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?

Not all accidents can be prevented but you can ensure that an accident is less severe for a driver, a passenger and a pedestrian.

- Physical laws can describe and predict what will occur during an accident.
- Safety measures based on physics principles can protect you during an accident.
- Seat belts, air bags, headrests and other technologies are based on physics principles.
- Accidents can be analyzed by using physics principles.

What will students understand as a result of this chapter?

- Many safety features have been added to automobiles such as seat belts, head restraints, air bags, crumple zones, etc.
- Newton's first law states that an object in motion will stay in motion unless acted upon by a force. If your vehicle stops suddenly, you continue to travel forward.
- Pressure is defined as the force per unit area. A seat belt made from a wire could slice through your body, while a seat belt of wide cloth will stop you without much pressure.
- A moving object has kinetic energy $KE = \frac{1}{2}mv^2$. To change that KE, there must be work (a force applied over a distance, $W = Fd$). To stop someone during an accident requires a certain amount of work. The person can be stopped with a large force over a very short distance or a small force over a larger distance. Cushioned dashboards and air bags are used to lengthen the distance over which the smaller force can bring you to a halt.
- A driver hit from behind will experience whiplash. This is where the head moves back and then snaps forward. Whiplash can be explained using Newton's first law and Newton's second laws ($F = ma$).
- When two moving vehicles collide, the change in motion depends upon the relative masses of the vehicles. This is described in terms of the momentum of the vehicles, $p = mv$.
- In all collisions, the total momentum before the collision is equal to the total momentum after the collision. This law of the conservation of momentum is true of collisions from planets to microscopic particles.
- The total momentum in a collision is conserved but the momentum of each vehicle can change. The change in momentum is equal to the force applied over a given time $\Delta(mv) = F\Delta t$.

What are the overarching "essential" questions?

- How do Newton's laws relate to automobile safety?
- How do seat belts, air bags, headrests, collapsible steering columns and other safety devices protect you?
- How can people reconstruct an accident after it has taken place to determine liability?
- What is the law of conservation of momentum?
- What physics principles would you take into account if you were designing a safety device for a bicycle or motorcycle?

What "essential" questions will focus this chapter?

- What safety features exist in automobiles?
- How do safety features in vehicles today improve upon those in cars from 30 years ago?
- How do seat belts protect us during a car accident?
- How does the thickness of the seat belt affect its utility?
- Why does an egg not break when it lands on a padded surface but does break when it lands on concrete?
- How is work related to the energy during a collision?
- What is whiplash? How can the events during whiplash be explained using Newton's first and second laws?
- How does the size of a vehicle impact its damage during a collision?
- What laws of physics are used by traffic-accident investigators to reconstruct an accident?
- How can "cushioning" decrease the severity of an accident?

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

CHAPTER 3