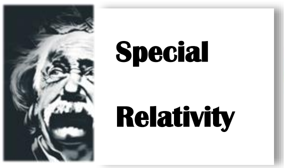
Khemis Miliana University
Faculty of Material Sciences & Computer Science
Department of Physics
L3 Fundamental Physics (2024/2025)



Series of Exercises 01

Galilean referential and Newton relativity

Exercise 01:

A train passenger is walking forward along the aisle of a train at a speed $v_p = 3km/h$, as the train moves along a straight track as a constant speed $v_t = 92km/h$ with respect to the ground. What is the passenger's speed with respect to the ground?

Exercise 02:

A Passenger in a train moving at $30m/s$ passes a man standing on a station platform at $t = t' = 0$. Twenty seconds after the train passes him, the man on the platform determines that a bird flying along the track in the same direction as the train is 800m away.

1. What are the coordinates of the bird as determined by the passenger?
2. Five seconds after making the first measurement, the man on the platform determines that the bird is 850 m away. From these data find the velocity of the bird (assumed constant) as determined by the man on the platform and by the passenger on the train.

Exercise 03:

On the highway, a car is moving on the road with a constant speed of $96km/h$ passes an observer standing aside the road. 20 seconds later this crossing, a lightning strike at a given point located $1.6km$ further away from the standing man in the same direction of the car.
What is the position of the lightning measured by the driver of the moving car?

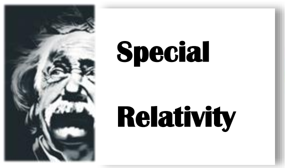
Exercise 04:

A hunter on the ground fires a bullet in the northeast direction which strikes a deer $0.40km$ from the hunter. The bullet travels with a speed of $2900\ km/h$. At the instant when the bullet is fired, an airplane is directly over the hunter at an altitude $h = 1600\ m$ and is traveling due east with a velocity of $960km/h$. When the bullet strikes the deer, what are the coordinates as determined by an observer in the airplane?

Exercise 05:

An observer, at rest with respect to the ground, observes the following collision. A particle of mass $m_1 = 3kg$ moving with velocity $v_1 = 4m/s$ along the x-axis approaches a second particle of mass $m_2 = 1kg$ moving with velocity $v_2 = -2m/s$ along the same axis. After a head collision the ground observer finds that $v_2' = 3m/s$ along the x-axis.

1. Find the velocity v'_1 of m_1 after the collision.
2. A second observer O', who is walking with a velocity $u = 2m/s$ relative to the ground along the x-axis observes the collision. What are the system momenta before and after the collision as determined by this observer?



Exercise 06:

AN open car traveling at 30m/s has a boy in it who throws a ball upward with a velocity of 6m/s. Write the equation of motion (giving position as a function of time) for the ball as seen y (a) the boy, (b) an observer stationary on the road.

Exercise 07:

Consider a mass attached to a spring and moving on a horizontal, frictionless surface. Show, from the classical transformation laws, that the equations of motion of the mass

$$-k(x - x_0) = m\frac{d^2x}{dt^2}$$

are the same as determined by an observer at rest with respect to the surface and by a second observer moving with constant velocity $u = cte$ along the direction of the spring.

Exercise 08:

Show that the electromagnetic wave equation:

$$\Delta\varphi - \frac{1}{c^2}\varphi = \frac{\partial^2\varphi}{\partial x^2} + \frac{\partial^2\varphi}{\partial y^2} + \frac{\partial^2\varphi}{\partial z^2} - \frac{1}{c^2}\varphi = 0$$

Is not invariant under the Galilean transformations.

$$x = x' + ut', y = y', z = z', t = t'$$

Use the following rules of the differential derivation to pass from a frame to another.

$$\frac{\partial\varphi}{\partial x_i} = \frac{\partial\varphi}{\partial x'}\frac{\partial x'}{\partial x_i} + \frac{\partial\varphi}{\partial y'}\frac{\partial y'}{\partial x_i} + \frac{\partial\varphi}{\partial z'}\frac{\partial z'}{\partial x_i} + \frac{\partial\varphi}{\partial t'}\frac{\partial t'}{\partial x_i}$$

Exercise 09:

Figure below depicts a Michelson-Morley interferometer oriented with one arm (A) parallel to the "ether wind".

1. Calculate the period t_A of the round-trip of the light ray along the arm (A), as well as the period t_B needed to achieve a round-trip of the light ray along the arm (B). Use the 1st order approximation in $\frac{v^2}{c^2}$ to express the difference $\delta = t_A - t_B$.
2. Deduce the durations t_A et t_B if the apparatus is rotated by 90°, as well as the corresponding difference δ'.
3. Knowing the wavelength λ of the used light in the experiment, determine the number of observable fringes: $\Delta N = \frac{c(\delta-\delta')}{\lambda}$ en fonction de l_A, l_B, v.
4. The original experiment of Michelson-Morley was conducted by using a light lamp with a wavelength $\lambda = 5900\text{Å}$ and by considering that the orbital speed of the Earth is $v = 30km/s$, what will be the detected fringes shifting during this experiment ΔN ?