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. $\Delta U = Q - W$
Second Law	The total entropy of an isolated system can only increase over time. $\Delta S \geq 0$
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. $Q = mc\Delta T$

Thermodynamic Processes

Isothermal	Constant temperature. $\Delta T = 0$, $Q = W$
Adiabatic	No heat transfer. $Q = 0$, $\Delta U = -W$
Isobaric	Constant pressure. $\Delta P = 0$, $W = P\Delta V$
Isochoric (Isometric)	Constant volume. $\Delta V = 0$, $W = 0$, $\Delta U = Q$
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. $\rho = m/V$
Specific Weight (γ)	Weight per unit volume. $\gamma = \rho g$
Viscosity (μ)	Resistance to flow. $\tau = \mu(du/dy)$
Kinematic Viscosity (ν)	Ratio of viscosity to density. $\nu = \mu/\rho$
Surface Tension (σ)	Force per unit length acting at the interface between two fluids. $F = \sigma L$

Fluid Statics

Pressure (P)	Force per unit area. P = F/A
Hydrostatic Pressure	Pressure due to the weight of a fluid column. $P = \rho gh$
Buoyancy	Upward force exerted by a fluid on an immersed object. $F_b = \rho Vg$

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. $\sigma = F/A$
Strain (ε)	Deformation per unit length. $\varepsilon = \Delta L/L$
Young's Modulus (E)	Measure of stiffness of a material. $E = \sigma/\varepsilon$
Shear Stress (τ)	Stress parallel to the surface. $\tau = F/A$
Shear Strain (γ)	Angular deformation. $\gamma = \Delta x/L$
Shear Modulus (G)	Measure of a material's resistance to shear deformation. $G = \tau/\gamma$
Poisson's Ratio (ν)	Ratio of lateral strain to axial strain. ν = -ε_lateral/ε_axial

Beams

Bending Stress (σ)	$\sigma = My/I$, where M is bending moment, y is distance from neutral axis, and I is moment of inertia.
Shear Stress in Beams (τ)	$\tau = VQ/Ib$, 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)	$\tau = T\rho/J$, where T is torque, ρ is radial distance, and J is polar moment of inertia.
Angle of Twist (θ)	$\theta = TL/GJ$, 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)	$\omega d = \omega n\sqrt{(1 - \zeta^2)}$