Special Relativity Problem Set

The standard MIT relativity curriculum, either from 8.033 or 8.20, far exceeds the level of detail tested on the GRE. This problem set is intended to refresh the essential concepts you can expect to encounter on the Physics GRE.

1. Relativistic Coordinate Transformation
An event occurs in a moving frame $S'$ at coordinates $(x', y', z', ct') = (3m, 1m, 0, 2m)$. $S'$ moves at velocity $v = 0.8c$ in the x-direction with respect to a rest frame $S$. Find the coordinates of the event in $S$.

(a) $(7.66, 1, 0, 7.33)$
(b) $(7.66, 1.66, 0, 7.33)$
(c) $(5, 1, 0, 3.33)$
(d) $(5, 1.66, 0, 3.33)$
(e) $(3, 1.66, 0, 7.33)$

2. Length Contraction
If a moving observer holds a rod of length $L = 1m$ at an angle of $\theta = 45^\circ$ from the x-axis, and is travelling at velocity $v = \sqrt{1/2}c$, find the length as measured by a stationary observer.

(a) $\sqrt{3/4}m$
(b) $\sqrt{5/8}m$
(c) $\sqrt{1/2}m$
(d) $\sqrt{3/2}m$
(e) $\sqrt{5/2}m$

3. Time Dilation
If a moving observer sees a time of $t_0 = 3s$ elapse on his own watch and a stationary observer measures $t = 5s$ for the same time interval, find the relative velocity of the two observers.
4. Relativistic Velocity Addition
A particle in rest frame $S$ moves at velocity $\vec{u} = (0.8c, 60^\circ)$. Find the particles velocity $u'$ in frame $S'$ which moves at a velocity $\vec{v} = v\hat{x}$ with respect to $S$.

(a) $(0.721c, 106^\circ)$ 
(b) $(0.589c, 110^\circ)$ 
(c) $(0.640c, 60^\circ)$ 
(d) $(0.775c, 110^\circ)$ 
(e) $(0.775c, 70^\circ)$

5. Relativistic Collision
A particle with rest mass $m_0$ travels at a velocity $v \approx c$ with relativistic factor $\gamma_v = 100$ and collides with a second particle of mass $m_0$. If the two particles stick together upon collision, find the factor $\gamma_u$ for the velocity $u$ with which the particles travel after the collision.

(a) $\gamma_u = 20$ 
(b) $\gamma_u = 30$ 
(c) $\gamma_u = 50$ 
(d) $\gamma_u = 80$ 
(e) $\gamma_u = 100$