Doug Fox, Editor

Volume II, No. 4

May 1981

AAPT-ONTARIO NEWSLETTER

CONFERENCE PROGRAMME

CURRICULUM EXPERTS

NEW EXECUTIVE

AAPT - ONTARIO GROWS AND GROWS AND ....

Membership in AAPT-Ontario continues to grow at an extremely rapid rate. Our membership now stands at 430 and grows with each passing day. The most recent spurt in growth is attributable to responses from the Grade Eleven Prize Contest. This added about 120 members to our ranks.

Welcome to these new members. We are a service organization. Let us know how we can serve your needs. The benefits of membership are many. They include four issues of this newsletter and a healthy reduction in registration fees at our June Conference.

If you are not now a member but wish to be, then simply send one dollar to -

Doug Cunningham,
Bruce Peninsula District School,
Box 178,
Lion's Head, Ontario,
N0H 1W0

Your membership will be good until June, 1982. Please indicate your professional affiliation: university, CAAT, high school, other.

CONFERENCE

With this newsletter you have likely received a copy of the programme for our June Conference at the University of Toronto, June 11, 12, 13, 1981. This year's programme highlights include Doug Bannister with new physics information from the Ministry of Education, Don Whitewood with Microcomputers in the Physics Classroom, a banquet address entitled "Sientific Litteracy" by Dr. Don Ivey of U of T, tours of the facilities at U of T, Jay Ingram and Jearl Walker plus a taping of Quirks and Quarks segments and George Vanderkuur with Programmes in Physics for Gifted Students.

There will be twenty or more tables of suppliers and publishers with their wares, sixteen contributed papers on various teaching topics of interest, the latest in Physics films for viewing and plenty of opportunity for conversation with collegues new and old from all over the province and beyond.

We hope to repeat the very popular Thursday evening social again this year. We hope that those who stay in residence will plan to come early for this and that those who do not commute from too great a distance will consider this worthwhile evening as a part of the Conference not to be missed. Report to New College as stated in the programme and see the poster there for directions to the social.

Another Conference event with high appeal is "My Favourite Demonstration". If you want to share a secret of yours then tick the box on the Conference pre-registration form. During this hour physics teacher after physics teacher quickly dash to the front of the room with a bag of goodies tucked underneath their arm. They might have a device or a tale of some sort. Don't miss this one as you are sure to find lots of things of use. The time fills up rapidly so be sure to send in early.

In the centre of the programme is your form for pre-registration. Be sure to use it and to use it right away to avoid bitter disappointment.

GRADE ELEVEN PRIZE CONTEST

At the time of this writing the Contest is still a week away. There are some preliminary things about the Contest that you might want to know. We sent out about 2852 papers to 178 schools and that averages about 16 per school. A few late responses are bolstering these numbers.

If you have not yet arranged for the prize for the first placed student in your school then may we suggest a copy of The Flying Circus of Physics With Answers by Jearl Walker. Contact the Order Department at John Wiley & Sons, 22 Worcester Road, Rexdale, Ontario, M9W 1L1. Order on school letterhead or on a purchase order to receive a reduced rate for the book.

Overall results and provincial winners will be announced at the June Conference at the University of Toronto and will also be published in the Newsletter scheduled for late September.

AAPT - Ontario will award calculators to the top twelve students in the province. This is through the generous support of the following institutions: the University of Guelph, the University of Waterloo, the University of Western Ontario, the University of Windsor, Laurentian University, the University of Ottawa, the University of Toronto and Trent University. This support is very much appreciated. In addition Guelph has supplied computer time and the University of Waterloo mailing labels. Questions and other such help came from the University of Guelph, the University of Western Ontario and the University of Windsor.

CURRICULUM EXPERTS

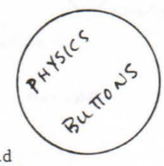
AAPT - Ontario has need of quite a number of people with curriculum expertise to work on various projects in the coming year. If you are interested in such a task then drop a line to

Doug Fox,
Belle River DHS,
Belle River, Ontario,
N0R 1A0.

Include your name, home and school addresses, the number of years experience teaching senior division physics and any other information that you feel pertinent. We need a fairly large number of people so do not feel shy about proclaiming your interest.

BUTTONS

Youth Science Foundation,
151 Slater Street, Suite 302,
Ottawa, Ontario. K1P 5N3



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A PRELIMINARY REVIEW:

PHYSICS: A PRACTICAL APPROACH Alan J. Hirsch

John Wiley and Sons Canada Limited, 1981
467 pages & appendices $_____

Alan Hirsch and John Wiley & Sons are to be commended on their production of a level four physics text. They are the first to fill the void which has existed and has been ignored for years.

The book consists of eight units entitled Preparing for Physics; Fluids; Motion Mechanical Energy and Machines; Heat Energy; Waves Sound and Music; Electricity and Electromagnetism; Light and Colour; and Atomic Physics. Six appendices complete the book.

Sample problems are often illustrated with sketches. Each chapter (23 in all) begins with a list of goals for that study section. Sample problems are scattered throughout the text and at the end of the sections are practice problems. At the end of each cahpter there are review problems. The problems which are more difficult are identified with a circle as being such. The last entry in each chapter is a set of answers to selected problems. Almost 60 experiments are also with the chapter in the sections that they pertain to. Questions at the end of each experiment try to focus attention on important points.

The type is large and well spaced. Print occupies only two thirds of the page leaving a wide margin at the right. Occasionaly this space is used for figure or notes. Conscious attempts at short sentences and easy wording is evident. Varying shades of green and grey aid the diagrams and the sketches in the book. These colours are used in the headings, titles and marginal notes as well. Photographs are plentiful (23 in a tested 100 pages) as are diagrams (63 in the same 100 pages). Many of the figures are combinations of 5 or more separate sketches to illustrate a point.

It is very difficult to criticize a text without actually having used it in the classroom. This is the final test and the only basis for a decision regarding a text. To work toward this I had five randomly selected students in grade eleven-four review the text in some detail. They rated the book an overall 9.4 out of 10 and found little fault. Two found that the language was occassionally a problem - too scientific.

Star Gazing in Summer
by Doug Cunningham

This summer, on a clear, dark, moonless night away from the light pollution of our urban areas ....

Just wander off by yourself
And look up from time to time
In perfect silence
At the stars.

Walt Whitman

One region of particular note, and certainly worthy of inspection by binoculars, is the Great Sagittarius Star Cloud. This splendid central section of our Milky Way can be viewed against the southern horizon in the late evenings of July and August. Not withstanding E.E. Barnard's comment in 1913 that "one necessarily fails in an attempt to describe this wonderful region of star masses" the imagery of some poets' verbal paint brushes gives one a reasonable preview. Consider Tennyson's imagery

...regions of lucid matter taking form
Brushes of fire, hazy gleams,
Clusters and beds of worlds, and bee like swarms
of suns and starry streams

or Robert Burnham's composition

...look now upon the River of Heaven
Sky road of the Immortals,
White with the Star-frost of a billion years.

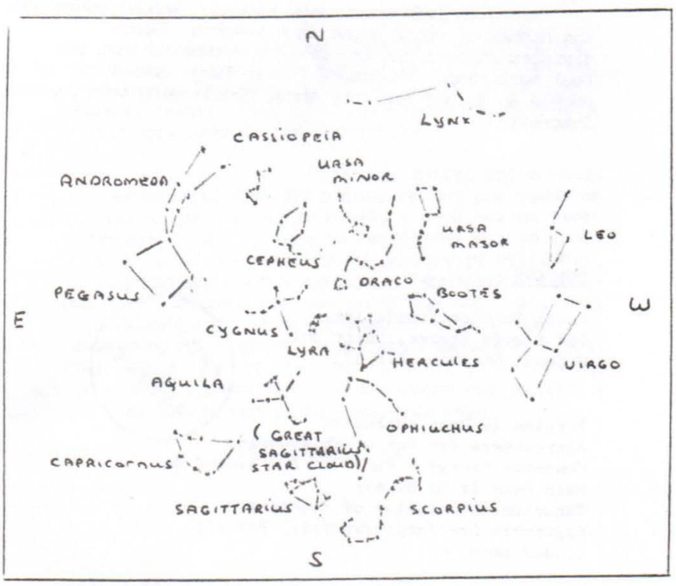
In addition to the outstanding views of our Milky Way and the summer constellations the summer skies will present a lunar eclipse on the evening of July 16th, a solar eclipse on July 30th, two occultations of stars by asteroids (June 4th and August 26th), two meteor showers, and numerous close approaches of the planets with one another and the moon. Clear skies and good observing!

June

Why a topic such as polarization and its application is continually missing from texts is something that I'll never understand. It is high in interest has many easy experiments and demonstrations, is a part of the students everyday life, shows the basic nature of light and the difference in behaviour between transvers light waves and longitudinal sound waves. This is a small point however and Hirsch has covered much ground in this text already which is of an non-traditional nature.

Can one really judge a text when it is the only one in its field? Probably not. My personal summation might be given this way - I order sets this morning for my classes next year.

The Summer Constellations



Late July : 10:00 PM

Wed. June 3	Venus 4° North of the Moon
	Mercury 3° North of the Moon
Thurs. June 4	Occultation of 7.1^m SAO 142674 by the Asteroid Antigone (10:16 EST)
Tues. June 9	Mercury 1.7°S of Venus
	First Quarter Moon
Wed. June 10	Close Approach of the Moon to Jupiter and Saturn
Wed. June 17	Full Moon
Sun. June 21	At 6:45 EST - Summer Begins
Wed. June 24	Lost Quarter Moon
Tues. June 30	Mars 4° North of the Moon

July

Wed. July 1	New Moon
Fri. July 3	Venus 1.3° North of the Moon
Tues. July 3	Close Approach of the Moon to Jupiter and Saturn
Wed. July 3	First Quarter Moon
Thurs. July 16	Full Moon
	Lunar Eclipse
	Moon Enters Penumbra 21^h 5^m EST July 16
	Moon Enters Umbra 22^h 25^m EST July 16
	Middle of Eclipse 23^h 47^m EST July 16
	Moon Leaves Umbra 1^h 8^m EST July 17
	Moon Leaves Penumbra 2^h 28^m EST July 17
Thurs. July 23	Venus 1.2°N of Regulus
Fri. July 24	Lost Quarter Moon
Tues. July 28	Delta Aquorid Meteors - Best Viewed on the morning of July 28 (20 per Hour)
	Mars 3° North of the Moon
Thurs. July 30	Jupiter 1.2° South of Saturn
	New Moon
	Solar Eclipse - The path of totality extends from the Black Sea, across the Soviet Union and eastward across the North Pacific

August

Sun. Aug. 2	Venus 2° South of the Moon
Tues. Aug. 4	Close Approach of the Moon to Jupiter and Saturn
Fri. Aug. 7	First Quarter Moon
Wed. Aug. 12	Perseid Meteor Shower (50 per Hour) Best Viewed Early Morning Aug. 12 After Moon Set.
Sat. Aug. 15	Full Moon
Sat. Aug. 22	Lost Quarter Moon
Tues. Aug. 25	Close Approach of Venus to Saturn
Wed. Aug. 26	Mars 1.4° North of the Moon
	Occultation of 8.7^m SAO 126198 by the Asteroid Artemis at 10:40 EST
Thurs. Aug. 27	Venus 0.9° South of Jupiter
Sat. Aug. 29	New Moon

NEW CURRICULA FOR HIGH SCHOOL PHYSICS

The Ministry of Education for Ontario is currently revising the Senior Division Physics outlines. The official document will not be released for about a year but usually reliable sources have informed us that it might look something like the following:

General Level - might consist of four core units of electricity, light, mechanics, and a smaller unit of nuclear. This would constitute about half the total course. The optional units might be the other half of the programme and might include astronomy, electronics, fluids, heat, machines, magnetism and electromagnetism, sound, sources of energy, or vibrations and sound waves of which about five would be chosen.

Advanced Level - might consist of three core topics of electricity mechanics and nuclear each of about equal weight and constituting a little less than half of the course. Optional topics make up the remainder of the time with some choice being offered among fluids, heat, machines, sources of energy and conservation, electronics, electromagnetism, astronomy, light and colour, models of light, sound and vibrations and waves. There might be a choice of about five from this group in a "choose one from column A..." style.

Grade thirteen - physics will, it is thought, consist of more core than the other grades. It might consist of 75% core and 25% optional topics. Core might include kinematics, dynamics, bodies in equilibrium momentum and energy, electric charge and field theory, relativity and early quantum theory. Optional topics might be circular and rotational motion, electromagnetic waves, elementary particles, quantum theory, vibrations and waves and light from which three or four might be chosen.

There is still a long road ahead in the development of these courses and their final form might not even resemble this preliminary view.

TEE-SHIRTS

If you are interested in very neat tee-shirts with physics, math and computer sayings and slogans, these are available at reasonable prices from:

Soft-Wear Unlimited International,
Star Route Box 38,
Winthrop, WA, U.S.A.,
98862

Some of the more interesting sayings are:

Neutrinos have no solidarity
The Dopplev Effect (red & blue)
There is hopeful symbolism that flags do not wave in a vacuum
Mom and Dad went to Alpha Centauri and all I got was this dumb T-shirt
Friction is a drag
Entropy isn't what it used to be
Friction is a drag
Last year I kouldn't spel Ph.D. Now I are one!
Reality is for those who can't face Science Fiction.
May the GLUON be with you
The meek shall inherit the Earth (The rest of us will escape to the stars)
Time is God's way of keeping everything from happening at once.

Send for their catalogue of more than 115 designs, each of which is illustrated.

LOST MEMBERS

Each time we mail a newsletter we find that we have lost a few members. The newsletter is returned to us as undeliverable. If you know the members listed below tell us where they are or let them know that they are lost and have them contact us. When you change your address be sure to let us know.

One nomination has been made for each of the two vacant positions on the 1981-82 Executive of AAPT-Ontario, and therefore these positions will be filled by acclamation.

George Kelly will be our new Vice-President (then President '82-'83, and Past President '83-'84). George was co-founder of AAPT-Ontario in 1979 and was heavily involved in the administrative work that was required to create the Section (preparing a constitution, planning the first conference, etc.). He has been a teacher for 27 years and a member of AAPT since 1969. At present he is the physics head at Lester B. Pearson C.I. in Scarborough. He has been active in arranging workshops for Scarborough P.D. days, and has been very involved in using P.S.E. (Personalized Student Instruction, i.e. modified Keller plan, mastery approach) in the P.S.S.C. Physics course for grade 13.

One new Member-at-Large will be Syed Ziauddin (better known to many AAPT-Ontario members as "Zee"), who is chairman of the physics department at Laurentian University. "Zee" has been very active in promoting dialogue between secondary school teachers and university faculty in the Sudbury area and in increasing AAPT-Ontario membership there. His research area is physics of the upper atmosphere and he is very interested in physics education at all levels. He worked for two summers as Director of Summer Institutes to introduce P.S.S.C. programs in schools and colleges.

AAPT-Ontario is looking forward to the leadership of George Kelly and Syed Ziauddin in strengthening and expanding the activities of the organization.

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Demonstrating interference

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Here is a way to show what happens when light from two coherent sources, e.g., two Young's slits, interferes. The rays of light from the two sources to the place in question (it is convenient often to think in terms of rays) may be represented by two cords. The heavy white cords often used for clotheslines are convenient. Alternate sections, of suitable length, are colored black and left white. The white sections may represent crests of the waves, the black, troughs.

Each cord may be fastened at one end to places a little apart. The cords are held by the other ends, stretched out, and let cross somewhere. The place at which they cross represents the place in question, at which the interference is being considered.

If there should be a white section of each cord at the place where they cross, that means, in terms of the waves, that crests from each source will meet there at a certain time. A little later, troughs from both sources will meet there, and so on. So the waves from the both sources will add in their effects; there will be what is called constructive interference. Likewise if the cords should cross where they are both black.

If, however, a white part of one cord should meet a black on the other, that would correspond to a crest from one source meeting a trough from the other. The one would counteract the other; there would be destructive interference.

It is easy, then, by moving both cords about, to have them cross at different places, and to see where there would be constructive, where destructive, interference. The former, in terms of light, would, of course, correspond to bright fringes, the latter to dark.

NOBEL PRIZE

The 1980 Nobel Prize for Physics was awarded to Val Fitch of Princeton University and James Cronin of the University of Chicago for their work on the violation of CP invariance. Their findings, first announced in 1964, have had implications for particle physics and for theories of cosmology.

Symmetry is important in physics. Not necessarily the geometrical symmetry we associate with a snowflake, but the more general symmetry, or invariance, of equations under the action of a mathematical operation. In the quantum mechanical language used in formulating particle interactions these equations have as their variables the wave functions which describe individual particles. These wave functions in turn are characterized by spatial coordinates (x,y,z), momentum coordinates, (P_x, P_y, P_z), and other attributes such as spin, charge, baryon number, etc.

The invariance of equations is important since it is linked to the conservation of those physical quantities which characterize systems of particles undergoing interactions. The conservation of momentum, for example, is related to the invariance of the Hamiltonian (the function which expresses the total energy of an isolated system of particles) under the mathematical operation consisting of a simple spatial translation; in other words, the physics does not change when you shift all x coordinates three feet to the left.

The conservation of energy and momentum are implicit in classical (pre-quantum mechanical) equations of motion. Other conservation laws, asserted only in recent times, have less physical foundation; examples of these are the conservation of parity and charge conjugation number. Parity is both a quantum number, an attribute which particles may have (even parity or odd), and a mathematical operation. To say that parity, the quantum number, is conserved in a reaction is to say that the parity of the system of particles before the interaction, whether two particles about to collide or a particle about to decay, equals the total parity of the system after the interaction. In this regard, the conservation of parity is a notion associated with the invariance of the reaction as a whole, and not with individual particles. Parity is assigned to particles on the basis of the behavior of their wave functions under the parity operation, which consists of inverting all spatial coordinates. This operation is similar to but not identical with reflection in an ordinary mirror: the parity operation reflects sets of coordinates through the origin (trades [x,y,z] for [-x,-y,-z]), while reflection in a glass mirror changes only one coordinate ([x,y,z] becomes [-x,y,z]). In particle physics, an interaction (or decay) conserves parity if it remains invariant when the wave functions of all the particles undergo the parity transformation. Until 1956 it was observed that the strong interaction (responsible for the nuclear force) conserved parity.

String and sticky tape experiments

THE PHYSICS TEACHER FEBRUARY 1978 105

Section Editor: R.D. Edge, Physics Department, University of South Carolina, Columbia, South Carolina 29208

It is truly amazing how many qualitative and quantitative physics experiments can be done with very simple equipment if you put your mind to it. There are many curious and paradoxical problems which can be solved using Bernoulli's principle. One is to get a dime off a table into a cup on the table without touching the coin. The cup must be shallow, or tilted so that the lip is about 2 cm off the top of the table, and about 2-3 cm behind the dime, which is placed 1-2 cm from the edge of the table, as shown. It looks impossible for the dime to get into the cup, but if you blow hard and suddenly, parallel to the table top, the dime hops in. As the air is blown rapidly over the top of the dime, Bernoulli's principle tells us that the pressure is lowered there, and the pressure differential between the top and bottom of the dime raises it off the table, and allows it to be blown into the cup. So much for the qualitative explanation, which will satisfy most people, but suppose we apply a little mathematics. Bernoulli's principle states that the pressure differential, p, between the top and bottom of the dime is given by

$$p = \frac{1}{2}\rho V^2$$

where ρ is the density of air (1 Kg/m^3) and V is the velocity of the air blown over the dime. Now, the area of the dime A ($2.5 \times 10^{-4} m^2$) multiplied by this pressure differential must equal the gravitational attraction on the dime, mg, if it is to rise off the table. Since the mass of the dime is 2.24 gm, the gravitational force is about 0.0224N.

So

$$mg = A\frac{1}{2}\rho\, V^2$$ and, putting in numbers,

$$0.0224 = 2.5 \times 10^{-4} \times \frac{1}{2} \times 1 \times V^2$$

This gives V = 13.4 m/sec which is 48 km/hr or 30 mph. If we perform the same trick with a quarter, we require 16 m/sec or 37 mph, and for a nickel it is 17 m/sec or 38 mph. In fact, it must be much more than this to get the coin into the cup. Our little calculation tells us a surprising fact—we can blow at least 30 to 40 mph—something you can tell any blowhards you know!

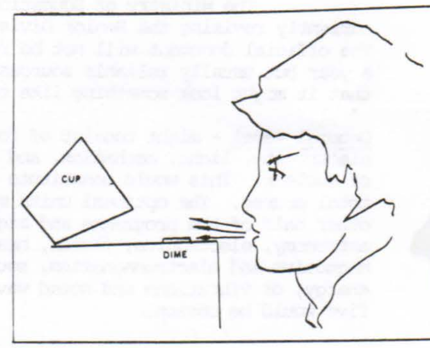

Fig. 1. Blowing the dime into the cup.

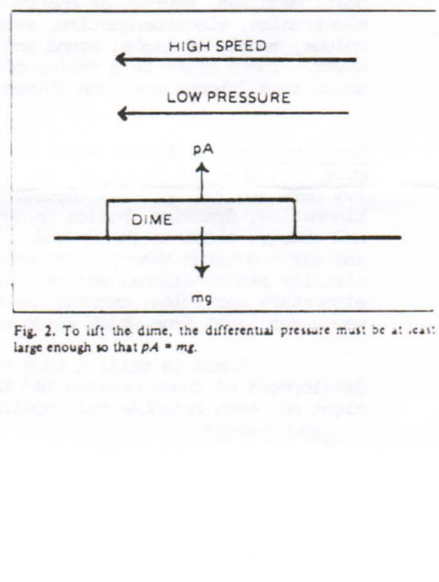

Fig. 2. To lift the dime, the differential pressure must be at least large enough so that $pA = mg$.

Center of gravity of a student

particle physics; it replaces all negative charges with positive charges and vice versa, but leaves spatial coordinates alone. This operation, in effect, exchanges particles for their antiparticles. Like parity (P), the charge conjugation operation has associated with it a quantum number (C).

Charge conjugation and parity invariance were upheld in various scattering experiments up to that time; C and P had therefore been deemed to be "conserved quantities." And then an experiment conducted in 1956 showed that parity was not conserved after all. In fact both C and P operations are violated by the "weak interaction" (responsible for radioactive decay, among other things). It was then felt that the interaction of particles would remain invariant under the combined action of parity and charge conjugation. Even CP invariance, though, was found to be violated in the K meson experiments of Fitch, Cronin, and their collaborators, James Christenson, and Rene Turlay.

This experiment, conducted at the Brookhaven AGS accelerator in 1964, observed the decays of neutral K_2 mesons. CP invariance specifies that the K_2 may decay into three pi mesons (pions) but not two. They observed, however, that one out of every 600 decays produced only two pions. This evidence for CP non-invariance was later supported by other experiments at Brookhaven and at Stanford involving other K_2 decay schemes in which the decay products included electrons or muons.

Apparently the violation of CP invariance implies the violation of T invariance. The T (time) invariance operation inverts the time variable (substitutes -t for t) in all wave functions. T invariance must be violated whenever CP is violated in order that an even more important symmetry, the triple operation of CPT, remain intact. The overthrow of CPT invariance would cause grave problems for current theories of particle interactions since it is founded upon Einstein's special theory of relativity.

The invariance or noninvariance of physical laws under the C, P, and T operations addresses the question of how symmetric the universe may be: T invariance implies that nature does not distinguish between backward and forward running reactions; P invariance implies that nature does not distunguish between left and right; C invariance implies that nature does not prefer matter to antimatter. The failure of these symmetries actually helps to promote, and not confound, the prevailing model of cosmology and elementary particles.

This theory, called the "grand unified theory," postulates, among other things, that during the early moments of the universe, shortly after the big bang, there existed many super-heavy particles, with a mass more than 10^{15} times that of the proton. These particles, known as X and $\bar{X}$ bosons, are thought to decay into quarks and leptons; the quarks then organized into baryons and antibaryons. These X bosons are therefore instrumental in creating baryons and, at a subsequent time, in destroying them. (See the article on proton decay in the particle physics chapter in this book.)

Two of the striking features of the universe are the relative scarcity of antimatter and the ratio of photons to baryons, about 10^9 (a billion to one). It is at this point that the CP noninvariance becomes important. At a very short time after the singularity of the big bang (10^{-35} sec), under conditions of high temperature (10^{28}K) and high energy (10^{15}GeV), the forces responsible for CP noninvariance are comparable to other forces. As the universe cooled production of baryons and antibaryons proceeded, but at slightly different rates, a result of the CP asymmetry. As the universe cooled further, many of the baryons and antibaryons annihilated each other in matching pairs creating in their place two photons. If the initial CP imbalance were as small as one part in a billion, the universe would eventually develop a preponderance of matter over antimatter: when, for example, one-billion-plus-one baryons interact with one billion antibaryons, what remains is one baryon, no antibaryons, and a billion photons. This scenario explains both the photon-to-baryon ratio and the scarcity of antimatter.

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Several textbooks[1] written for students in the life sciences show, in one of their problems, how the center of gravity of a person can be determined by weighing the person on a board supported by wedges on two scales, one at each end of the board. This problem is the keystone of one of our lab experiments dealing with forces, torques, and the center of gravity. The preparation time to start this lab is relatively short, particularly when workshop facilities are available to cut wood. The students enjoy it, possibly because it requires them to participate actively, and it starts them thinking about the forces and torques acting on them in daily life. Two students require the following equipment:

- one board of 2 x 6 ft plywood, 3/4 in. thick
- one bathroom scale, flat on top (no handle)
- one meter stick
- two wooden wedges, each 2 ft in length, but of different heights.

To determine the location of the center of gravity the wedges are placed near to and parallel with the ends of the board. One rests directly on the floor, the other on the bathroom scale. The wedges differ in height by the height of the bathroom scale. This ensures that the board is horizontal when laid on top of the wedges. The student of predetermined weight lies down on the board and his or her center of gravity can be determined by calculating the sum of the torques around the point where one of the wedges supports the student (Fig. 1). In this approach the weight of the board is ignored. It is our experience that some students gain sufficient insight into the problem to include the location of the center of gravity of the board and its weight – as determined by the bathroom scale – to obtain a more accurate location of the center of gravity of the student.

One can simplify the lab by allowing the students to use two bathroom scales. In that case, one can compensate for the weight of the board by adjusting the scales to read zero with the board alone resting on the scales.

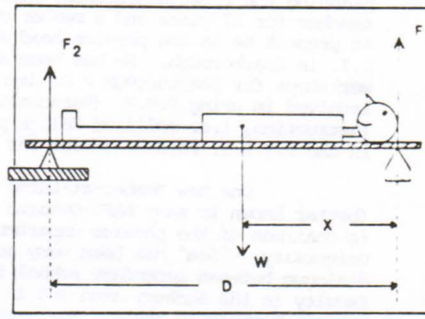

Fig. 1. The center of gravity of the student can be found from the equation $F_2 \cdot D = W \cdot X$. F_2 is read from the scale. W is the weight of the student, determined previously.

The experiment described above is a part of a more extensive lab dealing with forces.

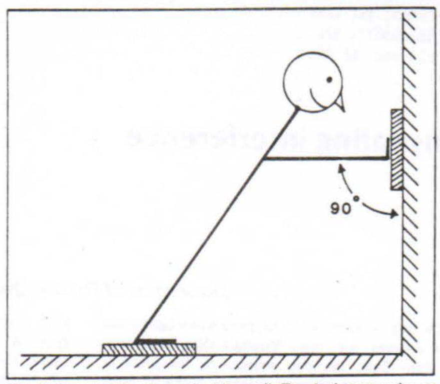

Fig. 2. A student leaning against the wall. Two bathroom scales are needed to determine all the forces that act on him in this position.

In this experiment students study the forces while standing on one scale and pushing down on a second scale located on the bench, they check their measured center of gravity by balancing on a single wedge, and locate the center of gravity of a person lying on the board with his legs straight up.

In another part of the experiment, the student leans against a wall as far as possible, as indicated in Fig. 2. Two scales are used to determine the magnitudes of the forces.

In analyzing this situation we assume that the vertical component of the force at the wall is negligible.

If "momentum and impulse" have been treated already in the course then the following experiment can be added: Ask the student to stand very quietly on the scale and let him look carefully at the scale indicator. The periodic movement that can be observed on the scale corresponding with his heart beat is a nice demonstration of how a change in momentum (of the blood) can produce a force. This principle is applied in the Ballisto cardiograph.[2]

References

1. A. H. Cromer, *Physics for the Life Sciences* (McGraw-Hill, New York), 2nd ed., p. 63.
J. Kane and M. Sternheim, *Life Sciences Physics* (John Wiley, New York), p. 78.
2. S. MacDonald and D. Burns, *Physics for the Life and Health Sciences* (Addison-Wesley, Reading, Mass.), p. 85.