

**THE FUNDAMENTAL EQUATIONS OF
DYNAMICS AND ITS MAIN
COORDINATE
SYSTEMS VECTORIALLY TREATED AND
ILLUSTRATED FROM RIGID DYNAMICS**

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The fundamental equations of dynamics and its main coördinate systems vectorially treated and illustrated from rigid dynamics by Frederick Slate

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FREDERICK SLATE

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BY
FREDERICK SLATE

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PREFACE

Don. U. of Cal. 1921

The day has clearly passed when any comprehensive presentation of all dynamics could be compressed and unified within the compass of one moderate volume of homogeneous plan. The established connections of dynamical reasoning with other fields in physics are of increasing number and closeness, as furnishing for them strongly rooted sequences in their interpretative trains of thought and linking together what would else have continued to stand separate. And that relation has reacted powerfully in modern times upon dynamics itself, perpetually enriching its substance, yet at the same time introducing within it certain sharpening differences that are stamped upon it by the type of use for which preparation is being made. These in fact modify superficially the modes of expression and their tone, and shift their own emphasis through a range that brings about what is in effect a subdivision of territory and an acknowledgment of practically diverse interests. It is in response to the situation which has been thus unfolding, and in conformity with its drift toward manifold adaptations, that special treatises have been rendered available whose measure of unquestioned excellence and authority would make superfluous an attempt to replace any such unit with a marked improvement upon it.

But undoubtedly these differentiations founded in divergencies and inevitably expressing them in some degree, are entailing a corresponding need and demand to offset them with a broadening survey of the common foundation and of the common stock of resources. And with that end in view another treatment of dynamics finds a place for itself and holds it for special service. This will propose to state with catholic inclusiveness the principles

that lay out and direct all the main lines of use, and to anticipate at their common source, as it were, the preferred methods and forms that are characteristic of various provinces.

On this side also reasonable requirements for the immediate future have been satisfied up to a definitely recognizable point. For works on abstract dynamics are at hand to help, whose number and quality have left no fair opening for renewed exposition, that could indeed scarcely attain excellence without duplicating them. In the same proportion, however, that their requisite perspective has grown, until it involves truly panoramic sweep, its due scope must cease to be secured except from a distance that expunges most details and spares only landmarks of the bolder outlines. And under the urgent pressure to condense in order to avoid neglecting and yet not become too voluminous in summarizing completely, to keep even pace with widening outlook, this view of dynamics cannot but endure the attendant risks of abstractness. Because it must lean in building toward great reliance upon the formal aid of mathematics, perforce the physical coloring will fade and the bonds with experimental reasoning be loosened. The stated results are progressively less likely to comprise what is charged with tentative quality and is held with the candidly provisional acceptance proper to inductive method.

For a student devoted to physical science though, as the gifted mathematicians Poincaré and Maxwell have been anxiously insistent that he should be aware, there are lurking elements of danger in magnifying a bare logical skeleton as a goal, and in spending best effort upon articulating it. It is a misguidance apt to control into rigidity thought which can scarcely prove worthily fruitful unless it is maintained plastic. There is a plain sense in which dependence upon clarity of demonstration in terms of mathematical brevity and rigor may operate as a defect; and that severe pruning which suppresses all but defini-

tive advance may mislead. There is a season for mitigating the austerity of algebra and daring to become discursive, for relaxing the ambition that is steadied to attain command of abstract principles on their highest level and for pausing in reflective examination of their genesis and their setting. Truly it would sterilize action to incline thus always; but never to turn aside from the more arduous pursuit tends to dissipate that atmosphere for dynamics which has given it life.

At the other extreme are found the practical temperaments, looking for tools with which to undertake their special tasks, and largely unmindful of the processes by which those have been shaped and of the far-reaching equipment in which their function is but one part, if only a particular routine can be adequately served or intelligently mastered. And this more empirical frame of mind that springs from absorption in monopolizing pursuits can be fostered and strengthened by the sheer difficulties in external form that are impressed upon abstract dynamics by the tendencies that have just been referred to, and by the air of remoteness from things material and mundane which that treatment, if uncorrected, confers. Unless it can be halted, therefore, a movement toward disintegration which must be coped with will confront the cultivators of dynamics that derives a backing also from other circumstances of the present situation.

The lifting of technical science to a better plane, where the habitual facing of new problems under the illumination of theoretical insight is coming to prevail, creates a demand in all the fundamental sciences that is a modern appeal. It has been incorporated into fixed plans of preparation for normal careers in active life to accomplish those things which were formerly undertaken with dominating inclination by minds self-selected through their special gifts. There must be, then, in the methods of presentation and in the execution of them, some recognition

of a constituency that is at once larger, less homogeneous, and more in need of aid. In a restricted sense of the word, there is a summons to popularize the abstruser sciences, and among them dynamics, with a design to favor their assimilation by students at an earlier stage. This will make concessions in view of hindrances inherent in the subject-matter, and allowance for faculties of comparison and of analytic judgment not yet ripened into full command of all resources.

There is some element in the immediate need that is due to passing a transition and that will be lost in a newly adjusted order; for it has appeared from manifold experience what marvels can be wrought by tradition in giving easy currency to scientific doctrine. Moreover, the obstacles that loomed larger by mere novelty suffer genuine reduction by more lucid statement. An older generation arrived but gradually at an understanding of the principle in conservation of energy, and caught the advantage and power of absolute measurements first in glimpses. Yet they have lived to find those unfamiliar ideas adopted among the smoothly working formulas of unquestioned truth. So it will not pass the limits of a reasonable anticipation to forecast how the younger generation of today can move at ease in their maturity among bold concepts that were obscure when imperfectly grasped. Nevertheless, as the call now is, so must the answer be given.

Every aspect of the thoughts here put down is framed in a personal experience: the profit from quickening perception and appreciation for the nexus between sharply generalized ideas and their narrower origins; the benefit of laying stepping-stones gauged to a student's stride; the reward of implanting human interest within the routine of an industrial calling; also the moral gain through confirming intellectual honesty under a sustained demand for actual comprehension of what one is challenged to attack among the papers rated as classics, or in