STEAMTOWN NHS EDUCATION PROGRAM

There's a Mountain in the Way! (4th-6th grades)

Transportation has always played an important role in American history. Finding ways to get people and goods over great distances helped our country expand, and made it possible to get products to market. Rivers first provided a way to move from place to place, but they only flowed one direction, they froze in winter, and they didn't go everywhere people wanted to go. Early roads called turnpikes came next, but cutting roads through the wilderness was difficult and dangerous. When the steam engine came along, railroads could be built which moved people and supplies across great distances much more quickly and efficiently.

The coal that was mined in our area provided a strong incentive to develop efficient transportation. Why? Because coal provided energy! It provided heat for homes, power for industry, and eventually fuel for transportation. Industrialists hoped to make money by selling coal to the big cities like New York and Philadelphia. But there was a mountain in the way!

The way they solved this problem is important because their efforts helped develop our railroad system that eventually allowed our country to spread across the continent. Let's take a look at how they did it.

After participating in the program, students will be able to:

1. Describe three geologic processes that formed the layers and topography of the Lackawanna Valley.
2. Trace the evolution of commercial transportation technology in 19th century NE Pennsylvania, from horse-drawn sledges, to canals and gravity railroads, to the steam locomotive.
3. Apply the basic principles of physics to solve real-world problems.

<u>The Science</u>

About 300 million years ago the earth was covered with swampy forests – lots of plants such as giant ferns, reeds and mosses – many plants were taller than our trees today. Water and dirt washed in, burying the plants in the process. After millions of years, many layers were formed.

The lower layers of plant matter were packed down by the weight of the water and the top layers. These plant layers first changed into **peat**. Peat is brown, crumbly and spongy, and is used to improve soil for lawns, golf courses, etc. In some places, like Ireland, peat is actually burned as fuel.

Thicker layers of sediment put more pressure on the plant layers. This raised the temperature, and because there was no oxygen, the plants didn't decompose. Heat and pressure changed the peat into carbon, or **lignite**. Lignite crumbles easily when shipped long distances, so it's usually used close to its source. Most lignite is used to produce electricity at power plants.

Bituminous coal (or soft coal) comes from lignite that has undergone more heat and pressure. Bituminous coal is hard, but in layers. It is the most abundant kind of coal we have and is usually burned to produce electricity. By-products from burning bituminous coal can be changed into many different chemicals that are used to make paint, synthetic rubber, insulation, nylon, aspirin, and many other things.

Anthracite is the final stage of coal. Often called 'hard coal,' it is dark black and shiny. Anthracite is mostly used for heating homes and generating electricity. Coal forms in layers a few inches to 12 feet thick. Deeper layers create a better product, but are more of a challenge to recover and transport.

Note: How do we know that coal was made from plants?
Because we can often find fossils, or impressions, of these early plants in coal. Fossils can be in the shape of stumps, leaves, seeds, or even whole plants.

Coal is the most abundant fossil fuel we have available. It has been mined for more than 200 years, but experts say there is enough coal to last another 200. More than ¼ of the world's supply of coal is in the U.S. and coal is exported to more than 35 countries around the world. It is present in 38 states.

The Lackawanna Valley holds tons of anthracite coal, but in the 19th century that presented a problem. How could we get it to market?

Simple Machines

Simple machines were the technology available at the time. Simple machines help people do work. "Work" has a specific definition in physics, but a basic way to think about it is that work is making things move. A machine is something that makes that work easier. Simple machines are one mechanism, compound machines are two or more simple machines working together.

Let's take a look at several simple machines and the work that they do.

The Lever

This is the most common simple machine. If you look around, you will spot many forms of this simple machine – like a pair of scissors, for example. And since we know that scissors cut better near the pivot point, we know that with levers, this is where the leverage is greatest.

In order to use a lever you need torque - what you apply to make something rotate. (Use a square piece of cardboard on a pivot point, then different size wrenches.)

Experiment – Place a can on the end of the lever and have students try to lift it by pushing down on the lever's other end, testing several fulcrum points to show the effect of distance on force needed to lift.

Real-life examples: hammers, pliers, screwdrivers, pry bar.

The Inclined Plane

Another common simple machine, the inclined plane is more commonly known as a ramp, something that makes moving weight easier by moving it over a longer distance.

Experiment – Adjust the angle of the inclined plane so that the weight of the hanging block provides exactly the right amount of force to balance the car on the ramp. Then adjust the angle downward and see how quickly the car moves up the ramp!

Real-life examples: set of stairs, gravity railroad.

Wheel and Axle - Pulleys

Everyone knows the easiest way to move something is to roll it on wheels. The wheel and axle are often combined with other simple machines such as in the pulley, or the gear and gear train, to make work easier. The pulley does this by changing the direction of an applied force.

If you throw a rope over a tree branch to lift a weight, you are using the tree branch to change the direction of the force just as a pulley does, but the pulley adds a wheel to the system. By reducing the friction of the rope on the branch, very little force is lost. As you pull down on the rope, the weight is lifted. Pulling down (you can use your weight to help) is much easier work than pushing up! Multiple pulleys can move the force to other positions too.

Experiment – Place the cord over a single pulley. Pull down on one block, noting the motion of the other block. Pulling in any direction results in upward movement of the block. The force has been redirected.

Place the cord over the top two pulleys and pull down on one block. The force of you pulling down is equal to the force of the other block moving up.

Now place the cord through all three pulleys (over the top two, under the lower pulley). The force is still equal but the motion has changed between pulleys – down to up, up to down – but the magnitude has not changed.

Try other ways of stringing the cord.

Real-life examples: an elevator, a flagpole, a crane.

Motion Converter

In a steam locomotive, hot steam enters a chamber and pushes against a piston. The piston moves back and forth: what we call linear motion. This worked well where linear force could be used, such as pumping water, but not for turning a wheel to propel something forward, such as a boat, a carriage or a train. In transportation, we need the wheels to go round and round: what we call rotational motion. The motion converter changes one form of motion into the other so that the energy of the steam can be transferred.

The 'choo choo' sound of an old steam locomotive is the sound of steam pushing the pistons, which run a motion converter, which transfers force to the wheels. The same principle lives on in the 4, 6, or 8 pistons under the hood of a car, as they turn their linear motion into the rotational motion of the car's wheels in just the same way.

> Experiment – The rod connected to the wheels works something like a piston. Gently push the piston (rod) – the wheels will begin to rotate. The linear motion of the piston is being converted to rotational motion. As you push the piston in, you will reach the midpoint of the motion. This is the point where the transfer of energy is most efficient. You will likely feel a surge in the motion.
>
> Finally you will reach the end of the travel of the piston. If you are careful, you can stop pushing here and the inertia of the wheels will keep them rotating until the system comes back to where it was. At this point you can push again. With some practice you can push repeatedly to keep the wheels spinning.

So, here's our Scientific Query:
Using these Simple Machines, how can we get the coal from the valley to the top of the ridge?

Have the students experiment with the simple machines in groups – each group testing one machine for 20 minutes, then moving on to the next one. At the end of this activity, have each group present their solutions using as many of the simple machines as they choose. Then share with them what really happened.

<u>Historical Background</u>

After the War of 1812, two Philadelphia dry goods merchants discovered outcroppings of anthracite coal in NE PA, a remote region that was known as the Great Swamp and the Endless Mountains. Desiring to make a profit from it, they had to first solve the problem of getting that coal to market. In 1822 they cut a trail over the Moosic Mountain wide enough for horses to haul the coal on sleds through the snow; then the coal was loaded onto rafts on the Lackawaxen River. The next year proved this method ineffective when the snow wasn't deep enough to support the sleds.

Water had long been the favored mode of transportation in America – there were few if any roads at the time, but streams and rivers crisscrossed the countryside. Direction of flow and depth of the channel limited use, so man-made **canals** were built to solve these problems. Canal systems had been built south of here in the Schuylkill and Lehigh Valleys, but their route to the Philadelphia market was shorter and less steep. The Wurtz brothers decided to sell to New York City instead, which meant transporting the coal about 200 miles. Until they figured out how to get it there, coal was stock-piled at Carbondale.

The brothers formed the Delaware & Hudson Canal Company and constructed a canal from Honesdale to Rondout, NY on the Hudson River. From there they could ship the coal to either NYC or Albany and Troy. Building the canal took 2500 men and 200 teams of horses, digging and blasting for 3 years.

The terminus of the canal in Honesdale, however, did not reach the coal fields near Carbondale. There was a particularly rugged stretch over Moosic Mountain – the steep elevation would take too many locks, and horse-drawn wagons couldn't carry enough tonnage to make it profitable. The engineers debated several solutions, such as hoisting canal boats over the mountain on primitive elevators, or rolling them over on a road of rails. They turned to technology already in use in England – **gravity railroads**. They decided to build this road of rails from the western end of the canal near Dyberry Forks to the Carbondale mines.

This **gravity railroad** covered 16 miles through the mountains. Long level stretches alternated with shorter inclined planes to move wagons up or down. The coal cars were first pulled by horses or mules, but they were eventually replaced by steam engines. Located at the top of the planes, the engines pulled cars up the hills or eased them down the other side. The weight of the full cars going down helped pulled the empty cars uphill.

Steam locomotives – already in use in England - were then purchased to move the cars from Valley Junction to Providence (Scranton).

The development of standard locomotive-powered railroad lines in the late 1800s eventually drove the gravity railroad – and the canals – out of business. A vast network of rail lines was constructed, expanding markets inland in all directions. By 1898 it cost 50 cents more to transport a ton of coal by the gravity/canal system than over the rails. That year the D&H Canal closed, and the gravity railroad closed a year later. The railroad was here to stay!

Note: The Lackawanna and Wyoming Valleys became known as the northern domain of "King Coal." The coal industry in Pennsylvania peaked in 1918 with 330,000 miners producing 277 million tons of coal.

Learning Standards Addressed

The activities integrated into this program will address the following PA Academic Standards:

Earth Structure, Processes and Cycles

Standard 3.3.4-6.A1 – Describe basic landforms. Recognize that the surface of the earth changes due to slow processes and rapid processes.
Standard 3.3.4-6.A2 – Describe the usefulness of Earth's physical resources as raw materials for the human-made world.

Physics
Standard 3.2.4-6.B2 – Examine how energy can be transferred from one form to another.

The Scope of Technology
Standard 3.4.4-6.A2 – Understand that systems have parts and components that work together

Technology and Society
Standard 3.4.4-6.B3 – Explain why new technologies are developed and old ones are improved in terms of needs and wants. Describe how community concerns support or limit technological developments.

Technology and Engineering Design
Standard 3.4-6.C3 – Identify how invention and innovation are creative ways to turn ideas into real things.

Pennsylvania History
Standard 8.2.6.C. – Transportation and Trade (e.g., methods of overland travel, water transportation…)

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Lackawanna Heritage Valley
Where America's Story Lives