Intro

① Be familiar with particles in Tables in inside Cover of Griffiths. (Tables will be suppied in Exam.)

Know 3 generations of quarks and leptons!

② Be able to do special relativity problems using 4-vectors.

[i.e. threshold energy calc: etc]

③ Understand simple Feynman diagrams for strong, E+M, weak int.

④ Be familiar with quark model multiplets. (mesons (nonet), baryons (octet, decuplet))

Conservation Laws

① understand correspondence between symmetries and conservation Laws [Noether's Theorem]

② Know which conservation laws apply to each interaction.

✓ (3) Know how to add ang. mom. and do Clebsch - Gordon decomposition.

✓ (4) Know effect of Parity and C transformation on quarks and therefore on hadrons. [ie. $P_\ell \, |meson\rangle = (-1)^{\ell+1}$] Also for photon.

~~(5) Know how to apply G parity to determine which multi-pion decay modes are allowed in Strong int.~~

(6) ✓ Know how to use isospin to predict cross section ratios. **Know isospin assignments.**

✓ (7) Know consequences of Parity violation in weak decay [ie. ν_L, $\bar{\nu}_R$]

(8) Understand CP violation and $K^0 - \bar{K}^0$ mixing.

ie $|K_S\rangle \doteq |K_1\rangle = \frac{1}{\sqrt{2}}\left[|K^0\rangle - |\bar{K}^0\rangle\right]$

$|K_L\rangle \doteq |K_2\rangle = \frac{1}{\sqrt{2}}\left[|K^0\rangle + |\bar{K}^0\rangle\right]$

(9) Understand K_S regeneration.

Griffiths Ch. 6, 7:

Ch. 6

① Know how to use Golden Rule to calc. cross-sections and decay rates. (Formula's will be provided.) **See App. B!**
i.e. 6.15, 6.34

[See Example 6.6 for decay rate calc + Example 6.7 for scatt. calc.]

Example: general formula for decay rate:
$1 \to 2 + 3 + \dots + n$

$$d\Gamma = |\mathcal{M}|^2 \frac{S}{2m_1} \left[\frac{d^3|\vec{p}_2|}{(2\pi)^3 2E_2} \frac{d^3|\vec{p}_3|}{(2\pi)^3 2E_3} \cdots \frac{d^3|\vec{p}_n|}{(2\pi)^3 2E_n} \right]$$

$$\times (2\pi)^4 \delta^4(p_1 - p_2 - \dots - p_n) \quad \textbf{Eq. B.1}$$

For 2 body decay:

$$d\Gamma = |\mathcal{M}|^2 \frac{S}{2m_1} \left[\frac{d^3|\vec{p}_2|}{(2\pi)^3 2E_2} \frac{d^3|\vec{p}_3|}{(2\pi)^3 2E_3} \right] (2\pi)^4 \delta^4(p_1 - p_2 - p_3)$$

Consider $\pi^0 \to \gamma + \gamma$ [Ex. 6.5]

$$\delta^4(p_1 - p_2 - p_3) = \delta(m - E_2 - E_3)\, \delta^3(-\vec{p}_2 - \vec{p}_3)$$

and $m_2 = m_3 = 0$ so $|\vec{p}_2| = E_2$, $|\vec{p}_3| = E_3$

$m_1 \equiv m$ = mass of π^0

Thus:
$$T' = \frac{S}{m}\left(\frac{1}{4\pi}\right)^2 \frac{1}{2} \int \frac{|\mathcal{M}|^2}{|\vec{P}_2|\,|\vec{P}_3|}\,\delta\left(m - |\vec{P}_2| - |\vec{P}_3|\right)$$
$$\times\, \delta^3\left(-\vec{P}_2 - \vec{P}_3\right)\, d^3|\vec{P}_2|\; d^3|\vec{P}_3|$$

Do $|\vec{P}_3|$ integral by replacing $\vec{P}_3 = -\vec{P}_2$:
$$T' = \frac{S}{m\,2(4\pi)^2} \int \frac{|\mathcal{M}|^2}{|\vec{P}_2|^2}\,\delta\left(m - 2|\vec{P}_2|\right)\, d^3|\vec{P}_2|$$

Go to spherical coord:
$$d^3|\vec{P}_2| = |\vec{P}_2|^2 \sin\theta\, d\theta\, d\phi = |\vec{P}_2|^2\, d\Omega$$

Since $\int \sin\theta\, d\theta\, d\phi = \int d\Omega = 4\pi$
$$T' = \frac{S}{m\,8\pi}\int_0^\infty |\mathcal{M}|^2\,\delta\left(m - 2|\vec{P}_2|\right)\, d|\vec{P}_2|$$
$$= \frac{S}{m\,8\pi}\int_0^\infty |\mathcal{M}|^2\,\delta\left(m - 2|\vec{P}_2|\right)\,\frac{d\left(2|\vec{P}_2|\right)}{2}$$
$$= \boxed{\frac{S}{16\pi\, m}\,|\mathcal{M}|^2}$$

where $\mathcal{M}$ is evaluated at $\vec{P}_3 = -\vec{P}_2$ and
$$|\vec{P}_2| = \frac{m}{2}$$

eq. B.4

Also $S = \frac{1}{2!} = \frac{1}{2}$

✓ (2) Know how to use toy Feynman theory to Calc. $\mathcal{M}$ (Rules will be provided.)

<u>Ch. 7</u> (Skip Secs. 7–9)

(1) Know and understand solutions to Dirac Eq. (Proofs related to this may be on exam such as Probs 7.1, 7.3)

✓ (2) Know how to use Feynman rules for QED to calc. $\mathcal{M}$.
(Rules will be provided.)