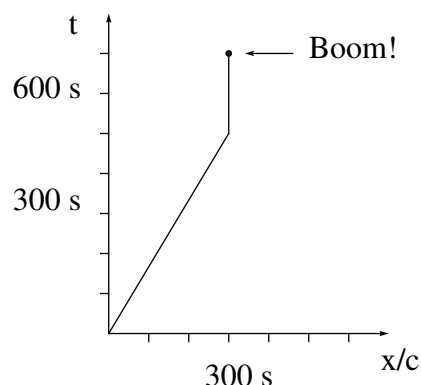1.

The space time diagram on the right shows the world-line of a rocket which leaves earth, travels for a certain amount of time, comes to rest for short time and then explodes.

(a) What are the spacetime coordinates of the three events?



(b) What was the speed of the rocket relative to the earth before it came to rest?

(c) How long was the rocket moving before it came to rest? (Answer both according to earth observers and according to rocket observers?)

(d) A light signal from earth reaches the rocket just as it explodes. Draw the worldline of this light signal. Also draw the world line of the light from the explosion. When do earth observers see the explosion?

2. (a) Electrons are accelerated from rest through a potential difference of $1.8 \times 10^5$ V. Calculate as measured in the laboratory reference frame the

   (i) total energy of the electron in $MeV$.

   (ii) electron velocity.

   (b) If another beam of electrons where to be accelerated through the same potential difference but in the opposite direction to the first beam what would be the relative velocity of an electron in one beam with respect to the other beam?

3. Use the microscope equation in the form

$$f(x) \approx f(0) + f'(0)x$$

when $x$ is small to show that the function

$$f(x) = \frac{1}{\sqrt{1-x}}$$

can be expressed as

$$f(x) \approx 1 + \tfrac{1}{2}\,x$$

when $x$ is small.

Use this result to find and simplify an approximate expression for

$$E = mc^2\gamma = \frac{mc^2}{\sqrt{1-(v/c)^2}}$$

when $(v/c)^2$ is small. Hence show that $\text{KE} \approx \tfrac{1}{2}\,mv^2$ at nonrelativistic speeds.

4. UPS plans a new Super-Express mail system to compete with email. They wish to send 25 g letters at 0.999c around the world. How much would it cost to send one letter? (Electricity cost $0.04 per $10^6$ Joules). What would happen to the person receiving such a letter? (Hint: A nuclear bomb releases $5 \times 10^{14}$ J.