AP Physics 1&2 Rapid Learning Series

Course Study Guide

AP Physics 1&2 Rapid Learning Series

Tutorial Series Summary

Introduction – The Foundation of AP Physics 1&2
In this section, you will learn about the courses and exams of AP Physics and build the basics to physics mastery. With these skills, you will form a solid foundation to understand physics and problem solving.

Chapter 01: Introduction to AP Physics 1&2
- What AP Physics is.
- What the AP Exam is.
- Seven Big Ideas.
- AP Physics 1 vs. 2
- AP Physics 1 and 2 Exam Content Outline
- How to Study AP Physics
- AP Test-Prep Strategies
- AP Exam-Taking Strategies

Chapter 02: Basic Math for Physics
- Using algebra to solve for a variable
- Performing calculations with significant figures
- Using scientific notation
- Geometry and trigonometry
- The quadratic formula
- Graphing
- Calculator tips

Chapter 03: Problem Solving in Physics
- When to follow problem-solving techniques
- A general problem-solving technique
- How to solve word problems
- How to prepare for an exam
- Tips for taking exams

COURSE #1 – AP PHYSICS 1
In this course, you will learn about AP Physics 1 contents and problem solving.

Chapter 04: Kinematics in One Dimension
- Constant Velocity
    - Distance
    - Displacement
    - Speed
    - Velocity
    - Average Velocity
    - Constant Velocity
- Constant Acceleration
    - Definition
    - Formula
    - Units

  - Free Fall

Chapter 05: Kinematics in Two Dimensions; Vectors

- Vectors
  - Definition and notation
  - Addition of vectors
  - Components
- Projectile Motion
  - Horizontally fired projectile, detailed examples
  - Angled projectile, detailed examples

Chapter 06: Newton's Laws of Motion

- Newton's Laws
  - Inertia
  - Net Force
  - Action and reaction forces
- Equilibrium
  - Dynamic equilibrium
  - Static equilibrium
- Resisting Forces
  - Friction
  - Air resistance
- Dynamics Problems

Chapter 07: Work, Power and Energy

- Work
  - Direction of force
  - Sign conventions
- Power
  - Calculation of power
- Energy
  - Kinetic energy
  - Potential energy
  - Work energy theorem
  - Conservation of energy

Chapter 08: Momentum and Collisions

- Momentum
  - Definition
  - Formula
- Impulse
  - Formula
  - Examples
  - Bouncing versus sticking
- Conservation of momentum
  - Collisions
  - Inelastic versus elastic collisions
  - 2-dimensional collisions

Chapter 09: Circular Motion and Gravitation

- Gravity
  - Formula
  - Gravitational constant
  - Gravitational fields

  - Gravitational pull at various points on Earth
- Circular Motion
  - Linear speed versus rotational speed
  - Centripetal acceleration
  - Centripetal force
  - Centrifugal force
  - Banked roads
  - Simulated gravity

Chapter 10: Rotational Motion and Equilibrium
- Angular motion compared to linear motion
  - Angular displacement, angle
  - Angular speed
  - Angular acceleration
  - Related formulas
- Torque
  - Units
  - Direction
  - Applications
- Moment of Inertia
  - Description
  - Example
  - Formulas
- Rotational Equilibrium
- Angular Momentum
  - Formula
  - Conservation of angular momentum
  - Examples

Chapter 11: Vibrations and Waves
- Simple harmonic motion
  - Vibration
  - Displacement
  - Amplitude
  - Period
  - Frequency
  - Angular frequency
  - Phase
  - Uniform circular motion
  - Pendulums
  - Oscillating springs
  - Resonance
- Wave motion
  - Mechanical vs. electromagnetic waves
  - Transverse vs. longitudinal waves
  - Wave speed
- Wave superposition
  - Interference
  - Wave reflection
  - Standing waves
  - Nodes and antinodes

Chapter 12: Sound
- The nature of sound

    - Our ears
    - Audible and inaudible sounds
    - Speed of sound
    - Types of waves
    - Speed of various sounds
- Properties of sound
    - Intensity
    - Pitch
    - Octaves
- Beats
- The Doppler Effect
    - Definition
    - Formula
    - Applications
- Echoes
- Diffraction

Chapter 13: Electrostatics

- The nature of electric charge
    - Charged particles
    - Charge movement
        - Charging by contact
        - Charging by induction
- Electric Forces
    - Coulomb's law
        - Formula
        - Examples
    - Electric Fields
    - Polarization
- Electric Potential
    - Definition
    - Units
    - Diagram
    - Formula

Chapter 14: Electric Circuits

- Ohm's law
    - Circuit diagrams
    - Alternating current
    - Direct current
    - Internal resistance
- Electric power
    - Formula
    - Example calculations
- Series circuits
    - Resistors combined in series
    - Current and voltage characteristics
    - Example calculations
- Parallel circuits
    - Resistors combined in parallel
    - Current and voltage characteristics
    - Example calculations
- Kirchoff's laws
    - Junction rule

- Loop rule

Course #2 – AP Physics 2

In this course, you will learn about AP Physics 2 contents and problem solving.

Chapter 15: Conductors, Capacitors and Dielectrics

- Conductors
  - Conductors
  - Insulator
  - Semiconductors
  - Superconductors
  - Resistance of a piece of wire
- Capacitors
  - Definition
  - Units
  - Diagram
  - Charge stored in a capacitor
- Dielectrics
  - Polarization
  - Dielectric constant

Chapter 16: Magnetic Fields

- Magnetism in nature
  - Magnetic domains
  - Ferromagnetism
  - Magnetic field diagrams
- Magnetism, force and moving charge
  - Right hand rule
  - Magnetic field notation
  - Magnetic force on a current carrying wire
  - Magnetic force on a moving charged particle
- Magnetism in technology
  - Mass spectrometer
  - Speakers, MRIs, and magnetic media

Chapter 17: Electromagnetism

- Magnetic flux
  - Formula
  - Angle
  - Units
  - Hoop analogy
  - Example
- Faraday's law
  - Formula
  - Induced electromotive force
  - Example
- Lenz's law
  - Right hand rule application
  - Examples
- Electromotive force in a moving conductor
- Applications

Chapter 18: Mechanics of Solids and Fluids

- States of matter
- Solids and elasticity
    - Crystalline and amorphous
- Thermal expansion
- Deformation of solids
    - Young's modulus
    - Shear modulus
    - Bulk modulus
- Fluids
    - Pascal's principle
    - Buoyancy and Archimedes principle
    - Surface tension
    - Capillary action
- Fluids in motion
    - Viscosity
    - Continuity
    - Laminar and turbulent flow
    - Bernoulli's equation

Chapter 19: Temperature and Kinetic Theory of Gases

- Temperature and kinetic energy of gasses
- Temperature Scales
    - Fahrenheit
    - Celsius
    - Kelvin and absolute zero
- Kinetic Molecular Theory
    - Assumptions
    - Number of molecules
    - Pressure
    - Temperature
- Atmospheric pressure
- Pressure in a container
- Gas Laws and combined gas law
- Ideal gas law
- Molar mass and density
- Real gas law
- Molecular motion
- Diffusion and effusion

Chapter 20: Heat and Thermodynamics

- Temperature
    - Expansion, linear and volume
    - Thermometers and thermostats
- Energy in thermal processes
    - Heat and internal energy equation
    - State functions
    - Specific heat and heat capacity
    - Endothermic and exothermic
    - Calorimetry
    - Phase changes
- Laws of thermodynamics
    - Thermal equilibrium and the 0th law
    - Pressure volume and work
    - 1st law of thermodynamics

        - Adiabatic
        - Constant volume
        - Cyclical engines
        - Entropy
    - 2nd law of thermodynamics

Chapter 21: Physical Optics

- Electromagnetic spectrum
    - Electromagnetic waves
    - Speed of light calculations
- Principle of superposition
    - Constructive interference
    - Destructive interference
- Coherent and monochromatic light
- Young's double slit experiment
    - Maxima positions
    - Minima positions
    - Formulas
    - Examples
- Diffraction gratings
    - Formula
    - Examples
- Polarization
    - Unpolarized light
    - Filters
    - Malus' law

Chapter 22: Geometric Optics

- Plane mirrors
    - Law of reflection
    - Virtual images
    - Diffuse reflection
    - Importance or wavelength
- Curved mirrors
    - Concave mirror ray diagram
    - Convex mirror ray diagram
    - Mirror equation and example
    - Magnification equation and example
- Refraction
    - Index of refraction
    - Refraction example and analogy
    - Snell's law
    - Dispersion
    - Total internal reflection
    - Fiber optics
- Lenses
    - Convex lens ray diagram
    - Concave lens ray diagram
    - Lens equation and example
    - Lens combinations
    - Lens defects

Chapter 23: Atomic Physics

- The discovery of electrons

- The Bohr model of the atom
  - Postulates
  - Radii and energy level values
  - Quantization
  - Spectrum explanation
- X rays
  - Characteristics
  - Production
- The wave nature of matter
  - Particle and wave duality
  - Formulas
- deBroglie hypothesis
- Heisenberg's uncertainty principle

Chapter 24: Nuclear Physics

- Nuclear composition
  - Notation
  - Forces
  - Binding energy
  - Mass defect
  - Isotopes
- Radioactive decay
  - Alpha decay
  - Beta decay
  - Gamma decay
  - Nuclear equations
- Half life
- Applications of nuclear science

01: Introduction to Physics 1&2

Tutorial Summary:

The science of physics describes matter, energy and forces in many respects. AP Physics is to teach the science of physics at the college level.

In this tutorial, you will learn about AP Physics, its scope and topical overview. The exam prep and exam taking strategies are also introduced for the exit exam.

Tutorial Features:

- Step by step easy explanation of example problems: dimensional analysis and significant figures.
- Concept map showing inter-connections of concepts introduced.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

- What AP Physics is.
- What the AP Exam is.
- AP Physics 1 vs. 2
- AP Physics 1 Exam Content
- AP Physics 2 Exam Content
- How to Study AP Physics
- AP Test-Prep Strategies
- AP Exam-Taking Strategies

Content Review:

AP Physics:
Advanced Placement (AP) Physics is a College General Physics course offered to high school students. An exam is taken at the end to obtain a college credit.

AP Physics Courses:
There are four AP Physics courses and exams – two are taught as in a full-year curriculum and the other two in one-semester each. The exams are given in May of each year.

AP Physics 1:
This is an algebra-based one year course in high school (equivalent to 1st semester general physics in college).

AP Physics 2:
This is an algebra-based one year course in high school (equivalent to 2nd semester general physics in college).

AP Physics C - Mechanics:
It's a calculus-based one semester course in high school (equivalent to one-semester introductory college course).

AP Physics C – Electricity & Magnetism:
It's a calculus-based one semester course in high school (equivalent to one-semester introductory college course).

AP Physics Exam:
The AP Physics exam is given each May. You score from a 1 (lowest) to a 5 (highest). Each college determines how much credit is given for each score in each subject. Check the colleges you're interested in—it varies between schools and even within the same school for different AP subjects.

Topical Scope:
The test is written so that it covers every topic. They are aware that teachers often vary in which topics they include in their course—both at the HS and college level. Therefore, they do not expect you to know everything.

Question Types:
The AP Physics exam is made up of two types of questions: multiple choice and free response.

Multiple Choices:
These questions test conceptual understanding and must be completed timely. There may be information contained in a paragraph, table or figure for each question and there are 4 possible answer choices.

Free Response:
These questions may ask for a written response, interpretation of a result or to derive an expression based on the information presented.

02: Basic Math for Physics

Tutorial Summary:

Mathematics is vital to your study of physics. Algebra is needed to isolate and solve for whatever variable is desired. Physics often deals with very large, or very small values. Significant figures and scientific notation make these extreme numbers manageable.

There are often many mathematical applications in physics. Your previous knowledge of geometry, trigonometry, and graphing will all come into play with physics. These tools will be used throughout many of the topics in this series.

Tutorial Features:

- Step by step mathematical examples showing all details: solving for variables, significant figures, scientific notation, etc.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

- Using algebra to solve for a variable
- Performing calculations with significant figures
- Using scientific notation
- Geometry and trigonometry
- The quadratic formula
- Graphing
- Calculator tips

Content Review:

Algebraic operations:

If a # is … to a variable,	**then … the # to solve for the variable**	**Example**
Added	Subtract	5 = x + 2 **-2 -2** **5-2 = x**
Subtracted	Add	3 = x – 6 **+6 +6** **3-6 = x**
Multiplied	Divide	2 = 4x **1. 4** **2/4 = x**
Divided	Multiply	**2 ·** 6 = x **· 2**

		2 **2 · 6 = x**

Adding & Subtracting with significant figures:

1. Perform the calculation
2. Determine the least # of decimal places in problem
3. Round answer to that # of decimal places

Multiplying & Dividing with significant figures:

1. Perform the calculation
2. Determine the least # of sig figures in problem
3. Round answer to that # of sig figures

Scientific Notation—a short hand method of writing numbers using powers of 10.

Writing scientific notation:

1. The decimal point is always moved to after the 1st non-zero number.
2. Count the number of times the decimal point is moved and use this as the power of 10.
3. "Big" numbers (>1) have positive exponents. "Small" numbers (<1) have negative exponents.

Trigonometry review:
Trig functions are often used to find resultants and components. The most useful relationships are:

$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}} \qquad \cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}} \qquad \tan\theta = \frac{\text{opposite}}{\text{adjacent}}$$

Quadratic formula:
The quadratic formula is sometimes useful for squared functions:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Graphing:
Data is often graphed in physics. Theses relationships are often analyzed to fit mathematical models.

03: Problem Solving in Physics

Tutorial Summary:

Problem solving doesn't just apply to working out physics problems. It applies to many academic and real life topics. This tutorial gives a very general outline to help attack any type of problem.

A common difficulty with science classes is the dreaded word problem. The KUDOS method gives the student a place to start and a step by step method to begin the solution. KUDOS stands for known, unknown, definition, output, and substantiation. In addition to problem solving, this tutorial give hints to succeed on tests. Multiple choice, free response, and essay tips are all covered.

Tutorial Features:

- Step by step examples to help apply problem solving techniques.
- Graphic organizers to help convey the problem solving tips discussed.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Animated examples—worked out step by step
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

- When to follow problem-solving techniques
- A general problem-solving technique
- How to solve word problems
- How to prepare for an exam
- Tips for taking exams

Content Review:

5 step problem solving strategy:
Step 1: Identify what's being given
Step 2: Clarify what's being asked.
If necessary, rephrase the question
Step 3: Select a strategy
Trial & error, search, deductive reasoning, knowledge-based, working backwards
Step 4: Solve using the strategy
Step 5: Review the answer

KUDOS method for solving work problems:
K = Known
U = Unknown
D = Definition
O = Output
S = Substantiation

Physics exam prep tips:

- Stay ahead of the game

- Make a cheat-sheet
- Know the format of the test and information that's fair game
- Make a mock exam
- Attend the review session
- Get help early

Exam taking tips:

- Arrive early and prepared
- Listen & Read instructions carefully
- Memory dump first
- Skim the test and form a plan
- Answer questions sequentially
- Apply the guessing rule

Multiple-choice tips:

- Scan all the choices
- Avoid word confusion
- Beware of absolutes

Essay tips:

- Understand the question
- Answer the whole question and only the question
- Watch your time

Free-Response tips:

- Show partial work
- Don't forget units
- Don't be fooled by blank space

04: Describing Motion – Kinematics in One Dimension

Tutorial Summary:

This tutorial describes motion in one direction. Motion at a constant rate will be discussed. In this type of motion the velocity remains the same. Accelerated or changing motion will also be analyzed. An example of this is a falling object that continually picks up speed as it descends.

The concept of vectors and scalars will be applied. Various kinematic equations will be used to calculate various quantities in physics problems. General problem solving hints will be applied to these formulas.

Tutorial Features:

- Problem-solving techniques are used to work out the example problems.
- Easy explanation for sometimes confusing physics formulas.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Constant Velocity
- Distance
- Displacement
- Speed
- Velocity
- Average Velocity
- Constant Velocity

Constant Acceleration
- Definition
- Formula
- Units
- Free Fall

Content Review:

Kinematics:
The mathematical description of motion without any reference to the cause. The cause of this motion will be described in a later tutorial.

Vector:
A quantity that has magnitude, size, and direction. Velocity and displacement are examples.

Scalar:
A quantity that has only magnitude, or size. Speed, distance, and time are examples.

Instantaneous velocity:

The speed of an object at any particular instant.

Average velocity: The total distance traveled divided by the total time of travel.

Acceleration: The rate of change of velocity. Acceleration describes how fast an objects speed is changing per amount of time.

Kinematic Equations:
Formulas that relate the variables of motion.

- $v=d/t$
- $a = \Delta v/\Delta t=(v_f-v_i)/t$
- $d=v_it+at^2/2$
- $v_f^2=v_i^2+2ad$
- acceleration due to gravity = $-9.8\ m/s^2$

Free Fall: Motion where gravity is the only force acting on an object. Gravity will accelerate an object at -9.8 meters per second per second.

05: Kinematics in Two Dimensions and Vectors

Tutorial Summary:

This tutorial describes motion in two dimensions. The concepts of vector and scalar will be emphasized, espically vector addition and vector components. These ideas will be applied to various projectile or motion in 2 dimension problems.

In these examples you will see how gravity only affects the vertical motion of a projectile. Any horizontal motion of a projectile will remain unchanged as long as air resistance is neglected. You will also see how to apply revious kinematic formulas to these new 2 dimensional situations.

Tutorial Features:

- Graphically see vectors added or broken into components.
- Problem-solving techniques are used to work out the example problems.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Animated examples—worked out step by step
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Vectors
- Definiton and notation
- Addition of vectors
- Components

Projectile Motion
- Horizontally fired projectile, detailed examples
- Angled projectile, detailed examples

Content Review:

Vector:
A quantity that has magnitude, size, and direction. Velocity and displacement are examples.

Scalar:
A quantity that has only magnitude, or size. Speed, distance, and time are examples.

Vector Addition:
When vectors are graphically added, they are drawn head to tail. This may also be described as placing the arrowhead of one vector next to the tail end of another vector.

Resultant:
The result of adding two or more vectors; vector sum. It is drawn from the tail of the first vector to the tip of the last vector.

Phythagorean Theorem:
$c^2=a^2+b^2$

Vector Component:

The parts into which a vector can be separated and that act in different directions from the vector.

Horizontal Motion of a Projectile:

- Since gravity acts only vertically, there is 0 acceleration.
- Horizontally, the projectile moves with a constant speed.
- We can use one of the previous kinematic formulas $v=d/t$

Vertical Motion of a Projectile:
Use previous kinematic formulas in the vertical direction.

- $a = \Delta v/\Delta t=(v_f-v_i)/t$
- $d=v_it+at^2/2$
- $v_f^2=v_i^2+2ad$
- acceleration due to gravity = $-9.8\ m/s^2$

06: Force and Motion - Newton's Laws

Tutorial Summary:

This tutorial will describe Newton's three laws of motion. These simple, but very powerful statements can describe a great deal of the behavior of motion.

Additionally, the concept of equilibrium will be discussed. This is a situation where the net force on an object is zero. In situations like this, forces such as friction and air resistance may come into play. Both of these forces tend to slow, or resist any movement. Finally, dynamics problems will be addressed. Here, there is no equilibrium. There is a net force exerted on something that causes an acceleration.

Tutorial Features:

- Graphically see force diagrams with animated components, especially the inclined plane problems.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Newton's Laws
- Inertia
- Net Force
- Action and reaction forces

Equilibrium
- Dynamic equilibrium
- Static equilibrium

Resisting Forces
- Friction
- Air resistance

Dynamics Problems

Content Review:

Newton's 1st law:
Inertia, the tendency to continue in a given state.

Newton's 2nd law:
The acceleration of an object is directly proportional to the net force, and inversely proportional to the mass. F=ma

Newton's 3rd law:
For every force, there is an equal and opposite force.

One Newton:
The force need to accelerate 1kg at 1 m/s/s.

Normal Force:
A reaction force pointing perpendicular to the surface.

Equilibrium:
When all the forces on an object balance out, or cancel out, the object has a net force of 0.

Static Equilibrium:
When an object is in equilibrium, and not moving, this is called static equilibrium.

Dynamic Equilibrium:
An object moving at a constant velocity; no net force acting on it.

Friction:
A force that always opposes motion.

Coefficient of friction:
The ratio between the frictional force and the normal force.

07: Work, Power and Energy

Tutorial Summary:

This tutorial will show you how to calculate work. Additionally, if the time taken to complete this work is known, the power generated can be found too. Work is related to energy. In fact, work is defined as the change in energy. This is the work energy theorem. This energy can come in many forms.

Two of the main types of mechanical energy are kinetic and potential. Kinetic energy is energy of motion, while potential energy is stored energy. In many situations, conservation of energy can be applied to help solve problems. This says that energy isn't created or destroyed, just transferred from one type to another.

Tutorial Features:

- Problem-solving techniques are used to work out and illustrate the example problems, step by step.
- Easy explanation for sometimes confusing physics formulas.
- Animation showing conservation of energy by a skydiver.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Work
- Direction of force
- Sign conventions

Power
- Calculation of power

Energy
- Kinetic energy
- Potential energy
- Work energy theorem
- Conservation of energy

Content Review:

Work:
The work, W, done by a constant force on an object is defined as the product of the component of the force along the direction of displacement and the magnitude of the displacement.

Calculation of Work:
When calculating work, only the force that is applied in the direction of motion is considered. $W=Fd\cos\theta$

Postive Work:
If the force and displacement are in the same direction, that would be considered positive work.

Power:
Power is a measure of how quickly work is done.

Kinetic Energy:
Kinetic energy is energy of motion. All moving object possess kinetic energy.

Gravitational Potential Energy:
Gravitational Potential energy is the energy an object possessed due to its position.

Base Level:
The point that height is measured from. Any point can be used as a base level because the energy amount you calculate will be relative.

Conservation of Energy:
Energy cannot be created or destroyed; it may be transformed from one form into another, but the total amount of energy never changes.

08: Momentum and Collisions

Tutorial Summary:

This tutorial describes the concept of momentum. This is very similar to inertia in motion. Once a moving object has momentum, it may be changed and brought to a halt. This change in momentum is called impulse. Anytime there is some type of collision or interaction, momentum is transferred.

This tutorial describes three main types of momentum collisions: hit and stick, hit and rebound, and explosion. In all of these, the conservation of momentum is observed. Momentum isn't created or destroyed, its just transferred from one item to the next.

Tutorial Features:

- Problem-solving techniques are used to work out and illustrate the example problems, step by step.
- Animated diagrams to accompany example problems, specifically vector diagrams to show conservation of momentum in 2 dimensions.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Momentum
- Definition
- Formula

Impulse
- Formula
- Examples
- Bouncing versus sticking

Conservation of momentum
- Collsions
- Inelastic versus elastic collisions
- 2 dimensional collisions

Content Review:

Momentum: Momemtum may be described as inertia in motion. It is the product of mass times velocity. $P = mv$

Impulse: A change in the momentum of an object. It is the product of force times time. $J=Ft$ The impulse may occur over a long or short time period, and with a large or small force applied to make the change in momentum.

Conservation of momentum: Momentum isn't created or destroyed in a given system. It may be transferred from one object to another. Only an outside or external force will change the total momentum.

- When comparing a bouncing collision to a collision where an object is brought to a halt, the bouncing object experiences a much larger impulse.

- A hit and stick collision is when one object impacts another, then they stay as one.
- A hit and rebound collision is when one object hits another and they both remain separate.
- An explosion collision is when an object breaks apart. It may not necessarily be an explosion.

Elastic collision: An elastic collision is one where:
- Momentum is conserved.
- The objects colliding aren't deformed or smashed
- Thus no kinetic energy is lost; kinetic energy is conserved also.
- *Ex:* billiard ball collisions

Inelastic collisions: An inelastic collsion is one where:
- Momentum is still conserved, but kinetic energy is lost.
- The lost kinetic energy will be transformed into other types.
- The objects often interlock and stick together, they may also be deformed and mangled.
- Ex: car crash

09: Circular Motion and Gravitation

Tutorial Summary:

Gravity is a force that you notice almost everyday. This tutorial explains how to calculate or quantify that force. The gravitational inverse square law depends upon the masses involved, and the distant between them. A universal gravitational constant is also needed.

In previous tutorials, motion in a line was extensively described. However, motion in a circle is also very common. The rate at which an object moves in a circular path is described by rotational speed. The rate at which its direction changes in that circular path is called centripetal acceleration. The force that provides this acceleration is called centripetal force. For motion in a circle, the dirction of motion is main quantity that will be described.

Tutorial Features:

- Problem-solving techniques are used to work out and illustrate the example problems, step by step.
- Vector diagrams showing force components for a car traveling around a banked curve.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Gravity
- Formula
- Gravitational constant
- Gravitational fields
- Gravitational pull at various points on Earth

Circular Motion
- Linear speed versus rotational speed
- Centripetal acceleration
- Centripetal force
- Centrifugal force
- Banked roads
- Simulated gravity

Content Review:

Universal law of gravitation:
The mathematical formula that relates the pull of gravity between two massive objects that are some distance apart. $F_g=Gm_1m_2/d^2$

Gravitation constant:
A proportionality constant that relates the strength of gravitational attraction in Newton's law of universal gravitation. $G=6.67\text{x}10^{-11}Nm^2/kg^2$ This value always remains constant.

Gravitational field:

The map of influence that a massive body extends into space around itself.

Rotational speed:
Number of rotations or revolutions per unit of time, often measured in rpm, revolutions per minute. Linear speed is the straight path distance moved per unit of time, also referred to as tangential speed.

Centripetal acceleration:
The acceleration that describes the change in direction for an object in a circular path.

Centripetal force:
A center seeking force for an object moving in a circular path.

Centrifugal force:
An apparent, but nonexistent, outward pointing force for an object moving in a circular path. A rotating object may seem to be pushed outward, but actually must be pulled inward in order to maintain any circular path.

10: Rotational Motion and Equilibrium

Tutorial Summary:

Instead of moving in a straight line, many object rotate. This rotation can be described with terms and formulas that are analogous to linear motion descriptors. For example, in linear motion a force causes a mass to accelerate.

In rotational motion, a torque causes a mass with some amount of rotational inertia, to exhibit angular acceleration. The concepts are very similar. Also, just as an object could be in equilibrium when the forces on it add up to zero, an object can be in rotational equilibrium when the net torque on it is zero. When studying these new concepts, apply your previous knowledge of linear motion.

Tutorial Features:

- Diagrams to illustrate the lever arms, angles, and other quantities encountered in problems.
- Animated diagrams to actually show the rotational motion.
- Problem-solving techniques are used to work out and illustrate the example problems, step by step.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Angular motion compared to linear motion
- Angular displacement, angle
- Angular speed
- Angular acceleration
- Related formulas

Torque
- Units
- Direction
- Applications

Moment of Inertia
- Description
- Example
- Formulas

Rotational Equilibrium

Angular Momentum
- Formula
- Conservation of angular momentum
- Examples

Content Review:

Radian:

A unit of rotational displacement; one revolution equals 2 π radians.

Angular Velocity:
Also called rotational speed, the number of rotations or revolutions per unit of time, often measured in rpm, revolutions per minute.

Table of rotational motion formulas, and the related linear motion formulas:

Linear motion formula	Rotational motion formula
$v = \frac{d}{t}$	$\omega = \frac{\Delta\theta}{\Delta t}$
$a = \frac{\Delta v}{\Delta t}$	$\alpha = \frac{\Delta\omega}{\Delta t}$
$d = v_i t + at^2/2$	$\theta = \omega_i t + \alpha t^2/2$
$v_f^2 = v_i^2 + 2ad$	$\omega_f^2 = \omega_i^2 + 2\alpha\theta$

Torque:
The rotational quantity that causes rotation; the product of force times lever arm.

Moment of inertia:
Also called rotational inertia, The rotational equivalent of linear inertia; a measure of the ease of rotating some object.

Newton's second law for rotational motion:

$\Sigma \tau = I \alpha$ The sum of the torques is equal to the rotational inertia times the angular acceleration.

Rotational Equilibrium:
The situation when the net torque on an object equals zero.

Angular momentum:
The rotational equivalent of linear momentum that describes the tendency of an object to continue rotating.

11: Vibrations and Waves

Tutorial Summary:

Periodic motion likes waves come in many types. Mechanical waves need a medium to travel, electromagnetic waves don't. Transverse waves vibrate perpendicular to the wave motion, longitudinal waves parallel. Even a simple swinging pendulum exhibits wave behavior.

All of these waves can be described in certain ways. They all have speed, frequency, period, amplitude and wavelength. Wave can also combine, or superimpose with each other. This phenomena leads to interference. This can be constructive or destructive interference. In some situations where there is a boundary to reflect from, this leads to a standing wave that seems to sit in one location. This creates points of no movement, nodes, and points of maximum movement, antinodes.

Tutorial Features:

- Animations to illustrate the dynamic properties of waves.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Simple harmonic motion
- Vibration
- Displacement
- Amplitude
- Period
- Frequency
- Angular frequency
- Phase
- Uniform circular motion
- Pendulums
- Oscillating springs
- Resonance

Wave motion
- Mechanical vs. electromagnetic waves
- Transverse vs. longitudinal waves
- Wave speed

Wave superposition
- Interference
- Wave reflection
- Standing waves
- Nodes and antinodes

Content Review:

Amplitude:
The maximum displacement of the body in vibration.

Period:
The time taken by a body to complete one vibration.

Frequency:
Frequency is the number of oscillations completed in a unit time
(f = 1/T).

Resonance:
The natural frequency of a body executing forced vibrations is equal to the input frequency. The body vibrates with maximum amplitude. The frequency is called resonant frequency

Mechanical Wave:
A mechanical wave is just a disturbance that propagates through a medium

Electromagnetic Wave:
An electromagnetic wave is simply light of a visible or invisible wavelength. Oscillating intertwined electric and magnetic fields comprise light. Light can travel without medium.

Transverse Wave:
In a transverse wave the particles in the medium move perpendicular to the direction of the wave. Eg. Light waves, waves on strings.

Longitudinal Wave:
The particles in the medium move parallel to the direction of the wave. Eg. Sound waves

Interference:
The superposition of two waves of the same frequency and wavelength traveling with a phase difference which remains constant with time. This phenomenon is called interference. The pattern so formed is called interference pattern.

Standing Wave:
Superposition of two waves of same amplitude and wavelength moving in opposite direction with no energy propagation.

Nodes:
The points of no displacement when standing waves are formed.

Antinodes:
The points along the medium which vibrate back and forth with maximum displacement.

12: Sound

Tutorial Summary:

Sound is one of the most important waves to us. It is both a transverse and longitudinal wave. It exhibits all the regular features of other types of waves. We can describe its frequency and period as it relates to the pitch of a sound heard. We can describe its amplitude as it relates to the intensity or loudness of a sound heard. Sound can travel through a variety of substances, but it must be traveling through something as it is a mechanical wave.

There are a variety of mathematical formulas to find the speed of sound through a particular substance. Many times sound waves reflect off hard surfaces. This is called an echo. We can use the Doppler effect for various applications. This relates the change in frequency of a wave to the speed of a moving wave source or wave observer.

Tutorial Features:

- Several example problems with step by step illustrations of solutions.
- Animations showing wave motion as it relates to sound.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

The nature of sound
- Our ears
- Audible and inaudible sounds
- Speed of sound
- Types of waves
- Speed of various sounds

Properties of sound
- Intensity
- Pitch
- Octaves

Beats

The Doppler effect
- Definition
- Formula
- Applications

Echoes

Diffraction

Content Review:

Audible sounds:

The audio spectrum extends from approximately 20Hz to 20,000 Hz.Sounds of frequency between 20Hz and 20,000Hz can be heard by human ear

Infrasonic sounds:

Sounds of frequency less than 20Hz are called "infrasonics".

Ultrasonic sounds:
Sounds of frequency greater than 20,000Hz are called"ultrasonics".
Ex: Sound produced by bats.

Nodes:
The points of no displacement when standing waves are formed.

Antinodes:
The points along the medium which vibrate back and forth with maximum displacement.

Sound Intensity:
The loudness of sound is directly proportional to the square of the amplitude or intensity (I).
It is convenient to use a logarithmic scale to determine the intensity level $\beta = 10 \log (I/I_0)$

Pitch:
Pitch is the highest or lowest sound an object makes.

Beats:
Beats are the periodic and repeating fluctuations heard in the intensity of a sound. Two sound waves of nearly same frequencies interfere with one another to produce beats
The intensity of the resultant wave at a given point in the medium becomes maximum (waxes) and minimum (wanes) periodically.

Doppler Effect:
The apparent change in the frequency of sound due to relative motion between the sound source and observer is called Doppler Effect.

Echoes:
The sound obtained by reflection at a wall, cliff or a mountain is called an echo.

Diffraction:
When waves encounter an obstacle with an edge, some of the wave energy bends around the edge behind the obstacle. This bending is called diffraction.

13: Electrostatics

Tutorial Summary:

Electrostatics describes the state of non moving charges. These charges originate from electron movement. Electrons may be added or removed from some object, but overall charge amount must be conserved.

Like charges will repel, and opposite charges attract. This force can be calculated using Coulomb's law. The scope of this electric force can be shown or visualized with an electric field. Electric potential is a quantity that describes the amount of electric potential energy per amount of charge.

Tutorial Features:

- Animation of the concept of charging by induction; shows the movement of charges.
- Animation of the polarization of a neutral object; shows the movement of charges.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

The nature of electric charge
- Charged particles
- Charge movement
  - Charging by contact
  - Charging by induction

Electric Forces
- Coulomb's law
  - Formula
  - Examples
- Electric Fields
- Polarization

Electric Potential
- Definition
- Units
- Diagram
- Formula

Content Review:

Electric Charge:
A fundamental intrinsic property of matter that gives rise to the attractions and repulsions between electrons and protons.

Coulomb:
The typical unit for measuring charge; a set number of electrons. 1 Coulomb = 6.25×10^{18} electrons

Charging by Contact:
The transfer of electric charge from one object to another by simple contact or conduction.

Charging by Induction:
Redistribution or charging of an object by bringing a charged item in close proximity to, but not touching, an uncharged object.

Coulomb's Law:
Mathematical relationship between electric force, charge, and distance. The electric force varies directly with the product of the charges, and inversedly to the square of the distance between the charges.

Polarization:
Separation or alignment of the charges in a neutral body so that like charges are grouped together, resulting in a positive and a negative region.

Electric Field:
A force field that fills the space near any charge.

Electric Potential:
The ratio of electric potential energy to electric charge at a particular spot in an electric field. It is often referred to as voltage since it is measured in volts.

Equipotential Line:
A line where all points have an equal electric potential, or voltage.

14: Electric Circuits

Tutorial Summary:

Electric circuits come in a variety of styles. Regardless of the type, Ohm's law can be used to find a few basic quantities. Voltage is equal to current times resistance. Also, power can be calculated by current times voltage. When circuit components are arranged one after another in a loop, this is a series circuit. When the components are arranged in separate, independent connections to the voltage source, that is a parallel connection.

For more complex circuits, with multiple loops or multiple voltage sources, Kirchoff's laws are the answer. The junction rule says that charge is conserved. The loop rule says that energy or voltage is conserved.

Tutorial Features:

- Step by step calculation of complex Kirchoff's laws problems.
- Circuits diagrams simplified into less complex circuits.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Animated examples—worked out step by step
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Ohm's law
- Circuit diagrams
- Alternating current
- Direct current
- Internal resistance

Electric power
- Formula
- Example calculations

Series circuits
- Resistors combined in series
- Current and voltage characteristics
- Example calculations

Parallel circuits
- Resistors combined in parallel
- Current and voltage characteristics
- Example calculations

Kirchoff's laws
- Junction rule
- Loop rule

Content Review:

Current:
Electrical charge flow past a given point per unit of time.

Direct current:
Electrical current that flows in only one direction.

Alternating current:
Electrical current that oscillates forward and backwards.

Voltage:
The ratio of electric potential energy to electric charge at a particular spot in an electric field. It is often referred to as voltage since it is measured in volts.

Ohm's law:
Basic law that describe current electricity; Voltage equals current times resistance.

Internal resistance:
Resistance from the processes inside a voltage source; reistance due to the battery itself.

Series circuit:
A circuit where the components form one continuous loop. The current is constant throughout.

Parallel circuit:
A circuit where each component is connected to form its own separate independent branch. The voltage is constant throughout.

Fuse/Circuit breaker:
A safety device designed to melt or disconnect a circuit after a predetermined amount of current is exceeded.

Junction rule:
A restatement of conservation of charge; the current going into a junction must equal the current going out of the junction.

Loop rule:
A restatement of conservation of energy; the sum of all voltages in the elements of a loop is zero.

15: Conductors, Capacitors and Dielectrics

Tutorial Summary:

Materials may conductor charge flow, resist charge flow, or some variation between those two. The resistance of a piece of wire depends upon several factors: the type of material, the length of wire, the cross section of wire, and the temperature of the wire.

Capacitors are oppositely charged sections of conductors held near each other. Although they have a net charge, they store energy due to the proximity of the oppositely charged plates. The strength or capacitance of a capacitor depends on the area of the plates, the distance between them, and a constant. This capacitance could also be increased by adding an insulating material between the plates. This is called a dielectric.

Tutorial Features:

- Animated diagram of a capacitor charging and discharging.
- Problem-solving techniques are used to work out and illustrate the example problems, step by step.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Animated examples—worked out step by step
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Conductors
- Conductors
- Insulator
- Semiconductors
- Superconductors
- Resistance of a piece of wire

Capacitors
- Definition
- Units
- Diagram
- Charge stored in a capacitor

Dielectrics
- Polarization
- Dielectric constant

Content Review:

Conductor:
Material where electrons are loosely bound and are able to flow throughout due to the free electrons.

Insulator:
Materials where electrons are bound and don't flow easily.

Semiconductor:
Materials in between insulator and conductor.

Superconductor:
A material where electrons flow without any resistance. Generally, superconductivity only occurs at very low temperatures.

Resistivity:
An intrinsic property of a material that partially determines the resistance of a wire.

Capacitor:
A device used to store or accumulate electric energy. This is done by oppositely charging two nearby conductive surfaces that are not in contact with each other.

Dielectric:
An insulating material is inserted between the plates of a capacitor.

Dielectric Constant:
The factor that describes the additional capacitance gained by adding a dielectric material between the plates of a capacitor.

16: Magnetic Fields

Tutorial Summary:

Magnetism is a naturally occurring phenomena. In most materials, the magnetic domains are randomly aligned. However, in some cases, they are all aligned to produce a magnet. This creates a magnetic field that extends around the object, moving from North to South. A magnetic field can also be created from a moving charge, or current.
The right hand rule is used to visualize this field. When a charge moves through an existing magnetic field, a magnetic force is exerted on it. There are many examples in science and technology that utilize magnetism.

Tutorial Features:

- Diagrams showing various magnetic fields.
- Illustrations showing all aspects of the right hand rule.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Magnetism in nature
- Magnetic domains
- Ferromagnetism
- Magnetic field diagrams

Magnetism, force and moving charge
- Right hand rule
- Magnetic field notation
- Magnetic force on a current carrying wire
- Magnetic force on a moving charged particle

Magnetism in technology
- Mass spectrometer
- Speakers, MRIs, and magnetic media

Content Review:

Magnetic Domain:
Microscopic areas of atoms where the magnetic fields are aligned.

Ferromagnetic:
A naturally magnetic class of materials where the magnetic domains are ordered and do not cancel out.

Magnetic Field:
Lines showing the shape and extent of a magnetic field around a permanent magnet or a moving charged object. To signify a field coming directly out of the plane of a page, dots are used. To signify a field going directly into the page, an X is used.

Right Hand Rule. RHR:
1. The fingers extend or curl in the direction of the magnetic field.

2. The outstretched thumb points in the direction of conventional current, or the direction of a positively charged moving particle.
3. A line perpendicular to the palm indicates the direction of the magnetic force.

Mass Spectrometer:
A device that magnetically separates charged ions according to their mass. A magnetic field is used to accomplish this separation.

17: Electromagnetism

Tutorial Summary:

Magnetic flux describes the number of magnetic field lines passing through a particular area. This idea is similar to rain falling through a hula hoop. Faraday's law describes the induced electromotive force as the change in flux per amount of time. Lenz's law describes the direction of that induced current.

Again, the right hand rule can be utilized. A conductor moving through a magnetic field can also create an induced electromotive force. These concepts are the basis for an electric generator. Mechanical motion is converted into electric energy.

Tutorial Features:

- Animation showing the relationship between magnetic flux and the induced current.
- Diagrams and animations showing induced emfs in moving conductors.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Animated examples—worked out step by step
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Magnetic flux
- Formula
- Angle
- Units
- Hoop analogy
- Example

Faraday's law
- Formula
- Induced electromotive force
- Example

Lenz's law
- Right hand rule application
- Examples

Electromotive force in a moving conductor
Applications

Content Review:

Magnetic flux:
A measurement of the number of magnetic field lines passing through a particular area or surface.

Faraday's law:
The voltage induced is directly proportionoal to the number of loops and the change in the magnetic flux. It is inversely proportional to the time that this change occurs throughout.

Lenz's law:
The induced emf always gives rise to a current whose magnetic flux opposed the original change in magnetic flux. Thus, the induced current tries to maintain the level of magnetic

flux.

Electromotive force:
A voltage that gives rise to a current flow. This voltage can be induced or created by a changing magnetic field.

Right hand rule, RHR:
The fingers extend or curl in the direction of the magnetic field. The outstretched thumb points in the direction of conventional current.

Generator:
A machine that produces electricity by a rotating coil of wire immersed in a stationary magnetic field. This rotating motion could be obtained from a variety of sources.

18: Solids and Fluids

Tutorial Summary:

This tutorial covers two topics, solids and fluids. The difference between the ordered atomic structure of crystalline solids, and the random nature of amorphous solids is discussed. Other properties of solids like thermal expansion and various deformations of solids are covered too.

Next the nature of fluids is described through key concepts like Pascal's, Archimede's, and Bernoulli's principle. Finally, fluid flow is described. Smooth laminar flow and chaotic turbulent flow are contrasted. This idea is extended with Bernoulli's equation which describes the relationship between the pressure, kinetic and potential energy in a system as a constant.

Tutorial Features:

- Example problems with step by step solutions and accompanying diagrams to help illustrate the usage of complex formulas.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

States of matter
Solids and elasticity
    Crystalline and amorphous
Thermal expansion
Deformation of solids
    Young's modulus
    Shear modulus
    Bulk modulus
Fluids
    Pascal's principle
    Buoyancy and Archimedes principle
    Surface tension
    Capillary action
Fluids in motion
    Viscosity
    Continuity
    Laminar and turbulent flow
    Bernoulli's equation

Content Review:

Matter:
Anything that has mass and takes up space.

Crystalline:
Solids with ordered atom-structure and fixed melting point.

Amorphous:
Solids with in ordered atom-structure and without melting point.

Young's modulus:
Ratio of stress to strain when solids is under tension.

Shear modulus:
Ratio of stress to strain when solids is under shear.

Bulk modulus:
Ratio of stress to strain when solids is under hydraulic pressure.

Buoyancy:
The force caused by pressure variation with depth to lift immersed objects.

Surface tension:
The force to attract surfaced molecular to make the surface area of fluid as small as possible.

Capillary action:
The phenomena of fluids automatically raising in open-ended tubes.

Continuity:
The net rate of flow of mass inward across any closed surface is equal to the rate of increase of the mass within the surface.

Viscosity:
The inter-friction mechanism in fluid to dissipate energy.

Laminar flow:
Every particle passing a particular point moves exactly along the smooth path followed by particles passing that point early.

Turbulent flow:
The irregular flow when the velocity of the flow is high.

19: Temperature and Kinetic Theory of Gases

Tutorial Summary:

This tutorial describes gas in a variety of ways. Initially the role of temperature is described. As a gas is heated, it moves more and possesses more kinetic energy. It may expand depending upon the container. There are a variety of mathematical ways to describe the motion and behavior of gases.

Avogadro's, Boyles', and Charles' law may be transformed into the combined gas law. The ideal gas law further unifies these ideas into one useful formula package. Although not all gasses behave as if they were ideal, there are corrections that can be applied to create the real gas law. Finally, the concepts of diffusion and effusion are described. Respectively, these are the spreading of gas through space, or a tiny hole.

Tutorial Features:

- Graphic organizers to illustrate concept relationships.
- Example problems with notions and hints for difficult sections.
- Pneumonic memory device for the ideal gas law.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Temperature and kinetic energy of gasses
Temperature Scales
  Fahrenheit
  Celsius
  Kelvin and absolute zero
Kinetic Molecular Theory
  Assumptions
  Number of molecules
  Pressure
  Temperature
Atmospheric pressure
Pressure in a container
Gas Laws and combined gas law
Ideal gas law
Molar mass and density
Real gas law
Molecular motion
Diffusion and effusion

Content Review:

Kinetic Molecular Theory (KMT):
An attempt to explain gas behavior.

Kelvin (K):

Temperature scale used in gas calculations. Has an absolute zero. °C + 273 = K

Pressure:
Force of gas molecules colliding with surfaces

Atmospheric pressure:
Pressure due to the layers of air in the atmosphere

Standard Temperature and pressure:
1 atm (or anything it's equal to) and 0°C (273 K)

Ideal Gas:
All assumptions of the kinetic molecular theory are true.

Molar Mass (Molecular Mass):
Grams per mole for a molecule.

Density:
Mass per volume of a sample

Average Translational Kinetic Energy (KE_{ave}):
Average kinetic energy (energy due to motion) of each particle.

Root-Mean-Square Speed (V_{rms}):
One measure of average particle speed in a gas

Maxwell's Probability Distribution:
Probability function that indicates the probability that a particle in a gas will be moving at a certain speed.

Real Gas:
Real gases have significant particle volume and significant attractions/repulsions

Diffusion:
The rate at which a gas travels through a container

Effusion:
The rate at which a gas escapes through a tiny hole

20: Heat and Thermodynamics

Tutorial Summary:

This tutorial is all about heat. First, the expansion effects of heat are described. Materials can expand linearly, or over some volume. Next, the some methods of describing heat added to materials are described. For example, specific heat tells the amount of heat needed to raise the temperature of a particular substance. Heats of vaporization and fusion describe the heat needed for phase changes.

Next, the laws of thermodynamics are described. The 0^{th} law says that objects in thermal equilibrium have the same temperature and no heat is exchanged. The 1^{st} law says that energy isn't created or destroyed, it changed from one form to another. The 2^{nd} law says that the disorder, or entropy, of the universe won't decrease. It will either increase or stay the same.

Tutorial Features:

- Animated diagrams showing thermal processes
- Graphic organizers to illustrate concept relationships.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Temperature
- Expansion, linear and volume
- Thermometers and thermostats

Energy in thermal processes
- Heat and internal energy equation
- State functions
- Specific heat and heat capacity
- Endothermic and exothermic
- Calorimetry
- Phase changes

Laws of thermodynamics
- Thermal equilibrium and the 0^{th} law
- Pressure volume and work
- 1^{st} law of thermodynamics
  - Adiabatic
  - Constant volume
  - Cyclical engines
  - Entropy
- 2^{nd} law of thermodynamics

Content Review:

Thermodynamics:
Study of heat changes.

Temperature (T):

Proportional to the average kinetic energy of the particles. The higher the temperature the faster the molecules move.

Linear Expansion Coefficient (α):
Linear expansion of a material per °C increase in temperature.

Volume Expansion Coefficient (ß):
Volume expansion of a material per °C increase in temperature.

Endothermic reaction:
Energy is absorbed into the system from the surroundings.

Exothermic reaction:
Energy is released from the system into the surroundings.

Specific Heat Capacity (C_p):
Amount of energy that 1 gram of material can absorb before increasing in temperature.
C_p for water: 4.18 J or 1.00 cal

Enthalpy of fusion (L_{fus}):
Energy needed to break enough intermolecular forces to change a solid into a liquid

Enthalpy of vaporization (L_{vap}):
Energy needed to break the intermolecular forces to change a liquid into a gas.

Thermal Equilibrium:
Two objects at different temperatures will come to the same temperature when placed together.

Zeroth Law of Thermodynamics:
Objects in thermal equilibrium are at the same temperature. Objects in contact will eventually come to thermal equilibrium.

1^{st} Law of Thermodynamics (Law of Conservation of Energy):
Energy cannot be created nor destroyed in a chemical or physical process.

Calorimetry:
Energy lost/gained from the system is equal & opposite to that lost/gaines from the surroundings

Entropy (S):
Disorder or random-ness

2^{nd} Law of Thermodynamics:
The total entropy of the universe can never decrease.

21: Physical Optics

Tutorial Summary:

The electromagnetic spectrum describes the wide variety of light observed. Light can behave as a particle, or a wave. In this tutorial topic, the wave nature of light is emphasized. Young's double slit experiment shows how light can constructively and destructively interfere. The alternating bright and dark fringes are explained mathematically.

Diffraction grating of multiple slits also exhibit similar behavior. Another wave feature of light is polarization. Because light is a transverse wave, it can be polarized to vibrate in only one direction. This can be accomplished with polarizing filters. Malus' law describes the reduced light intensity caused by a pair of polarizing filters.

Tutorial Features:

- Diagram showing interference during Young's double slit experiment.
- Examples with step by step assistance to solve problems.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Electromagnetic spectrum
- Electromagnetic waves
- Speed of light calculations

Principle of superposition
- Constructive interference
- Destructive interference

Coherent and monochromatic light

Young's double slit experiment
- Maxima positions
- Minima positions
- Formulas
- Examples

Diffraction gratings
- Formula
- Examples

Polarization
- Unpolarized light
- Filters
- Malus' law

Content Review:

Electromagnetic spectrum:
A diagram that illustrates all the varieties of electromagnetic waves based on their relative frequency/wavelengths. Our eyes observe only a small amount of this spectrum.

Speed of light:
In a vacuum $3x10^8$ m/s. It was first calculated by Olaus Roemer. Albert Michelson also performed an experiment to refine the value.

Principle of superposition:
When two or more waves occupy the same region of space simultaneously, the resulting wave disturbance is the sum of separate waves.

Constructive interference:
Two or more waves superimposing to create a resulting wave that has a larger amplitude.

Destructive interference:
Two or more waves superimposing to create a resulting wave that has a smaller amplitude.

Thin film interference:
The principle that creates colors on thin layers of transparent substances. The light reflecting off the interior of the substance interferes with light reflecting off the exterior.

Coherent light:
Light wave that are all in phase or in step.

Monochromatic light:
Light waves that possess the same frequency, color, or wavelength.

Diffraction:
The bending of waves around obstacles, corners, or openings.

Polarized light:
Light where the electric field fluctuates in only one direction.

22: Geometric Optics

Tutorial Summary:

Light can reflect as it bounces off a sufficiently smooth barrier. In doing this, it will obey the law of reflection that says the incident angle is equal to the reflected angle. Reflection can also occur for curved mirrors, both convex and concave. In these instances, real or virtual images can be formed. Ray diagrams can be used to trace the behavior of light and determine the image. The mirror formula can also be used to calculate variables. When light passes into transparent materials, it may refract or bend. Snell's law describes this quantitatively.

Sometimes the light is bend so much that it doesn't emerge from the transparent material. This is called total internal reflection. This bending of light is the basic behind the operation of a lens. Convex and concave lenses can form real and virtual images too. Again, both ray diagrams and the lens equation can be used to describe the resulting image.

Tutorial Features:

- Many animated ray diagrams for mirrors and lenses showing image formation.
- Examples with step by step assistance to solve problems.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Animated examples—worked out step by step
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Plane mirrors
- Law of reflection
- Virtual images
- Diffuse reflection
- Importance or wavelength

Curved mirrors
- Concave mirror ray diagram
- Convex mirror ray diagram
- Mirror equation and example
- Magnification equation and example

Refraction
- Index of refraction
- Refraction example and analogy
- Snell's law
- Dispersion
- Total internal reflection
- Fiber optics

Lenses
- Convex lens ray diagram
- Concave lens ray diagram
- Lens equation and example
- Lens combinations
- Lens defects

Content Review:

Law of reflection:
The angle of incidence equals the angle of reflection.

Diffuse reflection:
Reflection from a rough surface where variations in the direction of the surface cause light to reflect in different directions.

Convex mirror:
Also called a diverging mirror, a surface that diverges light as if it originates from a point behind the mirror, a focal point.

Concave mirror:
Also, called a converging mirror, a surface that converges light to a single point, focal point.

Real image:
An image where the rays of light actually meet at a location. It can be projected onto a screen.

Virtual image:
An image that cannot be projected onto a screen. The rays of light don't actually converge there, they just seem to originate from that location.

Refraction:
The bending of light due to its change in velocity in various media.

Index of refraction:
The ratio between the speed of light in a vacuum and a particular medium.

Snell's law:
The formula that describes the amount of refraction of light based on the two different media and the angle of the light ray: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

Total internal reflection:
The complete reflection of light when it strikes the boundary between two media at greater than a critical angle.

Convex lens:
A converging lens that gathers incoming light to a single focal point.

Concave lens:
A diverging lens that diverges light as if it originates from a point behing the lens, the focal point.

Spherical aberration:
A lens defect where light is imperfectly focused near the focal point.

Chromatic aberration:
A lens defect where various color focus at different locations.

23: Atomic Physics

Tutorial Summary:

Atomic physics deals with the structure and behavior of the atom. One of the most elementary and important parts of the atom is the electron. It was discovered in 1897 by J. J. Thomson. The behavior of these electrons, and thus the whole atom itself, was described by the Bohr theory of the atom. This said the electrons occupy certain discrete, quantized orbits. They cannot occupy the areas in between the set orbits. This unusual explanation explains atomic spectra observations very well.

Another important aspect of atomic structure is the wave particle duality. Sometimes light can behave as a wave, other times as a particle. The same can be said of matter. Louis deBroglie explained how particles can have wave attributes like a wavelength. These ideas, along with other contributions, helped explain the structure of the atom.

Tutorial Features:

- Animations of the discovery of electrons, the Bohr model of the atom, and electron transitions.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

The discovery of electrons
The Bohr model of the atom
    Postulates
    Radii and energy level values
    Quantization
    Spectrum explanation
X rays
    Characteristics
    Production
The wave nature of matter
    Particle and wave duality
    Formulas
deBroglie hypothesis
Heisenberg's uncertainty principle

Content Review:

Electron:
Electron was discovered during experiments on the discharge of electricity through rarified gases. The magnitude of electric charge (e) was determined by Millikan. Charge of the electron = 1.602 $X10^{-19}$ coulomb

Bohr Model of the Atom:
Proposed by Neil Bohr in 1913. Bohr applied the Planck's quantum theory to the Rutherford nuclear atom with remarkable success.

First postulate:
An atom consists of a positively charged nucleus at the centre. The electrons move round the nucleus in certain stationary orbits of definite radii and not all possible radii.

Second postulate:
The radius of the orbit is such that the angular momentum of the electron is an integral multiple of h/2p.

Third postulate:
Electron may jump from one orbit to the other, in which case the difference in energy between the two states of motion is radiated in the form of a light quantum.

X-Rays :
Invisible electromagnetic radiations, Wavelengths range form 0.010A – 100A. These are discovered by Roentgen. When a fast moving electron is suddenly stopped a part of its kinetic energy is converted into X-ray photon the rest of the energy is converted into heat.

Wave Particle Duality:
To understand any given experiment, we must use either the wave or the photon theory, but not both. Light sometimes behaves like a wave and some times like a particle

de Broglie Hypothesis:
Photons are treated as "packets of light" behaving like a particle. Momentum of a photon: $p = E / c = h/\lambda$ Energy of a photon: $E = hc/\lambda$

Heisenberg Uncertainty Principle:
If position is identified the momentum cannot be measured. If momentum is measured the position is lost. $\Delta x \ X \ \Delta p \geq h / 4\pi$

24: Nuclear Physics

Tutorial Summary:

This tutorial specifically describe the structure and behavior of the atomic nucleus. The nucleus is composed of neutrons and protons. Obviously the similarly charged protons repel each other, but nuclear forces usually overcome that tendency and the nucleus is kept intact.

However, sometimes that repulsion is too great and the nucleus crumbles apart. This is the process of radioactivity. Alpha, beta, and gamma are the three types of nuclear radioactivity. Each has different properties. A nucleus may also break apart into roughly two equal pieces, this is the process of nuclear fission.

Tutorial Features:

- Animations depicting nuclear processes like fission and radioactivity.
- Step by step analysis of an example of the concepts of binding energy and mass defect.
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Concepts Covered:

Nuclear composition
- Notation
- Forces
- Binding energy
- Mass defect
- Isotopes

Radioactive decay
- Alpha decay
- Beta decay
- Gamma decay
- Nuclear equations

Half life
Applications of nuclear science

Content Review:

Atomic Number:
The number equal to the number of protons in an atom that determines its chemical properties. Symbol: Z

Atomic Mass:
The mass of an atom expressed in atomic mass units.

Strong (nuclear) Force:
A fundamental force that is associated with the strong bonds between quarks and other subatomic particles.

Weak (nuclear) Force:
One of the four fundamental forces that is associated with nuclear decay.

Binding Energy:
The energy needed to separate the constituent parts of an atom or nucleus.

Mass Defect:
The difference between the mass of an atom and the sum of the masses of its individual components.

Mass-Energy Equivalence:
All mass represents an equivalent amount of energy. 1 amu = 931 MeV.

Radioactivity:
Emission of radiation as a consequence of a nuclear reaction, or directly from the breakdown of an unstable nucleus.

Half Life:
The time required for half of the nuclei in a sample of a specific isotope to undergo radioactive decay.

Alpha Particle:
A positively charged helium nucleus (consisting of two protons and two neutrons).

Beta Particle:
An energetic electron produced as the result of a nuclear reaction or nuclear decay.

Gamma Particle/Ray:
Very high frequency electromagnetic radiation emitted as a consequence of radioactivity.

Fission:
The process whereby one item splits to become two.