Understanding by Design*

The *Understanding by Design* template focuses on the three stages of backward design:

- **Identify desired results**
- **Determine acceptable evidence**
- **Plan learning experiences**

What overarching (enduring) understandings are desired?

Amusement park rides are physics laboratories where safety and thrills are both desired.

- The height and speeds of roller coasters can all be calculated.
- Roller-coaster designers take into account physics principles.
- The thrills of a roller-coaster ride are not linked to speed but to changes in speed.
- Roller-coaster rides can be analyzed using forces and/or energy principles.
- Safety issues are linked to physics calculations and are crucially important in designing a roller-coaster ride.

What will students understand as a result of this chapter?

- A three-dimensional roller coaster can be depicted using a side view and a top view diagram.
- Changes in velocity with respect to time (accelerations) are responsible for the thrills of a roller coaster.
- Gravitational potential energy: $GPE = mgh$
- Kinetic energy: $KE = \frac{1}{2}mv^2$
- Spring potential energy: $SPE = \frac{1}{2}kx^2$
- The sum of all energies in a roller coaster is identical at all places on the roller coaster. Specifically, $GPE + KE =$ a constant.
- The force of gravitational attraction between any two masses can be calculated using Newton's law. $F_G = Gm_1m_2/r^2$
- Hooke's law states the force of a spring is directly proportional to its stretch. $F = kx$
- If an object is suspended motionless from a spring, the Hooke's law force is equal to the weight.
- If an object is accelerating while suspended from a spring, the Hooke's law force may be larger or smaller than the gravitational force on the object leading to a change in the object's apparent weight.
- For an object to travel in a circular path at a constant speed, a force must continuously act on the object toward the center of the circle.
- Work applied to a coaster can increase the gravitational potential energy. $W = Fd$
- Power is the rate of doing work. $P = W/t$
- Energy and force are related through work.
- Safe roller coasters do not exceed an acceleration of 4 g. This acceleration must be calculated at all curves on the roller coaster.

What are the overarching "essential" questions?

- How can energy conservation be used to calculate the speed of the roller coaster at all points?
- Where does weight come from? What is the universal law of gravitation?
- How much apparent weight change do we experience during a roller-coaster ride?
- How are forces responsible for the thrills of a roller-coaster ride?
- Where does the energy originate for a roller-coaster ride?
- How are forces and energy related?

What "essential" questions will focus this chapter?

- How can you depict a three-dimensional roller-coaster ride on a piece of paper?
- Do thrills come from large speeds or from large changes in speed?
- What is the interplay between gravitational potential energy and kinetic energy for a roller-coaster ride?
- How can spring potential energy relate to kinetic energy and gravitational potential energy?
- What is Newton's law of gravitation?
- How can Hooke's law be used to weigh an object?
- How do accelerations during a roller-coaster ride affect the apparent weight of the passengers?
- How can you explain circular motion in terms of Newton's laws?
- What is "work"? How is work applied to a roller coaster to provide it with energy?
- Describe a roller-coaster ride using the physics principles of energy conservation and forces.
- What restrictions must be placed on speeds, accelerations and forces to ensure a safe roller-coaster ride?

* Grant Wiggins and Jay McTighe, *Understanding by Design* (Merril/Prentice Hall, 1998), 181.