NEET Formula Booklet

Physics | Chemistry | Biology

Every formula cited to its NCERT page and corpus ID.
Conditions of use and when-NOT-to-use included per formula.

Companion to the 30-Day Mechanics Master Sheet

Class 12 and Repeater NEET Aspirants

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How to Use This Booklet

This booklet is a compact reference for every NEET-relevant quantitative formula across Physics, Chemistry, and Biology. It is organised by subject then by unit, with formulas in corpus ID order within each unit.

Each formula entry shows:

* **Name** (bold, top left) and **formula ID** (muted, top right) -- the ID links this entry to the tamilgeniuslab NEET corpus record.
* **Equation** -- ASCII notation with proper super/subscripts rendered.
* **Meaning** -- one-sentence plain-English description.
* **Use when** -- the conditions under which this formula applies.
* **Don't use** -- scenarios where students commonly misapply it.
* **Source** -- the NCERT page this formula was extracted from.

Citation note: Physics formulas carry full NCERT citations (subject, chapter, page number). Chemistry and Biology formulas are marked *citation pending* -- the corpus Tier 2 extraction for these subjects is not yet complete. Equations, conditions, and IDs are correct corpus data; only the NCERT page reference is deferred. Future corpus updates will backfill these citations.

For deep treatment (derivation, exam traps, typical mistakes, PYQ patterns), see the *30-Day Mechanics Master Sheet* companion PDF.

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Why Every Formula Is Cited

Most coaching formula sheets give you equations without provenance. This booklet is different: every Physics formula traces back to a specific NCERT page, and every formula carries a stable corpus ID that links it to the tamilgeniuslab NEET-1 data pipeline.

The citation chain (Physics):

```
Corpus formula record (Tier 3) -> NCERT entry_id (Tier 2 extraction) -> source_document_id
(manifest entry) -> vault PDF with SHA-256 hash
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Why conditions of use matter: The most common NEET Physics traps arise from applying a formula outside its valid conditions. For example, v^2 = u^2 + 2as is valid only for constant acceleration -- applying it to a variable-force problem is the single most common kinematics error. Every formula in this booklet lists its conditions explicitly.

Chemistry and Biology: The corpus Tier 2 extraction pipeline for Chemistry and Biology is in progress (Phase D). All formulas in these sections carry their corpus ID and equation; NCERT page citations will be backfilled in the next corpus update. The equations themselves are authoritative -- taken from the respective NCERT chapters and validated by subject-matter review.

Physics

144 formulas

PHY.U01 -- Units and Measurement

Error in a power expression

F.PHY.U01.ERR_POWER

$$Z = A^p * B^q * C^r \Rightarrow \frac{\Delta Z}{Z} = |p| * \frac{\Delta A}{A} + |q| * \frac{\Delta B}{B} + |r| * \frac{\Delta C}{C}$$

Meaning: The maximum relative error in a power expression is the sum of the absolute exponents weighted by the relative errors of the bases. Negative exponents (division...

Use when: Use absolute values of exponents — signs do not cancel in worst-case error analysis

Use when: Independent measurements assumption

Source: NCERT Class XI Physics, Ch 1, p. 6

Combination of errors — product or quotient

F.PHY.U01.ERR_PROD_QUOT

$$Z = A * B \text{ or } Z = A / B \Rightarrow \frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

Meaning: When two measured quantities are multiplied or divided, the maximum RELATIVE errors add. The absolute error in the result is then Delta_Z = Z * (relative-error...

Use when: A and B are independent measurements

Use when: Errors are quoted as maximum absolute uncertainties (worst-case)

Use when: For powers (Z = A^p * B^q), the rule generalises: Delta_Z/Z = |p|*Delta_A/A + |q|*Delta_B/B

Don't use: Quantities are added or subtracted (use absolute-error rule instead)

Source: NCERT Class XI Physics, Ch 1, p. 6

Combination of errors — sum or difference

F.PHY.U01.ERR_SUM_DIFF

$$Z = A \pm B \Rightarrow \Delta Z = \Delta A + \Delta B$$

Meaning: When two quantities are added or subtracted, the maximum absolute errors of the inputs simply add to give the maximum absolute error of the output. The relative...

Use when: A and B are independent measurements (no correlated errors)

Use when: Errors are quoted as maximum absolute uncertainties (not standard deviations)

Use when: Use this rule for ADDITION or SUBTRACTION only — NOT for product/quotient

Don't use: Quantities are multiplied or divided (use relative-error rule instead)

Don't use: Errors are statistical (standard deviations) — quadrature-sum rule applies

Source: NCERT Class XI Physics, Ch 1, p. 6

PHY.U02 -- Kinematics

First kinematic equation (uniform acceleration)

F.PHY.U02.KIN_V1

$$v = v_0 + a*t$$

Meaning: Final velocity equals initial velocity plus acceleration times the time elapsed, for motion under constant acceleration.

Use when: Acceleration a is CONSTANT (uniform) in both magnitude and direction

Use when: All quantities measured in the same inertial reference frame

Use when: Motion is along a straight line; signs encode direction along chosen axis

Don't use: Acceleration changes in magnitude or direction (use a(t) integration)

Don't use: Motion is uniformly circular at constant speed (a is centripetal, not tangential)

Source: NCERT Class XI Physics, Ch 2, p. 4

Second kinematic equation (displacement under uniform acceleration)

F.PHY.U02.KIN_V2

$$x - x_0 = v_0 t + \frac{1}{2} a t^2$$

Meaning: Displacement equals initial-velocity-times-time plus half of acceleration-times-time-squared. The (1/2) factor is the area of the triangle on the v-t graph.

Use when: Acceleration constant (magnitude and direction)

Use when: Sign convention consistent across x, v, a (one chosen positive direction)

Source: NCERT Class XI Physics, Ch 2, p. 5

Third kinematic equation (velocity-squared)

F.PHY.U02.KIN_V3

$$v^2 = v_0^2 + 2a(x - x_0)$$

Meaning: Relates final velocity to initial velocity, displacement, and acceleration without using time. Most useful when t is unknown or unwanted.

Use when: Constant acceleration

Use when: Use signed values for v, v0, a, and (x - x0) consistently

Don't use: Time-dependent acceleration

Don't use: Curvilinear motion where acceleration is not parallel to displacement

Source: NCERT Class XI Physics, Ch 2, p. 6

Projectile maximum height

F.PHY.U02.PROJ_HMAX

$$H = \frac{v_0^2 \sin^2(\theta_0)}{2g}$$

Meaning: Maximum height attained by a projectile launched at speed v0 and angle theta0 above the horizontal, measured above the launch level.

Use when: Air resistance neglected

Use when: Constant g over trajectory

Source: NCERT Class XI Physics, Ch 3, p. 14

Projectile horizontal range

F.PHY.U02.PROJ_RANGE

$$R = \frac{v_0^2 \sin(2\theta_0)}{g}$$

Meaning: For a projectile launched from and returning to the same horizontal level with initial speed v0 at angle theta0 above the horizontal, the horizontal range R is...

Use when: Launch and landing are at the same vertical height

Use when: Air resistance neglected

Use when: g treated as constant over the trajectory

Don't use: Launch and landing heights differ (use full kinematics)

Don't use: Significant air drag (e.g. table-tennis ball, badminton shuttle)

Don't use: Variation of g (ballistic trajectories spanning large altitude changes)

Source: NCERT Class XI Physics, Ch 3, p. 14

Centripetal acceleration in uniform circular motion

F.PHY.U02.UCM_AC

$$a_c = v^2 / r = omega^2 * r$$

Meaning: An object moving in a circle of radius r at constant speed v has acceleration of magnitude v^2/r (or equivalently omega^2 * r) directed toward the centre. This...

Use when: Speed v is constant (uniform circular motion)

Use when: r and the centre are well-defined (instantaneous radius of curvature for general curved motion)

Don't use: Non-uniform circular motion (then there is also a tangential acceleration component)

Note: Acceleration is the change in VELOCITY (a vector). Constant speed does NOT mean zero acceleration — direction...

Source: NCERT Class XI Physics, Ch 3, p. 17

PHY.U03 -- Laws of Motion

Maximum safe speed on a banked road (with friction)

F.PHY.U03.BANKED_ROAD_VMAX

$$v_{max} = sqrt(g*r*(mu_s + tan_{theta}) / (1 - mu_s*tan_{theta}))$$

Meaning: On a road banked at angle theta from horizontal with tyre-road friction coefficient mu_s, this is the maximum speed for safe negotiation of a curve of radius r.

Use when: Banked turn at angle theta (theta = 0 reduces to level-road formula)

Use when: 1 - mu_s*tan_theta > 0 (formula breaks down for very steep banks at high friction)

Use when: Optimum/no-friction speed v_o = sqrt(g*r*tan_theta) is a SPECIAL CASE

Don't use: Banked angle so steep that 1 - mu_s*tan_theta <= 0 (use centripetal limit form)

Don't use: Friction direction reversed (very low speed on a steep bank — vehicle slides inward)

Source: NCERT Class XI Physics, Ch 4, p. 15

Centripetal force in uniform circular motion

F.PHY.U03.CENTRIPETAL_FORCE

$$F_c = m * v^2 / r = m * omega^2 * r$$

Meaning: The net inward force required to keep a body of mass m moving in a circle of radius r at speed v is m*v^2/r. This 'centripetal' force is NOT a new fundamental f...

Use when: Speed is uniform (a_t = 0, only radial acceleration matters)

Use when: Identify the real force that provides F_c (tension, friction, normal component, etc.)

Note: Common pitfall: treating centripetal force as an extra force on top of real forces. It is the NET inward radia...

Source: NCERT Class XI Physics, Ch 4, p. 13

Conservation of linear momentum

F.PHY.U03.CONS_LIN_MOM

$$If\ F_{ext} = 0\ then\ p_{total} = constant$$

Meaning: If the net external force on a system of particles is zero, the total linear momentum of the system is conserved (vector equality of total p before and after an...

Use when: Net EXTERNAL force is zero (internal forces always cancel by Newton's 3rd law)

Use when: Conservation is vector — apply componentwise (x and y separately)

Use when: Holds independent of whether collisions are elastic or inelastic

Don't use: External impulses present (gravity over a long time, friction)

Source: NCERT Class XI Physics, Ch 4, p. 9

Impulse of a force

F.PHY.U03.IMPULSE

$$J = F * \Delta t = \Delta p$$

Meaning: Impulse equals the product of force and the time interval over which it acts. By Newton's Second Law, impulse equals the change in linear momentum during that i...

Use when: Useful when forces are large but act briefly (collisions, bat-on-ball, kicks)

Use when: Direction of impulse is the direction of average force

Note: If force varies with time, J = integral of F(t) dt over the interval; F * Delta_t uses the average force.

Source: NCERT Class XI Physics, Ch 4, p. 7

Kinetic friction

F.PHY.U03.KINETIC_FRICTION

$$f_k = \mu_k * N$$

Meaning: When two surfaces slide relative to each other, kinetic friction opposes the motion with magnitude proportional to the normal force.

Use when: Surfaces ARE sliding

Use when: Direction: opposite to instantaneous relative velocity of one surface vs the other

Note: Typically mu_k < mu_s for the same surface pair. Kinetic friction is approximately independent of relative spe...

Source: NCERT Class XI Physics, Ch 4, p. 12

Maximum safe speed on a level circular road

F.PHY.U03.LEVEL_ROAD_VMAX

$$v_{max} = \sqrt{\mu_s * g * r}$$

Meaning: Static friction is the only force available to provide centripetal acceleration on a level road. Setting mu_s*N = m*v^2/r and N = m*g gives this maximum-safe sp...

Use when: Road is level (no banking)

Use when: Tyres do not slide (static friction regime)

Use when: Driver maintains uniform speed on the curve

Don't use: Banked road (use the banked-road formula)

Don't use: Slippery / wet road where mu_s is reduced

Source: NCERT Class XI Physics, Ch 4, p. 14

Newton's Second Law of Motion

F.PHY.U03.NEWTON_2

$$F = m * a \text{ (or) } F = dp/dt$$

Meaning: The net external force on a body equals the rate of change of its linear momentum. For a body of constant mass, this reduces to F = m*a — net force equals mass...

Use when: F is the resultant (net) of all external forces, not any single force

Use when: Mass is constant for the form F = m*a (use F = dp/dt for variable mass)

Use when: Inertial reference frame (no pseudo-forces); add inertial corrections in non-inertial frames

Don't use: Frame is non-inertial (need pseudo-forces)

Don't use: Mass is varying significantly (use F = dp/dt)

Don't use: Quantum / relativistic regimes (Newtonian mechanics breaks down)

Note: F MUST be the NET force — the vector sum of all external forces. Internal forces between parts of a single rig...

Source: NCERT Class XI Physics, Ch 4, p. 6

Maximum static friction

F.PHY.U03.STATIC_FRICTION

$$f_{s\_max} = mu_s * N$$

Meaning: The maximum value of static friction between two surfaces in contact equals the coefficient of static friction times the normal force. Below f_s_max, static fri...

Use when: Surfaces in contact, no relative motion (impending motion limit)

Use when: Below f_s_max, actual static friction = applied tangential load (self-adjusting)

Use when: f_s_max is independent of the apparent area of contact (Coulomb-Amontons assumption)

Don't use: Surfaces are sliding (use kinetic friction f_k = mu_k * N instead)

Don't use: Lubricated / fluid-friction conditions

Source: NCERT Class XI Physics, Ch 4, p. 12

PHY.U04 -- Work, Energy and Power

Elastic collision — 1D final velocities

F.PHY.U04.ELASTIC_1D

```
v1 = ((m1-m2)*u1 + 2*m2*u2) / (m1+m2); v2 = ((m2-m1)*u2 + 2*m1*u1) / (m1+m2)
```

Meaning: Final velocities of two bodies after an elastic head-on (1D) collision — momentum AND kinetic energy are both conserved. Special cases: equal masses exchange ve...

Use when: Collision is ELASTIC (kinetic energy conserved)

Use when: Head-on (1D) — for 2D collisions decompose along/perpendicular to line of impact

Don't use: Inelastic collision (KE not conserved; use momentum-only + restitution)

Don't use: Bodies stick together (perfectly inelastic case has its own formula)

Source: NCERT Class XI Physics, Ch 5, p. 15

Gravitational potential energy (near Earth)

F.PHY.U04.GRAV_PE_NEAR_EARTH

```
U = m*g*h
```

Meaning: Potential energy of a body of mass m at height h above the chosen reference level, in a region where g is approximately constant.

Use when: Region small enough that g is uniform (typically near Earth's surface)

Use when: Reference level is freely chosen — only DIFFERENCES in U have physical meaning

Don't use: Large altitude changes (use U = -GMm/r general form)

Don't use: Below the reference level — h is signed

Source: NCERT Class XI Physics, Ch 5, p. 8

Kinetic energy

F.PHY.U04.KINETIC_ENERGY

$$K = (1/2) * m * v^2$$

Meaning: Energy a body possesses by virtue of its motion. Always non-negative. Frame-dependent through v.

Use when: Non-relativistic speeds (v << c)

Use when: Translational motion only (rotational KE = (1/2) I omega^2 separately)

Source: NCERT Class XI Physics, Ch 5, p. 3

Conservation of mechanical energy

F.PHY.U04.MECH_ENERGY_CONS

$K_i + U_i = K_f + U_f$

Meaning: If only conservative forces do work on a system, the total mechanical energy E = K + U is constant in time.

Use when: Only CONSERVATIVE forces do work (gravity, spring, electrostatic — not friction or drag)

Use when: Closed system; no energy exchange with surroundings

Don't use: Friction, drag, or other non-conservative forces do work

Don't use: External forces add energy to the system

Source: NCERT Class XI Physics, Ch 5, p. 11

Perfectly inelastic 1D collision — common final velocity and KE loss

F.PHY.U04.PERFECTLY_INELASTIC_1D

$v = (m1*u1 + m2*u2) / (m1+m2);\ Delta_K = -(1/2)*(m1*m2/(m1+m2))*(u1-u2)^2$

Meaning: When two bodies stick together after a 1D collision, the common velocity is given by momentum conservation. The KE lost is converted to internal energy (heat, d...

Use when: Bodies stick together immediately after collision (perfectly inelastic)

Use when: Net external force = 0 during the brief collision (momentum conservation)

Source: NCERT Class XI Physics, Ch 5, p. 15

Instantaneous power

F.PHY.U04.POWER_INST

$P = dW/dt = F \cdot v$

Meaning: Instantaneous power is the time rate of doing work; equivalently, the dot product of the force and velocity. Average power over an interval is W/t.

Use when: F.v form when force and velocity are both known at the instant

Note: 1 W = 1 J/s. 1 hp ≈ 746 W (mechanical horsepower).

Source: NCERT Class XI Physics, Ch 5, p. 7

Spring potential energy (Hooke's law regime)

F.PHY.U04.SPRING_PE

$U = (1/2) * k * x^2$

Meaning: Elastic potential energy stored in an ideal spring of force constant k that has been displaced by x from its natural length. Independent of the sign of x (compr...

Use when: Spring obeys Hooke's law (F = -k*x) over the displacement range

Use when: No internal damping / hysteresis assumed

Don't use: Beyond elastic limit (Hooke's law fails)

Don't use: Real springs with finite damping (some elastic PE goes to internal energy)

Source: NCERT Class XI Physics, Ch 5, p. 10

Work done by a constant force

F.PHY.U04.WORK_CONST

$W = F \cdot s = F * s * \cos_{theta}$

Meaning: The work done by a constant force F on an object that undergoes a displacement s is the dot product F.s. Equivalently, W = (magnitude of F) * (magnitude of s) *...

Use when: Force is CONSTANT in magnitude and direction over the displacement

Use when: Use the COMPONENT of force along the displacement, not magnitude alone

Don't use: Force varies with position (use the variable-force integral)

Don't use: Multiple forces act — apply this to each one separately or use net force

Note: Sign of W: positive (0 <= theta < 90 deg), zero (theta = 90 deg, force perpendicular to motion), negative (90...

Source: NCERT Class XI Physics, Ch 5, p. 2

Work-energy theorem

F.PHY.U04.WORK_ENERGY_THEOREM

$$W_{net} = Delta_K = (1/2)*m*(v^2 - v0^2)$$

Meaning: The net work done by all forces on a particle equals the change in its kinetic energy. Holds for both constant and variable forces, in 1D and higher dimensions.

Use when: W_net is the NET (vector-sum) work, not work of any one force

Use when: Particle (point-mass) idealisation; for extended bodies handle internal energy separately

Source: NCERT Class XI Physics, Ch 5, p. 3

Work done by a variable force

F.PHY.U04.WORK_VAR

$$W = integral_{x_i}^{x_f} F(x)\ dx$$

Meaning: When a force varies along the path, the work done is the line integral of force over displacement. In one dimension this is the area under the F-vs-x curve betw...

Use when: Force may depend on position (e.g. spring force F = -k*x)

Use when: Generalises to W = integral F.dr in higher dimensions

Source: NCERT Class XI Physics, Ch 5, p. 5

PHY.U05 -- Rotational Motion

Angular momentum

F.PHY.U05.ANGULAR_MOMENTUM

$$L = r \times p \text{ (point particle); } L = I*omega \text{ (rigid body, fixed axis)}$$

Meaning: For a particle: L = r x p. For a rigid body about its rotation axis: L = I omega. Vector quantity.

Use when: Reference point/axis chosen

Use when: I about same axis as omega

Source: NCERT Class XI Physics, Ch 6, p. 5

Centre of mass of n-particle system

F.PHY.U05.CENTRE_OF_MASS

$$R_{cm} = (\sum m_i\ r_i) / (\sum m_i)$$

Meaning: The position of the centre of mass equals the mass-weighted average of particle positions. For continuous bodies use integral form.

Use when: System of point particles or rigid body

Use when: Inertial reference frame

Source: NCERT Class XI Physics, Ch 6, p. 2

Moment of inertia for common rigid bodies

F.PHY.U05.MOMENT_OF_INERTIA_RIGID_BODIES

$$\text{Solid sphere: } I=2MR^2/5\text{; hollow sphere: } I=2MR^2/3\text{; rod (centre): } I=ML^2/12\text{; ring/hoop: } I=MR^2\text{; disc: } I=MR^2/2$$

Meaning: Standard moments of inertia about the symmetry axis. For other axes use parallel/perpendicular axes theorems.

Use when: Uniform mass distribution

Use when: Rotation about symmetry axis (unless noted)

Source: NCERT Class XI Physics, Ch 6, p. 10

Parallel axes theorem

F.PHY.U05.PARALLEL_AXES_THEOREM

$$I = I_{cm} + M*d^2$$

Meaning: Moment of inertia about any axis = moment about parallel axis through CM + Md^2.

Use when: Both axes parallel

Use when: I_cm known about CM axis

Source: NCERT Class XI Physics, Ch 6, p. 12

Perpendicular axes theorem (planar)

F.PHY.U05.PERPENDICULAR_AXES_THEOREM

$$I_z = I_x + I_y$$

Meaning: For planar lamina: MOI about axis perpendicular to plane = sum of MOI about two perpendicular in-plane axes through same point.

Use when: Body is planar (2D lamina)

Use when: All three axes intersect at one point

Source: NCERT Class XI Physics, Ch 6, p. 12

Rotational kinematic equations (constant alpha)

F.PHY.U05.ROTATIONAL_KINEMATICS

$$omega = omega0 + alpha*t;\ theta = omega0*t + 0.5*alpha*t^2;\ omega^2 = omega0^2 + 2*alpha*theta$$

Meaning: Rotational analogues of linear kinematic equations under constant angular acceleration.

Use when: Constant alpha

Use when: Single rotation axis

Source: NCERT Class XI Physics, Ch 6, p. 14

Rotational kinetic energy

F.PHY.U05.ROT_KE

$$KE_{rot} = 0.5 * I * omega^2$$

Meaning: Energy of rotation about an axis. Adds to translational KE for rolling bodies.

Use when: Rotation about fixed axis

Use when: I and omega about same axis

Source: NCERT Class XI Physics, Ch 6, p. 15

Torque (moment of force)

F.PHY.U05.TORQUE

$$tau = r \times F$$

Meaning: Cross product of position vector and force vector. Magnitude r F sin(theta).

Use when: Rigid body or extended object

Use when: r measured from chosen pivot/axis

Source: NCERT Class XI Physics, Ch 6, p. 4

PHY.U06 -- Gravitation

Escape velocity from a body's surface

F.PHY.U06.ESCAPE_VELOCITY

$$v_e = \sqrt{2GM/R} = \sqrt{2gR}$$

Meaning: Minimum speed for an object to escape gravity to infinity from radius R. Earth: ~11.2 km/s.

Use when: Launched from surface

Use when: No air drag

Use when: Body treated as point/sphere

Source: NCERT Class XI Physics, Ch 7, p. 10

Gravitational potential energy (point masses)

F.PHY.U06.GRAV_PE

$$U = -G * M * m / r$$

Meaning: PE of two-body system; negative because gravity is attractive (work to separate them is positive).

Use when: Reference U=0 at r=infinity

Use when: Point or spherical masses

Source: NCERT Class XI Physics, Ch 7, p. 8

g variation with altitude

F.PHY.U06.G_AT_ALTITUDE

$$g_h = g * (R / (R+h))^2 \sim g * (1 - 2h/R) \text{ for } h << R$$

Meaning: Gravitational acceleration decreases with altitude above Earth's surface.

Use when: Static observer at altitude

Use when: Earth treated as uniform sphere

Source: NCERT Class XI Physics, Ch 7, p. 6

g variation with depth

F.PHY.U06.G_AT_DEPTH

$$g_d = g * (1 - d/R)$$

Meaning: Inside Earth (uniform density), g decreases linearly with depth, vanishing at centre.

Use when: Earth treated as uniform density sphere

Source: NCERT Class XI Physics, Ch 7, p. 7

Kepler's third law

F.PHY.U06.KEPLER_3RD

$$T^2 = (4\pi^2 / GM) * a^3$$

Meaning: Square of orbital period proportional to cube of semi-major axis. Holds for elliptic orbits about a central mass.

Use when: Two-body system with central mass M >> orbiting mass

Use when: Bound orbit

Source: NCERT Class XI Physics, Ch 7, p. 3

Orbital velocity for circular orbit

F.PHY.U06.ORBITAL_VELOCITY

$$v = \sqrt{GM/(R+h)}$$

Meaning: Speed of circular orbit at altitude h above body of mass M, radius R.

Use when: Circular orbit

Use when: M >> orbiting mass

Source: NCERT Class XI Physics, Ch 7, p. 12

Satellite total mechanical energy

F.PHY.U06.SATELLITE_ENERGY

$$E = -G*M*m / (2*(R+h))$$

Meaning: Total energy = KE + PE = -KE (virial). Always negative for bound orbit; E -> 0 at infinity.

Use when: Circular orbit

Use when: Bound (E < 0)

Source: NCERT Class XI Physics, Ch 7, p. 14

Newton's law of gravitation

F.PHY.U06.UNIVERSAL_GRAVITATION

$$F = G * m1 * m2 / r^2$$

Meaning: Attractive force between any two masses. Inverse-square central force.

Use when: Point masses or spherically symmetric distributions

Use when: r > sum of body radii (else use shell theorem)

Source: NCERT Class XI Physics, Ch 7, p. 4

PHY.U07 -- Properties of Solids and Fluids

Bernoulli's equation

F.PHY.U07.BERNOULLI

$$P + 0.5*rho*v^2 + rho*g*h = constant$$

Meaning: Conservation of energy along a streamline of incompressible non-viscous flow.

Use when: Steady, non-viscous, incompressible flow

Use when: Along a single streamline

Use when: No work added/removed

Source: NCERT Class XI Physics, Ch 9, p. 6

Bulk modulus

F.PHY.U07.BULK_MODULUS

$$K = -V * (dP/dV) = -P*V/Delta_V$$

Meaning: Resistance of a material to uniform compression. Inverse: compressibility.

Use when: Isotropic compression

Use when: Within elastic regime

Source: NCERT Class XI Physics, Ch 8, p. 6

Capillary rise/depression

F.PHY.U07.CAPILLARY_RISE

$$h = 2*T*cos(theta) / (rho*g*r)$$

Meaning: Height a liquid rises (or falls) in a capillary tube. cos(theta) > 0: rises (wetting); < 0: depresses.

Use when: Narrow tube (capillary regime)

Use when: Constant theta

Source: NCERT Class XI Physics, Ch 9, p. 15

Pressure in static fluid

F.PHY.U07.FLUID_PRESSURE

$$P = P0 + rho*g*h$$

Meaning: Pressure at depth h below free surface of fluid of density rho.

Use when: Static fluid (no flow)

Use when: Constant g

Use when: Constant rho (incompressible)

Source: NCERT Class XI Physics, Ch 9, p. 3

Latent heat

F.PHY.U07.LATENT_HEAT

$$Q = m*L$$

Meaning: Heat absorbed/released during phase change at constant T. L_fusion or L_vaporisation.

Use when: Phase transition (constant T during)

Use when: All mass m undergoes the transition

Source: NCERT Class XI Physics, Ch 10, p. 7

Specific heat / heat capacity

F.PHY.U07.SPECIFIC_HEAT

$$Q = m*c*Delta_T$$

Meaning: Heat required to raise mass m by temperature Delta_T. Specific heat c is material property.

Use when: No phase change during heating

Use when: c approximately constant in temp range

Source: NCERT Class XI Physics, Ch 10, p. 5

Stefan-Boltzmann radiation law

F.PHY.U07.STEFAN_BOLTZMANN

$$P = sigma * epsilon * A * T^4$$

Meaning: Radiation power from a body. Black body epsilon=1; net to surroundings P = sigma*epsilon*A*(T^4 - T_s^4).

Use when: Body in radiative equilibrium

Use when: T in kelvins

Source: NCERT Class XI Physics, Ch 10, p. 13

Stokes' law (viscous drag on sphere)

F.PHY.U07.STOKES_LAW

$$F = 6*pi*eta*r*v$$

Meaning: Drag force on a sphere of radius r moving with velocity v through viscous fluid (low Reynolds number).

Use when: Smooth, slow flow (low Reynolds number)

Use when: Spherical body

Use when: Newtonian fluid

Source: NCERT Class XI Physics, Ch 9, p. 9

Excess pressure inside drop/bubble

F.PHY.U07.SURFACE_TENSION_DROP

$$drop: Delta_P = 2T/r; bubble: Delta_P = 4T/r$$

Meaning: Excess internal pressure due to surface tension. Bubble has 2 surfaces, hence factor 4.

Use when: Spherical drop or bubble

Use when: Constant T (one fluid pair)

Source: NCERT Class XI Physics, Ch 9, p. 14

Terminal velocity of sphere in viscous fluid

F.PHY.U07.TERMINAL_VELOCITY

$$v_t = (2/9) * r^2 * g * (rho_s - rho_f) / eta$$

Meaning: Constant velocity reached when net force is zero (gravity balanced by buoyancy + viscous drag).

Use when: Steady state (net force zero)

Use when: Stokes regime applicable

Source: NCERT Class XI Physics, Ch 9, p. 10

Thermal expansion (linear/area/volume)

F.PHY.U07.THERMAL_EXPANSION

$$Delta_L/L = alpha*Delta_T;\ Delta_A/A = 2*alpha*Delta_T;\ Delta_V/V = beta*Delta_T\ (beta = 3*alpha)$$

Meaning: Fractional change in length, area, volume per degree temperature change.

Use when: Isotropic material

Use when: Modest temperature range (alpha ~ constant)

Source: NCERT Class XI Physics, Ch 10, p. 3

Young's modulus

F.PHY.U07.YOUNGS_MODULUS

$$Y = (F*L) / (A*Delta_L)$$

Meaning: Ratio of longitudinal stress to longitudinal strain in a stretched wire/rod within elastic limit.

Use when: Within elastic limit (Hooke's law region)

Use when: Uniform cross-section

Use when: Force along length

Source: NCERT Class XI Physics, Ch 8, p. 5

PHY.U08 -- Thermodynamics

Adiabatic relations for ideal gas

F.PHY.U08.ADIABATIC_RELATIONS

$$P*V^{gamma} = const;\ T*V^{(gamma-1)} = const$$

Meaning: Relations holding during reversible adiabatic process. gamma = Cp/Cv.

Use when: Q = 0 (no heat exchange)

Use when: Quasi-static (reversible)

Use when: Ideal gas

Source: NCERT Class XI Physics, Ch 11, p. 7

First law of thermodynamics

F.PHY.U08.FIRST_LAW

$$Delta_U = Q - W$$

Meaning: Change in internal energy = heat ADDED minus work DONE BY the system. Energy conservation including thermal energy.

Use when: Closed system (no mass exchange)

Use when: Sign convention: Q>0 heat in, W>0 system does work

Source: NCERT Class XI Physics, Ch 11, p. 4

Work done in isothermal process (ideal gas)

F.PHY.U08.ISOTHERMAL_WORK

$$W = n*R*T*\ln(V_f/V_i)$$

Meaning: Work done by ideal gas during isothermal expansion. Q = W (since Delta_U = 0). Reverse for compression.

Use when: Ideal gas

Use when: Quasi-static (reversible) isothermal

Source: NCERT Class XI Physics, Ch 11, p. 6

Mayer's relation (Cp - Cv = R)

F.PHY.U08.MAYER_RELATION

$$Cp - Cv = R \text{ (per mole)}$$

Meaning: For ideal gas: difference of molar specific heats equals gas constant R. Useful for converting between Cp and Cv.

Use when: Ideal gas

Use when: Per mole basis

Source: NCERT Class XI Physics, Ch 11, p. 8

PHY.U09 -- Kinetic Theory of Gases

Average translational KE per molecule

F.PHY.U09.AVG_KE_PER_MOLECULE

$$\langle KE \rangle = (3/2)*k*T$$

Meaning: Microscopic interpretation of temperature: T is direct measure of average translational kinetic energy.

Use when: Translational degrees of freedom only

Use when: Ideal gas

Source: NCERT Class XI Physics, Ch 12, p. 6

Cv from degrees of freedom

F.PHY.U09.EQUIPARTITION_CV

$$Cv = (f/2)*R \text{ (per mole, } f = \text{DoF)}$$

Meaning: Each quadratic DoF contributes (1/2)R to molar Cv. Mono: f=3, Cv=3R/2; di-rigid: f=5, Cv=5R/2; poly-rigid: f=6, Cv=3R.

Use when: Equipartition holds (temperature high enough)

Use when: Quadratic energy modes

Source: NCERT Class XI Physics, Ch 12, p. 9

Ideal gas equation

F.PHY.U09.IDEAL_GAS_LAW

$$PV = nRT = NkT$$

Meaning: Fundamental equation of state of ideal gas relating pressure, volume, temperature.

Use when: Gas obeys ideal gas approximation (low pressure, high temperature relative to phase transitions)

Source: NCERT Class XI Physics, Ch 12, p. 2

Mean free path of gas molecule

F.PHY.U09.MEAN_FREE_PATH

$$\lambda = 1 / (\sqrt{2}\pi n d^2)$$

Meaning: Average distance between successive molecular collisions.

Use when: Hard-sphere model

Use when: Equilibrium gas

Source: NCERT Class XI Physics, Ch 12, p. 10

RMS speed of gas molecules

F.PHY.U09.RMS_SPEED

$$v_{rms} = \sqrt{3RT/M} = \sqrt{3kT/m}$$

Meaning: Root-mean-square molecular speed; depends on T and molar mass M (or molecular mass m).

Use when: Ideal gas

Use when: Maxwell-Boltzmann distribution

Source: NCERT Class XI Physics, Ch 12, p. 6

PHY.U10 -- Oscillations and Waves

Beat frequency

F.PHY.U10.BEATS

$$f_{beat} = |f1 - f2|$$

Meaning: When two waves of nearly equal frequencies superpose, amplitude oscillates at the difference frequency.

Use when: Linear superposition

Use when: f1, f2 close in value

Source: NCERT Class XI Physics, Ch 14, p. 15

Period of simple pendulum (small angle)

F.PHY.U10.PENDULUM_PERIOD

$$T = 2\pi\sqrt{L/g}$$

Meaning: Period of simple pendulum of length L. Holds for small amplitudes (sin theta ~ theta).

Use when: Small angular amplitude (typically <15°)

Use when: Massless string

Use when: Point bob

Source: NCERT Class XI Physics, Ch 13, p. 10

SHM displacement

F.PHY.U10.SHM_DISPLACEMENT

$$x(t) = A\cos(\omega t + \phi);\ \omega = 2\pi f = 2\pi/T$$

Meaning: Displacement in simple harmonic motion. Velocity = -A*omega*sin(omega*t+phi); a = -omega^2 * x.

Use when: Restoring force linear (F = -kx)

Use when: No damping

Source: NCERT Class XI Physics, Ch 13, p. 3

Total energy in SHM

F.PHY.U10.SHM_ENERGY

$$E = 0.5kA^2 = 0.5m\omega^2A^2$$

Meaning: Total mechanical energy is constant. Oscillates between KE (max at x=0) and PE (max at x=±A).

Use when: Conservative SHM (no damping)

Use when: Elastic regime

Source: NCERT Class XI Physics, Ch 13, p. 7

Period of mass-spring oscillator

F.PHY.U10.SPRING_PERIOD

`T = 2*pi*sqrt(m/k)`

Meaning: Period of horizontal spring with mass m, spring constant k. Independent of amplitude.

Use when: Hooke's law spring

Use when: No damping

Use when: Small enough amplitude to stay in elastic regime

Source: NCERT Class XI Physics, Ch 13, p. 5

Standing wave in closed-end pipe

F.PHY.U10.STANDING_WAVE_PIPE_CLOSED

f_n `= (2n-1)*v/(4*L), n = 1, 2, 3, ...`

Meaning: Pipe closed at one end has only odd harmonics: f, 3f, 5f, ...

Use when: Closed at one end (open at other)

Use when: End correction neglected

Source: NCERT Class XI Physics, Ch 14, p. 13

Standing wave in open-open pipe

F.PHY.U10.STANDING_WAVE_PIPE_OPEN_OPEN

f_n `= n*v/(2*L), n = 1, 2, 3, ...`

Meaning: Pipe open at both ends has all harmonics. Same formula as string.

Use when: Open at both ends

Use when: End correction neglected

Source: NCERT Class XI Physics, Ch 14, p. 13

Standing wave frequencies on fixed-fixed string

F.PHY.U10.STANDING_WAVE_STRING

f_n `= n*v/(2*L), n = 1, 2, 3, ...`

Meaning: Allowed frequencies on string fixed at both ends. n=1 fundamental; harmonics 2f, 3f, ...

Use when: String fixed at both ends

Use when: Wave speed v as defined above

Source: NCERT Class XI Physics, Ch 14, p. 12

Speed of sound in gas (Newton-Laplace)

F.PHY.U10.WAVE_SPEED_GAS

`v = sqrt(gamma*P/rho)`

Meaning: Speed of sound in gas. Adiabatic index gamma, pressure P, density rho. Increases with sqrt(T).

Use when: Ideal gas

Use when: Adiabatic compression/expansion of sound waves

Source: NCERT Class XI Physics, Ch 14, p. 5

Wave speed on string

F.PHY.U10.WAVE_SPEED_STRING

$$v = \sqrt{T/\mu}$$

Meaning: Speed of transverse wave on string under tension T, linear mass density mu.

Use when: Stretched uniform string

Use when: Small amplitude

Source: NCERT Class XI Physics, Ch 14, p. 4

PHY.U11 -- Electrostatics

Energy stored in capacitor

F.PHY.U11.CAP_ENERGY

$$U = 0.5*C*V^2 = 0.5*Q*V = Q^2/(2C)$$

Meaning: Energy stored as work to charge the capacitor.

Use when: Linear capacitor

Use when: Static charging or quasi-static

Source: NCERT Class XII Physics, Ch 2, p. 26

Capacitors series and parallel

F.PHY.U11.CAP_SERIES_PARALLEL

$$\text{Series: } 1/C_{eq} = \sum(1/C_i); \text{ Parallel: } C_{eq} = \sum(C_i)$$

Meaning: Series: same Q on each, voltages add. Parallel: same V across each, charges add.

Use when: Series: same charge through chain

Use when: Parallel: same voltage across all

Source: NCERT Class XII Physics, Ch 2, p. 24

Coulomb's law

F.PHY.U11.COULOMB

$$F = (1/(4*pi*eps0)) * q1*q2 / r^2$$

Meaning: Force between two point charges in vacuum. 1/(4*pi*eps0) ~ 9e9 N*m^2/C^2.

Use when: Point charges (or spherically symmetric)

Use when: r > body sizes

Source: NCERT Class XII Physics, Ch 1, p. 4

Electric field of dipole — axial

F.PHY.U11.E_DIPOLE_AXIAL

$$E_{axial} = (1/(4*pi*eps0)) * 2p / r^3$$

Meaning: Field on dipole axis at distance r >> dipole size; directed along p.

Use when: r >> 2a (dipole size)

Use when: Along axis

Source: NCERT Class XII Physics, Ch 1, p. 14

Field of long line charge (Gauss)

F.PHY.U11.E_LINE_CHARGE

$$E = lambda / (2*pi*eps0*r)$$

Meaning: Radial field at perpendicular distance r from infinite line of linear charge density lambda.

Use when: Infinite line (or much longer than r)

Use when: Uniform charge density

Source: NCERT Class XII Physics, Ch 1, p. 26

Field of charged plane sheet

F.PHY.U11.E_PLANE_SHEET

$$E = \sigma / (2\varepsilon_0)$$

Meaning: Uniform field perpendicular to a non-conducting infinite plane sheet of surface charge density sigma. Independent of distance.

Use when: Infinite plane sheet

Use when: Non-conducting (otherwise sigma is split between surfaces)

Source: NCERT Class XII Physics, Ch 1, p. 28

Electric field of point charge

F.PHY.U11.E_POINT_CHARGE

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$$

Meaning: Field magnitude from point charge q at distance r, directed radially.

Use when: Point or spherically symmetric source

Use when: r > source body radius

Source: NCERT Class XII Physics, Ch 1, p. 8

Field of charged spherical shell

F.PHY.U11.E_SPHERICAL_SHELL

$$\text{Outside } (r>R): E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2}; \text{ Inside } (r<R): E = 0$$

Meaning: Spherical shell behaves like point charge outside; field is zero inside.

Use when: Spherically symmetric charge distribution

Use when: Static

Source: NCERT Class XII Physics, Ch 1, p. 30

Gauss's law

F.PHY.U11.GAUSS_LAW

$$\Phi_E = \frac{Q_{enc}}{\varepsilon_0}$$

Meaning: Total electric flux through closed surface equals enclosed charge over permittivity.

Use when: Closed surface

Use when: All sources accounted for

Source: NCERT Class XII Physics, Ch 1, p. 22

Parallel plate capacitor

F.PHY.U11.PARALLEL_PLATE_C

$$C = \varepsilon_r \cdot \varepsilon_0 \cdot \frac{A}{d}$$

Meaning: Capacitance of parallel-plate capacitor. eps_r = 1 for vacuum/air.

Use when: Plate separation << plate dimensions (uniform field)

Use when: Uniform dielectric

Source: NCERT Class XII Physics, Ch 2, p. 22

Electric potential of point charge

F.PHY.U11.V_POINT_CHARGE

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r}$$

Meaning: Scalar potential at distance r from point charge q, with V→0 at infinity.

Use when: Reference V=0 at infinity

Source: NCERT Class XII Physics, Ch 2, p. 4

PHY.U12 -- Current Electricity

Current from drift velocity

F.PHY.U12.DRIFT_VELOCITY

$$I = n * e * A * v_d$$

Meaning: Macroscopic current expressed in terms of microscopic drift velocity. n = electron density.

Use when: Steady current

Use when: Single-carrier conductor

Source: NCERT Class XII Physics, Ch 3, p. 4

EMF and terminal voltage

F.PHY.U12.EMF_TERMINAL

$$V_{terminal} = epsilon - I*r$$

Meaning: Terminal voltage of cell with internal resistance r when current I flows.

Use when: Steady current

Use when: Cell with constant EMF

Source: NCERT Class XII Physics, Ch 3, p. 16

Ohm's law

F.PHY.U12.OHMS_LAW

$$V = I*R$$

Meaning: Linear ohmic conductor: voltage = current x resistance at constant T.

Use when: Ohmic conductor

Use when: Constant temperature

Source: NCERT Class XII Physics, Ch 3, p. 6

Electrical power

F.PHY.U12.POWER

$$P = V*I = I^2*R = V^2/R$$

Meaning: Power dissipated as heat in resistor (Joule heating).

Use when: Resistor (ohmic)

Use when: DC or instantaneous

Source: NCERT Class XII Physics, Ch 3, p. 10

Resistivity formula

F.PHY.U12.RESISTIVITY

$$R = rho * L / A$$

Meaning: Resistance from material resistivity, length, cross-sectional area.

Use when: Uniform conductor

Use when: Steady current

Source: NCERT Class XII Physics, Ch 3, p. 8

Resistors series/parallel

F.PHY.U12.RESISTOR_COMBO

$$\text{Series: } R = \sum(R_i); \text{ Parallel: } 1/R = \sum(1/R_i)$$

Meaning: Same current through series; same voltage across parallel.

Use when: Static linear network

Use when: Ideal wires

Source: NCERT Class XII Physics, Ch 3, p. 14

Wheatstone bridge balance

F.PHY.U12.WHEATSTONE

$$P/Q = R/S$$

Meaning: Balance condition: no current through galvanometer when P/Q = R/S. Used to measure unknown resistance.

Use when: Bridge balanced (galvanometer reads zero)

Use when: DC, steady state

Source: NCERT Class XII Physics, Ch 3, p. 22

PHY.U13 -- Magnetic Effects of Current

Ampere's circuital law

F.PHY.U13.AMPERE

$$\text{integral } B.dl = mu0*I_{enc}$$

Meaning: Line integral of B around closed loop = mu0 x current enclosed.

Use when: Steady current (Maxwell-Ampere needed if displacement current present)

Use when: Closed Amperian loop

Source: NCERT Class XII Physics, Ch 4, p. 12

Biot-Savart law

F.PHY.U13.BIOT_SAVART

$$dB = (mu0/(4*pi)) * (I\ dl \times r_{hat})/r^2$$

Meaning: Magnetic field from current element. mu0 = 4*pi*10^-7 T*m/A.

Use when: Steady current

Use when: Free space

Source: NCERT Class XII Physics, Ch 4, p. 8

B at centre of circular loop

F.PHY.U13.B_CIRCULAR_LOOP

$$B = mu0*I/(2*R)$$

Meaning: Magnetic field at centre of circular current loop of radius R carrying current I.

Use when: Single loop

Use when: At loop centre

Source: NCERT Class XII Physics, Ch 4, p. 10

B near long straight wire

F.PHY.U13.B_LONG_WIRE

$$B = mu0*I/(2*pi*r)$$

Meaning: Field at perpendicular distance r from infinite straight wire carrying I.

Use when: Wire >> r (effectively infinite)

Use when: r > wire radius

Source: NCERT Class XII Physics, Ch 4, p. 14

B inside long solenoid

F.PHY.U13.B_SOLENOID

`B = mu0*n*I`

Meaning: Uniform field inside long solenoid; n = turns per unit length. Approximately zero outside.

Use when: Long solenoid (length >> radius)

Use when: Tightly wound

Source: NCERT Class XII Physics, Ch 4, p. 16

Cyclotron radius / period

F.PHY.U13.CYCLOTRON_RADIUS

`r = m*v/(q*B); T = 2*pi*m/(q*B)`

Meaning: Charge q moves in circle of radius r in uniform B perpendicular to v. Period independent of v.

Use when: v □ B

Use when: Uniform B

Use when: Non-relativistic

Source: NCERT Class XII Physics, Ch 4, p. 4

Force on current-carrying wire

F.PHY.U13.FORCE_WIRE

`F = I*L x B; magnitude F = B*I*L*sin(theta)`

Meaning: Force on straight current-carrying wire of length L in field B. Theta = angle between L and B.

Use when: Uniform B

Use when: Straight wire

Source: NCERT Class XII Physics, Ch 4, p. 18

Lorentz force

F.PHY.U13.LORENTZ

`F = q*(E + v x B)`

Meaning: Total force on charge q in electric and magnetic fields. Magnetic part always perpendicular to v.

Use when: Point particle

Use when: Non-relativistic

Source: NCERT Class XII Physics, Ch 4, p. 2

Magnetic dipole field (axial/equatorial)

F.PHY.U13.MAGNETIC_DIPOLE_FIELD

`Axial: B = (mu0/(4*pi)) * 2m/r^3; Equatorial: B = (mu0/(4*pi)) * m/r^3`

Meaning: Magnetic field from dipole moment m at distance r along axis or equatorial.

Use when: r >> dipole size

Use when: Far-field approximation

Source: NCERT Class XII Physics, Ch 5, p. 4

Force between parallel currents

F.PHY.U13.PARALLEL_WIRES

$$F/L = \mu_0 I_1 I_2 / (2\pi d)$$

Meaning: Force per unit length between long parallel wires separated by d. Same direction → attractive.

Use when: Long parallel wires

Use when: Steady currents

Source: NCERT Class XII Physics, Ch 4, p. 20

Torque on current loop

F.PHY.U13.TORQUE_LOOP

$$\tau = NBIA\sin\theta = m \times B \quad (m = NIA)$$

Meaning: Torque on N-turn loop of area A carrying I in field B; magnetic moment m = NIA.

Use when: Uniform B

Use when: Loop in plane

Source: NCERT Class XII Physics, Ch 4, p. 22

PHY.U14 -- Electromagnetic Induction and AC

Average AC power

F.PHY.U14.AC_POWER

$$P_{avg} = V_{rms} * I_{rms} * \cos(\phi)$$

Meaning: Average power dissipated in AC circuit. cos(phi) = power factor.

Use when: Steady-state AC

Use when: Pure sinusoid

Source: NCERT Class XII Physics, Ch 7, p. 16

Faraday's law of induction

F.PHY.U14.FARADAY

$$\varepsilon = -\frac{d(\Phi_B)}{dt}$$

Meaning: Induced EMF in circuit equals negative rate of change of magnetic flux. Lenz's law in the sign.

Use when: Closed loop

Use when: Flux change real (motion or B change)

Source: NCERT Class XII Physics, Ch 6, p. 4

Energy in inductor

F.PHY.U14.INDUCTOR_ENERGY

$$U = 0.5 * L * I^2$$

Meaning: Magnetic field energy stored in inductor carrying current I.

Use when: Linear regime

Use when: Energy referenced to I=0

Source: NCERT Class XII Physics, Ch 6, p. 16

LCR series impedance

F.PHY.U14.LCR_IMPEDANCE

$$Z = \sqrt{R^2 + (X_L - X_C)^2}; \quad \tan(\phi) = \frac{X_L - X_C}{R}$$

Meaning: Effective resistance of series LCR. Phase angle phi between V and I.

Use when: Series LCR

Use when: AC steady state

Use when: Single frequency source

Source: NCERT Class XII Physics, Ch 7, p. 12

Motional EMF

F.PHY.U14.MOTIONAL_EMF

epsilon = B*L*v

Meaning: Rod of length L moving with v perpendicular to both rod and B; induced EMF from magnetic force on charges.

Use when: v □ rod □ B (all mutually perpendicular)

Use when: Uniform B

Source: NCERT Class XII Physics, Ch 6, p. 8

Capacitive reactance

F.PHY.U14.REACTANCE_C

X_C = 1/(omega*C) = 1/(2*pi*f*C)

Meaning: Resistance-equivalent of capacitor in AC. Current leads voltage by 90°.

Use when: Pure capacitor

Use when: AC steady state

Source: NCERT Class XII Physics, Ch 7, p. 10

Inductive reactance

F.PHY.U14.REACTANCE_L

X_L = omega*L = 2*pi*f*L

Meaning: Resistance-equivalent of inductor in AC circuit. Voltage leads current by 90°.

Use when: Pure inductor

Use when: AC steady state

Source: NCERT Class XII Physics, Ch 7, p. 8

Resonance frequency LCR

F.PHY.U14.RESONANCE_FREQ

f0 = 1/(2*pi*sqrt(L*C))

Meaning: Frequency at which X_L = X_C, Z = R minimum, current maximum.

Use when: Series LCR

Use when: Steady AC

Source: NCERT Class XII Physics, Ch 7, p. 14

RMS values of sinusoidal AC

F.PHY.U14.RMS_VALUES

I_{rms} = I_{peak}/sqrt(2); V_{rms} = V_{peak}/sqrt(2)

Meaning: RMS values for pure sinusoid. Stated AC voltages are RMS unless noted.

Use when: Pure sinusoid

Use when: Steady state

Source: NCERT Class XII Physics, Ch 7, p. 3

Self-inductance EMF

F.PHY.U14.SELF_INDUCT

epsilon = -L * dI/dt

Meaning: EMF induced in coil due to its own changing current. L = inductance.

Use when: Coil/inductor

Use when: Linear regime (no core saturation)

Source: NCERT Class XII Physics, Ch 6, p. 12

Transformer ratios

F.PHY.U14.TRANSFORMER

$V_s/V_p = N_s/N_p;\ I_p/I_s = N_s/N_p$ (ideal)

Meaning: Voltage ratio = turns ratio. Ideal transformer: V_p I_p = V_s I_s.

Use when: Ideal transformer (no losses)

Use when: Common iron core

Source: NCERT Class XII Physics, Ch 7, p. 20

PHY.U15 -- Electromagnetic Waves

Displacement current

F.PHY.U15.DISPLACEMENT_CURRENT

$I_d = eps0 * d(Phi_E)/dt$

Meaning: Current associated with changing electric flux. Closes Ampere's law for time-varying fields.

Use when: Time-varying E field

Use when: Capacitor or vacuum region

Source: NCERT Class XII Physics, Ch 8, p. 2

Intensity of EM wave

F.PHY.U15.EM_INTENSITY

$I = (1/2) * c * eps0 * E0^2$

Meaning: Average power per unit area carried by EM wave with peak field E0.

Use when: Plane EM wave

Use when: Far-field

Source: NCERT Class XII Physics, Ch 8, p. 6

E/B ratio in EM wave

F.PHY.U15.E_OVER_B

$E0/B0 = c$

Meaning: In an EM plane wave, the amplitudes of E and B are related by speed of light.

Use when: Plane wave

Use when: Vacuum

Source: NCERT Class XII Physics, Ch 8, p. 6

Speed of EM waves in vacuum

F.PHY.U15.SPEED_OF_LIGHT

$c = 1/sqrt(mu0*eps0)$

Meaning: Speed of EM waves in vacuum from Maxwell's equations. ~3e8 m/s.

Use when: Vacuum or air

Use when: No dispersion at given frequency

Source: NCERT Class XII Physics, Ch 8, p. 4

PHY.U16 -- Optics

Brewster's law

F.PHY.U16.BREWSTER

$$\tan(i_B) = n$$

Meaning: When light is incident at Brewster's angle on a dielectric, the reflected light is fully plane-polarised.

Use when: Light from rarer to denser medium (plane interface)

Use when: Linearly polarised reflected component perpendicular to plane of incidence

Source: NCERT Class XII Physics, Ch 10, p. 16

Critical angle (TIR)

F.PHY.U16.CRITICAL_ANGLE

$$\sin(\theta_c) = n2/n1 \quad (n1 > n2, \text{ denser to rarer})$$

Meaning: Beyond this angle of incidence, total internal reflection occurs.

Use when: Light going from denser to rarer medium

Use when: Plane interface

Source: NCERT Class XII Physics, Ch 9, p. 8

Lenses in contact

F.PHY.U16.LENSES_CONTACT

$$1/F = 1/f1 + 1/f2 \quad (= P1 + P2 \text{ in dioptres})$$

Meaning: Equivalent focal length for thin lenses in contact. Powers add.

Use when: Thin lenses in contact

Use when: Same optical axis

Source: NCERT Class XII Physics, Ch 9, p. 15

Lens maker's formula

F.PHY.U16.LENSMAKER

$$1/f = (n - 1) * (1/R1 - 1/R2)$$

Meaning: Focal length from refractive index and surface curvatures.

Use when: Thin lens

Use when: Both surfaces specified with sign convention

Use when: Lens in air

Source: NCERT Class XII Physics, Ch 9, p. 12

Thin lens formula

F.PHY.U16.LENS_FORMULA

$$1/v - 1/u = 1/f$$

Meaning: Thin lens formula. Power P = 1/f (in dioptres if f in metres).

Use when: Thin lens

Use when: Paraxial rays

Use when: Sign convention used

Source: NCERT Class XII Physics, Ch 9, p. 14

Astronomical telescope magnification (normal)

F.PHY.U16.MAGNIFICATION_TELESCOPE

$M = -f_o/f_e$ (length $L = f_o + f_e$)

Meaning: Magnification of astronomical telescope in normal adjustment (final image at infinity).

Use when: Normal adjustment (image at infinity)

Use when: Object at infinity

Source: NCERT Class XII Physics, Ch 9, p. 24

Malus's law

F.PHY.U16.MALUS

$I = I0 * \cos^2(theta)$

Meaning: Intensity through a polariser depends on angle theta between light's polarisation and polariser axis.

Use when: Linearly polarised input

Use when: Ideal polariser

Source: NCERT Class XII Physics, Ch 10, p. 18

Mirror formula

F.PHY.U16.MIRROR_FORMULA

$1/v + 1/u = 1/f$; $m = -v/u$

Meaning: Spherical mirror formula. Sign convention: distances from pole, positive in direction of incident light.

Use when: Spherical mirror, paraxial rays

Use when: Sign convention used consistently

Source: NCERT Class XII Physics, Ch 9, p. 2

Prism minimum deviation formula

F.PHY.U16.PRISM_MIN_DEV

$n = \sin((A + \delta_m)/2) / \sin(A/2)$

Meaning: At minimum deviation (i1 = i2), refractive index from prism angle A and minimum deviation delta_m.

Use when: At minimum deviation only

Use when: Symmetric ray path

Source: NCERT Class XII Physics, Ch 9, p. 18

Snell's law

F.PHY.U16.SNELL

$n1*\sin(theta1) = n2*\sin(theta2)$

Meaning: Refraction at boundary between two media of different refractive indices.

Use when: Plane interface

Use when: Monochromatic light

Source: NCERT Class XII Physics, Ch 9, p. 5

YDSE fringe width

F.PHY.U16.YDSE_FRINGE

$beta = lambda*D/d$

Meaning: Fringe width in Young's double-slit experiment. Wavelength lambda, slit separation d, screen distance D.

Use when: D >> d

Use when: Coherent monochromatic source

Use when: Small angles

Source: NCERT Class XII Physics, Ch 10, p. 8

PHY.U17 -- Dual Nature of Matter

de Broglie wavelength

F.PHY.U17.DE_BROGLIE

$$\lambda = h/p = h/(m*v)$$

Meaning: Wavelength associated with any moving particle of momentum p. For electron through V volts: lambda ~ 12.27/sqrt(V) angstroms.

Use when: Non-relativistic (v << c)

Source: NCERT Class XII Physics, Ch 11, p. 10

Einstein's photoelectric equation

F.PHY.U17.EINSTEIN_PE

$$K_{max} = h*\nu - W; \; eV0 = K_{max}$$

Meaning: Maximum kinetic energy of photoelectron equals photon energy minus work function. Stopping potential V0 satisfies eV0 = K_max.

Use when: nu > nu_threshold = W/h (else no emission)

Use when: One-photon absorption

Source: NCERT Class XII Physics, Ch 11, p. 6

Photon energy and momentum

F.PHY.U17.PHOTON_ENERGY

$$E = h*\nu = h*c/\lambda; \; p = h/\lambda = E/c$$

Meaning: Energy and momentum of a photon. h = 6.626e-34 J*s.

Use when: Vacuum (c=speed of light)

Use when: Photon = EM quantum

Source: NCERT Class XII Physics, Ch 11, p. 8

PHY.U18 -- Atoms and Nuclei

Mass defect and binding energy

F.PHY.U18.BINDING_ENERGY

$$\Delta_m = Z*m_p + N*m_n - m_{nucleus}; \; B = \Delta_m * c^2$$

Meaning: Mass defect = sum of constituent masses minus nuclear mass. Binding energy = mass defect in energy units.

Use when: Non-relativistic

Use when: Stable nucleus

Source: NCERT Class XII Physics, Ch 13, p. 6

Bohr energy levels

F.PHY.U18.BOHR_ENERGY

$$E_n = -13.6/n^2 \text{ eV (hydrogen)}$$

Meaning: Energy of n-th Bohr orbit in hydrogen. n=1 ground state -13.6 eV; ionisation energy = 13.6 eV.

Use when: Hydrogen atom

Use when: Non-relativistic

Source: NCERT Class XII Physics, Ch 12, p. 6

Bohr orbit radius

F.PHY.U18.BOHR_RADIUS

$r_n = n^2 * a0 \ (a0 = 0.529 \text{ Å})$

Meaning: Allowed radii in Bohr model of hydrogen atom. Quantised by integer n.

Use when: Hydrogen-like atom (single electron)

Use when: Non-relativistic

Source: NCERT Class XII Physics, Ch 12, p. 6

Mass-energy equivalence

F.PHY.U18.MASS_ENERGY

$E = m * c^2; \ 1 \text{ u} = 931.5 \text{ MeV}/c^2$

Meaning: Einstein's mass-energy relation. 1 atomic mass unit = 931.5 MeV in energy units.

Use when: Conversion of mass to energy (or vice versa)

Source: NCERT Class XII Physics, Ch 13, p. 4

Nuclear radius scaling

F.PHY.U18.NUCLEAR_RADIUS

$R = R0 * A^{(1/3)}, \ R0 \sim 1.2 \text{ fm}$

Meaning: Nuclear radius scales with cube root of mass number A. Implies constant nuclear density.

Use when: Spherical nucleus assumption

Source: NCERT Class XII Physics, Ch 13, p. 2

Rydberg formula (hydrogen spectrum)

F.PHY.U18.RYDBERG

$1/\lambda = R * (1/n1^2 - 1/n2^2), \ n2 > n1$

Meaning: Wavelengths of hydrogen spectral lines. R = 1.097e7 1/m. Lyman (n1=1, UV), Balmer (n1=2, visible), Paschen+ (IR).

Use when: Hydrogen atom

Use when: Single electron transition

Source: NCERT Class XII Physics, Ch 12, p. 8

PHY.U19 -- Electronic Devices

p-n diode bias regimes

F.PHY.U19.DIODE_BIAS

Forward bias: p->+, n->-, current flows; Reverse bias: opposite, low current except Zener breakdown

Meaning: Conceptual: p-n junction conducts in forward bias, blocks in reverse (until breakdown).

Use when: Single p-n junction

Use when: DC operation

Source: NCERT Class XII Physics, Ch 14, p. 8

Common logic gate truth tables

F.PHY.U19.LOGIC_GATES

AND Y=A.B; OR Y=A+B; NOT Y=~A; NAND Y=~(A.B); NOR Y=~(A+B); XOR Y=A.~B + ~A.B

Meaning: Boolean operations on binary inputs. NAND and NOR are universal gates.

Use when: Binary digital logic

Use when: Ideal gates (no propagation delay considered)

Source: NCERT Class XII Physics, Ch 14, p. 18

Rectifier output frequency

F.PHY.U19.RECTIFIER_FREQ

Half-wave: $f_{out} = f_{in}$; Full-wave: $f_{out} = 2 * f_{in}$

Meaning: Output ripple frequency relative to input AC frequency.

Use when: Single-phase AC input

Use when: No filter (raw rectified output)

Source: NCERT Class XII Physics, Ch 14, p. 12

PHY.U20 -- Experimental Skills

Least count of screw gauge

F.PHY.U20.LEAST_COUNT_SCREW

LC = pitch / circular-scale divisions

Meaning: Smallest length resolvable by a screw gauge; typical pitch 0.5 mm, 50 head divisions □ LC = 0.01 mm.

Use when: Standard micrometer screw gauge

Use when: Backlash error eliminated

NCERT citation: pending (corpus Phase D not yet complete)

Least count of vernier callipers

F.PHY.U20.LEAST_COUNT_VERNIER

LC = 1 MSD - 1 VSD = 1 MSD / N (N = vernier divisions)

Meaning: Smallest length resolvable by a vernier; for standard 1-mm MSD with 10 VSD, LC = 0.1 mm = 0.01 cm.

Use when: Standard linear vernier calliper

Use when: 1 MSD value known

NCERT citation: pending (corpus Phase D not yet complete)

Percentage error in derived quantity

F.PHY.U20.PERCENTAGE_ERROR

$\%err(Z) = \text{sum of } (|n_i| * \%err(x_i)) \text{ for } Z = \text{product } x_1^{n1} * x_2^{n2} * \ldots$

Meaning: Combines fractional errors of independent measurements. Adds in absolute value (worst-case).

Use when: Independent measurements

Use when: Maximum-error analysis

NCERT citation: pending (corpus Phase D not yet complete)

Chemistry

52 formulas

CHE.U01 -- Basic Concepts of Chemistry

Molality

F.CHE.U01.MOLALITY

$$m = (\text{moles solute})/(\text{kg solvent})$$

Meaning: Molal concentration: moles of solute per kg of solvent. Temperature-independent.

Use when: Mass of SOLVENT (not solution)

NCERT citation: pending (corpus Phase D not yet complete)

Molarity

F.CHE.U01.MOLARITY

$$M = (\text{moles solute})/(\text{L solution})$$

Meaning: Molar concentration: moles of solute per litre of solution.

Use when: Volume of SOLUTION not solvent

Use when: Temperature dependent (volume changes with T)

NCERT citation: pending (corpus Phase D not yet complete)

Number of moles

F.CHE.U01.MOLE_NUMBER

$$n = \text{mass}/M = N/N_A = V_{gas}/22.4_{L}\ (\text{STP})$$

Meaning: Three equivalent ways to compute moles: from mass and molar mass, from number of particles, from gas volume at STP.

Use when: Use g/(g/mol) for mass route

Use when: STP for gas volume route

Use when: Pure substance

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U02 -- Atomic Structure

Bohr energy (hydrogen-like)

F.CHE.U02.BOHR_ENERGY

$$E_n = -13.6 * Z^2/n^2 \text{ eV}$$

Meaning: Energy of nth orbit. Negative (bound). Ground state H: -13.6 eV.

Use when: Hydrogen-like atom

Use when: Non-relativistic

NCERT citation: pending (corpus Phase D not yet complete)

Bohr radius (hydrogen-like)

F.CHE.U02.BOHR_RADIUS

$$r_n = 0.529 * n^2 / Z \text{ Å}$$

Meaning: Radius of nth Bohr orbit for hydrogen-like atom of nuclear charge Z.

Use when: Hydrogen-like (one-electron) atom

Use when: Non-relativistic

NCERT citation: pending (corpus Phase D not yet complete)

de Broglie wavelength

F.CHE.U02.DE_BROGLIE

$$\lambda = h/(m*v)$$

Meaning: Wavelength associated with moving particle of momentum mv.

Use when: Non-relativistic

NCERT citation: pending (corpus Phase D not yet complete)

Heisenberg uncertainty

F.CHE.U02.HEISENBERG

$$\Delta x * \Delta p \geq h/(4*\pi)$$

Meaning: Position and momentum cannot both be known with arbitrary precision.

Use when: Quantum scale; meaningful only when Δx, Δp comparable to atomic dimensions

NCERT citation: pending (corpus Phase D not yet complete)

Rydberg formula (H spectrum)

F.CHE.U02.RYDBERG

$$1/\lambda = R_H * Z^2 * (1/n1^2 - 1/n2^2),\ n2 > n1$$

Meaning: Spectral wavelengths of hydrogen-like atoms. Lyman (n1=1, UV), Balmer (n1=2, visible), Paschen (n1=3, IR).

Use when: One-electron atom

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U03 -- Chemical Bonding

Bond order from MO theory

F.CHE.U03.BOND_ORDER

$$BO = (N_b - N_a)/2$$

Meaning: Higher bond order: shorter, stronger bond. N_2: BO=3, O_2: BO=2, F_2: BO=1.

Use when: MO theory framework

Use when: Closed-shell molecule (or with appropriate treatment)

NCERT citation: pending (corpus Phase D not yet complete)

Dipole moment

F.CHE.U03.DIPOLE_MOMENT

$$\mu = q * d$$

Meaning: Product of charge magnitude and bond length. SI: C·m. Common: Debye (1 D = 3.336e-30 C·m).

Use when: Diatomic or vector-summed for polyatomic

Use when: Polar bond

NCERT citation: pending (corpus Phase D not yet complete)

Spin-only magnetic moment

F.CHE.U03.MAGNETIC_MOMENT

$$\mu = \mathrm{sqrt}(n(n+2))\ BM$$

Meaning: Magnetic moment from n unpaired electrons. 1 unpaired: 1.73 BM; 5: 5.92 BM.

Use when: Spin-only contribution (no orbital contribution)

Use when: Octahedral or tetrahedral complex

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U04 -- Thermodynamics

Enthalpy and ΔH at constant P

F.CHE.U04.ENTHALPY

$$H = U + PV;\ \Delta H = q_p \text{ (constant P)}$$

Meaning: Enthalpy = internal energy + PV. At constant pressure, heat absorbed equals enthalpy change.

Use when: At constant pressure

Use when: Closed system

NCERT citation: pending (corpus Phase D not yet complete)

First law of thermodynamics (chemistry)

F.CHE.U04.FIRST_LAW

$$\Delta U = q + w \text{ (chemistry sign convention)}$$

Meaning: Internal energy change = heat added to system + work done ON system. Note: chemistry uses w as work done ON system; physics uses w as work done BY.

Use when: Closed system

Use when: Sign convention chosen consistently

NCERT citation: pending (corpus Phase D not yet complete)

Gibbs free energy

F.CHE.U04.GIBBS

$$\Delta G = \Delta H - T\,\Delta S$$

Meaning: Spontaneity criterion. ΔG<0: spontaneous. ΔG=0: equilibrium. ΔG>0: non-spontaneous.

Use when: Constant T and P

NCERT citation: pending (corpus Phase D not yet complete)

ΔG° and K

F.CHE.U04.GIBBS_K

$$\Delta G^\circ = -RT \ln K$$

Meaning: Standard free energy change relates to equilibrium constant. K>1: ΔG°<0; K<1: ΔG°>0.

Use when: Standard state

Use when: Equilibrium

NCERT citation: pending (corpus Phase D not yet complete)

Hess's law

F.CHE.U04.HESS_LAW

$$\Delta H(\text{net}) = \text{sum of } \Delta H(\text{steps})$$

Meaning: Total enthalpy change is independent of path. Useful for computing ΔH of reactions not directly measurable.

Use when: State function (path-independent)

Use when: Same initial/final states

NCERT citation: pending (corpus Phase D not yet complete)

Standard enthalpy of reaction

F.CHE.U04.STANDARD_ENTHALPY

$$\Delta H^\circ_{rxn} = \text{sum}(\Delta H^\circ_f \text{ products}) - \text{sum}(\Delta H^\circ_f \text{ reactants})$$

Meaning: From standard formation enthalpies. ΔH°_f of element in standard state = 0.

Use when: Standard state (1 bar, 298 K)

Use when: Stoichiometric coefficients applied

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U05 -- Solutions

Boiling-point elevation

F.CHE.U05.BP_ELEVATION

$$\Delta T_b = K_b * m$$

Meaning: Solute raises boiling point. K_b is ebullioscopic constant of solvent (water: 0.52 K kg/mol).

Use when: Dilute solution

Use when: Non-electrolyte

NCERT citation: pending (corpus Phase D not yet complete)

Freezing-point depression

F.CHE.U05.FP_DEPRESSION

$$\Delta T_f = K_f * m$$

Meaning: Solute lowers freezing point. K_f is cryoscopic constant of solvent (water: 1.86 K kg/mol). Used for molar mass determination.

Use when: Dilute solution

Use when: Non-electrolyte (else multiply by i)

NCERT citation: pending (corpus Phase D not yet complete)

Osmotic pressure

F.CHE.U05.OSMOTIC

$$\pi = C * R * T = (W/M)*RT/V$$

Meaning: Pressure required to prevent osmosis. C in mol/L; T in K. Used for high-molar-mass biomolecules.

Use when: Dilute solution

Use when: Semipermeable membrane separating pure solvent from solution

NCERT citation: pending (corpus Phase D not yet complete)

Raoult's law

F.CHE.U05.RAOULT

$$p = p1^\circ * x1 + p2^\circ * x2$$

Meaning: Total vapor pressure of ideal solution = sum of mole-fraction-weighted vapor pressures of components.

Use when: Ideal solution

Use when: Both volatile

NCERT citation: pending (corpus Phase D not yet complete)

Relative lowering of VP

F.CHE.U05.RELATIVE_LOWERING

$$(p^\circ - p)/p^\circ = x_{solute}$$

Meaning: For non-volatile solute: relative lowering of VP equals mole fraction of solute.

Use when: Non-volatile solute

Use when: Dilute solution

Use when: Non-electrolyte (else use i)

NCERT citation: pending (corpus Phase D not yet complete)

Van't Hoff factor

F.CHE.U05.VAN_T_HOFF

i = (observed)/(calculated)

Meaning: Correction factor for electrolytes. NaCl: i≈2; $CaCl_2$: i≈3. Multiply colligative formula by i.

Use when: Electrolyte solution

Use when: Account for ion-pair association/dissociation

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U06 -- Chemical Equilibrium

Henderson-Hasselbalch (buffer)

F.CHE.U06.HENDERSON_HASSELBALCH

pH = pKa + log10([salt]/[acid])

Meaning: pH of acidic buffer in terms of conjugate base/acid concentrations. For basic buffer: pOH = pKb + log10([salt]/[base]).

Use when: Buffer (weak acid + conjugate base)

Use when: Concentrations not too dilute

Use when: Approximate (assumes negligible dissociation)

NCERT citation: pending (corpus Phase D not yet complete)

Ka, Kb, Kw relationship

F.CHE.U06.KA_KB_KW

$K_a * K_b = K_w = 10^{-14}$ (conjugate pair, 25°C)

Meaning: Stronger acid → weaker conjugate base, and vice versa. pKa + pKb = 14.

Use when: Conjugate acid-base pair

Use when: 25°C

NCERT citation: pending (corpus Phase D not yet complete)

Equilibrium constant K_p and K_c

F.CHE.U06.KP_KC

$K_p = K_c (RT)^{\Delta n}$, Δn = (mol gas products) - (mol gas reactants)

Meaning: Convert between pressure-based and concentration-based equilibrium constants. T in K; R = 0.0821 L atm/mol/K (when K_p in atm).

Use when: Gas-phase equilibrium

Use when: Same temperature

NCERT citation: pending (corpus Phase D not yet complete)

Solubility product

F.CHE.U06.KSP

$K_{sp} = [M+]^a * [X-]^b$ for M_{aX_b} salt

Meaning: Equilibrium constant for sparingly soluble salt. Q < K_sp: dissolves; Q > K_sp: precipitates.

Use when: Sparingly soluble salt

Use when: Saturated solution

NCERT citation: pending (corpus Phase D not yet complete)

pH and pOH

F.CHE.U06.PH

pH = -log10([H+]); pH + pOH = 14 (at 25°C)

Meaning: Logarithmic acidity scale. Pure water at 25°C: pH = 7 = pOH.

Use when: Aqueous solution

Use when: Use Kw = 10^-14 at 25°C

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U07 -- Electrochemistry

Cell EMF

F.CHE.U07.EMF

$$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$$

Meaning: Both as reduction potentials. E°_cell > 0 → spontaneous.

Use when: Standard conditions (1 M, 1 bar, 298 K)

Use when: Both half-reactions as reductions

NCERT citation: pending (corpus Phase D not yet complete)

Faraday's law of electrolysis

F.CHE.U07.FARADAY_ELECTROLYSIS

m = (M*I*t)/(n*F)

Meaning: Mass deposited at electrode. M = molar mass; I = current; t = time; n = electrons per ion.

Use when: Steady current

Use when: Single product

NCERT citation: pending (corpus Phase D not yet complete)

ΔG from EMF

F.CHE.U07.GIBBS_FROM_E

ΔG = -nFE, ΔG° = -nFE°

Meaning: Connection between thermodynamics and electrochemistry. F = 96485 C/mol.

Use when: Single redox process

NCERT citation: pending (corpus Phase D not yet complete)

Molar conductivity

F.CHE.U07.MOLAR_CONDUCTIVITY

$$\Lambda_m = \kappa * 1000 / C$$

Meaning: Molar conductivity from specific conductance. Increases with dilution as more ions are free.

Use when: Aqueous solution

Use when: Single electrolyte

NCERT citation: pending (corpus Phase D not yet complete)

Nernst equation

F.CHE.U07.NERNST

E = E° - (0.0591/n)*log10(Q) (at 298 K)

Meaning: Cell potential at non-standard conditions. n = electrons transferred. At equilibrium E=0, Q=K.

Use when: 298 K (else use RT/F)

Use when: Single redox process

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U08 -- Chemical Kinetics

Arrhenius equation

F.CHE.U08.ARRHENIUS

$$k = A * \exp(-Ea/(R*T))$$

Meaning: Temperature dependence of rate constant. Higher Ea → more T-sensitive rate.

Use when: T in kelvins

Use when: Most reactions in modest T range

NCERT citation: pending (corpus Phase D not yet complete)

Arrhenius for two temperatures

F.CHE.U08.ARRHENIUS_TWO_T

$$\ln(k2/k1) = (Ea/R) * (1/T1 - 1/T2)$$

Meaning: Compare rate constants at two temperatures to find Ea.

Use when: A constant across temperature range

Use when: T in kelvins

NCERT citation: pending (corpus Phase D not yet complete)

First-order kinetics

F.CHE.U08.FIRST_ORDER

$$\ln([A]_0/[A]) = k*t;\ t_1/2 = 0.693/k$$

Meaning: Concentration decays exponentially. Half-life independent of [A]_0.

Use when: First-order reaction (rate = k[A])

NCERT citation: pending (corpus Phase D not yet complete)

Zero-order kinetics

F.CHE.U08.ZERO_ORDER

$$[A] = [A]_0 - k*t;\ t_1/2 = [A]_0/(2k)$$

Meaning: Concentration decays linearly. Half-life depends on initial concentration.

Use when: Zero-order reaction (rate = k, no concentration dependence)

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U09 -- Periodic Properties

Ionization energy of hydrogen-like atom

F.CHE.U09.IONIZATION_ENERGY_HYDROGEN_LIKE

$$IE = 13.6 * Z^2 / n^2\ eV$$

Meaning: Energy required to ionize an electron from the n-th shell of hydrogen-like atom.

Use when: One-electron atom

Use when: Non-relativistic

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U10 -- d and f Block Elements

Spin-only magnetic moment for transition metal F.CHE.U11.MAGNETIC_MOMENT_TM

`mu = sqrt(n(n+2)) BM (n = unpaired electrons)`

Meaning: Predicts paramagnetic moment of d-block ion. n unpaired electrons in d-orbitals.

Use when: Spin-only contribution

Use when: Octahedral or tetrahedral complex

Use when: First-row d-block

NCERT citation: pending (corpus Phase D not yet complete)

Common oxidation states (first-row TM) F.CHE.U11.OXIDATION_STATE_RANGE

`Ti +2/+3/+4; V +2..+5; Cr +2..+6; Mn +2..+7; Fe +2/+3/+6; Co +2/+3; Ni +2; Cu +1/+2; Zn +2`

Meaning: Catalogues common stable oxidation states across first-row transition metals.

Use when: First-row d-block

Use when: Common (not exotic) compounds

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U11 -- Coordination Compounds

Crystal field splitting (octahedral vs tetrahedral) F.CHE.U12.CRYSTAL_FIELD_DELTA

`Delta_t = (4/9) Delta_o (approximately)`

Meaning: Tetrahedral splitting is smaller than octahedral due to fewer/farther ligands.

Use when: Same metal and same ligand

Use when: Mostly high-spin tetrahedral due to small Δ_t

NCERT citation: pending (corpus Phase D not yet complete)

Magnetic moment of coordination complex F.CHE.U12.MAGNETIC_MOMENT_COMPLEX

`mu = sqrt(n(n+2)) BM`

Meaning: Same spin-only formula but n depends on high-spin/low-spin from CFT.

Use when: High vs low spin determined by Δ_o vs P

Use when: Octahedral (or tetrahedral with Δ_t)

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U12 -- Organic Chemistry -- Basics

Carbocation stability order F.CHE.U14.CARBOCATION_STABILITY

`3° > 2° > 1° > methyl; benzyl ~ allyl >> 1° (resonance-stabilised)`

Meaning: Stability from hyperconjugation (more α-H) and inductive donation (alkyl groups). Resonance can elevate primary cations.

Use when: Gas phase or aprotic solvent

Use when: Compare similar reaction conditions

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U13 -- Hydrocarbons

Markovnikov's rule (and anti-Markovnikov)

F.CHE.U15.MARKOVNIKOV

`HX + alkene -> X on C with fewer H (without peroxide, ionic via more-stable carbocation)`

Meaning: Without peroxide: ionic mechanism — H goes to carbon with MORE hydrogens (carbocation stability rule). With peroxide (HBr only, Kharasch): radical mechanism — a...

Use when: Asymmetric alkene

Use when: H-X with X = Cl, Br, I

Use when: Without peroxide for Markovnikov

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U14 -- Oxygen-Containing Compounds

pKa of carboxylic acid

F.CHE.U17.CARBOXYLIC_PKA

`RCOOH pKa ~ 4-5 (acetic 4.76); EWG decreases (CCl3COOH pKa 0.7)`

Meaning: Stronger acid than phenol due to more effective resonance over two equivalent oxygens. EWG substituents (Cl, NO2) increase acidity.

Use when: Aqueous solution

Use when: α-substituent effects strongest

NCERT citation: pending (corpus Phase D not yet complete)

pKa of phenol vs aliphatic alcohol

F.CHE.U17.PHENOL_PKA

`Phenol pKa ~ 10; aliphatic alcohol pKa ~ 16-18`

Meaning: Phenols ~10^6× more acidic than aliphatic alcohols due to resonance stabilisation of phenoxide ion. Electron-withdrawing substituents lower pKa further.

Use when: Aqueous solution

Use when: Substituent effects shift values

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U15 -- Amines

pKb of common amines (aqueous)

F.CHE.U18.AMINE_PKB

`Methylamine pKb ~ 3.36; Dimethylamine ~ 3.27; Trimethylamine ~ 4.19; Aniline ~ 9.4`

Meaning: Aqueous basicity order: 2° ≈ 1° > 3° > NH3. Aromatic amines much weaker due to resonance delocalisation of lone pair.

Use when: Aqueous solution; gas-phase order is 3°>2°>1°

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U16 -- Biomolecules

DNA hydrogen bonds per base pair

F.CHE.U19.DNA_BASE_PAIRING_COUNT

A-T = 2 H-bonds; G-C = 3 H-bonds

Meaning: Used to compute total H-bonds in a duplex of given GC%/AT% composition.

Use when: Watson–Crick double helix

NCERT citation: pending (corpus Phase D not yet complete)

General formula of monosaccharides

F.CHE.U19.MONOSACCHARIDE_FORMULA

Cn(H2O)n; commonly n=5 (pentoses) or n=6 (hexoses)

Meaning: Empirical formula of simple monosaccharides; glucose/fructose are C6H12O6.

Use when: Open-chain or cyclic forms of aldoses/ketoses

NCERT citation: pending (corpus Phase D not yet complete)

Peptide bonds in a polypeptide of N residues

F.CHE.U19.PEPTIDE_BOND_COUNT

$$\text{peptide}_{\text{bonds}} = N - 1;\ \text{water lost} = N - 1$$

Meaning: Number of amide (peptide) bonds in a linear polypeptide of N amino acids.

Use when: Linear (non-cyclic) polypeptide

NCERT citation: pending (corpus Phase D not yet complete)

CHE.U17 -- Chemistry Practical Principles

Molarity-stoichiometry titration

F.CHE.U20.MOLARITY_TITRATION

$$M_a V_a / n_a = M_b V_b / n_b \quad (n = \text{stoichiometric coefficient})$$

Meaning: Use when normality is awkward (e.g., diprotic acids). Stoichiometric coefficients from balanced equation.

Use when: Balanced equation known

Use when: Same end-point

NCERT citation: pending (corpus Phase D not yet complete)

Normality equation in titration

F.CHE.U20.NORMALITY_TITRATION

N1 V1 = N2 V2 (equivalent law)

Meaning: Equivalents of acid = equivalents of base at end-point. Or for redox: equivalents of oxidant = equivalents of reductant.

Use when: Same titration end-point

Use when: Equivalent factors known

NCERT citation: pending (corpus Phase D not yet complete)

Biology

10 formulas

BIO.U03 -- Cell Biology and Biochemistry

Michaelis-Menten equation

F.BIO.U03.MICHAELIS_MENTEN

```
v = Vmax * [S] / (Km + [S])
```

Meaning: Initial reaction velocity v of an enzyme as a function of substrate concentration. Km = [S] at v = Vmax/2.

Use when: Single substrate

Use when: No allosteric/cooperative effects

NCERT citation: pending (corpus Phase D not yet complete)

BIO.U05 -- Human Physiology

Cardiac output

F.BIO.U05.CARDIAC_OUTPUT

```
CO = HR × SV
```

Meaning: Volume of blood pumped per minute = heart rate × stroke volume. Normal ~5 L/min at rest.

Use when: At rest

NCERT citation: pending (corpus Phase D not yet complete)

Respiratory volumes and capacities

F.BIO.U05.RESPIRATORY_VOLUMES

```
VC = TV + IRV + ERV; TLC = VC + RV; FRC = ERV + RV; IC = TV + IRV
```

Meaning: Defines lung volumes and their sums (capacities). TV ~500 mL, IRV ~3000 mL, ERV ~1100 mL, RV ~1200 mL.

Use when: Normal adult resting

Use when: Spirometry-measured (RV indirect)

NCERT citation: pending (corpus Phase D not yet complete)

BIO.U07 -- Genetics and Evolution

Mendel's monohybrid ratio

F.BIO.U03.BMI_OR_NA

```
Genotype 1:2:1 (AA:Aa:aa); Phenotype 3:1 (dominant:recessive)
```

Meaning: F2 ratio in monohybrid cross — products of independent assortment of two alleles per locus.

Use when: Single gene with complete dominance

Use when: Pure-bred parents

NCERT citation: pending (corpus Phase D not yet complete)

Mendel's dihybrid ratio

F.BIO.U07.DIHYBRID_RATIO

```
Phenotype 9:3:3:1 (both dom : one dom : other dom : both rec)
```

Meaning: F2 ratio in dihybrid cross with two independently-segregating loci, complete dominance, no linkage.

Use when: Two unlinked loci

Use when: Complete dominance

NCERT citation: pending (corpus Phase D not yet complete)

Hardy-Weinberg equation

F.BIO.U07.HARDY_WEINBERG

$$p^2 + 2pq + q^2 = 1;\ p + q = 1$$

Meaning: In an idealised population (no mutation, drift, selection, gene flow, random mating), allele and genotype frequencies remain constant.

Use when: Idealised population

Use when: All five conditions met

Use when: Diploid, autosomal, biallelic locus

NCERT citation: pending (corpus Phase D not yet complete)

Recombination frequency (genetic mapping)

F.BIO.U07.RECOMBINATION_FREQ

$$\text{RF} = (\text{recombinants} / \text{total progeny}) \times 100 \quad (1\%\ \text{RF} = 1\ \text{cM})$$

Meaning: Proportion of recombinant offspring measures genetic distance between linked loci. Capped at 50% (independent assortment).

Use when: Linked loci on same chromosome

NCERT citation: pending (corpus Phase D not yet complete)

BIO.U10 -- Ecology

Lindeman's 10% law of energy transfer

F.BIO.U10.LINDEMAN_10PCT

$$\text{Energy}_{\text{transfer}} = 0.10 \times \text{Energy}_{\text{previous\_trophic}}$$

Meaning: Approximately 10% of energy at one trophic level is transferred to the next; rest dissipated as heat.

Use when: Idealised trophic transfer

NCERT citation: pending (corpus Phase D not yet complete)

Logistic population growth

F.BIO.U10.LOGISTIC_GROWTH

$$dN/dt = rN(K-N)/K$$

Meaning: Population grows exponentially at small N; growth slows as N approaches K (carrying capacity); equilibrium at N = K.

Use when: Verhulst-Pearl assumptions

Use when: Limiting resource

NCERT citation: pending (corpus Phase D not yet complete)

Species-area relationship

F.BIO.U10.SPECIES_AREA

$$\log S = \log C + Z \log A \quad (\text{Arrhenius})$$

Meaning: Number of species S in area A increases as a power law. Z (slope) = 0.1-0.2 for small areas, 0.6-1.2 for continents.

Use when: Within a biogeographic region

NCERT citation: pending (corpus Phase D not yet complete)

Sources Index

All NCERT source documents referenced in this booklet, with manifest identifiers and SHA-256 hashes (from manifest/source_documents.json). Only Physics formulas carry confirmed citations in v1.

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Physics corpus: tamilgeniuslab NEET-1 pipeline, Class XI-XII NCERT Ch 1-20. 141 formulas with full NCERT citations.

Chemistry and Biology corpus: 65 formulas included with equation + conditions; NCERT page citations deferred to corpus Phase D completion.

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