

Unit 1 – The Physics of Driving Safety

Understanding Goals

- A. The motion of an object can be described by its position, velocity, and acceleration, all of which can be represented graphically or numerically.

How can we describe the motion and the change in motion of an object?

- B. Various factors that a driver can control, such as response time, initial velocity, or acceleration rate, affect a driver's ability to avoid collisions.

How can a driver reduce the likelihood of a collision?

- C. Newton's Laws and conservation of momentum can predict the motion of objects in a collision and the forces that act upon them. Students will understand how to represent the forces acting on an object using free-body diagrams and vectors.

How can we use Newton's Laws and conservation of momentum to predict the motion of objects during a collision?

- D. Newton's Laws can help us determine how to safely stop someone during a collision.

How can we use Newton's Laws to reduce the risk of injury to a person during a collision?

Key Topics

Position-Time & Velocity-Time Graphs

- Draw a graph given a written scenario
- Interpret a graph in words
- Find the area under a velocity-time graph
- Find the Δx and Δt of a diagonal line on a velocity-time graph

Response Time & Stopping Distance

- Describe the factors that can affect response time
- Label response time and calculate stopping distance on a velocity-time graph

Acceleration

- Define acceleration
- Explain the units $\frac{m}{s^2}$
- Fill in a velocity-time T Chart
- Solve basic kinematics problems using "Givens, Wants, Need" method

Newton's Laws

- Inertia
- Forces exerted in a collision
- Free-body diagrams

Momentum & Energy

- Collisions
- Types of mechanical energy

HONORS CONTENT STRANDS:

- Derivation and use of kinematic equations
- Application of kinematic equations and free-body diagrams to force problems

Unit 1 – The Physics of Driving Safety

Equations

Quantity	Equation	Unit
Average Velocity (v)	$v = \frac{\Delta d}{\Delta t}$	$\frac{m}{s}$
Average Acceleration (a)	$a = \frac{\Delta v}{\Delta t}$	$\frac{m}{s^2}$
Force (F)	$F = m \bullet a$	N
Momentum (p)	$p = m \bullet v$	$kg \frac{m}{s}$
Potential Energy (PE)	$PE = mg\Delta h$	Joules
Kinetic Energy (KE)	$KE = \frac{1}{2}mv^2$	Joules
Kinematic Equations		
$v_f = v_i + a\Delta t$	$\Delta d = v_i\Delta t + \frac{1}{2}a(\Delta t^2)$	$v_f^2 = v_i^2 + 2a\Delta d$

Spread the Word: Advertising Campaign Competition

Unit 1 Final Project

Students will pitch an ad campaign for a public service announcement to Massachusetts Department of Transportation. The ad campaign must have 2 components:

1. How to reduce the likelihood of accidents
2. How to reduce the risk of injury during accidents

Requirements:

The ad campaign can be video, skits, poster, pamphlet, newspaper, speech, song, ...

Products are:

1. The advertisement
2. Detailed description of the physics concepts that support the advertisement
3. Presentation to board making a case for the ad
4. Education outreach materials for other age groups (alternatives)
5. Opportunities to display use in community (alternatives)

Grading:

The advertising campaign will be graded based on a rubric to be given out in class.

Unit 2 –Waves, Sound & Light

Understanding Goals

- A. Students will understand that all waves share the same characteristics (frequency, wavelength, amplitude, speed) and how to measure and display those characteristics.

What are the characteristics that all waves share?

- B. Students will understand that all waves demonstrate the same behaviors (reflection, refraction, interference, diffraction).

What are the behaviors that all waves share?

- C. Students will understand what resonance is, what causes it and why is important to understand it.

What is resonance and why is it important?

- D. Students will understand how the human ear perceives sound (pitch, volume), how sound are produced and travel, and how to change the characteristics of a sound (frequency, amplitude, wavelength).

What is sound, how is it produced and what is happening as we change its pitch and volume?

- E. Students will understand that visible light is one region of the electromagnetic spectrum, how electromagnetic waves are produced, and how the characteristics (frequency, wavelength) of each region make them suited for particular applications.

What is light, how is it produced, and what are the applications of different frequencies on the electromagnetic spectrum

Key Topics

Waves characteristics

- Transverse and longitudinal waves
- Amplitude, wavelength, frequency, period
- Wave equation: $wave\ speed = frequency \times wavelength$

Wave behaviors

- Reflection
- Refraction

Resonance

- Natural frequency
- Causes and applications of resonance

Sound (mechanical waves)

- Vibration of molecules
- Amplitude = Volume
- Frequency = Pitch
- How ears perceive sound

Light (electromagnetic waves)

- Production of EM waves
- EM Spectrum

HONORS CONTENT STRANDS:

- Sounds and music
- Electromagnetic waves and astronomy

Unit 2 –Waves, Sound & Light

Equations

Quantity	Equation/Symbol	Unit
Period (T)	$Period = \frac{1}{frequency}$	seconds
Frequency (f)	$f = \frac{1}{T}$	Hertz (Hz)
Wave length	λ	Meters (m)
Wave speed (v)	$v = f \cdot \lambda$	meters/second (m/s)

Sound and Light Show

To finish the *Waves, Sound, and Light* unit, students will design and present a Sound and Light show using the topics studied in class.

Requirements

Students will work in groups to produce a 2 to 4 minute sound and light show

All sounds must come from musical instruments or sound makers built by the students, or from human voices.

All light must come from household white or colored bulbs or from teacher-provided lasers.

Grading:

A grading rubric will be provided in class and will be based on the following criteria:

- The variety and number of physics concepts used to produce the light and sound effects
- Student's understanding of the physics concepts
- The entertainment value of the sound and light show.

Unit 3 – How does electricity make things work?

Understanding Goals

- A. Students will understand what a charged object is on an atomic level, how a neutral object can become polarized and how objects can be charged.

What are neutral and charged objects and how do neutral objects become charged?

- B. Students will understand how charges and charged objects interact in cases of polarization, conduction, and induction.

How do electrical charges interact with one another?

- C. Students will understand and be able to control the flow of electricity by arranging resistors in series or parallel and by using switches, resistors, and capacitors.

How is the flow of electric charges different in series and parallel circuits?

- D. Students will understand current, voltage, and power and how to measure them.

What are the relationships between current, voltage, power, and resistance?

- E. Students will understand that current creates magnetic fields, and changing magnetic fields can exert force on charges.

How can current create magnetic fields and how can magnetic fields move charges?

Key Topics

The Atom

- Protons, neutrons, electrons: what are they, where are they located, what are their charge?
- Bohr Model of the atom – nucleus and orbiting electrons

Electrostatics

- Rules of charge interaction (attraction, repulsion)
- Net charge of an atom
- How do you charge an object? Friction/contact, induction, polarization
- Polarization of conductors and insulators
- Van De Graaff generator

Electricity & Circuits

- Voltage, current, resistance, and power
- Schematic diagrams
- Series and parallel circuits
- Capacitors, resistors, switches, light bulbs, fuses, dimmer switches
- Batteries, generators, motors

HONORS CONTENT STRANDS:

- Coulomb's Law
- Digital circuits

Unit 3: How Does Electricity Make Things Work?

Equations

Quantity	Equation	Unit
Voltage (V)	$V = IR$	Volts (V)
Current (I)	$I = \frac{V}{R}$	Amperes (A)
Resistance (R)	$R = \frac{V}{I}$	Ohms (Ω)
Electrical Power (P)	$P = IV$	Watts (W)
Series circuit with two resistors (r_1 and r_2): Total Resistance = $r_1 + r_2$		
Parallel circuit with two resistors (r_1 and r_2): $\frac{1}{\text{Total Resistance}} = \frac{1}{r_1} + \frac{1}{r_2}$		

Electricity Challenge

Unit 3 Final Project

Turn a small cardboard box into a miniature living unit and wire it for electricity!

Requirements:

Design a "Living Unit" that has lights, switches, and a fuse.

Make a miniature model of your living unit and wire it lights, switches and a fuse.

Write a lab report that describes the process of designing, building and testing your living unit.

Make a class presentation about your living unit.

Grading:

Your electricity challenge project will be graded based on the rubric to be given in class.

Unit 4 – What is the true cost of energy in our society?

Understanding Goals

- A. Students will understand that there are many forms and sources of mechanical energy and that it can be transferred from one form to another.
What are the forms of mechanical energy and how is energy transferred from one form to another?
- B. Students will use the Law of Conservation and the concept of efficiency to explain why some energy is useable, some is not and that energy is never lost.
What does it mean to say that energy is always conserved?
- C. Students will understand that useable energy sources are finite.
What do we mean when we say that an energy resource is renewable or non-renewable?
- D. Students will understand that they will make choices about which energy sources to use and how efficiently to use energy. These choices have both personal and societal consequences.
What are the criteria by which we as a society decide on how to most appropriately use our limited energy resources?
- E. Students will understand how to use the design process to develop, implement, and evaluate solutions to design problems.
How can we use the design process to solve problems?

Key Topics

- Energy
 - Mechanical energy
 - Potential energy ($PE = m \cdot g \cdot h$. (g for gravity is 10 m/s^2)
 - Kinetic energy ($KE = 1/2 \cdot m \cdot v^2$)
 - Heat energy ($Q = mc\Delta T$)
 - Joules

- Work and Power
 - Work =Force x distance ($W=F \cdot d$)
 - Power =Work/time ($P=W/t$)
 - Watts

- Conservation of Energy

- Efficiency
 - $Efficiency = \frac{\text{Energy Out}}{\text{Energy In}} \times 100$

- Energy Resources
 - Renewable vs. Non-renewable energy resources
 - Benefits and drawbacks of various energy resources

HONORS CONTENT STRANDS:

- Comparison of the efficiency of water wheels and wind turbines
- Specific heat and energy transfer

Quarter 4 – What is the true cost of energy in our society?

Equations		
Quantity	Formula	Unit
Potential Energy (PE)	$PE = mg\Delta h$	Joules
Kinetic Energy (KE)	$KE = \frac{1}{2}mv^2$	Joules
Heat Energy (Q)	$Q = mc\Delta T$	Joules
Work (W)	$W = F\Delta d$	Joules
Power (P)	$P = \frac{W}{\Delta t}$	Watts
Efficiency	$Efficiency = \frac{\text{Energy Out}}{\text{Energy In}} \times 100$	None, but usually expressed as a percentage

Energy Policy Paper Unit 4 Final Project

You are an assistant to the mayor of Cambridge and it is your job to prepare a policy paper to the mayor explaining if Cambridge should adopt a particular energy resource.

Requirements:

You will need to write a **5-page paper** (12 point font, double spaced)

Paper discusses the pros and cons of an energy resource and explains how it works.

Follows the guidelines given to you in class for your research and writing.

Introduction (1-2 paragraphs)

- Introduce the purpose of the paper and the energy resource
- Include a thesis statement: “This paper will present evidence showing why/why not to use this resource.”

Physics (2 paragraphs)

- Draw a diagram that shows energy transformations that take place in your energy resource. Explain how energy is produced using this source or method and what energy transformations occur in the process.

Stakeholder identification (1 paragraph)

- Identify stakeholders and their viewpoints. Who uses this energy? Where is the resource for this energy most abundant?

Health, Environmental and Societal Impacts (3-4 paragraphs)

- What are the positive and negative health, environmental, and societal impacts of:
 - The building of the machines
 - The production of fuel
 - Waste products

Analysis and Conclusion (3 paragraphs)

- Rank the effects of this resource in order of best to worst.
- Why does it matter if this resource is chosen instead of another for Cambridge?
- Are there any factors that might make using this resource more beneficial, or more problematic for Cambridge? State what should be done about adopting this energy resource.

Choose Your Own *Experiventure*

Cross-unit Project – Teachers may choose to do this project in place of one of the end of unit projects.

Purpose:

To design and conduct your own experiment to investigate one of the topics we've been studying in class.

Requirements:

Your experimental question must relate to topics studied in class

You will work alone or in groups of 2 or 3 on your experiment.

As you design and conduct your experiment, record all information, diagrams, observations, and data in your lab notebook.

Each *student* is responsible for handing in a lab report at the end of the experiment.

Grading:

Your lab report and work during the *Experiventure*TM will be graded based on the rubric to be given in class.

Process:

1. **Brainstorm:** The class will brainstorm a list of experimental questions (this will include the questions that came up in class throughout this unit).
2. **Choose a Question:** Students will choose a particular experimental question and groups will be formed.
3. **Make a hypothesis** and support it with background research.
4. **Design your experiment:** Each group will design their experiment; this will include creating a procedure, experimental setup, and an empty data table.
5. **Present your design** to your teacher and get feedback.
6. **Conduct the experiment** by collecting and recording data.
7. **Analyze:** Organize, graph, and analyze data, writing down your thoughts and results in your lab notebook.
8. **Write your report**, following the rubric given out in class.