Physics Reviewer Notes

Compiled by Nikko Angelo Carisma

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Reference

Padua, A., & Crisostomo, R. (2003). *Practical and explorational physics: Modular approach.* Vibal Publishing: Quezon City.

**The ninth part of these notes (IX. Circuits) was sourced from Victoria Chan's Supplementary Reviewer. This discusses further on series and parallel circuits, along with resistance.

I. What is Physics?

- **Physics** is a natural science that deals with the understanding of nonliving things. It deals specifically with matter and energy and their relationship
- It was two main branches: classical physics (i.e. mechanics, optics, etc.) and modern physics (quantum physics, etc.)

Fundamental vs. Derived Quantities

- **Fundamental** quantities are basic concepts that they are difficult to define. They can only be represented by one form of measurement.
  - Ex. distance, time, mass
- **Derived** quantities are those that may be represented by two quantities.
  - Ex. velocity = $\frac{\text{displacement}}{\text{time}}$

Accuracy vs. Precision

- **Accuracy** of measurement describes how well data agree with the accepted of a quantity being measured (how close to the actual).
- **Precision** refers to how exactly can a measurement be reproduced (how close the data are to each other).
  - Ex. **accepted value = 334 K**

	accurate and precise	**precise, but not accurate**	**neither accurate nor precise**
Trial 1	333 K	200 K	300 K
Trial 2	335 K	201 K	250 K
Trial 3	334 K	203 K	350 K

REVIEW: Scientific Notation, Conversion of Units

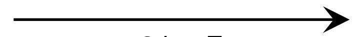
II. Scalars and Vectors

Identifying Scalars and Vectors

- A **scalar** quantity is described by <u>magnitude</u>
  - Examples
    - 40 kg
    - 35 minutes
    - 800 K
- A **vector** quantity is described by both <u>magnitude</u> and <u>direction</u>
  - Examples
    - 80 kph E
    - 20 N upward

Vector Representation

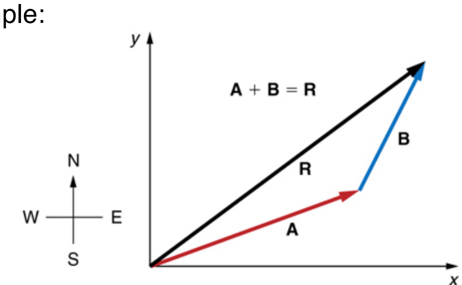
- A vector quantity is represented by an arrow
  - The orientation of the arrowhead indicates **direction**
  - The length of the arrow indicates **magnitude**
    - Example: *Displacement* $\vec{d}$, *of 3 km to the east.*
    - This means that a vector representing 4 km to the east would be <u>longer</u>, but oriented in the same direction.



3 km E

Vector Addition: An Introduction

- **Vectors do not add up like ordinary numbers.**
- One way of adding two or more vectors involves the head-to-tail method.
- The second vector is drawn from the arrowhead of the first vector.
  - The sum, or the **resultant** vector, is the one that runs from the tail of the first vector to the head of the last vector added.
- Example:



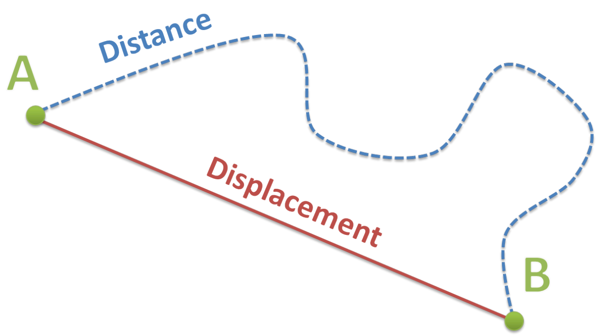
III. Kinematics

What is Kinematics?

- The study that deals with the description of motion.
- Kinematics uses the following basic concepts of motion: **distance, displacement, speed, velocity,** and **acceleration.**
- **Motion is relative**: to be able to adequately describe motion, one must be able to check where an object is located within a given frame of reference: the **reference frame**.
  - A <u>reference frame</u> is a physical entity to which the position and motion of an object is relative.
  - Example: A passenger is sitting in a bus that runs at 40 km/h. We can say that:
    a. The passenger is moving 40 km/h **in relation** to a street light the bus passed by; **or**
    b. The passenger is **not moving <u>in relation to the bus itself</u>**.

Distance vs. Displacement

- Distance involves the **total path length** traversed by object, while displacement involves the **length of separation** of that object and a reference point.
  - Distance = total path traveled
  - Displacement = shortest straight-line distance between starting and end points.



Speed and Velocity

- **Speed** is the measure of how fast or how slow something is moving: the rate at which a certain distance is covered at a given time.
  - The speed at any instant is called *instantaneous speed*
  - *Average speed* is the distance traveled divided by the <u>total time</u> elapsed:
  - $\text{average speed} = \dfrac{\text{distance traveled}}{\text{total time elapsed}}$
- When a direction is associated with speed, a new quantity is attained, called **velocity**.

Acceleration

- It is the rate of change of velocity and/or direction at a given time interval.
- $\text{acceleration} = \dfrac{\text{change in velocity}}{\text{elapsed time}}$
- The unit for acceleration is m/s^2.

The Kinematic Equations

- The description of motion in one dimension may be described using three basic equations:

$$v = \frac{d}{t}$$

equation 1
(describing speed/velocity)

$$v = \frac{v_f + v_i}{2}$$

equation 2
(describing average speed/velocity)

$$a = \frac{v_f - v_i}{t}$$

equation 3
(describing acceleration)

- With further derivations, the following equations may be attained:

$$d = \left(\frac{v_f + v_i}{2}\right)t$$

equation 4
(describing distance *d*)

$$d = v_i t + \frac{at^2}{2}$$

equation 5
(describing distance *d*)

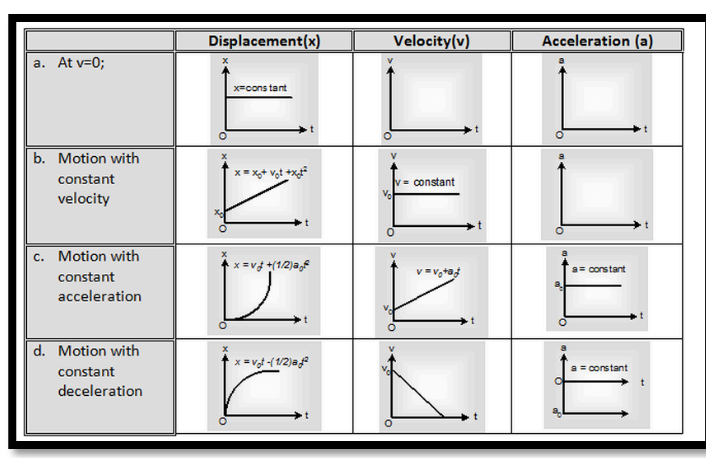
$$d = \frac{v_f^2 - v_i^2}{2a}$$

equation 6
(describing distance *d*)

Summary of Kinematic Equations

Type of Motion	Behavior of Objects	Equation
Object at Rest	• constant displacement • zero velocity • zero acceleration	$d = \text{constant}$ $v = 0$ $a = 0$
Constant/Uniform Velocity	• increasing or decreasing displacement • constant velocity and speed • no change in direction • zero acceleration	$d = vt$ $v = \dfrac{\Delta d}{\Delta t}$ $a = 0$
Constant Acceleration or Uniformly Accelerated Motion	• increasing or decreasing displacement, and velocity • constant speed but changing direction • constant acceleration	$d = v_i t + \dfrac{at^2}{2}$ (Use when **time is given** in a problem) $d = \dfrac{v_f^2 - v_i^2}{2a}$ (Use when **time is not given** in a problem) $a = \text{constant}$ $= \dfrac{v_f - v_i}{t}$

Graphical Analysis of Kinematics

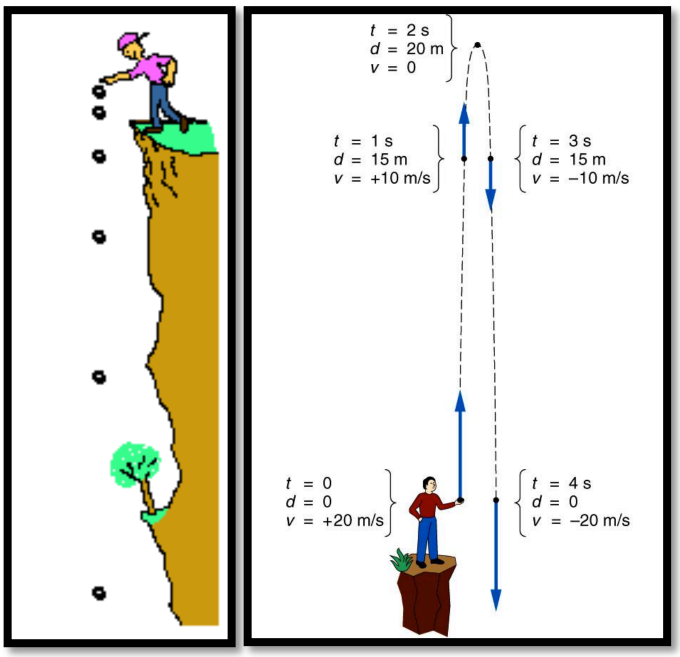


IV. Projectile Motion

What is Projectile Motion?

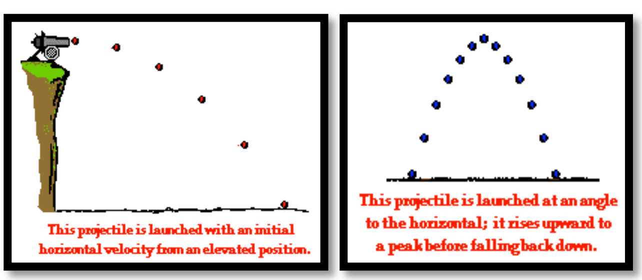
- Any objects that are shot, thrown, dropped, or ends up moving through the air are called **projectiles**.
    - An object is known to be in a state of **free fall** when gravity is the only force acting upon it.
- There are many possible cases in projectile motion:

a. Vertical motion



Left: *an object is dropped;* ***Right***: *an object is thrown upward*

b. Motion with vertical and horizontal components



Left: *an object is launched with horizontal velocity from a height;* ***Right***: *an object is launched at an angle, it rises to a peak before falling down*

Concepts about Projectile Motion

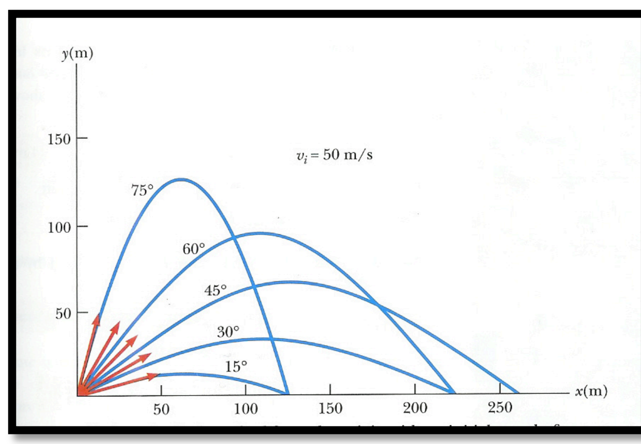
a. There is no horizontal acceleration involved in projectile motion

b. Projectile motion is also described by the kinematic equations. However, **the value for acceleration is dependent on the gravity of the planet.**

- The variable *a* becomes *g*, which represents the acceleration due to Earth's gravity. $g = 9.8\ m/s^2$ or $10\ m/s^2$

c. For projectile motion with vertical and horizontal components:

- An object travels the longest <u>horizontal distance</u> when it is launched at an angle **45 degrees** to the ground.
- An object travels the <u>highest vertical distance</u> when it is launched at an angle **90 degrees** to the ground.
- Two objects launched with equal initial velocities <u>travel the same horizontal distance</u> when they are launched at <u>complementary angles</u> to each other (sum of 90 degrees).



Equations Describing Projectile Motion

a. Vertical motion - **free fall (** when $v_i = 0$ **)**

$d = \frac{1}{2}gt^2$	Where: d = distance object has fallen/risen; v = velocity at a given time; t = time; $g = 9.8\ m/s^2$ **
$v = \sqrt{2gd}$	
$v = gt$	

b. Vertical and horizontal motion **(** $v_i \neq 0$ **)**

$t = \frac{2v_i \sin\theta}{g}$	Where: t = <u>total</u> time of object's flight H = maximum height reached R = maximum horizontal distance covered
$H = \frac{v_i^2 \sin^2\theta}{2g}$	
$R = \frac{v_i^2 \sin 2\theta}{g}$	

$d_x = vt$	Where: d_x = horizontal distance (at a given time) d_y = vertical distance (at a given time) ** v_y = vertical velocity (at a given time) **
$d_y = v_i t - \frac{1}{2}gt^2$	
$v_y = v_i - gt$	

V. Newton's Laws of Motion

First Law: The Law of Inertia

A body at rest remains at rest, and a body in motion remains in motion with a constant velocity (constant speed and direction) unless acted upon by an unbalanced force.

- From this idea, it may be said that an object with a larger *inertia* (natural tendency to stay in a state of motion or rest) has more resistance to change in motion.
- Application: The first law is the basis for designing safety belts**.** They prevent a passenger from moving away when a car suddenly stops.

Second Law: The Law of Acceleration

The acceleration of an object is directly proportional to the net force acting on the object and inversely proportional to the mass of the object.

- This shows that the greater force you apply to an object, the faster it will accelerate.
- This law may be summarized in the equation: $\vec{F}_{net} = m\vec{a}$
- Application: Race cars are designed structurally to have less mass, and this mass then allows them to increase their acceleration correspondingly.

Third Law: The Law of Interaction

When an object exerts a force on another object, the second object exerts on the first a force of the same magnitude but in the opposite direction.

- This law always applies to two different bodies, and the forces involved are equal and opposite in direction.
- Application: Rocket fuels operate on the third law. The burned fuel ejected from combustion provides the *downward* action force. This pushes the rocket *upward* into flight.

VI. Impulse and Momentum

- **Momentum** is defined by the product of mass and the velocity of an object. It is represented by the symbol p (for progress).

$$\vec{p} = mv$$

- **Impulse** is the change in the momentum of an object. It is defined by the product of the force exerted and time.
  - It is directly proportional to the change in momentum.
  - Application: Impulse helps explain why follow-throughs are important in some sports. For baseball, a follow-through allows to keep the bat in contact with the ball for a longer time, causing a greater change in momentum.

$$\vec{I} = \left(\vec{F}_{net}\right)\Delta t = \Delta\vec{p}$$

Conservation of Momentum

- There exists a law of conservation of momentum.

The total momentum of a system does not change if there are no net external forces acting on it.

- This means that the momentum of two objects does not change as long as no external force is exerted on them.
- This may be described mathematically:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1' + m_1\vec{v}_2'$$

$\vec{v}_1'$ and $\vec{v}_2'$ represent the new velocities of the two masses

Collisions

- When two objects collide, conservation of momentum is still observed.
- Collisions fall into two categories:
  - Elastic collisions: objects separate after collision
  - Inelastic collisions: objects do not separate after collision
- These may also be described mathematically:

Elastic collisions:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1' + m_1\vec{v}_2'$$

Inelastic collisions:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1 + m_2)\vec{v}'$$

It can be noted that the two masses have been added for inelastic collisions. It may be analogized to the two objects not separating after the collision.

VI. Work and Energy

Work

- **Work** is defined as the product of the magnitude of the displacement multiplied by the component of the force parallel to the displacement.
- For work to be accomplished:
  - There must be a force acting on the object
  - The object has to move a certain distance called the displacement
  - There must be a component of the force in the direction of motion
- Mathematically, work *w* is defined by:

$$W = Fd\cos\theta,$$

- Where F = force, d = displacement, and θ = angle between force and displacement.
- The unit for force is joule (J).

Energy

- **Energy** exists in many forms, like mechanical, chemical, thermal, etc.
- In Physics, two types of energy are discussed:
  - **Potential energy**, or energy at rest, is the energy that an object in an elevated position is said to have. This is mathematically described as:

$PE = mgh$, where m = mass, g = 9.8 m/s^2, and h = height.

  - **Kinetic energy**: anything that moves has kinetic energy. It depends on the mass and the velocity of the body. This is mathematically described as:

$KE = \frac{1}{2}mv^2$, where m = mass and v = velocity

Conservation of Mechanical Energy

Energy can neither be created nor destroyed; it can only be transformed from one form to another.

- This law talks about the conservation of energy in general. In a system, no energy is destroyed; it is only transformed. The total amount of energy stays the same.
- Example: A swing changes energy from potential to kinetic energy as it moves back and forth.
- In terms of mechanical energy, this is explained in the law of conservation of *mechanical energy*.

The sum of the kinetic energy and potential energy in a conservative system is constant and equal to the total mechanical energy of the system.

This may be mathematically described as:

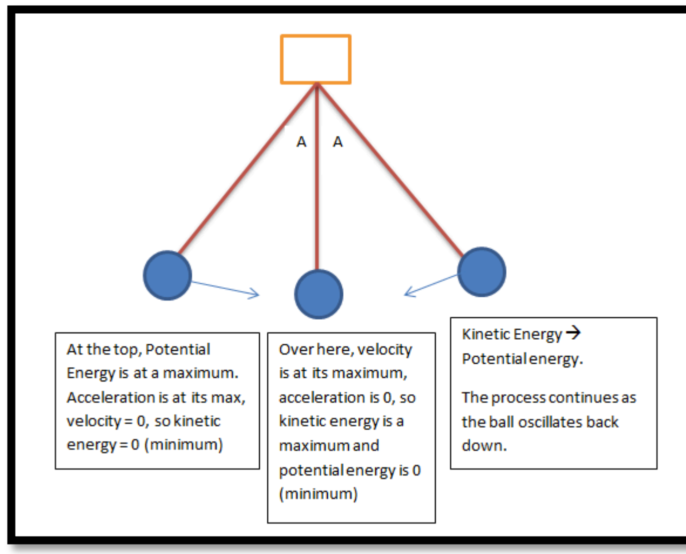
$$TE = PE + KE$$

Or

$$KE_1 + PE_1 = KE_2 + PE_2$$

$$\frac{1}{2}mv_1 + mgh_1 = \frac{1}{2}mv_2 + mgh_2$$

An example may be seen in a pendulum's swing:

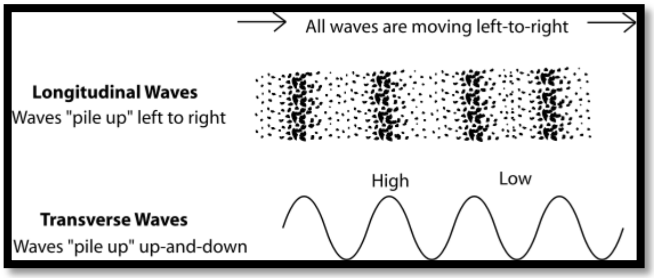


VIII. Waves and Heat

Wave

- A **wave** is a disturbance that carries energy through matter or space. The matter through which a wave travels is called the *medium*.
- They are classified into **mechanical** and **electromagnetic** waves.
  - **Mechanical** waves are those that require a medium (e.g. water waves)
  - **Electromechanical** waves are those that do not require a medium (e.g. light)
- They can also be classified depending on the direction of motion of the medium.
  - **Transverse** waves are where vibrations occur at right angles to the direction of the wave. An example of this is light.
  - **Longitudinal** waves are those where vibrations occur parallel to the direction of the wave. An example of this is sound.

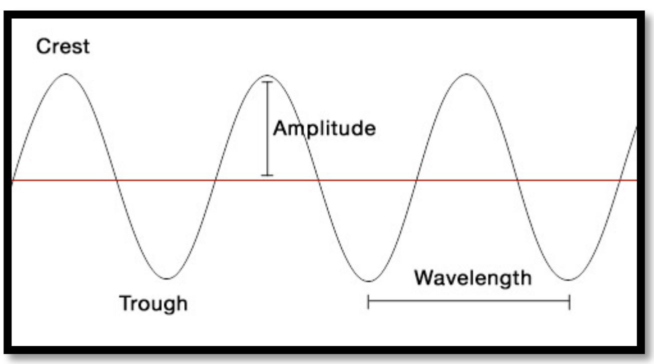
Transverse vs. Longitudinal Waves

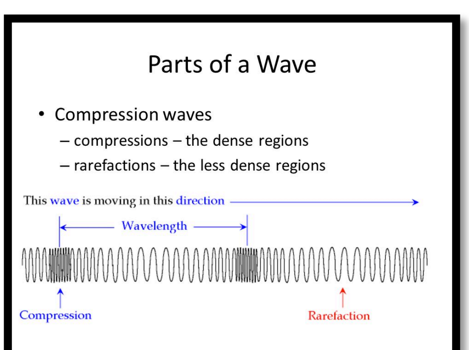


Measures of a Wave

- amplitude - the maximum height or displacement from the equilibrium position of a wave, this represents the amount of energy the wave is carrying
- wavelength - the distance between two maximum displacements: namely, two <u>crests</u> (high points) or two <u>troughs</u> (low points)
- frequency - describes how often a wave occurs within a given time frame; this is inversely proportional to period [i.e. the higher the frequency, the shorter the period]
  - the unit for frequency is hertz (Hz) or second^{-1} (s^{-1})
- period - the time it takes for a wave to occur, this is inversely proportional to wavelength
  - commonly, the unit for period is the second
- compression - a denser region of a wave
- rarefaction - a less denser region of a wave

Parts of a Wave:





The Electromagnetic Spectrum

- Accelerating electric charges, often by electrons, emits electromagnetic waves.
- Visible light is only a small part of an extensive range of waves known as the <u>electromagnetic spectrum</u>. These waves come from different sources and differ in their usage and effects.
  - **Radio waves** (longest, weakest) - used to transmit sound and picture information over long distances
  - **Micro waves** - used in satellite communications and are used in microwave ovens
  - **Infrared waves** - given off by hot objects, may be used to send instructions to electronic devices or seeing in the dark
  - **Visible light** - the portion of the EM spectrum that humans can see
  - **Ultraviolet waves** - used by banks to check for counterfeit bank notes; can sterilize water in drinking fountains
  - **X-rays** - allows doctors to look inside the body (x-ray photography)
  - **Gamma rays** (shortest, strongest)- often used in killing cancer cells

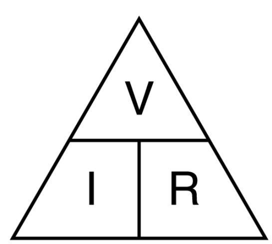
IX. Circuits

What are Circuits?

- **Circuits** are conducting loops in which a current can transfer electrical energy. It has the following parts:
  - A source for voltage
  - Conductors for the current to travel
  - A switch to cut off of connect the flow of the circuit

Ohm's Law

- This describes the relationship between current, resistance and voltage: $V = IR$
  - V = voltage
  - I = current
  - R = resistance



From this it also follows that:

$$I = \frac{V}{R} \quad \text{and} \quad R = \frac{I}{V}$$