IDX G9 Physics S+]

Study Guide Issue Semester 1 Midterm Exam

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Contents:

Chapter 2 Describing Motion: Kinematics In One Dimension

2.1 Reference Frames and Displacement

- Mechanics
  - **Kinematics (the study of motion) and Dynamics (the study of force)**
- Motion
  - **An object is in motion if it changes position relative to a frame of reference**
  - Motion is relative (different view of point leads to a different result)
- Frame of reference (reference point)
  - **A place or object used for comparison to determine of something is in motion**
  - Always assumed to be stationary
- Picturing Motion
  - Motion Diagram
    - **A series of images showing the positions of a moving object at equal time intervals**
    - to visualize displacement and velocity
  - Particle Model

        - **A simplified version of a motion diagram in which the object in motion is replaced by a series of particles**

- Vector and Scalar
    - Vectors: **Quantities which has a direction and a magnitude**
        - Examples: Force, position, acceleration, displace etc...
        - Can be represented by an arrow; the length is its magnitude and the direction is the direction of the vector
    - Scalars: **Quantities which have magnitude but no direction**
        - Examples: Mass, volume, speed, distance etc...
- Distance
    - **How far objects are, or the accumulation of path**
    - Is a scalar
- Displacement
    - **The distance moved in a particular direction, or the object's overall change in position**
    - Is a vector
    - **$\Delta d=d_f-d_i$ (position$_f$ - position$_i$)**

❗**Distance is the actual length of the whole Journey, while Displacement is the difference between the final distance (d_f) and the initial distance (d_i)**

2.2 Average Velocity: Speed and Velocity

- Speed
    - **The distance the object travels per unit of time, or the rate at which an object moves**
    - **Speed = $\frac{\text{distance}}{\text{time}}$ $v=\frac{d}{t}$**
        - Is a scalar
        - Units: m/s; km/h
    - Average speed
        - When an object's speed is constant, then the object has constant speed motion
        - **average speed = $\frac{\text{total distance}}{\text{total time}}$**
- Velocity

- **The speed in a given direction**
- Can be shown using an arrow
- For motion in a straight line, you can use a "+" or "-" sign to indicate direction
- The direction given by velocity is crucial
- **average velocity** $=\frac{\textbf{total displacement}}{\textbf{time}}$

2.3 Instantaneous Velocity

- Instantaneous Velocity (speed)
  - The velocity (speed) at any instant of time
    - $\mathbf{v=lim\times\frac{\Delta x}{\Delta t}}$
  - Magnitude of instantaneous velocity equals to instantaneous speed

2.4 Acceleration

- Acceleration
  - The rate at which an object's velocity changes is called the acceleration of the object
  - Average acceleration
    - $\vec{\mathbf{a}} = \frac{\Delta\vec{\mathbf{v}}}{\Delta \mathbf{t}} = \frac{\vec{\mathbf{v}}_f - \vec{\mathbf{v}}_i}{\mathbf{t}_f - \mathbf{t}_i}$ **unit: m/s²**
  - Instantaneous Acceleration
    - The change in velocity at an instant of time
    - $\vec{\mathbf{a}} = \mathbf{lim}\frac{\Delta\vec{\mathbf{v}}}{\Delta \mathbf{t}}$
    - $\vec{\mathbf{a}} = \frac{\mathbf{F_{net}}}{\mathbf{m}}$ **;** Direction of acceleration is the same as the direction of F_{net}
- Positive and Negative Acceleration
  - Acceleration Vector points
    - Positive direction: positive acceleration
    - Negative direction: negative acceleration
    - v_i and $\vec{a}$ same direction: speed up
    - v_i and $\vec{a}$ opposite direction: slowing down
    - The sign of acceleration doesn't indicate whether the object is speeding up or slowing down (initial velocity is needed)

2.5 Motion at Constant Speed

- Formula
  - Uniformly accelerated motion: Motion with constant acceleration
    - $\vec{a}$= constant, straight line
    - Instantaneous $\vec{a}$ = average a

    Important Formulas:
  - $\vec{\mathbf{a}} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{t_f - t_i} \rightarrow \vec{\mathbf{a}} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{t}$
  - $\Delta\mathbf{d} = (\mathbf{d_f} - \mathbf{d_i}) = \overline{\mathbf{v}} \times \mathbf{t} = \frac{(\vec{v}_f + \vec{v}_i)}{2}\mathbf{t}$
  - $\Delta\mathbf{d} = (\mathbf{d_f} - \mathbf{d_i}) = \vec{v}_i t + \frac{1}{2}at^2$
  - $\Delta\mathbf{d} = (\mathbf{d_f} - \mathbf{d_i}) = \frac{(\vec{v}_f 2 - \vec{v}_i 2)}{2\vec{a}}$

2.6 Solving Problems

- This section will explore hard multi-step problems with the formulas given in Chapter 2.5

2.7 Falling Objects

- Free Fall
  - **The motion of a falling object when air resistance is negligible and the action can be considered due to gravity alone**
  - Aristotle said that a heavier object falls faster than a lighter object
  - Galileo's thought experiment showed the improbability of Aristotle's view
    - Steeper inclines gives faster accelerations
    - Incline reaches absolutely vertical, means maximum acceleration (g)
    - all objects fall at g, neglecting air resistance; $g=9.8m/s^2$
- Acceleration Due to Gravity
  - No matter what the falling object is made of, how much it weighted, what height it dropped from, whether it was dropped down or thrown upward:
    - **$g=9.8m/s^2$**
    - "+g" defines downward to be the positive direction
    - "-g" defines upward to be the positive direction
  - Object is dropped: $\vec{v}_i=0m/s$, $\vec{a}=9.8m/s^2$ (down is +)
  - Object is dropped: $\vec{v}_i\neq 0m/s$, $\vec{a}=9.8m/s^2$ (down is +)

- Objects Thrown Upward
    - $\vec{v}_i \neq 0$m/s
    - (if upward is "+") $\vec{v}_i > 0$m/s $\vec{a} = -9.8$m/s^2
    - (if downward is "+") $\vec{v}_i < 0$m/s $\vec{a} = 9.8$m/s^2
    - initial Δd is 0; highest position v=0, and Δd is largest in + direction
    - Same Δd (height), same speed
    - Returns to original position, $v = -v_i$, $\Delta d = 0$
        - time of rising t_{rise}= time of falling t_{fall}

2.8 Graphical Analysis of Linear Motion

- Position-Time Graph
    - No motion (at rest)
        - Horizontal straight line/ straight line parallel to x-axis
    - Uniform motion
        - Slanted straight line
        - y-intercept: initial position; X-axis: time
    - Intersection of graph lines
        - Two objects meet
    - Average Velocity
        - The slope: rising "+", descending "-"
        - Steeper: speed larger, |v| larger
    - Instantaneous Velocity
        - When constant velocity: instantaneous velocity=average velocity
    - Equation for average velocity
        - $\mathbf{d_f = \vec{v}_t + d_i}$

Slope of d-t graph = Velocity

- Accelerated Motion
    - Graph line is a curve:
        - average velocity: slope of connection of the two dots on the line.
        - instantaneous velocity=slope of the tangent to the curve
        - Curve shape, v and +/- acceleration
- Velocity-Time Graph
    - Uniform motion (a = 0)
    - Horizontal line in v-t: v=constant, a=0

    - Information:
        - Velocity of an object at any moment
        - Velocity is "-" or "+"
        - The area between the v-t graph and time is equal to the object's displacement
        - above time-axis: $\Delta d>0$; below t-axis: $\Delta d<0$

        ❗**Slope of v-t graph = Acceleration**

- Acceleration-Time Graph
    - At rest/uniform motion a=0
        - Horizontal line on t-axis

    - Uniformly accelerated motion
        - Horizontal line parallel to t-axis

❗**Instantaneous acceleration = Slope of the tangent to the curve at a particular moment**

<u>Chapter 3: Kinematics in Two Dimensions; Vectors</u>

3.1 Vectors and Scalars

- Vector has magnitude and direction while scalar only has magnitude
- Represent vectors on graph with an arrow
    - Arrow should point to the direction of vector
    - The length of the arrow represents magnitude
- Represent direction using degree measures with accurate directions on the graph
    - Length is proportional to magnitude
    - At least 2 segments should be used to represent a single vector

❗**When drawn to scale, please label out all magnitudes, direction, symbol, and angle (if needed)**

3.2 Addition of Vectors

- Graphical Methods

        - Tail to tip method
            - Resultant is the sum of two or more vectors
            - Move a tail of one vector to the head of another vector without changing the magnitude or direction of the vector. The resultant points from the tail of the first vector to the head of the last vector
            - If all vectors are one dimensional, draw the vectors in parallel lines
            - Magnitude of resultant can never be larger than the sum of two individual vectors that form the net
            - When 3 or more vectors form a closed polygon, there's no resultant

    - Parallelogram method
        - Place component vectors tail to tail
        - Use two vectors as adjacent sides and construct a parallelogram
        - The diagonal from the common origin is the resultant vector

- Calculation
    - Pythagorean theorem
        - r square + b square = c square
        - angle = arctan *(B/A)
    - Law of cosine and Law of Sine

3.2 Subtraction of Vectors, and Multiplication of a Vector by a Scalar

- Subtracting Vectors
    - Two vectors are negative if they have the same magnitude but are 180 degrees apart which is in opposing directions (A = -B)
    - If add a negative vector B to a vector A. This is basically subtracting vector B from Vector A   [A -B = A+ (-B)]
- Multiply the Vector
    - A vector A can be multiplied by scalar C

    - If C is positive, then the product CA has the same direction and magnitude CA
    - If C is negative, then the magnitude is still CA but the direction is opposite of A

3.4 Adding Vectors by Components

- Once you place a vector in a coordinate plane, it can be broken into components
    - Process named as vector resolution
- Fundamental Trigonometry (Only for Right Triangles)
    - Sin 0 (angle) = A/C
    - Ay = Asin0
    - Cos 0 (angle) = B/C
    - Ax = Acos0
    - Tan 0 (angle) = A/B
    - 0 (angle) = tan to the power of negative one (Ry/Rx)

3.5 Projectile Motion with 3.6 Solving Problems Involving Projectile Motion

- Free Fall
    - Vf = gt
    - delta h = 1/2gt square
- Concepts of Projectile Motion
    - Projectile: An object shot through the air
    - Trajectory: Curved flight path that is followed by a moving object
    - After a projectile is launched, if no contact force (ignoring air resistance), the gravity is the net force
    - Projectile motion is a combination of 2 independent motions
        - Horizontal motion component: motion with constant velocity when there is no air resistance
        - Vertical motion component: motion with constant acceleration (gravitational force)

- Projectile Launched Horizontally
  - No initial vertical velocity
  - Horizontal Motion: Fnetx = 0, a = 0, constant velocity horizontally
  - Vertical Motion: Fnety = mg (free fall)
  - Range = Horizontal distance(R = dx)
  - Velocity vector at each instant is always tangent to the parabola
  - Solve magnitude using the Pythagoras Theorem, direction using 0 (angle) = tan to the power of negative one (Vy/Vx) [below horizontal]
  - Horizontal and vertical motions are independent (time till hit the ground same for both vectors)
    - Described by Galileo
  - The horizontal velocity and the height (the flight time) affects the range the projectile falls away

    Remember that time is always the same

3.8 Relative Velocity

- V A to B = -V B to A
- Relative Velocity: The velocity of one body relative to another is called its relative velocity
  - Vab+Vbc = Vac (vector sum)
  - Vab = -Vba (same magnitude but opposite direction)

Chapter 4: Dynamics, Newton's Laws of Motion

4.1 Force

- **Force**: push or pull exerted by one object on another.
  - It is a vector.
  - Interaction between 2 objects: **system** (to whom) and **agent** (by whom)
  - To cause deformation (change in dimension/shape)/change velocity
  - In Newtons (N); $1N=1kgm/s^2$; Measured using spring scale

- Three factors:
    - **Magnitude**: the strength of the force vector.
    - **Direction**: in which direction the force vector acts.
    - **Point of application**: the location the force is exerted.

- Drawing using arrow
  - Length is magnitude; tail is point of application, head is towards the force direction
    - Usually starts from central of mass of object or application
- Four fundamental forces
  - Gravity, Strong force, Weak force, and Electromagnetic force

- Contact force
  - An object from the external world touches a system and thereby exerts a force on it
  - Eg: Friction, Air resistance/fluid resistance, tension, normal force, spring force, applied force
- Field force
  - Exerted without contact
  - E.g. Gravitational force, Electric force, magnetic force

- Gravitational Force
  - **Weight** (W or Fg)
    - The force of Gravitational Force on an object at the surface of a planet.
    - $Fg = G\frac{m_1m_2}{r^2}$
- Spring Force
  - **Hooke's Law**:
    - The magnitude of the force is directly proportional to the amount of stretch/compression within the limit of a spring.

- **Fsp=-kx**
  - Fsp: the force exerted by the spring on the attached object (N)
  - x: the displacement of the spring end from its equilibrium position (cm)
  - k: spring constant (N/cm)
- Elastic limit:a point beyond which the spring will no longer return to its original shape when the force is removed.

- Friction

  Graphing: Direction is parallel to surface, and is opposite direction where the direction is moving/trying to move

  - **Sliding Friction**: the friction that occurs when two solid surfaces slide over each other.
    - **Static friction** (Ffs): Caused by tendency of relative motion.
      - (no relative motion between 2 objects in touch)
      - $F_{f,static} = F_{cause}$
    - **Kinetic friction** (Ffk) : Caused by the relative motion (relative motion between 2 objects in touch)
      - Same objects: Ffk ≤Ffsmax
      - Ffk= μ kFN
        - μ k --coefficient of kinetic friction
        - Ffk －kinetic friction
        - * Ffk does not change with the Fcause
  - **Rolling Friction**: the friction that occurs
    - When an object rolls over a surface. (smaller than sliding friction)
  - **Fluid Friction**: the friction that occurs when an object move through a fluid.
    - Eg.: air resistance/ friction in water, oil

- Air resistance
  - Depends on:
    - Shape of the object

            - Streamline: reduce friction
        - Size of an object
            - Surface area ↑ Fair ↑
        - Speed of an object
            - Speed ↑ Fair ↑
        - Fluid type: viscosity
            - More viscous Fair ↑
- Balanced Forces
    - Equilibrant and balanced force--> two forces are balanced.
        - When two difference forces acting on the same object (same point of application)
        - With the same magnitude
        - Opposite direction
        - Acts on the same line
    - Equilibrium (When objects experience balanced forces)
        - At rest
        - Uniform motion
    - Net force=0
    - Unbalanced forces: net force≠0 Motion is changed
        - Start moving
        - Stop moving
        - Change direction
        - Unbalanced forces will change the object's motion.

4.2 Newton's First Law

- Galileo did experiments: concludes that when zero resistance, horizontal motion never stops
- Newton's First law

- Every object continues in its state of rest or uniform velocity in straight line as long as no net force acts on it
- Also called “Law of **Inertia**”
- Inertia: Tendency of object to resist change in state of motion
    - Mass: measure of inertia on object
        - if Mass increase, Inertia increases, Motion: harder