Modeling Homework Appendix

One of the most important ways for students to communicate and receive feedback on their learning is through homework. Assessing and grading student work is something that we believe is unique and individual to each professor, but we did want to point out specific examples for evaluating good models such that the students and the professors value the same model development.

One of the most valued practices in modeling is the coordination and coherence between representations. The use of graphs, system schemas, motion maps, force vectors, energy charts, equations, and pictures should all coordinate to tell a complete coherent story of the physical phenomena. To best represent this coherence we will give an example.

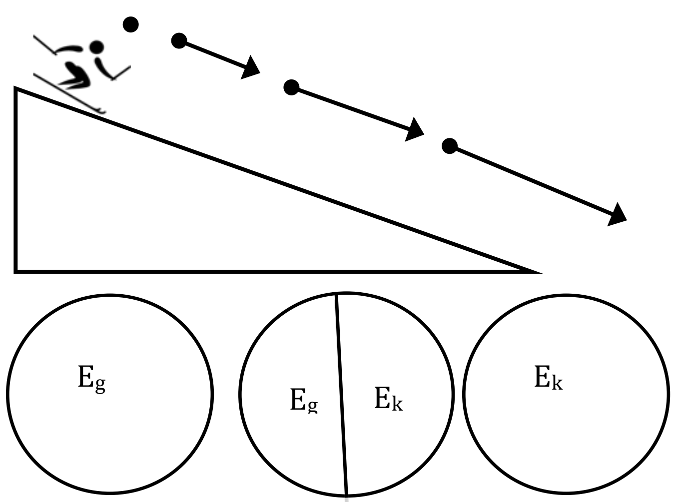
A typical problem in modeling will not necessarily have a question to answer and therefore the expectation is to create a model of the phenomena that would answer any question you could ask.

Example: A 70 kg woman skis down a 15-degree incline that is 700 meters long.

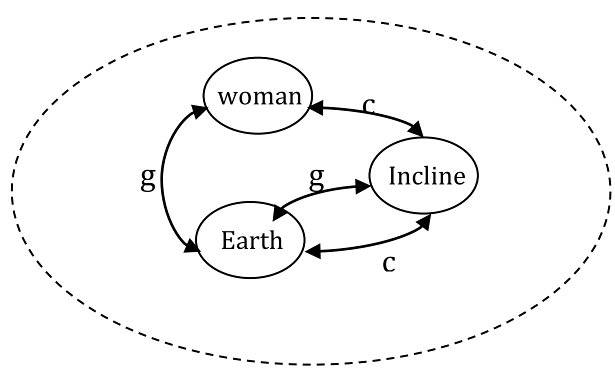
You can make this more traditional problem and ask what her final velocity at the bottom will be.

Traditional solution: use energy conservation to solve for the final velocity. But first we have to find the height by geometry and then apply energy conservation. Without knowing the time or acceleration, kinematics equations cannot help.

Modeling the situation: There are two models you can expect a student to make here. One is a specific model and the other is a full robust model. If the student were given the above situation with a specific disclaimer to create a model that answers what her velocity is at the bottom of the incline, then the specific model solution would be like this:



Assume a 1-dimentional constant acceleration model



Energy Conservation

$E_{initial} = E_{final}$
$E_g = E_k$
$mgh = ½ mv^2$

Where height is determined by Pythagorean geometry: sin(15)=h/700, so the height is 181 meters. And my final velocity is about 60 m/s after some algebra.

To give feedback on valuing good model development we would give credit for coordinating the diagram, system schema, and the energy pie charts to generate the energy conservation equation and using it to find the solution to the specific question. Evaluating the use of the representation lets the student know their importance and how the representations can lead them to generate equations. The representations together create a map that tells a story of how energy behaves in this situation, and how it explains her motion.

Now, in a case of a full and robust model of this situation there is no specific question. Model the following: A 70 kg woman skis down a 15-degree incline that is 700 meters long. The model would include the above representations in addition to kinematic graphs with time and acceleration and all unknown values determined, making sure that the kinematic graphs are coherent within themselves. Also include a force diagram of the woman (and in some extreme case, also for each object in the system). In coordinating a force diagram, the student can assume no friction model and use the rules of constant force in constant acceleration (or Newton's 2nd Law) to generate solutions for the forces acting on the woman. Then by the use of Newton's 3rd Law, students can even determine the forces on the other objects the woman is interacting with.

You can imagine that this robust model tells us every aspect of the woman's motion as she skis down the 700-meter long incline (what her energy is like, and why she has that certain acceleration due to the forces acting on her, etc.). The full and robust model is something that we do once the constant acceleration model is developed in the classroom. What we most value in their homework is their understanding of the use of the representations and how they all work together to complete the story. Just getting the right answer is not enough.