Minutes of Meeting December 10-12 1956 Prof. J. L. Zacharias – Chairman
Typed Minutes

MINUTES OF MEETING

December 10 - 12 1956

Chairman Prof. J. I. Zacharias

Agenda

Import features

10:45 coffe

12:45 lunch

Dinner 6:30

Cocktails before

No after dinner arrangements but time free for informal discussion

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Let us stick to syllabus- By experience soon we get to philosophy and psychology of education

This can be done at dinner

Various groups with syllabi

Local group more work, probably

So Friedman (Cambridge) will begin with our syllabus

Then Cornell

Illinois

B. L. L.

Cal Tech

Bell Lab has made film with strip

Starting point: debate for pedagogic reasons

Optic & wave phenomena provided advantages a lot simple, have seen.

Their gross observation enough to have them started but then can go deeper.

Kinematic description here. Examples with wave treatment through film technique. No large amount of math. Long session of optics: phenomena and underlying picture. They get something of how bodies move, so we can go fast to dynamics.

Under emphasized. They come to optics too late to understand wave picture.

So we make them think in terms of waves.

Bethe: How do you go on?

Friedman: Yes, in optics & mechanics.

Optical phenomena & waves. No dynamics nor wave formula

May take up to half course

Show how to simplify, how to investigate

Kinematics runs beyond, into the motion of bodies (throwing pieces of chalk, bow and arrows). You spread kinematic and goes on dynamics

Weeks

10 1 Optic phenomena & waves

Kinematics

2 Motion of bodies & dynamics

electricity & magnetism

Dynamics

the tie back ballistic electric field

Short fields (not math or theory) Faraday field

use 1 & 2 to attack

Big submicroscopic Physics - atoms using wave & dynamics

First section of optics is geometric. Emphasis on rectilinear bundles

reflection briefly

refraction first thing slow - to vary parameters find how themselves

not statement in book that ~~under~~ index ratio is constant. Then we play with it: index refraction relative

Total internal reflection

Loomis: At the beginning no waves?

Friedman: Only empirically

Lenses from this phenomena: as technical application: cyclic nature of physical science: technological, then back to science. No theory behind all this.

Loomis: How much the activity of the student: Explain position.

At first we do without algebra. We do not think we shall have in text or fun l/p ... In problems even more than is now in texts, and we could lead them into retracing. So in problem they would do something new. In general with think in ~~ex~~class, book & movie very much cut out in course.

Rossi: Also short monographs to expand various points.

Friedman: Movie will enable to do - participate by showing simple things. We should stimulate intrest in things to do by showing simple things in film. Optics

No. 2

You throw, or you push. Some people have overemphasized direction of light.

Historical examples and controversies but not primitive man.

General pictures and see what they fit.

So No. 2 is a check list: test concept velocity - it takes time for even light to propagate

Wave picutre: you build up a lot of pictures that they don't know

No. 3

We have to take > time of emphasis. A wealth of phenomena and ways of showing which we should show:

longitudinal ripples acoustical phenomena

Major difficulty: both pictures somewhat explored: splitting refreaction and reflection hard with drilled theory - rectilinear hard: not around corners. Intereference phenomena in ripple tanks playing back & forth with light - difference in scale - wave length

Qualitative explanation fairly natural

Interference: standing waves? No all in moving waves, and end up with standing with less emphasis than in books.

Question: It bothers that you make mechanical examples before mechanics

Friedman: I want examples qualitative, not quantitative, but do not want to exclude things.

Question: Paradoxical to start with kinematic of propagate where you do not see light and things.

Rabi: The phenomena are familiar. It is an introduction into scientific method without going into causes. Show that in lab you can see phenomena coreelate by single number: the index different for different color. Medium second level after they know

They know a lot about physics if they know how to order phenomena

Dynamics abstract from experience.

Question: Example of exercise - teaching as of inductive method - if one says

Rabi: Careful elimination of irrelevant, more conclusion, than another. This has no resemblance with what is science. It is a fraud to make it think.

Zacharias: Blind alleys. You have to point them out. Still you are trying present what took world many centuries to do; the frame is for growing in format in length of time. At this time not discuss whether optic waves are > or < concrete than motion of waves.

Coffee break

Starts side 2

There are things we may not have in this kind of time schedule.

Major emphasis here: Newtonian dynamics - real clean up job. Forces predict motion - From motion go back to forces - Momentum - Planetary motion you get forces from motion.

Ballistic pendulum - you do not just conserve momentum

Kinetic theory of gas motion

From light motion pressure other interactions

Angular momentum

You have to develop some electricity and magnet before you do ballistic

Charge - Coulomb law - make macroscopic bodies like pith balls, instead of electrons first

Some want to de-emphasize the structure of matter - not driving so hard - we are working on (some we shall have done earlier)

Kinetic

Ballistic

Conservation on cosmic rays

Wave phenomena

Existence of unit entitites

Electric charge

Molecular picture - perhaps historical

Faraday Millikenwise - ~~pic~~ picture of conservation

Pauline general chemistry

Atoms using wave view of DeBroglie relations

Many have worked on parts -

Rossi - various parts = screamed

Michels - put in presentation

Opt - Purcell Ingard

Dyre Gottfried Ingard Rossi etc.

Zacharias: If we go through all we shall know where to attack.

CORNELL Hans Bethe

We deviate from traditional point as much as MIT but had 2 chemists who wanted a physics-chemistry course for 2 years rather two 1 year course

Chemists and atomic physicists so they fill classical physics later and start atomic present without much foundation.

Aims: primarily for students who will never touch physics and chemistry who will not take a further course - and would be obligatory

First year unit in itself - person who stops has idea of world around him.

Not use inductive method on purpose

Will not deduce laws. Are complementary to MIT

Small numbers and large numbers - notations of power - measures.

Ques. Evidence on matter, quantitative, Geiger counters, scintillation

Point image microscope where you see an atom, crystal surface, how arranged. Weigh amount matter in monolayer. If more surface not uniform.

Length of a molecule (big, but order of)

Nature of gases. Qualitative Kneit theory. We have seen there are atoms - now pressure, semi quantitative proportion to number of atoms, to velocity.

Use some examples over and over again.

Say rely more than proportion vs temperature.

C. Mass spectograph. Not explained field here. But assure people know if two poles. Something happens. Deflection. Introduces qualitative different masses of particles, through deflection.

Chemistry, building molecules, isotopes, lightly.

We want to discard historic, but at end historical review.

Question: Ignore multiple charge at this point.

Question: How much about structure of atom

Bethe: Later on, here nothing

Simple formulas even $\begin{matrix} H \\ CH \\ H \end{matrix}$ - rearrangement of atoms in different molecules saying this has something to do with geometry

Mass spectrograph

Standard examples

Particle Mechanics

No statics

No mechanics of big bodies except as illustration

Speed and velocity by means of graphs - simple motion, acceleration through cars - displacement and velocity rather than forces. 1 & 3 law of motion later 2. No forces on macroscopic

Accleration at right angle with velocity in electric field - _____ the voltage fundamental difference. Cornell: act of faith difference in aim structure of matter primarily, not of how science works. MIT development thinking.

Bethe: Fill in a number of points later on. Took Pauling chemistry as example, skipped many steps as physicists we would like it

Frank: Why friction?

Morrison: Point out real world

Loomis: Then why not elastic forces?

Bethe: Feeling we want to counter criticism rather than discuss these things.

E. Dynamics

Something besides electric forces - quantum theory

Formula for Bohr's radius, without saying how derived. Is first introduction of h : there are some restrictive conditions to h ... much later in the course will take it up.

Energy levels - optical measurements as a possibility, as consequence of quantum theory - introduce h again, just happens to be the same. Wave length for first time.

Questions by Loomis: Why invert your philosophy?

Bethe: We do not want to neglect education side - avoid it when gets us too off main line. We would introduce L by Rutherford experiment. Some particle mechanics, one demonstrates deflection depends on Z and how.

History - at time Nivsley only certain elements available. Filling in elements missing in the plot.

Loomis You have to mention that radical idea in atom space is empty; electrons much smaller mass.

Bethe: Can do second with mass spectrograph, interaction between atoms, and atoms of nucleus.

Should expect that energy goes up - mono atomical atoms neutral.

Notion of charge will have been introduced with mass spectrogaphy. We have Coulomb law.

Properties of atoms on ionization potential have periodic variations.

This is how we swing.

first E (mon fee z); then we take

we see not monoatomic we know from Mosley pattern

Pauling's principle the system

Question: Why not show simply that properties of chemical elements vary discont.

Bethe: Want ionization potential

Loomis

Bethe: We have already the diff

Question: Possibility Agreement

Loomis

Logical chemistry in

Rabi: Question of principle; whether this is actually a course on how world works terminal course

Can he do himself - does his understanding reflection of scientific culture - will have scientific angle. Will retain any portion? Will it be a memory course? Coherent point of view later? Power of making analysis

Discussion of spirit later

Cornell man in chemistry:

Inclusion of chemistry

Had number of syllabus - far away from adequate

Students are ready to accept atoms and molecules

Building up a consistent series of arguments you do not

Rosse: You ought to teach them language of science, not translate into their language.

All basic physics and chemistry have been presented in this course. The principles of science.

Our point of view is that we must unite physics and chemistry.

Bethe: In one year hears about matter but not about waves --- one year picture, two, understanding

Michel: Two fundamental philosophies

Cornell man: In two years we can continue chemistry and physics only if we start from atoms. It is plausible if not logical - primarily want modern physics and chemistry.

Here there is a really interweaving of chemistry and physics.

We should have this kind of structure at all levels.

Bethe: Perhaps it would be better as a two year course in college, so we could add deb_____(?)

We might have two alternative courses.

Question: Frightened at first presentation - scared students are not interested.

Bethe: 2A - you can let them do a lot of experiments, even build a Geiger counter.

Loomis: Methods of participation. The easy ones have been left out.

Question: Bear in mind: there are ways of structure of learning - teacher's training, observation in class room - organization of mechanics of learning - must be related to situation in classroom.

Question: People who take these courses may become scientists, but physicists will be negligible by comparison with engineers.

One-third of high school enrolls in physics course, not far from a million.

Rabi: Not process of learning, but process of forgetting. Very few general principles, how much can be retained.

Bethe: We have not thought much of the ability of absorbing. But not memory course, connection between various part of physics - coherent.

Rabi:

Morrison:

Bethe: Beyond No. 8 they have not been discussed by the whole group. Of different solidity.

Second year

Approach vibrations and waves differently from MIT. Vibration first, waves deductively. ~~Intere~~ Interference pattern in radar - optical application at very end.

Certain parts of course can be omitted like electromagnetic waves without touching continuity enough to initiative of individual teacher.

Last chapter nucleus - ~~xxxxx~~ ought to have in high school.

AFTERNOON

Loomis: Illinois 8 or 10 met weekly. Discussed problem. Have no syllabus or beginning. Prepared several syllabi - ~~xx;xx~~ stuck to one for a time (rather conventional) discussed where from here. So wrote several first chapters. Found syllabus hard, not been of great help; there chapters have faults, and all are terrible. May be all right. The whole problem harder than realized. Harder than exposit for higher courses. Left out the eseential ingredient, student. You ought ot have day by day contact with student.

A group at Illinois doing same for math, have seen 9th grade. Three succeeding grade. They have two young men, not eminent math - enthusiastic - under guidance of real mathematician - they are trying out first in their own high school - correct, emendat (?), try out again in other schools. Learn a great deal about what can be done. Find more abstraction. This they do in a subject easier to teach than physics.

Zacharias: Publisher re-writes.

Loomis: Any book along lines of 2 presented may be very good because radical, but may be more hard to teach. An experience of a textbook at college level. Most of teachers consider it too hard to teach.

One more point. One of the important part, effective man to have students absorb is to find means of student participation. Any new path must have new study of how to get student participation.

Some of our people spent much time on this, other than their own. One worked out script of a film on motion.

Table with friction - combine with stroboscope, falling bodies.

In our thought we begin with mechanics as the place where we can make most experiments.

Questions: Man from Illinois:

Thought nice if at end of course we could go into atmoic physics. Give the minimum necessary.

Ques. Man from Illinois

Thought nice if at end of course we could go into atomic physics. Give the minimum necessary.

Bell Lab

1 year? 2 years?

Considering reality. MIT no chemistry representation at all. Bring in chemistry noly where overlap, like kinetic theory, electrolysis contrary to Cornell idea, we do not want to leave out potential scientist, hoping fraction will decide to go on. So syllabus must give some appreciation of tools and methods for those who do not want to go on.

Methods in science emphasis

precision rather early - do mechanics early. Disagree with MIT - conservation of movement, conservation energy. Talk about electricity. So this early but overlap with atoms - perhaps in 2 weeks what course is about, structure of material. So we go back, for instance, in kinetic theory, pressure what does it mean; electricty through atoms and electrons. Then apply angular momentum.

Other Bell Lab

The goal not only beauty of physics. Here student gains contact with understanding of nature, not all intuitively obvious. Some peripheral parts of physics.

Michels: Do we have to be taught (the peripheral)

Answer: They don't have to be included, but they don't have to be excluded.

Zach: Monographs (Morrison's idea)

If calorimetry considered, important we have have a monograph written on subject.

At the end of these day we should have a list.

Is the Cornell view to have the course in form of series of monographs?

Frank: Bell Lab more close to Loomis wish. Why statics considered best place for conservation of energy?

Bell Lab: Through simple machines.

Rabi: The problem of the congressman does not know anything about science. But it is what we mean about science, we physicists, we know little about chemistry, but can get together with chemists and talk politics, family, etc. - in same way. Same culture, not others. All had some kind of experience and some science, but the way of thinking, approach to problems, has not gone over. This is one of the main aims of the course: modify the course of culture. In this respect all outline fal l short. They do not connect up to make the man who is not going to be a scientist have this approach. Difficult. Nom mersion in this culture. For us part of this process might have been dull. We have not connected with historical ideas, controversies, etc. We ought to keep this end in view.

Rossi: Question of time - one example, would like Pfoleniaic (?)

Rabi: I do not care question of time. Even if more subject matter, provided we bring judgement.

Rossi: Much of the material can be in monography

Friedin: In movie you may show some episodes and popular books.

Zach: Nobody knows what knowledge would be if things had been done differently. Maybe Rabi's point may be got across if we do several things, like monographs.

Question - Osborne: Text could be in several styles - would be in keeping with ~~wxk~~ what to do.

In submicroscopic - have for atom, then use model you had made to show all we want. Head toward atom, and then use to explain solid, liquid, etc. Heading - ride theoretic and experimental very closely. Cheap equipment. As a subsection, wave mechanics and dynamics. Do a piece of detective work to go into atom. Then have model for explaining macroscope.

Man from Cornell: Philosophy of IC methodology. Experiment and Theory. The four make up science. We cannot do them all unless we do very little pieces of science. The alternative is to take one.

Bell Lab: Aware of Rabi's points. But in reflecting how to teach; found only by examples, Many high school teachers will not see what physicists are. We ought to start talking about compromise soon.

Michels: Is science or scientists part of the culture? I think the scientist is. We build up gradually scientific intuition. Cornell was trying to bring intuition before student was ready for intuition and so was memorization.

Question: Give details in one example. Doing very slowly, then Cornell approach.

Axle: Even with 2-year course we cannot give picture of science. But we can improve quality of articles, etc.

Greieson: We want to put much more. There should be science interwoven in all other subjects. An educator in Michigan attempted to this with good results.

Rabi: Opportunity to talk of high school education.

Loomis: We want to put in course ideas we do not quite express ourselves.

Bethe: Agrees with Rabi, but to give the feeling you have to have something on which to give the feeling.

In literature, hard to be interested in life of Goeth because I do not know why I should be.

Interested in science first. Then take one field and describe approach. Give them idea of solidity of our view. But the subject matter is important. So important modern physics.

Aman: High school want what Rabi said

Don't know how - would accept any of course is reduced as ~~fa~~ feasible. Factors in structure of learning.

Assume that structure of science is hammered out

1. Fact is teacher, background. Teacher of literature better grounded than physics. Substitute teacher or give him better tools?
2. Curriculum - in high school there is congeries(?) of subject.
3. Time schedule
4. Size of class - spectrum of abilities
5. Demonstration
6. Recitation - in lab 30 children doing same thing
7. Laboratory itself - now is cookbook type. They know already what they are expected to do - no exploration
8. Extra curriculum activity by evaluation and examination

Present courses imperfect. Basic is whether we have in mind top 10% or 20%. There is no difficulty, if teacher is also of top 20%.

Zach: ~~Rxxx~~ Preparatory work at MIT

Cal Tech: Whaling only survided

Bogged in philosophy

2 or 3 ideas: 1. math emphasized - calculus

2. what is not known; somewhere you should say these models, but may be will change
3. do not slight engineering, for instance, fluid mechanics is attached to airplanes so we would like to do.

They are more interested in technology.

Syllabus

1. Mechanics

2. Kinetic theory

Display, time, velocity, acceleration, idea of differential calculus

At Cal Tech we assume that they have had no physics.

Zach: Only assumption is that students will be at Cal Tech.

Greieson: Want even more technology.

Axle: If Dubridge were to describe how a refrigerator works, would be different from high school texts. If physical principles of refrigeration, then OK. But separate.

Morrison: Impossible to explain refrigerators and planes, not even Feinman.

Cooper: Tremendous interest in ideas if teacher enthusiastic.

Zach: Film acts out something, but then some things must be said by someone feeling deeply.

Loomis: Cofernicus(?), Ptolemy would make a beautiful fim.

Osborne: Sympathy for refrigerator, but must kshow he has not set his own experiment.

Steve White

His personal story, journalist, assigned to physics

learned about physics, was getting intellectual stimulation,

aesthetic, order his life, he had learned about spirit and methods,

better debates in interest of

subject matter useless

value why people interested in a const,

So course should do things, Rabi said. High school should be exposed to material, not very important which.

So cultural primary aspect, not subject matter, this or nothing

How I don't know

Choice of subject should be subordinate to purpose. If too difficult, omit.

If question refrigeration, teacher should say, don't know but can find out.

I am trained to find out.

Question of the education of congressman.

Purcell: They should know there is difference between scientist and screwball.

Greieson: Temperary science, show that with time they change, transient; that does not mean they were wrong.

Rabi: Science is process, Congressman again.

Friedman

Whaling: Conant's book

Rabi: No, doomed to failure. All aware of the period.

Morrison: The importance of the network, the spread.

Bethe: Motivation. You (St Wh) were assigned for hug(?) sc

1. motivation to know how world is made
2. technological motivation.

December 10 Cambridge Friedman

10 wks Optical Phen & Waves

8 wks Motion of Bodies Kinetics

Motion of Bodies Dynamics

5 wks E & M Field

8 wks Sub nuclear physics

Geometric optics

- -

3. (1) Regularities

5. (2) Model

6. (3) (Extrapolation) or extension

8. (4) Limitations

Cornell

1. ~~Unity~~ Unity of Physical Science

2. Coverage

Some subject matter imp. (atoms)

4. Many independent arguments for one law

7. Ded of phen from laws

(Math)

(Conflicts)

9. New models include the old

10. Controversy and context in .....

Zach: Full meeting ended with Bell Lab cut Rabi short

Rabi: Do not want to lecture child about philosophy. Utilize strip film to give indication of altitude, how injected in demonstration. I would demonstrate phenomenon

Repat experiment with pins to have more accurate angels

Make list of

Historical point: Greeks had done same experiment

Plot angle of _____ over angle refraction, explain that if you know about points you believe you know about intermediate points - check

When have list, have all needed.

Scientists would go diff

Time of _____ Galileo

Kipler (length of spring and _____)

Science tendence: simplicity and economics

Ratio of as function pretty much linear

There is no rule how to do this. Give a few math functions. Show that sin does, cosine does not (no constant)

So law: more economically. We may express property of material with one number - So some simple property of light and matter. Aim is to find these properties. This may be interesting to student of English and History.

Question: How fully do you want whole course this way?

Rabi: This particularly good case. But I would do wherever it is a good case. In weather you do not find law. Greeks had information in refraction but not clever enough to find law.

Rossi: We should make a list of our principles and a list of examples. Zach on blackboard - erases.

Maisters: Good results with 1/3 class. Teacher should understand.

Question: Not very difficult. With these summer programs we'll reach large group of teachers.

Rabi: Newtonian explanation of refraction that light is attracted and goes faster. But there refuted. Found regularity, then the challenge is to find the model

Maisters: Iathus between ray of light and the line we draw on paper.

Rabi: See displacement. So we see that angle changes. Takes time. I do not know how much in course. But if we have such a beautiful opportunity I would take all needed time; do from all angles.

Loomis: In almost all cases in which child explores new field, nomenclature and definition is very important.

Rabi: If right class, half way I might turn classroom into lab. I was not trying to compose lecture, but just leading principles

Question: Would you let student go to wrong places and then show mistake?

Rabi: Don't know. Maybe introduce confusion, pedagogically.

Rossi: There is a step from seeing ray, and then drawing as Maisters said.

Friedman: Do you want to tell us all steps

1. Regularities
2. Model show that steps are not one after other. Sometimes go back and question previous.

Rabi: At each opportunity full advantage, push of regularities to generalization. extrapolation (Bell man: can be left to student)

Zacharias: In Bell film off set

Rabi: It would be better to eliminate effect, is complication of main line.

Axle: Have to be very careful. Careful development. If student looks ahead the whole thing will fall flat

Rabi: Teacher can say I am trying to teach something more.

Friedman: Children at least younger like to take over and over things from different angles.

Rossi: Teacher must be aware, but teacher must know so much as to bring to higher and higher levels.

Question: Useful purpose if you can reintroduce this kind of teaching regardless of time (1 or 2 yr course); is Darwin

Loomis: These are techniques - more motivation.

Question: At some time students sick and tired. Teacher then changes.

Friedman: 3 am worried; 2 ideas; one reuse of ideas

2 simplific, and then backward from simple to complicate

So now 3 is

3 extension

4 extrapolation

Question Two other acts of faith. Any experiment he would do does not give sufficient precision. He does not have apparatus. Act of faith is precision possib.e

Friedman: On 1, method of science includes also crude data. Also in film can accumulate enough precise data in front of his eyes, slow moving.

Rabi: Precision not important at this stage.

Friedman: Occasionally we can show they cannot do themselves, but we show.

Zacharias: Here feel strongly. You are dead wrong in emphasizng precision. It is a means to gain sharp ideas. We are looking precision ideas rather than data.

Question Laws are exactly right, conservaton law.

Rossi: You cannot get it completely.

Question Students who want precision must be allowed to fix it the way they want to

Zacharias: Principle.

Rabi: Teahcer can do it, show value of plot.

Illinois, Cooper: In film you can give precision data.

Rabi: Another point, with very simple means in refraction get good results of data. Falling bodies require complicated apparatus. Discussions on data, moves, tabulation scroboscope.

Rabi: I am worried about stroboscope, Galileo not have; I would not want to introduce this kind of equipment becomes distractive. Let's get ideas out with simplest possible means.

Rossi: Illustrations.

Friedman: You do not go to ideals, but go as close as possible. Historically had greater.

Rossi: Was rather intuition than experiment.

Question: Intuition often wrong, make point that inferences are reliable only to the point they have been tested.

Rabi: Story of misuse of scientific method.

Loomis: Every opportunity to point out that law good only within limits.

Loomis: Ram hom that everying is model. How far from reality?

Rossi: Limitation of sense of reality.

Loomis: Examples of universe model, how thoroughly unimportant you are. But all we know about this is through ourselves. Religious reasons.

Friedman: Models, what they learn is not unique. There can be other ways of seeing.

Rabi: Refraction beautiful case, show all other interpretations.

Friedman: If students argue, will be really interested in physics.

Bethe: Scared by transistory models; we do not emphasize solidity of physics. Fine; model has limit. This is a caution, but not give idea that we do not know what we are doing.

Rabi: Model to explain some facts, a tool.

Rossi: Hans' point is if you question model, you question reality of all physics world.

Axle: Discussion of the "Pisa" story - it is a phony.

Brandwine: Freedom of physicist to discover something new is privilege of college but in high school we go down line.

Question: How does student know it is a model.

Man(?) Used troup of teachers, as if they were students.

Zacharais:

1. 2 yr of 1 chemistry
2. 2 approahces physics
3. points of agreement
   a. inclusion what?
   b. exclusion on what grounds
4. Jobs to be done
   a. what
   b. who
   c. when

We need to hear more discussion in Cornell group to decaricature their syllabus complicated by fact that Cornell is 2 years, MIT, 1. Cornell, chemistry, MIT, not.

Rossi: Teacher ought to be allowed to go on where he can build enthusiasm.

1. A skeleton absolutely necessary

2. Other things that can be included, one or two right to

Zacharias: You want priority list. There are some musts.

Bethe: Considerable emphasis must be made in developing scientific method. Difference: emphasis and exclusiveness should not be the only objective. Is the one we heard most about. What is our outline is too full. Not one-half as full as present curriculum, but still too. To accomodate development of scientific though must sacrifice some matter.

In the working of law: objectives - unity of physical science. Best demonstrated by laws as conservation of energy: particle and wave for light and matter. Many for this unit of physics. To do this not only one subject in physics. If >one subject in physics, not all in depth. For one in depth optics is very good. But plea for many subjects - not in depth. We cannot say wherever opportunity we do as Rabi - in 1, 2, 3, occasions but not in all.

Question was raised whether subject matter is covered. It seems to me certain subjects have ti be covered. Incomplete a course without good idea of atoms and what are. Should not be at end, may be squeezed out. We cannot do justice.

Some subject matter is important. Atoms seems important.

Our group: pleax for two year inclusive course of chemistry and physics. See arguments against easier one year - involves > people.

Still like our view.

Rossi: Which chemistry essential for atoms?

Bethe: Other way around. Few important for instruction periodic chemistry better off by this foundation.

Rossi: If we do not succeed in two years, what chemistry.

Question: Teachers must learn both.

Rossi: Two years: First lot phys and little chemistry

Second lot chemistry and little physics

Loomis: Question of tactics. Then we ~~migh~~ right to think in terms of the four years and what education may eventually be. What students will enter courses? What in 9th grade general science? A group like this ought to think about the whole secondary study of science.

Kind of physics discussed ought to come first, but in general chemistry comes first. Little chemistry simpler and more by rote.

Question: World War I - more physics than chemistry - then chemistry was sold (chemistry won).

Bethe: Writes: many independent arguments for one law $\rightarrow$ solidity. Deduction of phenomena from laws Mathematics.

Maisters: Course ought to be independent, but integrated - only 1/5 would have time for two.

Azacharias: What have to do better than this.

Question: Real situation is cirriculum - have requirements.

Question: New Jersey only four hours gym is requirement, great variation in states. There is no time for everything if there are.

Bethe: Some arguments for coverage, some for coverage of modern physics. A physics law allows a number of phenomena to be deducted (unit ~~sfacpre~~x of extension)

Rossi: At some place emphasize cause and effect, dynamicatical to mechanics.

Bethe: Point not much said, in connection with Whaling: emphasis on technology disagree. But inclusion of math and development of mathematical ideas. Controversy and present time conflicts so this is the reason for present time physics rather four years of math and no science than vice versa.

Friedman: Considerable attempt to show how much we can do without math

Rossi: Except algebra

Friedman: Not much of that either

Bethe: Change in physics: explain new model include old. Do not advocate to take outline prepared.

Cooper: Model including the old: also old model may be new in small area.

Friedman: We agree.

Rabi: On one and two (two years versus one, chemistry and physics, two approaches) Chemistry can be studied with very little preparation.

For the physics we have thought physics requires little chemistry. At higher levels the two are unified.

Motivation: In this outline to unify them one distorts aim, changes standpoint that may be very confusing; little relation between dynamic and chemical reactions per table. So afraid little gained, much lost if unify here.

On emphasis, we got to get atms. How to do in way that would be solid, not a series of things. Not much logical connection. Apparatus but not atoms (experience of course that died although started with great enthusiasm. Democritus(?) atoms. Much agreement, disagreement on weight and teaching techniques.

Zacharias: Think many things we should try to teach, full body and flavor. At least best carry away well. In this list only things of which we have good understanding of; Coulomb law, Lorenz force. On other hand there are many devices, ideas, subjects not good understanding; flow of current electricity (Ohm law). We will use Ohm's law, admit how much we do not know. Use human eye, do not understand physiology of vision. In chemistry there is more items in second category; wet chemistry is mysterious, dipole forces, weak electrolytes, strong electromagnets(?) More of this in chemistry than we need to find in physics. Molecule complicated if three atoms. Familiar with H_2

Man Cornell Chemist

Many chemists feel like me. Those consulted do not teach one year of chemistry. The fact in 11 years parcels by rote, routine material, not understood. Reflected in physicists. We want to change. Importance of stressing reconsider - Outline: you see in terms of course you had

Rabi: Questions outline II atoms, molecules, molecular structure III particle mechanics. You change reference; course episodics, II does not prepare student for III.

Man Cornell Bauer

Three concepts to see in chemistry.

1. Matter has structure Differences of matter due to structure this is what attempted in II

2. There are reactions; can change structure; laws covering reaction. Idea of law. Notion of dynamic equil

Rabi agrees you don't need physics.

Cornell chemist: Let me finish - we need physics to explain ydynamic equil which very important.

Rabi interrupts

Chemist Bauer

3. Rates of reaction. What are factors? Temperature for instance Present students high school have no ideas of these factors. Missed in present curriculum.

Rabi: Why cannot give it without combning with physics?

Question: Many models derived from physics, like temperature.

Cornell chemist Bauer:

Point 2: Working in vacuum if we pretend that structure of matter does not influence property.

Simplest example vapour pressure. Measurement and plot of press against temperature.

Man Cornell on floor:

We study world around Friedinan, missed a lot of chemistry pictures at wrong place, too early. Question of how far you can go, perhaps historically not too good.

Bethe: Jump from II to II you are right but VI is structure of matter, where chemistry and physics come together.

Rabi: Chemical interest comes into reactions, structure of matter only for understanding. Achievement of chemistry is to have gone so far by the use of notions that were so hard to understand, only now become barely understandable. By and large underlying reasoning developed later, was not motivated to go ahead. At this level they are different disciplinary. At this point you are not giving chemical point of view of chemist. The student will not have the chemist historic point of view. Chemistry developed with .... He better use notions developed for chemical purposes, and that are not understood by physics. The kind of physics we want to give will not help chemistry.

Organic chemistry:

Chemistry should come after physics. It is hard to divorce it from physics. Physics can contribute enormously to teaching of chemistry; not vice versa. Teaching of chemistry changed in 20 or 30 years. You (Rabi) not speaking as modern chemisty.

Teacher High School:

Beneficial to go into chemistry from physics. Students did better in both if physics first. Kids take to separate subject argument, sounds like 1890 where Zoology and botany were separate. Inevitably the two came together; it is biology. This is evolution of a course. Competition find. Unfortunately in most high schools science teacher most science, chemistry and physics by same man. Cornell outline too difficult, but enticing. Much though. Spiral system: we start atom, asked then what disciplines needed.

Man with paralyzed hand:

Physics ~~fixk~~ first. Physics has so much to offer to chemistry. Mechan, electr, wave, atoms first. After this chemistry deeper foundation.

Goldwasser: We should say first things first, time schedule: physics first 1/2 with some exceptions, simplifies things to do this.

Zacharias: Smell law used accidentally. Not best example of a principle.... Diferences of gases, theories and Ohm's law.

Pollard: Argument for chemistry first, in physics you need much more math done well.

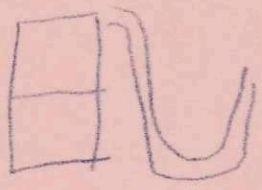
Bauer writes:

We must assume that the student knows about.

1. atoms and molecules
2. gases and liquids
3. molecules move.

   aver KE prop to T
4. there is a distribution in speeds, this must precede the point of vapor pressure. Vapor pressure as example. Gas can condense to form liquids.

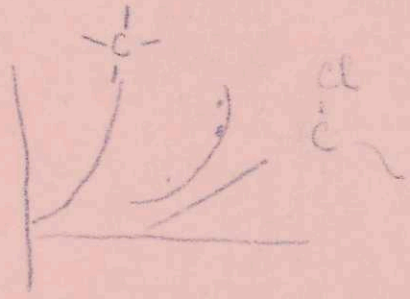
Relation between a liquid and gas (molecules are same - temperature) Experiment must be careful in designing.



Series of operations where vapor pressure as function of temperature.

a. substance

b. vapor pressure, tabulated plot is strange. Usual question about points in between, etc.



What about other liquids: There is a different molecule.

Search for proper function, find logartthm - get straight line, in Snell case is easy, here not. Something lost if too easy. Various straight lines for various substances.

Process of liquid from gas and gas from liquid are same type.

More concerned with 3 and 4. Why does law work? What are properties? Why molecules condense to form liquids. Nature of molecule, whether symmetric or not. Distribution of speeds: which molecules will escape? fast. How many are there, etc.

Real gain by talking about forces between molecules and atoms at some time, rather than a year or 2 years later.

Rabi: This fine if you want to treat vapor pressure here, at this level. Bauer given perfect lesson, but question of selection of topics.

Frank: Illusion: do we really give an understanding that high school' student can really get in different way than theory statement.

Friedman: If you do this

Rabi: This at Columbia 2nd year graduate.

Millman: At Bell's to graduate engineer.

Axle: How important vapor pressure is to chemistry. If he really wants to teach ~~kk~~ it, we could put into our course. Immediate integration does not do much good.

Slichter: Agree with Bauer; but difficulties. It is the burden of chemist to talk about structure, but physics sould do it also, perhaps macroscopic.

If we take this as an opportunity of something new, then integrate.

Suggest meritorious considerations in Bell Lab. Primarily a physics course reinforced by chemistry. But I would like personally more chemistry.

Two curricula: 1 elective of one year contains mostly outline pf hhysics

2 elective of two years with Cornell outline.

Friedman: Possibility blending. Does not need to be uniform blending. We do not have to decide proportion at each step. Agree 1st year heavy in physics and 2nd year heavy in chemistry.

When we actually work out we shall find out how to do.

Bethe: If we blend, this flexibility will exist. If we separate was impressed by remark that physics requires much more mathematical sophistication. If physics first, chemistry last, physics will lose. If present math curriculum, physics better in second year. So physics in 12th year. In our group Cornell, 2 chemists knowing what they want. Would gain in presentation. If we talk as separate course, structure of matter must be repeated in both.

Question: You talk as student is tabula vasa(?) Unrealistic. Suggesting that you may be obliged to find out how much he knows. One or two years of general science, stress on concept of function. Could be in general science. Pilot has a return plot. In general science we may suggest that child be done graph of run of information.

Major problem is to take what they have and accept.

Zacharias: Points 3 and 4 (inclusions and exclusions) Jobs to be done. If we have many points of agreement in 6 weeks or 2 months we may have another meeting.

4 first. What, Who, When last night.

Projectors: most poor, We have to take care, not in this group, Purcell will.

Placards: many things require simultaneous view of several topics with subtopics converging. It would be nice to have paper printed in color to be put on wall.

At each step test. Subsidiary ~~s~~testing and already are schools in this area prepared to test.

Loomis: Separate things in what has to be done now, what later.

Most important points of agreement.

Discussion mass spectrograph. So easy there, should be one in each school.

Friedman: Personnel. Where are people - Who - 20 high school people who might be available. People on chunks of part time rather than full time.

Five groups, uncertain about Cal Tech. So 4 or 5

Cornell almost impossible to get to.

Brandwine: Let us talk in terms of things to do rather than ~~to~~ time. People could work part time, some session.

Axle: A couple people at Illinois for 2 years.

Maisters: Two types of tasks. 1 or 2 require priority and kind of jobs if syllabus is agreed. Many of other tasks can be assigned to individual on contracts, by part time. Once syllabus 2 or 30 people from all country brought together. Given point of view. Give try out.

Loomis: Are you aiming: 1 book combined from 5 groups. 5 books? How awkward this would be.

Zacharias: Suppose we could agree on 5 things. We would be busy for a while. We would stew about implications of combined course. Oscillating.

Loomis: How to slice work?

Zacharias: One group.

Perhaps MIT would prepare optics.

Axle: Does not see why by subject, its more technique.

Zacharias: No. You write book, does not carry if then is given to film people.

Axle: I would learn how to make film.

Loomis: Axle question can be postponed yet. First some work on text. So and so has thought about a movie.

Zacharias: He should make it or his spirit is lost.

Friedman: MIT would like to do may be this is starting point for

To combine on optics way and mechanics

Syllabus

Draft of tests

Film treatment

Trial "movie" Hill shots, in audio visual type, and run sequence without details of professional filming. It is very ambitious thing.

Zacharias: Contine

Optics awaves and mechanics

As to syllabus

Draft of texts

Treatment movie

Trial movie

Keep worrying about other things. Get some interaction with high school people (2 people to help us invent, not so much testing)

Brandwine: In this discussion missed, you must build evaluation when scientist is right; what testing do you plan.

Loomis: Axle made same point.

Chauncey: Examination of tests. People who are doing work. They are the ones who ought to write questions. Terribly important to think of examination. Some time when exam you find you have accomplished something else. Some parts don't get across with the kids. The questions must be made by those who develop course. We can help by showing sample questions along these lines.

Loomis: Accept, but what surprises me you want questions before text.

Zacharias: In order to appreciate what Chancey says must examine some question of modern education exams. Physics think of exam in terms of long range goal. Variety of long range goals. Most of us feel it would take 10 - 20 years to evaluate long term effects. This not talk about now. Let's see what can do with tools available.

Loomis: You want some question who would guide in 2nd edition.

Chauncey: Yesterday and today most of discussion on physics and chemistry in course. Someone said culture important, not this. My feeling some parts important, some parts ready for developing. Content important but element. If you do that you build a scientist without explaining. What Rabi said, you are trying to develop new thought process; must be spelled out in exam as content.

Kind of thinking 1 group:

Ability to identify and delineate problem

Ability to suggest or recognize hypothesis

Ability to select procedure

Ability to select procedures for date

Ability to recognize or formulate valid conclusions

Ability to apply law logic to familiar and unfamiliar situations

Nine cause and effect relations

These relate to the kinds of mental process that may be permanent residues rather than facts learned.

Mental processes, concept, principles should stick. Congressman more able to _____ science.

Plea for though to what each topic will be in developing these kind of thoughts.

Axle: Are you suggesting this will help in evaluation of outlines? Where evaluation will start and help.

Chauncey: Evaluation would not be able to say whether achieve this aim, but whether you have made what you teach understood.

Zacharias: Testing on students must have barrage ready before we try testing. Reading questons we see it is possible to find out whether.

Chauncey: Testing can be administered to students and also control group who did not have same course.

Brandwine: Also testing the two approaches, chemistry and physics, separate, and integrate. When prepare questions? In 6 weeks but if we have ideas, put them down.

Loomis: Has anybody determined whether those objectives were accomplished?

Chauncey: Not widely used yet.

Friedman: Optics waves and mechanics, we want to overlap not necessarily 1 group, reemphasize in terms of amount work to be done, we certainly will not leave the rest out, keep on worrying. We have to cooperate with high school teachers.

Goldwasser: Illustrate thought in terms of mechanics and heat as a package. We don't need so what to start on.

Question: We know where we are going if we agree on objectives. Is the objective better understanding, mor physicists, general outlook.

Zacharias: It is for 20%, or it is bad if for 10%. Scientific approaches somewhat different from other intellectual approaches, must be understood. Russians may be they will have another industrial revolution. It does not matter.

Loomis: You address yourselves to 20% in any case, so objectives unimportant. For all do same thing.

Friedman: Same point, has thought, same to those who will go on in science and not.

Morrison: Had lousy education.

Friedman: We shall do the best anyhow. Too difficult to do 2 different things.

Brandwine:q Group is powerful, Should not do things lightly, are leaders. Don't realize effect on teaching.

Zacharias: 20% is students who are now taking physics.

Brandwine: You are talking of physics in 4 ways, future physicists, physics for culture, for housewife. This group myst say something to sustain physicist.

Loomis: These people will write text that overshoots even brightest students. We need high school teachers. Not so sure we need a definition of range of students.

Brandwine: This group should say, this is what we have in mind. But state other types of physics are fair. Other groups can develop other types of physics.

Loomis: Have no interest in educating congressmen, but don't mind doing it accidentally.

Axle: Nothing we are trying to do would be different if we are trying to write for 20% or 10% or 2. This will come from testing. Important not to make decision but would be important if we could have infromation, how much math with a certain IQ.

Question: Should this program

Zacharias: This too technical for university physicist, let's hoot, then try and see. Let's aim at 25% who take physics of these 20% of the 25% go on in science, some in physics, more in chemistry.

Bethe: Important to know we do not aim to 100%, we do not aim at 1%.

Zacharias: We know if we aim of 25% we do not harm 1% too much.

Brandwine: If you aim at 25% you can refresh your math as needed.

Zacharias: No question her daughter needs it today.

Channcey: No. 3 is the point to work on, the rest will come from here. This must be the best thing to do, put down topics, do the best can do then see if it has chemistry or more physics.

Zacharias: Follow suggestion first voiced by Rossi that we may agree on what must be in. Is there anyone who wants to say important,

Get them on first.

Zacharias: Starts on Cornell syllabus, ~~xxyxxdiscus~~

I Any discussion? Do we want as separate subject or wherever it comes up.

Brandwine: Topicallyy separate, but in teaching separate.

Other man: Separate.

Zacharias: II

A A & M All yes

B Most kinetic theory. Last item: to lead in chemistry, most there, but perhaps leave out mixture of no chemistry integraded.

C

Loomis: You have to decide whether you do atoms as combined weights, if for chemistry or protons, neutrons, and electrons if physics only.

Zacharias: C is made of 9 If its 2 years IIC-8

II C which if 1 year are must:

1, 2, 3, 6 1 year course

III Rossi suggests eliminating electric potential

Bethe wants it

Bethe potential energy

So omit electric potential but not potential, use electron - volt but not volt

IV A and half B (to Rutherford inclusive

V VI makes no sense if V has not be done

Rabi: It is good third year course if we have had 2 year course fits.

Bauer We do not do them thoroughly

Zacharias: No, all we do, we do thoroughly

Dicussion: Saying aginst backing Rabi against Bauer

Rossi Leave VI in 2 year eliminate some

VI

Discussion: We had agreed that some things would have to be taught thoroughly and some less thoroughly.

Brandwine: Course must exceed classroom. We should not give student idean that they learn all from classroom.

Loomis: Kinetic theory of gas: 3 levels pressure and temperature Bethe gave simplest yesterday: qualitative, 2nd more quantitative, 3rd and much more advanced, which Rabi says takes a year.

Bethe: We had in mind the second level. We had in mind Bolthman to point that not all atoms have velocity

Zacharais back

Cooper: We had several subjects to be emphasized, other stated.

Zacharias: On board both those to be emphasized and those not

Loomis

Zacharias

Bauer Notion of solution is important

Rabi: Hard to explain even in college hard

Bauer: Level of abstract

Rabi: Antagonistic

Bauer:

Zacharias: We agree

Cooper If we want chemistry in second year we should leave it to chemists to sa6 what they want it

Maiseters: Make the assumption first whether chemistry independent or integrated 2-year course

Zacharias Some worry about VI C Did not hear anything about present course of physics or chemistry

Bethe: Again xk for the right side the chemist will have to decide.

Question: Are you concerned with subject matter or student: Keep in mind students.

Rabi: You are forgetting students

Zacharias: We argued already on aims

Loomis: Are you planning so college can count on them to know something. You say no. But since you deal with students, you change them and then the college will be able to count on them knowing.

Brandwine

Axle Is that physics on right hand. Then if it is chemistry goes automatically on right hand

Zacharias Some things must go like Newton Law.

Loomis: What on blackboard will not help in chemistry htat have to go in the ~~b~~ writer

Brandwine Let's go on in your bedeviled way

VII A Discussion on 2nd half of A too hard for chemistry

B Basic things like magnetic forces on moving charges

C Some of the rest of VII

VIII

IX A Subject to trepidation on detail A 2, 3 ?

C91/2)

Friedman want many examples, all of C 1, a bit fo C 2, rest off altogether.

Friedman on D one must decide whether one wants to do interference I would try

D3 D6 D6 F

Meeting - 12/12/56

Zacharias: Yesterday: how choosing subjects

Leaving out heat and so on

There were informal meetings

More agreement than disagreements

Troubles ⟶ some people ?

A pure Rabi appraoch (Rabi science taught many more yearsz

C Presenting a lot of material and Euclidian approach only in very few case (Bethe) Call it Survey course Most of us for intermediate position.

Some of the topic in full detail, leaving out no appropriate step, but also some things with no detail: takes too long to say how we got nucleus

Morrison: Is tendency toward this line

Zacharias: Feeling that Masters and Brandwine sympathetic to take longer time. Intermediate B(A/3 + 2 C/3) or $(\frac{2A}{3} + \frac{C}{3})$. Predominantly survey and predominantly Rabi. Let us leave it roughly 1/a dnd 1/2 so later we shall have better feeling when we will have started to work on.

Zacharias: We may leave Rabi unhappy and chemists unhappy.

Axle: If Rabi and Bethe would write chapter they would not be too ~~xxx~~ different.

Bethe: No, easy to go to extremes. R bi would write one topic course.

Bell Lab Man: Two topics a la Rabi waves. Millman and mechanics (1/2 time) the rest on survey method.

Friedman: We got to point these most likely. Some Cambridge view: picture of atomics ... we come closer even in subjects. So we come closer to writing same thing.

Zacharias: In 5 minutes code off. One at blackboard writing down 1 year vs 2 - combining physics and chemistry/

Friedman: Feel strong. Impressed not. In long run chemistry. Now undertake mostly physics. How keep from freezing so that we conserve unity of physical science. Should we not arriave at what we do for ~~xxxxx~~ 11th grade rather 12; and encourage Bauer to do something for 2nd year. Also have strong statement that we want undergraduate course of 2 years. So we could make integration, shift some of the second into first.

Schlichter: The solitary presence of chemist. It should not be a separate endeavor. We should bring in more chemists. A few more. We are to make a revision of education. Desirable physics first, but not two separate groups ~~xxx~~ working.

Zacharias: Can spend some on chemistry; would be mistake to exclude them, but some initiative must come from chemistry, perhaps from those who have been here. It will not add much burden to physicists to revise program, after chemist done their part.

Axle: Chemists could travel around.

Zacharias: No discussion on this.

Bethe: With people we have now not possible. Good job on integration. Bad to preclude integration. What we want now is a mature course in physics. Until we see mature course in chemistry I advocate physics in 12th grade.

Morrison: We are reconstructing, effect on long range. We cannot exchange very 3 or 4 years.

Zacharias: At this point hard to kno whether we arriving 11 or 12. If not storm let us not take this point.

Question: We want to appeal to _____ We have distincly 2 disciplines, 2 different appeals. So distinguish in 2 courses.

Rossi: Outline according to ideas, concepts and facts no order

1 St ructure of matter

2 Atoms

3 Mechanics

4 Light

5 Electromagnetism

1 Molecules, gases, (kinetic theory) temperature very briefly

model for a liquid, for a crystal conductor. All of this

qualitative with possible exclusion of kinetic theory.

2 How large at, how heavy, nucleus and electrons (Rutherford)

___ of nucleus and its charge.

3 Inertia, ft - mv in 1 and 3 dimensions circular not in some detail

Planets great st ess

Mass, force, momentu, every conservation of tie back to gases, etc.

4 Geometric optics - models (discussion of value of models) waves,

Discuss interference in detail, leading to ? how can we measure

is important ?

5 Charge and Coulomb law

Mayfield qualitatively, not compute but examples

$F = \vec{E} +$ x B

Briefly electromagnetic induction on moving conductors (from

Lorenz force)

Question: Create and annihilate of matter should be ignored? Reaction, chemical and nuclear, equivalence of mass and energy.

Zacharias: Already too much. Let us chew now on a fraction of this. Then if we see we can add we will

Rossi: Now let us try to subtract, not add now

Maisters: Agree on this outline

Zacharias: We shall have monograph; one on nuclear reactions. Role of teacher, role of aids. Not purpose to present everything.

Question: You worry me with written word

Zacharias: The list of other devices

Question: Conductors, crystal and liquid removed?

Rossi: Only a few minutes, just to say that molecules are arranged in layer. We talk about conductor moving in magnetic field.

Cooper: Do not teach them separately. When you come to it you mention. So strike out Liquid Crystal and Conductor.

Axle: T as KT

Question: This is not a suggested order. Strike out last item in _____ last 2, Other things in pamphlet.

Rossi: The ~~kx~~ 2 last lines now are motors and generators.

Morrison: Only kineheat of waves. Take of strings or materials

Bethe: What about vibration?

Audience: Like vibrations better than geometric opt.

Floor: No

Zacharias: Some manufacturer may supply good pamphlets.

Question: Electrons are really particles and light really waves?

Rabi: Do you have light quantum then no point to take DeBroglie wave.

Rossi: Compton effect and DeBroglie wave? No time.

Cooper: Would like 2 theories and how came together

Rabi: Refraction

Rossi: Chapter at end with all these difficult things

Question: We are unimaginative. Discussion on high school level and graudate level.

Rabi: We want to leave student with clear idea of subject. That it is difficult. Wave-particle beautiful story but extremely difficult. Doubt sublety can be satisfactory to high school even at graduate level we laeve them unsatisfied. Theory of measure and uncertainty.

Cooper: Just because subtle idea we should introduce early. The difficulty at graduate level is that they had not exposed before.

Morrison: Modern physics is that contradictory exists. We cannot leave student idea that everything is clear.

Rabi: By clarity I mean that they understand what said. Wave-particle is unresolved, unfinished. So will not be finished for student. Would take very, very long time. Would need moment, Young's experience, light quantum sure too. Can be done. Doubt you can give that background without changing all outline and putting much more _____

Maisters: Quite possible that student be satisfied by one experience and dissatisfied by other. Learning goes on. May be satisfied with Snell law. A few weeks later encountering interference may have problems which dissatisfy him.. The two are compatible. Possible to leave him dissatisfied.

Loomis: Two confusions; studen'ts and that of modern physicists.

Rabi: After interference idea. To present other in mechanical collision, momentum. In light would have to have number of examples interference. Light quantum Compton effect. Particle idea; resolving power of microscope, lens, etc. concept of measurement of position. Lenses. What are you going to cut out. Also show that idea has application. Go back to atom, bring in Shroedinger.

Zacharias: Fortunately we have candidate for writing within this present frame work.

Zacharias: In coffee break got idea should discuss.

Frank: As I looked at material I wondered whether everybody had idea of correlation of these subjects. What are you driving at? Wolud make sense to think of material as not only teaching, but focal point of use of ideas. Area may be understanding structure of matter. This would in agreemen of Cornell. If we agreed this would be aim, focus, then subjects would be treated in reference to garget area.

Rossi: Three focal points

Structure

Universal gravitation

Light (measure this elusive)

Frank: If target atoms you leave them

Rossi: One closed, one open subject

Millman: Make clear bearly started to u

see very little of

Maisters: The more I think about process , more I think we'll come out with something useful if we think important role of monoglraph. Want world picture, every cut wounds a soul, but also method, culture job. If teecher could have picture in dramatic way, their job is to put spot light on some areas or in all if there is time. Teacher says: Are you interested in this? Here is a monograph. We ought not to abandon either extremes: Rabi and survey, and then let room for variation. Students vary. Some must be fed with motors applications. Some waves etc. Not all for everybody. The Cornell sweep of everything in monographs. The Rabi in the classroom.

Loomis: We have to drive ~~forc~~ fairly fast on what each group should do. This steam of things on blackboard is one attempt. A few alternatives ~~Write difference~~ Write different conceptl. Three parts or wholes of physics, mechanics, substantial

light, could also stand on itself.

These only twi choices to start. Third leading up to atoms.

Rossi: Three focal points

Structure

Universal gravitation } bind together

Light (measure this elusive)

Frank: If target atoms you leave them with idea so much to learn

Rossi: One closed, one open subject

Millman: Make clear bearly started to understand matter. They will see very little of

Maisters: The more I think about process going on here, more I think we'll come out with something useful if we think important role of monoglraph. Want world picture, every cut wounds a soul, but also method, culture job. If teecher could have picture in dramatic way, their job is to put spot light on some areas or in all if there is time. Teacher says: Are you interested in this? Here is a monograph. We ought not to abandon either extremes: Rabi and survey, and then let room for variation. Students vary. Some must be fed with motors applications. Some waves etc. Not all for everybody. The Cornell sweep of everything in monographs. The Rabi in the classroom.

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These only twi choices to start. Third leading up to atoms.

Another approach is Cornell's, that difficult although historical. Would use mechanics and light as building blocks. MIT could take light and make a course or half a course. Another group the others.

Bethe: Most happy to hear Frank; first good word for Cornell. In thorough way only in way we did. If we really focus on atoms two year course and lot of things. If leading to atoms, then Rossi outline.

Rossi: Order of material needed for assignment, could one ~~them~~ focus attention begin by giving atomic approach without dynamics. then chemical idea. Does not r;quire anything, then light and mechanics and bring in all we can about atoms. Then electronics. Not clear how much atom at beginning.

Bethe: Part 2.

Rossi: In part 2 you assume magnetic deflection, how much with less than you proposed.

Morrison: To begin ~~with~~ mechanics, it was important in 18th century. There is no other way but cope with idea of science. May be in some year with satellite interest go back to mechanics.

Millman: This closer to Bell Lab syllabus. No obvious advantage for the understanding of mechanics to have light first.

Friedman: You can give enough dynamical feeling (pushes, shoves) without force in light. So you can do kinematics.

Rabi: Outline that may combine, assume to begin with existence of atoms then say qualitative great deal about matter gas, gas press, solids, si.... of atom

Rossi: How sure

Rabi: Tell it is small, without explaining. Then there are different atoms, chemical and physical colors, insulators, conductors, liquids, hardness, melting point. Then talk these atoms differ because structure differs. Prove existence of atoms by some of these differences. External effects: most important light: Inside atoms only by effects. This is provoking curiosity, including possible experimental proofs at time, light as beam?

Rabi: Know not what method for showing, etc.

Rossi: Agree

Morrison: It is just what inituitively want. What we objected was from here to go to mechan. If you go do light very well. Gives good motivation.

Rabi: Attitude of teachers in Snell then is this both nature of atom and wave, etc.

Loomis: Requires cleverness. After light cold shower if you give mechanics.

Rabi: Start mechanics by saying internal moving parts. Cannot describe without mechanics.

Loomis: Assignment independent of order.

Bethe: Disagree. Knowledge of method/

Axle: Inconceivable for group to accept pieces without version. Job of version negligible with that of putting mechanics into paper.

Osborne: Mechanics avoided by postponement. First, everyone would want semi-quantitative way.

Rossi: When I do mass in mechanics I would like to say is approximately neutrons + photons.

Copper: Mechanics later because most difficult mathematically.

Friedman: Despite diversions. Bruno's and Rabi now. We can go on.

Schlichter: Be glad to have a crack at this part of introductory. Cooper will do - no backing

Outline

1. Atoms
2. Light
3. Mechanics including Coulomb and Lorentz
4. Atoms

How much criticism for leaving out currents, bells, etc.

Loomis: Introduce state focus. Say if you want college course go to college.

Zacharias: Sure can pay for monograph.

Rabi: Adds a No. 5 macorscopic. Don't know what: heat? currents? motors? Kinetic theory between 2 and 3?

Friedman: Having atoms, kinetic theory as one example of thorough Two atoms woven in, so lot information all through course.

Floor: Consequence of approach always atoms in mind rather than bodies.

Friedman: Each group 2 sections and over lapping. So fellows who do atoms should see how go into light

Floor: Group 1 and 2

Group 2 and 3

Group 3 and 4, etc.

Rossi: Before writing very detailed outline 10 pages for each section.

Discussion: phrase, paragraph, possibility

Maisters: In lower grades done before. Teachers often have left hand ideas They are:

Ideas	Teacher	Student
	Demonstration	Activity that kids can do

Suggest this.

Osborne: Take in mind laboratory, have thought of experiments on atoms. Expense would influence in selection of experiments. This would influence text.

Zacharias: In terms of apparatus we wwere modest. A few thousand dollars expense for each high school. Doubt if 30th possible.

Osborne: In making experiment, used cathode tube often. How expensive? But then arrived at atoms not historically.

Morrison: Want O section. Counting and measurement. Want? or wnat when needed?

Rabi: Often you try some quantitative section.

Little: Can be spread out in parts.

Rabi: Not meaningful at beginning.

Morrison: Number. Can you count beyond? Large, big, ...

Zacharias: Measurement qualitative, symmetry, yes, no, left, right.

Rabi: Psychologically wrong at beginning.

Rossi: Why not call target area universe rather than atoms, then give feeling of sizes. 1 then is universe and other things. Bell does not want 1 any more.

Axle: Bell can do what plan. Morrison would go on with sure.

Rabi: Actually you stay on atoms.

Rossi: Give idea of what is number of atoms.

Cooper: On 4. Quantitative atom. What you teach?

Rossi: Bethe on Bohr atom and planetary. Better than nothing? Not decided. Two or 3 groups should take 4.

Bethe: In what sense do we take 4? We are busy people who are willing to give ideas. Not suitable for writing but may do 15 page outline.

Audience: Let us _____ us only for 15 page outline.

Zacharias: Plus. You'll try get people to write. Must be good high school teacher. When put down ideas, keep in mind other 2 columns. No law against taking from specially good book. Bohr has written some clear things.

Morrison: Where?

Schlichter: In making outline individual puts his slant. Must not be under pressure to dictate.

Rossi: We have changed ideas. This merit of coming together.

Zacharias: Back to assignments.

Bell Lab takes atom part of universe.

Phil Morrison, atoms and universe

Cornell does 1 and 4

MIT 2 and 3

Cooper wave particle duality

Ill MIT → 3 mech

Bell Lab mechanical waves

Osborne and Caldwell 4

Suggestions and discussion of 5

Loomis: Question to Bethe. Kinetic theory. Would write disregarding fact that light has torque.

Bethe: Process of scientific reasoning introduced in stage. If you write mechanics without showing scientific process to more slowly.

Zacharias: Kids want to know same questions again, again. You can paint thing over on another topic.

Question: People learn slowly.

Whaling: Instruction: Cal Tech. we can write monographs. Exist in Femian's lectures. If they are agove students; heads. We would like technological monographs. Femian has notes. Will try to write them out.

Zacharias: Technological then will be Nebrila

Question: Section 5 can be all monograph?

Morrison: Two or 3 diverse and short monographs presented as 5.

Maisters: Cornell outline would be better as resource book. Cornell book on the type of H. G. Wells. Maisters one of goalss.

Chemistry question again. Combining very much spherical symmetry.

Rabi: Do not forget that other parts. Historical parts. Ask some science historians.

Zacharias: Monographs and people. Recommendations.

Morrison: List of Scientific Americans

Rabi: Overall editor - staff.

Zacharias: Bert Little at this time.

Loomis: Get students back in this picture. We would like at early stage to try on students. We would like to start next September. We would have easy support from education. This element should be brought in.

Maisters: Don't forget teacher.

Zacharias: Try to get this teacher right now.

Axle: We would like suggestions.

Question: When you meet with outline bring in teachers of physics. Those who will teach it.

Loomis: Two points, 1 - trying, 1 - bring many in committee.

Zacharias: Not hard here. Cal Teach 2 courses:

1. Elucidating a book as a course for geachers
2. Atoms and molecules

Cornell, would you like to do something in this line?

Salmen(?): Johnson. If you ask him start right away. Has thought along these lines. Then go on to teaching.

Zacharias: Rabi, is it possible find somebody at Columbia to work with Maisters?

Maisters: Would like 1 man.

Axle: We want man to come after class, then tell us what happened.

Morrison: A center set up at physical socity.

Zacharias: With bar?

Morrison: Beginning of a permanent staff.

Osborne: Inclusion of special relativity, with just algebra. Done with freshmen. Talk back, question, understand something that Einstein did, is very exciting. So Osborne does it.

Axle: Need not say now, but may want a 1 or 1-1/2 day meeting in New York. Sunday, the day after meeting, 30-31 Jan, 1-2 Feb, Meet on 3 if we want to meet.

Axle: If Fran has a film we all want to see. If some of White film.

Zacharias: We can easily find a room.

Loomis: Maybe in hotel.

Chauncey: Trying material premature. When outline comes in people must agree is it. Then small group with psychol, film etc., and look at different ways of accomplishing outline. Then write up and try with your students.

Zacharias: Target date for outlines physical society meeting. Should we meet after lunch?

Question: Organizations of superintendents, of principals, etc. Should be involved in implementation.

Zacharias: Point is, when?

R bi: At very next meeting of this group. So they have feeling they will be in the process.

Zacharias: Target is in ~~1~~18 months. Perhaps not able.

Rabi: They must be in process.

Zacharias: OK. Perhaps a meeting for that purpose but not one of our meetings.

Maisters: Meeting with structure.