

**ANALYSIS OF ROTARY  
MOTION, AS APPLIED  
TO THE GYROSCOPE**

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Analysis of Rotary Motion, As Applied to the Gyroscope by J. G. Barnard

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BY  
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## P R E F A C E .

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THE apparatus discussed here under the name Gyroscope was exhibited by Professor Walter R. Johnson, of the University of Pennsylvania, in 1831. It was then called the Rotascope, but it excited but little interest.

Professor Foucault, of France, brought it forward in 1855, and employed it as a means of making the earth's rotation visible to the eye. Since that time some form of Gyroscope (the name given it by Foucault) has formed a part of the philosophical apparatus for schools.

For some time the impression prevailed in the popular mind that the phenomena exhibited by the apparatus could not be explained by natural laws. This idea was perhaps strengthened by the name applied to it by Professor Olmstead, who called it "The Mechanical Paradox."

The following analytical exposition of

OLMSTEAD.

the motions of the Gyroscope was written by General (then Major) Barnard in 1858, for the *Journal of Education*. It was immediately reprinted in pamphlet form and was eagerly sought for by students of Analytical Mechanics. It yet remains the best treatise on this interesting apparatus.

As the former editions were long since exhausted, while the demand for the essay continued, it was considered advisable to republish it in its original form, first as a Magazine article and then as a volume of the Science Series.

G. W. P.



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After reading most of the popular explanations of the above phenomenon given in our scientific and other publications, I have found none altogether satisfactory. While, with more or less success, they expose the more obvious features of the phenomenon and find in the force of gravity an efficient cause of horizontal motion, they usually end in destroying the foundation on which their theory is built, and leave an effect to exist *without a cause*; a horizontal motion of the revolving disk about the point of support is supposed to be accounted for, while the descending motion, which is the first and direct effect of gravity (and without which no horizontal motion can take place), is ignored or supposed to be entirely eliminated. Indeed, it is gravely

stated as a distinguishing peculiarity of rotary motion, that, while gravity acting upon a non-rotating body causes it to descend vertically, the same force acting upon a rotary body causes it to *move horizontally*. A *tendency to descend* is supposed to produce the effect of an *actual descent*; as if, in mechanics, a mere tendency to motion ever produced any effect whatever without that motion actually taking place.

Whatever "mystification" there may be in analysis—however it may hide its results under symbols unintelligible save to the initiated, it is most certain that the greater portion of the physical phenomena of the universe are utterly beyond the grasp of the human mind without its aid. The mind can—indeed it *must*—search out the inducing causes, bring them together and adjust them to each other, each in its proper relation to the rest; but farther than that (at least in complicated phenomena) unaided, it cannot go. It cannot *follow* these causes in all their various actions and reactions and at a

given instant of time bring forth the results.

This, analysis alone can do. *After* it has accomplished this, it indeed usually furnishes a clue by which to trace how the workings of known mechanical laws have conspired to produce these results. This clue I now propose to find in the analysis of rotary motion as applied to the gyroscopes.

The analysis I shall present, so far as determining the equations of motions is concerned, is mainly derived from the works of Poisson (vide "Journal de l'École Polytech." vol. XVI—*Traité de Mécanique*, vol. II, p. 162). Following his steps and arriving at his analytical results, I propose to develop fully their meaning, and to show that they are expressions not merely of a visible phenomenon, but that they contain within themselves the sole clue to its explanation; while they dispel all that is mysterious or paradoxical, and in reducing it to merely a "particular case" of the laws of "rotary