

Review

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from actual experience, or from an intuition proceeding, perhaps, from a long series of predispositions accumulated in the race. The empiric geometry of the Egyptians would seem to have been derived by intuition from looking at a figure. M. de Freycinet asks the question: Is geometry purely rational or is it partly experimental? Does it belong to Pure Mathematics or to Mathematical Physics? His answer is that it belongs to the former if the axioms are self-evident, and to the latter if they are based on experience. He treats his subject in connection with geometrical concepts, the axioms, and those propositions which deductive geometry sets itself to prove. He finds them all to be the outcome of experience and observation. His monograph is well worth reading for its charm of style, and should be found interesting to the mathematician and the philosopher alike. In connection with the discussion, it may not be amiss to quote the following from Mr. Russell's *Principles of Mathematics*. "The common desire for self-evident axioms is entirely mistaken. This desire is due to the belief that the Geometry of our actual space is an *a priori* science, based on intuition. If this were the case it would be properly deducible from self-evident axioms, as Kant believed. But if we place it along with other sciences concerning what exists, as an empirical study based on observation, we see that all that can be legitimately demanded is that observed facts should follow from our premisses, and, if possible, from no set of premisses not equivalent to those that we assume. No one objects to the law of gravitation as not self-evident, and similarly, when Geometry is taken as empirical, no one can legitimately object to the axiom of parallels except, of course, on the ground that, like the law of gravitation, it need be only approximately true in order to yield observed facts. It cannot be maintained that no premisses except those of Euclidean Geometry will yield observed results; but others which are permissible must closely approximate to the Euclidean premisses."

**Kinematics of Machines.** By R. J. DURLEY. Pp. viii. and 379. 17s. net. 1903. (Chapman & Hall.)

This is an excellent text-book, written under the influence of *Die praktischen Beziehungen der Kinematik zu Geometrie und Mechanik* and its predecessor. Reuleaux conceived of a mechanism as a chain made up of links, any one of which may be considered fixed. With this conception as basis, and taking account of the relative motion of the links as determined by the pairing of their elements, we are enabled to develop the whole kinematic theory of mechanisms. The book is too technical to be reviewed in these columns, but the teacher of mechanics might do worse than read the first half of the volume. From the first six chapters he will be able to construct a large number of examples to be worked out by his classes. Chapter III., for instance, on plane mechanisms containing only turning pairs, deals with quadric crank chains, virtual centres and centrodes, the skew pantagraph, Peaucellier cells, etc. In most cases the relations between the linear and angular velocities are obtained graphically and analytically.

**The School Arithmetic.** By W. P. WORKMAN. Pp. viii. and 495. 3s. 6d. 1903. (Clive.)

This is a school course adapted from the *Tutorial Arithmetic*. It is amplified by a large selection of miscellaneous examples arranged in carefully graduated papers, new examples in approximate methods, and an additional collection of miscellaneous problems. "Harder Problems" of the *Tutorial Arithmetic* have disappeared. It is undoubtedly the best arithmetic for schools on the market.

**Spherical Trigonometry.** By D. A. MURRAY. Pp. ix. and 114. 2s. 6d. 1902. (Longmans, Green.)

The matter of this little book is confined to what is requisite for attacking the solution of spherical triangles and the simple practical problems depending thereon. After a revision of the elements of spherical geometry, the attention of the student is at once directed to the right-angled spherical triangle. The section dealing with it and the explanations in the sections (pp. 84-93) dealing with the application of spherical trigonometry to astronomy are full and singularly clear.