QUARKS

The *u*-, *d*-, and *s*-quark masses are the $\overline{\text{MS}}$ masses at the scale μ = 2 GeV. The *c*- and *b*-quark masses are the $\overline{\text{MS}}$ masses renormalized at the $\overline{\text{MS}}$ mass, i.e. $\overline{m} = \overline{m}(\mu = \overline{m})$. The *t*-quark mass is extracted from event kinematics (see the review "The Top Quark").

u

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

$m_u = 2.16^{+0.49}_{-0.26}$ MeV   Charge $= \frac{2}{3}$ e $I_z = +\frac{1}{2}$
$m_u/m_d = 0.474^{+0.056}_{-0.074}$

d

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

$m_d = 4.67^{+0.48}_{-0.17}$ MeV   Charge $= -\frac{1}{3}$ e $I_z = -\frac{1}{2}$
$m_s/m_d = 17\text{–}22$
$\overline{m} = (m_u+m_d)/2 = 3.45^{+0.35}_{-0.15}$ MeV

s

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

$m_s = 93.4^{+8.6}_{-3.4}$ MeV   Charge $= -\frac{1}{3}$ e Strangeness $= -1$
$m_s \,/\, ((m_u + m_d)/2) = 27.33^{+0.67}_{-0.77}$

c

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

$m_c = 1.27 \pm 0.02$ GeV   Charge $= \frac{2}{3}$ e Charm $= +1$
$m_b - m_c = 3.45 \pm 0.05$ GeV

b

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

$m_b = 4.18^{+0.03}_{-0.02}$ GeV   Charge $= -\frac{1}{3}$ e Bottom $= -1$

t

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

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

Mass (direct measurements) $m = 172.69 \pm 0.30$ GeV [a,b] (S = 1.3)
Mass (from cross-section measurements) $m = 162.5^{+2.1}_{-1.5}$ GeV [a]
Mass (Pole from cross-section measurements) $m = 172.5 \pm 0.7$ GeV
$m_t - m_{\overline{t}} = -0.15 \pm 0.20$ GeV (S = 1.1)
Full width $\Gamma = 1.42^{+0.19}_{-0.15}$ GeV (S = 1.4)
$\Gamma\big(W b\big)/\Gamma\big(W q(q = b,\ s,\ d)\big) = 0.957 \pm 0.034$ (S = 1.5)

t-quark EW Couplings

$F_0 = 0.693 \pm 0.013$
$F_- = 0.315 \pm 0.010$
$F_+ = -0.005 \pm 0.007$
$F_{V+A} < 0.29$, CL = 95%

t DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	*p* (MeV/*c*)
$W q(q = b,\ s,\ d)$				–
$W b$				–
$e \nu_e b$		(11.10±0.30) %		–
$\mu \nu_\mu b$		(11.40±0.20) %		–
$\tau \nu_\tau b$		(10.7 ±0.5) %		–
$q \overline{q} b$		(66.5 ±1.4) %		–
$\gamma q(q{=}u,c)$		[c] < 1.8 $\times 10^{-4}$	95%	–
$\Delta T = 1$ weak neutral current (*T1*) modes				
$Z q(q{=}u,c)$	*T1*	[d] < 5 $\times 10^{-4}$	95%	–
$H u$	*T1*	< 1.9 $\times 10^{-4}$	95%	–
$H c$	*T1*	< 7.3 $\times 10^{-4}$	95%	–
$\ell^+ \overline{q} \overline{q}' (q{=}d,s,b;\ q'{=}u,c)$	*T1*	< 1.6 $\times 10^{-3}$	95%	–
Lepton Family number (*LF*) violating modes				
$e^\pm \mu^\mp c$	*LF*	< 8.9 $\times 10^{-7}$		–
$e^\pm \mu^\mp u$	*LF*	< 7 $\times 10^{-8}$		–

b' (4^{th} Generation) Quark, Searches for

Mass $m >$ 190 GeV, CL = 95% ($p\overline{p}$, quasi-stable b')
Mass $m >$ 1390 GeV, CL = 95% ($B(b' \to Z b) = 1$)
Mass $m >$ 1350 GeV, CL = 95% ($B(b' \to W t) = 1$)
Mass $m >$ 1570 GeV, CL = 95% ($B(b' \to H b) = 1$)
Mass $m >$ 46.0 GeV, CL = 95% ($e^+ e^-$, all decays)

t' (4^{th} Generation) Quark, Searches for

$m(t'(2/3)) >$ 1280 GeV, CL = 95% ($B(t' \to Z t) = 1$)
$m(t'(2/3)) >$ 1295 GeV, CL = 95% ($B(t' \to W b) = 1$)
$m(t'(2/3)) >$ 1310 GeV, CL = 95% (singlet t')
$m(t'(2/3)) >$ 1350 GeV, CL = 95% (t' in a weak isospin doublet (t',b'))
$m(t'(5/3)) >$ 1.350×10^3 GeV, CL = 95% ($t'(5/3) \to t W^+$)

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*] This limit is for $\Gamma(t \to \gamma q)/\Gamma(t \to W b)$.

[*d*] This limit is for $\Gamma(t \to Z q)/\Gamma(t \to W b)$.