1D motion

1. $\left(^{*}\right)$ The period of small oscillations of a pendulum is independent of its amplitude (Galileo). Use this to find the dependence of the period $T$ on the length of the pendulum $L$, gravitational acceleration $g$ and, possibly, mass $M$. Namely, look for

$$
T \sim L^{\alpha} g^{\beta} M^{\gamma}
$$

and find $\alpha, \beta$ and $\gamma$.
2. A motorcycle with $V_{M}=60 \mathrm{~m} / \mathrm{s}$ is catching up with a car with $V_{C}=30 \mathrm{~m} / \mathrm{s}$, originally $\mathrm{D}=300 \mathrm{~m}$ ahead. When and where will they meet? Give the graphic solution.
3. A driver hits the brakes on icy road, and the car slows down at $\mathrm{a}=0.5 \mathrm{~m} / \mathrm{s}^{2}$. After $\mathrm{L}=100 \mathrm{~m}$ it has $\mathrm{v}=2 \mathrm{~m} / \mathrm{s}$. Find the initial velocity $v_{0}$.
4. The catch-a-ruler demo is used to find the reaction time t. (a) Derive a formula relating $t$ to $h$, the vertical displacement of the ruler. (b) Do several experiments and find the average $t$. (c) derive an expression for the velocity v just before the ruler is caught. Calculate $v$ from your average $t$.
5. A fast train moving at a constant speed $\mathrm{v}=70 \mathrm{~m} / \mathrm{s}$ passes the platform. 10 seconds later a second train starts from from rest and accelerates at $a=3 \mathrm{~m} / \mathrm{s}^{2}$ . When and how far from the platform will it catch up with the first train?
6. Two trains leave two stations separated by 100 km at the same time and move towards each other. The speeds of trains A and B is $30 \mathrm{~km} / \mathrm{h}$ and $70 \mathrm{~km} / \mathrm{h}$, respectively. Plot the position vs. time graphs for both trains on the same plot and determine the meeting point.
7. $\left(^{*}\right)$ The same, but the A train with $v_{0}=30 \mathrm{~km} / \mathrm{h}$ also has acceleration of 60 $\mathrm{km} / \mathrm{h}^{2}$. (You do not have to change units in this problem.)
8. A projectile is fired vertically up from a cliff $\mathrm{H}=100 \mathrm{~m}$ tall above the ground. The initial sped of the projectile is $40 \mathrm{~m} / \mathrm{s}$. How long will it take before the projectile hits the ground? What will be the speed upon impact?

