QUARKS

The u-, d-, and s-quark masses are estimates of so-called "current-quark masses," in a mass-independent subtraction scheme such as $\overline{\text{MS}}$ at a scale $\mu \approx 2$ GeV. The c- and b-quark masses are the "running" masses in the $\overline{\text{MS}}$ scheme. For the b-quark we also quote the 1S mass. These can be different from the heavy quark masses obtained in potential models.

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u

$$I(J^P) = \tfrac{1}{2}(\tfrac{1}{2}^+)$$

$m_u = 2.2^{+0.6}_{-0.4}$ MeV   Charge $= \tfrac{2}{3} e$ $I_z = +\tfrac{1}{2}$

$m_u/m_d = 0.38\text{–}0.58$

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d

$$I(J^P) = \tfrac{1}{2}(\tfrac{1}{2}^+)$$

$m_d = 4.7^{+0.5}_{-0.4}$ MeV   Charge $= -\tfrac{1}{3} e$ $I_z = -\tfrac{1}{2}$

$m_s/m_d = 17\text{–}22$

$\overline{m} = (m_u + m_d)/2 = 3.5^{+0.7}_{-0.3}$ MeV

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s

$$I(J^P) = 0(\tfrac{1}{2}^+)$$

$m_s = 96^{+8}_{-4}$ MeV   Charge $= -\tfrac{1}{3} e$ Strangeness $= -1$

$m_s / ((m_u + m_d)/2) = 27.3 \pm 0.7$

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c

$$I(J^P) = 0(\tfrac{1}{2}^+)$$

$m_c = 1.27 \pm 0.03$ GeV   Charge $= \tfrac{2}{3} e$ Charm $= +1$

$m_c/m_s = 11.72 \pm 0.25$

$m_b/m_c = 4.53 \pm 0.05$

$m_b - m_c = 3.45 \pm 0.05$ GeV

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b

$$I(J^P) = 0(\tfrac{1}{2}^+)$$

Charge $= -\tfrac{1}{3} e$ Bottom $= -1$

$m_b(\overline{\text{MS}}) = 4.18^{+0.04}_{-0.03}$ GeV

$m_b(1S) = 4.66^{+0.04}_{-0.03}$ GeV

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t

$$I(J^P) = 0(\tfrac{1}{2}^+)$$

$$\text{Charge} = \tfrac{2}{3}\,e \qquad\qquad \text{Top} = +1$$

Mass (direct measurements) $m = 173.21 \pm 0.51 \pm 0.71$ GeV [a,b]
Mass ($\overline{\text{MS}}$ from cross-section measurements) $m = 160^{+5}_{-4}$ GeV [a]
Mass (Pole from cross-section measurements) $m = 174.2 \pm 1.4$ GeV
$m_t - m_{\bar{t}} = -0.2 \pm 0.5$ GeV $\quad$ (S = 1.1)
Full width $\Gamma = 1.41^{+0.19}_{-0.15}$ GeV $\quad$ (S = 1.4)
$\Gamma(W\,b)/\Gamma(W\,q(q = b,\,s,\,d)) = 0.957 \pm 0.034$ $\quad$ (S = 1.5)

t-quark EW Couplings

$F_0 = 0.690 \pm 0.030$
$F_- = 0.314 \pm 0.025$
$F_+ = 0.008 \pm 0.016$
$F_{V+A} < 0.29$, CL = 95%

t DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$t \to W\,q(q = b,\,s,\,d)$				−
$\quad t \to W\,b$				−
$\qquad t \to \ell\nu_\ell\,\text{anything}$	[c,d]	(9.4±2.4) %		−
$t \to e\nu_e\,b$		(13.3±0.6) %		−
$t \to \mu\nu_\mu\,b$		(13.4±0.6) %		−
$t \to q\bar{q}\,b$		(66.5±1.4) %		−
$t \to \gamma\,q(q=u,c)$	[e]	< 5.9 $\times 10^{-3}$	95%	−
$\Delta T = 1$ weak neutral current ($T1$) modes				
$t \to Z\,q(q=u,c)$ $\quad$ $T1$	[f]	< 5 $\times 10^{-4}$	95%	−
$t \to \ell^+\,\overline{q}\,q'\,(q=d,s,b;\ q'=u,c)$		< 1.6 $\times 10^{-3}$	95%	−

b' (4th Generation) Quark, Searches for

Mass $m > 190$ GeV, CL = 95% $\quad$ ($p\overline{p}$, quasi-stable b')
Mass $m > 755$ GeV, CL = 95% $\quad$ (pp, neutral-current decays)
Mass $m > 675$ GeV, CL = 95% $\quad$ (pp, charged-current decays)
Mass $m > 46.0$ GeV, CL = 95% $\quad$ (e^+e^-, all decays)

t' (4th Generation) Quark, Searches for

$m(t'(2/3)) > 782$ GeV, CL $= 95\%$ (neutral-current decays)
$m(t'(2/3)) > 700$ GeV, CL $= 95\%$ (charged-current decays)
$m(t'(5/3)) > 800$ GeV, CL $= 95\%$

Free Quark Searches

All searches since 1977 have had negative results.

NOTES

[a] A discussion of the definition of the top quark mass in these measurements can be found in the review "The Top Quark."

[b] Based on published top mass measurements using data from Tevatron Run-I and Run-II and LHC at $\sqrt{s} = 7$ TeV. Including the most recent unpublished results from Tevatron Run-II, the Tevatron Electroweak Working Group reports a top mass of 173.2 ± 0.9 GeV. See the note "The Top Quark' in the Quark Particle Listings of this *Review*.

[c] ℓ means e or μ decay mode, not the sum over them.

[d] Assumes lepton universality and W-decay acceptance.

[e] This limit is for $\Gamma(t \rightarrow \gamma q)/\Gamma(t \rightarrow W b)$.

[f] This limit is for $\Gamma(t \rightarrow Z q)/\Gamma(t \rightarrow W b)$.