TAREA 2 DE RELATIVIDAD GENERAL
Fecha límite de entrega: POR DETERMINAR. Tarea INDIVIDUAL.

1. Escribe tu nombre completo.
2. Ejercicio 1.12 (libro de Spacetime Physics).

1-12 time stretching with π^+-mesons

Laboratory experiments on particle decay are much more conveniently done with π^+-mesons (pi-plus mesons) than with μ-mesons, as is seen in the table.

In a given sample of π^+-mesons half will decay to other elementary particles in 18 nanoseconds (18×10^{-9} seconds) measured in a reference frame in which the π^+-mesons are at rest. Half of the remainder will decay in the next 18 nanoseconds, and so on.

a In a particle accelerator π^+-mesons are produced when a proton beam strikes an aluminum target inside the accelerator. Mesons leave this target with nearly the speed of light. If there were no time stretching and if no mesons were removed from the resulting beam by collisions, what would be the greatest distance from the target at which half of the mesons would remain undecayed?

b The π^+-mesons of interest in a particular experiment have a speed 0.9978 that of light. By what factor is the predicted distance from the target for half-decay increased by time dilation over the previous prediction — that is, by what factor does this dilation effect allow one to increase the separation between the detecting equipment and target?

3. Ejercicio 2.4 (libro de Spacetime Physics).

2-4 synchronization by a traveling clock

Mr. Engelsberg does not approve of our method of synchronizing clocks by light flashes (Section 2.6).

a "I can synchronize my clocks in any way I choose!" he exclaims. Is he right?

Mr. Engelsberg wishes to synchronize two identical clocks, named Big Ben and Little Ben, which are relatively at rest and separated by one million kilometers, which is 10^9 meters or approximately three times the distance between Earth and Moon. He uses a third clock, identical in construction with the first two, that travels with constant velocity between them. As his moving clock passes Big Ben, it is set to read the same time as Big Ben. When the moving clock passes Little Ben, that outpost clock is set to read the same time as the traveling clock.

b "Now Big Ben and Little Ben are synchronized," says Mr. Engelsberg. Is he right?

c How much out of synchronism are Big Ben and Little Ben as measured by a latticework of clocks — at rest relative to them both — that has been synchronized in the conventional manner using light flashes? Evaluate this lack of synchronism in milliseconds when the traveling clock that Mr. Engelsberg uses moves at 360,000 kilometers/hour, or 10^5 meters/second.

d Evaluate the lack of synchronism when the traveling clock moves 100 times as fast.

e Is there any earthly reason — aside from matters of personal preference — why we all should not adopt the method of synchronization used by Mr. Engelsberg?

4. The r^{-1} dependence of the gravitational potential on distance arises because the graviton, which carries the gravitational field, is massless. If the graviton had a mass m_g, the gravitational potential due to a body of mass M would be $\Phi(r) = -GMe^{-\alpha r}/r$, where $\alpha = m_g c/\hbar$ (the Yukawa potential), which reduces to the Newtonian potential in the limit $\alpha \to 0$. What is the flux of the gravitational acceleration field through a sphere of radius R around the body of mass M?
5. Resuelva el ejercicio 64.

    64. Un sistema binario de estrellas consta de dos estrellas, cada una con la misma masa que el Sol, que gira en torno al centro de masa común del sistema. La distancia entre ellas es la misma que la distancia entre la Tierra y el Sol. ¿Cuál es el periodo de revolución en años?

6. Resuelva el ejercicio 72.

    72. Un satélite meteorológico está un una órbita geosíncrona, quieto sobre Nairobi, ciudad muy cercana al ecuador. Si el radio de su órbita se aumenta en 1.00 km, ¿a qué razón y en qué dirección se movería su punto de referencia, que anteriormente estaba estacionario, en la superficie de la Tierra?

7. ¿Cuál de las siguientes fórmulas sería una aproximación adecuada a la situación del ejercicio 72 si el aumento o disminución en el radio órbita es Δr y el periodo de rotación de la Tierra es T_0?

18(a) The Einstein velocity-addition law, Eq. (1.13), has a simpler form if we introduce the concept of the *velocity parameter* u, defined by the equation

$v = \tanh u.$

Notice that for $-\infty < u < \infty$, the velocity is confined to the acceptable limits $-1 < v < 1$. Show that if

$v = \tanh u$

and

$w = \tanh U,$

then Eq. (1.13) implies

$w' = \tanh(u + U).$

This means that velocity parameters add linearly.

(b) Use this to solve the following problem. A star measures a second star to be moving away at speed $v = 0.9c$. The second star measures a third to be receding in the same direction at $0.9c$. Similarly, the third measures a fourth, and so on, up to some large number N of stars. What is the velocity of the Nth star relative to the first? Give an exact answer and an approximation useful for large N.