Serway 39.32

\(u'_x\) = velocity of other jet in frame of jet
\(u_x\) = velocity of other jet in frame of galaxy center
\(v\) = speed of galaxy center in frame of jet

From equation 39.16
\[
u'_x = \frac{u_x - v}{1 - u_x/c^2} = \frac{-0.75c - 0.75c}{1 - (-0.75)(0.75)} = -0.96c
\] (1)

Serway 39.34

The velocity components of the first spacecraft in our frame
\(u_x = 0.6 \cos(50^\circ) = 0.39c\) \hspace{1cm} (2)
\(u_y = 0.6 \sin(50^\circ) = 0.46c\) \hspace{1cm} (3)

The velocity of the second spacecraft in our frame \(v = -0.7c\) Lorentz transforming first spacecraft velocity from our frame to second spacecraft frame, we get
\[
u'_x = \frac{u_x - v}{1 - u_x/c^2} = 0.86c
\] (4)
\[
u'_y = \frac{u_y}{\gamma(1 - u_x/c^2)} = 0.51c
\] (5)

Directions relative to x-axis: \(\theta = \tan^{-1}\left(\frac{u'y}{u'_x}\right) = 30.58^\circ\)

Serway 39.49

\[
W = \Delta K = K_f - K_i = \left(\frac{1}{\sqrt{1 - (v_f/c)^2}} - \frac{1}{\sqrt{1 - (v_i/c)^2}}\right) mc^2
\] (6)

(a)
\[
W = \left(\frac{1}{\sqrt{1 - (0.75)^2}} - \frac{1}{\sqrt{1 - (0.5)^2}}\right)(1.673 \times 10^{-27})(2.998 \times 10^8)^2
= 5.37 \times 10^{-11} J = 335 \text{ MeV}
\] (7)
(b) 

$$W = \left( \frac{1}{\sqrt{1 - (0.995)^2}} - \frac{1}{\sqrt{1 - (0.5)^2}} \right) \left( 1.673 \times 10^{-27} \right) \left( 2.998 \times 10^8 \right)^2$$

$$= 1.33 \times 10^{-9} \text{ J} = 8.21 \text{ GeV}$$

Serway 39.54

$$\Delta m = \frac{E}{c^2} = \frac{p \Delta t}{c^2} = \frac{0.8 \left( 10^9 \right) \left( 3 \times 3.16 \times 10^7 \right)}{(3 \times 10^8)^2} = 0.842 \text{ kg}$$

Serway 39.56

The total energy is conserved. The photon must have enough energy to be able to create an electron and a positron, both having the same rest mass:

$$E_\gamma \geq 2m_e c^2 = 1.02 \text{ MeV} \Rightarrow E_\gamma \geq 1.02 \text{ MeV}$$