

**THE CORRELATION OF HIGH SCHOOL AND COLLEGE PHYSICS.\***

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During the past twenty years, through college entrance examinations, college entrance requirements, and syllabi originating largely with college men, the colleges have as a whole exercised a large influence, perhaps we might even say a control, over the character of the course in physics given in the secondary schools. I do not intend to attempt to balance the good and evil which has resulted from this situation. Suffice it to say that there is doubtless a tendency to underestimate the good and overestimate the evil, since it is easy to attribute everything which is bad in present conditions to this influence, while it is equally easy to be oblivious of the good. Indeed, we should be in position to correctly estimate the good only if we could know what sort of physics would have been taught to-day in our high schools if college influences had been absent.

The problem which is assigned to me this afternoon is that of attempting to point out how college and high school physics may be made to fit together better than they do to-day. I cannot well do this without defining in some way the field of each. I confess this is a task which I am loath to undertake, for, unless I can take the time to go over with you in minute detail outlines of both courses—a procedure which time obviously forbids—I am in very grave danger of precipitating one of those profitless discussions which arise from misunderstandings. Indeed, it seems well-nigh impossible to avoid discussions of this sort so long as we speak *in general terms* of the aims and methods of physics. It is only when we discuss the *details* of our courses that we discover just what our fundamental differences really are, and, I may add also, how small they are. I am aware that here and there one may feel that to minimize these differences is to cry, "Peace, peace, when there is no peace;" and yet, despite the floods of extravagant denunciation of all physics which occasionally break loose in our journals, it is a most remarkable fact that, in general, when the denouncer makes his denunciation concrete (which is far too seldom the case) he de-

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nounces something of which practically nobody is guilty, and when, on the positive side, he gives *concrete illustrations* of what he means by "vitalizing physics" he brings forward some of the pet illustrations of nine tenths of the rest of us physics teachers. I have recently seen a list of illustrations of this sort fully three fourths of which are found in practically all of the standard elementary texts. Again it is a notable fact that the most striking characteristic of the various outlines of units which have been put forward by the several parties in our physics discussions—by the "terrible reds" on the one hand, who hold, in print at least, that conditions are so bad that there is nothing to do but blow them up and start over, by the "constitutional democrats" who want moderate reform, by the Octoberists, or stand-patters, and by the ultra-reactionaries, is their remarkable similarity. The fact is that when we consider the actual detailed outline of a first course in physics, and turn our eyes away from the horrible straw men whom we conjure up to represent the opposition, while we grow warm and eloquent over general principles, there isn't a very large range of topics about which experienced and thoughtful teachers can seriously disagree. Finding the real issue in many a heated discussion in physics conferences is quite as difficult as finding the real difference between a Republican and a Democrat. I know, of course, that we have our party shibboleths, but half of them at least are nothing but shibboleths, that is, they are *words rather than ideas*. One man, for example, says that he wants physics to be *essentially quantitative*, and straightway, before he has had time to define what he means by quantitative, another interjects the vehement assertion that he doesn't want it to be quantitative, that he wants it to be a study of *the hows and whys of the phenomena of daily observation*, and at once the fight is on. Now, if the declaration of war could only have been delayed long enough to make it possible to ask the first man if he meant that he wished to omit teaching the hows and the whys of the phenomena of daily life, he would have said, "Certainly not. Every respectable teacher always does, and always has done that anyway, but my opponent over there is attacking the idea of quantitative work and that attack is pernicious." If then we can ask No. 2 if he wishes to omit all quantitative work he will reply in every case, "Certainly not; but I don't believe in my opponent's kind of quantitative work." Now if we can only persuade

these two men to compare each other's courses in a friendly way we usually find that they differ by perhaps four or five experiments in forty.

Barring then the occasional extremist, who doubtless deludes himself into imagining that he represents general opinion, I am ready to assert with considerable positiveness that our fundamental differences are very much smaller than many of us imagine, and that if we would come together in a spirit of harmony rather than of strife it is a relatively easy matter for any body of able and experienced physics teachers to agree upon the essential elements of a first course.

Turning next to the topic of the afternoon, if we are to effect a cure for existing evils we must know how they have arisen. When then we seek to know the reason that the colleges have exercised so large an influence upon secondary school work, we find that it has been rather the result of a situation for which the colleges have not been responsible than because of a deliberate attempt on the part of college men to dictate to the secondary schools. And let me say in this connection that nothing could possibly be farther from the truth than the idea that to-day college and high school men are arranged in antagonistic camps over the question of the character of a high school course in physics. If college men are well nigh unanimous in opposing certain particular types of suggested changes it is only because these changes are of such a character that experienced and thoughtful teachers, whether in colleges or in high school, regard them as subversive of the foundation principles of sound education. College men are not only ready and anxious to cooperate in every possible way in effecting real improvements in high school physics, but they are as a whole ready to turn over entirely to the high school teachers of the country the complete determination of the high school unit in physics. I have been repeatedly assured of such willingness by some of the most conservative college physicists in the country. The only reason that it has not been done in the past is that *the secondary school physics teachers have not been so organized as to make it possible to obtain representative opinion from them.* There has never been prepared in the history of this country a syllabus, or outline of a secondary school unit in physics, which originated in such a way as to make it possible to assert with any sort of confidence that it represented the consensus of opinion

of the competent secondary school physics teachers of the country as to what the high school course in physics should contain. The fact that the colleges have exercised during the past twenty years a predominating influence upon the character of the high school course has arisen simply because colleges must, in the nature of the case, have some kind of standards of admission, and since the high schools have had absolutely no uniform standards of graduation, in other words, since units have not been defined by secondary school men, the colleges have been obliged to define them whether they wanted to or not.

College men recognize just as fully as high school men the evils which have resulted from this situation. They recognize that college entrance examinations and the fixing of college entrance requirements have often been put into the hands of men who were little conversant with secondary school conditions. They recognize that college standards have thus often been forced down into the high school where they have no place. They recognize too that there has been little uniformity among the colleges in the matter of their entrance requirements, and that high school courses have sometimes almost been torn to shreds by the frantic efforts of teachers to meet the entrance requirements of all sorts of schools. And it has been because college men *have* recognized these conditions that organizations like the College Entrance Examination Board and the North Central Association have been formed with a view to remedying these very evils. And I am glad to be able to say that the worst of the evils have already been remedied, at least, in the middle West. Certain it is that in a city like Chicago, or in almost any other city in the territory of the North Central Association, the high school teachers of physics do not feel the pressure of college entrance requirements. They have practically a free hand to teach physics according to the dictates of their own consciences, their own intellects, and their own experience. If they are teaching a dead physics instead of a living one (a supposition I think quite contrary to fact), it is because they do not know how to teach a live physics, and not because the colleges are forcing them to continue teaching a dead physics.

And yet taking the country as a whole it is undoubtedly true that some evils which have resulted from college domination still remain to be eliminated, and certainly there is still a great deal to do in the way of *unifying* the teaching of high school

physics. But if I analyze the situation correctly the colleges have gone about as far in the way of remedying these evils as it is possible for them to go so long as they are constituted and organized as at present. *The remedy, and in my judgment the only remedy for the evils which remain is to be found in the setting up of a representative unit in physics by the secondary school physics teachers of the country.* There cannot be a particle of question that if such a unit could be set up in a way which would make it practically certain that it represented the consensus of opinion of the most competent secondary school teachers in the whole country, the colleges from Maine to California would, without exception, accept that unit in satisfaction of their entrance requirements. In so far, then, as the secondary schools are still oppressed by college entrance requirements the sole remedy for the situation is for them to get together and set up their own norm. A national convention of say fifty representative secondary school teachers of physics would cost some money, but that is after all not an insuperable obstacle. After such an assembly had once been convened I should anticipate that it would have little difficulty in agreeing upon an outline of a unit.

This then is the part which the secondary schools must take in the correlation of high school and college physics. The remainder of the problem is the problem of the colleges. Their first step should be, and doubtless would be to accept the norm established by the secondary schools in satisfaction of their entrance requirements. Their second step in my judgment should be, and I certainly hope that it would be, to do away with all college courses which are neither first courses nor second courses but crosses between them designed to strike some sort of a mean between the needs of the students who have had no preceding work in physics and those who have had a full year of such work. Such courses may have been necessary in the past in some institutions, in view of the very irregular preparation in physics of entering students, but, in my judgment, all excuse for them disappears as soon as secondary school physics becomes fairly well unified. Certainly the mixing in the same class of students who have had no preceding work in physics with those who have had a full year of such work is wholly unsound pedagogically, and furthermore it furnishes one of the most just grounds of complaint on the part of the high schools against

the colleges, for it amounts to discrediting completely the high school course. There is precisely the same need of continuity and progression in the study of physics as in the study of mathematics or of language. A first year course should obviously be of a wholly different character from a second year course unless we make the astonishing admission that we teach nothing in beginners' courses. The assertion sometimes credited to college physicists that it is a matter of entire indifference to them whether their pupils have had preceding work in physics or not is one which it is difficult to believe that any thoughtful man has ever uttered. It amounts to expressing indifference as to whether a part of one's pupils waste a year of valuable time or not. If actual conditions involve such a waste it is high time that such conditions were changed.

In my judgment there are just two ways of obtaining effective instruction in physics in the college and at the same time of being fair to all classes of students. These are (1) to exclude entirely from work in physics in college all students who have not had a good high school course, and then to build up the college course in full recognition of the high school course and as a continuation of it, or (2) to do as is done now in the University of Chicago, Harvard, and I think a considerable number of other prominent institutions; namely, to offer in college two courses, one a beginner's course, covering essentially the ground of high school physics, and one, an advanced course to which students gain entrance either through taking in college the beginner's course or through offering for entrance a satisfactory high school course. During the last ten years the first plan; namely, that of making physics a prescribed subject for admission, and offering in college only an advanced course, has been abandoned by most of the prominent universities of the country; because, no doubt, of a growing recognition of the principle that the function of the American college or university is not to dictate what the secondary school shall give, but rather to build the best possible education upon such foundations as is actually furnished in the secondary schools. The second plan, namely, that of prescribing for entrance merely a year of work in some science, and then offering in college beginners' courses in all sciences for the benefit of those who do not offer the first courses for entrance, is one which is rapidly gaining adherents among the better schools of the country. From my point of

view then the proper machinery for the correlation of high school and college physics is: (1) the setting up of a norm by secondary school men for a first course; (2) the full recognition of this norm by college men and the adaptation of their courses to the *continuation* not the repetition of the work begun in the first course.

It only remains to point out what, in my judgment, should be the character of this first course, whether given in the high school or in the college, and what the character of the second course. It seems to me obvious that every good first course in physics should be a *fairly extended survey course*. It should be thorough in the sense that the principles of physics of the first order, not those of the second or third order, should be clearly stated and their most direct and simple applications clearly understood by the pupils. It should most emphatically not be thorough in the sense that a relatively small number of topics is exhaustively studied or that any particular topic is turned over and looked at from every possible point of view. All these are obviously the functions of *advanced* courses. In a word, the function of a first course is to *open up the field*. In such a course we should be particularly careful, I think, not to commit what has perhaps been the greatest mistake of the past two decades in beginning courses in physics, namely, the mistake of attempting to carry our pupils so far into the details and subtleties and refinements of the subject that they lose sight of the woods on account of the trees. The course should not be so intensive as to destroy perspective, nor so restricted as to fail to leave upon the student's mind a vivid picture of what is the extent of the field covered by the subject, what is the method which it uses, and what are the foundation principles which underlie it. So much for the character of a first course, whether it be given in the high school or in college.

The second course in physics will assuredly not be a survey course if the first course has been such. It will take up the subject more in detail. It will be more intensive, more mathematical, more analytical. There is no reason why the materials of the two courses need overlap to any appreciable extent. The college course will have all it can do to develop the formulæ and analyze the problems which high school physics cannot in the nature of the case touch upon at all; for example, in mechanics, the formulæ of impact, of simple harmonic motion,

those relating to moments of inertia, to centrifugal force, to the compound pendulum, to the ballistic pendulum; in electricity, to the Wheatstone bridge, to capacity determination, self-induction measurements, to the finding of magnetic constants, etc., etc. I need not specify further. The field is almost limitless. Since the student obviously needs a survey course as a prerequisite to such a course, it seems to me that the only thing for the colleges to do in physics is to do what they do as a matter of course in botany and in most of the other sciences; namely, to offer the beginners' course to the students who enter without having had this course in the high school. In other words the part which the colleges have to take in the correlation of high school and college physics is to recognize the existence of high school physics and to rate it at its full value on the assumption that it is properly taught.

#### DISCUSSION OF PROFESSOR MILLIKAN'S PAPER.

By A. A. UPHAM,

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He said in part:

"I do not think there is much need of my discussing this paper, because I am heartily in accord with most of it. We have all of us, and I as much as anyone, spent our days and nights devising experiments and endeavoring to get apparatus in sets that pupils might perform quantitative experiments. While I am in favor of some quantitative experiments, it seems to me we have ignored the facts in the development of children; we have forgotten that the boy of high school age has much more interest in seeing things go than he has in measuring things accurately. It is a fact that some of our greatest physicists, Clark Maxwell and Tyndall, were not, as boys, interested in the quantitative aspect of physics. We have gone so far in omitting the quantitative experiments, spectacular, if you please, that we have squeezed the juice of interest out of the whole subject. We have emphasized the mathematical part to the exclusion of the practical and human interest. We have allowed the colleges to dictate courses in the face of the fact that a very small per cent of the high school pupils go to college. The high school courses should be planned with reference to the mental condi-