**Physics C Notes**

*Mechanics*

1. Kinematics
   1. Motion in one dimension
   2. Motion in two dimensions
   3. Projectile Motion
2. Newton’s laws of motion
   1. Stable equilibrium (first law)
   2. Dynamics of a single particle (second law)
   3. Systems of two or more objects (third law)
3. Work, energy, power
   1. Work and the work-energy theorem
   2. Forces and potential energy
   3. Conservation of energy
   4. Power
4. Systems of particles, linear momentum
   1. Centre of mass
   2. Impulse and momentum
   3. Conservation of linear momentum, collisions
5. Circular motion and rotation
   1. Uniform circular motion
   2. Torque and rotational statics
   3. Rotational kinematics and dynamics
   4. Angular momentum and its conservation
6. Oscillations and gravitation
   1. Simple harmonic motion
   2. Mass on a spring
   3. Pendulum and other oscillations
   4. Newton’s law of gravity
   5. Orbits of planets and satellites
      1. Circular
      2. General

*Electricity and Magnetism*

1. Electrostatics
   1. Charge and Coulomb’s Law
   2. Electric field and electric potential – including point charges
   3. Gauss’s Law
   4. Fields and potentials of other charge distributions
2. Conductors, capacitors, dielectrics
   1. Electrostatics
   2. Capacitors
      1. Capacitance
      2. Parallel plate
      3. Spherical and cylindrical
   3. Dielectrics
3. Electric circuits
   1. Current, resistance, power
   2. Steady-state direct current circuits with batteries and resistors only
   3. Capacitors in circuits
      1. Steady state
      2. Transients in RC circuits
4. Magnetic fields
   1. Forces on moving charges in magnetic fields
   2. Forces on current-carrying wires in magnetic fields
   3. Fields of long current-carrying wires
   4. Biot-Savart law and Ampere’s law
5. Electromagnetism
   1. Electromagnetic induction
      1. Faraday’s Law
      2. Lenz’s Law
   2. Inductance
      1. LR and LC Circuits
   3. Maxwell’s Equations

**Notes Start**

Centripetal Acceleration: Given an object moving around a circle with a velocity **v** and a radius **r**, it experiences an acceleration towards the centre of the circle which causes a change in angular momentum that allows it to move circularly. This acceleration is called centripetal acceleration and is given by the equation .

Component Vectors: Given a vector  , it consists of vectors which define its motion along the x and y directions. These vectors and respectfully are defines by the relationship and . Note that the addition these vectors results in being formed again.

Kinematic Equations for Motion in a Straight Line Under Constant Acceleration:

(Velocity as a function of time)

(Position as a function of velocity and time)

(Position as a function of time)

(Velocity as a function of position)

Motion in Multiple Dimensions: With regards to motion in multiple dimensions, velocity and position are broken down into their x and y components which are dealt with separately with their own constraints.

Note: If one regards acceleration and velocity of derivatives (of and ) respectively, then the equations above make more sense.

Projectile Motion: Projectile motion is usually measured in a simplified model with horizontal motion not considered and motions only being considered in terms of forward and vertical motion, expressed in the variables x and y respectively. The motion of projectiles always experiences the downward force of gravity thus in the case of the Earth. In addition to this, forward acceleration is 0 when ignoring air resistance, thus leading to the following equations:

Meanwhile the maximum height can be found by the equation below:

The equation below gives the range of the projectile:

These equations may be derived by manipulating the 5 equations above. Note that the maximum possible range is at 45° due to the equation above where reaches its maximum value of 1 at or 90°.

Period of an Object in Uniform Circular Motion: Given the radius **r** of the circle as well as the velocity **v**, the period **T** may be found using .

Tangential Acceleration: The change in the speed of a particle moving in a circle. Given by the equation

Radial Acceleration: The change in direction of a particle’s velocity which allows it to remain in a circular path around a point. It is given by the equation . The negative sign indicates its direction towards the circle’s centre.

Total Acceleration of a Particle Moving Around a Circle: Given and , the total acceleration **a** is given by due to the perpendicular nature of and to each other.

Relative Motion: Given a particle, **P** and two observes, **O** and **O’**, each with a frame of reference set upon themselves, the relation of their perceptions of the particle’s position and time is given by the equations below-

Newton’s First Law: In the absence of external forces, an object at rest remains at rest and an object in motions continues in motion with a constant velocity.

Inertia: The tendency of objects to stay at motion or rest as determined by Newton’s First Law.

Inertial Frame of Reference: A frame of reference where Newton’s first law remains valid. This exists when the frame of reference isn’t accelerating itself. If it is accelerating fictitious forces exist.

Inertial Mass: The measure of an object’s resistance to a change in motion in response to an external force. This is an inherent quantity which is fixed. It is also distinguished from weight which is the magnitude of the gravitational force exerted on an object.

Newton’s Second Law: The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass. Mathematically this is represented by or .

Newton (Unit): The SI unit of force – .

Newton’s Third Law: If two objects interact, the force exerted by object 1 on object 2 is equal in magnitude, but opposite in direction to the force exerted by object 2 on object 1. This is represented by the equation . It is important to note this interaction is on two different objects and not on the same object and these forces always occur in pairs as well as will be of the same type of force.

Normal Force: The support force an object exerts while in contact with another stable object. The direction of this force is perpendicular to the surface and is a direct application of Newton’s Third Law. It is not necessarily equal to the gravitational force.

Tension: The magnitude of the force along a rope or string which is the result of the rope exerting a force on an object. This force is perpendicular and away from the object and is a reaction force.

Force of Friction: The resistance an object encounters when moving along a surface due to the nature of its contact along the surface. Friction may be encountered in two situations, for an object at rest and an object in motion called the force of static friction and force of kinetic friction respectively where . Their values are given by and respectively, with being the coefficient of static friction, being the coefficient of kinetic friction, and n being the magnitude of the normal force. Friction is a reaction force and is proportional to the normal force and also perpendicular to it.

Resistive Force: The force exerted by a medium which resists an object’s movement. Represented by R, it can be calculated in two different ways depending on the size and speed of the object. For low mass and speed R = -bv where b is a constant dependant on the object’s shape and the medium. For high mass and speed where D is the drag coefficient the medium’s density, and A is the cross-sectional area of the object.

Terminal Speed: The speed when the resistive force cancels the acceleration of other forces for a falling object it is given by or . Note since directly comparing the time to reach terminal speed is impossible the time constant T = m/b is used which represents 63.2% of terminal speed, though this is only used on the first equation. In addition, acceleration is 0, so it the net force.

Gravitational Force: The attractive force between any two given objects. Determined by the equation with G being the universal gravitational constant and equal to .

Electromagnetic Force: The force that determines the interaction between charged particles with being the Coulomb constant and is equal to .

Fundamental Unit of Charge (e): .

Nuclear Force: The force that binds the nucleus together. Its range is very short and is negligible around m.

Weak Force: A short-ranged force relating to radioactivity.

Free Body Diagram Guidelines:

1. Think of acceleration, not velocity. Keep in mind Newton’s Second and Third Laws.
2. Gravity is applied in the majority of cases, unless otherwise specifies or the object is in deep space.
3. Look for key words as seen below
   1. Constant Speed 🡪Forces in equilibrium
   2. Slowing down 🡪 Net force opposite current direction
   3. Speeding up 🡪 Net force in current direction
4. The normal force on an object does not necessarily equal mg
5. Bear in mind the difference between mass and weight
6. When a rope, string, or cable is involved, so is tension.
7. Breaking forces into their components might help in analysis
8. ma is not a force, it represents net force

Atwood Machine: An arrangement of two unequal masses hung over a frictionless pulley. If the masses are given as and we find that by applying Newton’s second law as seen below-

(Applied to object 1)

(Applied to object 2)

(Cancellation of T)

(Solving for acceleration)

(Solving for tension)

Note: To determine the accuracy of a numerical solution, we may calculate the same number with smaller intervals and the same method and take the digits that are agreed upon between the two solutions.