Physics 565 - Spring 2010, Assignment #7, Due April 7th

1. The differential partial decay width for a 2-body decay can be expressed

$$d\Gamma = \frac{1}{32\pi^2}|\overline{\mathcal{M}}|^2\frac{|\vec{k}|}{M^2}d\Omega$$

where M is the mass of the decaying particle and the two final state particles particles which have momentum $\pm\vec{k}$.

(a) Ignoring the masses of the final state particles, show that the partial width for $W^+ \to \mu^+\nu_\mu$ can be expressed

$$\Gamma = \frac{G_F M_W^3}{6\sqrt{2}\pi}$$

(b) Ignoring the masses of the final state particles, calculate the partial widths for $Z^0 \to \mu^+\mu^-$ and $Z^0 \to \nu_\mu\overline{\nu}_\mu$.

2. **(a)** Show that the $Z^0 f\overline{f}$ vertex factor

$$\frac{-ig}{\cos\theta_W}\gamma^\mu\frac{1}{2}(c_V^f - c_A^f\gamma^5)$$

can also be written

$$\frac{-ig}{\cos\theta_W}\gamma^\mu\left(c_L^f\frac{1}{2}(1-\gamma^5) + c_R^f\frac{1}{2}(1+\gamma^5)\right).$$

where the left- and right-handed couplings, c_L^f and c_R^f, are expressed in terms of the vector and axial vector couplings, c_V^f and c_A^f.

(b) The general expressions for c_V^f and c_A^f are

$$c_V^f = T_f^3 - 2\sin^2\theta_W Q_f$$
$$c_A^f = T_f^3$$

where T_f^3 is the third component of the weak isospin and Q_f is the charge of the fermion, in units where $Q_e = -1$. Complete the entries in the following table of couplings for quarks and leptons in the Standard Model:

f	Q_f	T_f^3	c_A^f	c_V^f	c_L^f	c_R^f
ν_e, ν_μ, ν_τ	0	1/2	...	...	...	...
e^-, μ^-, τ^-	−1	−1/2				
u, c, t	2/3	1/2				
d, s, b	−1/3	−1/2				

Express the couplings both symbolically, and numerically, using $\sin^2\theta_W = 0.231$.