Acceleration.

IN NATURE, No. 1415, p. 125, Prof. Lodge asserts that the subject of acceleration is at the root of the perennial debate between engineers and teachers of mechanics; and he urges clearness of idea and accuracy of speech on all who deal with the junior student. Towards this end I would suggest that the too common phrase "acceleration of velocity" should be abandoned when the idea intended is "velocity of velocity." V and $\dot{V}$ ought not to be confounded. Let the student be told that the time-rate of change of a particle's speed in any given *fixed* direction at a given instant is called the acceleration of the *particle* in the given direction at the given instant. If the direction of the particle's motion at the given instant makes an angle θ with the given fixed direction L, and if the speed of the particle in its own direction at this instant is V, its speed in the direction L is V cos θ. The time-rate of change of this is called the acceleration of the *particle* in the direction L. It is $[\dot{V}\cos\theta - V\dot{\theta}\sin\theta]$ units of speed per unit of time. If $\theta = 0$, L coincides with the line of motion, hence the acceleration of a particle along its line of motion is $\dot{V}$ units of speed per unit of time. If $\theta = \frac{1}{2}\pi$, L coincides with a normal, hence the acceleration of the particle along a normal is $V\dot{\theta}$, *i.e.* it is the product of the linear speed and the angular speed. Linear speed is expressed in units of length per unit of time; angular speed is expressed in units of angle per unit of time. Acceleration is expressed in units of speed per unit of time. EDWARD GEOGHEGAN.

Bardsea.

THIS is simply kinematic, and well known; but perhaps its adduction at the present time is useful as emphasising the fact that acceleration in general is not a ludicrously simple and obvious idea. The term "velocity" is, however, hardly a good synonym for "rate of change" of everything: the term "fluxion" would be better; moreover, none of the phrases about "units" are necessary. O. J. L.

The Rydberg-Schuster Law of Elementary Spectra.

THE interesting law of connection shown so clearly by Prof. Schuster in the recent pages of NATURE (vol. lv. p. 200, and p. 223), to exist between the primary and secondary series of lines in the representations given by Kayser and Runge of the spectra of certain metallic elements, is a law which seems so suggestive of the musical phenomena termed in acoustics "difference-tones," as a possible explanation of its origin, that it may perhaps be of some use in seeking for a true account of the connection, to show here how it may be held, if not quite perfectly and exactly, at least up to a certain point of great resemblance, to possess that aspect.

The set of fundamental and over agitation-rates comprised in a Balmer-series, form a sort of chime of rays together, perhaps not very unlike the mixture of notes composing the almost vocal-sounding scream, or buzz, rather than a pure note, which a humming-top emits. From combined actions of the proper members of this chime, sets of vibrations would no doubt arise, with oscillation-rates in a succcession of secondary series, equal to the surplus rates of all the succeeding proper members of the chime above the oscillation-rate of some starting member. In the case of Balmer's series, $n = \frac{1}{\lambda} = A\left(1 - \left(\frac{2}{m}\right)^2\right)$, the differential set for all the vibration-rates following the first, or fundamental rate, $n_1 = A\left(1 - \left(\frac{2}{3}\right)^2\right)$, is represented generally by

$$n'_1 = A\left\{\left(1 - \left(\frac{2}{m}\right)^2\right) - \left(1 - \left(\frac{2}{3}\right)^2\right)\right\} = A\left\{\left(\frac{2}{3}\right)^2 - \left(\frac{2}{m}\right)^2\right\};$$

or $n'_1 = \left(\frac{2}{3}\right)^2 A\left(1 - \left(\frac{3}{m}\right)^2\right)$, a slightly modified Balmer-series, of which the convergence frequency,

$$\left(\frac{2}{3}\right)^2 A, \text{ is } = A - A\left(1 - \left(\frac{2}{3}\right)^2\right),$$

or the excess of the primary series' convergence-frequency, A, above its fundamental rate of vibration, $A\left(1 - \left(\frac{2}{3}\right)^2\right)$; the law of dependence of the secondary on the primary series found to hold good in a number of line-spectra of the elements, by Prof. Schuster and Prof. Rydberg. But the form of the second series is a little different from that of the first, in that the coefficient of its second term is nine times instead of four times the fixed value of the first term. I regret that I am not familiar enough with the measurements obtained, and with the very important discussions that have been based upon them, to be able to say if any secondary series of this modified form, or of the similar higher forms, as $n'_2 = \left(\frac{1}{2}\right)^2 A\left(1 - \left(\frac{4}{m}\right)^2\right)$, &c., are met with in the ranks of lines found by Kayser and Runge to accompany the chief, or leading ranks in so many of the spectra of the elements. But as a supposition which seems thus to present itself most prominently and invitingly for trial and consideration, I would yet venture to suggest that real or actual productions of secondary rays by differences of rates of vibration among primary rays, may perhaps occur in molecules in some such way as that recently expounded by Prof. Everett[1] to account for the corresponding phenomenon of audition of difference-tones in acoustics without excluding those tones as purely subjective existences from a real place in physics. If the possibility of such secondary, differential light rays' origination from primary vibrations in molecules is admissible, then this present description of their long secondary, tertiary and other higher ranks or scales of vibration-rates, may perhaps prove a means (with some transformations very possibly not quite inexplicable, in the least complicated cases) of comprising all the secondary ranks' array of vibration-frequencies, and the surprisingly exact law of numerical dependence shown so very certainly and clearly by Prof. Schuster to hold between the primary and secondary ranks' terminal oscillation-rates, in one view of physical relationship together. A. S. HERSCHEL.

Observatory House, Slough, January 9.

P.S.—The answer to this suggestion is, I see, supplied already by Prof. Schuster in his first letter on this newly-found relationship; for he has there noted (this vol., p. 201), that the above supposed successive differences, although their series, $A'\left(1 - \left(\frac{3}{m}\right)^2\right)$, is of the type $A - \frac{B}{m^2}$, only approach to, without exactly reproducing the set of frequencies of the subordinate spectrum-series. If $A - \frac{B}{3^2}$ represents the lowest or "fundamental" rate of vibration, F, in all the primary line-series, and therefore $\frac{B}{3^2} = A - F$ the "convergence frequency," A′, common, by the observed law, to both the line-series subordinate to such a primary one, then whatever values, near 4, B may have been found to have in the chief series, the first of the above ideal series of differences may easily be seen to be always $A'\left(1 - \left(\frac{3}{m}\right)^2\right)$; and this does not correspond more than approximately, except in rays of frequencies very near to the "convergence-value."

Sailing Flight.

ALL students of aerodynamics must be sorry to learn of the death of Herr Lilienthal, on August 11 last. His loss is serious, as he evidently had the courage necessary to put these exceptionally dangerous experiments to practical test, which few care to do, and had thereby gained a large experience.

I have just secured a Cyrus (*Grus antigoni*), 5 feet 2 inches in height. It weighs 16 pounds, and has a spread of wings 8 feet 8 inches.

The primary feathers require 10 ounces each to bend them to the curve seen when the bird is soaring; they are 17 inches long on the feathered portion, not all identical in size or strength, but their total comes so nearly to the weight of the bird, that it is obvious the primary feathers constitute the lifting mechanism.

From the almost universal arrangement of the mode of support in relation to the weight, as seen amongst birds, bats, and

[1] *Proceedings* of the Physical Society of London, vol. xiv. p. 93; and *Philosophical Magazine*, March 1896.