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# Mechanik, Herbstsemester 2020

**Blatt 12 = letztes "offizielles" Übungsblatt**
**(Blatt 13 = Bonus-Übungsblatt)**

Abgabe: 8.12.2020 **auf adam in den entsprechenden Ordner. Ein File pro Abgabe; der Filename muss Ihren Namen enthalten, sonst wird nicht korrigiert!**
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(1) **Police chases criminals** (2 Punkte)
As the outlaws escape in their getaway car, which goes $\frac{3}{4}c$, the police officer fires a bullet from the pursuit car, which only goes $\frac{1}{2}c$. The muzzle velocity of the bullet (relative to the gun) is $\frac{1}{3}c$.

Does the bullet reach its target (a) according to Galileo, (b) according to Einstein?

(2) **Simultaneity** (3 Punkte)
Event $A$ happens at ($x_A = 5$, $y_A = 3$, $z_A = 0$) and at time $ct_A = 15$; event $B$ occurs at (10,8,0) and $ct_B = 5$, both in system $K$.

(a) Calculate the invariant interval $I \equiv c^2(t_A - t_B)^2 - (\mathbf{x}_A - \mathbf{x}_B)^2$ between $A$ and $B$. Why is it the same in all inertial systems?

(b) Is there an inertial system $K'$ in which they occur simultaneously? If so, find its velocity (magnitude and direction) relative to $K$.

(c) Is there an inertial system $K''$ in which they occur at the same point? If so, find its velocity relative to $K$.

Repeat (a) – (c) for $A = (2, 0, 0)$, $ct_A = 1$; and $B = (5, 0, 0)$, $ct_B = 3$.

(3) **Communicating with rockets** (3 Punkte)
A rocket ship leaves earth at a speed of $\frac{3}{5}c$. When a clock on the rocket (system $K'$) says 1 hour has elapsed, the rocket ship sends a light signal back to earth (system $K$).

(a) According to *earth* clocks, when was the signal sent?

(b) According to *earth* clocks, how long after the rocket left did the signal arrive back on earth?

(c) According to the rocket observer, how long after the rocket left did the signal arrive back on earth?

(4) **Relativistic Doppler effect** (3 Punkte)
A source emits plane monochromatic electromagnetic waves (frequency $\omega$) in $z$-direction. An observer moves with velocity $v$ in $x$- resp. in $z$-direction. Calculate the frequency $\omega'$ that she measures for the wave, and the direction in which the wave propagates. Plot and discuss the frequency as a function of $v$.

Hint: $(\omega/c, \mathbf{k})$ is a 4-vector, i.e., has the same transformation properties as $(ct, \mathbf{x})$.