

G. W. Leibniz DE CALCULO SITUS

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De Calculo Situs

(1) Via determinata a puncto A ad punctum B ,] AB . vocatur
recta. AB . via scilicet quae transit per puncta determinate se
ad A et B habentia, minusque distantia ab A , quam A distat
a B .

(2) Itaque recta est via minima, seu si C non sit in recta
 AB , erit via ab A ad B per C major quam recta AB seu
 $AC + CB \sqsupset AB$. quoniam via minima ex positis extremis
determinata est. Nam utique manifestum est viam maximam
non esse determinatam, quia via ire potest per punctum da-
tum quodcunque adeoque quacunque assumpta sumi potest
major at viam non posse minorem assumi in infinitum, sunt
enim puncta quae propiora sunt, itaque datur quaedam via
minima.

(3) Duae quoque rectae inter A et B coincident seu si sit ACB
via recta, et ADB via recta, erit $ACB \oslash ADB$. Alioqui utique

De Calculo Situs

(1) The determined path from a point A to a point B ¹ is called the
straight line AB , that is, the path which passes through the points
relating determinately to A and B and being less distant from A than
 A is from B .

(2) And so the line is the minimal path, i.e. if C is not on the line
 AB , a path from A to B through C will be greater than the line AB ,
or $AC + CB \sqsupset AB$,² since the minimal path is determined by the
posited extremes. Indeed it is certainly clear that a maximal path
is not determined, because a path can go through any given point,
and so whatever path is assumed, a greater can be taken, whereas
a lesser path cannot be assumed to infinity, nevertheless there are
points which are closer, and so there is a certain minimal path.

(3) Also, two lines between A and B coincide, i.e. if ACB is a straight
path, and ADB a straight path, then $ACB \oslash ADB$. Otherwise the

¹The manuscript has an extra ' AB ' here. It seems he meant to cross it out along with two adjacent words that he crossed out.

²The manuscript has ' $\text{less than the line } AC, \text{ or } AC + CB \sqsupset AB$,' presumably a mistake.

ex punctis datis, via non esset determinata, cum incertum sit quae debeat eligi.

(4) Punctum quoque in recta sumtum est sui situs unicum ad duo puncta extrema seu ex datis punctis illis suoque ad ea situ determinatur. Itaque si sit in recta AB punctum Y dico situm $Y.A.B$ esse determinatum. Itaque si daretur aliud punctum E sitque situs $E.A.B \infty$ (congruus) situi $Y.A.B$ sintque E et Y in recta AB . erit $E \oslash Y$ seu coincident E et Y .

(5) *Situm* autem puncti ad punctum determinare possumus per rectas inter ea interceptas, eo ipso quia determinata est recta, ita situs E ad A dici potest EA .

(6) Recta rectae est similis seu $AB \sim CD$ et contra quae rectae similis est recta est quia similia sunt quae eodem modo determinantur. At ABC non statim simile est ipsi LMN , nisi constat prius eodem modo determinari seu in determinantibus nullum esse discrimen seu $AB \sim LM$ et $BC \sim MN$ et $AC \sim LN$.

(7) Si duae rectae sint aequales, erunt congruae, seu si sit $AB = CD$ erit $AB \infty CD$. Nam $AB = CD$ ex hypothesi et $AB \sim CD$ per artic. praecedentem. Ergo per axioma articuli sequentis $AB \infty CD$.

(8) Axioma: Si duo sint similia et aequalia erunt congrua seu si $\odot = \triangleright$ et $\odot \sim \triangleright$ erit $\odot \infty \triangleright$.

(9) Si situs $E.A.B \infty$ situi $Y.A.B$. erit $E.A. \infty Y.A.$

(10) Si $E.A. \infty Y.A.$ erit $EA = YA$ per artic. 5. et contra

path would certainly not be determined from the given points, since it would be uncertain which one ought to be chosen.

(4) Also, a point taken on the line is unique with its situation to the two extreme points; that is, it is determined by the given points and its situation to them. And thus if a point Y is on the line AB , I say that the situation $Y.A.B$ is determined. And thus if another point E were given and the situation $E.A.B \infty$ (is congruent to) the situation $Y.A.B$ and E and Y are on the line AB , then $E \oslash Y$, or E and Y coincide.

(5) Moreover, we can determine the situation of a point to a point through the lines intervening between them by the very fact that the line is determined, so the situation of E to A can be called EA .³

(6) A line is similar to a line, or $AB \sim CD$, and conversely whatever is similar to a line is a line, because things are similar which are determined in the same way. But ABC is not immediately similar to LMN , unless it is previously established that they are determined in the same way, or there is no difference in the determiners, or $AB \sim LM$ and $BC \sim MN$ and $AC \sim LN$.

(7) If two lines are equal, they are congruent, i.e. if $AB = CD$ then $AB \infty CD$. For $AB = CD$ by hypothesis and $AB \sim CD$ by the preceding article. Therefore $AB \infty CD$ by the axiom of the subsequent article.

(8) Axiom: If two things are similar and equal, they are congruent, i.e. if $\odot = \triangleright$ and $\odot \sim \triangleright$, then $\odot \infty \triangleright$.

(9) If the situation $E.A.B \infty$ the situation $Y.A.B$, then $E.A. \infty Y.A.$ ⁴

(10) If $E.A. \infty Y.A.$, then $EA = YA$ by article (5), and conversely if

³The dot in ' EA ' is unclear in the manuscript and likely absent.

⁴Leibniz appears to use a different version of the congruence symbol, one which is partially open on the left, in (9) and (10), and reverts in (12). He does not use either symbol in this essay after (12), and it is not clear whether the change is deliberate.

si $EA = YA$ erit $EA \propto YA$. Hoc intellige si E, A, Y sint puncta.

(11) Si $A.B \propto L.M$ et $A.C \propto L.N$ et $B.C \propto M.N$ erit $A.B.C \propto L.M.N$.

5 (12) Hinc si $AB = LM$ et $AC = LN$ et $BC = MN$ erit $A.B.C \propto L.M.N$ per 10 et 11.

$EA = YA$ then $EA \propto YA$. This is considered when E, A, Y are points.

(11) If $A.B \propto L.M$ and $A.C \propto L.N$ and $B.C \propto M.N$, then $A.B.C \propto L.M.N$.

5R (12) Hence if $AB = LM$ and $AC = LN$ and $BC = MN$, then $A.B.C \propto L.M.N$ by (10) and (11).

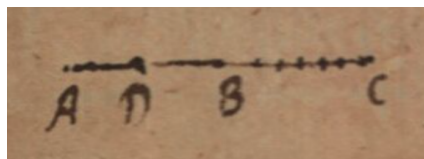


Figure 1

(13) Pars rectae est recta, nam cum recta sit via determinata, erit per determinata. Itaque si $AD + DB \propto AB$ erit AD recta et DB recta. Seu si ADC recta erit AD recta.

10 (14) Omnis recta produci potest. Sit recta AB dico eam produci posse in C . Sumatur in AB punctum D utique recta AD produci potest; (producta est enim reapse in B) ergo et recta AB , quae similis est rectae AD per artic. 6. produci poterit aliquousque ut in C .

15 In notis: Datur AB recta. Ergo datur ABC recta. Probatur. Nam datur AB recta. Ergo datur ADB recta. Ergo (per artic. 13) AD recta. Ergo per (artic. 6) $AD \sim AB$.

(15) Jam similia similiter tractari possunt et similiter tractantur similia, quod est axioma a nobis saepius adhibendum.

(13) A part of a line is a line, for since a line is a determined path, it will be fully determined. And so if $AD + DB \propto AB$, then AD is a line and DB is a line. Or if ADC is a line, then AD is a line.⁵ [See Figure 1.]

10R

(14) Every line can be extended. Let AB be a line; I claim it can be extended to C . Let a point D be taken in AB ; certainly the line AD can be extended (since indeed it actually is extended to B); therefore also the line AB , which is similar to the line AD by article (6), can be extended to somewhere, say C .

15R

In symbols: Line AB is given. Therefore line ABC is given. The proof: Indeed, line AB is given. Therefore line ADB is given. Therefore (by article (13)) AD is a line. Therefore (by article (6)) $AD \sim AB$.

(15) Now similars can be treated similarly, and being treated similarly, they yield similars, which is an axiom we employ rather frequently.

20R

⁵Article (13) was inserted after Leibniz wrote (14), which he then renumbered, and this explains the appearance of point C in (13).

Ergo quia datur ADB dari etiam poterit $ABC \sim ADB$. Et quia ADB recta est ex hypothesi erit (per 6) etiam ABC recta. Itaque producta est recta AB . Quod fieri posse erat demonstrandum.

- 5 (16) Punctum in recta sumtum ad duo alia puncta in eadem recta sita determinate se habet, seu sui situs unicum est.

Sit recta $ALMNB$ dico aliquod ex punctis mediis ut N esse sui situs unicum ad puncta L et M . Nam $N.A.B$ est situs determinatus ex natura rectae, (seu N est situs sui ad A et B unicum) per artic. 4. Et eodem modo $M.A.B$ est determ. Et
10 $L.A.B$ est determ.

(17) Jam Axioma esto in situ aliquo pro puncto determinato substitui possunt puncta determinantia.

Itaque in situ determinato $N.A.B$ pro A substitui potest $M.B$
15 (quia A . determinatur ex $M.B$. seu situs $M.A.B$ est determinatus) et fiet $N.M.B.B$, vel omitta inutili reduplicatione ipsius B fit $N.M.B$. qui etiam est determinatus. Similiter demonstrari potest situm $N.L.B$. esse determinatum, itaque in situ $N.M.B$ pro B substituendo $N.L$. fiet denique $N.L.M$.
20 situs determinatus, Q. E. D.

(18) Omne punctum sui situs unicum ad duo puncta, minusque distans ab utroque quam ea distant inter se cadit in rectam inter ea interceptam. Si sit $AC \cap AB$ et $BC \cap AB$ et $A.B.C$. determ. erit ACB recta, patet ex defin. rectae artic. 1.
25 Forte tamen et aliter demonstrari poterit; ex intersectionibus circulorum, ita ut definitionem rectae liceat assumere adhuc strictiorem in speciem, quae tamen idem efficiat.

Therefore since ADB is given, $ABC \sim ADB$ can be given as well. And since ADB is a line by hypothesis, ABC will also be a line (by 6). And so the line AB is extended. That is what we sought to show was possible.⁶

- 5R (16) A point taken on a line relates determinately to two other points situated on the same line, i.e. it is unique with its situation to them.

Let there be a line $ALMNB$; I claim that one of the middle points, say N , is unique with its situation to points L and M . For $N.A.B$ is a determined situation due to the nature of a line (or N is unique with its situation to A and B) by article (4). And in the same way, $M.A.B$ is determined. And $L.A.B$ is determined.
10R

(17) Now let it be an axiom that, in any situation, determiner points can be substituted for the determined point.

And so $M.B$ can be substituted for A in the determined situation $N.A.B$ (since A is determined from $M.B$, or the situation $M.A.B$ is determined) and it will become $N.M.B.B$, or omitting the pointless duplication of B , it becomes $N.M.B$, which is also determined. Similarly one can demonstrate that the situation $N.L.B$ is determined, and so, by substituting $N.L$ for B in the situation $N.M.B$, it finally becomes a determined situation $N.L.M$, Q.E.D.
15R

20R (18) Every point unique with its situation to two points, and less distant from either one than they are distant from each other, falls on the line intervening between them. If $AC \cap AB$ and $BC \cap AB$ and $A.B.C$ is determined, then ACB is a line, as is clear from the definition of a line in article (1). But perhaps it can also be demonstrated another way from the intersections of circles, so that a definition of a line even
25R stricter in kind can be assumed, which nonetheless achieves the same thing.

⁶Literally: 'That which was to be demonstrated to be able to be done', an extended variation on 'Q.E.D.'.

(19) Omne punctum sui situs unicum ad duo puncta cadit in rectam per ea duo puncta transeuntem, si opus productam.

Sint tria puncta $A. B. C$, quorum situs inter se sit determinatus, dico ea cadere in eandem rectam. Est enim aliquod
 5 ex ipsis medium, quod minus vel certe non magis distet a reliquis quam ipsa inter se. Quod sic ostendo, jungantur AB, BC, AC rectae et sit ex his maxima vel certe non minor ulla reliquarum AB , proxima vel certe non minor ultima sit AC , tertia seu nulla alia major sit BC .

(19) Every point unique with its situation to two points falls on the line passing through those two points, extended if necessary.

Let there be three points, $A.B.C$, whose situation among themselves is determined; I claim that they fall on the same line. Indeed, one of
 5R them is the middle one, which is less, or at least not more, distant from the remaining ones than they are from each other. I show this as follows: let lines AB, BC, AC be joined and let AB be the greatest of these, or at least not less than any of the remaining ones, let AC be the next, or at least not less than the last one, and let BC be the third,
 10R i.e. not greater than any of the others.

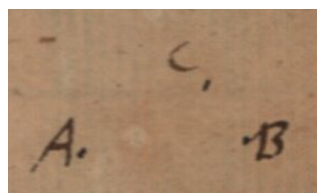


Figure 2

10 Patet C fore medium, seu non magis distare ab A et B , quam ea inter se. Ergo per praecedentem ACB erit recta. Itaque pro recta talem possumus habere propositionem localem. Sit $Y.A.B$ determ. et $\bar{Y}$ (seu locus omnium Y) erit recta. Hinc si
 15 duae rectae habere ponantur plus quam duo puncta communia coincident si opus productae et proinde duae rectae non habent segmentum commune, nec spatium claudunt.

(20) Sequitur et locum omnium punctorum ad duo puncta unicum esse lineam, seu in viam puncti determinatam per duo puncta transeuntem incidere.

It is clear that C will be the middle one, i.e. not more distant from A and B than they are from each other. Therefore, by the preceding, ACB is a line. And so for the line we can have such a local proposition:⁷
 15R Let $Y.A.B$ be determined, and $\bar{Y}$ (or the locus of all Y) will be a line. Hence if we suppose two lines have more than two points in common, they coincide when extended if necessary, and accordingly two lines do not have a common segment, nor do they enclose space.

(20) It also follows that the locus of all points unique with respect to two points is a curve, i.e. it falls on the determined path of a point
 20R passing through the two points.

⁷Latin '*propositionem localem*'; probably indicates a proposition regarding geometric loci as defined through situational properties. We have added the colon where the manuscript has a new line but no punctuation.

(21) Nam linea est via puncti.

(22) Planum est extensum ex tribus punctis determinatum, seu locus omnium punctorum sui ad tria puncta situs unicum. Seu si $Y.A.B.C$ determinatum est erit $\bar{Y}$ planum. Datis autem tribus quibusvis punctis non in eandem rectam cadentibus determinatur aliquid quod planum voco. Et generaliter assumtis quibuslibet aliquid determinatum est, seu ad ea determinate se habens.

(23) Tria puncta determinantia planum cadunt in ipsum planum. Nam situs ipsius A ad A est determinatus, ergo et situs ipsius A ad $A.B.C$.

(24) Si duo puncta rectae sint in plano, ipsa recta est in plano. Sit recta $\bar{Z}.L.M$ et planum $\bar{Y}.A.B.C$. et L sit Y , itemque M sit Y . dico omne Z esse Y . Nam primo $L.A.B.C$ est determinatum, item secundo $M.A.B.C$. et tertio $Z.L.M$. Ergo in determinatione tertia pro L . et M ex determ. 1. et 2. substituendo determinantia, fiet $Z.A.B.C$ determinatum. Ergo omne Z est Y .

Hinc manifestum est omnem rectam omni plano ubique applicari posse; itemque rectam in plano posse moveri.

(25) Tria quaevis puncta in plano sumta idem planum determinant, seu punctum quodvis in plano sui ad tria plani puncta (non in eandem rectam cadentia) situs unicum est. Hoc potest demonstrari ad modum articuli 16 in recta. Item sic: Sint illa tria puncta $L. M. N$. dico ea determinare planum in quo sunt, nam determinare utique possunt aliquod planum si non cadant in rectam, et id planum est unicum, per artic. 22 et sunt in plano quod determinant per artic. 23. Ergo planum in quo sunt determinant.

(21) For a curve is the path of a point.

(22) A plane is the extensum determined from three points, or the locus of all points unique with their situation to three points. That is, if $Y.A.B.C$ is determined, $\bar{Y}$ will be a plane. Now, given any three points not falling on the same line, something is determined which I call a plane. And in general, assuming any things whatever, something is determined, i.e. relates determinately to them.

(23) Three points determining a plane fall on the plane itself. For the situation of A to A is determined, therefore the situation of A to $A.B.C$ is also.

(24) If two points of a line are on a plane, the line itself is on the plane. Let the line be $\bar{Z}.L.M$ and the plane $\bar{Y}.A.B.C$ and let L be Y and likewise let M be Y . I claim that every Z is Y . For first, $L.A.B.C$ is determined, and likewise second, $M.A.B.C$, and third, $Z.L.M$. Therefore, substituting the determiners from determinations 1 and 2 for L and M in the third determination yields that $Z.A.B.C$ is determined. Therefore every Z is Y .

Hence it is clear that every line can be brought into [*applicari*] every plane; likewise a line can be moved in a plane.⁸

(25) Any three points taken in a plane determine the same plane, i.e. any point on a plane is unique with its situation to three points of the plane (not falling on the same line). This can be demonstrated in the manner of article 16 for a line. Thus, likewise: Let the three points be $L.M.N$; I claim that they determine the plane they are on; for certainly they can determine some plane if they do not fall on a line, and that plane is unique by article 22, and they are on the plane which they determine by article 23. Therefore they determine the plane they are in.

⁸Leibniz originally began this statement as article (25), and then he crossed out the number.

(26) Circumferentia circuli est locus in plano omnium punctorum quorum situs ad unum aliquod punctum sit idem seu describitur ab extremo rectae in plano motae (quod fieri potest per artic. 24) uno puncto immoto. Et notis ita designabitur:
 5 Si $YA = BA$ in plano, $\bar{Y}$ est circumferentia circuli.

(27) Omne planum plano simile est si indefinite sumantur, (seu si duorum planorum ambitus sint congrui ipsa plana congrua sunt) nam si planum determinatur per $A.B.C$ sumantur in alio plano puncta $L. M. N$ sic ut sit $L.M.N. \sim A.B.C$, erit
 10 et determinatum per $L.M.N.$ simile determinato per $A.B.C$. eo scilicet sensu quo determinationem explicuimus.

(28) Si planum a plano secetur, sectio communis est recta. Si duo plana se secant, saltem plus quam unum punctum commune habent, sumamus ergo duo puncta communia A et
 15 B . Et in uno plano $\bar{Y}$ sumamus tertium C , in altero plano $\bar{Z}$ tertium L . et pro plano $\bar{Y}$ erit $Y.A.B.C$ det. pro plano $\bar{Z}$ erit $Z.A.B.L$ determ. Sit jam recta $\bar{V}$ ita ut sit $V.A.B$ determ. dico omne V fore Z et omne V fore Y . Nam si $V.A.B$ determ. Ergo et $V.A.B.C$ determ. et $V.A.B.L$ determ. Ergo V est Y et V est
 20 Z . seu V cadit et in $\bar{Y}$ et in $\bar{Z}$. Verum nullum praeterea aliud punctum his duobus planis commune dari potest, quod non in hanc rectam cadit. Nam si tria puncta in eandem rectam non cadentia communia forent, coinciderent duo plana, talia enim tria puncta planum determinant.

25 (29) In plano locus omnium punctorum eodem modo se ad duo puncta habentium est recta seu sit $YL = YM$ erit $\bar{Y}$ recta.

Sint duo puncta in loco proposito, nempe A et B quorum unumquodque se eodem modo habeat ad L quo ad M , etiam quod ipsis determinatur eodem modo se habebit ad L quo ad

(26) The circumference of a circle is the locus in a plane of all points whose situation to some one point of the plane is the same, or is described by the extreme of a line moved in a plane (which can be done by article 24) with one point unmoved. And it is expressed thus with
 5R symbols: If $YA = BA$ in a plane, $\bar{Y}$ is the circumference of a circle.

(27) Every plane is similar to every plane when taken indefinitely (or if the ambits⁹ of two planes are congruent, the planes themselves are congruent); indeed, if a plane is determined by $A.B.C$, let $L.M.N$ be taken in another plane such that $L.M.N \sim A.B.C$, and what is determined by $L.M.N$ will also be similar to what is determined by $A.B.C$, in the sense of determination, that is, which we have explained.

(28) If a plane crosses a plane, the common section is a line. If two planes cross each other, they have at least more than one point in common; let us therefore take two common points A and B . And let us take a third C in one plane $\bar{Y}$, and a third L in the other plane $\bar{Z}$, and for the plane $\bar{Y}$, $Y.A.B.C$ will be determined, and for the plane $\bar{Z}$, $Z.A.B.L$ will be determined. Now let the line $\bar{V}$ be such that $V.A.B$ is determined. I claim that every V will be Z and every V will be Y . Indeed, if $V.A.B$ is determined, $V.A.B.C$ is therefore also determined and $V.A.B.L$ is determined. Therefore V is Y and V is Z , or V falls both in $\bar{Y}$ and in $\bar{Z}$. In fact, no additional point can be given, common to these two planes, which does not fall on this line. For if three points not falling on the same line were in common, the two planes would coincide, because three such points determine a plane.

25R (29) In a plane, the locus of all points relating in the same way to two points is a line, i.e. if $YL = YM$, then $\bar{Y}$ is a line. [See Figure 3.]

Let there be two points in the proposed locus, namely A and B , each of which relates in the same way to L as to M , and now what is determined by them will also relate in the same way to L as to M ,

⁹Latin 'ambitus'.

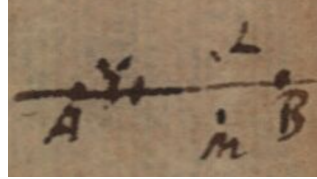


Figure 3

M . nempe recta $\bar{Y}A.B$. Nullum autem aliud tale punctum
 datur, quod non sit in hac recta, esto enim tale punctum
 H quod non cadat in rectam AB . Cumque ex punctis $A, B,$
 H , quippe non in eandem rectam cadentibus determinetur
 5 totum planum, sequeretur totum planum eodem modo se
 habere ad L quo ad M , quod est absurdum, vel ideo quia
 sequeretur ipsum M eodem modo se habens ad L quo ad
 M , id est coincidere cum L , quia coincidit cum M , contra
 Hypothesin. Dantur autem plura quam duo puncta eodem
 10 modo se habentia ad L et ad M . Nam si circuli centris L et M ,
 radiis LM describa[n]tur, se secabunt et quidem in duobus
 punctis, quia unus est partim intra alium partim extra. Sed
 de his mox.

(30) Eodem modo demonstrabitur locum omnium punctorum
 15 eodem modo se habentium ad duo data puncta esse planum.

(31) Hinc ex artic. 31 sequitur planum indefinite protensum
 a recta indefinite protensa secari in duas partes indifferentes.
 Et ex 31 similiter spatium secari a plano. Sed haec distinctius
 ostendenda.

20 (32) Recta rectam indefinita indefinitam secat in duas partes,
 quarum qualibet eodem modo se habet ad secantem. Sit recta
 $\bar{Y}$ et recta $\bar{Z}$ et B sit Y item B sit Z . Rursusque sit $\bar{Z} \oslash \bar{V} + \bar{X}$

namely the line $\bar{Y}A.B$. No other such point is given that is not on
 this line. Indeed, let H be such a point which does not fall on the line
 AB . Because the whole plane is determined from the points A, B, H ,
 not falling on the same line of course, it would follow that the whole
 5R plane relates in the same way to L as to M , which is absurd, since¹⁰
 it would then follow that M itself relates in the same way to L as to
 M , that is, it coincides with L because it coincides with M , contrary
 to the hypothesis. Now, more than two points are given relating in
 the same way to L as to M . For if circles are described with centres L
 10R and M and radii LM , they will cross each other, indeed in two points,
 since one is partly inside the other and partly outside. But more on
 this soon.

(30) It will be demonstrated in the same fashion that the locus of all
 points relating in the same way to two given points is a plane.

15R (31) Hence from article (31)¹¹ it follows that a plane extended indefi-
 nitely is cut by a line extended indefinitely into two parts not differing
 [*partes indifferentes*]. And it follows from (31) that space is cut simi-
 larly by a plane. But these things must be shown more distinctly.

20R (32) An indefinite line divides an indefinite line into two parts, each
 of which relates in the same way to the dividing one. Suppose $\bar{Y}$ is
 a line and $\bar{Z}$ is a line and B is Y and B is Z . Again let $\bar{Z} \oslash \bar{V} + \bar{X}$

¹⁰Latin 'vel ideo quia', 'or for the reason that because'; it seems Leibniz should have deleted the 'vel ideo'.

¹¹It is not clear why Leibniz seems to refer to this article itself. He wrote and cancelled an initial draft of the previous article (30), but it is not clear how that explains this reference.

(vel omne Z sit V vel X) et aliq. V sit B et aliq. X sit B dico
fore $\overline{Y}.\overline{V} \varphi \overline{Y}.\overline{X}$.

(or every Z is V or X) and some V is B and some X is B . I claim that
 $\overline{Y}.\overline{V} \varphi \overline{Y}.\overline{X}$.¹²

¹²The essay was not finished.