

Ch. 5 1. $a^\mu = (-2, 0, 0, 1)$ $b^\mu = (5, 0, 3, 4)$

a. $\underline{a} \cdot \underline{a} = -(-2)(-2) + 0 \cdot 0 + 0 \cdot 0 + 1 \cdot 1 = -3$ timelike

$\underline{b} \cdot \underline{b} = -5 \cdot 5 + 0 \cdot 0 + 3 \cdot 3 + 4 \cdot 4 = 0$ null

b. $\underline{a} - 5\underline{b} = (-2 - 25, 0 - 0, 0 - 15, 1 - 20)$
 $= (-27, 0, -15, -19)$

c. $\underline{a} \cdot \underline{b} = -(-2 \cdot 5) + (0 \cdot 0) + (0 \cdot 3) + (1 \cdot 4) = 14$

12. a. $\frac{d\vec{p}}{dt} = e\vec{E}$

$\vec{p}(t) = e\vec{E}t + C$
 $= \vec{F}t$

Take $\vec{p}(0) = 0 \Rightarrow C = 0$

$\vec{F} = e\vec{E}$

$\vec{v} = \frac{d\vec{x}}{dt} = \frac{\vec{p}}{E} = \frac{\vec{p}}{\sqrt{m^2 + \vec{p}^2}} = \frac{\vec{F}t}{\sqrt{m^2 + (\vec{F}t)^2}}$

$\vec{x}(t) = \frac{1}{F} \sqrt{m^2 + (\vec{F}t)^2} + \vec{x}(0)$

b. $E = \sqrt{m^2 + (\vec{F}t)^2}$

$= Fx$

Let $E = 40 \text{ GeV}$ and $x = 2 \text{ mi}$

$$F = \frac{40 \text{ GeV} \cdot \frac{10^9 \text{ eV}}{\text{GeV}} \cdot \frac{1.6 \times 10^{-19} \text{ J}}{\text{eV}}}{2 \text{ mi} \cdot \frac{1609 \text{ m}}{\text{mi}}} = 1.99 \times 10^{-12} \frac{\text{J}}{\text{m}}$$

$$|\vec{E}| = \frac{F}{e} = \frac{1.99 \times 10^{-12} \frac{\text{J}}{\text{m}}}{1.69 \times 10^{-19} \text{ C}} = 1.18 \times 10^7 \frac{\text{V}}{\text{m}}$$

