Review

These should be review from PHYSICS 1D03. They will not be explicitly tested or even used all that much in my experience, but may be helpful in deriving equations or finding relations on the fly.

1. $v_x = v_{0x} + a_x t$
   - **Explanation**: This formula describes the velocity in the x-direction as a function of time. It is derived from the definition of acceleration.
   - **Variables**:
     - v_x: Velocity in the x-direction at time t.
     - v_{0x}: Initial velocity in the x-direction.
     - a_x: Acceleration in the x-direction.
     - t: Time.
   - **Notes**:
2. $x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2$
   - **Explanation**: This is the kinematic equation for position as a function of time.
   - **Variables**:
     - x: Position in the x-direction at time t.
     - x_0: Initial position in the x-direction.
     - v_{0x}: Initial velocity in the x-direction.
     - a_x: Acceleration in the x-direction.
     - t: Time.
   - **Notes**:
3. $a_r = \frac{v^2}{r}$
   - **Explanation**: This formula gives the radial (centripetal) acceleration in circular motion.
   - **Variables**:
     - a_r: Radial acceleration.
     - v: Velocity.
     - r: Radius of the circular path.
   - **Notes**:
4. $K = \frac{1}{2} m v^2$
   - **Explanation**: This is the formula for kinetic energy.
   - **Variables**:
     - K: Kinetic energy.

- m: Mass.
- v: Velocity.
- **Notes**: Many other formulas for types of energy will follow the same format.

Electric Charges and Electric Field

5. $\vec{F} = k_e \frac{q_1 q_2}{r^2} \hat{r}$
   - **Explanation**: This is Coulomb's Law, which describes the electrostatic force between two point charges.
   - **Variables**:
     - $\vec{F}$: Electrostatic force.
     - k_e: Coulomb's constant.
     - q_1, q_2: Charges.
     - r: Distance between the charges.
     - $\hat{r}$: Unit vector pointing from q_1 to q_2. The direction ($q_1 \to q_2$) is important.
   - **Notes**:
6. $\vec{F} = q_0 \vec{E}$
   - **Explanation**: This is the formula for the electric force on a particle in a uniform magnetic field.
   - **Variables**:
     - $\vec{F}$: Force on the test charge.
     - q_0: Test charge. Remember that a 'test charge' is the same thing as charge, q, but basically just saying that the charge has no effect on the environment, i.e does not affect the electric field, we're using it as a testing charge to see what happens to it.
     - $\vec{E}$: Electric field.
   - **Notes**: Note Coulomb's Law is the force between two charged particles, while this one is the force on one charged particle (in a field). This is the definition of the 'electric field', which is the force exerted per unit charge ($E = \frac{F}{q_0}$).
7. $\vec{E} = k_e \frac{q}{r^2} \hat{r}$
   - **Explanation**: This formula gives the electric field due to a point charge.
   - **Variables**:
     - $\vec{E}$: Electric field.
     - k_e: Coulomb's constant.
     - q: Charge.
     - r: Distance from the charge.
     - $\hat{r}$: Unit vector pointing from the charge.

- **Notes**: Do not confuse this with Coulomb's law.

8. $E_x = k_e \int \frac{\hat{r} \cdot \hat{\imath}\, dq}{r^2}, etc.$
   - **Explanation**: This is the integral form of the electric field due to a continuous charge distribution.
   - **Variables**:
     - E_x: Component of the electric field in the x-direction.
     - k_e: Coulomb's constant.
     - $\hat{r}$: Unit vector from the charge element to the point of interest.
     - $\hat{\imath}$: Unit vector in the x-direction.
     - dq: An infinitesimal charge element.
     - r: Distance from the charge element to the point of interest.
   - **Notes**: The 'etc' means you repeat this process for each dimension, eg. $(x, y, z, \ldots)$

Flux

9. $\Phi_E = \int \vec{E} \cdot d\vec{A}, \qquad \Phi_B = \int \vec{B} \cdot d\vec{A} \qquad \Phi_{B(\text{net,closedsurface})} = 0$ (**magnetic flux Φ_B is here too**)
   - **Explanation**: These formulas define the electric and magnetic flux.
   - **Variables**:
     - Φ_E: Electric flux.
     - Φ_B: Magnetic flux.
     - $\vec{E}$: Electric field.
     - $\vec{B}$: Magnetic field.
     - $d\vec{A}$: Area element vector.
   - **Notes**:
10. $\Phi_E = \frac{Q_{enclosed}}{\epsilon_0} = 4\pi k_e Q_{enclosed}$
    - **Explanation**: This is Gauss's Law for electric fields.
    - **Variables**:
      - Φ_E: Electric flux.
      - $Q_{enclosed}$: Charge enclosed in a closed face.
      - ϵ_0: Permittivity of free space.
      - k_e: Coulomb's constant.
    - **Notes**: You will usually have to set this and the flux integral (above) equal to one another to solve problems.
11. $|\vec{E}| = \frac{\sigma}{2\epsilon_0} = 2\pi k_e \sigma$

- **Explanation**: This formula gives the electric field due to an **infinite plane** of charge.

- **Variables**:
  - $|\vec{E}|$: Magnitude of the electric field.
  - σ: Surface charge density.
  - ϵ_0: Permittivity of free space.
  - k_e: Coulomb's constant.
- **Notes**: This and the formula below are derived from Gauss's Law.

12. $|\vec{E}| = \frac{\sigma}{\epsilon_0} = 4\pi k_e \sigma$
    - **Explanation**: This formula gives the electric field **just outside a conductor**.
    - **Variables**:
      - $|\vec{E}|$: Magnitude of the electric field.
      - σ: Surface charge density.
      - ϵ_0: Permittivity of free space.
      - k_e: Coulomb's constant.
    - **Notes**:

Electric Potential

13. $\Delta V = V_B - V_A = \frac{\Delta U}{q_0} = \frac{U_B - U_A}{q_0} = -\int_A^B \vec{E} \cdot d\vec{s}$
    - **Explanation**: These formulae relate the change in electric potential to the change in potential energy and the electric field. The third expression and the integral are usually the most important.
    - **Variables**:
      - ΔV: Change in electric potential.
      - V_B, V_A: Electric potential at points B and A.
      - ΔU: Change in potential energy.
      - q_0: Test charge.
      - U_B, U_A: Potential energy at points B and A.
      - $\vec{E}$: Electric field.
      - $d\vec{s}$: Path element vector.
    - **Notes**: Use the integral for uneven fields distributions, especially when $\vec{E}$ is given as a function of position.
14. $V = \frac{k_e q}{r}$
    - **Explanation**: This formula gives the electric potential due to a point charge.
    - **Variables**:
      - V: Electric potential.
      - k_e: Coulomb's constant.
      - q: Charge.

    - r: Distance from the charge.
  - **Notes**: Remember that when a question asks for potential difference 'from infinity' or 'compared to V at infinity', it just means the potential difference at the second potential (remember, 'potential difference' implies a **difference** between two potentials) is zero. Ergo, $\Delta V = V_B - V_A = V_B - 0 = V_B$. For example, if a question asks for the potential difference at a point with relation to infinity, just use this equation even though it only defines V and not ΔV since $\Delta V = V_B - V_A = V$.

15. $V = \int \frac{k_e dq}{r}$
    - **Explanation**: It's the last formula, but for if it's a charge distribution instead of a point charge.
    - **Variables**:
      - V: Electric potential.
      - k_e: Coulomb's constant.
      - dq: Charge element.
      - r: Distance from the charge element.
    - **Notes**: Use this when the charge is not discrete point charges but charge spread out over an area/line.
16. $U = k_e \frac{q_1 q_2}{r}, \qquad U = k_e \sum_{i<j} \frac{q_i q_j}{r_{ij}}$
    - **Explanation**: These formulas give the electric potential energy between two point charges and between multiple point charges. The summation basically counts every pair of charges in the system with no duplicate pairs ($i < j$), then executes the same formula for each pair.
    - **Variables**:
      - U: Electric potential energy.
      - k_e: Coulomb's constant.
      - q_1, q_2: Charges.
      - r: Distance between the charges.
      - q_i, q_j: Charges in a system of multiple charges.
      - r_{ij}: Distance between charges q_i and q_j.
    - **Notes**: Can be helpful when finding potential differences using $V = \frac{U}{q}$.

Capacitance

17. $C \equiv \frac{Q}{\Delta V} = \epsilon_0 \frac{A}{d} = \frac{A}{4\pi k_e d}, \qquad C = \kappa C_0 = \kappa \frac{\epsilon_0 A}{d}$
    - **Explanation**: These formulas define capacitance ($\frac{Q}{\Delta V}$), capacitance for a parallel-plate capacitor ($\epsilon_0 \frac{A}{d} = \frac{A}{4\pi k_e d}$), and the effect of a dielectric on a parallel-plate capacitor (κC_0).

- **Variables**:
  - C: Capacitance.
  - Q: Charge.
  - ΔV: Potential difference.
  - ϵ_0: Permittivity of free space.
  - A: Area of the plates.
  - d: Distance between the plates.
  - κ: Dielectric constant.
  - C_0: Capacitance in vacuum.
- **Notes**: Keep in mind that only $C = \frac{Q}{\Delta V}$ applies to non-parallel plate capacitors. The other two only apply for that one kind of capacitor. Dielectric constants are usually > 1.

18. $U = \frac{Q^2}{2C} = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2$
    - **Explanation**: This formula gives the energy stored in a parallel-plate capacitor.
    - **Variables**:
      - U: Energy stored.
      - Q: Charge.
      - C: Capacitance.
    - **Notes**: The first is self-explanatory. The second and third, however, are NOT ON THE FORMULA SHEET! It is reasonably simple to derive using $C = \frac{Q}{\Delta V}$, but you could just save yourself the hassle by remembering they at least exist.

Series and Parallel Configurations

For complex circuits, remember to collapse capacitors into parallel/series configurations until you get a final configuration, using these formulas for all the abstractions.

19. $C_{series}^{-1} = C_1^{-1} + C_2^{-1} + C_3^{-1} + \dots$
    - **Explanation**: This formula gives the equivalent capacitance of capacitors in series.
    - **Variables**:
      - C_{series}: Equivalent capacitance in series.
      - $C_1, C_2, C_3, \dots$: Capacitances of individual capacitors.
    - **Notes**:
20. $C_{parallel} = C_1 + C_2 + C_3 + \dots$
    - **Explanation**: This formula gives the equivalent capacitance of capacitors in parallel.
    - **Variables**:

- $C_{parallel}$: Equivalent capacitance in parallel.
- $C_1, C_2, C_3, \ldots$: Capacitances of individual capacitors.
- **Notes**:

21. $R_{parallel}^{-1} = R_1^{-1} + R_2^{-1} + R_3^{-1} + \ldots$
    - **Explanation**: This formula gives the equivalent resistance of resistors in parallel.
    - **Variables**:
        - $R_{parallel}$: Equivalent resistance in parallel.
        - $R_1, R_2, R_3, \ldots$: Resistances of individual resistors.
    - **Notes**:
22. $R_{series} = R_1 + R_2 + R_3 + \ldots$
    - **Explanation**: This formula gives the equivalent resistance of resistors in series.
    - **Variables**:
        - R_{series}: Equivalent resistance in series.
        - $R_1, R_2, R_3, \ldots$: Resistances of individual resistors.
    - **Notes**:

Misc. Electrical

23. $J = \frac{I}{Area} = nqv_d = \sigma E, \qquad \vec{J} = \sigma \vec{E}$
    - **Explanation**: These formulas define current density.
    - **Variables**:
        - J: Current density.
        - I: Current.
        - $Area$: Cross-sectional area.
        - n: Number density of charge carriers.
        - q: Charge of each carrier.
        - v_d: Drift velocity.
        - σ: Conductivity.
        - $\vec{E}$: Electric field.
    - **Notes**: nqv_d can be useful when dealing with cable or wire questions. Current density is just a nice concept to understand for the future chapters. $\vec{J} = \sigma \vec{E}$ is surprisingly useless for tests but may be niche-ly helpful somewhere.
24. $\rho \equiv \frac{1}{conductivity} = \frac{1}{\sigma} = \frac{RA}{l}$; $R = \rho \frac{l}{A}$
    - **Explanation**: These formulas define resistivity and relate it to resistance.
    - **Variables**:
        - ρ: Resistivity.
        - σ: Conductivity.

    - R: Resistance.
    - A: Cross-sectional area.
    - l: Length of the conductor.
- **Notes**: All of these equations are helpful in some way.

Electric Circuits

25. $V = IR, \qquad P = VI$
    - **Explanation**: These formulas describe Ohm's Law and the power dissipated in a circuit.
    - **Variables**:
        - V: Voltage.
        - I: Current.
        - R: Resistance.
        - P: Power.
    - **Notes**: Be careful with $P = VI$. For dissipated power, you should use $P = I^2R$ (technically you can use any other expression from Ohm's law and the power formula, but this one is the most intuitive in my opinion. It's current getting impeded by resistance. Simpler than $\frac{V^2}{R}$.) It's also possible to get multiple answers using either I^2R or $\frac{V^2}{R}$, so if a question asks for "both answers", you should probably look into those two.

RC Circuits

26. $q(t) = q_\infty + (q_0 - q_\infty)e^{-t/\tau}; \qquad \tau = R_{eff}C$
    - **Explanation**: This formula describes the charge on a capacitor in an RC circuit as a function of time.
    - **Variables**:
        - $q(t)$: Charge at time t.
        - q_∞: Final charge.
        - q_0: Initial charge.
        - t: Time.
        - τ: Time constant.
        - R_{eff}: Effective resistance.
        - C: Capacitance.
    - **Notes**: The first equation is the general form for the charge stored in an RC circuit, starting from any charge. Do not confuse this time constant τ with the time constant τ from RL circuits down this page.
27. $q(t) = q_f(1 - e^{-t/\tau}) \qquad or \qquad q(t) = q_0e^{-t/\tau}$

- **Explanation**: More formulas describing charge stored in a capacitor in an RC circuit as a function of time.
- **Variables**:
  - $q(t)$: Charge at time t.
  - q_f: Final charge.
  - q_0: Initial charge.
  - t: Time.
  - τ: Time constant.
- **Notes**: You may only use the first formula when you are starting from $q_0 = 0$. You may only use the second one for discharging a capacitor.

Magnetic Force

28. $\vec{F}_B = q\vec{v} \times \vec{B}$
    - **Explanation**: This formula describes the magnetic force affecting a moving charge.
    - **Variables**:
      - $\vec{F}_B$: Magnetic force.
      - q: Charge.
      - $\vec{v}$: Velocity.
      - $\vec{B}$: Magnetic field.
    - **Notes**: Remember to use right hand rule to determine direction. **Be careful:** if q is negative, then the direction you get from the right hand rule will be reversed! The determinant/matrix method of calculating cross products will come in useful for non-90° cross product operations.
29. $r = \frac{mv}{qB}$
    - **Explanation**: The radius of a charged particle's path in a uniform magnetic field.
    - **Variables**:
      - $\vec{F}_B$: Magnetic force.
      - q: Charge.
      - $\vec{v}$: Velocity.
      - $\vec{B}$: Magnetic field.
    - **Notes**: THIS FORMULA IS NOT ON THE FORMULA SHEET! I DON'T KNOW WHY. IT BASICALLY SOLVES MOST CYCLOTRON/MASS SPECTROMETER QUESTIONS. REMEMBER IT!
30. $\vec{F}_B = \int I d\vec{s} \times \vec{B}$
    - **Explanation**: This formula describes the magnetic force on a current-carrying wire.

- **Variables**:
  - $\vec{F}_B$: Magnetic force.
  - I: Current.
  - $d\vec{s}$: Infinitesimal length element of the wire.
  - $\vec{B}$: Magnetic field.
- **Notes**: Remember that all integral formulas are designed for when one of the things in the integral are non-constant. In this case, this formula is for when $\vec{B}$ is not constant. However, this happens surprisingly little in tests. In that case, you should make the mental note of the non-integral form for when $\vec{B}$ is constant, $\vec{F}_B = I\vec{L} \times \vec{B}$. Note similarity to $q\vec{v} \times \vec{B}$.

Magnetic Torque

31. $\vec{\tau}_{(loop)} = I\vec{A} \times \vec{B} = \vec{\mu} \times \vec{B}$
   - **Explanation**: This formula describes the magnetic torque on a circular current item (eg. loop, coil).
   - **Variables**:
     - $\vec{\tau}_{(loop)}$: Magnetic torque.
     - I: Current.
     - $\vec{A}$: Area vector of the loop.
     - $\vec{B}$: Magnetic field.
     - $\vec{\mu}$: Magnetic dipole moment.
   - **Notes**: Torque itself is tested surprisingly little, but magnetic dipole moment $\vec{\mu}$ is. Remember that although it is not on the formula sheet, $\vec{\mu}$ changes when there are multiple loops in the coil, becoming $NI\vec{A}$ where N is the number of loops in the coil.

Magnetic Field

32. $d\vec{B} = \frac{\mu_0}{4\pi} \frac{Id\vec{s} \times \hat{r}}{r^2}$
   - **Explanation**: This formula describes the magnetic field due to a current distribution at a single point.
   - **Variables**:
     - $d\vec{B}$: Infinitesimal magnetic field.
     - μ_0: Permeability of free space.
     - I: Current.
     - $d\vec{s}$: Infinitesimal length element of the wire.
     - $\hat{r}$: Unit vector pointing from the current element to the point of interest.

  - r: Distance from the current element to the point of interest.
- **Notes**: This is **Biot-Savart Law**. Note in some textbooks/sources, you may see a version with an r^3 in the denominator instead of r^2. This is because those sources use a **position vector** $\vec{r}$ instead of a **unit vector** $\hat{r}$, and the position vector has a magnitude of r, meaning it cancels out. If you use $\hat{r}$, you must use r^2. **Do not mix them up.** You will usually need to integrate this to solve it with a non-constant current.

33. **Straight wire:** $B = \frac{\mu_0 I}{2\pi r}$; **Solenoid:** $B = \mu_0 I \frac{N}{L}$
    - **Explanation**: These formulas describe the magnetic field due to a straight wire and a solenoid.
    - **Variables**:
      - B: Magnetic field.
      - μ_0: Permeability of free space.
      - I: Current.
      - r: Distance from the wire.
      - N: Number of turns in the solenoid.
      - L: Length of the solenoid.
    - **Notes**: These are derived from Biot-Savart law. I recommend reading how this was done, since you will likely need to derive equations for unique current distributions from Biot-Savart yourself at some point. The solenoid formula is for points inside a solenoid (B outside a solenoid is zero). Note the straight wire formula assumes an infinitely long wire. Challenge: find an expression for the magnetic field at a point away from a finitely long wire.

Ampere's Law

34. $\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{enc}$
    - **Explanation**: This formula is Ampere's Law, which relates the magnetic field to the enclosed current.
    - **Variables**:
      - $\oint \vec{B} \cdot d\vec{s}$: Line integral of the magnetic field.
      - μ_0: Permeability of free space.
      - I_{enc}: Enclosed current.
    - **Notes**: The Gauss's Law of magnetism (well, technically, Gauss's Law is the Gauss's Law of magnetism). It's Biot-Savart Law but for when you have sufficient symmetry to form a Amperian loop, thus making it so you don't need to do all of those complex integrations. Try using this with a long straight wire and see how easy it is compared to deriving the equation from Biot-Savart. Also, this is best

used when the Amperian loop is either: parallel to a constant $\vec{B}$ (ideal), perpendicular to $\vec{B}$, or zero. If one of the latter two are true, it means $\vec{B} \cdot d\vec{s} = I_{enc} = 0$.

Faraday's Law

35. $\varepsilon = -\frac{d\Phi_B}{dt}$; $\quad \varepsilon = \vec{L} \cdot (\vec{v} \times \vec{B})$; $\quad \varepsilon = Blv$
    - **Explanation**: These formulas describe Faraday's Law of induction.
    - **Variables**:
        - ε: Induced emf.
        - Φ_B: Magnetic flux.
        - t: Time.
        - $\vec{L}$: Length vector.
        - $\vec{v}$: Velocity.
        - $\vec{B}$: Magnetic field.
        - B: Magnetic field strength.
        - l: Length of the conductor.
    - **Notes**: The first equation is the general form. Remember when the coil has multiple turns, you must add a factor of N, thus $\varepsilon = -N\frac{d\Phi_B}{dt}$. You cannot tell anything about the direction of the induced emf from this equation; you must use **Lenz**'s **Law** and critical thinking (scary!) to determine the direction. The second equation is strictly for the induced emf in a straight wire moving with a velocity in a magnetic field. The third equation is equivalent to the second formula. However, to use this equation, $\vec{v} \perp \vec{B}$ and $\vec{L} \perp \vec{v} \times \vec{B}$, i.e the dot/cross products in the second formula must resolve to zero. In other words, all three $\vec{L}, \vec{B}, \vec{v}$ must be mutually perpendicular.

Inductance

36. $L = N\frac{\Phi_B}{I}$; $\quad L = \pi\mu_0 r^2(N^2/l)$
    - **Explanation**: These formulas describe the inductance of a coil.
    - **Variables**:
        - L: Inductance.
        - N: Number of turns.
        - Φ_B: Magnetic flux.
        - I: Current.
        - μ_0: Permeability of free space.
        - r: Radius of the coil.

  - l: Length of the coil.
- **Notes**: The first is more fundamental. The second is for a solenoid.

37. $\varepsilon = -L\frac{dI}{dt}$
    - **Explanation**: This formula describes the induced emf in an inductor.
    - **Variables**:
      - ε: Induced emf.
      - L: Inductance.
      - I: Current.
      - t: Time.
    - **Notes**: The negative sign is Lenz's law. I actually find it easier to just ignore the negative sign and do Lenz separately. Emf's 'direction' is different from vectorial direction, as there are only two possible directions it can go. Just remember to consider the rate of change of current, not current itself.
38. $U = \frac{1}{2}LI^2$
    - **Explanation**: This formula describes the energy stored in an inductor.
    - **Variables**:
      - U: Energy stored.
      - L: Inductance.
      - I: Current.
    - **Notes**:

RL Circuits

39. $I(t) = I_\infty + (I_0 - I_\infty)e^{-t/\tau}; \qquad \tau = \frac{L}{R_{eff}}$
    - **Explanation**: This formula describes the current in an RL circuit as a function of time.
    - **Variables**:
      - $I(t)$: Current at time t.
      - I_∞: Final current.
      - I_0: Initial current.
      - t: Time.
      - τ: Time constant.
      - L: Inductance.
      - R_{eff}: Effective resistance.
    - **Notes**: Same deal as RC circuits.
40. $I(t) = I_f(1 - e^{-t/\tau}) \qquad or \qquad I(t) = I_0e^{-t/\tau}$

- **Explanation**: These formulas describe the current in an RL circuit during charging and discharging.
- **Variables**:
  - $I(t)$: Current at time t.
  - I_f: Final current.
  - I_0: Initial current.
  - t: Time.
  - τ: Time constant.
- **Notes**: Same deal as RC circuits. Side note: for RC/RL circuits, I highly recommend looking up charts of charge/current/potential difference compared to time. Note how for these two equations, one goes from maximum to minimum as time progresses, and one goes from minimum to maximum as time progresses. It turns out that all of the aforementioned values will follow one of these trends, and I recommend memorizing all of them for both RC and RL circuits. Sure, you can derive it, but that takes time and energy. For example, voltage follows an inverse trend from current, thus its formula while the RL circuit is charging is $V(t) = V_0 e^{-t/\tau}$.

Waves

41. $\omega = 2\pi f = \frac{2\pi}{T}; \qquad k = 2\pi/\lambda$
    - **Explanation**: These formulas describe the angular frequency and wave number.
    - **Variables**:
      - ω: Angular frequency.
      - f: Frequency.
      - T: Period.
      - k: Wave number.
      - λ: Wavelength.
    - **Notes**:
42. $y = A \sin(kx \pm \omega t - \phi)$
    - **Explanation**: This formula describes a sinusoidal wave.
    - **Variables**:
      - y: Displacement.
      - A: Amplitude.
      - k: Wave number.
      - x: Position.
      - ω: Angular frequency.
      - t: Time.

- ϕ: Phase constant.
- **Notes**: Remember $+$ means shifting to the left and $-$ means shifting to the right.

43. $v = f\lambda = \sqrt{\frac{k}{\mu}}$
    - **Explanation**: These formulas describe the speed of a wave.
    - **Variables**:
        - v: Speed of the wave.
        - f: Frequency.
        - λ: Wavelength.
        - k: Spring constant.
        - μ: Linear density.
    - **Notes**:
44. $v = \sqrt{F_T/\mu}$
    - **Explanation**: This formula describes the speed of a wave on a string.
    - **Variables**:
        - v: Speed of the wave.
        - F_T: Tension in the string.
        - μ: Linear density.
    - **Notes**:

Interference and Diffraction

45. $\Delta\phi = 2\pi\frac{\Delta r}{\lambda}$
    - **Explanation**: This formula describes the phase difference due to a path difference.
    - **Variables**:
        - $\Delta\phi$: Phase difference.
        - Δr: Path difference.
        - λ: Wavelength.
    - **Notes**: We (Winter 2025) didn't even get tested on anything in this chapter. You may be though. Learn these formulas if you went over them in class, otherwise don't.
46. $d \sin\theta = m\lambda$
    - **Explanation**: This formula describes the condition for constructive interference in a diffraction grating.
    - **Variables**:
        - d: Spacing between slits.
        - θ: Angle of diffraction.

- m: Order of interference.
- λ: Wavelength.
- **Notes:**

Trigonometric Identities

47. $\sin a + \sin b = 2\cos\left(\frac{a-b}{2}\right)\sin\left(\frac{a+b}{2}\right)$
    - **Explanation**: This formula is a trigonometric identity for the sum of sines.
    - **Variables:**
        - a, b: Angles.
    - **Notes**: You will usually use this while solving complex integrals using Gauss's Law/Biot-Savart Law.
48. $\cos a + \cos b = 2\cos\left(\frac{a-b}{2}\right)\cos\left(\frac{a+b}{2}\right)$
    - **Explanation**: This formula is a trigonometric identity for the sum of cosines.
    - **Variables:**
        - a, b: Angles.
    - **Notes**: You will usually use this while solving complex integrals using Gauss's Law/Biot-Savart Law.

Geometry

49. **Sphere:** $A = 4\pi r^2; \qquad V = \frac{4}{3}\pi r^3$
    - **Explanation**: These formulas describe the surface area and volume of a sphere.
    - **Variables:**
        - A: Surface area.
        - V: Volume.
        - r: Radius.
    - **Notes:**
50. **Cylinder:** $A = 2\pi r^2 + 2\pi rL; \qquad V = \pi r^2 L$
    - **Explanation**: These formulas describe the surface area and volume of a cylinder.
    - **Variables:**
        - A: Surface area.
        - V: Volume.
        - r: Radius.
        - L: Length.
    - **Notes:**

MORE RESOURCES