KEY AND SUPPLEMENT TO ELEMENTARY MECHANICS

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TO

ELEMENTARY MECHANICS.

BY

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KEY AND SUPPLEMENT

TO

ELEMENTARY MECHANICS.

PAGE 1, ARTICLE 1.—Motion is a change of position. Motion is determined by the relative position of bodies at different times. If bodies retain the same relative position during successive times, they are said to have no motion in reference to each other; in other words, they are said to be at rest in reference to each other. All bodies of which we have any knowledge are in motion; hence all motion is, so far as we know, relative. Absolute motion implies reference to a point absolutely at rest, but as no such point is known, such motion has only an ideal existence.

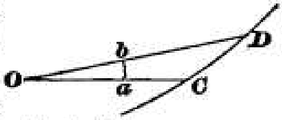
PAGE 2, ART. 6.—No definition of space will give a better idea than that obtained by experience. Metaphysicians have indulged in speculations in regard to its nature, but they are able to assert with certainty only that it has the property of extension. Descartes taught that the properties of extension, known as length, breadth, and thickness, were solely properties of matter, and hence when a body was removed no space remained in the place formerly occupied by it. So far as we know, no space exists which is perfectly de-void of matter. Perfectly void space is an ideality; still modern philosophy distinguishes between the thing contained, and that which contains it—between matter and the place occupied by matter. It abstracts (so to speak) space from matter, and, in a measure, matter from space. It seems impossible to conceive of matter not occupying space, but it is not difficult to conceive of a given quantity of matter as occupying a very small or a very large space. We are able to consider matter in the abstract without considering the dimensions of the space it occupies; and also we may consider space in the abstract as not including matter. The latter is called *absolute space;* it is conceived as remaining always similar to itself and immovable.

Time is duration. We gain a knowledge of it by the order of events. Every event has its place in time and space, and by means of memory we gain a knowledge of the order in which events occur. Without memory we would gain *by experience* no knowledge of time. Sir Isaac Newton considered mathematical time as *flowing* at a uniform rate, unaffected by the motions of material things. This idea induced him to call his new calculus *fluxions*.

Rate refers to some unit as a standard. Thus, to illustrate, rate of interest is a certain amount of money paid for the use of *one* dollar; passenger rates refer to the amount paid for *one* passenger; rate of shipping per ton is the amount paid for carrying *one* ton; *rate of motion* is the space passed over in *one* second, *one* minute, *one* hour, *one* day, or *one* of any other unit. The term *velocity* is simply the equivalent of *the rate of motion*. Angular velocity is *rate* of angular motion

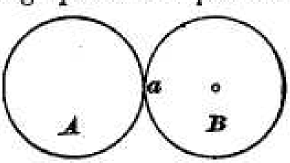
(p. 4, Art. 12). Acceleration is the *rate* of change of velocity, being the amount of *change* in the velocity for *one* second, or *one* of any other unit (p. 10, Art. 22). Mechanical power is the *rate* of doing work (p. 55, Art. 99). Rates may involve two units. Thus, rate per ton-mile implies a certain amount paid for *one* ton for *one* mile; passenger rates are often an amount for *one* person for *one* mile; mechanical power, or rate of doing work, is the amount of work done in *one* foot for *one* second, or by *one* pound for *one* second, etc. *Rate* is a thing used for measuring quantities, as a yard-stick is used for measuring cloth, a chain for measuring land, the pound for weighing groceries, ton for measuring merchandise, etc.

PAGE 4, ART. 12.—The definition here given for rotary motion is applicable to the case where the motion is in a curved path not circular, as *CD*. But the analysis given in the text is not applicable to this case.

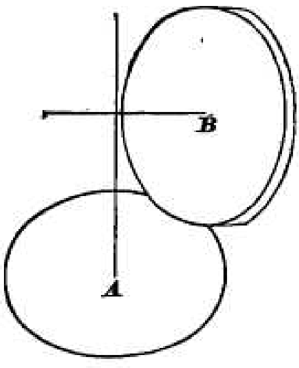


PAGE 6, ART. 14.—Just after Fig. 5, for *If two velocities*, etc., read *If two concurrent simultaneous velocities*, etc.

PAGE 8, ART. 20.—Speaking of the rotation of the moon, suggests an interesting question in practical mechanics. If the wheel *B* rolls around on the circumference of an equal wheel *A*, will the former turn once or twice on its own axis?



Mark the point *a* which, initially, is in contact with the wheel *A*, and roll *B* half around *A*; it will be observed that the marked point will then be at the left of the centre of *B*, as it was at the start. Continuing the rolling, the point *a* will again be at the left of the centre when *B* has gone completely around *A*; hence it is sometimes asserted that the wheel *B* has turned twice on its axis. But we wish to show that it has turned but once on its own axis, and the whole wheel has been rotated once about the axis of the wheel *A*. Let the axis of the wheels be at right



angles with each other, then it will be evident, from mere inspection, that when *B* has turned once on its axis it will have gone once around *A*. Thus *B* will have gone once around the axis of *A*, and once about its own axis. Next, incline the axis of *B* upward, so as to approach a parallelism to *A*, and the same result will be seen from mere inspection, and it will continue to remain evident as it becomes nearer and nearer parallel, and when they become actually parallel, the same condition will hold true. Hence, in the former figure, the wheel *B* will turn but once on its own axis in rolling once around *A*. The same result may be shown in another way. Let a block be placed at *a* facing a mark on the axis of *B*, and conceive this axis to be rigidly connected with the axis of *A* while the wheel *B* is free to turn on its own axis. In this way the axis of *B* will be carried bodily about *A*. When *B* has rolled half around *A*, it will be found that the block will face the same direction in space—say towards the east—but that it will not face the mark on the axis, for the mark will be on the opposite side of the axis. Continuing the rotation, it will be found that the block will face the mark only once at each revolution about *A*.

Similarly, the moon turns but once on its *own* axis in one revolution about the earth, but the rotation about the two centres are not exactly coincident; for it is found by observation, that in some parts of the orbit more of the surface of the moon is seen on the eastern (or western) side than in other parts of the orbit; thus showing that the rotation about the earth is sometimes faster, and at other times slower than the rotation of the moon about its own axis. This phenomenon is called *Libration*.

EXERCISES.

PAGE 9.

1. $4\frac{1}{8}$ miles.
2. The former.
3. 66 feet per second.
4. 17 feet; $17n$ feet.
5. $400 \div \frac{40 \times 5280}{60 \times 60} = 6\frac{9}{11}$ seconds.
6. $\frac{200 \times 2\pi}{60} = 6\frac{2}{3}\pi$ in arc; or $\frac{200 \times 360}{60} = 1200$ degrees.
7. $\sqrt{3^2 + 2^2} = \sqrt{13} = 3{\cdot}605 +$ miles per hour.

PAGE 10.

8. $\sqrt{15^2 + \left(\frac{44}{3}\right)^2} = \frac{1}{3}\sqrt{3961} = 20 \cdot 98$ ft. per second.

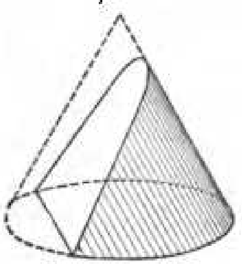
9. $0 \cdot 0009\frac{1}{4}$.

10. See Article 14. $v = \sqrt{5^2 + 10^2 + 100 \cos 60^\circ}$ $= \sqrt{125 + 50} = \sqrt{175} = 13 \cdot 22 +$ feet; hence the distance between them in two seconds will be $2 \times 13 \cdot 22 + = 26 \cdot 44 +$ feet.

PAGE 10, ART. 22.—Observe that *acceleration* is not the rate of change of motion, but the rate of change of the rate of motion. It is the rate of change of a rate. *The rate of change* is usually measured in the same units as the *rate of motion*. If one is in feet per second, the other is also. It is possible to conceive of mixed units. Thus in the case of falling bodies, the velocity at the end of the first second is $16\frac{1}{12}$ feet, and the acceleration is $643\frac{1}{3}$ yards per minute.

Strive to get a clear conception of the meaning of acceleration and of its measure. It is one of the elements of the absolute measure of force.

PAGE 13, ART. 26.—The expression "The locus of these points will be a parabola," means that if any number of points in the path be determined in the same manner, they will all be in the arc of a parabola.



A parabola is a curve which may be cut from a right cone by a plane parallel to one of its elements. (See Author's Coördinate Geometry.)