UNIT OVERVIEW

FORCE AND MOTION

Unit Issue: Car and driver safety, specifically how people can reduce the risk of motor vehicle accidents.

Anchoring Phenomenon: Some cars and driving behaviors result in fewer accidents and less damage than others.

Listed below is a summary of the activities in this unit. Note that the total teaching time is listed as 25–32 periods of approximately 45–50 minutes (approximately 5–7 weeks). If there is insufficient time to complete the unit, consider skipping Activity 7 and or Activity 11.

Activity Description	Topics	Advance Preparation	Assessment	Teaching Periods
1. **Talking It Over: Improving Car and Driver Safety** This activity introduces students to a scenario about car and driver safety. They analyze and compare some features of two vehicles in order to choose the one they determine is safer. In the process, they discover that they need to know more about the science involved in accidents and the design of vehicle safety features if they are to make good decisions. They also consider how engineers contribute to the design of safer vehicles.	Analyzing data, evidence, trade-offs LITERACY	Prepare Student Sheets, prepare Literacy Sheet (optional)	E&T A3	1–2
2. **Laboratory: Measuring and Graphing Speed** Students use a cart, ramp, and track to measure the time it takes for a cart to roll 100 cm. They calculate speed from their distance and time measurements and express it as a rate of motion. Students then match segments of a distance-vs.- time graph to portions of a narrative describing two students' journeys to school. The graphs allow students to determine both the speed and the relative position of an object with respect to a fixed point.	Distance, time, speed, rate, motion graphs	Cut trip slips or gather scissors, choose method for measuring speed, prepare Student Sheets.	AID QUICK CHECK A2	2

FORCE AND MOTION (continued)

Activity Description	Topics	Advance Preparation	Assessment	Teaching Periods
3. **Laboratory: Speed and Kinetic Energy** Students use the same cart system to explore the qualitative relationship between the speed of the cart and its kinetic energy. Students release the carts from different heights on the ramp and measure the speeds of the carts. Students know based on their understanding of energy transformation that a cart with a greater release height has more gravitational potential energy that can be transformed into kinetic energy of motion. They then use their understanding of energy transfer to investigate what happens when a block is in the path of a cart. Using different release heights, students compare how far a block placed on the track moves after a cart hits it. Students discover that a faster-moving cart moves the block farther—more kinetic energy has been transferred from the cart to the block.	Speed, kinetic energy, experimental design	Choose method for measuring speed, prepare Student Sheets.	ODA QUICK CHECK Proc. 9 AID A2	1–2
4. **Laboratory: Mass and Kinetic Energy** Students plan and carry out an investigation on the effect that a cart's mass has on its kinetic energy. Similar to the previous activity, they measure how far a block on the track moves after a cart hits it. They vary mass by loading one or more metal cylinders onto the cart. They discover that the more massive the cart, the farther the block moves, indicating a greater transfer of kinetic energy.	Mass, kinetic energy, experimental design		PCI Proc. AID A1	2
5. **Investigation: Quantifying Kinetic Energy** Students examine cards indicating the kinetic energy of cars of different masses going different speeds. Each pair of students will examine either one car type going at different speeds or multiple car types all going the same speed. Pairs of students construct graphs of the data they collected and organized, and then share with the other pair in their group. The class conducts a gallery walk of all of the graphs, and determines that kinetic energy is directly proportional to mass, and proportional to the square of the speed.	Kinetic energy, speed, mass, graphing, linear, nonlinear MATHEMATICS		AID A2 (Summative Assessment)	2

FORCE AND MOTION (continued)

Activity Description	Topics	Advance Preparation	Assessment	Teaching Periods
6. **Laboratory: Changing Direction** Students investigate direction of motion by making observations of a marble's motion around a circular track. They predict and then observe the direction the marble rolls when a section of the track is removed. They develop an argument to explain their observations. They also investigate whether changing the mass of the marble affects the motion of the marble.	Change in motion, acceleration, force	Gather large sheets of paper (optional), prepare Student Sheet.	ARG QUICK CHECK A1	2
7. **Laboratory: Changing Speed** Students conduct a hands-on investigation using a modified cart system to investigate balanced and unbalanced forces. Students observe that a cart's motion doesn't change when forces are balanced. When students apply unbalanced forces to the cart and analyze the cart's speed, they discover that the greater the imbalance, the greater the change in cart speed.	Change in motion, acceleration, deceler-ation, balanced and unbalanced forces	Assemble cart apparatuses, choose method for measuring speed.	EXP A1	2
8. **Investigation: Force, Mass, and Acceleration** Students interact in a teacher-led demonstration using a motion sensor to determine that acceleration is the change in an object's motion over a period of time. Students further investigate the quantitative relationship between force and other variables using the SI units for force and acceleration. Students derive the equation that relates force, mass, and acceleration by analyzing provided data. They graph the relationship between these variables and are introduced to Newton's second law.	Force, mass, acceleration, equations, graphing MATHEMATICS	Download *Graphical Analysis* software to use with motion sensor.	EXP A5	2
9. **Reading: Newton's Laws of Motion** Students complete a reading about forces and are introduced to two of Newton's laws of motion. The reading is supported by a literacy strategy designed to address common misconceptions about force and motion. Students apply their understanding of Newton's first two laws to car and driver safety features.	Force, mass, acceleration, Newton's first and second laws of motion LITERACY	Prepare Student Sheet.	COM QUICK CHECK A4	1

FORCE AND MOTION (continued)

Activity Description	Topics	Advance Preparation	Assessment	Teaching Periods
10. **Investigation: Interacting Objects** Students conduct a series of investigations to explore the forces involved when objects interact. From these investigations, students begin to notice that interacting objects apply forces to each other. Students engage in a class discussion to make sense of their observations and draw conclusions about the forces involved when objects interact. Students begin to build understanding that the forces applied by interacting objects are equal in size and opposite in direction, which is Newton's third law of motion.	Force, system, Newton's third law of motion, criteria, constraint	Review demonstrations.	MOD A2	2–3
11. **Modeling: Newton's Third Law** In this activity, students complete a short reading about Newton's third law. After an introduction to the crosscutting concept of systems and system models, students create their own system models that illustrate Newton's third law. Students share their system models with the class and discuss the similarities and differences between their classmates' system models and their own. Students reflect on the use of system models in science during class discussion.	Force, system, Newton's third law of motion	Prepare materials and locations for student to post system models.	MOD Proc.	1–2
12. **Problem Solving: Collisions and Changes in Motion** Students use system models to investigate collisions between objects of the same mass and objects of different masses. Students use their conclusions from this investigation as well as their understanding of Newton's third law to address the issue of car and driver safety in the event of a collision.	Mass, force, Newton's third law of motion	Prepare Student Sheets.	EXP A3 (Summative Assessment) E&T A4	2–3
13. **Laboratory: Braking Distance** In this activity, students investigate the effect of speed and mass on braking distance. To begin, students use a model cart-and-track system to conduct an investigation to determine the effect of speed on braking distance. Then, students plan and carry out their own investigations to determine the effect of mass on braking distance. Using their data as evidence, students determine that higher speeds and larger masses result in larger braking distances. Students relate these findings to the work of engineers.	Mass, force, speed	Review concept of friction from "Changing Direction" activity.	PCI Proc. (Summative Assessment) ARG QUICK CHECK A4, A5	2

FORCE AND MOTION (continued)

Activity Description	Topics	Advance Preparation	Assessment	Teaching Periods
14. **Problem Solving: Coming to a Stop** Students learn that the distance a car takes to stop is a result of two separate factors—the distance traveled during the driver's reaction time and the distance traveled once the brakes have been engaged, both of which increase with increased speed. They investigate the actual stopping distances of cars by calculating and graphing data for different speeds, road conditions, and states of driver alertness (assuming the mass of the car is fixed in these calculations). Students consider how technology could be used in the design of vehicles to ensure that an alert driver is operating the vehicle.	Braking distance, stopping distance, speed, technology	Prepare Student Sheet.	AID A5	1–2
15. **Design: Designing a Car and Driver Safety System** In this culminating activity, students design car and driver safety systems. These systems are designed to alert drivers to changes in the various factors that will affect their abilities to stop their vehicles. First, students brainstorm the requirements, criteria, and constraints for their systems. Then, they review scientific concepts that relate to the components of the systems they are focused on. Students use their understanding of force and motion to precisely define the criteria and constraints of the design problems and work with their groups to create preliminary designs of the systems.	Engineering design, problem solving, system modeling LITERACY	Develop time frame for activity, plan classroom configuration for groups of 8, prepare Student Sheets, prepare Literacy Sheet (optional)	E&T A1 COM A3 (Summative Assessment)	2–3