

Solutions

2.1 D $\gamma=5/3$, so $\gamma\tau_0=10\ \mu\text{s}$.

Compare the rejected options: $3.6\ \mu\text{s}$; $4.8\ \mu\text{s}$; $6\ \mu\text{s}$; $30\ \mu\text{s}$. Use the stated model and conditions.

2.2 C $\sqrt{100-36}=8\ \text{GeV}$.

Compare the rejected options: $4\ \text{GeV}$; $6\ \text{GeV}$; $10\ \text{GeV}$; $16\ \text{GeV}$. Use the stated model and conditions.

2.3 0.25 . $\gamma=1.25$, so $\gamma-1=0.25$.

2.4 False. $\beta=(4-1)/(4+1)=0.6$.

3.1 Total energy is $2E$; total momentum magnitude is $2(E/c)|\cos(\theta/2)|$. $M^2c^4 = 4E^2 - 4E^2\cos^2(\theta/2) = 4E^2\sin^2(\theta/2)$. Thus $Mc^2 = 2E\sin(\theta/2)$ for $0 \leq \theta \leq \pi$. Parallel photons have zero pair invariant mass; head-on photons have $Mc^2 = 2E$. Award vector momentum, invariant, result and limits. Each photon remains massless.