**Torque**
- Varignon's theorem is related to it
- A system is known as a "couple" if it has a nonzero value of it, but no resulting force
- Cross product of displacement and force
- Time derivative of angular momentum
- Measured in newton meters or Joules per radian
- It was zero in the Trouton-Noble experiment
- When it is constant, it causes free precession and it characterizes lots of other types of precession
  - Gyroscopic precession = this induced precession, when angular velocity is perpendicular to it
- Cross product of electric dipole moment and electric field or cross product of magnetic moment and b field gives it
- Slonczewski form and three other forms are in the Landau-Lifshitz equation to give the magnetization of the free layer of a ferromagnet
- Moment of inertia times angular momentum
- Gyromagnetic ratio times angular momentum vector crossed with magnetic field
- Torsion = deformation due to this
- Power = cross product of this and angular velocity
- Richard Beth discovered this was exerted by polarized light
- Liouville's generalization of Euler's to nonrigid motion gives this for each of three axes
- Kenelly approach - its maximum over field strength gives magnetic moment

**Moment of Inertia**
- **Stretch rule** (Routh’s rule): if the object can be stretched parallel to the axis without changing the distribution of mass, then the moment of Inertia does not change.
- Poinsot’s Ellipsoid
- Definition: A property which defines the amount of torque needed to change an object’s rotation around an axis.
- **Radius of Gyration:** \( I = mK^2 \) where I is moment of inertia, m is mass, and k is the radius of rotation from the axis.

**Angular Momentum**
- For a rigid body, it equals the product of moment of Inertia and angular velocity.
- One of the three properties of a black hole with mass and charge
- In physics, this value is quantized and is given in terms of Dirac constant (aka h-bar, reduced Planck constant)
- Equal to cross product of linear momentum and axis position.
- The total angular momentum for a particle is the combination of the orbital angular momentum and the intrinsic spin and is denoted J.
- Clebsch-Gordan coefficients

**Momentum (Linear)**
- \( P = Mv \)
• Relativistic form of this is found by \( P = \frac{h}{\lambda} \). Called the de Broglie’s equation with lambda being de broglie’s length.

• Given position, this can be found using dirac constant divided by “i” times the gradient operator

• Conjugated to position

• Impulse over a period of time equals change in momentum

• For an elastic collision, this is conserved along with kinetic energy

**Work**

• equal to area under curve on phase diagram

• pressure times change in volume

• equals product of distance moved and size of charge and magnitude of field for charges moving in a uniform e field

• this overcharge equals voltage between two points

• useful amount equal to Helmholtz free energy at constant temp and volume

• closed paths in conservative vector fields have a net value of 0 for it

• change in it equals the integral of pressure through change in volume

• equals line integral along the path of the force dotted with dx

**Power**

• pressure times volumetric flow rate

• angular velocity times torque

• current squared times resistance

• velocity times force

• sound intensity times area

• proportional to amplitude squared time frequency squared times wave velocity for sinusoidal waves

• in optics-reciprocal of focal length, measured in diopters

• namesake factor equals ratio or real to apparent this

• complex form- vector sum of real and reactive this, measured in volt-amperes

• current times voltage

• integral with respect to time equals work

• energy flux= this per area

• calculated by Larmor formula- proportional to charge squared times acceleration squared

**Kinetic Energy**

• planck’s constant times frequency minus work function

• von Weizsacker functional- edescribes it as a function of electron density for a gas

• operator equals negative hbar suared over 2 times mass del squared

• virial theorem- equals negative one half of total potential energy

**Potential Energy**

• work needed to move a charge an infinite distance from another charge

• 1/2 spring constant times square of displacement

• for a magnetic dipole subject to a magnetic field= negative dot product of moment and electric field
- for an e field- product of k and two charges divided by r
- one form=charge times voltage
- conservative force equals a gradient in this
- one type= \((q_1 \times q_2) / 4\pi r^2\) times electric constant times radius
- Morse names an empirical function for it
- Lennard-Jones- contains \(1/r^6\) term
- Jeans length gives scale at which one form of it will result in stability of a gas cloud

**Frequency**
- log of it: x-axis of Bode plot
- Nyquist type: half a system's sampling rate, aliasing occurs above it
- for a pendulum- sqrt of \(g\) over \(L\) divided by \(2\pi\)
- skin depth- sqrt of \(2(\text{resistivity})\) over product of permeability, conductivity, and (angular) this
- energy of a photon equals Planck's constant times this
- roll-off- steepness of the loss curve as a function of the log of this quantity
- for lc circuit, natural type= \((L*C)^{-\frac{1}{2}}\)
- namesake domain related to the time domain by the Fourier transform

**Electric field**
- splits spectral lines in the **Stark Effect**
- alters index of refraction in **Kerr Effect**
- their energy density=their magnitude times \(1/2\) the permittivity
- crossed with b field to give Poynting vector
- controls size of conductive channels in field-effect transistors- contrasted with bipolar junction transistors

**Magnetic field**
- **Chemical Shift**: The variation of nuclear magnetic resonant frequencies a magnetic field used. Examined as part of NMR spectroscopy.
- **SQUID**: very sensitive magnetometers used to measure weak magnetic fields based on superconducting units called johnson Junctions.
- **Hall Effect**: electrical difference between a current in a conductor and a magnetic field perpendicular to it.
- Measured in Teslas

**Current**
- its the only electrical quantity with a density so know that
- \(I=\sqrt{V/R}\) (current equals voltage over resistance) ohms law
- Biot-Savart law measures the strength of a field created by it
- large amounts can lead to avalanche breakdown
- displacement type is in Ampere's law
- can be represented as motion of electron holes in p-type semiconductors
- proportional to the integral of magnetic field in Ampere's law

Don't worry about these for the quiz, to be added later
Voltage

Resistance
Energy
Time
Speed of Light
Velocity
Mass
Density
Volume
Acceleration