

TAREA 3 DE RELATIVIDAD GENERAL

Fecha límite de entrega: POR DETERMINAR. Tarea INDIVIDUAL.

1. Escribe tu nombre completo.

- 28 Let $\vec{A} \rightarrow_{\mathcal{O}} (5, 1, -1, 0)$, $\vec{B} \rightarrow_{\mathcal{O}} (-2, 3, 1, 6)$, $\vec{C} \rightarrow_{\mathcal{O}} (2, -2, 0, 0)$. Let $\bar{\mathcal{O}}$ be a frame moving at speed $v = 0.6$ in the positive x direction relative to \mathcal{O} , with its spatial axes oriented parallel to \mathcal{O} 's.
- (a) Find the components of \vec{A} , \vec{B} , and \vec{C} in $\bar{\mathcal{O}}$.
 - (b) Form the dot products $\vec{A} \cdot \vec{B}$, $\vec{B} \cdot \vec{C}$, $\vec{A} \cdot \vec{C}$, and $\vec{C} \cdot \vec{C}$ using the components in $\bar{\mathcal{O}}$. Verify the frame independence of these numbers.
 - (c) Classify \vec{A} , \vec{B} , and \vec{C} as timelike, spacelike, or null.
- 30 The four-velocity of a rocket ship is $\vec{U} \rightarrow_{\mathcal{O}} (2, 1, 1, 1)$. It encounters a high-velocity cosmic ray whose momentum is $\vec{P} \rightarrow_{\mathcal{O}} (300, 299, 0, 0) \times 10^{-27} \text{ kg}$. Compute the energy of the cosmic ray as measured by the rocket ship's passengers, using each of the two following methods.
- (a) Find the Lorentz transformations from \mathcal{O} to the MCRF of the rocket ship, and use it to transform the components of \vec{P} .
 - (b) Use Eq. (2.35).
 - (c) Which method is quicker? Why?
- 31 A photon of frequency ν is reflected without change of frequency from a mirror, with an angle of incidence θ . Calculate the momentum transferred to the mirror. What momentum would be transferred if the photon were absorbed rather than reflected?
- 33 Space is filled with cosmic rays (high-energy protons) and the cosmic microwave background radiation. These can Compton scatter off one another. Suppose a photon of energy $h\nu = 2 \times 10^{-4} \text{ eV}$ scatters off a proton of energy $10^9 m_P = 10^{18} \text{ eV}$, energies measured in the Sun's rest frame. Use Eq. (2.43) in the proton's initial rest frame to calculate the maximum final energy the photon can have in the solar rest frame after the scattering. What energy range is this (X-ray, visible, *etc.*)?

8-16 creation of proton – antiproton pair by an electron

What is the threshold kinetic energy K_{th} of the incident electron for the following process?

electron (fast) + proton (at rest) \longrightarrow
electron + antiproton + two protons

8-20 the physicist and the traffic light

A physicist is arrested for going through a red light. In court he pleads that he approached the intersection at such a speed that the red light looked green to him. The judge, a graduate of a physics class, changes the charge to speeding and fines the defendant one dollar for every kilometer/hour he exceeded the local speed limit of 30 kilometers/hour. What is the fine? Take the wavelength of green light to be 530 nanometers $= 530 \times 10^{-9}$ meter) and the wavelength of red light to be 650 nanometers. The relation between wavelength λ and frequency f for light is $f\lambda = c$. Notice that the light propagates in the negative x -direction ($\phi = \phi' = \pi$).

Realice **un ensayo** de aproximadamente una cuartilla en donde responda el siguiente ejercicio. Los criterios para la calificación serán:

- El tema del ensayo es fácilmente identificable y es el punto central de toda la disertación. El manuscrito presenta claramente una introducción, un desarrollo del tema y conclusiones.
- El autor sustenta la validez de sus opiniones y confronta sus razonamientos con los de otros autores.
- La redacción del texto es clara y precisa, la presentación del texto y las figuras es ordenada, y no se observan errores evidentes de ortografía, de sintaxis o de gramática.

4-2 one-way twin paradox?

A worried student writes, “I still cannot believe your solution to the Twin Paradox. During the outward trip to Canopus, each twin can regard the other as moving away from him; so how can we say which twin is younger? The answer is that the twin in the rocket makes a turn, and in Lorentz spacetime geometry, the greatest aging is experienced by the person who does not turn. This argument is extremely unsatisfying. It forces me to ask: What if the rocket breaks down when I get to Canopus, so that I stop there but cannot turn around? Does this mean that it is no longer possible to say that I have aged less than my Earthbound twin? But if not, then I would never have gotten to Canopus alive.” Write a half-page response to this student, answering the questions politely and decisively.