Griffiths

6.7(a). $(m_1 m_2 c^2)^2 = m_1^2 c^2 m_2^2 c^2$

$m_1^2 c^2 = \left(\frac{E_1}{c}\right)^2 - |p|^2$, $m_2^2 c^2 = \left(\frac{E_2}{c}\right)^2 - |p|^2$.

$\Rightarrow (m_1 m_2 c^2)^2 = \left(\frac{E_1}{c}\right)^2\left(\frac{E_2}{c}\right)^2 - \left(\frac{E_1}{c}\right)^2|p|^2 - \left(\frac{E_2}{c}\right)^2|p|^2 + |p|^4$.

$(p_1 \cdot p_2)^2 = \left[\left(\frac{E_1}{c}\right)\left(\frac{E_2}{c}\right) + |p|^2\right]^2$

$= \left(\frac{E_1}{c}\right)^2\left(\frac{E_2}{c}\right)^2 + 2\left(\frac{E_1}{c}\right)\left(\frac{E_2}{c}\right)|p|^2 + |p|^4$

$(p_1 \cdot p_2)^2 - (m_1 m_2 c^2)^2 = 2\left(\frac{E_1}{c}\right)\left(\frac{E_2}{c}\right)|p|^2 + \left(\frac{E_1}{c}\right)^2|p|^2 + \left(\frac{E_2}{c}\right)^2|p|^2$.

$= \left[\left(\frac{E_1}{c}\right)|p| + \left(\frac{E_2}{c}\right)|p|\right]^2$

$\sqrt{(p_1 \cdot p_2)^2 - (m_1 m_2 c^2)^2} = \frac{E_1}{c}|p| + \frac{E_2}{c}|p| = \boxed{(E_1 + E_2)\frac{|p|}{c}}$.

(b). for particle 2 at rest, $p_1 = \left(\frac{E_1}{c}, \vec{p}\right)$, $p_2 = (m_b c, 0)$.

$p_1 \cdot p_2 = \frac{E_1}{c} m_b c$, $(p_1 \cdot p_2)^2 - m_a^2 m_b^2 c^4 = E_1^2 m_b^2 - m_a^2 m_b^2 c^4$.

$= m_b^2\left[E_1^2 - m_a^2 c^4\right]$

$= m_b^2 |p|^2 c^2$.

$\Rightarrow \sqrt{(p_1 \cdot p_2)^2 - m_a^2 m_b^2 c^4} = \boxed{m_b |p| c}$