Mechanical Engineering Cheatsheet

A comprehensive cheat sheet covering essential formulas, concepts, and principles in mechanical engineering.

Thermodynamics

Basic Concepts

Zeroth Law	If two systems are each in thermal equilibrium with a third system, then they are in thermal equilibrium with each other.
First Law	Energy cannot be created or destroyed, only converted from one form to another. ΔU = Q - W
Second Law	The total entropy of an isolated system can only increase over time. ΔS ≥ 0
Third Law	As temperature approaches absolute zero, the entropy of a system approaches a minimum or zero.
Enthalpy (H)	H = U + PV, where U is internal energy, P is pressure, and V is volume.
Specific Heat (c)	The amount of heat required to raise the temperature of one unit mass of a substance by one degree. Q = mcΔT

Thermodynamic Processes

Isothermal	Constant temperature. ΔT = 0, Q = W
Adiabatic	No heat transfer. Q = 0, ΔU = -W
Isobaric	Constant pressure. ΔP = 0, W = PΔV
Isochoric (Isometric)	Constant volume. ΔV = 0, W = 0, ΔU = Q
Polytropic	Process described by PV^n = constant, where n is the polytropic index. W = (P2V2 - P1V1) / (1-n)

Cycles

Carnot Cycle	Theoretical thermodynamic cycle with the highest possible efficiency. Efficiency = 1 - (Tc/Th)
Otto Cycle	Idealized cycle for spark-ignition internal combustion engines. Efficiency = 1 - (1/r^(k-1))
Diesel Cycle	Idealized cycle for compression-ignition internal combustion engines. Efficiency = 1 - (1/r^(k-1)) * ((rc^k - 1) / (k*(rc-1)))

Fluid Mechanics

Fluid Properties

Density (ρ)	Mass per unit volume. ρ = m/V
Specific Weight (γ)	Weight per unit volume. γ = ρg
Viscosity (μ)	Resistance to flow. τ = μ(du/dy)
Kinematic Viscosity (ν)	Ratio of viscosity to density. ν = μ/ρ
Surface Tension (σ)	Force per unit length acting at the interface between two fluids. F = σL

Fluid Statics

Pressure (P)	Force per unit area. P = F/A
Hydrostatic Pressure	Pressure due to the weight of a fluid column. P = ρgh
Buoyancy	Upward force exerted by a fluid on an immersed object. Fb = ρVg

Fluid Dynamics

Continuity Equation	A1V1 = A2V2 (for incompressible fluids)
Bernoulli's Equation	P + (1/2)ρV^2 + ρgh = constant
Reynolds Number (Re)	Dimensionless number indicating whether flow is laminar or turbulent. Re = (ρVD)/μ

Solid Mechanics

Stress and Strain

Stress (σ)	Force per unit area. σ = F/A
Strain (ε)	Deformation per unit length. ε = ΔL/L
Young's Modulus (E)	Measure of stiffness of a material. E = σ/ε
Shear Stress (τ)	Stress parallel to the surface. τ = F/A
Shear Strain (γ)	Angular deformation. γ = Δx/L
Shear Modulus (G)	Measure of a material's resistance to shear deformation. G = τ/γ
Poisson's Ratio (ν)	Ratio of lateral strain to axial strain. ν = -ε_lateral/ε_axial

Beams

Bending Stress (σ)	σ = My/I, where M is bending moment, y is distance from neutral axis, and I is moment of inertia.
Shear Stress in Beams (τ)	τ = VQ/Ib, where V is shear force, Q is first moment of area, I is moment of inertia, and b is width.
Deflection of Beams (δ)	Depends on loading and support conditions. Common formulas are available for various cases.

Torsion

Torsional Shear Stress (τ)	τ = Tρ/J, where T is torque, ρ is radial distance, and J is polar moment of inertia.
Angle of Twist (θ)	θ = TL/GJ, where L is length, G is shear modulus, and J is polar moment of inertia.

Dynamics and Vibrations

Kinematics

Displacement (s)	Change in position. Measured in meters (m).
Velocity (v)	Rate of change of displacement. $v = ds/dt$. Measured in meters per second (m/s).
Acceleration (a)	Rate of change of velocity. $a = dv/dt$. Measured in meters per second squared (m/s^2).
Uniform Acceleration Equations	$v = u + at$, $s = ut + (1/2)at^2$, $v^2 = u^2 + 2as$

Kinetics

Newton's Second Law	$F = ma$, where F is force, m is mass, and a is acceleration.
Work (W)	$W = Fd\cos(\theta)$, where F is force, d is displacement, and θ is the angle between them.
Kinetic Energy (KE)	$KE = (1/2)mv^2$, where m is mass and v is velocity.
Potential Energy (PE)	$PE = mgh$, where m is mass, g is acceleration due to gravity, and h is height.
Power (P)	$P = W/t$, where W is work and t is time. Also, $P = Fv$.

Vibrations

Natural Frequency (ωn)	$\omega n = \sqrt{(k/m)}$, where k is spring stiffness and m is mass.
Damping Ratio (ζ)	$\zeta = c / (2\sqrt{(mk)})$, where c is damping coefficient.
Damped Frequency (ωd)	$\omega d = \omega n\sqrt{(1 - \zeta^2)}$