CALCULUS-BASED PHYSICS

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PHYSICS

- Scientific study of matter and energy and how they interact with e/o.
- Study of properties, behavior and interaction between matter and energy.
- Study of natural phenomena
- Investigates and formulates the fundamentals laws of nature.

SYSTEMS OF MEASUREMENT

MKS (meter-kilogram-second)

- Most common measurement in introductory physics
- Referred to as SI (International System of Units, Système International d'Unités)

quantity	unit	symbol
Length	meter	m
Mass	kilogram	kg
Temperature	kelvin	K
Time	second	s
Amount of Substance	mole	mol
Luminous Intensity	candela	cd
Electric Current	ampere	A

FPS (foot-pound-second)

- You may sometimes also encounter this measurement system

SCIENTIFIC METHOD

- The principles and processes that guide scientific investigation
- Provides framework within which scientist try to discover the laws of governing the observable world
- Regulates the way the inquiries are concluded

Theory

- Logical explanation or reason for related events
- Probabilities

Law

- Proven accepted theory, statement, explanation or description of an event
- Principle

ACCURACY VS PRECISION

Accuracy

- How close an experiment comes to the "true" value
- Measures correctness of the result

Precision

- Measure of how exactly the result is determined without reference to what the result means
- Measure of precision of instruments being used in the experiment

SIGNIFICANT FIGURES

- Number of meaningful numbers in a measurement

1. **Non-zero digits are always significant**
   1.1. 134.7 = 4 sf
2. **Any zeros between two significant digits are significant**
   2.1. 802.901 = 6 sf
3. **Trailing zeros in the decimal portion are significant**
   3.1. 45.000 = 5 sf
4. **Leading zeros are not significant**
   4.1. 0.000045 = 2 sf
5. **Trailing zeros in a whole number with a decimal point are significant**
   5.1. 600. = 3 sf
6. **Trailing zeros in a whole number with no decimal point are not significant**
   6.1. 67,003,000 = 5 sf

ADDITION AND SUBTRACTION

- Final answer is determined by the LEAST number of significant figures AFTER the decimal.
  - 5.324 + 6.8459834 + 3.1 = 15.2699834 = 15.3

MULTIPLICATION AND DIVISION

- Final answer is determined by the LEAST significant figure
  - 5.638 x 3.1 = 17.4778 = 17

SCIENTIFIC NOTATION

- expressed as a number between 1 and 10 multiplied by a power of 10.
- 300 000 000 m/s = 3×10^8
- 0.000 000 62 kg. = 6.2×10^{-7}

VECTOR ARITHMETIC

VECTOR
- Quantity that has both magnitude (value + unit) and direction
- Typically represented by an arrow whose direction is the same as that of the quantity and whose length is proportional to the quantity's magnitude
- Does not have a position

Vector's Direction
- Can be described from its starting to final point

SCALAR
- Specified by only a magnitude (value + unit)

PROPERTIES OF VECTORS

Equality of Two Vectors
- If they have the same magnitude and the same direction

Movement of vectors in a diagram
- Any vector can be moved parallel to itself without being affected

Negative Vectors
- If they have the same magnitude but are 180° apart (opposite directions)

ADDING VECTORS GEOMETRICALLY

Resultant
- The vector sum of two or more vectors

01. Graphical Methods
  a. Parallelogram Method
  b. Polygon Method

02. Analytical Methods
  a. Algebraic Method
  b. Triangle Method
  c. Component Method

PARALLELOGRAM METHOD

$|R| = \sqrt{(P^2 + Q^2 + 2PQ\cos\theta)}$

$\beta = \tan^{-1}[\,(Q\sin\theta)\,/\,(P+Q\cos\theta)\,]$

POLYGON METHOD

TRIANGLE METHOD

(a)

$R^2 = a^2 + b^2$

$\tan\theta = a/b$ or $\theta = \tan^{-1}(a/b)$

(b)

$C^2 = A^2 + B^2 - 2AB\cos c$

$B/\sin b = C/\sin c$

$\theta c = \theta b - \theta a$

ALGEBRAIC METHOD

- Applicable only for parallel vectors

$|R| = |A + B|$

COMPONENT METHOD

$R = \sqrt{x^2 + y^2}$

$\theta = \tan^{-1}(\sum y/\sum x)$

x-component = $x\cos\theta$

y-component = $y\sin\theta$

- Ang pagkuha ng angle, θ ay nakabase kung san quadrant pumatak ang vector
  - Q1=90°
  - Q2=180°
  - Q3=270°
  - Q4=360°
- Imuminus yung given angle sa quadrant na pinatakan

MAGNITUDE	ANGLE, θ	x-component	y-component
x	θ	xcosθ	xsinθ
y	θ	ycosθ	ysinθ
		∑x	∑y

KINEMATICS

DIsplacement
- Magnitude and direction of the straight line joining one's starting point to one's final point
- A vector with direction

Distance

- Refers to the total length of path taken by an object in moving from its initial to final position

Starting from the church, a procession has to take the following route: 50m, north; 40m, east; and 60m, north. To go back, it has to follow the same route but in opposite direction.

A. What is the total distance traveled?
B. What is the total displacement?

A. Total distance traveled = 50m + 40m + 60m + 60m + 40m + 50m
Total distance traveled = 300m

B. The displacement is zero because the procession went back to where it Started.

Velocity

- rate of change of displacement with respect to time
- Describes how much displacement changes for a certain change in time.

$$v = \frac{x - x_0}{t - t_0} = \frac{\Delta x}{\Delta t}$$

v = average velocity
x = final position
x_0 = initial position
t = final time
t_0 = initial time
Δx = change in position
Δt = change in time

Speed

- How quickly something is moving
- Is not a vector, it doesn't tell you which direction something is moving
- The magnitude of the velocity vector

$$\text{Average Speed} = \frac{\text{distance traveled}}{\text{time interval}}$$

Acceleration

- Rate of change in of velocity with respect to time
- Is also a vector

$$a = \frac{\Delta v}{\Delta t}$$

where: a = average acceleration
Δv = change in velocity
Δt = change in time

OTHER KINEMATICS EQUATIONS:

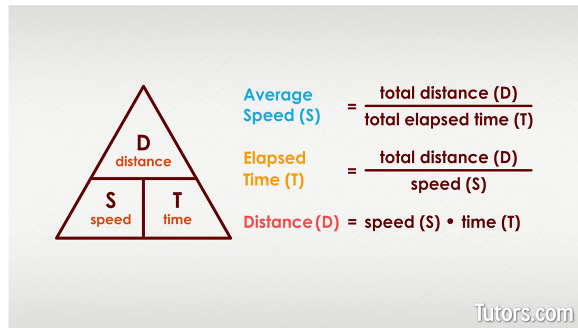
$$d = \left(\frac{V_i + V_f}{2}\right) t$$

$$V_f = V_i + at$$

$$V_f^2 = V_i^2 + 2ad$$

$$d = V_i t + \frac{1}{2} a t^2$$

Where:
d = distance
t = time
a = acceleration
Vi = initial velocity
Vf = final velocity



VERTICAL MOTION (FREE FALL)

- Motion of falling body under the influence of the earth's gravity
  - Free falling objects do not encounter air resistance
  - All free falling objects (on earth) accelerate downwards at a rate of $9.8 m/s^2$

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

$$v_f = v_i + gt$$

$$v_f^2 = v_i^2 + 2gh$$

$$h = v_i t + \frac{1}{2} g t^2$$

where:
t = time
h = height
a = acceleration
v_i = initial velocity = v_1
v_f = final velocity = v_2
$g = \pm 9.8 m/s^2$
(positive if acceleration; negative if deceleration)

PROJECTILE MOTION

Projectile

- Any object that once projected or dropped continues in motion by its own inertia
- Influenced only by the downward force of gravity

Range

- Horizontal displacement of a projectile

Trajectory

- Curve path of a projectile

Formulas for Projectile Motion

$$h = v_i t + \frac{1}{2} g t^2$$

$$v_f = v_i + gt$$

$$v_f^2 = v_i^2 + 2gh$$

$$v^2 = {v_x}^2 + {v_y}^2$$

$$R = v_i t$$

where:
t = time
h = height = y
R = range
v_i = initial velocity = v_1
v_f = final velocity = v_2
g = ±9.8m/s^2
(positive if acceleration or going down; negative if deceleration or going up)

CIRCULAR MOTION

- Movement of an object along the circumference of a circle or rotation along a circular path
- It can be uniform, with constant angular rate of rotation

$$a_c = \frac{v^2}{r}.$$

NEWTON'S LAW OF MOTION

- Isaac Newton published the three laws of motion in 1686 in the Philosophiae Naturalis Principia Mathematica ("Mathematical Principles of Natural Philosophy"), which extended Galileo's observations.

1. **A body at rest remains at rest or, if in motion, remains in motion at constant velocity unless acted on by a net external force.**
2. **For any particle of mass m, the net force F on the particle is always equal to the mass m times the particle's acceleration a.**
3. **For every Action, there is an equal but opposite Reaction.**

NEWTON'S FIRST LAW - INERTIA

Inertia
- tendency of an object to maintain their state of rest of uniform motion

Remains
- Preserving the status quo of motion

Constant Velocity
- Objects maintains a path along a straight line, since neither the magnitude nor direction of the velocity vector changes

NEWTON'S SECOND LAW - ACCELERATION

Mass
- Measure of inertia
- Scalar quantity called inertial mass
- Inherit property of an object and is independent of the object's surroundings and the method used to measure it
- Amount of matter a body contains; always constant
- SI unit: *kg*

Weight
- Measure of the force gravity exerted by Earth
- SI unit: *kg.m/s² = N*

> Mass of a body is constant, while its weight depends on the value of the acceleration due to gravity.

NEWTON'S THIRD LAW - INTERACTION

- Every interaction, there is a pair of forces acting on two two interacting objects
- The size of the forces on the first object equals the size of the force on the second object.
- The direction of the force on the first object is opposite to the direction of the force on the second object.
- Forces always come in pairs - equal and opposite action-reaction force pairs.

Force
- A push or pull upon an object; there must be two objects (one being pushed and the one doing the pushing)
- Result from interaction between objects

Contact Force
- a compressive force that exists whenever two bodies come into contact with each other
- also called Notmal Force

Rigid Body

- If the shape or dimension of a body cannot be altered

APPLICATION OF NEWTON'S LAW

Free Body Diagram

- Graphical representation of all forces acting on an object
- Powerful tool for solving problems

Key ideas for drawing a free-body diagram:

1. Include ALL forces acting on the body matter
2. When a problem includes more than one body — draw a separate free body diagram for each body
3. Not to include: any forces that the body exerts on any other body
4. Not to include: non-existing forces (no object — no force)

Common forces:

- Friction *f*
- Normal Force *N*
- Tension *T*
- Spring Force

Friction

- Resistive force opposing motion or its tendency
- Frictional force is proportional to magnitude of normal force, and has more or less constant coefficient

Static friction

- If the body doesn't move, the static frictional force f_s and the component of F that is parallel to the surface balance each other

Kinetic friction

- If the body begins to slide along the surface, the magnitude of the frictional force rapidly decreases to a value f_k
- This does not depend on speed
- Independent on area of contact between body and the surface

Spring Force

- *Spring* is a medium with a specific atomic structure that has the ability to restore its shape, if deformed
- To restore its shape, a spring exerts a resisting force that is proportional to and in the opposite direction in which it is stretched or compressed
- Hooke's Law

Normal Force

- When a body presses against a surface, the surface deforms and pushes on the body with a normal force that is perpendicular to the surface
- It prevents the object from penetrating the surface
  - *Magnitude*: component, perpendicular to the surface of contact, of the exerted force on object
  - *Direction*: perpendicular and away from the surface

Tension force

- Force along the length of a medium
- Pulling force that acts along a stretched flexible connector, such as a rope or cable
- Tension comes from a latin word meaning "to stretch"

Equilibrium

- state of being balance
- It must be experiencing acceleration; both net force and the net torque on the object must be zero
  - Static equilibrium: object's velocity is zero, body is at rest
  - Dynamic Equilibrium: object is moving at a constant velocity/ constant speed along a straight path
  - Transitional equilibrium : when there is no resultant force acting on a body at anout any given axis