FAST CARS AND ROLL-OVER

Performance Standard 12D/11B/13B.I

Students will apply the processes of technological design to investigate motion relationships in natural and forced settings accordingly:

- *Knowledge*: Describe various dimensions of forces involved in racing car design.
- *Application*: Design models which test the forces associated with center of mass.
- *Communication*: Correlate the principles of torque and center of mass in equilibrium of car design examples.

Procedures

1. ***In order to know and apply concepts that describe force and motion and the principles that explain them (12D) and the concepts, principles and processes of technological design (11B) and the concepts that describe the interaction between science, technology, and society (13B),*** students should experience sufficient learning opportunities to develop the following:
   - Examine historic engineering dilemmas driven by science and engineering principles associated with car racing.
   - Researching historical design barriers or circumstances for design changes.
   - Determine success criteria for technological design to investigate stability of car design (center of gravity).
   - Sketch a progression of design schematics for center of gravity models.
   - Propose logical sequence of steps in design construction.
   - Construct and test variations for center of gravity designs,
   - Predict proportional scale for actual race car parameters and materials,
   - Record reliable and precise data and anecdotal observations.
   - Analyze data to evaluate center of gravity investigation models.
   - Compare examples of balanced or unbalanced forces in car racing.
   - Explain torque and center of mass in relation to the conditions of equilibrium.
   - Communicate evaluation report to generalize factors associated with stability from controlling center of gravity in model designs.
   - Analyze components of motion and dimensions of force graphically.
   - Generate possible applications of car design which incorporate additional scientific concepts, such as:
     - Explain the dimensions of speed/time with directional units.
     - Compare speed, average speed, velocity, acceleration and momentum with race car examples.
     - Associate advances in the past century in automobile design and career settings which have responded to force and motion concepts.

   Note to teacher: This activity relates to knowledge associated with standard 12D, while addressing the performance descriptors for stage I within standard 11B. Additional connections to the scientific technologies advanced in the past century and career decisions are applicable from standard 13B. This highlighted activity is offered through http://www.superspeedway.com/eng/home.html and may be used with a 50-minute video available for $29.95. Permission for its use was granted. Preview all materials offered through the free, downloaded teacher's guide. Activity 5 is highlighted for this example; sequencing multiple activities from this resource will enhance it success. The video can be useful, but is not required for the success of this particular segment. An additional page of suggestions for extension activities is provided. An additional, free, excellent resource (27 pages of activities and explanations) is available from the Insurance Institute for Highway Safety, Understanding Car Crashes: It's Basic Physics from its website: www.highwaysafety.org
2. Have students review and discuss the assessment task and how the rubric will be use to evaluate their work.
3. Set the stage for generation and solution of engineering dilemmas using the application of race car design with concepts of kinematics. Explore historical designs and testing processes for racing car design with consideration of banked curves, faster acceleration, track friction variations and lighter carriage factors, etc.
4. By testing varying angles and model design, the processes of technological design are practiced. Following instructions from teacher's guide:

Create a ramp with two pieces of cardboard hinged together with tape. Make a ridge by taping a straw 2 cm (0.8 in) above the hinge. Tape the protractor to the end of the cardboard to measure the angle at which it opens. Place empty milk carton against the straw. Have students slowly raise the cardboard until the milk carton falls over the straw. Record the angle. Encourage the students to experiment. They can add between one and six washers at different areas on the milk carton to see if it will tip over at lower or higher angles. Have the students determine where the washers must be placed to make the milk carton the most stable. Ask them to explain in terms of the center of gravity and base area.

This activity can be integrated into a greater unit which can demonstrate additional real-world applications.

5. Evaluate each student's work using the Science Rubric as follows and add the scores to determine the performance level:
   - *Knowledge*: The descriptions of applicable forces associated with race car design were complete and correct,
   - *Application*: The model testing procedures and data were correct and
   - *Communication*: The correlations to torque and center of mass were well-reasoned, thorough and well-detailed.

Examples of Student Work not available

Time Requirements
- 1 class period for center of mass activity within a possible 3-4 week kinematics unit

Resources

- Free teacher's guide from http://www.superspeedway.com/eng/home.html
- Video: Super speedway $29.95; can be ordered from website (not required)
- Per student or team: Tape, 2 pieces of cardboard 15 cm x 15 cm, protractor, 15 cm straw, 150 cm3 empty milk carton, 6 metal washers
- Science Rubric

Possible Ideas for Car Racing and Physics Investigations

1. Calculating kinematics of linear, rotational and circular motion:

   - How does the velocity and acceleration of a race car change at different points of the track? How does the design of the car affect this positively and negatively? Diagram vectors
   - How does the amount of friction on the track (increased or decreased, during or between races.) Diagram vectors
   - How does the design (composition, engineering specifications, placement, etc.) of the spoiler, nose cover, tires, wheel base, brake system, suspension system affect the acceleration and control of the car? Diagram vectors
   - How are the static, kinetic and spring weights altered at different points of the track? What is cross weight and its effect? Diagram vectors

2. Explaining torque and center of mass in relation to conditions of equilibrium
   - Explain the importance of the ROLL CENTER of mass determinations in the design of a race car---Show diagrams; consider if it is displaced to the front or the rear of the car—what is the effect? Diagram vectors

3. Calculate forces in elastic and inelastic collisions
   - Relate the designs for the driver's body safety (head, body, legs) and body momentum in potential crash situations/prevention—Diagram vectors
   - How does the driver BUMP STEER when needed? Diagram the vectors.
   - How are the CRUSH ZONES considered in the design of the race car? Diagram vectors—explain composition and force/momentum factors and magnitude. Diagram vectors.
   - How does the design of the gas tank relate to the elasticity considerations? Diagram vectors.

4. Consider how the Doppler Effect in demonstrated at the race track

5. Consider the precision of time keeping.