Problem 1.

(a) Derive Equation 8.1, from the Feynman rules for QED.
(b) Obtain Equation 8.2 from Equation 8.1
(c) Derive Equation 8.3 from Equation 8.2
(d) Derive Equation 8.4 from Equation 8.3

Feynman Rules

1. Notation :
external lines with momentum $p_1, p_2...$, arrow direction forwards in time
internal lines with momentum $q_1, q_2...$, arrow direction forwards in time

3. Vertex factors (where lines meet) :

$$ig_e\gamma^\mu$$

4. propagator : each internal lines' factors

$$\text{Electrons and positrons : } \frac{i(\gamma^\mu q_\mu + mc)}{q^2 - m^2c^2}$$

$$\text{Photons : } \frac{-ig_{\mu\nu}}{q^2}$$

5. Conservation of E and P for each vertex :

$$(2\pi)^4 \ \delta^4(k_1+k_2+k_3)$$

where k's are the three four-momenta

6. Integrate over internal momenta : For internal moment q, the factors are

$$\frac{d^4q}{(2\pi)^4}$$

And then integrate

7. Cancel the delta function :

$$(2\pi)^4\delta^4(p_1 + p_2 + ... - p_n)$$

This will simplify the integral → only one of q left by the conservation and return 1 by the delta function.