GIREP newsletter

Groupe international de recherche sur l'enseignement de la physique
International Research Group on Physics Teaching
Internationaler Arbeitskreis zur Förderung des Physikunterrichts

No. 28 June 1992

GIREP '91

Teaching about Reference Frames:
from Copernicus to Einstein

The 1991 GIREP meeting was held at Nicolaus Copernicus University in Torun Poland from 19 to 24 August. Approximately two-hundred physics teachers from thirty-five countries participated. The conference focused on various aspects of introducing, developing and understanding the basic physical concepts concerning frames of reference from Copernicus to Einstein and beyond. Special attention was devoted to the present state of the art in educational approaches. Torun, where Copernicus was born and received his early education, was a most appropriate setting for the conference and participants had the oportunity to visit historical places: museums and historical sites associated with Copernicus.

Professor Wilhelmina Iwanowska, one of the University's founders, set the conference in historical perspective in her opening lecture, "The Universe of Nicolaus Copernicus". The plenary sessions, workshops, poster sessions, and informal interchanges which followed were stimulating, thought provoking, interesting and informative. Topics touched upon virtually every aspect of the theme from the meaning of a "How Long is a Second" (G. Marx, Hungary) to the "Origins of the Hot Big Bang Model" (R. Alpher, USA). Philosophical, pedagogical, and practical implications of various approaches to reference frames were discussed. The final lecture by Andrzej Wroblewski of Poland, "Children of Aristotle", brought the conference reminded participants of the long and continuing development of concepts relating to frames of reference.

Paul Black (UK) concluding his terms as president of GIREP paid tribute to the Polish organizers of the conference with his accustomed urbane elegance. It was an outstanding conference in every respect. Many thanks the organisers for it.

John Fitzgibbons, USA

This issue of the Newsletter was printed by the generous help of

the Atomic Physics Department of Eötvös University, Budapest

Future Physics Teachers
what do they get, what do they need?
PROVOCATIVE THESES

1. Studying physics leads to three types of knowledge: declarative, procedural and operational knowledge. All three types of knowledge are necessary if one wants to become a physics teacher.

2. Declarative knowledge means that the learner can memorize e.g. the speed of light, the definiton of vector product, the fact that matter is composed of atoms and molecules, Heisenberg's uncertainty relation etc. Declarative knowledge requires only a certain capacity of short-term memory. Memorizing constants, words and phrases may be sufficient to pass a multiple choice test. But this ability is no proof that one has any idea of what physics is all about.

3. Gaining procedural knowledge means emphasizing technique-drills. Learning to calculus, to write a program for the PC or to calibrate a spectrometer are activities that can be learned on a cookbook manner. Even solving so-called 'problems' as they appear at the end of chapters in text-books can often be 'solved' by just following a recipe: turn back in a few pages in the book, look for a formula in which the quantities that are given in the 'problem' appear, make some algebraic manipulation, fill in figures and come out the 'right answer'.

4. For the application of procedural knowledge the possesion of declarative knowledge is very often needed. One may need to know that E means electric field strength and that the order of magnitude of Planck's constant is 10^{-34}. However, most of the declarative knowledge required for the application of procedural knowledge can be found in physics dictionaries or encyclopedias. They are more reliable than human long-term memories.

5. The question is whether students learn physics or not. They have their physics classes and as long as memorizing facts and formulas is considered to be the main goal of physics classes, as long as teachers are satisfied with certain stockpile of declarative and procedural knowledge, they can claim that they teach and that the students learn. But it is not physics, it is results of physics that are taught and learned. It is mainly not physics as it is needed as an important tool for

(a) the intellectual and ethical development of the individual and

(b) the social and economical development of the society in the age of science and technology.

Physics teachers should realize:

Presenting subject matter	is not teaching.
Storing stuff away	is not learning.
Memorizing what is stored away	is not proof of understanding.

Understanding has to do with operational knowledge.

6. Operational knowledge involves the ability to use, apply, transform and connect declarative and procedural knowledge. It is further characterized by capacity to construct and reconstruct connections between different subdisciplines of physics and to recognize the insight where this knowledge comes from and what underlies it. All this can be put in short by saying that operational knowledge requires understanding of physics.

7. The way in which physics student teachers themselves are learning physics determines the way they teach when they are teachers, and how they use the teaching material in the class room, much more than the amount of subject matter to which they are exposed. Teachers teach as they were tought. The professors' lecture with some prearranged demonstrations and a set of additional predigested cook-book experiments in the laboratory does – in general – not provide the ability to teach in a manner that stresses inquiring, provokes logical thought, and preserves the ability to wonder. But all these are also constituents of understanding.

8. Ideas, concepts or theories need to be rooted in experience accesible to the students themselves. Students must 'see' how ideas are generated, how concepts originate and how theories come to be validited and accepted. These are hints on how to understand physics.

9. There are many levels of understanding. One and the same phenomenon of physics may be considered understood by pupils and their teachers, whereas specialists who are working at the development of a comprehensive theory including the phenomenon consider it not yet understood.

10. School must realize that is impossible to provide the pupils all the knowledge they need in their whole life time. The only viable and realistic function of school is to put the young people on their own intellectual feet and train them so that they can move. There is no subject matter in school which is more useful for this purpose than physics, if physics teachers put emphasis on operational knowledge and understanding.

11. What student teachers need at the university is what they are supposed to pass on to their pupils: give them time to explore, to manipulate, to argue about meaning and interpretation, to test, to articulate hypotheses, to make mistakes, to revise views and interpretations, to discuss them with their class mates, to look for alternatives etc. With other words: to learn from experience rather than from verbal indoctrination. If we do not change the way we teach future physics teachers, than we continue to produce 'lesson-givers' who are – in their majority – unable to present physics in a way which is accepted and understood by the vast majority of the pupils. This means that physics remains meaningless to them.

12. The understanding of physics concepts by pupils and students is very often blocked due to existence of individual preconceptions in their minds, developed by themselves and applied successfully during many years to explain and make sense out of the phenomena in the life world.

13. If the preconceptions are not made conscious and the teacher does not confront them with the concepts of physics, which they often contradict, than the preconceptions easily survive all physics courses at school and at the university. They then serve as the reasoning basis for attempts to explain physical phenomena in daily life.

14. In most cases the fact that preconceptual reasoning is utilized is masked by usage of physics vocabulary. Thus, preconceptual thinking and physics vocabulary make manifest that the learner, in place of understanding, is mislead by misconceptions, and the teachers face the fact that several years of teaching physics have left nearly no trace of operational knowledge and understanding. In other words: it was waste of time!

D. K. Nachtigall, University of Dortmund, Germany
Conference: *Education for Physics Teaching, 21-25 Sept 1992, Dortmund*

Guide to the Brave New World

When speaking about the role of physics in the school curriculum, we physics teachers used to argue proudly that physics is the base of all science subjects (from astronomy and chemistry up to geology and molecular genetics). Physics participated indeed in the development of industrial revolution and the high-tech revolution. It is true that in the Westminster Cathedral Newton has been placed in a tomb more magnificent than those of the great English kings. It is true that the inventors of transistor, tunneling diode, laser and electron microscope were honoured by Nobel prizes in physics. But the fact many of us have faced already that it is hard to convince future poets and politicians why it is utmost importance to memorize Kirchhoff's Laws.

The everyday environment of modern teenagers is surrounded by gadgets and words rooted in *modern physics*, but our *school books* do not offer a guidance in this Brave New World. A split has been created between *school physics* (of rigid bodies, direct currents, calorics, Bohr's model) and *actual physics* (of telecommunication, computation, nuclear power, climatic changes). This is why pupils are not interested in sientific or engineering carrier, do not like and do not take physics lessons in secondary school. The future prime minister may be one of these scientifically illiterate people!

Newton's causality serves as base for predictibility, it enables us to create phenomena never seen before (what means technology). Maxwell's equations enabled society to create clean and efficient network to distribute energy and information to every citizen. Without the concepts introduced by Clausius and Boltzmann we could never understand gain and loss, order and pollution. Without Heisenberg's and Schrődinger's ideas it could be hard to catch how chips work within our laptop computer. Without the story of Madame Curie, Chadwick, Fermi and Szilárd our students can not learn to live with nuclear technology. I am convinced that the message of physics is relevant to the citizens of the 21th century. Therefore it is the moral duty of school physics to offer a guide from the empirical scientific methods of Galileo, Faraday and Madame Curie through the rational reasoning of Newton, Maxwell and Heisenberg to the high-tech marvels of today and tomorrow.

GIREP's conferences always intended to assist in constructing this bridge. At former conferences Newton's Laws were coupled to the possibilities of the school computers. Nuclear education was related to nuclear power and radiation protection. Copernicus name was connected to that of Einstein. At GIREP '93 the topics will be Light and Information. It is time to think about topics to be discussed at the end of the 20th century.

From historical perspective the most important event of 1992 may be the Rio de Janeiro conference. Climatic changes, ozone hole are strongly related to transport phenomena and molecular structure. Physics–biology interface reaches from molecular bounds through quantum-jump-mutations to the risks of ionizing radiation. Consumption, comfort and baby boom are correlated to draught and greenhouse warming. Electronics and semiconductors are used to create models of neural networks and artificial intelligence. These examples are very human issues, very relevant for the economy of the nation – and they offer beautiful physics highly motivating our students.

We ask the members of GIREP: please, express your interests, send your suggestions, offer your proposals for GIREP '95, GIREP '97, GIREP '99. Do not forget: 21st century is already at the corner!

G.M.

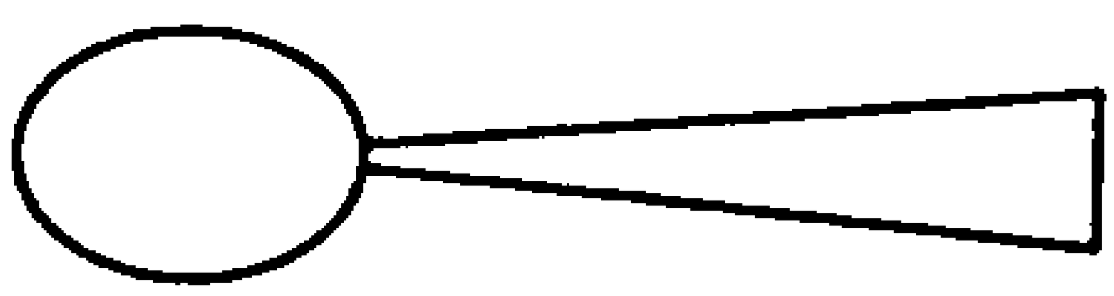
Examples from National Competitions

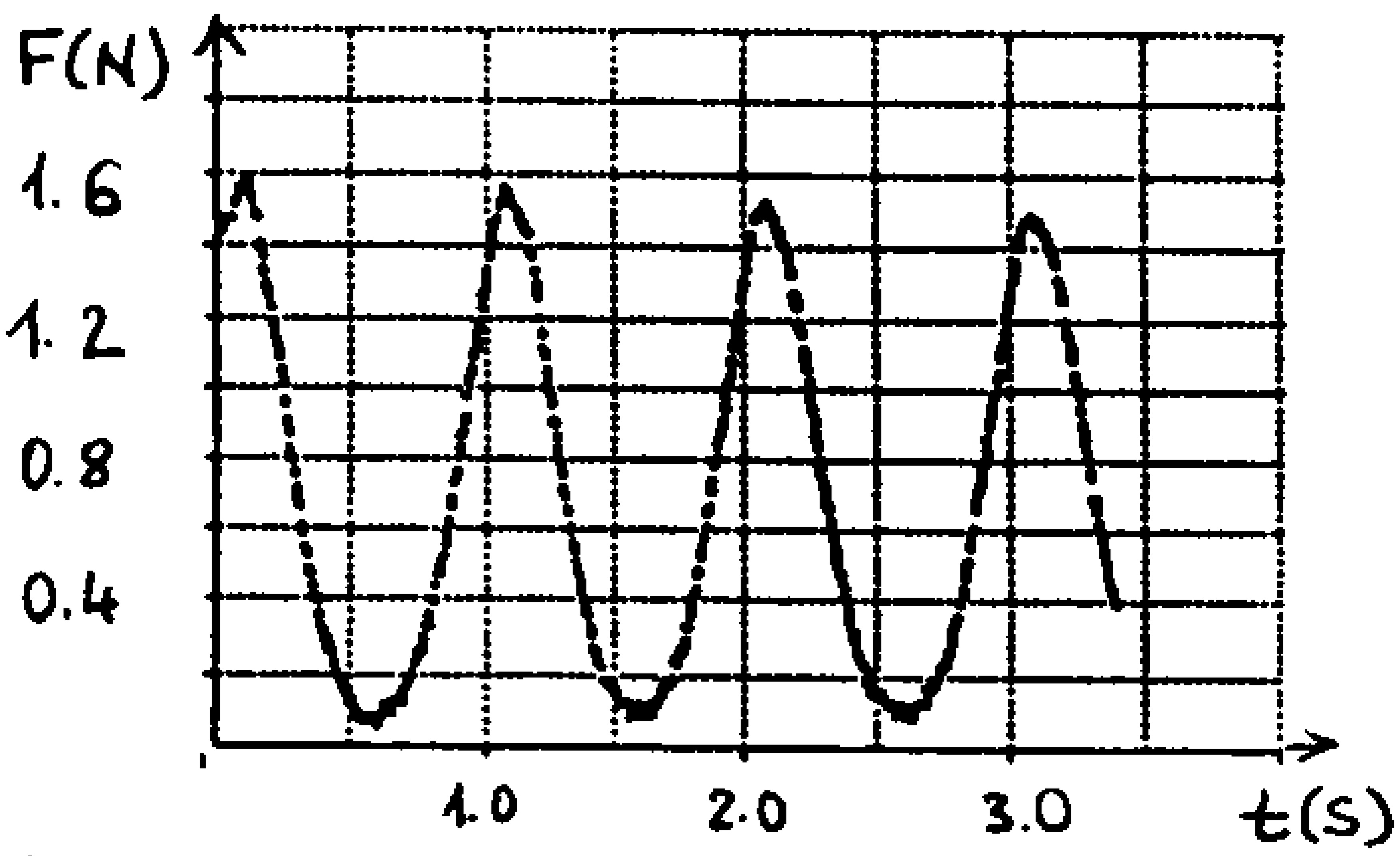
Some samples of the Second Round of Swedish National Competition

1. In order to electroplate a spoon made of brass (shown in quarter size in the figure) with silver, it is placed in a silvering bath. The spoon is silvered for 10 minutes with a current of 0.20 A. Estimate the thickness of the silver plating.

2. Two persons with different masses start from rest and go down a hill on identical bicycles without pedalling. Determine the ratio of the speeds of the bicycles when they have come down the hill if you are allowed to neglect all friction looses. Assume that the two persons have masses 40 kg and 60 kg respectively, and that each bicycle has a mass 20 kg, and that a wheel has a mass of 5 kg. (Hint: A rotating body has a kinetic energy given by $W_{rot}=0.5J\omega^2$ where J is the moment of inertia and ω is the angular velocity. For a homogenous, circular disk with radius r and mass m is $J = mr^2/2$, for a circular ring you have $J = mr^2$.)

3. With a dynamic force sensor connected to a computer you can regist rapidly varying forces. A spherical pendulum bob is hanging in a wire attached to such a sensor. The bob, drawn to the side and released, will oscillate from side to side. The figure shows the vertical component of the force in the wire varies with time.

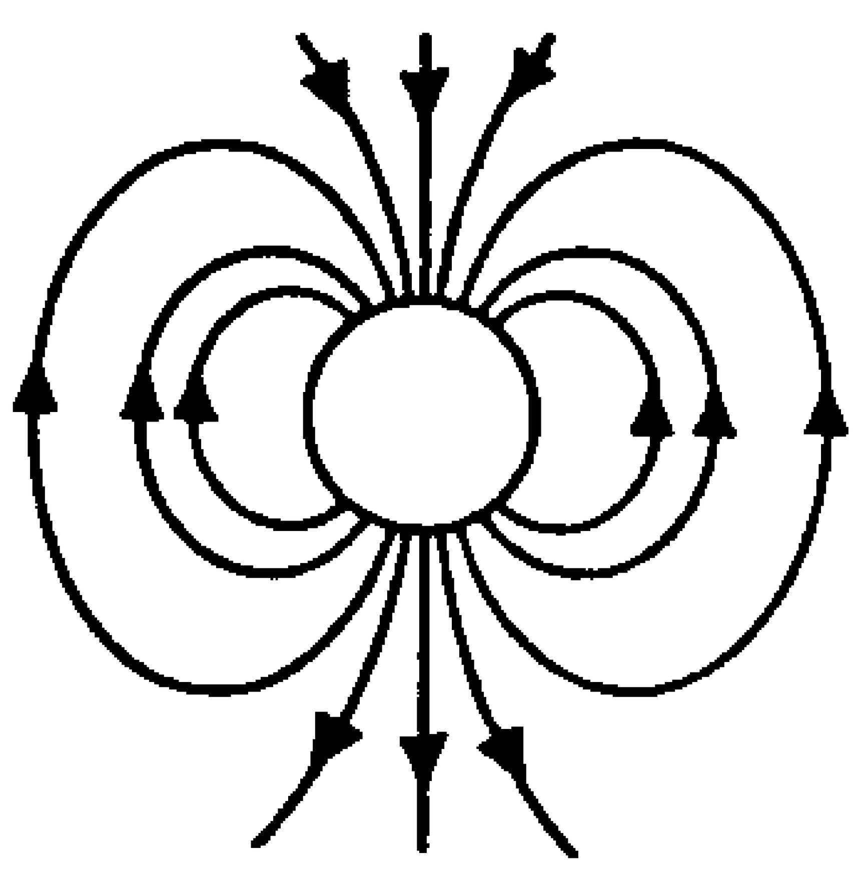




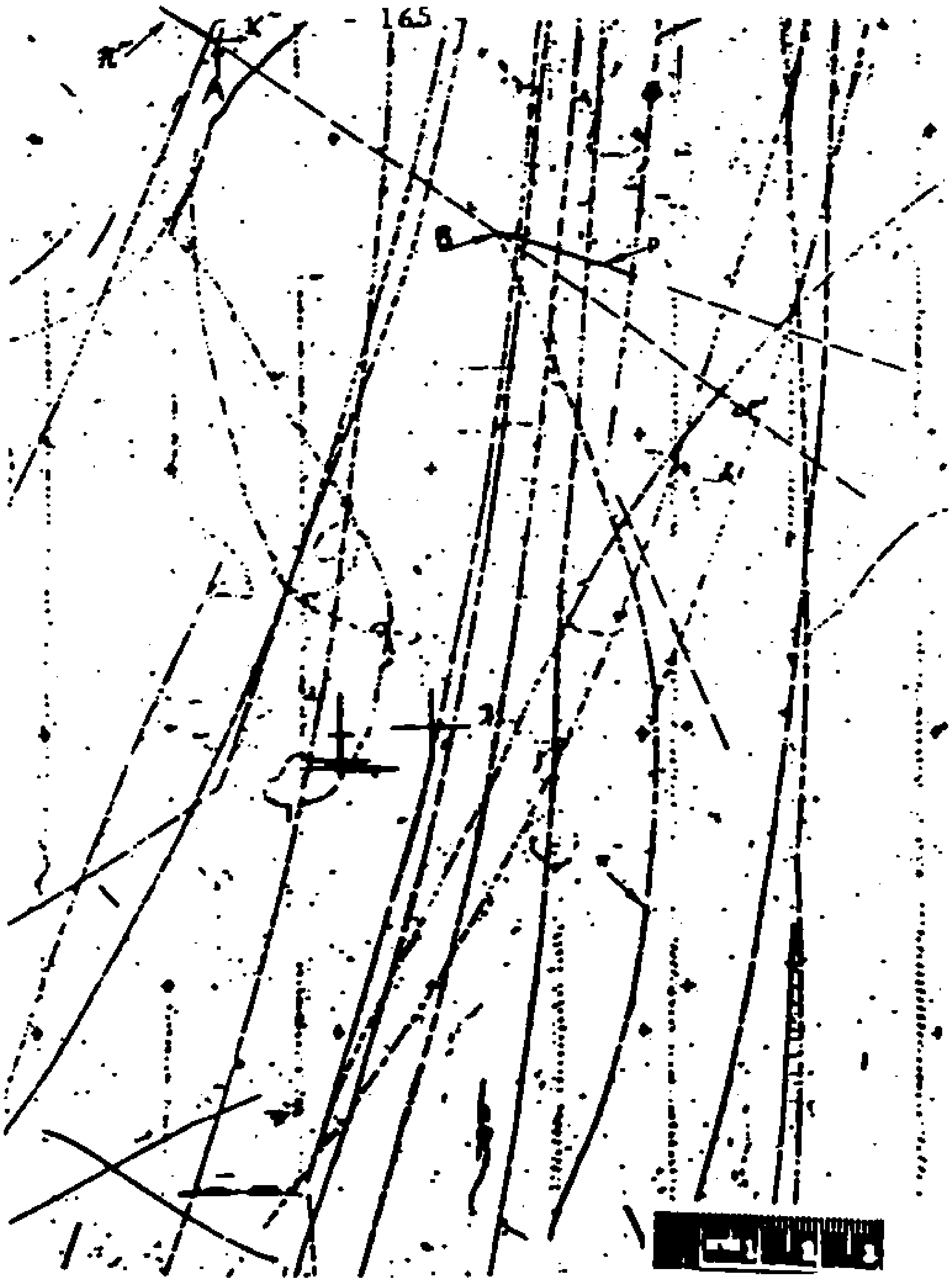
a) Determine the maximum angle between the vertical and the wire.

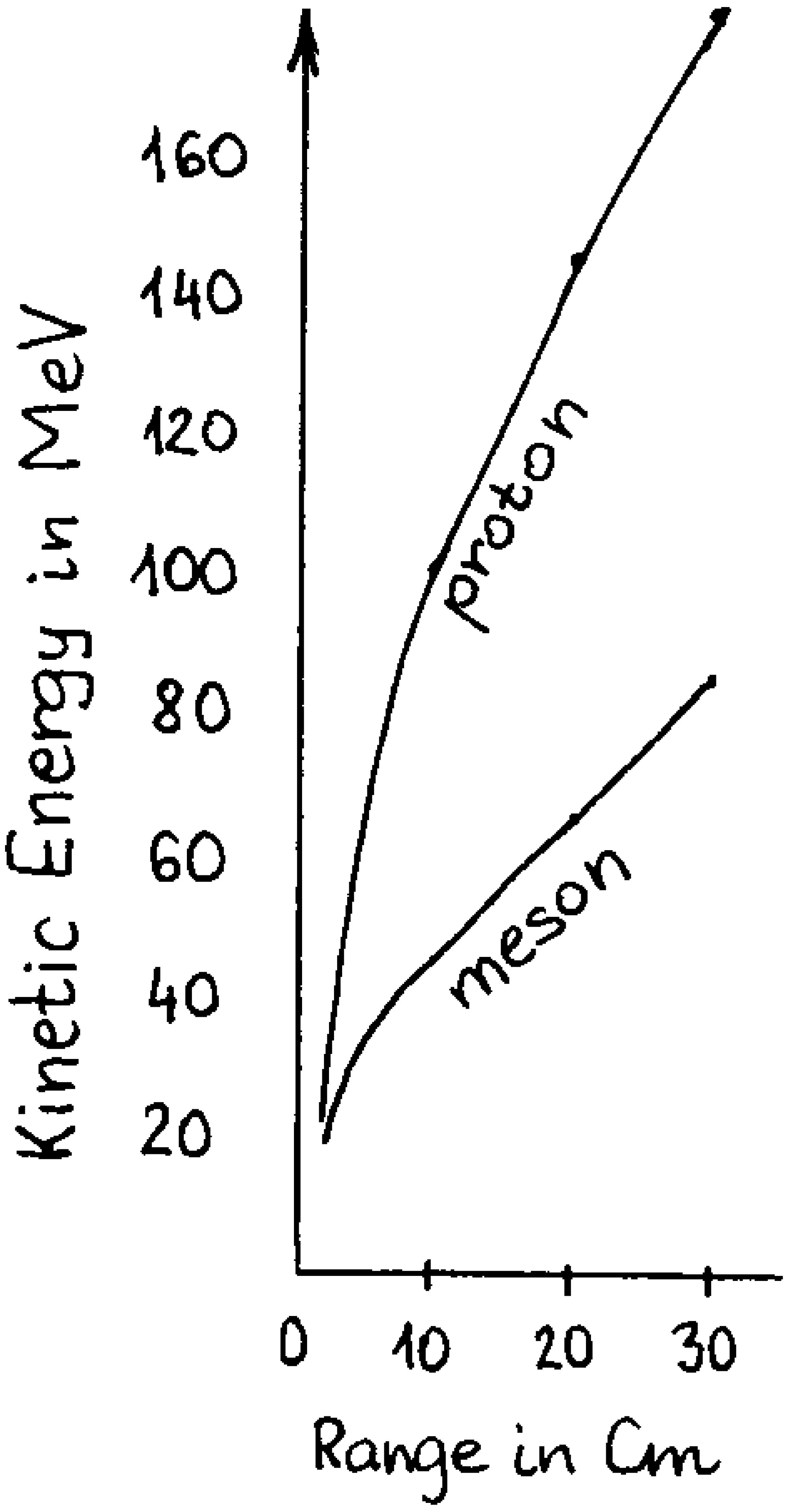
b) Determine the mass of the bob.

Neglect the influence of air resistance altough the figure shows that the oscillation is slightly damped. However, you can not use formulas for the simple mathematical pendulum as the amplitude of the oscillation is *not small.*



4. The magnetic flux density of the magnetic field of the Earth is on the average 60μT. Assume that the magnetic field is due to a circular current along the Equator in the liquid core of the Earth. The core has a radius of 3500 km. Estimate roughly the current.





5. K^- mesons enter a bubble chamber containing a mixture of organic liquids. The K^- mesons react with the protons and neutrons in the bubble chamber according to the reactions:

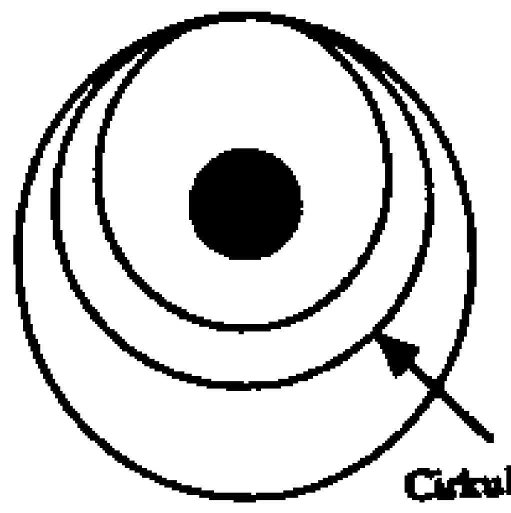
$$K^- + p \longrightarrow \Lambda^\circ + \pi^\circ.$$

$$K^- + n \longrightarrow \Lambda^\circ + \pi^-.$$

The charged particles form traces of bubbles in the chamber. The Λ particle which is created in the reaction (it does not leave any trace as it is not charged), decays after a very short time according to: $\Lambda^\circ \longrightarrow p + \pi^-$.

You see such an event in the bubble chamber picture. The Λ was created at A (according to reaction 2), it moved to B where it decayed. The dotted lines are not part of the original picture. There is a centimeter range on the picture. The diagram relates to the proton and pi-meson range (Range in Centimeters) in the buble chamber with their respective kinetic energies. Determine the mass of the lambda particle. You may use the non-relativistic expression for kinetic energy. The proton mass (in energy units mc^2) is 938 MeV, the pi-meson mass is 140 MeV.

6. Helge and Hulda are each sitting in one of two indentical space modules attached to each other. The modules move in a circular orbit around the Earth, 500 km above the surface. Helge, who is somehow clumsy, happens to trigger an explosive charge placed between the modules. The modules move in two opposite directions along a tangent of the original circular orbit. Their relative speed is 22 m/s just after the explosion.



The modules with Helge and Hulda will move in two separate elliptical orbits as shown schematically in the figure. After a while they will pass the point where the accident happened but at different times. Detemine time difference between these two times. (Here the Kepler's Laws are written for the students.)

Languages

There are languages that divide us, and there are languages that bring us together. In the International Commission on Physics Education thirteen people speak twelve different languages: Arabic, Chinese, English, French, German, Hungarian, Japenese, Polish, Portugese, Russian, Spanish, Swedish. There are, of course, hundreds and hundreds of other languages, spoken around the world. These are the languages which divide us and that make it difficult for us to understand each other as we would like to.

But there are also languages that bind us together. These are the languages of Nature and Physics, and the language of teaching and of caring for our students. It is these languages which allow us to speak with friends anywhere in the world where physics is taught. May it always be so that the things that bring us together are more powerful than the things that divide us.

Closing words of the Fuji Conference by *Leonard Jossem*

Light and Information

GIREP'93, Braga, Portugal, 1924 July 1993

The conference will be organized by the Sociedade Portuguesa fe Física in co-operation with GIREP, EPS, IUPAP and UNESCO. It will take place at the modern campus of the University of Minho. The Physics Department of the University and the Vice-Rector Prof. L. Chainho Pereira will be involved in the organization. The organizers will give a special attention to the attraction of physics teachers of the European Community and from Latin America and Eastern countries. The languages will be English and Portuguese in plenary sessions. In the workshops English is used. The lectures will be related to the following topics: historical development of the theory of light; fundamental aspects of photosynthesis; light and communication; light, eyes and medicine; artificial vision; advance in teaching of optics.

Coming Events: See the ICPE Newsletter coming in the same envelope.

Articles, notes, information to the Newsletter: Please, send these things to the Secretary directly! Correct address is on the last page of this Newsletter.

Please, do not forget your membership fee for 1992! The NewsLetter of January 1993 could be sent only those members who updated their membership – because of the increasing cost of the posting.

GENERAL INFORMATION

GIREP COMMITTEE

President: *George Marx*, Dept. Atomic Physics, Eötvös University, Puskin u. 5., 1088, Budapest, Hungary (telex 225459, tel 361-118-79-02, fax 361-118-02-06)

Vice-presidents: *Joseph Depireux*, Institute de Physique, 4000 Sart-Tilman (Liege 1), Belgium (tel 3241-563-612, fax 3241-562-355) *Silvia Pugliese Jona*, via San Nazario 22, 10015, Ivrea (Torino), Italy (tel 39-125-436-37, fax 39-125-621-872)

Secretary: Esther Tóth, Logodi u. 48, 1012 Budapest, Hungary (tel 361-175-29-43, fax 361-118-02-06)

Treasurer: Brian Davies, The Institute of Physics, 47 Belgrave Sq, London SW1X 8QX, UK (tel 44-71-235-6111, fax 44-71-259-6002)

FEES

The accounting year runs from January 1 to January 1, Fees paid after September in any year will be credited on the following year, unless the applicant specifies otherwise. – The current fee (1992) is 10 £st, **preferably paid into one of the two London accounts** or, if that is not possible, the equivalent of 10 £st in the currencies and into the accounts indicated application for (or renewal of) membership, with members paying their own bank charges and mailing costs. It is possible and advisable, in order to reduce bank expenses, to pay several years together in advance. – In cases of real difficulty of payment, please contact the Secretary who is ready to advise whether special arrangements can be made.

London accounts:

a) GIRO: Fees in £st should be made out to "Brian Davies re GIREP" GIRO Account n° 53 889 4806. This number must be quoted and the money sent to GIROBANK, c/o The Post Office, Eccleston Street BO LONDON SW11 9LS, UK. At the same time, please send a note to the Treasurer confirming how much money you sent and when and for what years. b) Non GIRO: made out to "GIREP ACCOUNT N° 90301248" and sent to the Treasurer.

Italian Account: Equivalent of 10 £st can be paid, in Italian Lire only, made out to "Marisa Michelini" and sent to: Dr Marisa Michelini, Istituto di Fisica dell'Universitá, via Campi 213/A, 41100 Modena, Italy.

APPLICATIONS AND NEW MEMBERS

Applicants for membership should, please require the Application Form from the Treasurer.

INQUIRIES – CHANGES OF ADDRESS

Please, address inquiries concerning fees to the Treasurer. Other inquiries may be addressed to the Secretary or to any other member of the Committee. Please, send notice of changes of address to the Secretary.

COPYRIGHTS ON GIREP MATERIALS