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

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

Mass $m = 1.5$ to 3.0 MeV [a]   Charge $= \tfrac{2}{3} e$ $I_z = +\tfrac{1}{2}$

$m_u/m_d = 0.3$ to 0.6

d

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

Mass $m = 3$ to 7 MeV [a]   Charge $= -\tfrac{1}{3} e$ $I_z = -\tfrac{1}{2}$

$m_s/m_d = 17$ to 22

$\overline{m} = (m_u + m_d)/2 = 2.5$ to 5.5 MeV

s

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

Mass $m = 95 \pm 25$ MeV [a]   Charge $= -\tfrac{1}{3} e$ Strangeness $= -1$

$(m_s - (m_u + m_d)/2)/(m_d - m_u) = 30$ to 50

c

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

Mass $m = 1.25 \pm 0.09$ GeV   Charge $= \tfrac{2}{3} e$ Charm $= +1$

b

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

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

Mass $m = 4.20 \pm 0.07$ GeV   ($\overline{\text{MS}}$ mass)

Mass $m = 4.70 \pm 0.07$ GeV   (1S mass)

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

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

Mass $m = 174.2 \pm 3.3$ GeV [b] (direct observation of top events)
Mass $m = 172.3^{+10.2}_{-7.6}$ GeV (Standard Model electroweak fit)

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) %		−
$\quad\quad \tau\nu_\tau\,b$				−
$\gamma\,q\,(q=u,c)$	[e]	< 5.9 $\times 10^{-3}$	95%	−
$\Delta T = 1$ **weak neutral current ($T1$) modes**				
$Z\,q\,(q=u,c)$	T1 [f]	< 13.7 %	95%	−

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b' (4th Generation) Quark, Searches for

Mass $m > 190$ GeV, CL = 95% ($p\overline{p}$, quasi-stable b')
Mass $m > 199$ GeV, CL = 95% ($p\overline{p}$, neutral-current decays)
Mass $m > 128$ GeV, CL = 95% ($p\overline{p}$, charged-current decays)
Mass $m > 46.0$ GeV, CL = 95% ($e^+ e^-$, all decays)

Free Quark Searches

All searches since 1977 have had negative results.

NOTES

[a] The ratios m_u/m_d and m_s/m_d are extracted from pion and kaon masses using chiral symmetry. The estimates of u and d masses are not without controversy and remain under active investigation. Within the literature there are even suggestions that the u quark could be essentially massless. The s-quark mass is estimated from SU(3) splittings in hadron masses.

[b] Based on published top mass measurements using data from Tevatron Run-I and Run-II. Including also the most recent unpublished results from Run-II, the Tevatron Electroweak Working Group reports a top mass of $172.5 \pm 1.3 \pm 1.9$ 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 $\Gamma(t \to \gamma q)/\Gamma(t \to W b)$.

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