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Center of Gravity and Center of Mass

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DISCUSSION AND CORRESPONDENCE

Concerning the New Book on Demonstration Experiments

MANY of those who have been so patiently awaiting the publication of the A. A. P. T. book on *Demonstration Experiments in Physics* will be interested to know that the manuscript is now in the hands of the publisher, the McGraw-Hill Book Company, and that the prospects are good for its publication by June 1. We wish to take this opportunity to thank the many members of the Association who have cooperated in this undertaking, and to invite their continued interest in it. After the book appears, there will doubtless be numerous points where members can suggest additional experiments. We will welcome this information and any suggestions for improvements in the experiments already described.

The book will comprise 500–600 pages, with more than 400 illustrations and line drawings. There are nearly 1200 individual experiments described, covering the gamut of physical principles and ranging in grade from the very simple to the comparatively difficult. We have tried to include sufficient experiments requiring only modest equipment so that *every* teacher of physics in either college or secondary school will find the book valuable to him; and we have likewise included enough advanced material to keep even the best-equipped department busy for some time to come.

Advance order for the book may be made on a postal card addressed to me. The book will be billed at list price less the professional discount, at an actual cost of somewhat under five dollars.

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Center of Gravity and Center of Mass

THE terms *center of gravity* and *center of mass* are usually used almost interchangeably in elementary and intermediate mechanics texts—yet such loose usage overlooks a distinction in principle of some importance. Because of the large number of texts that have appeared recently in which the conceptual difference between center of mass and center of gravity is not stressed or even pointed out, the writers think it desirable to focus attention on the distinction.

The term *center of mass* can be given an essentially geometrical definition,

$$\mathbf{r}_{\text{c.m.}}=\frac{\int \mathbf{r}dm}{\int dm},$$

which is always used in actual center of mass calculations.

The situation is not as clear-cut when we deal with *center of gravity*; at least three conceptually different definitions of center of gravity can be given. First, it can be defined, and usually is, as the point (not necessarily inside the body, as in the case of a hoop) such that when a body on the earth's surface is supported from that point it will remain in equilibrium regardless of its orientation. This definition assumes uniformity of the earth's gravitational field near its surface; in all cases the center of gravity so defined is identical with the center of mass.

Second, center of gravity of a body can be defined as that point at which a single force must be applied to maintain the body in equilibrium when the body is in a non-uniform gravitational field. For any assigned orientation of the body, such a point exists, at least for fields in which couples may not arise; but it is certainly not truly that for most bodies such a point exists independently of orientation. For various orientations the intersections of the lines of action of the single equilibrating forces cut out a region in space which converges to a point as the field approaches uniformity.

Finally, center of gravity can be defined as center of gravitational attraction; that is, the single point at which all the mass of a body can be concentrated without changing the gravitational field of the original object. Again such a definition implies that only certain very special bodies have centers of gravity—namely, the centrobaric bodies,[1] such as homogeneous spheres, and bodies obtained by inversion of such spheres.

Since our first definition of center of gravity always leads to a coincidence of the centers of mass and of gravity, and since most objects do not have centers of gravity as defined in the other two senses, it would make for economy and accuracy of expression if the term center of mass were used exclusively in examples in which the earth's field is considered uniform. According to this usage the weight of an object would act at its center of mass. The term center of gravity could then be reserved for situations (astronomical, electrostatic etc.) in which non-uniform fields are considered. Whether the second or third definition of center of gravity is appropriate would depend on the particular problem; but in any case stress should always be placed on the fact that centers of gravity so defined do not exist for most bodies.

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[1] W. D. MacMillan, *The Theory of the Potential* (McGraw-Hill), p. 212.