PRODUCING RESOURCES AND MATERIALS FOR THE IN-SERVICE TRAINING OF PHYSICS TEACHERS.

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One of the urgent problems posed by the school reform in Italy is the in-service updating of teachers. Since year 2001 the Ministry of Education indicated procedures for teacher in-service up-dating in which the use of distance training was strongly suggested. This implies research, experimentation and dissemination of innovative models of communication.
Consequently, the General Division for the Formation and Updating of the School Personnel of the Ministry of Education (MIUR) asked for the involvement of the Teachers' Associations and Scientific Societies that were already co-operating with the Ministry in a project for developing an integrated research-and-trial of new forms of distance up-dating. For physics, the didactic resources are intended for young teachers at their first appointment in the school and/or for in-service self up-dating. The materials will be disseminated through the documentation system administrated by the National Institute for Documentation, Innovation and Educational Research (INDIRE). The author of this paper is the MIUR Technical Inspector responsible for the project.
The activities were launched by a Committee in which MIUR, AIF (Association for Physics Teaching), SAIt (Italian Astronomical Society), SIF (Italian Physical Society) and the Liceo Scientifico "Vallisneri", Lucca (responsible for the logistics and administration) were represented. In designing the activities, the Committee was guided by the following MIUR recommendations:
The didactic materials should:

- incorporate both the scientific competence of the Universities and the didactic experience of expert schoolteachers in order to promote innovation in physics teaching;
- be, when possible, interactive and in a format suitable for on-line consultation or for downloading on the teachers' personal PCs;
- suggest, if possible, a variety of activities suitable to a number of age groups in order to give support to teachers at different school levels.

The production of the materials took place in two sessions. The participants were expert teachers indicated by AIF, SAIt and SIF. The first session (17 to 21 February 2003) was devoted to planning the materials to be developed. The second session (8 to 10 April 2003) was attended by a smaller number of participants and was primarily devoted to examining and organising the materials that had been developed in the meantime.
The participants were distributed in five working groups on the following topics:

- Interaction and Motion (WG1) was lead by Rosa Maria Sperandeo (University of Palermo, first session) and by Marisa Michelini (University of Udine, second session)
- Interaction and Energy (WG2) was lead by Fabrizio Mazzucconi (Astronomical Observatory of Arcetri, Firenze)
- Electromagnetic Waves and Light (WG3) was lead by Silvia Pugliese Jona (VicePresident of AIF)
- Physics and Medicine (WG4) was lead by Silvano Sgrignoli (Steering Committee of AIF and expert teacher, first session) and by Ernesta De Masi (expert teacher, AIF, second session)
- Integrating Physics and Mathematics (WG5) was lead by Filomena Rocca (MIUR expert for modular planning and school counselling).

Furthermore, during the first working session the participants were assisted by the expert advice of Paolo Mascheretti and Anna De Ambrosis (University of Pavia).
Because of the relevant overlap in their topics, WG1 and WG2 actually worked together. WG5 exclusively worked on developing *vertical proposals*, organised according to the different school levels. All the other working groups mainly produced materials for the secondary school level.
The following table synthetically illustrates the materials developed by the five working groups.

WG1-Interaction and Motion

Trajectories in rotating reference frames

We show how to find the trajectory in a rotating reference frame once the kinematic parameters of the moving body and of the rotating frame are known, with different approaches: experiment, graphics, calculations, simulations. The unit foresees two levels. First, recalling familiar everyday contexts, we develop the concept of inertial (and not inertial) reference frame. Then we treat the dynamics, we introduce the centrifugal force and we find the formula of the Coriolis force.

Velocity and acceleration, with reference to dynamics

An experimental approach to kinematics that starts by analysing the motion (timed manually by students spaced 10 m apart) of several students who run a straight 110 m bout on the school athletic grounds. Data are represented in a space vs time graph. The activities proceed in the school lab with ultrasound motion sensors connected on-line to a PC.

A drop of water falls in oil

A drop of pure water falls in a graduated cylinder containing olive oil at room temperature. The experiment supports two levels of sophistication according to the school level and the interest and previous knowledge of the pupils.

Gases: from observations to models

We study some typical behaviours of gases, easily observed in everyday phenomena. Models are used to describe and interpret the most relevant processes and to foresee their evolution. Two main aspects of the proposal are:

- looking for answers to questions concerning how and why the phenomena evolve as they do;
- promoting teaching strategies focalised on *building* descriptive and interpretative models of real phenomena.

For a more complete description of the activity in the context of the thermal properties of matter see: http://griaf.fisica.unipa.it/termomod/Default.htm

Real time study of motion: the case of oscillations

The unit is targeted to 16+ students. It aims at integrating theoretical and experimental knowledge through phenomenological exploration from ones own body perceptions to the "almost free" oscillations of the mass-and-spring system. After studying some oscillatory motions in real time, the model that best represents the oscillations of a mass attached to a spring is found in the case of negligible friction. The special attention reserved to the elastic force acting in the system helps to confront some difficulties related with the concept of force and helps treating the kinematics and the dynamics in an integrated manner.

The bounces of a ball

The bounces of a ball are common and replicable events. They can be analysed at different levels: from a simple formal description suited to young students to a dynamical modelling achievable in the last years of secondary school. They are a starting point for an experimental analysis of a real dynamical process and for building relations between relevant variables. They can also be used to promote (or assess) the students' ability to look at real phenomena using physical models. See also: http://www.fisica.uniud.it/URDF/

WG2-Interaction and Energy

The light of an incandescent lamp

Everyone knows how to use lightbulbs but few know that fundamental concepts on electric currents are at the heart of their working. We propose four simple experiments suited to 14-16 year-old pupils for studying the light emitted by the incandescent filament of a bicycle lamp. The measurements require the use of sensors on-line with a computer. See also: http://web.uniud.it/cird/secif/ottica/ and http://www.fisica.uniud.it/GEI/GEIweb/index.htm

Light transfers energy Five simple experiments on radiant energy, suitable to 11-13 year-olds, in which low-cost materials are used in connection with a computerised measuring system with which the evolution of temperature is followed in real time. Each activity is a micro-sequence on a specific issue; each issue is related to a precise conceptual difficulty about energy associated with electromagnetic radiation and about the macroscopic effects of the interaction of radiation with matter. See also: http://web.uniud.it/cird/secif/ottica/
Thermal processes in the first two years of secondary school The activity was planned and implemented with 14-16 year-old pupils. Everyday qualitative experiences are replicated and discussed and followed by quantitative experiments. The aims are to promote the use of scientific language and to help achieving experimental abilities using low-cost or structured laboratory devices, including sensors connected to computers.
Thermal processes in the middle school In this proposal, aimed at pupils in the 11-13 year range, the relations between the perception of hot and cold, the thermal properties of materials and the mechanisms of heat transfer are investigated through explorative activities that start from everyday experience.
The "positive gravity" of air The proposal, originally targeted to the 14-16 age group, can also be used with older students. In the school lab density is usually measured as an "invariant" property of solids and liquids; gases are neglected. We describe 3 ways of measuring the density of air. Some equipment is commonly available in any school lab, some is easily built with low-cost and/or disposable materials.
Problem solving strategies in physics Solving problems is situated at the high end of the cognitive taxonomies. The experts in the field have developed operative strategies that optimise the chances of achieving the goal. Some rules and behaviours that can support students in analysing and solving physics problems are reported.

WG3-Electromagnetic waves and Light

Electromagnetic waves: unscientific ideas and conceptual difficulties A survey of the most common conceptual difficulties encountered, also at the tertiary level, when studying electromagnetism.
Electric fields and potentials: experiments and models The theoretical bases of electrostatics and magnetism are strongly abstract. A strong foundation of guided phenomenological exploration can help the students to: (a) recognise what the teacher is talking about, (b) appreciate the effectiveness of the theory that explains the phenomena and (c) acknowledge the conceptual difficulties that accompanied the development of the theory.
From electromagnetic induction to electromagnetic waves In order to reach a useful understanding of electromagnetic waves it's advisable to include in the course a careful sequence of experiments on electromagnetic induction, gradually guiding the students towards recognising the conditions that maximise wave emission and propagation.
Electromagnetic waves and matter Several phenomena in which electromagnetic waves interact with material bodies are analysed and experiments are suggested.
Experiments on electromagnetic wave propagation Familiar objects such as cellular phones, radio sets, microwave ovens, piezoelectric gas lighters, camera flashes, video-recorders are used in experiments on electromagnetic waves. The experiments can be performed in the school lab or at home.
A computer based laboratory study of the electric bell The traditional electric bell found in many school physics labs is an application of the studied theory and a useful teaching tool. Measuring voltage and magnetic field with sensors connected to a portable graphic calculator allows to "see" and discuss the transient phenomena that occur while the bell rings.

The electromagnetic brake, a simple application of Lenz's law The classical experiment in which a ring magnet slides down a metallic (not ferromagnetic) ramp is revisited.
Light: naive ideas and conceptual difficulties The most common naive ideas on light and seeing that can be found in students aged 11 to 14 are presented and discussed.
Light: waves and rays. A preventive treatment for some misunderstandings in geometrical optics Some mostly qualitative or semiquantitative activities that can be used with the students before the formal study of the properties of mirrors and lenses are presented. The main idea is to show in some relatively simple cases that the behaviour of light can be described equally well by a wave model or a ray model.
Two experiments on the propagation of light Two worksheets inspired by experiments on shadows proposed at the AIF Summer School on "Optics and real world" (2001).
Illumination between tradition and new technologies The activity was developed for an open day at the author's school with the aim to present physics to the pupils of the last year of middle school, as a subject they would study the following year. Utmost effort is made to make all the phases of the activity clear, explaining even the seemingly obvious points. With few changes the activity can serve older students too.
An experimental sequence for understanding the polarisation of light The applications of polarised light open a window on the science&technology relationship. The main phenomena are simple and easy to observe. Practical activities suitable to different school levels are suggested, using low-cost materials and sensors connected to a computer.
From analogic to digital: measurements and information Our instruments must translate measurements in a readable format; in the computerised lab this is achieved through digitalisation. Digitalisation is increasingly important in communication, too. The proposal discusses and exemplifies these topics.
Electromagnetic waves in astronomy Information from the cosmos is carried by electromagnetic waves. The role of the atmosphere in selecting which spectral components arrive on the earth's surface, the historical consequences of these limitations and the knowledge made available by the technological developments of today are discussed.
Wave modulation A multimedial lesson describes with the help of animations how information is transmitted by electromagnetic waves in the cases of amplitude and frequency modulation.
Propagation of an impulse in a material medium The dispersivity of a medium doesn't affect a monochromatic wave but does affect a wave containing different harmonics. The best known example is the dispersion of white light by a prism. In digitised communication, dispersion harms the quality of the transmission. A computer animation shows what happens.

WG4-Physics and Medicine

Is the human body a heat machine? We try to show that the "human machine" is not a heat machine. For this we compute its efficiency by comparing the energy made available by burning sugar with the work done when performing some physical activities.
Effects of electric and magnetic fields on the human nervous system Nerves transmit electric impulses, so we might think that external electric impulses can influence our nervous system. The topic is explored in its physical, chemical and biological aspects, scaling the exposition at different levels of difficulty.

Interaction of radiation and matter, a module for students at the end of secondary school The technical applications of physics are at the heart of many problematic societal issues, e.g. the uses of radiation in medical diagnosis and therapy, the electromagnetic pollution of the environment, the use of radioactive materials by the military. Citizens are asked to express their ideas on these topics that are frequently reported by the media with an unscientific approach.
The doctor's bag Many applications of physics can be found in the doctor's bag. In this multimedial proposal the doctor's instruments are analysed and the physics they contain is discussed.

WG5-Integrating Physics and Mathematics

"Astrovia" – A window on the Universe The educational role of Astronomy is particularly significant because of its strong multidisciplinarity. This sequence spanning from the 1st year of primary school to the end of secondary school offers an opportunity for researching and analysing the channels through which scientific thinking can be transmitted.**.**
A sea of waves The wave concept is an investigative tool in diverse fields of physics; its formalisation exemplifies the interrelations between physics and mathematics. This sequence from the 1st year of primary school to the end of secondary school focuses on the wavelike nature of some natural phenomena and, through steps of increasing difficulty, aims at giving the students essential tools for interpreting the world around us.
A thousand Q springs This sequence, from the 1st year of primary school to the end of secondary school, uses linear superposition as conceptual base of modern physics. The sequence foresees a continuous interplay of empirical-phenomenological and mathematical-theoretical aspects. Great attention is reserved to the related epistemological and philosophical issues.
Which geometry for which Universe The goal of this sequence is understanding the properties of space (euclidean and curved), keeping in mind that what we know about the observations made by ancient astronomers suggests that the space they hypothesised was not completely flat.

Conclusions

The production phase ended June 2003. The next steps will be the trial of the materials with teachers in different regions of Italy and, finally, their publication on the web in order to make them available to the regional school authorities and to all the Italian teachers.