SCIENCE

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THE TEACHING OF ELEMENTARY PHYSICS

In Science for October 29, 1909, p. 578, nine propositions were printed as the basis for expected discussion at the next meeting of the American Association for the Advancement of Science. This discussion occurred on Friday, December 31, 1909, and, though coming very late in the week's program of the association, was well attended. Section B, Physics, and Section L, Education, met together for this occasion, Vice-president Bauer, of Section B, presiding. The previously announced speakers came forward in the following order: Professor Edwin H. Hall, Harvard University; Professor John F. Woodhull, Teachers College, Columbia University; Mr. N. H. Black, Roxbury Latin School, Boston; Professor C. R. Mann, Chicago University; Professor A. G. Webster, Clark University. Several others took part in the general debate which followed.

The substance of what I gave in opening the discussion was placed before the meeting in printed form and is reproduced below under the heading "Comments on Propositions 1–9." The only other formal paper was the one read by Professor Woodhull, which was published in full in Science, May 13, 1910. The only definite proposition looking toward action by the meeting in regard to the matter before it was made by myself, to the effect that, after debate, the meeting should vote on the nine propositions which had been printed in Science, in their original form or as they might be amended, and should transmit to the National

Educational Association for its consideration any of these propositions which might be approved. Objection was made on the ground that many of those present were not sufficiently familiar with the propositions in question to vote upon them at this meeting, and it was suggested as an alternative that I should issue a circular giving opportunity for the expression of individual opinions on the questions raised in these propositions. I agreed to do this, if names and addresses were left with me at the close of the meeting. About ninety names were left, and a postal-card circular (the contents of which will be given later) was sent out accordingly about January 10. To this circular I have received sixty replies, which are tabulated below.

In order to put the whole matter clearly before the readers of SCIENCE it seems best to reprint here the original nine propositions, which were made, substantially as here given, at Clark University in September, 1909, and were there approved, *as a basis for discussion,* by a considerable number of well-known teachers of physics.

PROPOSITIONS 1–9

(From SCIENCE, October 29, 1909)

1. That, while the amount of academic attainment in physics which the prospective school teacher of this subject should have can not be definitely fixed, it may be usefully, if somewhat vaguely, indicated as the state of advancement at which, if the man were to be a candidate for the doctorate, he would naturally begin the special research intended for his thesis.

2. That this preparation should include an elementary knowledge of the calculus and some acquaintance with the general facts, principles and laboratory methods of chemistry.

3. That school authorities should not be content with the appointment of a well-trained and competent teacher. They should see to it that the good teacher has good tools and good conditions for his work, a well-appointed laboratory, an equally well-appointed lecture room and relief from unnecessary manual labor.

4. That this relief of the teacher from unnecessary manual labor will require, as a rule, the services of a man of all work, sufficiently skilled to use well the elementary tools of the mechanic, sufficiently permanent in his place to know thoroughly the building in which he works and its equipment, sufficiently teachable and willing to make him a cheerful helper to the teachers of physics and chemistry in whatever assistance they may with reason ask of him.

5. That the school teacher, so trained and so equipped, should have all the liberty in the method and scope of his teaching which is consistent with the general consensus as to good practise, this consensus to be reached, in the case of schools which have close relations with the colleges, by painstaking, sympathetic and persistent efforts on the part of all concerned to come to an understanding with each other for the purpose of promoting their common interest, the best attainable instruction in science for the youth of our country.

6. That the examination by means of which the attainments of school pupils are estimated in their candidacy for admission to college should include a laboratory test.

7. That colleges which accept but do not require physics as a part of the preparation for admission should so arrange their elementary teaching of physics as to make an important distinction between those who have and those who have not passed in physics at admission.

8. That, accordingly, such colleges should maintain a physics course substantially equivalent to the physics courses of good secondary schools.

9. That colleges should require of the schools no quantitative treatment of kinetics, or the behavior of matter undergoing acceleration.

COMMENTS ON PROPOSITIONS 1–9

(Made by the writer at the joint meeting of Sections B and L of the American Association for the Advancement of Science, December 31, 1909.)

1 and 2. The standard here suggested would probably require the ordinary college student to devote considerably more than half of a four-year course to physics, mathematics and chemistry. To get his special training without neglecting other fields of study too much, he would do well to take a graduate year, leading, perhaps, to the A.M. degree.

3 and 4. Teachers are now in danger of neglecting the lecture table work rather than the labora-

tory work; partly, no doubt, because the former is not directly tested by college entrance examinations. Examiners might well ask an occasional question relating to what the candidate may have seen in the lecture room.

The training of such assistants as are described in (4) might be undertaken by "vocational" schools.

5. The following table gives the titles of those laboratory exercises which, according to an inquiry made by circular in November and December, 1909, are most generally used by the secondary

	N. E.	M. A.	C. W.	Neb.	Cal.	Total	
Measurement of volume (by scale and by displacement)	59	69	87	90	88	77	
Mass of unit volume of solid	92	87	85	67	82	85	
Principle of Archimedes: sinking bodies	94	81	93	100	100	94	
" " " floating bodies	80	69	71	86	94	78	
Specific gravity of heavy solids	100	100	95	95	100	97	
" " " light solids (with sinker)	92	87	85	86	100	89	
" " " liquids (by filled bottle, by submerged solid)	98	94	78	67	76	84	
" " " liquids (by balancing columns)	82	38	56	57	76	65	
Compressibility of air	92	75	89	86	100	89	
The straight lever: first class	86	56	89	100	65	87	
Center of gravity and weight of a lever	88	87	64	57	76	74	
Equilibrium of three parallel forces in one plane	59	94	80	86	82	76	
Parallelogram of forces	92	100	96	86	100	95	
Inclined plane	39	75	73	76	71	63	
Laws of the pendulum	53	100	91	81	82	78	
Testing a mercury thermometer	82	31	60	62	35	61	
Coefficient of linear expansion	92	75	80	52	94	81	
Specific heat of a solid	100	100	87	81	100	93	
Heat of fusion of ice	94	100	85	86	94	91	
Heat of vaporization of water	96	81	78	57	88	82	
Determination of dew point	78	56	73	81	88	75	
Law of reflection of light	47	63	87	86	100	73	
Images by a plane mirror	100	94	93	95	100	96	
Images by a convex mirror	86	50	69	90	71	75	
Images by a concave mirror	86	50	75	86	76	77	
Index of refraction of glass	100	81	84	62	88	86	
Focal length of a converging lens	96	100	85	71	94	89	
Conjugate foci of a converging lens	96	94	62	43	82	75	
Shape and size of a real image formed by a lens	90	75	67	48	82	74	
Lines of force near bar magnets (iron filings)	63	81	89	90	100	82	
Lines of force near bar magnets (small compass)	82	87	56	71	76	72	
Study of a single-fluid galvanic cell	90	100	91	95	88	92	
Study of a two-fluid galvanic cell	88	81	71	67	65	76	
Magnetic effect of an electric current	37	50	76	67	100	63	
Resistance of wires by substitution (various lengths)	71	44	51	48	82	60	
Resistance by a Wheatstone bridge	84	69	71	62	71	73	
The electromagnet	35	75	67	95	76	63	
The electric bell	45	81	65	90	88	66	
Uniformly accelerated motion (N. Y.)	24	13	33	48	71	34	68
Laws of " " (C. E. B.)	24	6	44	43	47	34	
Wave length of sound (N. Y.)	12	63	53	62	71	44	72
" " " " (H.)	31	13	31	29	24	28	
Use of Rumford photometer (H.)	45	44	16	19	41	31	78
" Bunsen " (N. Y.)	39	44	51	43	65	47	
Lines of force about a straight conductor (N. Y.)	43	50	53	57	94	54	103
Lines of force about a galvanoscope (H.)	78	19	29	43	71	49	
Arrangement of cells for strongest current	29	56	56	71	82	53	98
Battery resistance and combination of cells (H.)	59	31	38	33	53	45	
The electric telegraph (N. Y.)	22	56	49	71	65	46	91
Telegraphic sounder and key (H.)	39	19	44	67	65	45	
Electric motor (H.)	41	38	64	81	88	59	77
Study of an electromotor (N. Y.)	12	19	18	29	24	18	
Coil of wire moving in magnetic field (N. Y.)	12	38	42	48	35	32	86
Study of induced currents (C. E. B.)	37	25	71	71	59	54	
The dynamo (H.)	35	0	40	48	71	39	66
Study of a dynamo (N. Y.)	18	25	25	57	18	27	

schools of this country in preparing youths for college. The replies tabulated were 158 in all, 49 from New England, 16 from the Middle Atlantic States, 55 from the Central West, 21 from Nebraska and 17 from California. The numbers given in this table are per cents., showing what portion of the tabulated replies reported the exercises opposite which these numbers are placed.

No exercise is named in the first part of the table, which was reported by less than 60 per cent. of the total number of replies tabulated. But in the second part of the table a number of pairs of exercises are named, in each of which pairs one exercise may be regarded as a mere variant of the other, the added per cent. for each pair being greater than 60, though no one of these exercises alone was reported by 60 per cent. of the total number of replies.

(C. E. B.) refers to the revised list of the College Entrance Board, (H.) to the Harvard list and (N. Y.) to the syllabus of the regents of New York State.

6. Such a test has been found entirely practicable at Harvard, where it has been used for many years. Teachers who are familiar with its workings seem to be, as a rule if not unanimously, strongly in favor of it.

7 and 8. College teachers are apt to conclude, from the fact that boys a year or two from the schools often appear ignorant of elementary laws and facts in physics, that the school teaching in this subject is of little value and should be disregarded. But how do the results of the college teacher's own efforts on these same boys appear when tested a year or two later by an unsympathetic examiner?

It is not to be expected that the college course referred to in (8) would be exactly like a school course. It might, for example, have a somewhat fuller treatment of kinetics than the schools would find advisable, though college teachers find it difficult to put the ideas of accelerating force, dynes, poundals, ergs, foot poundals, etc., into permament and useful form in the minds of their students in a one-year general course of physics.

9. As an alternative for the complete ignoring of kinetics, colleges might, while requiring nothing about "absolute units" of force or energy, encourage the schools to do as follows:

Give the "laws of falling bodies," $v = gt$, $s = \frac{1}{2}gt^2$, $v^2 = 2gs$, as facts shown by observation, and with lecture-room experiments and the simplest problems illustrate these laws.

Teach the application of the same laws to *rising bodies*, as justified by observation, using still the simplest cases, avoiding, for example, instances in which s is the distance of an uncompleted ascent.

Define work and energy in gravitation units only and make the pupil familiar with the formulas,

work of raising a mass m to a height $s = ms$.

work a mass m can do in descending a distance $s = ms$,

or potential energy of mass m at height $s = ms$.

Then show that a mass m, starting upward with a velocity v, which will carry it to a height $s = (v^2 \div 2g)$, thus doing an amount of work $= ms = (mv^2 \div 2g)$, is properly said to have at the start an amount of energy $= (mv^2 \div 2g)$, which energy is called *kinetic*.

POSTAL-CARD CIRCULAR OF JANUARY 10, 1910

I am sending cards to those who, at my request, left their names for me after the joint meeting of Sections B and L of the A. A. A. S. in Boston, December 21, 1909.

I beg that you will indicate, on the return part of this card, your opinion concerning each of the nine propositions which were formally before that meeting (and which had been printed in SCIENCE for October 29, 1909, p. 578) by crossing out the word *not* in the case of each proposition that you approve and leaving it standing in the case of each proposition that you do not approve, with whatever changes in the words following the numerals may be necessary in any case.

Will you please write me any suggestions which you have to make that are not covered by the propositions in question?

I wish to publish the replies in substance.

FOR REPLY

I am

not in favor of (1), with (without) the suggestion of A.M. degree;

not " " " (2);

not " " " (3);

not " " " (4), with the suggestion of "vocational" training for the assistant;

not " " " (5);

not " " " (6), if any *examination* is maintained;

not " " " (7);

not " " " (8), with the understanding that the college course need not be the duplicate of a school course;

not " " " (9), as originally written;

not " " " (9), in the alternative form, encouraging schools to teach the "laws of falling bodies" in their simplest form and so [go on] to the formula $K.\ E. = mv^2 \div 2g$, but with no recognition, in admission requirements or examinations, of "absolute" units of force or energy or of the formula $f = m \times a$.

Name ....

Position ....

TABULATION OF REPLIES[1] TO CIRCULARS

In the following tabulation the sign — indicates approval of the original proposition in question without the suggestion which is attached to it in the postal-card circulars. The sign + indicates approval of the proposition in question with the suggestion which is attached to it in the same circulars. A numeral put with either of these signs refers to a foot-note in which some comment by the individual replying is given or indicated. Absence of any sign indicates lack of approval of the proposition in question.

In the class of College Teachers are included a number of men who are no longer teaching, being now members of government bureaus.

Approvals by College Teachers	Propositions								
	1	2	3	4	5	6	7	8	9
C. A. Butman, Clark Coll., Worcester, Mass.	—	—	—	+	—		—		+
W. G. Cady, Wesleyan Univ.	+	—	—	—	—	+	—	+	
L. L. Campbell, Simmons Coll., Boston	+	—	—	+	—	+	—	+	+
J. G. Coffin, C. C. N. Y., New York City	+	—	—	+	—	+	—	+	—
Henry Crew, Northwestern Univ.	+	—	—	+	—	+	[24]		
Grace C. Davis, Wellesley Coll.	+	—	—	+	—	+	—	+	+
H. N. Davis, Harvard Univ.	+	—	—	+	—	+	—?	+?	+
H. G. Dorsev, Cornell Univ.	+	—	—	+	—	+	—	+	+
C. K. Edmunds, Canton Christian Coll.	—	—	—	+	—	+[25]	—[26]	+	
C. F. Emerson, Dartmouth Coll.	+	—	—	+	—		—[27]	+	—[28]
W. G. Fisher, Cornell Univ.	—	—	—	+	—	+	—	+	+
W. S. Franklin, Lehigh Univ.	+	—	—	+	—	+	—	+	+[29]
H. G. Gale, Univ. of Chicago	—	[30]	—	+	—	[31]	—	+	+
C. M. Gordon, Lafayette Coll.	+	—	—	+	—		—[32]	+	[33]
K. E. Guthe, Univ. of Michigan	—	—	—	+	—	+	—	+	
E. A. Harrington, Williams Coll.	+	—	—	+	—	+	—	+	+
J. E. Hayford, Northwestern Univ.	—	—	—	—	—		—	+	+[34]
W. L. Hooper, Tufts Coll.	—	—	—	+	—	+	—		
J. C. Hubbard, Clark Coll.	+	—	—	+	—	+	—	+	
G. F. Hull, Dartmouth Coll.	—	—	—	+	?[35]		—[36]	+	
W. J. Humphreys, U. S. Weather Bureau	—	—	—	+	—	+[37]	—[38]	+	+
J. E. Kershner, Franklin & Marshall Coll.	—[39]	—	—	+	—	+	—	+	+
Elizabeth R. Laird, Mt. Holyoke Coll.	[40]	—	—	[40]	—	+	—		
W. F. Magie, Princeton Univ.	—	—	—	+	—	[41]	[41]	[41]	
W. E. McElfresh, Williams Coll.	+	—	—	+	—	+	—	+	+
F. W. McNair, Mich. Coll. of Mines	—	—	—	+	—	+	—	+	+[42]
C. R. Mann, Univ. of Chicago	[43]	[44]	—[45]	+[45]	[46]	[47]	—[48]	?[49]	+[50]
A. A. Michelson, Univ. of Chicago	+	—	—	+	—		—	+	+
W. A. Mitchell, Soochow Univ., China	+	—	—	—	—[51]	+	—	+[52]	+[53]
C. C. Murdock, Cornell Univ.	+	—	—	+	—	+	—	+	
A. de F. Palmer, Brown Univ.	—	—	—	+	—[54]		—	+	+[55]
R. A. Porter, Syracuse Univ.	+	—	—	+	—	+			+
E. B. Rosa, Bureau of Stand.	+	—	—	+	—	+	—	+	—
F. A. Saunders, Syracuse Univ.	—[56]	—[56]	—	+	—	+	[57]		—
F. Slate, Univ. of California	[58]	—[58]	—	+	—	[59]	—	+	+[60]
M. H. Walbridge, Rand. Ma. Coll.	+	—	—	+	—				+
F. A. Waterman, Smith Coll.	+	—	—	+	—	+	—	+	+
A. G. Webster, Clark Univ.	+	—	—	+	—	+	—	+	+
W. R. Whitehouse, Bates Coll.	[62]	[62]	—	—	—	[63]	—	—	—
J. F. Woodhull, Teachers Coll., New York.	+	—	—	+	—	+	—	+	[61]

[1] I have studied these replies with care and hope, without being sure, that no errors will be found in the details of the tabulation.

Approvals by School Teachers	Propositions								
	1	2	3	4	5	6	7	8	9
F. C. Adams, H. S., Boston	—	—	—	+	—	+	—	+	+[1]
C. H. Andrews, S. H. S., Worcester, Mass.	—	—	—	+	—	+	—	+	
N. H. Black, Rox. L. S., Boston	+	—	—	+	—	+	—	+	
C. Boylston, H. S., Milton, Mass.	—	—	—	+[2]	—	+	—	+	+
P. S. Brayton, H. S., Medford, Mass.	—	—	—	+	—	+	—	+	+
Louise Brown, Dana Hall, Wellesley, Mass.	+[3]	—	—	+	—	+[4]	—	+	+
W. C. Campbell, H. S., New Rochelle, N. Y.	—	—	—	+	—	+	—	+	+
C. E. Dickerson, Mt. Hermon School, Mass.	—[5]	—	—	+	—	+	—	+	—
Harriet V. Elliott, H. S., Dorchester, Mass.	—	—	—	+[6]	—	+	—	+	—
F. M. Gilley, H. S., Chelsea, Mass.	—	—	—	+	—	+	—	+	?
F. M. Greenlaw, R. H. S., Newport, R. I.	+	—	—	+[7]	—[8]	+	—	+	+
C. M. Hall, C. H. S., Springfield, Mass.	—[9]	—	—	+[10]	—[11]	+	—	+	+
Laura M. Lundin, Wheaton Sem., Mass.	+[12]	—	—	+	—		13		+
F. R. Miller, E. H. S., Boston, Mass.		—[14]	—	+	—	+	—	+	+
J. C. Packard, H. S., Brookline, Mass	—[15]	—	—	+	—	+[16]			+
I. O. Palmer, H. S., Newtonville, Mass.	+	—[17]	—[18]	+[19]	—	+	—	+	
Roswell Parish, M. A. H. S., Boston, Mass.	+[20]	—	—	+[21]	—	+	—	+	+[22]
P. E. Sabine, Wor. Acad., Worcester, Mass.	+	—	—	+	—		—	+	—
Helen F. Tiedick, Student in Teachers College, formerly at Rob. Sem., Exeter, N. H.	—	—	—	+	—		—	+	—
C. A. Washburn, H. S., Framingham, Mass.	—	—	—	+	—	—	—	+	+

NOTES REFERRED TO BY NUMBERS IN THE TABULATION OF REPLIES

1. Crosses out *no* before *recognition* and puts *possibly* after $f = m \times a$.

2. "For large schools."

3. "I think that teachers of physics need a knowledge of the elements of all the sciences in addition to the attainment in physics suggested in the report. A knowledge of English seems to me also essential."

4. "I like the idea of a laboratory test. I always give one myself in my classes." "It seems to me that an elementary course in physics should aim to give a student the power to understand the numerous applications of the principles of physics in his world. A list of such applications might be more useful to a young teacher than a list of the laboratory exercises he should have done."

5. "Men from *technical schools* or with such training in *accuracy* at least as these give."

6. "Well-paid boy of school."

7. "While favoring a mechanical assistant, I doubt very strongly the possibility of securing such an assistant for public high schools. An advanced or post-graduate pupil is frequently employed afternoons at a moderate wage and is very helpful."

8. "I should favor further reduction in the entrance requirement. While it is difficult to make any suggestion for omission, the time devoted to optics might possibly be reduced and in my opinion the subject of thermodynamics should be excluded."

9. "The candidate, in my opinion, should have a year of shop experience or some work where he actually applies principles of physics. It seems to me this would make him more valuable for high-school work than an additional degree, representing work in pure physics at some college, perhaps."

10. "The assistant may well be a senior boy in the high school who has been through the courses in elementary physics or chemistry. We have found such boys very efficient and they can easily be taught to make many simple devices, if the teacher has had a shop experience so he can direct them. Such a boy can be hired here for ten cents an hour."

11. "The teacher should not be influenced by the necessity for getting the pupils when they can pass a college entrance examination to the extent of making all the class prepare for college when only a few will have the chance to go. He might well teach a kind of physics that would be more directly applicable to the locality where the students will have to work when they leave school, and in this sense, perhaps, the physics ought to be applied physics, with special emphasis on the local industries."

12. "Except for graduates of technical schools."

13. "Found in my three years of college teaching that no 'important distinction' could be made" [between those who had and those who

had not passed an examination in physics at admission].

This remark led me to write Miss Lundin, asking a number of questions concerning the experience on which her observation was based. I give here a number of quotations from her reply to these new questions:

"Those who had taken physics the last year in high school did seem to retain something of their previous work; however, after a very few lectures and recitations these girls no longer objected to having to 'repeat' the subject, and their work was not noticeably better than the average." "There was no entrance examination conducted by the college. The college board examinations were at most taken by a very few students, as I saw but two laboratory note-books presented in the three years." "I should expect the college board examinations to be a fairly effective sieve and should expect students passing such or similar examinations to be able to take a more difficult course than those who had not passed or who had not studied the subject. At the same time, it is generally true that, where a board examination may be taken for entrance to college, a certificate will be accepted, and herein lies the difficulty of determining the fitness of the student for more advanced work. I have students who hold certificates in physics and mathematics from other schools, public and private, who fail to get, even on repeating the work, a recommendation to take the board examinations."

14. "As referring to chemistry but not calculus."

15. "Extra course to be pursued at a technical or industrial or normal school or in a shop."

16. "Yes, on 'originals' with printed directions."

17. "I think the 'preparation' ought to include such training that the teacher is able to do a good piece of work in the carpenter's shop and *especially* the machine shop—if he can blow a little glass so much the better. He should also know, *by virtue of teaching given in the university*, the source of supply, cost and method of importing the lecture and laboratory apparatus suitable for his work in secondary-school teaching."

18. "I agree perfectly with your statement, *but* the teacher ought to spend some *necessary* 'manual labor' in shop in directing his amanuensis and in some cases helping to build apparatus."

19. "It is quite probable that the *helper* will need more skill, a wider range of shop training and a greater acquaintance with the principles of science than the present-day *vocational* schools will give.

"If we can get a school where boys are as well trained as they are in the school for instrument makers at the University of Leyden, we'll be all right."

20. "Year of general practise work."

21. "Where possible; but this is impracticable in the great majority of schools."

22. "Until text-book makers give the subject simple but adequate treatment."

24. "I find myself in hearty agreement with all your nine propositions save only the last three."

"Twenty years' experience with students coming from . . . high schools to the university has taught me that the student who comes into our course in general physics without any previous study of the subject does quite as good work as the student who comes to us after having already studied the subject in the high school.

"The fact appears to be that general physics, as presented by university instructors, is a subject *very different* from that which is presented by the high school instructor. The university presents the subject as a connected whole, as a single great body of truth. The student here, for the first time, meets a philosophical connection between the different parts of the subject.

"In the high school, as a matter of fact, the subject is presented as a number of different subjects, each subject having one chapter devoted to it. The result is that when these two groups of students come to college (namely, those who have and those who have not studied physics) each finds sufficient new material for thought and work in the university course in general elementary physics.

"As to your proposition 9, I have the feeling that the science of physics began when Galileo, in his 'Dialogues' (1638), after carefully defining what is meant by uniform velocity and uniform acceleration, introduced the idea of force to describe the behavior of a body whose momentum is changing from any cause whatsoever. Feeling as I do, that this is the central idea about which modern physics has been built up and that the idea of momentum and change of momentum is essentially simple, and feeling that every boy, of even ten years of age, is loaded to the muzzle with practical illustrations, I find it very difficult to think a high-school teacher should not make some effort to help the boy towards a clear and *simple* apprehension of this great group of facts, namely, accelerated motions."

25. "But am not in favor of examination at all."

26. "But think every college should require some physics for entrance."

27. "We have given credits for admission to college in physics for a great many years, but have made no difference in the course pursued in college between the course for those men who present physics and for those who do not present physics; this seems to me wrong, yet the difference in preparation which students have had in physics in the preparatory school would almost necessitate this plan.

"I hope your efforts will make the requirements very definite and that the students presenting physics for admission to college may take a different course in college from that taken by those who begin the subject. We accept chemistry for admission, but require such students to take our second course in chemistry at the first and it ought to be the same with physics and biology."

28. "I enclose the postal marked as you requested except in the alternative form of the ninth question, about which I do not feel positive. I should wish to leave that entirely to the judgment of the secondary-school teacher. I certainly would not require for admission to college any examination of absolute units of force or energy."

29. Crosses out *not* before both of the alternatives (9).

30. "Depends entirely on grade of school."

31. "I doubt the practicability."

32. "Not easy to arrange in a small or medium-sized college."

33. "Think the last formulas should be taught in connection with experiments in which acceleration is more readily observed and appreciated than in the case of falling bodies."

34. Crosses out *or of the formula* $f = m \times a$.

35. "There should be coordination and therefore a rather definite course."

36. "Though we have not done it, except in laboratory work, we expect to comply with No. 7 in a year or so."

37. "Opposed to formal written entrance examinations of all kinds."

38. "If practicable."

39. "This, I fear, is somewhat indefinite outside of the large universities. Why not say a requirement equal to A.M. with physics as special for A.M.?"

40. "I should be glad to vote for it, if I thought it capable of practical realization; but it seems to me that it would be of more practical benefit to place the standard of preparation for the average good high school at something that would require about fifty semester hours' college work in physics, mathematics and chemistry. In the same way proposition 4 would be desirable if realizable."

41. "I want to explain my votes on 6, 7, 8 by saying that in my opinion the propositions ignore the fact that the student undergoes a considerable mental development in the later years of his school life and his early years at college. A physics course in college 'substantially equivalent,' etc., would be too childish for him—even if it covered exactly the same topics. The plane of the teaching—the philosophic attitude of the teacher—ought to be more advanced. So I oppose 8. Similarly for 7, I do not believe that the best school course does for the student what his first college course should do, even if it covers exactly the same topics, and so I oppose 7.

"As to 6, I think laboratory work, while essential in making physicists, not essential in giving students the knowledge of scientific methods and ideals. I should let a student offer laboratory work if he thinks he can show his knowledge of physics better in that way.

"As to 9, I simply should leave each teacher his liberty, without forbidding him to teach $f = ma$, and I should sanction a question on such matters in the entrance papers, if the examiner used sense and discretion in marking."

42. Crosses out all following $2g$ in the statement following the second (9) and writes: "Am much opposed to the omission of subject of force and acceleration. Many boys who need in after life a clear conception of the relation between the two never get to college."

43. "As to No. 1, I do not think that more of the present sort of college training in physics is what the teachers need. They must know their subject, of course; but they must also know something about the school problems they are going to have to face, and must have some appreciation of the needs and mental habits of high school pupils."

44. "Hence to No. 2 I would say that a knowledge of the calculus does not seem to me as important as a knowledge of the ways of children's minds. The history of science and the philosophy of it are, it seems to me, more needed than mere technique. Works like Poincaré's 'Science and Hypothesis' should be studied."

45. "With No. 3 and No. 4 I have no quarrel. These are self-evident. They, however, mean little. What is meant by 'well-trained and competent

teacher?' Well-trained in what line?" "Where is the proposed assistant to get the 'vocational' training suggested in the post card? We find it very difficult to get this type of man even for the university, where we can offer a better place than can a high school."

46. "With (5) I can not agree at all, because of the restrictive clause 'consistent with the general consensus of good practise.'" "High schools must serve their communities efficiently, and colleges must take their product and do their best with it. Useful cooperation between the high school and the college is possible only when the college men take this view—the high-school men already have it."

47. "Since we have outgrown these [entrance examinations] out here, the question has no significance in the west."

48. "To No. 7 I vote yes without comment (*mirabile dictu!*)."

49. "To No. 8 I say we have not enough data yet to answer one way or the other. We have been giving a course here exactly like a high school course for six or seven years. The number who have taken it has dwindled from about 60 to 13. This seems to show that the course is not wanted in that form. We shall probably change the arrangement next year and try something else."

50. "With (9) you know I am in complete agreement. In fact the proposition seems to me to contain the meat of the whole set. We have data enough to demonstrate that this conclusion is perfectly sound and helpful. Your suggestion on the card and your comments as to the method of treating kinetic energy is the method which I have been using with good success for the past three years. It is pragmatically true; *i. e.*, it works. So I heartily commend your proposition 9 in either form or in both forms."

51. "But would not accept the list in your comments as a true consensus."

52. Puts *must* for *need*.

53. Crosses out all after *in their simplest form*.

54. "This might be less restrictive."

55. Puts w instead of m in the formula and crosses out *or of the formula* $f = m \times a$.

56. "As an ideal to hope for in this state."

57. "Not in New York state."

58. "I do not differ from you in the main sense of your question [No. 1]; I feel strongly the need in a teacher of 'mastery.' My 'not' involves rather a criticism of the standard of comparison. My assent to No. 2 is then hearty, because I want broad horizon in the teacher; ditto to Nos. 3, 4 and 5."

59. "As regards (6) there is perhaps real divergence. Without writing a disquisition, I put (to myself) a dilemma: (*a*) the experiment of the examination repeats (essentially) one of the school course; or (*b*) it is new. Against (*a*) I object that *repetition* brings no adequate benefit and is no real test. Against (*b*) I have to say that strangeness, unfamiliarity with spaces, apparatus, persons cripples the candidate."

60. "I stand in the matter of (9) firmly in my adherence to the alternative. *Also*, I see every reason to follow the plan of bringing in 'dynamics' in two instalments."

61. "With regard to the teaching of kinetics I do not quite share your pessimism, as I believe it can be done, but only by the very good teacher. I feel that it is a pity to argue so much about the dyne and erg. I would teach them, and give credit to those who can do them well, but not make this a *sine qua non*."

62. "The propositions which you present can in the nature of the case relate to only about 5 per cent. of the high schools of the country—the largest but not necessarily the best schools.

"Regarding Nos. 1 and 2: Graduate courses are to be commended, but courses in education are quite as important as those in physics for the teacher of physics. Both should count toward his master's degree, but if he must sacrifice either in his graduate work, let pure physics give way. The undergraduate four years shall not be so largely devoted to physical science and mathematics as you propose."

63. "Not in favor of No. 6 as it has been conducted."

SUMMARY OF CATEGORICAL REPLIES

— = approval of proposition in first form.

+ = approval of proposition as modified by myself.

× = approval of proposition as modified by my correspondent.

DISCUSSION

Examination of the preceding summary shows that each of the nine propositions is approved in a majority of the replies, either in its original form or as it has been modified by myself or by my correspondents. Nevertheless, the reception of the

Proposition		Favorable				Unfavorable	Doubtful
		−	+	×	Total		
(1)	School ...	9	5	5	19	1	
	College...	12	22	2	36	4	
(2)	School ...	18		2	20	0	
	College...	36		1	37	3	
(3)	School ...	20			20	0	
	College...	39		1	40	0	
(4)	School ...		14	6	20	0	
	College...	4	34	1	39	1	
(5)	School ...	18		2	20	0	
	College...	36		2	38	1	1
(6)	School ...	1	15	1	17	3	
	College...		26	1	27	13	
(7)	School ...	18			18	2	
	College...	30		4	34	5	1
(8)	School		18		18	2	
	College....	1	28	1	30	8	2
(9)	School	4	11	1	16	3	1
	College....	4	18	5	27	12	1

various propositions has been notably different, and accordingly it seems well to discuss separately, for the most part, the treatment of each.

One general explanation, or admission, however, may as well be made here once for all. There is doubtless much truth in the statement of Professor Woodhull (note 62) that the propositions in question can, "in the nature of the case," relate to a small proportion only of the high schools of the country. I may even go farther with Professor Woodhull and admit that the larger and financially stronger schools, for which especially these propositions are intended, are "not necessarily the best schools." A small town high school, as compared with a large city school, is likely to show the advantages and the disadvantages which country institutions in general show in comparison with city institutions. The city must, in order not to be entirely worsted in the trial of merits, make the most of such advantages as are possible to it, and one of these is the service of teachers, more thoroughly trained and better equipped teachers than the country town can afford. Suggestions for the improvement of teaching in large schools expressly should not be regarded—they are certainly not in the present case intended—as injurious to or unfriendly to, or even unsympathetic with, the small schools. It will hardly be possible to improve the conditions and methods of teaching in large schools without seeing the good influence of the changes extended automatically to the small schools.

The present discussion is frankly, and has been from the start, on the ground of the relations of schools and colleges, and it is, indeed, "in the nature of the case" that large schools should have closer relations to the colleges than small schools have.

This must be my answer to most of the criticisms which intimate or declare that the first two or three of the nine propositions are impracticable.

Proposition 1.—This calls for an amount of academic training in physics much greater than most of those who are now teaching physics in schools ever had. Approval of this is very general among the school teachers as well as among the college teachers; but whereas the college teachers, as a rule, favor the suggestion of the A.M. standard, the school teachers, as a rule, object to it. A number (see notes 9, 15, 20), who apparently approve strongly of increased preparation, propose something different from that which the A.M. suggests. They would have shopwork, technical school work, or "general practise," for example. I have no quarrel with these propositions. They would certainly give good preparation for teaching. No beginners in this profession can be expected to have all the useful equipment that he will have a few years later. If he is distinctly strong on either the theoretical or the practical side, he can work up the other, with much labor, no doubt, but without overburdening labor, while teaching. But if he is not strong on either side at the beginning, things must go badly, and though he may in time, by reason of native force and toughness of constitution, become a good teacher, he must suffer, and his pupils must suffer, during his novitiate.

On a somewhat different footing are the suggestions made by Professor Mann, of Chicago (note 43), and Professor Woodhull, of Teachers College (note 62), who advise studying "the needs and mental habits of high-school pupils," or taking "courses in education," rather than getting more knowledge of the theory or the practise of physics. This raises a familiar question, which it would be useless to discuss here. There is but little in the replies received from others, whether in school or college, to indicate opinions similar to those here expressed by Professor Mann and Professor Woodhull. I suppose, however, that among school superintendents and principals they would find a good deal of support. It seems likely that, in the long run, this question will be practically settled by finding whether those who profess physics or those who profess the child mind produce the best books or devise the best courses for school use. Meanwhile it is not quite safe for either party to despise altogether the representations and arguments of the other.

Proposition 2.—This proposition, with its call for an elementary knowledge of the calculus as well as some acquaintance with chemistry, is very generally approved in the replies, whether from school or from college. Note 14, from a school teacher, rules out the calculus; note 30 (college) makes the requirement depend "entirely on grade of school"; note 43 (college) prefers to the calculus "the ways of children's minds"; note 56 (college) refers to it, not very confidently, as "an ideal to hope for in this state [New York]." Only two, Professors Mann and Woodhull, are flatly opposed to the whole proposition.

Proposition 3.—Nobody rejects (3), a fact that makes me a little uneasy about it. Indeed, one or two replies intimate that (3) doesn't amount to much. To me it means a good deal. I am convinced that American schools, while in advance of German schools in laboratory equipment and methods, are very much behind German schools in the lecture-room treatment of physics, in which most of the qualitative aspects and the applications of the science are best shown. Moreover, I believe that we shall not see this very important side of our teaching properly developed so long as the manual labor required in the handling and care of apparatus must be done wholly or mainly by the teacher, heavily burdened, as he usually is, with other work.

Very much of the criticism now directed against the kind of physics teaching that college influence has fostered in schools would disappear, if school teachers found time and strength really to follow the suggestions given them from college as to the lecture-room treatment of the subject.

Proposition 4.—This calls for and describes a "man of all work" fit to give the kind of assistance needed to afford the "relief from unnecessary manual labor" asked for in (3). This proposition, in its general aspect, is naturally a welcome one to all teachers; but some think that the individual pictured in (5) is too good to be true. Some school teachers (notes 6, 7, 10) suggest, as an attainable reality more or less remotely resembling this ideal, "a well paid boy of school," "an advanced or post-graduate pupil," "a senior boy in the high school who has been through the courses in elementary physics and chemistry" and who "can be hired here for ten cents an hour.'' The practise of employing school pupils in this way is, I think, rather a common one in large schools, and evidently it is very good, so far as it goes. The great objection to it is the lack of permanency in the helper's tenure, which must devolve upon the teacher the painful labor of breaking in a new assistant every year or two, and must, in general, prevent the temporary incumbent from acquiring any great amount of skill and responsibility in his work. One school teacher of much experience (note 19) fears that the present-day ''vocational schools'' will not be able to give the training needed and speaks with enthusiasm of the boys who are taught in ''the school for instrument makers at the University of Leyden.'' But is it not possible that the people who are, in this country, just beginning to grapple with the vocational-school problem will welcome the suggestion here made, to give a varied course of training with tools, with some theoretical instruction also, qualifying the pupil to be, not a first-class carpenter, a first class plumber, or a highly skilled electrician, but a good jack-at-all-trades, a character who may at last come into his own and be recognized and respected for what he is, a most useful individual, in the right place.

Proposition 5.—Only one, Professor Mann, entirely rejects this proposition, though two or three (notes 8, 11, 43) qualify it somewhat, and Professor Hull, of Dartmouth, declares himself in doubt, with the remark (note 35), ''there should be coordination and therefore a rather definite course.'' Professor Mitchell, of Soochow University, China, approves the general proposition. ''But would not accept the list in your [my] comments as a true consensus.''

The remark of Professor Mitchell prompts me to explain that I did not offer the list he mentions, which is given earlier in this paper, as representing a final, or even a strictly ascertained present, consensus. I offered it as evidence tending to show college men, many of whom have been very skeptical as to the seriousness and value of the school study of physics, that work deserving their respectful consideration is now done in this science in many of the schools of this country. For this purpose it seems to me important and, though I am not personally quite satisfied with the list just as it now stands, I do not think it best to discuss its details in this paper, except as I may have to speak of them in connection with proposition 9.

Professor Mann, who, as I have already said, alone rejects (5) outright says (note 46), ''High Schools must serve their communities efficiently, and colleges must take their product and do their best with it,'' etc. This somewhat harsh profession of humility on the part of a college man is in accordance with occasional declarations of school men, not usually, I think, teachers of physics, but more often principals of schools.

But just what is meant by the phrase ''serve their communities efficiently''? One might suppose that school teachers when left to themselves, without interference from the colleges, know just what their pupils ought to have and that the pupils gladly accept what the teachers or the principals offer. One might suppose, though I do not think Professor Mann intended to imply this, that schools left to themselves soon establish a satisfactory definite course of study, or at most one or two fairly definite and satisfactory courses. Probably this is done in some cases, perhaps in many cases. But I remember being told some years ago by the principal of an ''English high school'' not far from Boston that his pupils had almost unrestricted freedom of election of studies, and that it took him a long time (*all summer,* I believe was his phrase) to arrange his school program for a coming year. I have lately read the following statement from one who has very recently been looking over a great mass of material relating to schools. "The larger high schools run an entirely distinct course of four years for these pupils who intend to go to college, and other courses—sometimes as many as eight others—for those who do not plan to enter college."

Must we, then, admit that, while different interests in one community require as many as eight different courses of study in the high school, any one of these eight courses of study ought to be regarded as fitting a boy for college?

I still hope that we shall be able to frame a course of school physics which will be sound in theory and apt for daily use, good preparation for college study and good equipment for the active-minded boy whose academic career ends with his high-school training.

Proposition 6.—A large majority of the replies, whether from schools or from colleges, favor a laboratory test as a part of the entrance examination, if there is to be any examination, though a few of the school teachers and a considerable minority, about one third, of the college teachers reject this suggestion.

Professor Gale, of the University of Chicago, probably speaks the opinion of many when he says (note 31) "I doubt the practicability." The question of practicability here is very closely connected with propositions 7 and 8. At Harvard, where our practise for many years has been in accordance with (7) and (8), there is no question as to the practicability of the laboratory examination. We have had it there for more than twenty years, and, on the whole, it has worked well, as most teachers who are in the habit of preparing boys for it would, I think, testify. New England school teachers familiar with this practise at Harvard have been for some time urging the middle states teachers to ask for a like practise in connection with the college entrance board examinations; but the middle states teachers are doubtful.

The laboratory test is easily managed at Harvard because we have there in regular use in our college course for beginners laboratory apparatus very similar to that used in high school laboratory courses. If the physics teachers in the schools about Cambridge think that things are taking a wrong turn in this test they are very likely to tell us so. The latest complaint, made to me last fall by a well-known school teacher, was that the laboratory examination of June, 1909, was too easy, that his pupils were laughing over it. Investigation showed that our examiners, who were unusually few last June, had fallen into the way of using certain experiments, the most convenient ones, too frequently, and using many others not at all. This danger must be looked out for in future. A laboratory examination will no more run itself successfully than any other examination will; but neither the care nor the expense needed for its proper maintenance is formidably great. At Harvard, where the examiners are paid \$1.50 an hour each, the average expense to the university of examining a boy in the laboratory is probably less than fifty cents.

It would, of course, be impracticable for the college entrance board to apply the laboratory test; for its examinations are conducted at many different places, not usually in laboratories, by proctors or monitors who are not usually physicists.

It would have to limit itself to giving a provisional grade, on the written examination alone, leaving to the individual college to which the candidate goes the conduct of the laboratory test. This is the function of the college entrance board now with respect to candidates taking the board examination in physics with a view to entering Harvard.

Professor Mann (note 47) remarks that the question raised in (6) "has no significance in the west," where they have "outgrown" entrance examinations.

Propositions 7 and 8.—18 school teachers out of 20 replying and 34 college teachers out of 40 replying are in favor of making, in the college elementary teaching of physics, "an important distinction between those who have and those who have not passed in physics at admission," though a number of the college teachers (notes 26, 27, 32, 38) add some qualifying remark.

Proposition 8, which is a natural though not an inevitable corollary of (7), was favored as freely by school teachers, though not quite so freely by college teachers.

Professor Saunders (note 57) rejects (7) with the brief comment, "Not in New York State." Professor Crew (note 24) and Professor Magie (note 41) make longer statements explaining their opposition. Professor Crew says: "The university presents the subject as a connected whole, as a single great body of truth. The student here, for the first time, meets a philosophical connection between the different parts of the subject." Professor Magie says that "the student undergoes a considerable mental development in the later years of his school life and his early years at college. A physics course in college 'substantially equivalent,' etc., would be too childish for him," etc. "The plane of the teaching—the philosophic attitude of the teacher—ought to be more advanced."

I am by no means out of sympathy with the general feeling expressed by Professor Crew and Professor Magie concerning the proper difference between the school treatment and the college treatment of any subject of study, even with beginners. Some feeling of this sort is involved in my own amendment to (8). It seems to me, however, that the college teacher of physics can philosophize to much better advantage, if his students already know some rudiments of fact and theory. It is possible for schools to give sound instruction in these rudiments in physics, and a large proportion[1] of the students will naturally, if the school teachers of physics are properly trained and supported, come to college with such instruction. Proposition 7 would merely require those who do not enter college with this attainment to get it, and would offer them opportunity to get it, before entering the higher and more philosophical course which Professor Crew and Professor Magie describe.

Note 13, which begins thus, "Found in my three years of college teaching that no 'important distinction' could be made," and follows with some details brought out by a special letter of inquiry, is interesting as showing the kind of evidence on which, in some colleges at least, the teachers come to the conclusion that school physics is of little account. In the case referred to in this note 13 "there was no

[1] At Harvard we have for the last ten years allowed the candidates for admission to offer in place of physics, formerly required of all, an equivalent amount of work in chemistry, or in certain other natural sciences, the usual practicable choice, however, lying between physics and chemistry. In 1906 about 73 per cent. of those entering as candidates for the A.B. and the S.B. had *passed* in physics; in 1907, about 73 per cent.; in 1908, about 72 per cent.; in 1909, about 75 per cent.

entrance examination conducted by the college,'' and apparently very few of the candidates took any entrance examination in the subject of physics. But, even if this college had maintained a stiff entrance examination for those offering physics for admission, would those students who had passed this examination, if placed after entering college in the same physics course with an equal number of students who had never taken physics before, the course being designed for beginners, show at the end of a year any marked superiority over the others? Probably not; but what should we infer from this? If we should put lumps of chalk and lumps of charcoal into the same box and shake them well together for a day or two, would there be any important distinction plainly visible between them at the end of the experience? Perhaps not. But they were different at first and the difference might have been maintained by keeping them separate. If colleges should try with French, for example, the same kind of experiment which they try in physics, ignoring the school teaching and putting those who had entered with French into the same college course with those having no previous knowledge of the language, would there be any important distinction between the two sets of students at the end of a year? Probably not.

The successful realization of Propositions 7 and 8 will probably require, in every college making the experiment, some one of respectable attainments in physics and enough interest in the teaching of physics to bring into some hazard his reputation for ''productive scholarship.'' Every college department that is concerned with entrance requirements should have at least one member who will make a business of knowing personally the school teachers of his subject and of conferring frequently with them on matters of interest and importance to schools and colleges alike.

Proposition 9.—Only 4 of the school teachers and the same number of the college teachers would cut out kinetics wholly from college requirements. It appears, then, that Proposition 9 in its original form would have been rejected by a majority of both classes of the teachers replying.

As it is reasonable to assume that every one who voted for the original (9) as a first choice would approve my amended (9) as a second choice, it seems that a majority of each class, 15 in 20 school teachers and 22 in 40 college teachers, would go at least as far in restricting kinetics as my amended (9) goes.

Several replies put some new amendment on the proposition, but only 3 school teachers in 20 and only 12 college teachers in 40 are distinctly opposed to any restriction of the ground now covered, or which may be covered, by college entrance requirements in kinetics.

These minorities in opposition may seem numerically small; but in each there are those with whom I do not like to differ. Moreover, it must be remembered that a majority of the first committee, and the whole of the final committee, appointed a year or two ago for revision of the college entrance board requirement in physics declined to recommend such a restriction as that called for by (9) or even that proposed by the amended (9). It therefore seems to me that it would be unwise to ask the college entrance board to reopen this question formally at present; but just now is the time for such discussion as may help toward a wise interpretation of the somewhat general terms of the new requirement and toward a salutary practise in teaching and examining in accordance with this interpretation.

Professor Webster (note 61) says: "I feel that it is a pity to argue so much about the dyne and erg. I would teach them, and give credit to those who can do them well, but not make this a *sine qua non.*" That is, the practical question before us here is one of proportion and proper emphasis. I do not intend to deny or question the statement that a boy of average high-school intelligence can at the age of seventeen grasp the principle of the formula $f = m \times a$ or learn and understand the definitions of *dyne* and *erg*. But to understand and learn definitions is one thing; to remember them is another thing. Initially, by their mere sound or form, these two words mean little or nothing to the boy. So far as he can see, the names dyne and erg might perfectly well be exchanged. Moreover, and this is the really significant fact here, he practically never hears or sees these words outside the physics class room. *Volt* and *ampere* are much harder words to define than dyne and erg, but they are in common speech; they are in the newspapers. It is true that common speech and the newspapers show a tendency to dispense with *amperes* and reckon current strength in *volts;* but the boy knows, when he is studying the meaning of these words, that he is getting hold of terms that men use familiarly in business, that he is making acquaintances for life. He sees voltmeters and ammeters, and he knows that they are indispensable instruments of applied science. But even in the physical laboratory he never sees an instrument measuring force in dynes or work in ergs. Of course, we could make such instruments. We could, for example, take any spring balance and mark its scale in dynes. But how could we justify such an operation? We should have to say, It is important to make the boy familiar with this kind of an instrument in his physics course, because he will never see it anywhere else.

Even the word *poundal,* which because of its relation to pound is more easily assimilated than dyne and erg, has never come into much use outside physics courses. Engineers will have none of it, and mathematicians in their dynamical writings are serenely independent of any units to which they need give names. Accordingly, when we ask the youngsters in school to remember and distinguish the "absolute" units of force and work by name, we should not take them or their teachers very seriously to task if in the stress of examinations they get these terms a little mixed. I would suggest that the examiner who does not feel free to leave out all mention of dynes and ergs can use them rather helpfully than otherwise by framing his questions in such a way as to test the candidate's knowledge of principle and fact rather than his memory of words. For example, *How great a force (dynes), acting on a 50-gram mass for 10 seconds, will impart to it a velocity of 100 centimeters per second, and how much work (ergs) will the force do in this time?*

But such a question, little as it taxes the verbal memory of the candidate, seems almost too academic for a college entrance examination. I am sure that the boy would feel himself much nearer the important realities of life in dealing with a question like the following: *If a shell weighing 800 pounds acquires in 0.04 second a velocity of 2,000 feet per second in the bore of a gun, how great (reckoned in pounds) is the accelerating force (supposed uniform), and how many foot-pounds (or foot tons) of work does this force do in giving this velocity?*

I am not here advocating English units as against the units of the metric system. I am merely illustrating the greater *nat-*

uralness, common usefulness, of the gravitation units, the pound-force, as a unit, being thoroughly familiar to us from childhood, because of our acquaintance with spring balances graduated in this unit.

But can we get rid of all our verbal difficulties by keeping to the gravitation units? What shape does our acceleration equation, which I have written $f = m \times a$, take in this case? I ask this question, even on paper, with a feeling of trepidation, an uncomfortable sense that some engineer is reaching out for his club while I write the words. Let me hasten to put W for the number of pounds of matter in the body dealt with, F for the number of pounds of accelerating force applied to it, g for the gravity constant 32.2, A for the acceleration in feet per second per second. I thus get $F = W/g \times A$.

But we like to give names to things which we use often, and the quotient W/g is such a thing. What shall we call it? I will here take as my guide for the moment Professor William Kent and will quote from an article by him which appeared in SCIENCE December 24, 1909, under the title, "The Teaching of Elementary Dynamics in the High School."

"*Mass.*—It is convenient to call the quantity $M = W/g$ by a name, and the name 'mass' has been given to it, although this name is perhaps unfortunate, since the word mass is also used in other senses. Thus it is commonly used to mean an indefinite quantity of matter, as a lump or portion. It is also used by many textbook writers in the sense in which we have used the word weight, for a definite quantity of matter stated in pounds, and these writers try to restrict the word weight to mean only the force with which the earth attracts matter. (Do not tell the student that, 'the engineer's unit of mass is 32.2 pounds.' The engineer has no such unit. When he weighs a quantity of matter he records the result as a weight, and his unit is a pound.)"

I think I see the point which Professor Kent wishes to make in the warning contained in his parenthesis. To be accurate we must say, *The unit of mass, according to the engineer, is the mass of 32.2 pounds of matter.* But even this morsel is a bit difficult of assimilation.

I do not propose to criticize Professor Kent's syllabus—as intended for the use of engineering students. His ideas are of course perfectly clear and consistent, his words also. His general method of presenting the subject of elementary dynamics I find rather wearisome to read, not because it is so "heretical" from my point of view, but because it is so much like my own.

I like to teach, so far as I can succeed in teaching, these simple elements of dynamics; but when I think of the capacities and needs of the high-school pupil and remember that he will very likely not be an engineer, I can not feel that Professor Kent's syllabus would make the subject anything less than formidable to him. If we enter upon the definite quantitative treatment of Newton's second law, of the formula $f = m \times a$, we must use the unfamiliar and academic, though logically simple, *poundal* or *dyne,* or we must, turning to gravitation units, meet the difficulty which Professor Kent recognizes in the passage on *mass* which I have quoted. In fact, the school teacher, not knowing what particular system of units the unknown future examiner of his pupils will prefer, must, in order to be sure, train them in both systems, or, rather, in four systems, the absolute and also the gravitation metric units, the absolute and also the gravitation English units.

Then let all of us who are, or who may be, examiners be merciful.

At the end of a paper so long as this one, and so full of the author's opinions, it may seem insatiate in me to express the hope that this discussion will not prove to be the conclusion of the matter. But I have not been concerned merely to express my opinions or even to get them assented to. I want to see a number of things done, certain relations formed, certain practises established, which I believe and which, apparently, many others believe would be greatly to the advantage of the elementary teaching of physics in this country. Now there is, of course, no individual or association of individuals having decisive general authority in the questions here raised. If anything much is to issue from this debate, it must come as the result of action by many institutions moving singly or, perhaps, in groups. But the National Educational Association, if its council should elect to consider the propositions of this paper or any similar ones, would probably have a good deal of influence in deciding their fate during the next few years.

EDWIN H. HALL

CAMBRIDGE, MASS.,
April 2, 1910

CHARLES ABIATHAR WHITE

SOON after coming to Washington in 1895 I formed the acquaintance of Dr. White who then had an office in the National Museum. As one of the older men he knew many, if not all, of the distinguished geologists of the country, and especially those who had been active in building up the great state surveys and his fund of information in regard to them was most interesting to me. Among others he expressed his sincere admiration for Professor J. S. Newberry, of Columbia University, for whom I, in common with all of the older graduates of the School of Mines, had the greatest affection. I learned from Dr. White that it was largely through Professor Newberry that he obtained an election to the National Academy of Sciences, and I may add that Dr. White was quite proud of the fact that for the first time in its history the Academy by his election completed its membership; that is to say, he was the first one hundredth member of that distinguished body. It may not be too much to say that it was due to my efforts that Dr. White was led to prepare the delightful sketch of Newberry that appears among the biographical memoirs of the academy. It was the fact that among the older men none was left save White who was in a position to write from his own contemporary knowledge the details of the interesting career of Professor Newberry. It was also this argument which I presented as strongly as I possibly could to Dr. White that led him a few days later to send to my office the biographical notes which I now have much pleasure in presenting to the readers of SCIENCE, giving in full detail the career of the oldest and one of the ablest of our American paleontologists.

MARCUS BENJAMIN

CHARLES ABIATHAR WHITE was born at Dighton, Bristol County, Mass., on January 26, 1826. He was the second son of Abiathar White and his wife Nancy, daughter of Daniel Corey, of Dighton. His ancestors were among the early settlers of New England. Upon his father's side he was descended from a line of English-American yeomen, a leading object in the life of each of whom was the establishment of a family in a permanent home, with the ownership of his land in fee simple. The first of this line in America was William White, who established himself at "Windmill Point," in Boston about 1640. About the year 1700, his grandson, Cornelius White, removed from Boston to Taunton, Mass., whence he purchased a tract of land for a homestead farm, a part of which extended to the adjacent town of Dighton. This homestead has ever since, more than two hundred years, been owned and occupied by descendants bearing the family name. It was upon the Dighton