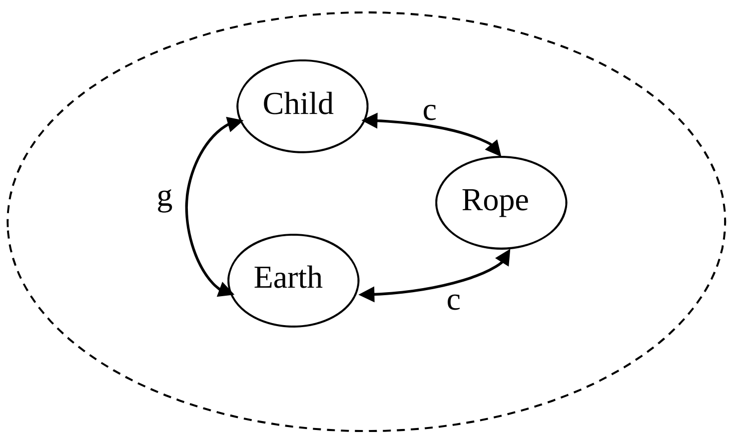
Analysis Tool – Energy Pie Charts

For the following example it is useful to have an example to draw upon. The situation described below will provide context for the description of the process of making a set of energy pie charts.

A child pulls herself up a rope using only her hands.

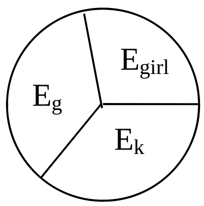
1. Identify what are the relevant objects and interactions in the system and identify the system boundaries. (Note: See System Schema Handout)

In this example certainly the girl is relevant, but would it matter what color her hair is? Not for this model. So we should simplify and just identify the girl. Other objects would include the earth (we need to have the whole earth as we want to have a gravitational interaction), the rope might be important, and we can argue away other things (no air, so we don't have to worry about air resistance, for example). Given these objects, there are three interactions, contact between the girl and the rope, contact between the rope and the earth (we don't really know how, nor do we care), and gravitational interaction between the girl and the earth. We assume the girl is not standing on the ground (otherwise why would she be pulling herself up). Finally we need a system boundary, if we choose it so that all the objects are within the system we have a closed system, which means that no interactions are crossing the system boundaries, and therefore energy is not going in or out of the system, so the energy in the system remains constant.

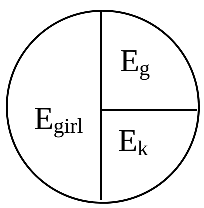


2. Once we have the objects, interactions and system boundaries we can try to draw the pie charts. Sometimes it is easy to start at the beginning, sometimes it is easier to start at the end and work backwards. If we start at the beginning, we know that the girl is going to move up the rope (so there will be some energy stored in the gravitational interaction), and that she will be moving (so there will

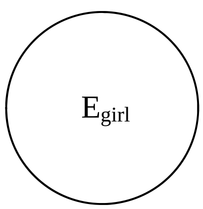
be some kinetic energy). Where did this energy come from? Well the girl ate breakfast we assume, so the energy from the food is stored in the girl. (Since this isn't a chemistry or biology course, we aren't going to worry too much about how this happens, but we could be more specific if we wanted to be.) I digress, we need to draw some pies. Notice that only one pie isn't very useful, since energy is most useful when talking about change. In this example, since we have a closed system, the energy remains constant inside, so we will draw all pies the same size.



Later still, the girl is moving faster and is higher up the rope.



Some time later, girl is moving up rope.



At time, t=0, assuming girl is not moving yet, and is at the bottom of the rope.

1. Starting with a pie at the bottom. One assumption would be she starts from rest (which means no kinetic energy), and that she is at the lowest point of this situation (so we can set $E_g = 0$). The only source of energy then is in the girl.
2. As the girl moves up, she is now moving, therefore she must have some kinetic energy, and because she has moved up, she must have some gravitational energy (she is higher up than before). Since the total must remain the same, that means the E_{girl} must have gone down.
3. Depending on your model, this final pie might be different, but I assumed constant acceleration, so E_k has grown, the girl continues upward, so E_g grows and as a result, E_{girl} must shrink.

3. Go back and see if the pies you drew tell the story of the situation you are trying to model. In this case the girl is transferring energy out of herself and into gravitational and kinetic energies. She is moving up the rope (E_g is growing) constantly increasing her speed (E_k is growing).