Physics NEET Formula

PHYSICAL CONSTANTS

- Speed of light $c = 3\times10^{8}$ m/s
- Plank constant $h = 6.63\times10^{-34}$ J s

  $hc = 1242$ eV-nm
- Gravitation constant $G = 6.67\times10^{-11} m^3 kg^{-1} s^{-2}$
- Boltzmann constant $k = 1.38\times10^{-23}$ J/K
- Molar gas constant $R = 8.314$ J/(mol K)
- Avogadro's number $N_A = 6.023\times10^{23} mol^{-1}$
- Charge of electron $e = 1.602\times10^{-19} C$
- Permeability of vacuum $\mu_0 = 4\pi\times10^{-7} N/A^2$
- Permittivity of vacuum $\in_0 = 8.85\times10^{-12} F/m$
- Coulomb constant $\frac{1}{4\pi\in_0} = 9\times10^{9} Nm^2/C^2$
- Faraday constant $F = 96485 C/mol$
- Mass of electron $m_e = 9.1\times10^{-31} kg$
- Mass of proton $m_p = 1.6726\times10^{-27} kg$
- Mass of neutron $m_n = 1.6749\times10^{-27} kg$
- Atomic mass unit $u = 1.66\times10^{-27} kg$
- Atomic mass unit $u = 9.31.49 MeV/c^2$
- Stefan Boltzmann constant $\sigma = 5.67\times10^{-8} W/\left(m^2K^4\right)$
- Rydberg constant $R_\infty = 1/097\times10^{7} m^{-1}$
- Bohr magneton $\mu_B = 9.27\times10^{-24} J/T$
- Bohr radius $a_0 = 0.529\times10^{-10} m$

- Standard atmosphere $\text{atm} = 1.01325 \times 10^5\, Pa$
- Wien displacement constant $b = 2.9 \times 10^{-3}\, mK$

MECHANICS

- Notation: $\vec{a} = a_x \hat{i} + a_y \hat{j} + a_z \hat{k}$
- Magnitude: $\vec{a}.\left|\vec{a}\right| = \sqrt{a_x^2 + a_y^2 + a_z^2}$
- Dot product: $\vec{a}.\vec{b} = a_x b_x + a_y b_y + a_z b_z = ab\cos\theta$
- Cross product:

$$\vec{a} \times \vec{b} = \left(a_y b_z - a_z b_y\right)\hat{i} + \left(a_z b_x - a_x b_z\right)\hat{j} + \left(a_x b_y - a_y b_x\right)\hat{k}$$

$$\left|\vec{a} \times \vec{b}\right| = ab\sin\theta$$

KINETICS

- Average and Instantaneous vel. And Accel.:

$$\vec{u}_{av} = \Delta\vec{r}/\Delta t, \vec{u}_{inst} = d\vec{r}/dt$$

$$\vec{a}_{av} = \Delta\vec{u}/\Delta t, \vec{a}_{inst} = d\vec{u}/dt$$

- Motion in a straight line with constant a:

$$v = u + at, s = ut + \frac{1}{2}at^2, v^2 - u^2 = 2as$$

- Relative velocity: $\vec{u}_{A/B} = \vec{u}_A - \vec{u}_B$
- Projectile Motion:

$$x = ut\cos\theta, y = ut\sin\theta - \frac{1}{2}gt^2$$

$$y = x\tan\theta - \frac{g}{2u^2\cos^2\theta}x^2$$

$$T = \frac{2u\sin\theta}{g}, R = \frac{u^2\sin 2\theta}{g}, H = \frac{u^2\sin\theta}{2g}$$

NEWTONS LAWS AND FRICITION

- Linear momentum: $\vec{p} = m\vec{v}$
- Newton's first law: internal frame
- Newton's second law: $\vec{F} = \frac{d\vec{p}}{dt}, \vec{F} = m\vec{a}$
- Newton's third law: $\vec{F}_{AB} = -\vec{F}_{BA}$
- Frictional force: $fstatic, \max = \mu_s N, f\text{kinetic} = \mu_K N$
- Banking angle: $\frac{v^2}{rg} = \tan\theta, \frac{v^2}{rg} = \frac{\mu + \tan\theta}{1 - \mu\tan\theta}$
- Centripetal force: $F_c = \frac{mv^2}{r}, a_c = \frac{v^2}{r}$
- Pseudo force: $\vec{F}_{\text{Pseudo}} = -m\vec{a}_0, F_{\text{centrifugal}} = -\frac{mv^2}{r}$
- Minimum speed to complete vertical circle: $u_{\text{min,bottom}} = \sqrt{5gl}, u_{\text{min,top}} = \sqrt{gl}$
- Conical pendulum: $T = 2\pi\sqrt{\frac{l\cos\theta}{g}}$

WORK POWER AND ENERGY

- Work: $W = \vec{F}.\vec{S} = FS\cos\theta, W = \int\vec{F}.d\vec{S}$
- Kinetic energy: $K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$

- Potential energy: $F = -\partial U / \partial x$ for conservative forces.

  $U_{\text{gravitational}} = mgh, U_{\text{spring}} = \frac{1}{2}kx^2$

- Work done by conservative force is path independent and depends only on initial and final points: $\oint \vec{F}_{conservative} . d\vec{r} = 0$.
- Work energy theorem: $W = \Delta K$
- Mechanical energy: E=U+K. conserved if forces are conservative in nature.
- Power: $P_{av} = \frac{\Delta W}{\Delta t}, P_{\text{inst}} = \vec{F}.\vec{v}$

CENTRE OF MASS AND COLLISION

1. Centre of mass: $x_{cm} = \frac{\sum x_i m_i}{\sum m_i}, x_{cm} = \frac{\int xdm}{\int dm}$
2. CM of few useful configurations:

- m_1, m_2 separated by r:
- Triangle: (CM=centroid) $y_c = \frac{h}{3}$
- Semi-circular ring: $y_c = \frac{2r}{\pi}$
- Semi-circular disc: $y_c = \frac{4r}{3m}$
- Hemispherical shell: $y_c = \frac{r}{2}$
- Solid hemisphere: $y_c = \frac{3r}{s}$
- Cone: the height of CM from the base is h/4 for the solid cone and h/3 for the hollow cone.

1. Motion of the CM: $M = \sum m_i$

$$\vec{v}_{cm} = \frac{\sum m_i \vec{v}_i}{M}, \vec{p}_{cm} = M\vec{v}_{cm}, \vec{a}_{cm} = \frac{\vec{F}_{ext}}{M}$$

2. Impulse: $\vec{J} = \int \vec{F}\, dt = \Delta \vec{p}$

3. Collision:

Momentum conservation: $m_1 v_1 + m_2 v_2 = m_1 v'_1 + m_2 v'_2$

Elastic collision: $\frac{1}{2} m_1 v_1^2 + m_2 v_2^2 = \frac{1}{2} m_1 v'^2_1 + \frac{1}{2} m_2 v'_2$

$$\in = \frac{-\left(v_1' - v_2'\right)}{v_1 - v_2} = \begin{cases} 1, & \text{completely elastic} \\ 2, & \text{completely in-elastic} \end{cases}$$

If $v_2 = 0$ and $m_1 << m_2$ then $v_1' = -v_1$.

If $v_2 = 0$ and $m_1 >> m_2; v_1' = v_2$ and $v_2' = v_1$.

RIGHT PHYSICS

1. Angular velocity: $w_{av} = \frac{\Delta \theta}{\Delta t}, w = \frac{d\theta}{dt}, \vec{v} = \vec{w} \times \vec{r}$

2. Angular Accel.: $\alpha_{av} = \frac{\Delta w}{\Delta t}, \alpha \frac{dw}{dt}, \vec{a} = \vec{a} \times \vec{r}$

3. Rotation about an axis with constant α:

   $$w = w_0 + \alpha t, \theta = wt + \frac{1}{2}\alpha t^2, w^2 - w_0^2 = 2\alpha\theta$$

4. Moment of inertia: $I = \sum_i m_i r_i^2, I = \int r^2 dm$

5. Theorem of parallel Axes: $I_{\parallel} = I_{cm} + md^2$

6. Theorem of Perp. Axes: $I_z = I_x + I_y$

7. Radius of Gyration: $k = \sqrt{I/m}$

8. Angular momentum: $\vec{L} = \vec{r} \times \vec{p}, \vec{L} = I\vec{w}$

9. Torque: $\vec{r} = \vec{r} \times \vec{F}, \vec{r} = \frac{d\vec{L}}{dt}, \tau = I\alpha$

10.Conservation of $\vec{L}: \vec{T}_{ext} = 0 \Rightarrow \vec{L} = const.$

11.Equilibrium condition: $\sum \vec{F} = \vec{0}, \sum \vec{r} = \vec{0}$

12.Kinetic energy: $K_{rot} = \frac{1}{2} I w^2$

13.Dynamics:

$\vec{\tau}_{cm} = I_{cm} \vec{\alpha}, \vec{F}_{ext} = m \vec{a}_{cm}, \vec{p}_{cm} = m \vec{v}_{cm}$

$K = \frac{1}{2} m v_{cm^2} + \frac{1}{2} I_{cm} w^2, \vec{L} = I_{cm} \vec{w} + \vec{r}_{cm} \times m \vec{v}_{cm}$

GRAVITATION

1. Gravitation force: $F = G \frac{m_1 m_2}{r^2}$
2. Potential energy: $U = -\frac{GMm}{r}$
3. Gravitational energy: $g = \frac{GM}{R^2}$
4. Variation of g with depth: $g_{inside} \approx g \left(1 - \frac{h}{R}\right)$
5. Variation of g with height: $g_{outside} \approx g \left(1 - \frac{2h}{R}\right)$
6. Effect of non-spherical earth shape on g:

   $g_{at} \, pole > g_{at \text{ equator}} \left(\because R_e - R_p \approx 21 km\right)$
7. Effect of earth rotation on apparent weight: $mg_{\theta}^{'} = mg - mw^2 R \cos^2 \theta$
8. Orbital velocity of satellite : $v_0 = \sqrt{\frac{GM}{R}}$
9. Escape velocity: $v_e = \sqrt{\frac{2GM}{R}}$

10.Kepler's laws:

First: elliptical orbit with sum at one of the focus.

Second: A real velocity is constant $\left(\because d\vec{L}/dt = 0\right)$

Third: $T^2 \propto a^3$. In circular orbit $T^2 = \frac{4\pi^2}{GM}a^3$

SIMPLE HARMONIC MOTION

- Hooke's Law: F=-kx (for small elongation x)
- Acceleration: $a = \frac{d^2x}{dx^2} = -\frac{k}{m}x = -w^2x$
- Time period: $T = \frac{2\pi}{w} = 2\pi\sqrt{\frac{m}{k}}$
- Displacement: $x = A\sin(wt+\phi)$
- Velocity: $v = Aw\cos(wt+\phi) = \pm w\sqrt{A^2 - x^2}$
- Potential energy: $U = \frac{1}{2}kx^2$
- Kinetic energy: $k = \frac{1}{2}mv^2$
- Total energy: $E = U + K = \frac{1}{2}mw^2A^2$
- Simple pendulum: $T = 2\pi\sqrt{\frac{l}{9}}$
- Physical pendulum: $T = 2\pi\sqrt{\frac{I}{mgl}}$
- Torsional pendulum: $T = 2\pi\sqrt{\frac{I}{k}}$
- Springs in series: $\frac{1}{k_{eq}} = \frac{1}{k_1} + \frac{1}{k_2}$
- Spring in parallel: $k_{eq} = k_1 + k_2$
- Superposition of two SHM's:

$$x_1 = A_1 \sin wt, x_2 = A_2 \sin(wt + \delta)$$
$$x = x_1 + x_2 = A\sin(wt + \in)$$
$$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\delta}$$
$$\tan \in = \frac{A_2 \sin\delta}{A_1 + A_2\cos\delta}$$

PROPERTIES OF MATTER

- Modulus of rigidity: $Y = \frac{F/A}{\Delta t/t'}, B = -V\frac{\Delta P}{\Delta V}, \eta = \frac{F}{A\theta}$
- Compressibility: $K = \frac{1}{B} = -\frac{1}{V}\frac{dV}{dP}$
- Poisson's ratio: $\sigma = \frac{\text{lateral strain}}{\text{longitudinal strain}} = \frac{\Delta D/D}{\Delta t/t}$
- Elastic energy: $U = \frac{1}{2}\text{stress} \times \text{strain} \times \text{volume}$
- Surface tension: $S = F/l$
- Surface energy: $U = SA$
- Excess pressure in bubble: $\Delta_{pair} = 2S/R, \Delta_{\rho soap} = 4S/R$
- Capillary rise: $h = \frac{2S\cos\theta}{r\rho g}$
- Hydrostatic pressure: $p = \rho gh$
- Buoyant force: $F_B = \rho Vg = \text{weight of displaced liquid}$
- Equation of continuity: $A_1v_1 = A_2v_2$
- Bernoulli's equation: $p + \frac{1}{2}pv^2 + \rho gh = \text{constant}$
- Torricell's theorem: $v_{efflux} = \sqrt{2gh}$
- Viscous force: $F = -\eta A\frac{dv}{dx}$
- Stoke's law: $F = 6\pi\eta rv$

❖ Poiseuilli's equation: $\frac{\text{volume flow}}{\text{time}} = \frac{\pi p r^4}{8\eta l}$

❖ Terminal velocity: $v_t = \frac{2r^2(\rho - \sigma)g}{9\eta}$

WAVES MOTION

(i) General equation of wave: $\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$

(ii) Notation: Amplitude A, frequency v, Wavelength λ, Period T,

Angular Frequency w, Wave number k, $T = \frac{1}{v} = \frac{2\pi}{w}, v = v\lambda, k = \frac{2\pi}{\lambda}$

(iii) Progressive wave travelling with speed v : $y = f(t - x/v)$, +x;

$y = f(t + x/v)$, -x

(iv) Progressive sine wave:

$y = A\sin(kx - wt) = A\sin(2\pi(x/\lambda - t/T))$

WAVES ON A STRING

(i) Speed of waves on a string with mass per unit length μ and tension T: $v = \sqrt{T/\mu}$

(ii) Transmitted power: $P_{av} = 2\pi^2 \mu v A^2 v^2$

(iii) Interference:

$y_1 = A_1 \sin(kx - wt), y_2 = A_2 \sin(kx - wt + \delta)$

$y = y_1 + y_2 = A\sin(x - wt + \in)$

$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos\delta}$

$\tan \in = \dfrac{A_2 \sin\delta}{A_1 + A_2 \cos\delta}$

$\delta = \begin{cases} 2n\pi & \text{constructive} \\ (2n+1)\pi, & \text{destructive} \end{cases}$

(iv) Standing waves:

$y_1 = A_1 \sin(kx - wt), y_2 = A_2 \sin(kx + wt)$

$y = y_1 + y_2 = (2A\cos kx)\sin wt$

$x = \begin{cases} \left(n + \dfrac{1}{2}\right)\dfrac{\lambda}{2}, & \text{modes}; n = 0,1,2.... \\ n\dfrac{\lambda}{2}, & \text{antinodes. } n = 0,1,2.... \end{cases}$

- String fixed at both ends:
  1. Boundary conditions: y=0 at x=0 and at x=L
  2. Allowed Freq.: $L = n\dfrac{\lambda}{2}, \nu = \dfrac{n}{2L}\sqrt{\dfrac{T}{\mu}}, n = 1,2,3...$
  3. Fundamental/1st harmonics: $\nu_0 = \dfrac{1}{2L}\sqrt{\dfrac{T}{\mu}}$
  4. 1st overtone/2nd harmonics: $\nu_1 = \dfrac{2}{2L}\sqrt{\dfrac{T}{\mu}}$
  5. 2nd overtone/3rd harmonics: $\nu_2 = \dfrac{3}{2L}\sqrt{\dfrac{T}{\mu}}$
  6. All harmonics are present.
- String fixed at one end:
- Boundary conditions: y=0 at x=0
- Allowed Freq.: $L = (2n+1)\dfrac{\lambda}{4}, \nu = \dfrac{2n+1}{4L}\sqrt{\dfrac{T}{\mu}}, n = 0,1,2....$
- Fundamental /1st harmonics: $\nu_0 = \dfrac{1}{4L}\sqrt{\dfrac{T}{\mu}}$

- 1st overtone/3rd harmonics: $v_1 = \frac{3}{4L}\sqrt{\frac{T}{\mu}}$
- 2nd overtone/5th harmonics: $v_2 = \frac{5}{4L}\sqrt{\frac{T}{\mu}}$
- Only add harmonics are present.
- Sonometer: $v \propto \frac{1}{L}, v \propto \sqrt{T}, v \propto \frac{1}{\sqrt{\mu}}. v \propto = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$

SOUND WAVES

- Displacement wave: $s = s_0 \sin w(t - x/v)$
- Pressure wave: $p = p_0 \cos w(t - x/v), p_0 = (Bw/v)s_0$
- Speed of sound water: $v_{liquid} = \sqrt{\frac{B}{\rho}}, v_{solid} = \sqrt{\frac{Y}{\rho}}, v_{gas} = \sqrt{\frac{\gamma P}{\rho}}$
- Intensity: $I = \frac{2\pi^2 B}{v} s_0^2 v^2 = \frac{p_0^2 v}{2B} = \frac{p_0^2}{2\rho v}$
- Standing longitudinal waves:

  $p_1 = p_0 \sin w(t - x/v), p_2 = p_0 \sin w(t + x/v)$

  $p = p_1 + p_2 = 2p_0 \cos kx \sin wt$
- Closed organ pipe:
  1. Boundary conditions: y=0 at x=0
  2. Allowed freq.: $L = (2n+1)\frac{\lambda}{4}, v = (2n+1)\frac{v}{4L}, n = 0,1,2....$
  3. Fundamental/1st harmonics: $v_0 = \frac{v}{4L}$
  4. 1st overtone/3rd harmonics: $v_1 = 3v_0 = \frac{3v}{4L}$
  5. 2nd overtone/5th harmonics: $v_2 = 5v_0 = \frac{5}{4L}$
  6. Only add harmonics are present.

- Open organ pipe:

1. Boundary condition: y=0 at x=0

   Allowed Freq.: $L = n\frac{\lambda}{2}, v = n\frac{v}{4L}, n = 1, 2, ...$

2. Fundamental/1st harmonics: $v_0 = \frac{v}{2L}$

3. 1st overtone/2nd harmonics: $v_1 = 2v_0 = \frac{2v}{2L}$

4. 2nd overtone/ 3rd harmonics: $v_2 = 3v_0 = \frac{3v}{2L}$

5. All harmonics are present.

- Resonance column:

$$l_1 + d = \frac{\lambda}{2}, l_2 + d = \frac{3\lambda}{4}, v = 2(l_2 - l_1)v$$

Beasts: two waves of almost equal frequencies $w_1 \approx w_2$

$$p_1 = p_0 \sin w_1 (t - x/v), p_2 = p_0 \sin w_2 (t - x/v)$$
$$p = p_1 + p_2 = 2p_0 \cos \Delta w(t - x/v) \sin w(t - x/v)$$
$$w = (w_1 + w_2)/2, \Delta w = w_1 - w_2 \text{(beasts freq.)}$$

- Doppler effect:

$$v = \frac{v + u_0}{v - u_s} v_0$$

Where, v is the speed of sound in the medium, u_0 is the speed of the observer w.r.t the medium, considered positive when it moves towards the source, and u_s is the speed of the source w.r.t. the medium, considered positive when it moves towards the observer and negative when it moves away from the observer.

LIGHT WAVES

- Plane wave: $E = E_0 \sin w\left(t - \frac{x}{v}\right), I = I_0$
- Spherical waves: $E = \frac{aE_0}{r}\sin w\left(t - \frac{r}{v}\right), I = \frac{I_0}{r^2}$
- Young's double slit experiment:
- Path difference: $\Delta x = \frac{dy}{D}$
- Phase difference: $\delta = \frac{2\pi}{\lambda}\Delta x$
- Interference conditions: for integer n,

$$\delta = \begin{cases} 2n\pi, \text{ constructive;} \\ (2n+1)\pi, \text{ destructive;} \end{cases}$$

$$\Delta x = \begin{cases} n\lambda, \text{ constructive} \\ \left(n + \frac{1}{2}\right)\lambda, \text{ destructive} \end{cases}$$

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\delta,$$

- Intensity: $I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2, I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

$$I_1 = I_2 : I = 4I_0\cos^2\frac{\delta}{2}, I_{max} = 4I_0, I_{min} = 0$$

- Fringe width: $w = \frac{\lambda D}{d}$
- Optical path: $\Delta x' = \mu\Delta x$
- Interference of waves transmitted through this film:

$$\Delta x = 2\mu d = \begin{cases} n\lambda, \text{ constructive} \\ \left(n + \frac{1}{2}\right)\lambda, \text{ destructive} \end{cases}$$

- Diffraction from a single slit:

  For minima: $n\lambda = b\sin\theta \approx b(y/D)$

- Resolution: $\sin\theta = \frac{1.22\lambda}{b}$
- Law of malus: $I = I_0\cos^2\theta$

REFLECTION OF LIGHT

- Laws of reflection:
- Incident ray, reflected ray, and normal lie on the same plane
- $\angle i = \angle r$.
- Plane mirror:
- The image and the object are equidistant from mirror
- Virtual image of the real object
- Spherical mirror:
- Focul length $f = R/2$
- Mirror equidistant: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$
- Magnification $m = -\frac{v}{u}$

REFRACTION OF LIGHT

- Refractive index: $\mu = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}} = \frac{c}{v}$
- Snell's law: $\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$
- Apparent depth: $\mu = \frac{\text{real depth}}{\text{apparent depth}} = \frac{d}{d'}$
- Critical angle: $\theta_c = \sin^{-1}\frac{1}{\mu}$
- Deviation by a prism:

  $\delta = i + i' - A,$ general result

  $$\mu = \frac{\sin\frac{A+\delta_m}{2}}{\sin\frac{A}{2}}, i = i' \text{ for minimum deviation}$$

$\delta_m = (\mu - 1)A,$ for small A

1. Refraction at spherical surface:

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}, m = \frac{\mu_1 v}{\mu_2 u}$$

2. Lens marker's formula: $\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

3. Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}, m = \frac{v}{u}$

4. Power of the lens: $P = \frac{1}{f}$, P in dioptre if f in metre.

5. Two thin lenses separated by distance d:

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

OPTICAL INSTRUMENTS

1. Simple microscope: m=D/f in normal adjustment.
2. Compound microscope:

1. Magnification in normal adjustment: $m = \frac{v}{u}\frac{D}{f_\in}$

2. Resolving power: $R = \frac{1}{\Delta d} = \frac{2\mu \sin\theta}{\lambda}$

1. Astronomical telescope:

1. In normal adjustment: $m = -\frac{f_o}{f_c}, L = f_o + f_c$

2. Resolving power: $R = \frac{1}{\Delta\theta} = \frac{1}{1.22\lambda}$

DISPERSION

3. Cauchy's equation: $\mu = \mu_0 + \frac{A}{\lambda^2}, A > 0$

4. Dispersion by prism with small A and i:

1. Mean deviation: $\delta_y = (\mu_y - 1)A$

2. Angular dispersion: $\theta = (\mu_v - \mu_r)A$

1. Dispersive power: $w = \frac{\mu_v - \mu_r}{\mu_y - 1} \approx \frac{\theta}{\delta_y}$ (if A and i small)

2. Dispersion without deviation: $(\mu_y - 1)A + (\mu'_y - 1)A' = 0$

3. Deviation without dispersion: $(\mu_v - \mu_r)A = (\mu'_v - \mu'_r)A'$

HEAT AND TEMPERATURE

1. Temp. scales: $F = 32 + \frac{9}{5}C, K = C + 273.16$

2. Ideal gas equation: $pV = nRT$, n; number of moles

3. Van der Waals equation: $\left(p + \frac{a}{V^2}\right)(V - b) = nRT$

4. Thermal expansion: $L = L_0(1 + \alpha\Delta T)$,
$A = A_0(1 + \beta\Delta T), V = V_0(1 + \gamma\Delta T), \gamma = 2\beta = 3\alpha$

5. Thermal stress of a material: $\frac{F}{A} = Y\frac{\Delta l}{l}$

KINETIC THEORY OF GASES

1. General: $M = mN_A, k = R / N_A$

2. Maxwell distribution of speed:

3. RMS speed: $v_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3RT}{M}}$

4. Average speed: $\bar{v} = \sqrt{\frac{8kT}{\pi m}} = \sqrt{\frac{8RT}{\pi M}}$

5. Most probable speed: $v_p = \sqrt{\frac{2kT}{m}}$

6. Pressure: $p = \frac{1}{3}\rho v^2{}_{rms}$

7. Equipartition of energy: $K = \frac{1}{2}kT$ for each degree if freedom. Thus, $K = \frac{f}{2}kT$ for molecule having f degrees of freedoms.

8. Internal energy: of n mole of an ideal gas is $U = \frac{f}{2}nRT$

SPECIFIC HEAT

1. Specific heat: $s = \frac{Q}{m\Delta T}$

2. Latent heat: $L = Q/m$

3. Specific heat at constant volume: $C_v = \left.\frac{\Delta Q}{n\Delta T}\right|_V$

4. Specific heat at constant pressure: $C_P = \left.\frac{\Delta Q}{n\Delta T}\right|_P$

5. Relation between C_p and C_v: $C_P - C_V = R$

6. Ratio of specific heats: $\gamma = C_P / C_V$

7. Relation between U and C_V: $\Delta U = nC_v\Delta T$

8. Specific heat of gas mixture:

$$C_v = \frac{n_1C_{v1} + n_2C_{v2}}{n_1 + n_2}, \gamma = \frac{n_1C_{p1} + n_2C_{p2}}{n_1C_{v1} + n_2C_{v2}}$$

9. Molar internal energy of an ideal gas: $U = \frac{f}{2}RT$, f=3 for monatomic and f=5 for diatomic gas.

THERMODYNAMICS PROCESSS

10.First law of thermodynamics: $\Delta Q = \Delta U + \Delta W$

11.Work done by the gas:

$$\Delta W = p\Delta V, W = \int_{v_1}^{v_2} pdV$$

$$W_{isothermal} = nRT\ln\left(\frac{V_2}{V_1}\right)$$

$$W_{isobaric} = p(V_2 - V_1)$$

$$W_{adiabatic} = \frac{p_1V_1 - p_2V_2}{\lambda - 1}$$

$$W_{isochoric} = 0$$

12.Efficiency of the heat engine:

$$\eta = \frac{\text{work done by the engine}}{\text{heat supplied to it}} = \frac{Q_1 - Q_2}{Q_1}$$

$$\eta_{carnot} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

13.Co eff. Of performance of refrigerator:

$$\text{COP} = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2}$$

14.Entropy:

$$\Delta S = \frac{\Delta Q}{T}, S_f - S_i = \int_i^f \frac{\Delta Q}{T}$$

$$\text{const. T:}\Delta\text{S}=\frac{Q}{T},\ \text{var ying T: } \Delta S = ms\ln\frac{T_f}{T_i}$$

15.Adiabatic process: $\Delta Q = 0, pV^{\gamma} = \text{constant}$

HEAT TRANSFER

1. Conduction: $\frac{\Delta Q}{\Delta t} = -KA\frac{\Delta T}{x}$

2. Thermal resistance: $R = \frac{x}{KA}$

$$R_{series} = R_1 + R_2 = \frac{1}{A}\left(\frac{x_1}{K_1} + \frac{x_2}{K_2}\right)$$

$$\frac{1}{R_{parallel}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{x}\left(K_1A_1 + K_2A_2\right)$$

3. Kirchoff's Law: $\frac{\text{emissive power}}{\text{absorptive power}} = \frac{E_{body}}{a_{body}} = E_{blackbody}$

4. Wien's displacement law: $\lambda_m T = b$

5. Stefan-Boltzmann law: $\frac{\Delta Q}{\Delta t} = \sigma e A T^4$

6. Newton's law of cooling: $\frac{dT}{dt} = -bA\left(T - T_0\right)$

ELECTROSTATICS

1. Coulomb's law: $\vec{F} = \frac{1}{4\pi \in_0} \frac{q_1 q_2}{r^2} \hat{r}$

2. Electric field: $\vec{E}\left(\vec{r}\right) = \frac{1}{4\pi \in_0} \frac{q}{r^2} \hat{r}$

3. Electrostatic energy: $U = -\frac{1}{4\pi \in_0} \frac{q_1 q_2}{r}$

4. Electrostatic potential: $V = \frac{1}{4\pi \in_0} \frac{q}{r}$

$$dV = -\vec{E}.\vec{r}, V\left(\vec{r}\right) = -\int_{\infty}^{\vec{r}} \vec{E}.d\vec{r}$$

5. Electric dipole moment: $\vec{p} = q\vec{d}$

6. Potential of a dipole: $V = \frac{1}{4\pi \in_0} \frac{p\cos\theta}{r^2}$

7. Field of a dipole: $E_r = \frac{1}{4\pi \in_0} \frac{2p\cos\theta}{r^3}, E_\theta = \frac{1}{4\pi \in_0} \frac{p\sin\theta}{r^3}$

8. Torque on a dipole placed in $\vec{E}$: $\vec{r} = \vec{p} \times \vec{E}$

9. Pot. Energy of a dipole placed in $\vec{E}$: $U = -\vec{p}.\vec{E}$

GAUSS'S LAW AND ITS APPLICATIONS

1. Electric flux: $\phi = \oint \vec{E}.d\vec{S}$

2. Gauss's law: $\oint \vec{E}.d\vec{S} = q_{in} / \in_0$

3. Field of a uniformly charged ring on its axis:

$$E_P = \frac{1}{4\pi \in_0} \frac{qx}{\left(a^2 + x^2\right)^{3/2}}$$

4. E and V of a uniformly charged sphere:

$$E = \begin{cases} \frac{1}{4\pi \in_0} \frac{Qr}{R^3}, \text{ for } r < R \\ \frac{1}{4\pi \in_0} \frac{Q}{r^2}, \text{ for } r \geq R \end{cases}$$

$$V = \begin{cases} \frac{Q}{8\pi \in_0 R}\left(3 - \frac{r^2}{R^2}\right), \text{ for } r < R \\ \frac{1}{4\pi \in_0} \frac{Q}{r}, \text{ for } r \geq R \end{cases}$$

5. E and V of a uniformly charged spherical shell:

$$E = \begin{cases} 0, \text{ for } r < R \\ \frac{1}{4\pi \in_0} \frac{Q}{r^2}, \text{ for } r \geq R \end{cases}$$

$$V = \begin{cases} \frac{1}{4\pi \in_0} \frac{Q}{R}, \text{ for } r < R \\ \frac{1}{4\pi \in_0} \frac{Q}{r}, \text{ for } r \geq R \end{cases}$$

6. Field of a line charge: $E = \frac{\lambda}{2\pi \in_0 r}$

7. Field of an infinite sheet: $E = \frac{\sigma}{2 \in_0}$

8. Field in the vicinity of conducting surface: $E = \frac{\sigma}{\in_0}$

CAPACITORS

- Capacitance: C=q/V
- Parallel plate capacitor: $C = \in_0 A/d$
- Spherical capacitor: $C = \frac{4\pi \in_0 r_1 r_2}{r_2 - r_1}$
- Cylindrical capacitor $C = \frac{2\pi \in_0 l}{\ln(r_2/r_1)}$
- Capacitors in parallel: $C_{eq} = C_1 + C_2$
- Capacitors in series: $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$
- Force between plates of a parallel plate capacitor: $F = \frac{Q^2}{2A \in_0}$
- Energy stored in capacitor: $U = \frac{1}{2}CV^2 = \frac{Q^2}{2C} = \frac{1}{2}QV$
- Energy density in electric field $E : U/V = \frac{1}{2} \in_0 E^2$
- Capacitor with dielectric: $C = \frac{\in_0 KA}{d}$

CURRENT ELECTRICITY

- Current density: $j = i/A = \sigma E$
- Drift speed: $v_d = \frac{1}{2}\frac{eE}{m}T = \frac{i}{neA}$
- Resistance of a wire: $R = \rho l/A$, where $\rho = 1/\sigma$
- Temp. dependence of resistance: $R = R_0(1 + \alpha \Delta T)$
- Ohm's law: V=iR
- Kirchhoff's law:

(i) the junction law: The algebraic sum of all the currents directed towards a node is zero i.e., $\sum_{node} Ii = 0$.

(ii) The loop law: the algebraic sum of all the potential along a closed loop in a circuit is zero i.e., $\sum_{loop} \Delta V_i = 0$

- Resistance in parallel: $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$
- Resistance in sectors: $R_{eq} = R_1 + R_2$
- Wheatstone bridge:

  Balanced if $R_1 / R_2 = R_3 / R_4$
- Electric power: $P = V^2 / R = I^2 R = IV$
- Galvanometer as an Ammeter:

  $i_g G = (i - i_g) S$
- Galvanometer as a Voltmeter:

  $V_{AB} = i_g (R + G)$
- Charging of capacitors:

  $q(t) = CV\left[1 - e^{-\frac{t}{RC}}\right]$
- Discharging of capacitors: $q(t) = q_0 e^{-\frac{t}{RC}}$
- Time constant in RC circuit: $\tau = RC$
- Peltier effect: $\text{emf e} = \frac{\Delta H}{\Delta Q} = \frac{\text{peltier heat}}{\text{charge transferred}}$
- Seeback effect

1. Thermo-emf: $e = aT + \frac{1}{2} bT^2$
2. Thermoelectric power: $de / dt = a + bT$
3. Neutral temp: $T_n = -a / b$
4. Inversion temp: $T_i = -2a / b$

- Thomson effect: $\text{emf } e = \frac{\Delta H}{\Delta Q} = \frac{\text{Thomson heat}}{\text{charge transferred}} = \sigma \Delta T$
- Faraday's law of electrolysis: The mass deposited is $m = Zit = \frac{1}{F} Eit$ where I is current, Z is electrochemical equivalent, E is chemical equivalent and F=96485C/g is Faraday constant.

MAGNETISM

- Lorentz force on a moving charge: $\vec{F} = q\vec{v} \times \vec{B} + q\vec{E}$
- Charged particle in a uniform magnetic field:

  $r = \frac{mv}{qB}, T = \frac{2\pi m}{qB}$
- Force on a current carrying wire:

  $\vec{F} = i\vec{l} \times \vec{B}$
- Magnetic moment of a current loop (dipole):

  $\vec{\mu} = i\vec{A}$
- Torque on a magnetic dipole placed in $\vec{B} : \vec{r} = \vec{\mu} \times \vec{B}$
- Energy of a magnetic dipole placed in $\vec{B} : U = -\vec{\mu}.\vec{B}$
- Hall effect: $V_w = \frac{Bi}{ned}$

MAGNETIC FIELD

- Biot-Savart law: $d\vec{B} = \frac{\mu_0}{4\pi} \frac{id\vec{l} \times \vec{r}}{r^3}$
- Field due to a straight conductor: $B = \frac{\mu_0 i}{4\pi d}(\cos\theta_1 - \cos\theta_2)$
- Field due to an infinite straight wire: $B = \frac{\mu_0 i}{2\pi d}$

- Force between parallel wires: $\frac{dF}{dt} = \frac{\mu_0 i_1 i_2}{2\pi d}$
- Field on the axis of a ring: $B_P = \frac{\mu_o i_a^2}{2\left(a^2 + d^2\right)^{3/2}}$
- Field at the centre of an arc: $B = \frac{\mu_0 i\theta}{4\pi a}$
- Field at the centre of a ring: $B = \frac{\mu_0 i}{2a}$
- Ampere's law: $\oint \vec{B}.d\vec{l} = \mu_0 I_{in}$
- Field inside a solenoid: $B = \mu_0 ni, n = \frac{N}{l}$
- Field inside a toroid: $B = \frac{\mu_0 Ni}{2\pi r}$
- Field of a bar magnet: $B_1 = \frac{\mu_0}{4\pi}\frac{2M}{d^3}, B_2 = \frac{\mu_0}{4\pi}\frac{M}{d^3}$
- Angle of dip: $B_h = B\cos\delta$
- Tangent galvanometer: $B_h \tan\theta = \frac{\mu_0 ni}{2r}, i = K\tan\theta$
- Moving coil galvanometer: $niAB = k\theta, i = \frac{k}{nAB}\theta$
- Time period of magnetometer: $T = 2\pi\sqrt{\frac{1}{MB_h}}$
- Permeability: $\vec{B} = \mu\vec{H}$

ELECTROMAGNETIC INDUCTION

- Magnetic flux: $\phi = \oint \vec{B}.d\vec{S}$
- Faraday's law: $e = -\frac{d\phi}{dt}$
- Lenz's law: Induced current create a B-field that opposes the charge in magnetic flux.

- Motional emf: e=B/v
- Self inductance: $\phi = Li, e = -L\frac{di}{dt}$
- Self inductance of a solenoid: $L = \mu_0 n^2 \left(\pi r^2 l\right)$
- Growth of current in LR circuit: $i = \frac{e}{R}\left[1 - e^{-\frac{t}{L/R}}\right]$
- Decay of current in LR circuit: $i = i_0 e^{-\frac{t}{L/R}}$
- Time constant of LR circuit: $\tau = L/R$
- Energy stored in an in inductor: $U = \frac{1}{2}Li^2$
- Energy density of B field: $u = \frac{U}{V} = \frac{B^2}{2\mu_0}$
- Mutual inductance: $\phi = Mi, e = -M\frac{di}{dt}$
- EMF induced in a rotating coil: $e = NAB\omega \sin \omega t$
- Alternating current:

  $i = i_0 \sin\left(\omega t + \phi\right), T = 2\pi/\omega$
- Average current in AC: $\bar{i} = \frac{1}{T}\int_0^T i dt = 0$
- RMS current: $i_{rms} = \left[\frac{1}{T}\int_0^T i^2 dt\right]^{1/2} = \frac{i_0}{\sqrt{2}}$
- Energy: $E = i_{rms}{}^2 RT$
- Capacitive reactance: $X_c = \frac{1}{\omega C}$
- Inductive reactance: $X_L = \omega L$
- Impedance: $Z = e_0 / i_0$
- RC circuit:

  $Z = \sqrt{R^2 + \left(1/\omega C\right)^2}, \tan\phi = \frac{1}{\omega CR}$

- LR circuit:

$$Z=\sqrt{R^2+\omega^2L^2},\tan\phi=\frac{\omega L}{R}$$

- LCR circuit:

$$Z=\sqrt{R^2+\left(\frac{1}{\omega C}-\omega L\right)^2},\tan\phi=\frac{\frac{1}{\omega C}-\omega L}{R}$$

$$v_{resonance}=\frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

- Power factor: $P=e_{rms}i_{rms}\cos\phi$

- Transformer: $\frac{N_1}{N_2}=\frac{e_1}{e_2},e_1i_1=e_2i_2$

- Speed of the EM waves in vacuum: $c=1/\sqrt{\mu_0\in_0}$