GATE · MECHANICAL ENGINEERING

FORMULA & PREPARATION HANDBOOK

A single quick-reference sheet set covering every core GATE ME subject — formulas, unit conversions, and a structured revision plan, laid out like an engineering drawing sheet for fast recall under exam conditions.

14+
FORMULA TOPICS COVERED

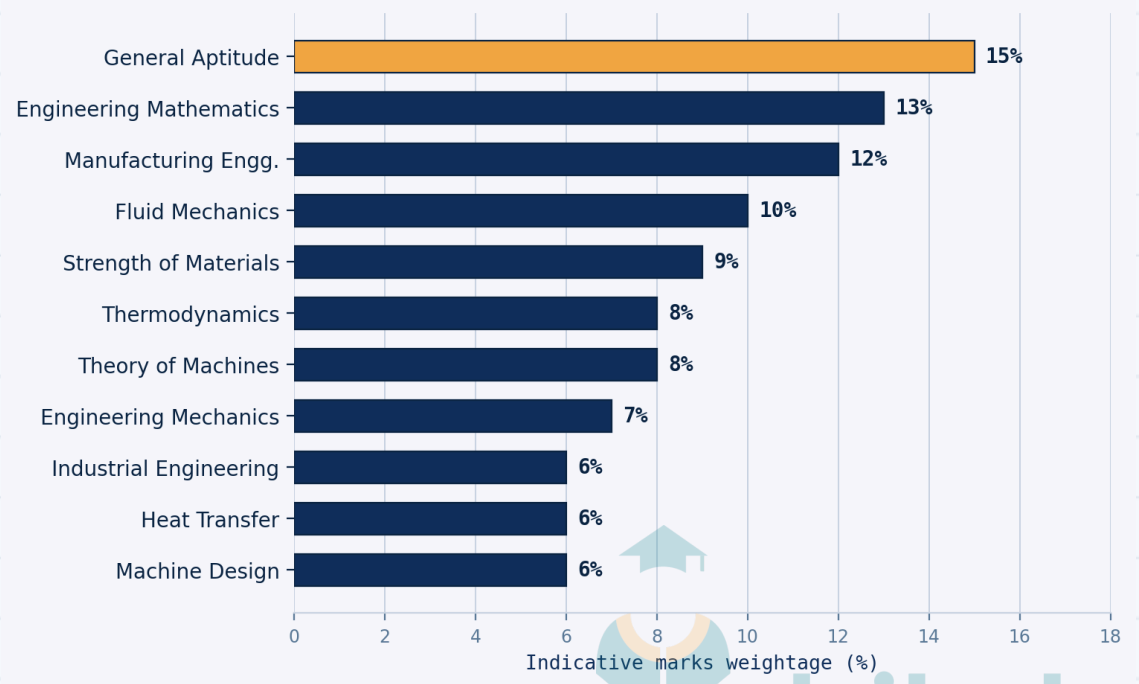
77
UNIT CONVERSIONS, TABULATED

20-wk
STRUCTURED PREP TIMELINE

00 EXAM MAP & HOW TO USE THIS HANDBOOK

GATE Mechanical Engineering tests the same core subjects year after year — the sheets that follow give you the formula for each, in the order most papers actually test them. Start here to see where the marks are concentrated before you plan study hours.

INDICATIVE SUBJECT-WISE WEIGHTAGE



Reading this chart: figures are indicative, based on typical multi-year GATE ME trends — actual weightage shifts slightly every year. Treat this as a planning guide, not a guarantee, and always cross-check against the latest official GATE syllabus.

HOW THE SHEETS ARE ORGANISED

01–02

Maths, Materials & Mechanics — the foundation every other subject builds on.

03–05

Machines & transmission — simple machines, belts, gears, shafts, beams, springs.

06–07

Fluids & thermal — fluid mechanics, thermodynamics, plus the full unit-conversion set.

BEFORE YOU START EACH SHEET

- Cover the formula column with your hand and try to derive or recall it from the label alone.
- Circle any formula you hesitate on — that's your revision list for the night before the exam.
- Re-derive one boxed formula per subject from first principles at least once; GATE often tests the step, not just the final expression.

01 ENGINEERING MATHEMATICS & MATERIALS

BASIC MATHEMATICS

Area of circle	$A = \pi d^2 / 4$
Circumference	$C = \pi d$
Area of rectangle	$A = b \times h$
Area of triangle	$A = \frac{1}{2}\, bh$
Pythagorean theorem	$c^2 = a^2 + b^2$
Sine rule	$a/\sin A = b/\sin B = c/\sin C$
Cosine rule	$c^2 = a^2+b^2-2ab\cos C$
Volume of cylinder	$V = (\pi d^2/4) \times L$
Volume of sphere	$V = (4/3)\pi r^3$	

CORE UNIT RELATIONS

Power	$1\ kW = 1000\ W$
Length	$1\ m = 1000\ mm$
Pressure	$1\ bar = 10^5\ N/m^2$
Pressure	$1\ MPa = 10^6\ N/m^2$
Force	$1\ N = 1\ kg\cdot m/s^2$
Energy	$1\ J = 1\ N\cdot m$
Power from tangential force & speed	$1\ kW = P(N) \times v(m/s) / 1000$

ENGINEERING MATERIALS — STRESS & STRAIN

Direct stress	$\sigma = F / A$
Strain	$\varepsilon = \Delta L / L$
Young's modulus	$E = \sigma / \varepsilon$
Shear stress	$\tau = F / A$
Bulk modulus	$K = p / (\Delta V/V)$

Common trap: σ = F/A always uses the *original* cross-sectional area unless a question explicitly asks for true stress — GATE frequently tests this distinction in one-mark conceptual questions.

02 MECHANICS — FORCE, MOTION, FRICTION, CG

FORCE & MOTION

Newton's 2nd law	$F = ma$
Weight	$W = mg$
Work	$W = F \times s$
Power	$P = W/t = F \cdot v$
Kinetic energy	$KE = \frac{1}{2}mv^2$
Potential energy	$PE = mgh$
Momentum	$p = mv$
Impulse	$J = F \cdot t = \Delta p$
Angular velocity	$\omega = 2\pi N/60$
Angular acceleration	$\alpha = \Delta\omega/\Delta t$

FRICTION

Friction force $F = \mu N$	Angle of friction $\varphi = \tan^{-1}\mu$	Angle of repose $\theta = \tan^{-1}\mu$

CENTRE OF GRAVITY

CASE	RULE
Symmetrical body	CG lies at the geometrical centre
Composite body — $\bar{x}$	$\bar{x} = \Sigma(W_i\ x_i) \ / \ \Sigma\ W_i$
Composite body — $\bar{y}$	$\bar{y} = \Sigma(W_i\ y_i) \ / \ \Sigma\ W_i$

Where W_i = weight of each constituent part, taken about a common reference axis.

SIMPLE MACHINES

Velocity ratio **V.R. = dist. by effort / dist. by load**	Mechanical advantage **M.A. = Load / Effort**	Efficiency **η = (M.A./V.R.) × 100%**

03 POWER TRANSMISSION

Belt, rope, and chain drives all reduce to the same two questions: what speed ratio does the geometry give you, and how much power do the two tensions/tooth-forces actually transmit?

DRIVE TYPE	VELOCITY RATIO	POWER TRANSMITTED
Belt drive	$N_1/N_2 = D_2/D_1$	$P = (T_1 - T_2) \times v$
Rope drive	$N_1/N_2 = D_2/D_1$	$P = (T_1 - T_2) \times v$
Chain drive	$N_1/N_2 = T_2/T_1$	$P = 2\pi N_1 T_1 / 60$

Notice the pattern: belts and ropes ratio on pulley *diameter*; chains ratio on *tooth count* (T here means teeth, not torque) — mixing these two up is a classic one-mark GATE mistake.

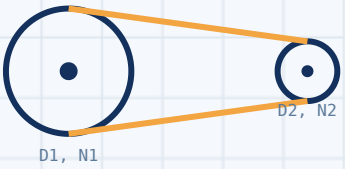
GEAR TRAINS

Simple gear V.R.	$N_1/N_2 = T_2/T_1 = D_2/D_1$
Gear train V.R.	$N_1/N_n = T_n/T_1$
Module	$m = D / T$
Pitch circle diameter	$D = m \times T$
Tangential force	$F_t = 2T / D$

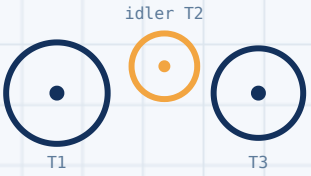
T = torque (N·m), D = pitch diameter (m) — here T switches meaning to torque; always check units in context.

READING THE SCHEMATICS

BELT DRIVE



GEAR TRAIN



Idler gears: an idler (middle gear) reverses direction twice, so it changes rotation sense back to the original — but it never appears in the overall train velocity-ratio expression at all.

04 SHAFTS & BEAMS

SHAFTS

Power transmitted	$P = 2\pi NT / 60$
Torque	$T = 9550 \times P / N$
Torsional shear stress (solid shaft)	$\tau = 16T / \pi d^3$
Diameter for torsion	$d = (16T / \pi \cdot \tau_{allow})^{(1/3)}$

P in kW, N in rpm for the torque formula; d = diameter (m), τ_allow = allowable shear stress.

BEAMS

Bending stress	$\sigma_b = My/I = M/Z$
Section modulus	$Z = I / y_{max}$

MOMENT OF INERTIA	EXPRESSION
Rectangle	$I = bh^3 / 12$
Circle	$I = \pi d^4 / 64$

CANTILEVER DEFLECTION	EXPRESSION
End point load	$\delta = WL^3 / (3EI)$
Uniformly distributed load	$\delta = wL^4 / (8EI)$

SPRINGS

Spring rate	$k = F / \delta$
Deflection	$\delta = 8WD^3n / Gd^4$
Shear stress in spring	$\tau = 8WD \cdot Kw / \pi d^3$

Wahl's factor: Kw = (4C−1)/(4C−4) + 0.615/C, where C = D/d (spring index). W = load, D = mean coil diameter, d = wire diameter, n = number of active coils.

05 FLUID MECHANICS & THERMODYNAMICS

FLUID MECHANICS

Pressure	$p = F / A$
Pascal's law	$F_1/A_1 = F_2/A_2$
Continuity equation	$A_1v_1 = A_2v_2$
Bernoulli's equation	$p/\rho g + v^2/2g + z = \text{const.}$

ρ = density, v = velocity, z = elevation head — all three terms carry units of length ("head").

THERMODYNAMICS

Heat	$Q = mc\Delta T$
Work	$W = p\Delta V$
First law	$Q = \Delta U + W$
Heat engine efficiency	$\eta = (W_{out}/Q_{in}) \times 100\%$
COP — refrigerator	$COP = Q_L / W$

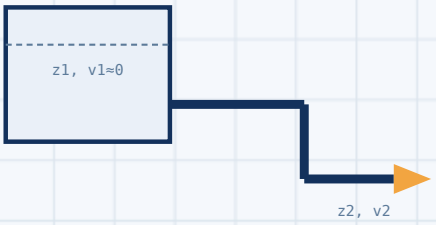
Sign convention: take heat added to the system and work done by the system as positive — GATE numericals lose marks almost entirely on sign-convention slips, not on the physics itself.

FAST SELF-CHECK

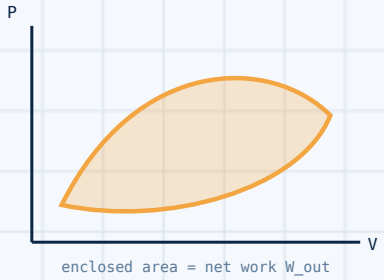
- Can you state which quantities in Bernoulli's equation are heads (length) vs. pressures?
- Can you derive COP for a heat pump from the refrigerator COP in one line?
- Do you know when Q = mcΔT breaks down (phase change — use latent heat instead)?

READING THE SCHEMATICS

BERNOULLI — TANK & PIPE



P-V CYCLE (HEAT ENGINE)



06 ENGINEERING UNIT CONVERSIONS — I

LENGTH

1 mm	10^{-3} m
1 cm	10^{-2} m
1 m	10^{3} mm
1 km	10^{3} m
1 in	25.4 mm
1 ft	0.3048 m
1 yd	0.9144 m
1 mile	1.60934 km

VOLUME

1 m^3	10^{9} mm^3
1 cm^3	10^{-6} m^3
1 L	10^{-3} m^3
1 mL	10^{-6} m^3
1 in^3	16.387 mm^3
1 ft^3	0.0283168 m^3
1 US gal	3.78541 L
1 Imp gal	4.54609 L

TIME

1 s	10^{3} ms
1 min	60 s
1 hr	3600 s
1 day	86400 s
1 week	604800 s
1 year	3.1536×10^{7} s

AREA

1 m^2	10^{6} mm^2
1 cm^2	10^{-4} m^2
1 in^2	645.16 mm^2
1 ft^2	0.092903 m^2
1 acre	4046.86 m^2
1 hectare	10^{4} m^2

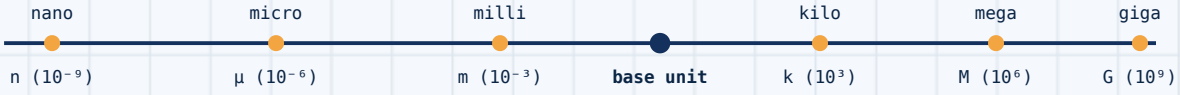
MASS

1 mg	10^{-6} kg
1 g	10^{-3} kg
1 kg	10^{3} g
1 tonne	10^{3} kg
1 lb	0.453592 kg
1 oz	28.3495 g

VELOCITY & ACCELERATION

1 m/s	3.6 km/h
1 km/h	0.27778 m/s
1 ft/s	0.3048 m/s
1 mph	1.60934 km/h
1 knot	1.852 km/h
1 m/s^2	3.6 km/h/s
1 g	9.81 m/s^2

METRIC PREFIX LADDER — THE PATTERN BEHIND MOST ROWS ABOVE



Memory shortcut: almost every metric row on this sheet is this ladder in disguise — learn it once (nano → micro → milli → base → kilo → mega → giga) and you can rebuild any SI conversion without memorising it as a separate fact. Only imperial/US rows (in, ft, gal, lb, psi…) need direct memorisation, since they don't follow a power-of-ten pattern.

06 ENGINEERING UNIT CONVERSIONS — II

FORCE

1 N	$1\ kg \cdot m/s^2$
1 kN	10^3 N
1 lbf	4.44822 N
1 kip	4448.22 N

PRESSURE

1 Pa	$1\ N/m^2$
1 kPa	10^3 Pa
1 MPa	10^6 Pa
1 bar	10^5 Pa
1 atm	101325 Pa
1 psi	6894.76 Pa
1 torr	133.322 Pa

ENERGY / WORK / HEAT

1 J	$1\ N \cdot m$
1 kJ	10^3 J
1 MJ	10^6 J
1 cal	4.184 J
1 kcal	4184 J
1 kWh	3.6×10^6 J
1 Btu	1055.06 J

POWER

1 W	1 J/s
1 kW	10^3 W
1 MW	10^6 W
1 hp	745.7 W

TEMPERATURE

°C → °F	$T(°F) = (T°C \times 9/5) + 32$
°F → °C	$T(°C) = (T°F - 32) \times 5/9$
°C → K	$T(K) = T(°C) + 273.15$

FLOW RATE

1 m^3/s	1000 L/s
1 L/min	1.6667×10^{-5} m^3/s
1 gpm (US)	3.78541 L/min
1 cfs	0.0283168 m^3/s

MISCELLANEOUS

1 N·m	0.73756 ft·lbf
1 W/m·K	0.5778 Btu/h·ft·°F
1 Ω	1 V/A
1 Hz	$1\ s^{-1}$

HIGHEST-YIELD CONVERSIONS TO KNOW COLD

Pressure base unit	**1 bar = 100 kPa**
Energy base unit	**1 kWh = 3.6 MJ**
Power base unit	**1 hp ≈ 0.7457 kW**

Exam habit: when a numerical answer looks "off" by a neat factor of 10, 60, or 1000, suspect a unit slip before suspecting your physics — misreading kPa as Pa, or rpm as rad/s, is the single most common source of wrong GATE numericals, far more than a wrong formula.

07 PREPARATION STRATEGY & FINAL CHECKLIST

A 20-WEEK STRUCTURE

WEEKLY RHYTHM THAT ACTUALLY STICKS

Study

4–5 focused sessions covering one subject's theory + solved examples each.

Practice

2 sessions of subject-wise previous-year questions, timed.

Review

1 session revisiting this handbook's formula boxes and your error log.

FINAL CHECKLIST BEFORE THE EXAM

- Every formula box on Sheets 03–07 can be recalled in under 5 seconds, without hesitation.
- You've attempted at least 3 full-length mock tests under real time pressure, GATE-format.
- You maintain (and have reviewed) a running error log of mistakes from mocks and PYQs.
- You know your calculator's shortcut keys cold — no fumbling during the actual exam.
- Unit-conversion sheets (08–09) are second nature; convert without pausing to think.
- You've slept on a full-length mock at the same time of day as your real exam slot.

Last word: GATE ME rewards breadth held lightly, not depth in one subject. Spend your final two weeks converting "familiar" formulas into "instant recall," not chasing new topics.

SHEET INDEX — FOR FAST PAGE-FLIPPING IN THE EXAM HALL

SHEET	TOPIC	SHEET	TOPIC
01	Mathematics & materials	06	Shafts & beams
02	Overview & weightage	07	Fluids & thermodynamics
03	Mechanics, friction, CG	08–09	Unit conversions
05	Power transmission & gears	10	Strategy & checklist