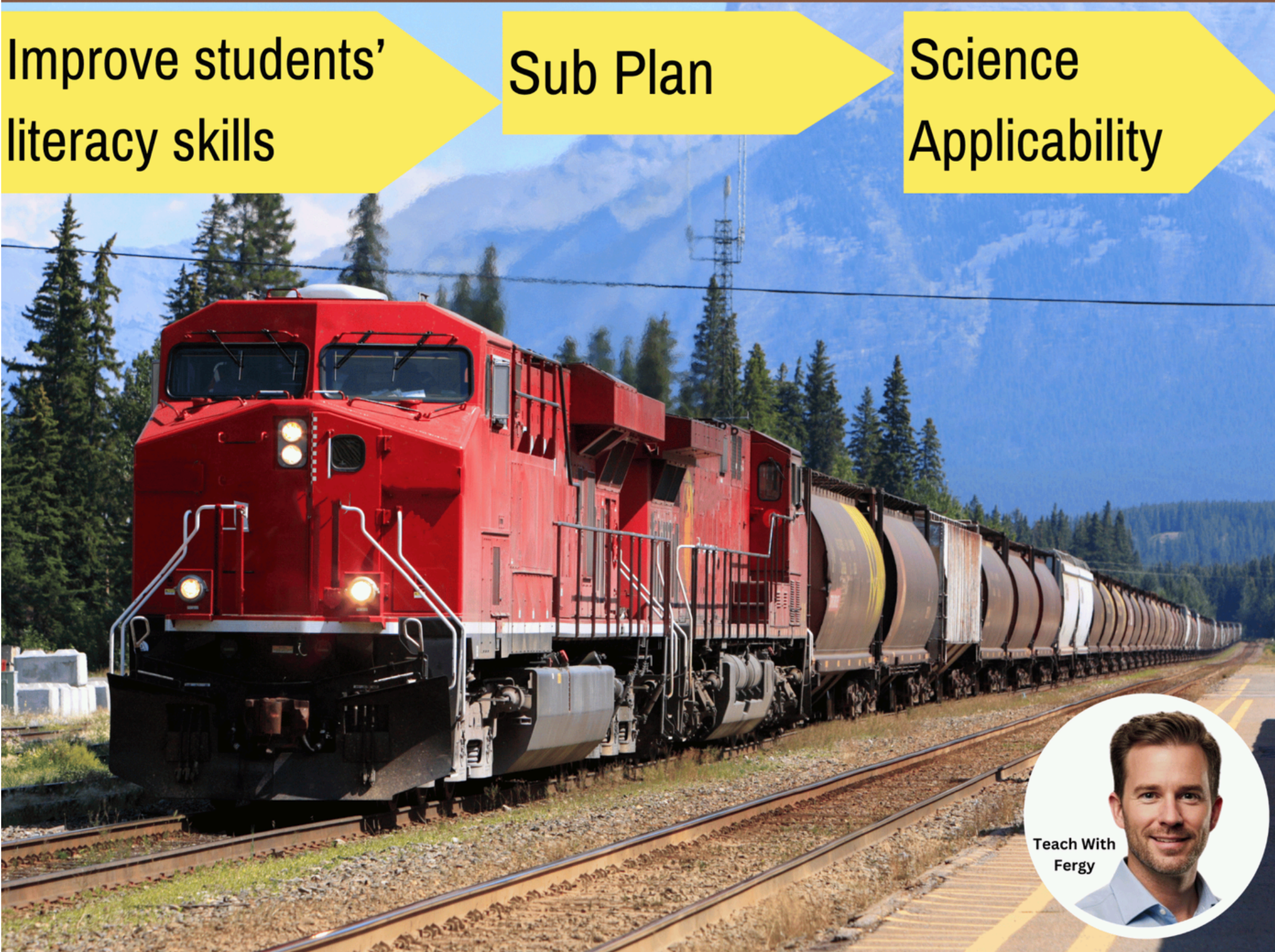


HOW TRAINS WORK: THE SCIENCE OF MOTION, POWER, & SAFETY GRADE 8 & UP READING

Improve students'
literacy skills

Sub Plan

Science
Applicability



Teach With
Fergy

Reading Comment



Extremely satisfied - Great resource to work on student reading comprehension and it tied into the topic I was teaching. My students have been struggling with reading and I've been incorporating more reading into my lessons. Thank you for the resource.



SCROLL
to take a look inside!

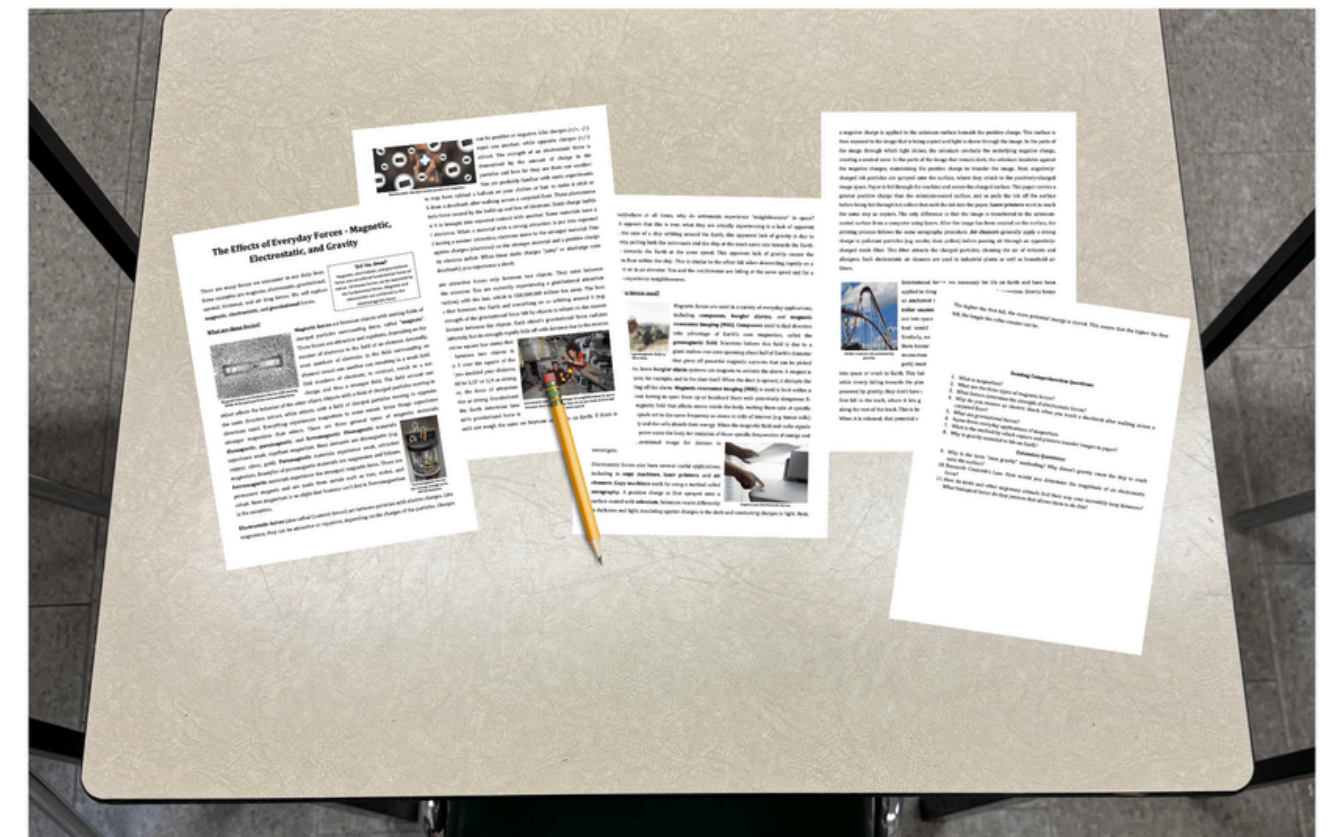


THE PROBLEMS YOU FACE

- Limited time to teach scientific literacy and strengthen students' reading and analysis skills.
- Need meaningful extension activities to engage fast-moving learners.
- Difficulty creating effective last-minute sub plans that still support student learning.

NO-PREP - PRINT/UPLOAD

- **CLASSROOM READY - No Prep, Ready-to-Use:** Print or assign digitally with Google Docs, Microsoft Word, and PDF formats for flexible classroom use
- **Questions and Answer Key**
- **Includes Varied Question Types:** Knowledge, thinking, connecting, application, and open-ended questions.



What Will Your Students Learn?

READING COMPREHENSION ARTICLE & QUESTION BUNDLE

Article with Comprehension Questions

Grade 8 and Up

Print & Digital

- **Newton's Third Law and Train Motion**
- Tractive Effort and Adhesion
- **Rolling Resistance and Efficiency**
- Diesel-Electric vs. Electric Locomotives
- **Energy Transfer and Traction Motors**
- Simple Machines in Rail Transportation
- **Axle Load and Momentum**
- Railway Grades and Gravity
- **Rack-and-Pinion Railways**
- Curves, Superelevation, and Air Resistance
- **Automatic Air Brakes and Dynamic Braking**
- Railway Safety Systems and Positive Train Control

Your Reading

How Trains Work: The Science of Motion, Power, and Safety

Trains may look simple from the outside, but they are carefully designed machines that must control enormous amounts of weight, force, and energy. A train has to create enough force to move hundreds or even thousands of tonnes rolling, climb hills, travel safely around curves, and stop. The science behind trains explains why they can move so much cargo efficiently over long distances to slow down.



How Trains Begin Moving

A train moves because its powered wheels push backward against the rails. The rails push forward on the wheels, causing the train to move. This is an example of Newton's Third Law of Motion. On another, the second object pushes back in the opposite direction.



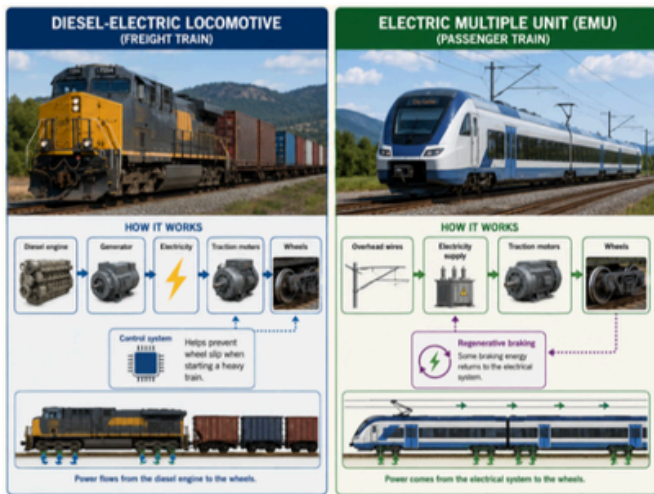
The pulling force created by a locomotive is called **tractive effort**. The amount a train can use depends partly on the grip between the wheels and rails, called **adhesion**. Steel wheels do not grip steel rails as strongly as rubber tires grip a road. Rain, frost, oil, and crushed leaves can make rails slippery. Locomotives may spread sand onto the rail to improve grip when starting, climbing, or braking.

Steel wheels also have an important advantage: they roll with very little resistance. A steel wheel changes shape much less than a rubber tire as it rolls, so less energy is lost. Once a train is moving, it's efficient.

How Locomotives Supply Power

Many freight trains use **diesel-electric locomotives**. The diesel engine does not use electricity directly. Instead, it powers a generator that produces electricity. The electricity runs through wires connected to the wheels. This system works well because electric motors create less heat than diesel engines. That matters when a heavy train starts moving. The control system also adjusts the power to the wheels.

Electric trains receive electricity from overhead wires or an electrified rail beside the track. They can accelerate quickly and may use regenerative braking when slowing down.



Simple Machines in Rail Transportation

Trains use several simple machines. The clearest example is the **wheel and axle**, which allows heavy railcars to move with less resistance than if they were dragged.

Levers are used in brake systems to transfer force from brake cylinders to brake pads or shoes. Railways also use the idea of the **inclined plane**. Instead of building tracks straight up a steep mountain, engineers often build a longer route with gentle slopes, curves, tunnels, and bridges. The train travels farther, but the climb is easier. Pulleys and lifting systems are also used in repair shops to move heavy parts.

Train Weight and Axle Load

Freight trains can be extremely heavy because each car may carry coal, grain, containers, fuel, vehicles, or other materials. The total weight is spread across many wheels and axles. **Axle load** means the amount of weight supported by one axle. Axle load matters because every wheel presses down on the rail. The rails, ties, crushed stone, bridges, and ground beneath the track must support these repeated loads. Heavy freight routes need stronger track and bridges than lighter passenger routes. If axle loads are too high, tracks wear faster and bridges may be damaged.

A heavier train requires more pulling force to start and climb. It also has more **momentum** once moving. Momentum describes how difficult it is to stop a moving object. A massive freight train moving at a moderate speed can have more momentum than a faster but lighter vehicle.

Why Trains Avoid Steep Hills

Railway slopes are called **grades**. A one-percent grade rises one metre for every 100 metres of travel. That may not sound steep, but it matters greatly to a heavy train. On an uphill grade, gravity pulls the train backward. The locomotive pull as well as normal resistance usually use gentle grades. Some mountain railways use steeper slopes with a **rack-and-pinion system**. A toothed wheel on the train connects with a toothed rail. This prevents the train from depending only on friction. Cog railways on Pikes Peak and Mount Washington use this design.



Going downhill creates an advantage. Gravity pulls the train forward, so control its speed for a long planned so trains can climb.

Special mountain railways use a **rack-and-pinion system**. A toothed wheel on the train connects with a toothed rail. This prevents the train from depending only on friction. Cog railways on Pikes Peak and Mount Washington use this design.

Curves and High-Speed Travel

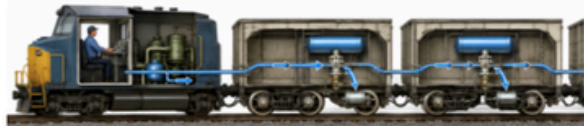
A train moving around a curve tends to continue in a straight line, so the rails must guide it. If a train enters a curve too quickly, sideways forces can make the ride uncomfortable, increase wear on the rails, and even cause derailment.

Engineers reduce these forces by using wide curves and raising the outer rail. This is called **cant**. It tilts the train slightly inward so gravity helps it follow the curve.

Freight trains and high-speed passenger trains have different designs. Freight trains are heavy and usually slower. High-speed trains are lighter, streamlined, and designed for smoother travel. Their pointed noses reduce air resistance. Some passenger trains also tilt slightly on curves.

How Trains Stop

Most trains use **automatic air brakes**. A brake pipe runs along the train, and each car carries compressed air. When the engineer applies the brakes, pressure in the pipe drops. Valves on each car send stored air into the brake cylinders, which press brake pads or shoes against the wheels or discs. The system is called **fail-safe** because if the train separates or a hose breaks, the cars stop.



Many locomotives also use **dynamic braking**. The traction motors act like generators as the train slows down. The electrical energy is changed into heat. Electric trains may return the power to the power system. Dynamic braking is useful on long downhill grades because it reduces wear on the brakes.

Trains cannot stop quickly. Their mass gives them large momentum, and steel wheels have limited grip. It takes time for the brake command to reach every car. Weather, track slope, speed, and train weight all affect stopping distance.

Efficiency and Safety

Trains are efficient because steel wheels create low rolling resistance and one locomotive can pull many cars. At high speeds, air resistance becomes more important, so high-speed trains have smooth shapes.

Because stopping distances are long, railway safety depends on planning ahead. Signals tell the train ahead is clear. Dispatchers control train movement, and computer systems can warn of problems. Positive Train Control systems in the United States are designed to prevent collisions, excessive speed, movement into work zones, and travel through incorrectly set switches. Every railway must manage force, motion, energy, friction, and momentum. Freight trains, high-speed passenger trains, and mountain cog railways may look different, but all must move large loads safely and efficiently.

Reading Comprehension Questions

- How does Newton's Third Law help explain why a train moves forward?
- What is adhesion, and why is it important to a train?
- How does a diesel-electric locomotive transfer energy from its diesel engine to its wheels?
- What is one advantage of an electric train compared with a diesel-electric train?
- Name two simple machines used in rail transportation and explain how each is used.
- What is axle load, and why must railway engineers consider it?
- Why do freight railways usually use gentle grades?
- How does a rack-and-pinion system help a mountain railway climb steep slopes?
- How does superelevation help a train travel safely around a curve?
- Why are railway air brakes described as fail-safe?

Extension Questions

- Research a diesel-electric locomotive and an electric locomotive. What is one advantage and one disadvantage of each type?
- Research either the Pikes Peak Cog Railway or the Mount Washington Cog Railway. How steep is its route, and how does its climbing system work?
- Why might wet leaves on railway tracks create a serious safety problem? Research how some companies deal with this problem.
- Compare a heavy freight train with a high-speed passenger train. How are their shapes, weights, and purposes different?
- Imagine that engineers are planning a passenger railway through a mountainous area. What should they include to help trains climb, turn, and stop safely?

Reading Comprehension Questions – Answer Key

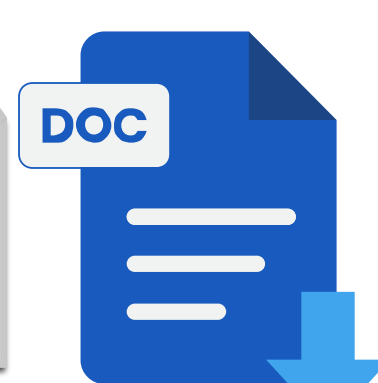
- How does Newton's Third Law help explain why a train moves forward?
The powered wheels push backward against the rails. The rails push forward against the wheels, causing the train to move forward.
- What is adhesion, and why is it important to a train?
Adhesion is the grip between the wheels and the rails. It allows the locomotive to pull the train without its wheels slipping.
- How does a diesel-electric locomotive transfer energy from its diesel engine to its wheels?
The diesel engine powers a generator that produces electricity. The electricity runs traction motors connected to the wheels.
- What is one advantage of an electric train compared with a diesel-electric train?
Possible answers include that electric trains can accelerate quickly, do not need to carry a diesel engine and fuel supply, and may return energy to the electrical system while braking.
- Name two simple machines used in rail transportation and explain how each is used.
Possible answers include the wheel and axle, which allows heavy railcars to roll; levers, which transfer force in brake systems; inclined planes, which allow trains to climb gradual slopes; and pulleys, which lift heavy parts in repair shops.
- What is axle load, and why must railway engineers consider it?
Axle load is the amount of weight supported by one axle. Tracks, bridges, ties, and the ground must be strong enough to support repeated axle loads.
- Why do freight railways usually use gentle grades?
Freight trains are very heavy and pull them backward on an uphill grade, so steep slopes require much more pulling force and can make traveling difficult.
- How does a rack-and-pinion system help a mountain railway climb steep slopes?
A toothed wheel on the train connects with a toothed rail. This mechanical connection gives the train a stronger grip than ordinary steel wheels alone can provide.
- How does superelevation help a train travel safely around a curve?
Superelevation raises the outer rail and tilts the train inward. This helps the train follow the curve and reduces uncomfortable or dangerous sideways forces.
- Why are railway air brakes described as fail-safe?
A major loss of air pressure causes the brakes to apply. If a hose breaks or the train separates, the cars should begin braking automatically.

Extension Questions – Answer Key

- Research a diesel-electric locomotive and an electric locomotive. What is one advantage and one disadvantage of each type?
A strong answer should explain that a diesel-electric locomotive can operate on tracks without electrical wires, but it burns fuel and produces exhaust. An electric locomotive can accelerate quickly and produce no exhaust from the train itself, but it requires costly electrical equipment along the railway.
- Research either the Pikes Peak Cog Railway or the Mount Washington Cog Railway. How steep is its route, and how does its climbing system work?
Answers will vary. The Pikes Peak Cog Railway reaches grades of about 25%, while the Mount Washington Cog Railway reaches grades of about 37%.

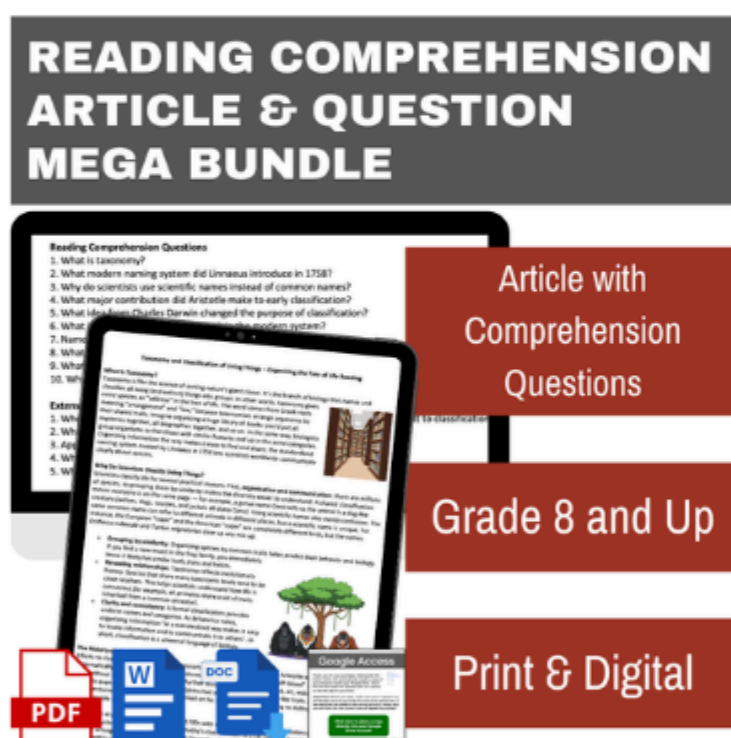
Full Answer Key

Comprehension and Extension Questions



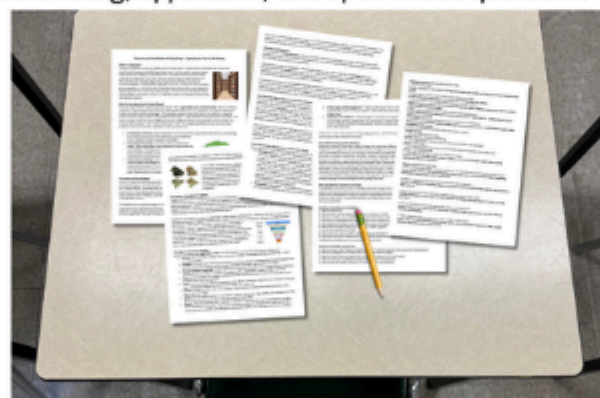
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CLASSROOM READY

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- **Includes Varied Question Types:** Knowledge, thinking, connecting, application, and open-ended questions.



★★★★★ Extremely satisfied - It is a good supplemental activity either for review and at the same time introducing some concept. I also use this for sub plan. It is well presented, organized and interesting.

★★★★★ Extremely satisfied - This a great resource. I used this for a sub plan. It was fun and engaging for my students.

Grade 8 and Up Scientific Reading Comprehension Article Mega Bundle

ALL my current and future grade 8 and up readings, covering the following subject areas:

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