January 2010   **Name:** _____

Useful Equations

$c = 3 \times 10^8$ m/s.

$$\left(c\Delta t\right)^2 - \left(\Delta x\right)^2 = \left(c\Delta t'\right)^2 - \left(\Delta x'\right)^2 = \left(\text{interval}\right)^2$$

Transformations involve a constant called gamma:

$$\gamma = \frac{1}{\sqrt{1 - v^2}}, \quad \text{where } v \text{ is expressed as a fraction of } c.$$

Transformations from one frame of reference to another are given by:

$$x' = \gamma\left[x - v(ct)\right] \qquad\qquad x = \gamma\left[x' + v(ct')\right]$$
$$t' = \gamma\left(ct - vx\right) \qquad\qquad t = \gamma\left(ct' + vx'\right)$$

The relativistic relative velocity equation: $\bar{v}_{AC} = \dfrac{\bar{v}_{AB} - \bar{v}_{CB}}{1 - \dfrac{\bar{v}_{AB}\,\bar{v}_{CB}}{c^2}}$.

Scores

Problem 4: _____ / 20

Problem 5: _____ / 10

TOTAL: _____ / 30

PROBLEM 4 – 20 points

According to You, who remain on Earth, Ben left for Planet Zorg a number of years ago. Ben's clock, when he left, read zero. Gail is passing Earth and heading in the direction of Zorg right now, and both your clock and Gail's clock read zero now. According to You, Zorg is at rest 60 light-years away. Ben has already covered a distance of 15 light-years, according to You, when Gail passes You.

Ben travels toward Zorg at a constant velocity of 0.6c, relative to You.

Gail travels toward Zorg at a constant velocity of 0.8c, relative to You.

[3 points] (a) According to Ben, what is the distance between You and Planet Zorg? How long does Ben think it takes for him to travel from Earth to Zorg?

[3 points] (b) According to Gail, what is the distance between You and Planet Zorg? How long does Gail think it takes for her to travel from Earth to Zorg?

[4 points] (c) According to you, who passes Zorg first? How many years is it until the other traveler passes Zorg?

[5 points] (d) Sketch a spacetime diagram for the situation described on the previous page, from the perspective of You. Show worldlines for You, Ben, Gail, and Planet Zorg.

Assume that each box on the diagram measures 5 lightyears by 5 lightyears.

ct

X
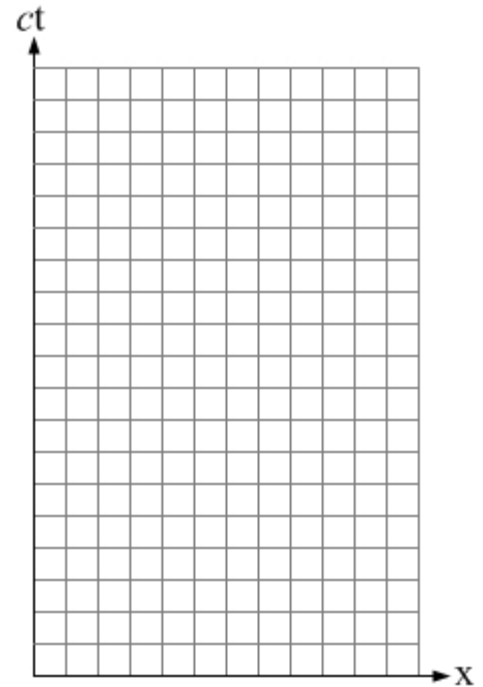
[5 points] (e) Now draw the spacetime diagram from Gail's frame of reference. For this diagram, use a scale of one box measuring 3 lightyears by 3 lightyears.

ct'

x'
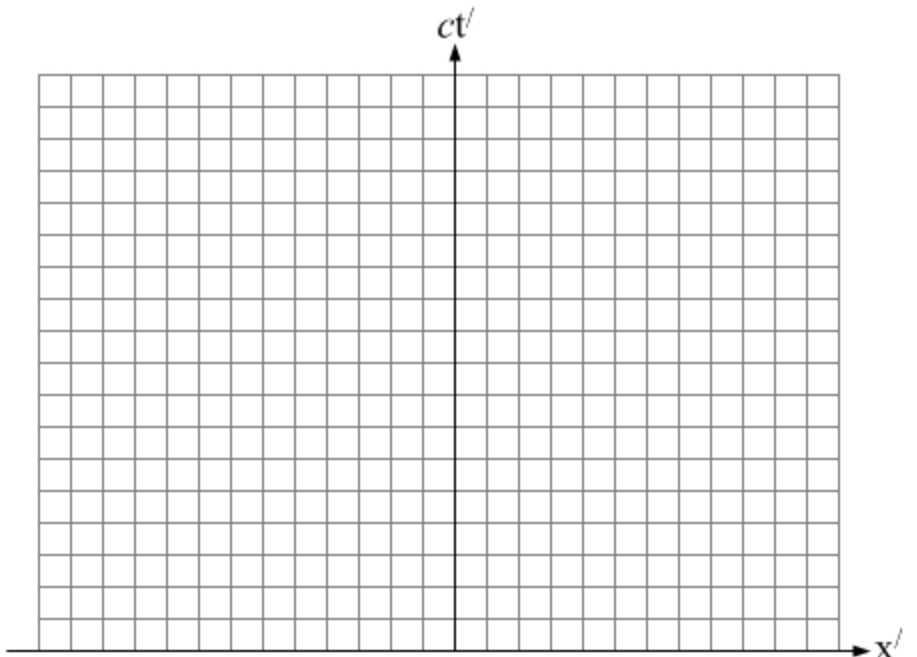
PROBLEM 5 – 10 point essay question
(These points contribute toward your conceptual history grade for the course)

Describe one scientific or technical hurdle to the practical application of atomic energy. How was this hurdle overcome? Which scientists were involved in overcoming it, and what were their contributions?

You may also discuss conceptual difficulties they had to overcome (changes with respect to their predecessors, missing concepts), related to this scientific or technical problem.

Your response may be between ½ and 1½ pages long. Be sure to include specific examples to support your assertions (including specific and precise references to *The Making of the Atomic Bomb* book), and to avoid irrelevant information.