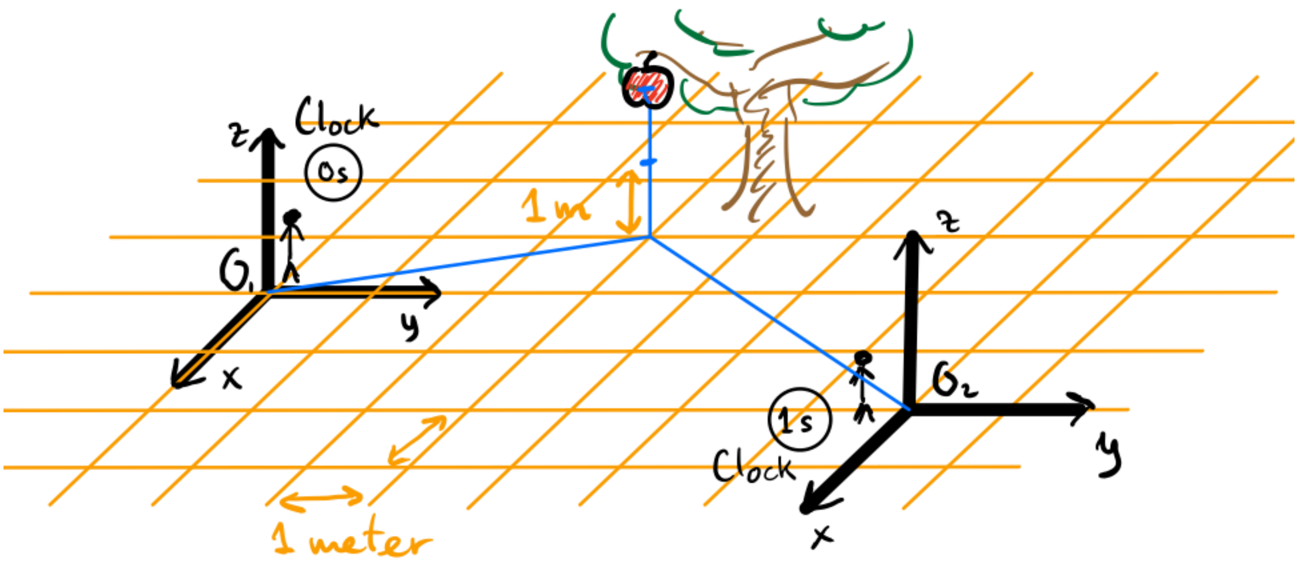
NAME:

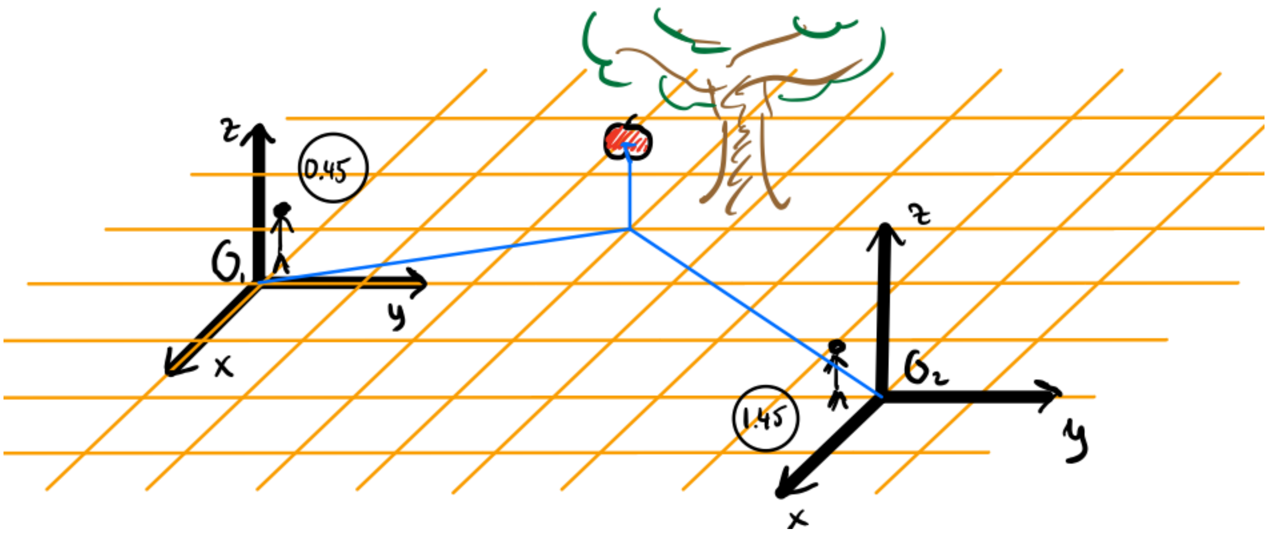
Today's worksheet consists of a few questions related to the concepts covered in Lecture 4. Please read/watch the lecture if you haven't done so yet.

1. The physical system under consideration is an apple falling from a tree. In class we established a way to measure the position of an object in space and in time by giving the spatial coordinates and time coordinate of a succession of events. Imagine that two different observers, denoted by $\mathcal{O}_1$ and $\mathcal{O}_2$ in the figure, want to record the coordinates of each of these events. Each observer carries with them a timer and a three of measuring sticks that allow them to measure the coordinates of any event. Let's say that at the initial event of the fall, their timers are not synchronized, and that they differ by the amount given in the figure.
   The figure below corresponds to the initial event of the apple detaching from the tree branch (we will refer to it as *event 1*). Give the coordinates of *event 1* with respect to each of the observers.



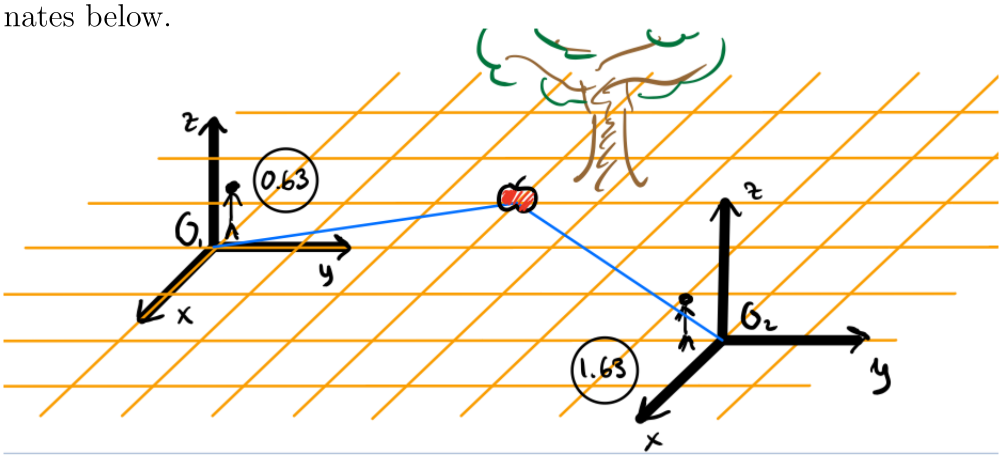
Event 1 coordinates according to observer $\mathcal{O}_1$:
$x =$
$y =$
$z =$
$t =$
Event 1 coordinates according to observer $\mathcal{O}_2$:
$x =$
$y =$
$z =$
$t =$

2. The second event we will consider, *event 2*, is when the apple is half way from reaching the ground. Give the coordinates below.



Event 2 coordinates according to observer $\mathcal{O}_1$:
$x =$
$y =$
$z =$
$t =$
Event 2 coordinates according to observer $\mathcal{O}_2$:
$x =$
$y =$
$z =$
$t =$

3. Finally, a third event, *event 3*, will be the apple hitting the ground. Give the coordinates below.



Event 3 coordinates according to observer $\mathcal{O}_1$:
$x =$
$y =$
$z =$
$t =$
Event 3 coordinates according to observer $\mathcal{O}_2$:
$x =$
$y =$
$z =$
$t =$

4. Use the Pythagorean theorem to calculate the spatial distance between the observer $\mathcal{O}_1$ and the apple sitting on the ground (give units). Can you guess what will be the formula to calculate the distance between an observer and the object in the general case?

5. Take a look at how the coordinates are changing as the apple falls in 1-3. Which coordinates remained the same? Which ones changed?

6. The trajectory (aka path) of an object is the succession of events where the object lies. Predicting the motion of an object means being able to predict how the spatial coordinates change as the time coordinate changes. For example for this system of the falling apple, Newton's theory tells us that the z coordinate is related to the t coordinate by the following equation:

$$z = z_0 + \frac{1}{2}g(t - t_0)^2 \tag{1}$$

where $g = -9.8\ m/s^2$, t_0 is the initial reading of the observer's clock and z_0 is the initial position of the apple (initial event). So g, t_0 and z_0 are fixed numbers that don't change in time (although t_0 and z_0 they depend on the observer we choose). The only thing that changes as the object moves is t and z.
Verify that this equation holds for each of the three events in 1-3 and with respect to each observer (observers clocks measure time with an error of ± 0.01 seconds).

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7. Classify the following observers in order of increasingly better inertial frames of reference (that is, think about how much each observer deviates from being at rest or moving at a constant speed in a straight line with respect to the distant stars): Observer at rest w.r.t. distant stars, observer sitting on a slowly spinning Carrousel on earth, observer in a car moving at a constant speed of 220km/h on a straight highway, observer on a ship navigating through a storm, observer at rest w.r.t the Sun, observer at rest on the surface of the earth, an observer on the earth's surface as isolated as possible from friction forces.