1 (a) $(\Delta x)^2 < (\Delta t)^2$

or $|\Delta x| < |\Delta t|$

(b) $v = \dfrac{\Delta x}{\Delta t}$

(c) $0 \overset{!}{=} \Delta t' = \gamma(\Delta t - v\,\Delta x)$

$\Rightarrow \Delta t = v\,\Delta x$

$\Rightarrow v = \dfrac{\Delta t}{\Delta x}$

Solution to
term 3
final exam

2. (a) and (b)

	1	2	3
0	spacelike no	timelike yes	spacelike no
1		timelike yes	lightlike yes
2			spacelike no

(c) $\Delta t = 3\,yrs \quad \Delta x = 1\,ly$

$$v = \frac{\Delta x}{\Delta t} = \frac{1}{3}$$

(d) $\Delta t = 3\,yrs \quad \Delta x = 4\,ly$

$$v = \frac{\Delta t}{\Delta x} = \frac{3}{4}$$

3. Before

E_A	20
p_A	0
m_A	20

BTW,

$\sqrt{21} \approx 4.6$

$\sqrt{204} \approx 14.3$

and

$m_C + p_D \simeq 16.3$

After

E_C	5
p_C	$-\sqrt{21}$
m_C	2

E_D	15
p_D	$+\sqrt{21}$
m_D	$\sqrt{204}$

$$m_A > m_C + m_D$$

Here is my work for filling in the above tables

$$p_C^2 = E_C^2 - m_C^2 = 5^2 - 2^2 = 21$$

$$p_C = \pm\sqrt{21} \qquad p_D = \mp\sqrt{21}$$

$$m_D^2 = E_D^2 - p_D^2 = 15^2 - 21 = 225 - 21 = 204$$

4 (a) $E_{electron} = \sqrt{m_e^2 + p^2}$

(b) $E_{positron} = \sqrt{m_e^2 + p^2}$

(c) $E_{\gamma} = 2\sqrt{m_e^2 + p^2}$

(d) $p_{\gamma} = 0$

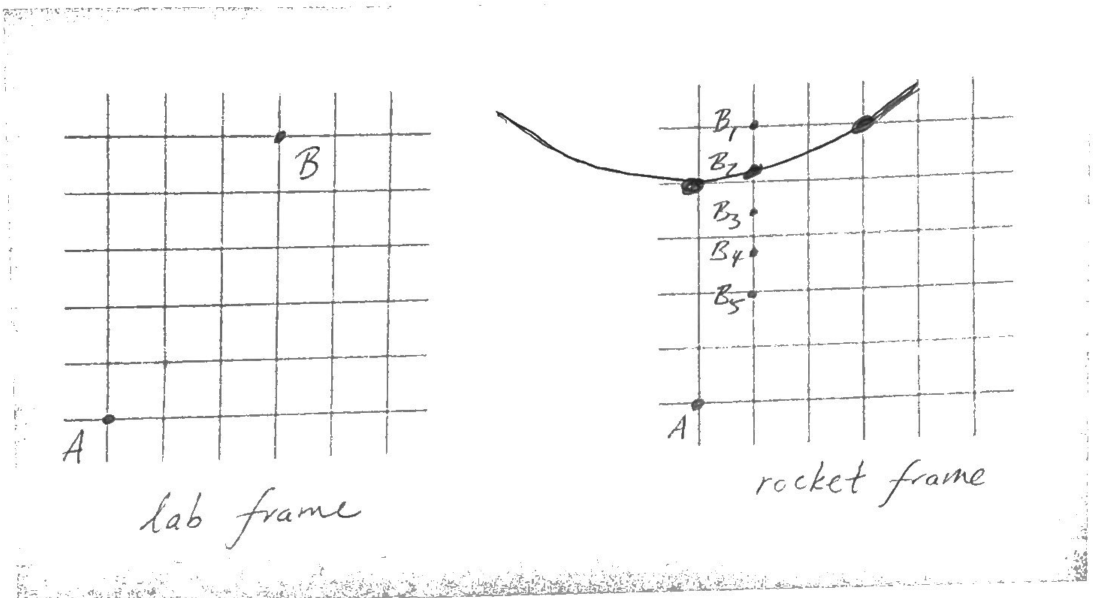
(e) $E_{\gamma}^2 - p_{\gamma}^2 = 4(m_e^2 + p^2)$

> 0

but the mass of a photon is zero.

5. Invariant Hyperbola

On the left are two events A and B in the lab frame. On the right are 5 possible positions for B in the rocket frame. On both plots, each grid spacing in the horizontal direction represents one light-year, and each grid spacing in the vertical direction represents one year.



On the right hand plot, sketch the invariant hyperbola of possible positions for event B relative to event A. It will go through only one of the events B_1 to B_5. HINT: Computing the invariant τ^2 might help you draw an accurate hyperbola.

$$\tau^2 = 5^2 - 3^2 = 16$$

$$\tau \doteq 4$$

Hyperbola goes through B_2