Phys 4900, Fall 2011
Problem Set #5

1. *Griffiths EP*, **3.11**

2. *Griffiths EP*, **3.15** Get the following form momentum–energy conservation:

$$\gamma m_\pi c^2 = E_\nu + \sqrt{\mathbf{p}_\mu^2 c^2 + m_\mu^2} \qquad \text{where} \quad \gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

$$\gamma m_\pi v = |\mathbf{p}_\mu| \cos\theta$$
$$\frac{E_\nu}{c} = |\mathbf{p}_\mu| \sin\theta$$

Then do lots of algebra to get the desired result. It may be useful to show

$$E_\nu = \frac{c^2}{2\gamma m_\pi}(m_\pi^2 - m_\mu^2)$$

3. *Griffiths EP*, **3.16** Suppose in the lab frame the momentum 4-vectors of the colliding particles are

$$p'_A = (E'_A/c,\, \mathbf{p}'_B) \qquad p'_B = (E'_B/c,\, \mathbf{p}'_B)$$

In the CM frame they will be

$$p_A = (E_A/c,\, \mathbf{p}) \qquad p'_B = (E_B/c,\, -\mathbf{p})$$

where

$$E_A^2 = \mathbf{p}^2 c^2 + m_A^2 c^4 \qquad E_B^2 = \mathbf{p}^2 c^2 + m_B^2 c^4$$

At the threshold energy, the products are all at rest in the CM frame, so energy conservation gives

$$E_A + E_B = Mc^2 \qquad \text{where} \quad M = m_1 + m_2 + \cdots + M_n$$

Use invariance of the total momentum squared between reference frames

$$(p'_A + p'_B)^2 = (p_A + p_B)^2$$

and algebra to get the desired result.

4. *Griffiths EP*, **3.17**