the symbols themselves and focus on the meaning of the relationships represented in the mathematical relationships. The mathematical relationships must, by necessity, be represented with symbols. The symbols are typically different for the different physical phenomena to which the relationship is applied, even though it is the same underlying relationship. Each of the three models treated in this chapter, the steady-state energy density model, the linear transport model and the exponential change model, apply to multiple kinds physical phenomena. The symbols used to express the relationship, however, are typically different for each different application. In the case of exponential change, the equations for exponential growth look very different from the equation expressing the charge on a capacitor, because some of the symbols are different. Likewise, the expression for diffusion or osmosis "looks different" from the expression for heat flow, because many of the symbols are different. Working through this chapter gives you many opportunities to practice getting past the symbols to the meaning of the relationship behind the symbols. Take advantage of this opportunity.