Type of material: Lesson plan

Subject: Physics
Topic: Uniformly Accelerated Motion

General competencies developed during the lesson:
program-based thinking
design thinking

Equipment/resources required:
Computer (program LoggerPro)
Overhead projector
School board
Equipment for experiment: small toy cart, weights, pulley, cord, motion detector, Vernier LabQuest

General Objectives:
Drawing graphs
Being able to perform measurements

Physics Objectives:
Understanding basics of motion and accelerated motion
Understanding graphs of motion and being able to draw graphs: *s(t), v(t), a(t)*
Being able to use motion equations for calculations of missing parameters
Being able to solve problems regarding uniformly acceleration motion
Being able to design an experiment describing accelerated motion

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1. Lead-in

Warm up questions regarding uniform motion and non-uniform motion**:**

a) What kind of motion do you know/recall?

b) What is uniform linear motion? Can you give some examples?

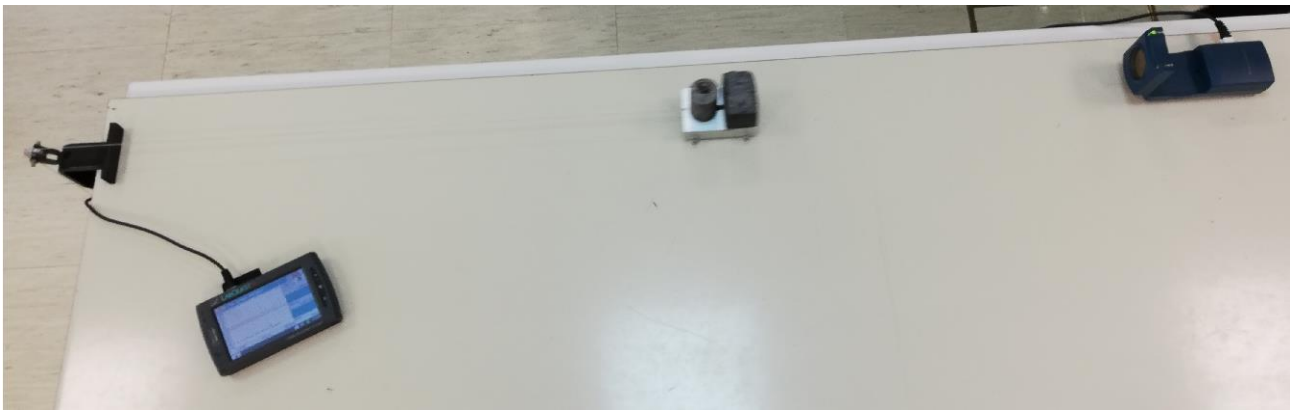
c) Which equations represent uniform linear motion? Does velocity depend on time for this kind of motion?

d) Can you draw a displacement-time graph of the given example?

2. Experiment

A. Demonstration

Teacher demonstrates experiment of uniformly acceleration motion in which motion detector measures the distance between the small toy cart and the detector. The detector is connected to a Labquest device which is able to measure displacement, velocity and acceleration of the toy cart. The device is connected to the PC and the overhead projector.



Before the demonstration the teacher gives some questions about the possible outcomes of the experiment (type of motion, acceleration, velocity, displacement, how graphs should look like, …). At the end of the discussion students should be able to predict the outcome (make a hypothesis) of the experiment.

Outcome of the experiment:

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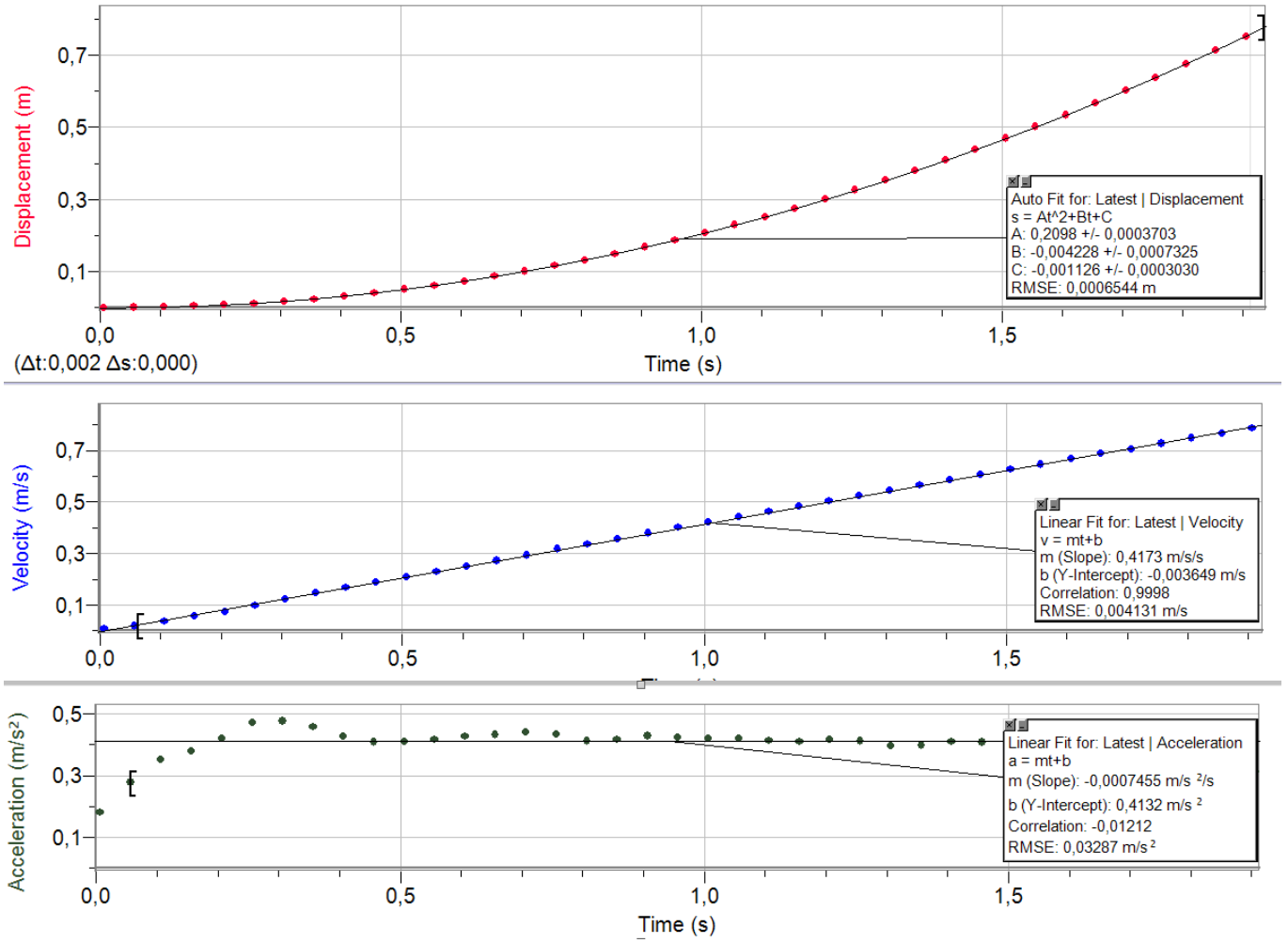

Explanation of the outcome is followed by a discussion.

After the discussion the teacher derives equations for uniformly acceleration motion:

$$1.)\quad a=\frac{\Delta v}{\Delta t}=\frac{v-v_0}{t}\quad\Rightarrow\quad v=v_0+at$$

$$2.)\quad s=\overline{v}\cdot t,\quad \overline{v}=\frac{v_0+v}{2}\quad\Rightarrow\quad s=\frac{v_0\cdot t}{2}+\frac{v\cdot t}{2}$$

Combine $1.)\rightarrow 2.)$:

$$s=\frac{v_0\cdot t}{2}+\frac{(v_0+at)\cdot t}{2}=v_0\cdot t+\frac{a\cdot t^2}{2}$$

Final equations for uniformly acceleration motion:

$$a=\frac{\Delta v}{\Delta t}=\frac{v-v_0}{t}$$

$$v=v_0+at$$

$$s=v_0\cdot t+\frac{a\cdot t^2}{2}$$

B. Controlled practice:

a) Draw graphs of the demonstration experiment: *s(t)*, *v(t)* and *a(t)*.

C. Free practice:

a) Read the graph and find displacement, velocity and acceleration at t = 1,0 s.

s = 16.5 cm, v = 0.415 m/s, a = 0.42 m/s^2

b) Calculate the acceleration of the toy cart from graph *v(t)*.

$$a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{0.62\,\text{m/s} \;-\; 0.21\;\text{m/s}}{1.5\;\text{s} \;-\; 0.5\;\text{s}} = 0.41\,\text{m/s}^2$$

c) Exercise: Peter rides on a motorcycle at a speed of 36 km/h for 10 seconds. Then he starts accelerating. His speed increases to 144 km/h in 6.0 seconds. Calculate the acceleration.

$$a = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{t} = \frac{40\,\text{m/s} \;-\; 10\;\text{m/s}}{6.0\;\text{s}} = 0.50\,\text{m/s}^2$$

3. Conclusion

Review and Follow up:

a) Continue with the given exercise and calculate the total displacement of Peter and his motorcycle for the given time.

b) Draw graphs: *s(t)*, *v(t)* and *a(t)* for the given exercise.

c) Gravitational acceleration – vertical motion