Arts & Science 2D06

Quiz #4 2007 Nov 23 **Name:**

NB: Mark values are given in brackets [ ] beside each problem. Write all your answers on the quiz paper. No books or notes allowed. Time to write quiz: 50 minutes.

Taylor series: $(1+x)^a \simeq 1+ax$ for small x

Gamma factor: $\gamma = (1-v^2/c^2)^{-1/2}$ Momentum: $p = \gamma mv$

Lorentz transformation: $x' = \gamma(x-vt), \qquad t' = \gamma(t-\frac{v}{c^2}x).$

Velocity addition: $u' = \frac{(u-v)}{(1-uv/c^2)}$

Rest-mass Energy: $E = mc^2$ Kinetic energy: $K = (\gamma-1)mc^2$

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1. [2] The momentum of an object moving at $0.1c$ is:

(Explain/derive your answer.)

a) slightly less than mv

b) slightly more than mv

c) exactly equal to mv

d) zero

e) infinite

2. [2] A spaceship is moving towards the Earth with a speed of $0.9c$. It emits a laser beam, which moves away from the ship at the speed of light towards the Earth. From our vantage point on earth, the beam is moving toward us with a speed of: (Explain/derive your answer.)

a) $1.9c$

b) $1.2c$

c) $0.98c$

d) c

e) $0.9c$

3. [2+2+2] As measured by an observer on earth, a spacecraft runway on earth has a length of 3600 m.

a) What is the length of the runway as measured by a pilot of a spacecraft flying past at a speed of $0.25c$ m/s relative to earth?

b) An observer on earth measures the time interval from when the spacecraft is directly over one end of the runway until it is directly over the other end. What result does he get?

c) The pilot of the spacecraft measures the time it takes her to travel from one end of the runway to the other end. What value does she get?

4. [3] Two rockets leave a space station in the same direction along parallel paths. The space station crew records their speeds as $v_1 = 0.80\ c$ and $v_2 = 0.65\ c$. What is the speed of the first rocket as measured by the crew on the second?

5. [3] Find the speed at which an object should move such that its kinetic energy is equal to half of its rest-mass energy.

6. [2+2] Two events are observed in a frame of reference S to occur at the same space point, with the second event occurring 2.80 seconds after the first. In a second frame S' moving relative to S, the second event is observed to occur 3.35 s after the first.

b) What is the velocity of the frame S'?

a) What is the difference between the two positions of the two events as measured in S'?

[20] total marks