Mechanics in a wheel-chair

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Students with disabilities are underrepresented in higher education[1–2] in Sweden and the situation is probably the same in other countries. In education programmes leading to science or engineering degrees students with disabilities are even more seriously underrepresented[3 – 6]. This is unfortunate since it's reported from USA that persons, with a disability, who have a science or an engineering degree, have higher employment rate than persons with a disability in general have[5].

Young people are deterred from studying science or engineering because of misconceptions among parents, teachers, counselors, school and college administrators and others who believe that it is unsuitable or even hazardous for a student with a disability to study science or engineering. However for most students with a disability only very small adaptations are necessary and for many attitudes are a much more serious impediment than physical barriers[3,4,6,7].

As part of a diploma work[8, 9] the advantage of using Microcomputer Based Laboratory (MBL) tools for students with mild physical disabilities have been studied. As part of that study it was tested if it was feasible to do some kinematics graph-matching experiments while sitting in a wheel-chair. While doing the testing, as will be discussed below, it was discovered that it is of educational value for non physically disabled students to perform some mechanics activities sitting in a wheel-chair.

Wheel-chair mechanics

Many active-engagement physics curricula[10 – 15] are asking the students to be *part* of the experiment and move in front of an motion sensor attached to a computer. While moving in front of the motion sensor the computer is arranged in such a way that distance – time and velocity – time graphs are displayed on the computers screen in real-time. Some activities ask the student to move in such a way that a given graph is matched. It have been shown (see for example reference 10 – 12) that this enhance student learning of kinematics concepts. We have tested such graph-matching activities while sitting in a wheel-chair. As shown in the photo (figure 1) and in figure 2 this can be done successfully. The graph-matching activity in figure 2 is performed using PASCO[16] ScienceWorkshop MBL equipment and software and using PASCO activity, P01 Understanding Motion 1, without any adaptations.

A good and well-maintained wheel-chair have low friction and rolls on a floor with low rolling friction. This offers extra educational value for both physically and non physically disabled students. Because of the friction involved in walking it is easy to acquire the common ”force-follow-velocity” view instead of a ”physicist” view while doing the activity mentioned above by walking. Because of the low friction in a wheel-chair very little force is required to keep it moving on a plain floor, but a considerable force is required to change its state of motion. Thus students can kinesthetically get a feeling for Newton’s first and second laws. Or as our youngest daughter (7 years old) stated while riding in a wheel-chair: ”It moves by itself”. She had thus discovered Newton’s first law by herself sitting in a wheel-chair. In figure 3 is shown a graph from the motion of a person sitting in a wheel-chair in front of a motion-sensor. Connecting different graphs with immediate experience is of great learning value. In this exercise it is of special value to feel, with our own hands, that a force is needed to change the velocity.

Another kinesthetically important exercise is shown in figure 4 there the first author is driving a wheel-chair uphill at a ramp. A student who have had the experience of trying to move a wheel-chair uphill at ramp (or to brake it downhill) will easily appreciate that work is needed to elevate a mass. This exercise can easily be varied with ramps of different gradients and letting students investigate the maximum slope they comfortable can handle uphill and downhill. Such an experiential exercise is a good starting point for a discussion about force components and free-body diagrams.

The mechanics of a wheel-chair is a good starting point for inquiry or problem based learning[17] and for connecting many mechanics concept to a real-world phenomena. A social dimension is also involved in a wheel-chair which engages and motivates many students. Many students conceives mechanics as something theoretical with little connection. A wheel-chair be used as a common thread in a mechanics course to be connected to when discussing friction, rolling friction, linear motion, rotary motion, torque, work, force components, free-body diagram, stability, center of mass (why is a wheel-chair for a grown-up less stable when used by a child?) and other mechanical concepts.

Conclusion

As discussed above it is not only possible for a student sitting in a wheel-chair to participate in many active engagement activities. Using a wheel-chair is also of *extra* value for non physically disabled students in many experiential mechanics activities since the friction is low and kinesthetic experience involved. A wheel-chair can also be used as an engaging ”tool” for connecting mechanical concepts and real-world phenomena.

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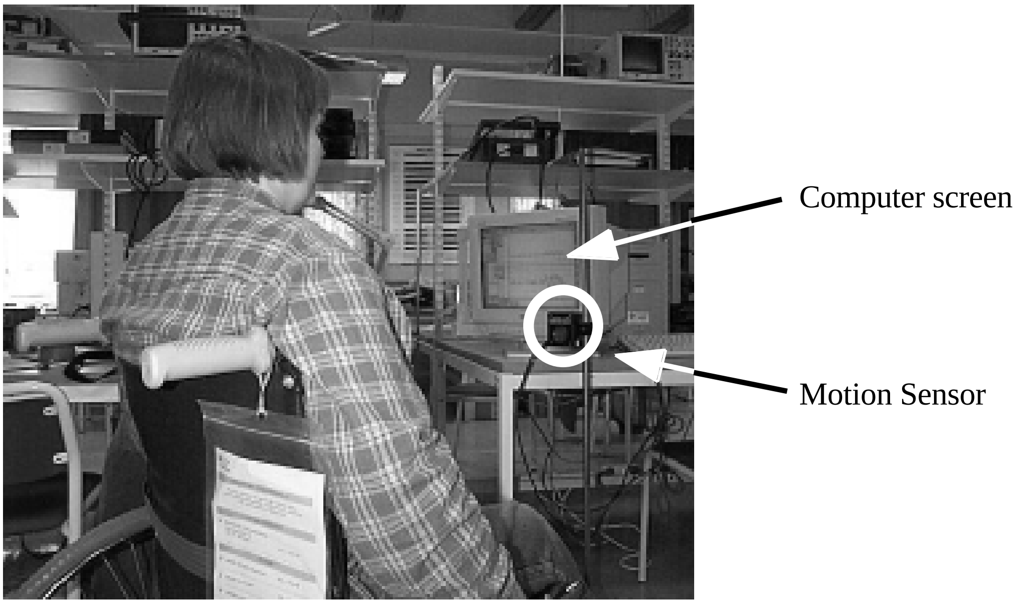

Figure 1. Kinematics experiment performed in a wheel-chair in front of a motion sensor. As seen the computer screen is arranged in such a way that the real-time graphs can be simultaneously viewed.

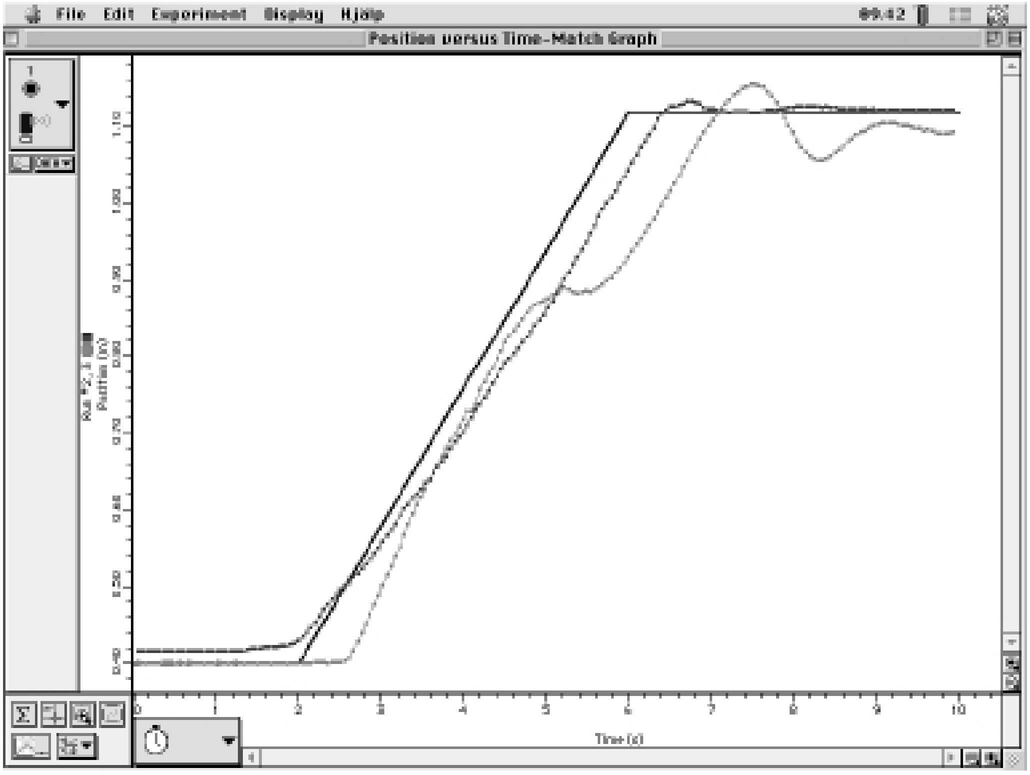

Figure 2. Matching graphs while sitting in a wheel-chair in front of a motion-detector as shown in figure 1. The student are trying to match the black solid line with his or her movement. In many curricula students are asked to match different position – time and velocity – time graphs. The activity shown are usually done by students walking in front of the motion detector and the activity is taken from PASCO activity, P01 Understanding Motion 1, without any adaptations.

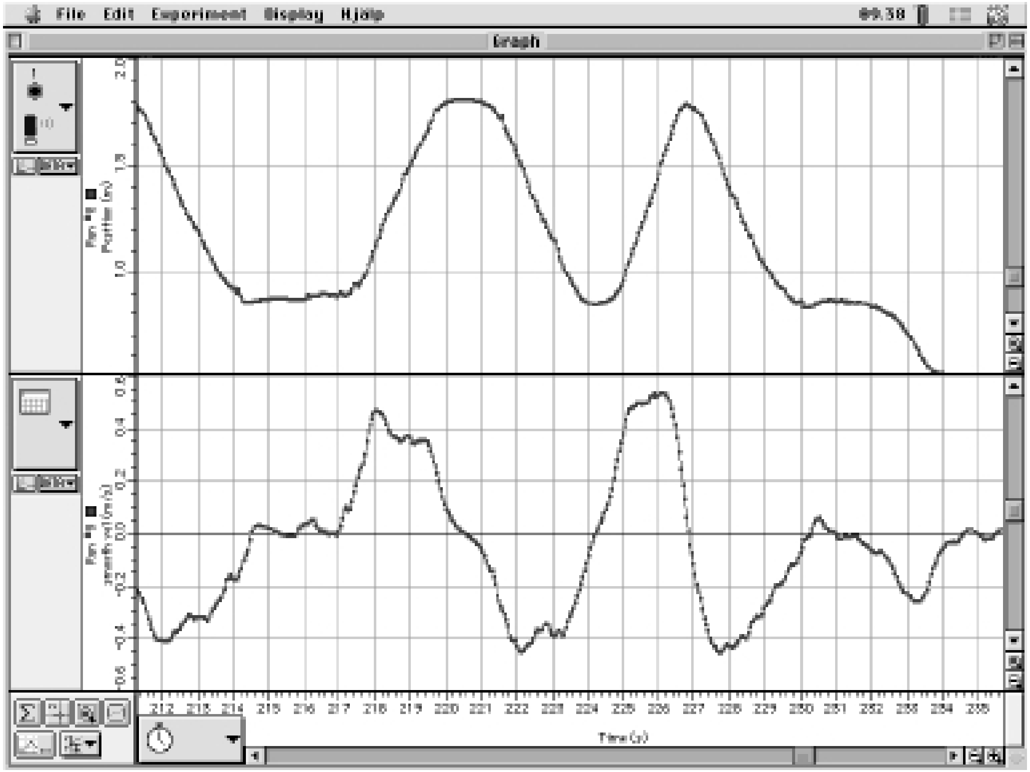

Figure 3. The graphs shows position-time and velocity-time graphs for motion of a person in a wheelchair in front of a motion detector. Connecting different graphs with immediate experience is of great learning value.

Figure 4. First author moving a wheel-chair uphill a ramp. This gives a direct kinesthetic feeling for the work involved.