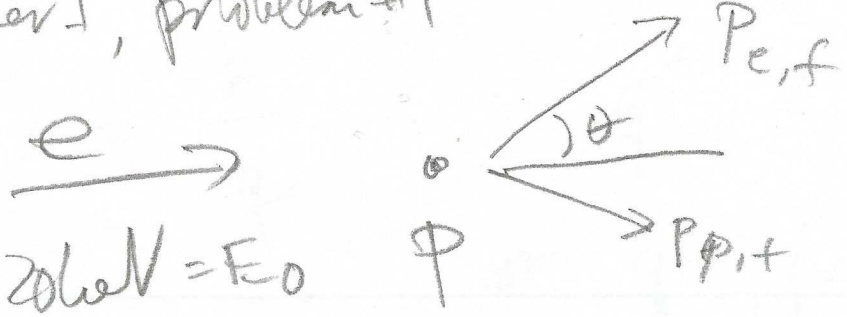
Chapter 1, problem #1



$\theta = 5^\circ$

$m_e = 0 \qquad m_p = 0.938$

$$P_{e,i} + P_{p,i} = P_{e,f} + P_{p,f}$$

$$P_{e,i} = (E_0, 0, 0, E_0)$$

$$P_{p,i} = (m_p, 0, 0, 0)$$

$$P_{e,f} = (E, 0, E\sin\theta, E\cos\theta)$$

$$P_{p,f} = (E_p, 0, -E\sin\theta, -E\cos\theta)$$

$$q^2 = (P_{e,i} - P_{e,f})^2$$

$$= (E_0 - E)^2 - (E_0 - E\cos\theta)^2 \qquad -E^2\sin^2\theta$$

$$= -2.82 \text{ GeV}^2$$

$E_0 \approx E$

$$q^2 \approx -E_0^2(1 - \cos\theta)$$

$$= -(20 \text{ GeV})^2$$

$$\Delta r = \frac{h}{q}$$

$$q^2 = 2.8\ \text{GeV}^2$$

or $q = 1.68\ \text{GeV}$

↓ removing $\hbar = c = 1$

$$q = 1.68\ \text{GeV}/c$$

$$\Delta r = \frac{hc}{1.68\ \text{GeV}}$$

$$\hbar = 6.59 \times 10^{-25}\ \text{GeV s}$$

$$c = 3.00\ \text{fm/s}$$

$$\Delta r = \frac{2\pi\hbar c}{1.68\ \text{GeV}} = \frac{2(3.14)(6.59\times10^{-25}\ \text{GeV s}) \times 3.00\times10^{23}\ \text{fm/s}}{1.68\ \text{GeV}}$$

$$= 0.739\ \text{fm}$$