PC4245 PARTICLE PHYSICS
HONOURS YEAR
Tutorial 3

1. Consider the case of elastic scattering, $A + B \rightarrow A + B$, in the lab frame (B initially at rest), assuming the target B is so heavy ($m_B c^2 >> E_A$) that its recoil is negligible. Show that the differential scattering cross section is given by

From here,
$\frac{d\sigma}{d\Omega} = \left(\frac{\hbar c}{8\pi}\right)^2 \frac{S|\mathcal{M}|^2}{(E_1 + E_2)^2} \frac{|\mathbf{p}_f|}{|\mathbf{p}_i|}$ (6.42)
E_2 >> E_1, sub E_2=m_B c^2 yields ->

$$(d\sigma/d\Omega) = (\hbar/(8\pi\, m_B\, c))^2 |M|^2$$

[This question is from the D J Griffiths, Introduction to Elementary Particles, 2nd Edition, Problem 6.8, page 223].

2. Consider the collision $1+2 \rightarrow 3 + 4$ in the lab frame (2 at rest), with particles 3 and 4 massless. Obtain the formula for the differential cross section.

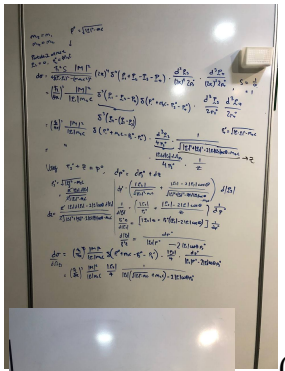
|P| -> four-momentum
|p| -> three-momentum

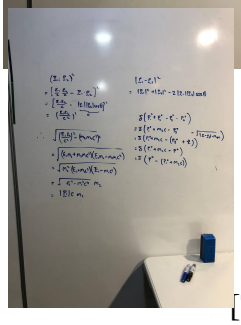
Particles 3 and 4 massless:
|P_3|^2 = (E_3/c)^2-|p_3|^2=0
(E_3/c)=|p_3|

$$Answer: \frac{d\sigma}{d\Omega} = \left(\frac{\hbar}{8\pi}\right)^2 \frac{S|M|^2 \left|\underset{\sim}{p_3}\right|}{m_2 \left|\underset{\sim}{p_1}\right| (E_1 + m_2 c^2 - \left|\underset{\sim}{p_1}\right| c \cos\theta}$$

[This question is from the D J Griffiths, Introduction to Elementary Particles, 2nd Edition, Problem 6.9, page 223].

3. (a)Analyze the problem of elastic scattering $(m_3 = m_1, m_4 = m_2)$ in the lab frame (particle 2 at rest). Derive the formula for the differential cross section.





$$Answer: \frac{d\sigma}{d\Omega} = \left(\frac{\hbar}{8\pi}\right)^2 \frac{\underset{\sim}{p_3}^2 S|M|^2}{m_2 \left|\underset{\sim}{p_1}\right| \left|E_1 + m_2 c^2)\left|\underset{\sim}{p_3}\right| - \left|\underset{\sim}{p_1}\right| E_3 \cos\theta\right|}$$

(b) If the incident particle is massless ($m_1 = 0$), show that the result in part (a) simplifies to

$$\frac{d\sigma}{d\Omega} = S\left(\frac{\hbar E_3}{8\pi m_2 c E_1}\right)^2 |M|^2$$

[This question is from the D J Griffiths, Introduction to Elementary Particles, 2nd Edition, Problem 6.10, page 223].