PHYSICAL REFERENCE · CHEAT SHEET

Force & weight *reference*.

Real-world forces and weights from **structural loads to atomic forces**. Newtons, pound-force, kilogram-force side by side. Bridge between physics intuition and engineering practice.

The chart

FORCE / WEIGHT	NEWTONS	LBF	KGF	CONTEXT
1 μN	10^{-6} N	2.25×10^{-7}	1.0×10^{-7}	Weight of a single grain of sand
1 mN	10^{-3} N	0.000225	0.000102	Weight of a small ant
10 mN	0.010 N	0.0022	0.0010	Weight of a US dollar bill (~1 g)
1 N	1.0 N	0.225	0.102	Weight of a small apple (~102 g) on Earth
10 N	10 N	2.25	1.02	Holding a 1 L bottle of water
100 N	100 N	22.5	10.2	Light grocery bag, ~10 kg of weight
500 N	500 N	112	51	Heavy bag of cement, ~50 kg
700 N	700 N	157	71	Average adult body weight (~70 kg)
1 kN	1,000 N	225	102	~100 kg load, refrigerator weight
5 kN	5,000 N	1,124	510	Climbing rope rated minimum breaking strength (single)
10 kN	10,000 N	2,248	1,020	Compact car weight (~1,000 kg / 2,250 lb)

FORCE / WEIGHT	NEWTONS	LBF	KGF	CONTEXT
15-20 kN	15-20 kN	3,370-4,500	1,500-2,040	Standard climbing rope rated breaking strength
30 kN	30,000 N	6,744	3,060	Mid-size SUV weight (~3,000 kg)
50 kN	50,000 N	11,240	5,100	Typical structural steel bolt yield (M16 grade 8.8)
100 kN	100 kN	22,480	10,200	Pickup truck loaded (~10,000 kg)
200 kN	200 kN	44,960	20,400	Semi-truck wheel load (~20,000 kg)
500 kN	500 kN	112,400	51,000	Concrete column design load (small building)
1 MN	10^6 N	224,800	102,000	Large building column reaction, locomotive weight
1.7 MN	1.7 MN	382,000	173,000	Maximum thrust of an F-16 fighter jet engine
7-9 MN	7-9 MN	1.6-2 M lbf	700-900 t	Saturn V first-stage thrust per engine (×5 = 35 MN)
35 MN	35 MN	7.9 M lbf	3,570 t	Saturn V total liftoff thrust
0.5 GN	0.5×10^9 N	112 M lbf	51,000 t	Approximate weight of the Empire State Building

Mass vs weight. The 'kgf' column is the weight (force) that a given mass would exert under standard gravity ($g = 9.80665$ m/s^2). On the moon, the same mass would weigh about 1/6 as much. The numeric coincidence that 1 kg of mass weighs 1 kgf only applies at Earth's surface.

Common applications

STRUCTURAL / ENGINEERING REFERENCE	MAGNITUDE	NOTES
Office floor live load (residential)	1.92 kN/m² (40 psf)	Code minimum per IBC
Office floor live load (office)	2.40 kN/m² (50 psf)	Standard office
Office floor live load (heavy storage)	11.97 kN/m² (250 psf)	Warehouse / heavy storage
Snow load (light, southern US)	0.48 kN/m² (10 psf)	Mild winter region
Snow load (heavy, New England)	2.39 kN/m² (50 psf)	Severe winter region
Wind pressure (90 mph design)	0.69 kN/m² (14.5 psf)	ASCE 7 standard wind
Hurricane wind pressure (180 mph)	2.78 kN/m² (58 psf)	Coastal exposure category
Roof load (typical residential)	0.72 kN/m² (15 psf)	Dead load only
Bridge HS-20 truck wheel	72 kN (16,000 lbf)	Standard AASHTO design truck
Earthquake force (typical)	5-20% of building weight	Depends on seismic zone
Allowable bolt tension (1/2-13 Grade 5)	30 kN (6,750 lbf)	60% of proof load

Common pitfalls

- **Pounds are ambiguous.** The 'lb' alone can mean pound-mass (lbm) or pound-force (lbf). They're numerically equal at Earth's surface but dimensionally different. Engineering work should always specify which.

- **kgf is non-SI but widely used.** 1 kgf = 9.80665 N (the weight of 1 kg under standard gravity). Common in older European engineering documents and many catalog specs. Convert to newtons for any modern analysis.
- **'Tons' has three meanings.** Metric tonne (1000 kg ≈ 9.81 kN), US short ton (2000 lbm ≈ 8.90 kN), and UK long ton (2240 lbm ≈ 9.96 kN). Always specify which.
- **Loads vs reactions.** A 1 ton load on a beam produces equal and opposite reactions at supports — but the analysis depends on where the load is applied. Static equilibrium reactions are typically 50% each for symmetric loading.
- **Static vs dynamic loading.** A 100 kg person walking on a beam produces dynamic forces up to 1.5× static weight. Vehicles and machinery produce even higher impact factors. Design loads include impact multipliers per code (often 30-100% increase).

Common questions

Why do I weigh different on the moon?

Mass stays the same — you have the same amount of matter. Weight is force, equal to mass × gravitational acceleration. On Earth g = 9.81 m/s^2; on the Moon g = 1.62 m/s^2. So a 70 kg person weighs 686 N on Earth but only 113 N on the Moon. In pounds: 154 lb on Earth, 26 lb on the Moon. Same mass, ~6× less weight.

What's a 'pound-force' vs 'pound-mass'?

Pound-mass (lbm) is a unit of mass — what you'd measure on a balance. Pound-force (lbf) is a unit of force — what you'd measure on a scale. They're numerically equal at Earth's standard gravity (1 lbm weighs 1 lbf at sea level). In equations, F = ma requires consistent units — that's where the 'slug' or the g_c conversion factor comes in.

Why does kg appear as both a mass and a force unit?

Strictly, kg is mass only; the SI unit of force is the newton. But 'kgf' (kilogram-force) was widely used in older engineering — defined as the weight of 1 kg at standard gravity = 9.80665 N. Many older European load specs still use kgf or just kg. When you see '50 kg load', verify whether it's mass (50 kg) or force (50 kgf = 490 N).

How do I convert a 100-lb force to newtons?

100 lbf = 444.8 N. The exact conversion is 1 lbf = 4.4482216 N. Reverse: 100 N = 22.48 lbf. These are exact since both units have formal SI-based definitions; the conversion factor isn't an approximation.

What's the 'normal force' and why does it matter?

Normal force is the perpendicular component of contact force between two surfaces. For an object on a flat floor, normal force equals weight. On a slope, it's weight × cos(angle). Normal force matters because friction = µ × normal force, so traction, braking, and stability all depend on it — not on total weight.

Sources

- **Force unit definitions:** SI: newton = kg·m/s² (defined exact). Imperial: lbf = lbm × standard gravity (32.174 ft/s²).

- **Building load reference values:** ASCE 7 — Minimum Design Loads and Associated Criteria for Buildings and Other Structures.
- **Bridge loads:** AASHTO LRFD Bridge Design Specifications, HS-20 standard design truck.
- **Climbing rope ratings:** UIAA-101 (single dynamic rope, minimum 5 kN; falls equivalent).

Disclaimer. Structural loads are highly application-specific and governed by local building codes. Always use the relevant code (IBC, ASCE 7, AASHTO, Eurocode, etc.) for actual design work — these numbers are for context and intuition only.