Madison Public Schools

Grade 7 - Unit 3 - Forces and Motion

Unit Focus

By performing several investigations that demonstrate the laws of physics, students will develop an understanding of the forces that are at work everyday in their lives. Students will begin the unit investigating the forces at work as our local Olympians fly through the air as aerial skiers. As students engage in hands-on, inquiry-based experiences they will uncover not only how these athletes use the laws of physics in their performance, but also how our world operates according to these laws. In order to engage in and quantify how Newton's Laws impact the world around us, students will apply their understanding of math and graphical analysis to solve physics problems and communicate experimental results. Students will demonstrate their understanding of forces and motion when they develop a testable hypothesis and procedure to test a race car and track that they have designed using the Engineering Design Process. At the end of the unit, students will tie together all of the concepts they have investigated as they create an original roller coaster design that requires them to employ this content explored during the unit to allow marbles to safely travel through the course.

Stage 1: Desired Results - Key Understandings

Established Goals

Next Generation Science

Middle School Engineering Design: 6 - 8

- Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. *MS-ETS1-1*
- Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. *MS-ETS1-4*

Middle School Physical Science: 6 - 8

- Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. *MS-PS2-1*
- Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. *MS-PS2-2*

Next Generation Science Standards (DCI)

Science: 7

- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In

Transfer

T1 Create models to explore complex systems, show mastery of key science concepts, and/or develop solutions through creation of a product open to testing and redesign.

Meaning

Understandings

U1 Objects possess a potential energy that is dependent upon their position and gravitational force.
U2 The motion of an object can be determined and/or predicted by using its position, velocity, and acceleration.
U3 Objects in motion remain in straight-line motion at constant speed, and objects at rest remain at rest unless acted upon by unbalanced forces. (Newton's 1st law).
U4 The acceleration of an object depends upon its mass and the net force acting on it. (Newton's 2nd Law)
U5 Forces between objects come in pairs that are equal in magnitude but opposite in direction (Newton's 3rd law)
U6 Established knowledge provides the foundation for future scientific and engineering advances.

Essential Questions

Q1 How do forces cause and affect motion?
Q2 How do the principles of physics explain natural phenomenon?
Q3 How do engineers use physics to develop equipment that is safe and functional?

Stage 1: Desired Results - Key Understandings

order to share information with other people, these choices must also be shared. *PS2.6.A3*

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process-that is, some of those characteristics may be incorporated into the new design. *ETS1.6.C1*
- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton"s third law). *PS2.6.A1*
- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. *PS3.6.A2*
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. *PS2.6.A2*
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time. *PS3.6.B1*
- When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. *PS3.6.C1*

Student Growth and Development 21st Century Capacities Matrix

Creative Thinking

- Design: Students will be able to engage in an appropriate process to refine their product. *MM.2.3*

Collaboration/Communication

- Collective Intelligence: Students will be able to work respectfully and responsibly with others, exchanging and evaluating ideas to achieve a common objective. *MM.3.1*

Acquisition of Knowledge and Skill

Knowledge

K1 The total energy within a system is conserved.
K2 The greater the mass of an object, the greater the force needed to achieve the same change in motion.
K3 For a given object, a larger force causes a larger change in motion.
K4 In order to detect motion, objects must be compared to a designated frame of reference.
K5 Gravitational forces are always attractive and can have an impact on potential energy.
K6 How acceleration and velocity combine to impact the movement of object (speed up, slow down).
K7 *Scientific Literacy Terminology*: potential energy, kinetic energy, motion, point of reference, speed, constant speed, average speed, position-time graph, slope, force, friction, gravity, inertia, mass, acceleration, balanced/unbalanced forces, net force, circular motion.

Skills

S1 Plan and conduct an investigation to explore aspects of Newton's Laws of Motion. Identify variables, collect and analyze data.
S2 Interpret graphs to describe the relationships among position, velocity, and acceleration.
S3 Conduct simple experiments that show and explain how forces work to change the motion of an object.
S4 Use mathematical equations to solve force and motion problems.
S5 Plan and conduct an experiment to investigate the effects of mass, surface texture and pressure on the amount of friction between objects.
S6 Apply understanding of Physics to create a functional roller coaster.