IDX G9 Physics S+

Study Guide Issue Semester 1 Monthly 2

By Sissi and Desheng, Edited by Jillian

Contents:

Chapter 4: Dynamics, Newton's Laws of Motion

4.1 Force

- **Force**: push or pull exerted by one object on another.
  - 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
    - **When drawing a free-body diagram, label all forces' directions from the center of the object**
  - 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, drag force (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.
  - $\mathbf{Fg = G\frac{m_1m_2}{r^2}}$
- **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**
  - **Sliding Friction**: the friction that occurs when two solid surfaces slide over each other.

  - **Static friction** (Fsf): Caused by tendency of relative motion.
  - No relative motion between 2 objects in touch
  - $\boldsymbol{F_{f,static} = F_{cause}}$

- **Kinetic friction** (Fkf) : 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
  - Depends on: Size of an object
    - Surface area ↑ Fair ↑
  - Depends on: Speed of an object
    - Speed ↑ Fair ↑
  - Depends on: 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$\neq$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 **(Law of Inertia)**
    - Every object continues in its state of rest or uniform velocity in straight line as long as no net force acts on it
    - Inertia: Tendency of object to resist change in state of motion
    - Mass: measure of inertia on object
    - if Mass increase, Inertia increases, Motion: harder

4.4 Newton’s Second Law

- The acceleration of an object is directly proportional to the net force acting on it, and is inversely proportional to the object’s mass.
- The direction of the acceleration is in the direction of the net force acting on the object
  - $\mathbf{a} = \frac{\mathbf{Fnet}}{\mathbf{m}}$ **or** $\mathbf{Fnet} = \mathbf{m} \times \mathbf{a}$
  - Fnet : net force, a: acceleration, m: object’s mass
  - Unit: N
    - 1N is 1kg/s^2
- Increasing acceleration
  - Increase net force; when mass is constant
  - Decrease mass; when net force is constant

4.5 Newton's Third Law

- If object A exerts a force on object B, then object B exerts an equal but opposite force on object A
  - Forces always come in pairs : Force (A on B) and Force (B on A)
  - **Opposite directions, equal magnitude, different systems, but Force of the same type**
  - Also called "**Action-Reaction pair of Forces**"
  - **When drawing the free-body diagram, remember to label the action and reaction pair of forces when needed!**
- **Balanced Forces**
  - **Same magnitude and Directions**
  - **Objects have the same system**; so they cancel each other
  - Doesn't always occur/change at the same time
  - **Not always the same type**
  - Doesn't change motion
- **Action-Reaction Forces**
  - **Same magnitude and Directions**
  - **Objects have the different systems**
  - Always occur/change at the same time
  - **Always the same type of force**
  - May change motion
- **Problem solving strategies**
  - Separate system(s) from external world
  - Draw a free body diagram and label the x,y-axis
  - **Connect the interaction pairs using dashed lines**
  - Use Newton's second or relate to acceleration/mass
  - Use the third law to balance the magnitudes of the forces
  - Solve the problem

4.7 Solving Problems with Newton's Laws : Free-Body Diagrams&4.8 Problems Involving Friction, Inclines

- **Translational Equilibrium**
  - If the net force of an object is zero, then the object is in translational equilibrium
  - Object at rest
  - Object moving at constant velocity
  - Formula : **F=0 Fx=0 Fy=0**
- You can **modify the coordinate system** for convenience of calculation, **this way finding the force that needs to break down into x and y components will be easier**