Useful Formulae in Advanced Level Physics

A1. \( a = \frac{v^2}{r} = \omega^2 r \) centripetal acceleration

A2. \( a = \omega^2 \chi \) simple harmonic motion

A3. \( L = I \omega \) angular momentum of a rigid body

A4. \( T = \frac{dL}{dt} \) torque on a rotating body

A5. \( E = \frac{1}{2} I \omega^2 \) energy stored in a rotating body

B1. \( v = \sqrt{\frac{T}{m}} \) velocity of transverse wave motion in a stretched string

B2. \( v = \sqrt{\frac{E}{\rho}} \) velocity of longitudinal wave motion in a solid

B3. \( n = \tan \theta_p \) refractive index and polarizing angle

B4. \( d = \frac{\lambda D}{a} \) fringe width in double-slit interference

B5. \( d \sin \theta = n \lambda \) diffraction grating equation

B6. \( f' = f \left( \frac{V - u_0}{V - u_s} \right) \) Doppler frequency

B7. \( 10 \log_{10} \left( \frac{I_2}{I_1} \right) \) definition of the decibel

C1. \( F = \frac{Gm_1 m_2}{r^2} \) Newton’s law of gravitation

C2. \( V = \frac{GM}{r} \) gravitational potential

C3. \( r^3 / T^2 = \text{constant} \) Kepler’s third law

C4. \( E = \frac{Q}{4\pi \varepsilon_0 r^2} \) electric field due to a point charge

C5. \( V = \frac{Q}{4\pi \varepsilon_0 r} \) electric potential due a point charge
C6. \( E = \frac{V}{d} \)  
   electric field between parallel plates (numerically)

C7. \( C = \frac{Q}{V} = \frac{\varepsilon_0 A}{d} \)  
   capacitance of a parallel-plate capacitor

C8. \( Q = Q_0 e^{-t/RC} \)  
   decay of charge with time when a capacitor discharges

C9. \( Q = Q_0(1 - e^{-t/RC}) \)  
   rise of charge with time when charging a capacitor

C10. \( E = \frac{1}{2} CV^2 \)  
    energy stored in a capacitor

C11. \( I = n A \nu Q \)  
    general current flow equation

C12. \( R = \frac{\rho l}{A} \)  
    resistance and resistivity

C13. \( F = BQ \nu \sin \theta \)  
    force on a moving charge in a magnetic field

C14. \( F = BI \nu \sin \theta \)  
    force on a current carrying a conductor in a magnetic field

C15. \( V = \frac{BI}{nQt} \)  
    Hall voltage

C16. \( B = \frac{\mu_0 I}{2\pi r} \)  
    magnetic field inside a long straight wire

C17. \( B = \frac{\mu_0 NI}{l} \)  
    magnetic field inside long solenoid

C18. \( F = \frac{\mu_0 I_1 I_2}{2\pi r} \)  
    force per unit length between long parallel straight current carrying conductors

C19. \( T = BAN \sin \phi \)  
    torque on a rectangular current carrying coil in a uniform magnetic field

C20. \( E = BAN \omega \sin \omega t \)  
    simple generator e.m.f.

C21. \( \frac{V_s}{V_p} \approx \frac{N_s}{N_p} \)  
    ratio of secondary voltage to primary voltage in a transformer

C22. \( E = -\frac{LdI}{dt} \)  
    e.m.f. induced in an inductor

C23. \( E = \frac{1}{2} LI^2 \)  
    energy stored in an inductor

C24. \( X_L = \omega L \)  
    reactance of an inductor
C25. \[ X_c = \frac{1}{\omega C} \] reactance of a capacitor

C26. \[ P = IV\cos \theta \] power in an a.c. circuit

C27. \[ \frac{\Delta V_{\text{out}}}{\Delta V_{\text{in}}} = \beta \frac{R_f}{R_b} \] voltage gain of transistor amplifier in the common emitter configuration

C28. \[ V_o = A_o(V_+ - V_-) \] output voltage of op amp (open-loop)

C29. \[ A = -\frac{R_f}{R_i} \] gain of inverting amplifier

C30. \[ A = 1 + \frac{R_f}{R_i} \] gain of non-inverting amplifier

D1. \[ pV = nRT = NkT \] equation of state for an ideal gas

D2. \[ pV = \frac{1}{3} N m c^2 \] kinetic theory equation

D3. \[ E_k = \frac{3}{2} \frac{RT}{N_A} = \frac{3}{2} kT \] molecular kinetic energy

D4. \[ E = \frac{F}{A} \frac{x}{L} \] macroscopic definition of Young modulus

D5. \[ E = \frac{1}{2} Fx \] energy stored in stretching

D6. \[ F = -\frac{dU}{dr} \] relationship between force and potential energy

D7. \[ E = k / r \] microscopic interpretation of Young modulus

D8. \[ P + \frac{1}{2} \rho v^2 + \rho gh = \text{constant} \] Bernoulli’s equation

D9. \[ \Delta U = Q + W \] first law of thermodynamics

D10. \[ E_n = -\frac{13.6}{n^2} eV \] energy level equation for hydrogen atom

D11. \[ N = N_0 e^{-kt} \] law of radioactive decay

D12. \[ t_{\frac{1}{2}} = \frac{\ln 2}{k} \] half-life and decay constant
D13. \( \frac{1}{2} m v_m^2 = h\nu - \phi \)  
Einstein’s photoelectric equation

D14. \( E = mc^2 \)  
mass-energy relationship