



On Some Early Propositions of Statics

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form method of division. Mr. Grant moreover admits that "the factor method" is advisable sometimes, since he suggests that

$$\frac{40.96}{.032} = \frac{40960}{32} = \frac{5120}{4} = 1280.$$

Lastly, in Contracted Work, the writer thinks that the *whole point* is to devise a simple mechanical method, since, for all practical purposes, it is only used incidentally in the solution of other problems where it is desired to make such calculations as quickly as possible and with mechanical accuracy.

W. G. BORCHARDT.

ON SOME EARLY PROPOSITIONS OF STATICS.

THE current method of founding the teaching of Theoretical Statics on the experimental proof of the "Parallelogram of Forces" seems open to grave objection. The experiment is too remote from the facts of ordinary observation; and it is not so very easily performed. Moreover, the result, when accurately obtained, appears to the pupil to be so remarkable, that it is a pity not to reserve it for use as a verification of the soundness of pure reasoning.

The alternative treatment of the elementary bookwork which is given below is based, experimentally, on a simple fact of universal knowledge and daily experience. It possesses two additional advantages; *i.e.* it leads at once to perhaps the easiest type of numerical examples, *viz.* those on parallel forces and moments; and it gives the pupil the sense of 'power' by arriving very early at the "Principle of the Lever."

It is suggested that the following seven propositions should be taken in the order named.

I. *Experimental basis.* At the same place on the earth's surface equal volumes of the same material have equal weights.

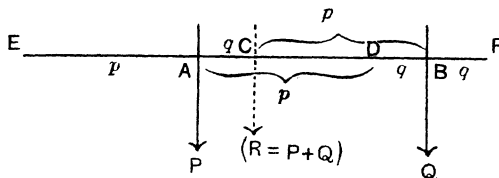
II. The weights of bodies of the same material are proportional to their volumes.

[Follows from I., by addition.]

III. The weight of a uniform rigid *horizontal* rod may be supposed to act through its middle point.

[*Proof.* If supported solely at its middle point, it will remain at rest, \therefore there is no reason why it should drop on one side more than on the other. Hence its resultant weight is equal and opposite to the pressure of the support.]

IV. To find the resultant R of two like parallel forces P and Q , acting on a rigid body.



Let any straight line AB , drawn \perp to the lines of action of P and Q and terminated by them, be divided at C and D , so that

$$BC : CA :: AD : DB :: P : Q.$$

Let $AD = BC = p$ units of length, $BD = AC = q$ units of length.

(1) Suppose the system held so that the directions of P and Q are vertically downwards.

(2) Suppose P and Q to be due respectively to the weights of two uniform horizontal rods EAD , DBF (lengths $2p$ and $2q$ respectively) rigidly fixed to the body (II. and III.).

(3) We now have a single uniform rigid horizontal rod EF , length $2p+2q$, with its centre at C ($\because EA+AC=p+q$).

The weight of this rod $=P+Q$ (II.), and acts vertically through C (III.).

$\therefore R=P+Q$ and acts in the same direction as P and Q , through a point C , such that $P \cdot AC=Q \cdot BC$.*

V. The "moment" (as ordinarily defined and represented) of a force about a point is a true measure of its turning effect about that point.

[Proof. Let P , Q have equal moments Pq , Qp in the same sense round O .

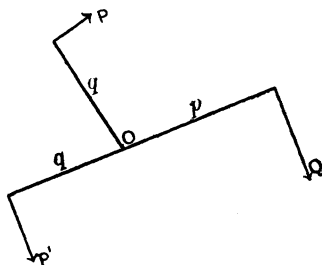
Consider a force P' ($=P$) acting in the same direction as Q , but with moment $P'q$ equal and opposite to that of Q round O .

The turning effect of P' round O would balance that of Q , \therefore their resultant passes through O (IV.).

But, by symmetry, the turning effect of P' would balance that of P .

\therefore the turning effect of P round O = the turning effect of Q .

\therefore the moment is a true measure of the turning effect.]

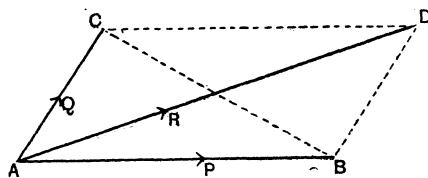


VI. The moment of the resultant of any number of coplanar forces acting on a rigid body about any point is equal to the algebraical sum of the moments of the components about the same point.

[Proof. By definition, the resultant has in every way the same effect as that of the forces combined.

\therefore this proposition is an immediate corollary of V.]

VII. To prove "The Parallelogram of Forces."



Let two forces P , Q , acting at a point A , and their resultant R , be represented in magnitude and direction by the straight lines AB , AC , AD respectively.

Then the moment of R about B = the sum of the moments of P and Q about B (VI.).

$$\therefore 2\triangle ABD = 0 + 2\triangle ABC;$$

$$\therefore \triangle ABD = \triangle ABC;$$

$$\therefore CD \text{ is parallel to } AB.$$

Similarly, BD is parallel to AC .

$$\therefore ABDC \text{ is a parallelogram.}$$

Q.E.D.

W. E. BRYAN.

* This proof was in substance communicated to me by my father, the Rev. R. G. Bryan, M.A., who invented it in 1841.