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.

u

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

$m_u = 2.3^{+0.7}_{-0.5}$ MeV   Charge $= \tfrac{2}{3}\,e$ $I_z = +\tfrac{1}{2}$

$m_u/m_d = 0.38\text{–}0.58$

d

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

$m_d = 4.8^{+0.5}_{-0.3}$ MeV   Charge $= -\tfrac{1}{3}\,e$ $I_z = -\tfrac{1}{2}$

$m_s/m_d = 17\text{–}22$

$\overline{m} = (m_u + m_d)/2 = 3.5^{+0.7}_{-0.2}$ MeV

s

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

$m_s = 95 \pm 5$ MeV   Charge $= -\tfrac{1}{3}\,e$ Strangeness $= -1$

$m_s\,/\,((m_u + m_d)/2) = 27.5 \pm 1.0$

c

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

$m_c = 1.275 \pm 0.025$ GeV   Charge $= \tfrac{2}{3}\,e$ Charm $= +1$

b

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

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

$m_b(\overline{\text{MS}}) = 4.18 \pm 0.03$ GeV

$m_b(1\text{S})\ = 4.66 \pm 0.03$ GeV

t $\qquad\qquad\qquad\qquad I(J^P) = 0(\frac{1}{2}^+)$

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

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) $m = 176.7^{+4.0}_{-3.4}$ GeV
$m_t - m_{\bar{t}} = -0.2 \pm 0.5$ GeV $\quad$ (S = 1.1)
Full width $\Gamma = 2.0 \pm 0.5$ GeV
$\Gamma(W\,b)/\Gamma(W\,q(q = b,\, s,\, d)) = 0.91 \pm 0.04$

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)
$W\,q(q = b,\, s,\, d)$				−
$\quad W\,b$				−
$\quad\quad \ell\nu_\ell$ anything	[c,d]	(9.4 ± 2.4) %		−
$\gamma\,q(q=u,c)$	[e]	$< 5.9 \quad \times 10^{-3}$	95%	−
$\Delta T = 1$ **weak neutral current ($T1$) modes**				
$Z\,q(q=u,c)$	$T1$ [f]	$< 2.1 \quad \times 10^{-3}$	95%	−

b' (4th Generation) Quark, Searches for

Mass $m > 190$ GeV, CL = 95% $\quad$ ($p\overline{p}$, quasi-stable b')
Mass $m > 400$ 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

Mass $m > 782$ GeV, CL = 95% $\quad$ (pp, neutral-current decays)
Mass $m > 700$ GeV, CL = 95% $\quad$ (pp, charged-current decays)

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 $\Gamma(t \rightarrow Z q)/\Gamma(t \rightarrow W b)$.