ELEMENTS BOOK 10

Incommensurable Magnitudes[†]

[†]The theory of incommensurable magntidues set out in this book is generally attributed to Theaetetus of Athens. In the footnotes throughout this book, k, k', *etc.* stand for distinct ratios of positive integers.

Ὅροι.

α´. Σύμμετρα μεγέθη λέγεται τὰ τῷ αὐτῷ μετρῳ μετρούμενα, ἀσύμμετρα δέ, ὧν μηδὲν ἐνδέχεται κοινὸν μέτρον γενέσθαι.

β´. Εὐθεῖαι δυνάμει σύμμετροί εἰσιν, ὅταν τὰ ἀπ᾽ αὐτῶν τετράγωνα τῷ αὐτῷ χωρίῳ μετρῆται, ἀσύμμετροι δέ, ὅταν τοῖς ἀπ᾽ αὐτῶν τετραγώνοις μηδὲν ἐνδέχηται χωρίον κοινὸν μέτρον γενέσθαι.

γ´. Τούτων ὑποκειμένων δείκνυται, ὅτι τῇ προτεθείσῃ εὐθείᾳ ὑπάρχουσιν εὐθεῖαι πλήθει ἄπειροι σύμμετροί τε καὶ ἀσύμμετροι αἱ μὲν μήκει μόνον, αἱ δὲ καὶ δυνάμει. καλείσθω οὖν ἡ μὲν προτεθεῖσα εὐθεῖα ῥητή, καὶ αἱ ταύτῃ σύμμετροι εἴτε μήκει καὶ δυνάμει εἴτε δυνάμει μόνον ῥηταί, αἱ δὲ ταύτῃ ἀσύμμετροι ἄλογοι καλείσθωσαν.

δ´. Καὶ τὸ μὲν ἀπὸ τῆς προτεθείσης εὐθείας τετράγωνον ῥητόν, καὶ τὰ τούτῳ σύμμετρα ῥητά, τὰ δὲ τούτῳ ἀσύμμετρα ἄλογα καλείσθω, καὶ αἱ δυνάμεναι αὐτὰ ἄλογοι, εἰ μὲν τετράγωνα εἴη, αὐταὶ αἱ πλευραί, εἰ δὲ ἕτερά τινα εὐθύγραμμα, αἱ ἴσα αὐτοῖς τετράγωνα ἀναγράφουσαι.

Definitions

1. Those magnitudes measured by the same measure are said (to be) commensurable, but (those) of which no (magnitude) admits to be a common measure (are said to be) incommensurable.†

2. (Two) straight-lines are commensurable in square‡ when the squares on them are measured by the same area, but (are) incommensurable (in square) when no area admits to be a common measure of the squares on them.§

3. These things being assumed, it is proved that there exist an infinite multitude of straight-lines commensurable and incommensurable with an assigned straight-line—those (incommensurable) in length only, and those also (commensurable or incommensurable) in square.¶ Therefore, let the assigned straight-line be called rational. And (let) the (straight-lines) commensurable with it, either in length and square, or in square only, (also be called) rational. But let the (straight-lines) incommensurable with it be called irrational.*

4. And let the square on the assigned straight-line be called rational. And (let areas) commensurable with it (also be called) rational. But (let areas) incommensurable with it (be called) irrational, and (let) their square-roots$ (also be called) irrational—the sides themselves, if the (areas) are squares, and the (straight-lines) describing squares equal to them, if the (areas) are some other rectilinear (figure).‖

† In other words, two magnitudes α and β are commensurable if $\alpha : \beta :: 1 : k$, and incommensurable otherwise.

‡ Literally, "in power".

§ In other words, two straight-lines of length α and β are commensurable in square if $\alpha : \beta :: 1 : k^{1/2}$, and incommensurable in square otherwise. Likewise, the straight-lines are commensurable in length if $\alpha : \beta :: 1 : k$, and incommensurable in length otherwise.

¶ To be more exact, straight-lines can either be commensurable in square only, incommensurable in length only, or commenusrable/incommensurable in both length and square, with an assigned straight-line.

* Let the length of the assigned straight-line be unity. Then rational straight-lines have lengths expressible as k or $k^{1/2}$, depending on whether the lengths are commensurable in length, or in square only, respectively, with unity. All other straight-lines are irrational.

$ The square-root of an area is the length of the side of an equal area square.

‖ The area of the square on the assigned straight-line is unity. Rational areas are expressible as k. All other areas are irrational. Thus, squares whose sides are of rational length have rational areas, and *vice versa*.

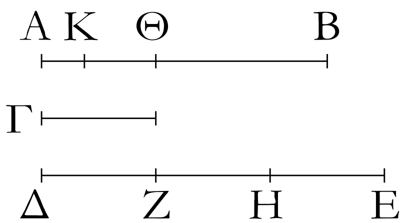
α´.

Δύο μεγεθῶν ἀνίσων ἐκκειμένων, ἐὰν ἀπὸ τοῦ μείζονος ἀφαιρεθῇ μεῖζον ἢ τὸ ἥμισυ καὶ τοῦ καταλειπομένου μεῖζον ἢ τὸ ἥμισυ, καὶ τοῦτο ἀεὶ γίγνηται, λειφθήσεταί τι μέγεθος, ὃ ἔσται ἔλασσον τοῦ ἐκκειμένου ἐλάσσονος μεγέθους.

Ἔστω δύο μεγέθη ἄνισα τὰ ΑΒ, Γ, ὧν μεῖζον τὸ ΑΒ·

Proposition 1†

If, from the greater of two unequal magnitudes (which are) laid out, (a part) greater than half is subtracted, and (if from) the remainder (a part) greater than half (is subtracted), and (if) this happens continually, then some magnitude will (eventually) be left which will λέγω, ὅτι, ἐαν ἀπὸ τοῦ ΑΒ ἀφαιρεθῇ μεῖζον ἢ τὸ ἥμισυ καὶ τοῦ καταλειπομένου μεῖζον ἢ τὸ ἥμισυ, καὶ τοῦτο ἀεὶ γίγνηται, λειφθήσεταί τι μέγεθος, ὃ ἔσται ἔλασσον τοῦ Γ μεγέθους.



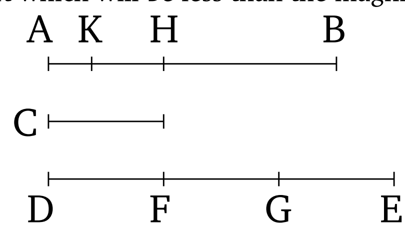
Τὸ Γ γὰρ πολλαπλασιαζόμενον ἔσται ποτὲ τοῦ ΑΒ μεῖζον. πεπολλαπλασιάσθω, καὶ ἔστω τὸ ΔΕ τοῦ μὲν Γ πολλαπλάσιον, τοῦ δὲ ΑΒ μεῖζον, καὶ διῃρήσθω τὸ ΔΕ εἰς τὰ τῷ Γ ἴσα τὰ ΔΖ, ΖΗ, ΗΕ, καὶ ἀφῃρήσθω ἀπὸ μὲν τοῦ ΑΒ μεῖζον ἢ τὸ ἥμισυ τὸ ΒΘ, ἀπὸ δὲ τοῦ ΑΘ μεῖζον ἢ τὸ ἥμισυ τὸ ΘΚ, καὶ τοῦτο ἀεὶ γιγνέσθω, ἕως ἂν αἱ ἐν τῷ ΑΒ διαιρέσεις ἰσοπληθεῖς γένωνται ταῖς ἐν τῷ ΔΕ διαιρέσεσιν.

Ἔστωσαν οὖν αἱ ΑΚ, ΚΘ, ΘΒ διαιρέσεις ἰσοπληθεῖς οὖσαι ταῖς ΔΖ, ΖΗ, ΗΕ· καὶ ἐπεὶ μεῖζόν ἐστι τὸ ΔΕ τοῦ ΑΒ, καὶ ἀφῄρηται ἀπὸ μὲν τοῦ ΔΕ ἔλασσον τοῦ ἡμίσεως τὸ ΕΗ, ἀπὸ δὲ τοῦ ΑΒ μεῖζον ἢ τὸ ἥμισυ τὸ ΒΘ, λοιπὸν ἄρα τὸ ΗΔ λοιποῦ τοῦ ΘΑ μεῖζόν ἐστιν. καὶ ἐπεὶ μεῖζόν ἐστι τὸ ΗΔ τοῦ ΘΑ, καὶ ἀφῄρηται τοῦ μὲν ΗΔ ἥμισυ τὸ ΗΖ, τοῦ δὲ ΘΑ μεῖζον ἢ τὸ ἥμισυ τὸ ΘΚ, λοιπὸν ἄρα τὸ ΔΖ λοιποῦ τοῦ ΑΚ μεῖζόν ἐστιν. ἴσον δὲ τὸ ΔΖ τῷ Γ· καὶ τὸ Γ ἄρα τοῦ ΑΚ μεῖζόν ἐστιν. ἔλασσον ἄρα τὸ ΑΚ τοῦ Γ.

Καταλείπεται ἄρα ἀπὸ τοῦ ΑΒ μεγέθους τὸ ΑΚ μέγεθος ἔλασσον ὂν τοῦ ἐκκειμένου ἐλάσσονος μεγέθους τοῦ Γ· ὅπερ ἔδει δεῖξαι. — ὁμοίως δὲ δειχθήσεται, κἂν ἡμίση ᾖ τὰ ἀφαιρούμενα.

be less than the lesser laid out magnitude.

Let AB and C be two unequal magnitudes, of which (let) AB (be) the greater. I say that if (a part) greater than half is subtracted from AB, and (if a part) greater than half (is subtracted) from the remainder, and (if) this happens continually, then some magnitude will (eventually) be left which will be less than the magnitude C.



For C, when multiplied (by some number), will sometimes be greater than AB [Def. 5.4]. Let it have been (so) multiplied. And let DE be (both) a multiple of C, and greater than AB. And let DE have been divided into the (divisions) DF, FG, GE, equal to C. And let BH, (which is) greater than half, have been subtracted from AB. And (let) HK, (which is) greater than half, (have been subtracted) from AH. And let this happen continually, until the divisions in AB become equal in number to the divisions in DE.

Therefore, let the divisions (in AB) be AK, KH, HB, being equal in number to DF, FG, GE. And since DE is greater than AB, and EG, (which is) less than half, has been subtracted from DE, and BH, (which is) greater than half, from AB, the remainder GD is thus greater than the remainder HA. And since GD is greater than HA, and the half GF has been subtracted from GD, and HK, (which is) greater than half, from HA, the remainder DF is thus greater than the remainder AK. And DF (is) equal to C. C is thus also greater than AK. Thus, AK (is) less than C.

Thus, the magnitude AK, which is less than the lesser laid out magnitude C, is left over from the magnitude AB. (Which is) the very thing it was required to show. — (The theorem) can similarly be proved even if the (parts) subtracted are halves.

† This theorem is the basis of the so-called *method of exhaustion*, and is generally attributed to Eudoxus of Cnidus.

β′.

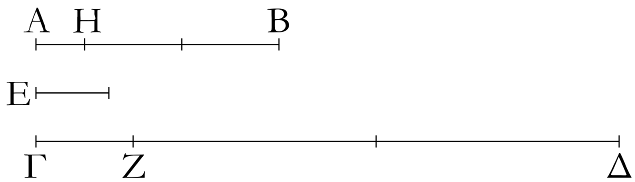
Ἐὰν δύο μεγεθῶν [ἐκκειμένων] ἀνίσων ἀνθυφαιρουμένου ἀεὶ τοῦ ἐλάσσονος ἀπὸ τοῦ μείζονος τὸ καταλειπόμενον μηδέποτε καταμετρῇ τὸ πρὸ ἑαυτοῦ, ἀσύμμετρα ἔσται τὰ μεγέθη.

Δύο γὰρ μεγεθῶν ὄντων ἀνίσων τῶν ΑΒ, ΓΔ καὶ ἐλάσσονος τοῦ ΑΒ ἀνθυφαιρουμένου ἀεὶ τοῦ ἐλάσσονος ἀπὸ τοῦ μείζονος τὸ περιλειπόμενον μηδέποτε καταμε-

Proposition 2

If the remainder of two unequal magnitudes (which are) [laid out] never measures the (magnitude) before it, (when) the lesser (magnitude is) continually subtracted in turn from the greater, then the (original) magnitudes will be incommensurable.

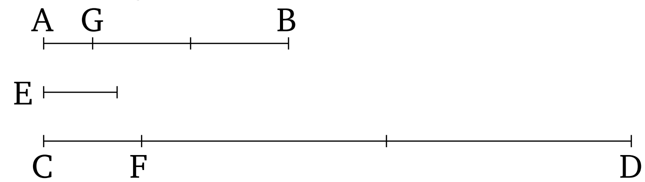
For, AB and CD being two unequal magnitudes, and AB (being) the lesser, let the remainder never measure τρείτω τὸ πρὸ ἑαυτοῦ· λέγω, ὅτι ἀσύμμετρά ἐστι τὰ ΑΒ, ΓΔ μεγέθη.



Εἰ γάρ ἐστι σύμμετρα, μετρήσει τι αὐτὰ μέγεθος. μετρείτω, εἰ δυνατόν, καὶ ἔστω τὸ Ε· καὶ τὸ μὲν ΑΒ τὸ ΖΔ καταμετροῦν λειπέτω ἑαυτοῦ ἔλασσον τὸ ΓΖ, τὸ δὲ ΓΖ τὸ ΒΗ καταμετροῦν λειπέτω ἑαυτοῦ ἔλασσον τὸ ΑΗ, καὶ τοῦτο ἀεὶ γινέσθω, ἕως οὗ λειφθῇ τι μέγεθος, ὅ ἐστιν ἔλασσον τοῦ Ε. γεγονέτω, καὶ λελείφθω τὸ ΑΗ ἔλασσον τοῦ Ε. ἐπεὶ οὖν τὸ Ε τὸ ΑΒ μετρεῖ, ἀλλὰ τὸ ΑΒ τὸ ΔΖ μετρεῖ, καὶ τὸ Ε ἄρα τὸ ΖΔ μετρήσει. μετρεῖ δὲ καὶ ὅλον τὸ ΓΔ· καὶ λοιπὸν ἄρα τὸ ΓΖ μετρήσει. ἀλλὰ τὸ ΓΖ τὸ ΒΗ μετρεῖ· καὶ τὸ Ε ἄρα τὸ ΒΗ μετρεῖ. μετρεῖ δὲ καὶ ὅλον τὸ ΑΒ· καὶ λοιπὸν ἄρα τὸ ΑΗ μετρήσει, τὸ μεῖζον τὸ ἔλασσον· ὅπερ ἐστὶν ἀδύνατον. οὐκ ἄρα τὰ ΑΒ, ΓΔ μεγέθη μετρήσει τι μέγεθος· ἀσύμμετρα ἄρα ἐστὶ τὰ ΑΒ, ΓΔ μεγέθη.

Ἐὰν ἄρα δύο μεγεθῶν ἀνίσων, καὶ τὰ ἑξῆς.

the (magnitude) before it, (when) the lesser (magnitude is) continually subtracted in turn from the greater. I say that the magnitudes AB and CD are incommensurable.



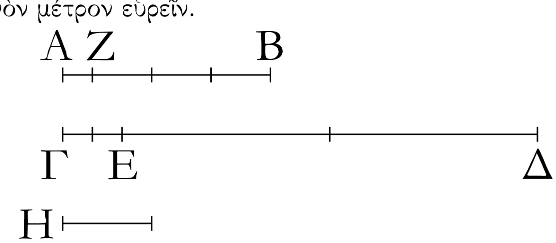
For if they are commensurable then some magnitude will measure them (both). If possible, let it (so) measure (them), and let it be E. And let AB leave CF less than itself (in) measuring FD, and let CF leave AG less than itself (in) measuring BG, and let this happen continually, until some magnitude which is less than E is left. Let (this) have occurred,† and let AG, (which is) less than E, have been left. Therefore, since E measures AB, but AB measures DF, E will thus also measure FD. And it also measures the whole (of) CD. Thus, it will also measure the remainder CF. But, CF measures BG. Thus, E also measures BG. And it also measures the whole (of) AB. Thus, it will also measure the remainder AG, the greater (measuring) the lesser. The very thing is impossible. Thus, some magnitude cannot measure (both) the magnitudes AB and CD. Thus, the magnitudes AB and CD are incommensurable [Def. 10.1].

Thus, if ... of two unequal magnitudes, and so on ....

† The fact that this will eventually occur is guaranteed by Prop. 10.1.

γ΄.

Δύο μεγεθῶν συμμέτρων δοθέντων τὸ μέγιστον αὐτῶν κοινὸν μέτρον εὑρεῖν.



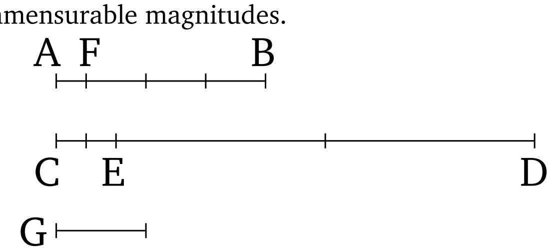
Ἔστω τὰ δοθέντα δύο μεγέθη σύμμετρα τὰ ΑΒ, ΓΔ, ὧν ἔλασσον τὸ ΑΒ· δεῖ δὴ τῶν ΑΒ, ΓΔ τὸ μέγιστον κοινὸν μέτρον εὑρεῖν.

Τὸ ΑΒ γὰρ μέγεθος ἤτοι μετρεῖ τὸ ΓΔ ἢ οὔ. εἰ μὲν οὖν μετρεῖ, μετρεῖ δὲ καὶ ἑαυτό, τὸ ΑΒ ἄρα τῶν ΑΒ, ΓΔ κοινὸν μέτρον ἐστίν· καὶ φανερόν, ὅτι καὶ μέγιστον. μεῖζον γὰρ τοῦ ΑΒ μεγέθους τὸ ΑΒ οὐ μετρήσει.

Μὴ μετρείτω δὴ τὸ ΑΒ τὸ ΓΔ. καὶ ἀνθυφαιρουμένου ἀεὶ τοῦ ἐλάσσονος ἀπὸ τοῦ μείζονος, τὸ περιλειπόμενον μετρήσει ποτὲ τὸ πρὸ ἑαυτοῦ διὰ τὸ μὴ εἶναι ἀσύμμετρα τὰ ΑΒ, ΓΔ· καὶ τὸ μὲν ΑΒ τὸ ΕΔ καταμετροῦν λειπέτω ἑαυτοῦ

Proposition 3

To find the greatest common measure of two given commensurable magnitudes.



Let AB and CD be the two given magnitudes, of which (let) AB (be) the lesser. So, it is required to find the greatest common measure of AB and CD.

For the magnitude AB either measures, or (does) not (measure), CD. Therefore, if it measures (CD), and (since) it also measures itself, AB is thus a common measure of AB and CD. And (it is) clear that (it is) also (the) greatest. For a (magnitude) greater than magnitude AB cannot measure AB.

So let AB not measure CD. And continually subtracting in turn the lesser (magnitude) from the greater, the ἔλασσον τὸ ΕΓ, τὸ δὲ ΕΓ τὸ ΖΒ καταμετροῦν λειπέτω ἑαυτοῦ ἔλασσον τὸ ΑΖ, τὸ δὲ ΑΖ τὸ ΓΕ μετρείτω.

Ἐπεὶ οὖν τὸ ΑΖ τὸ ΓΕ μετρεῖ, ἀλλὰ τὸ ΓΕ τὸ ΖΒ μετρεῖ, καὶ τὸ ΑΖ ἄρα τὸ ΖΒ μετρήσει. μετρεῖ δὲ καὶ ἑαυτό· καὶ ὅλον ἄρα τὸ ΑΒ μετρήσει τὸ ΑΖ. ἀλλὰ τὸ ΑΒ τὸ ΔΕ μετρεῖ· καὶ τὸ ΑΖ ἄρα τὸ ΕΔ μετρήσει. μετρεῖ δὲ καὶ τὸ ΓΕ· καί ὅλον ἄρα τὸ ΓΔ μετρεῖ· τὸ ΑΖ ἄρα τῶν ΑΒ, ΓΔ κοινὸν μέτρον ἐστίν. λέγω δή, ὅτι καὶ μέγιστον. εἰ γὰρ μή, ἔσται τι μέγεθος μεῖζον τοῦ ΑΖ, ὃ μετρήσει τὰ ΑΒ, ΓΔ. ἔστω τὸ Η. ἐπεὶ οὖν τὸ Η τὸ ΑΒ μετρεῖ, ἀλλὰ τὸ ΑΒ τὸ ΕΔ μετρεῖ, καὶ τὸ Η ἄρα τὸ ΕΔ μετρήσει. μετρεῖ δὲ καὶ ὅλον τὸ ΓΔ· καὶ λοιπὸν ἄρα τὸ ΓΕ μετρήσει τὸ Η. ἀλλὰ τὸ ΓΕ τὸ ΖΒ μετρεῖ· καὶ τὸ Η ἄρα τὸ ΖΒ μετρήσει. μετρεῖ δὲ καὶ ὅλον τὸ ΑΒ, καὶ λοιπὸν τὸ ΑΖ μετρήσει, τὸ μεῖζον τὸ ἔλασσον· ὅπερ ἐστὶν ἀδύνατον. οὐκ ἄρα μεῖζόν τι μέγεθος τοῦ ΑΖ τὰ ΑΒ, ΓΔ μετρήσει· τὸ ΑΖ ἄρα τῶν ΑΒ, ΓΔ τὸ μέγιστον κοινὸν μέτρον ἐστίν.

Δύο ἄρα μεγεθῶν συμμέτρων δοθέντων τῶν ΑΒ, ΓΔ τὸ μέγιστον κοινὸν μέτρον ηὕρηται· ὅπερ ἔδει δεῖξαι.

remaining (magnitude) will (at) some time measure the (magnitude) before it, on account of AB and CD not being incommensurable [Prop. 10.2]. And let AB leave EC less than itself (in) measuring ED, and let EC leave AF less than itself (in) measuring FB, and let AF measure CE.

Therefore, since AF measures CE, but CE measures FB, AF will thus also measure FB. And it also measures itself. Thus, AF will also measure the whole (of) AB. But, AB measures DE. Thus, AF will also measure ED. And it also measures CE. Thus, it also measures the whole of CD. Thus, AF is a common measure of AB and CD. So I say that (it is) also (the) greatest (common measure). For, if not, there will be some magnitude, greater than AF, which will measure (both) AB and CD. Let it be G. Therefore, since G measures AB, but AB measures ED, G will thus also measure ED. And it also measures the whole of CD. Thus, G will also measure the remainder CE. But CE measures FB. Thus, G will also measure FB. And it also measures the whole (of) AB. And (so) it will measure the remainder AF, the greater (measuring) the lesser. The very thing is impossible. Thus, some magnitude greater than AF cannot measure (both) AB and CD. Thus, AF is the greatest common measure of AB and CD.

Thus, the greatest common measure of two given commensurable magnitudes, AB and CD, has been found. (Which is) the very thing it was required to show.

Πόρισμα.

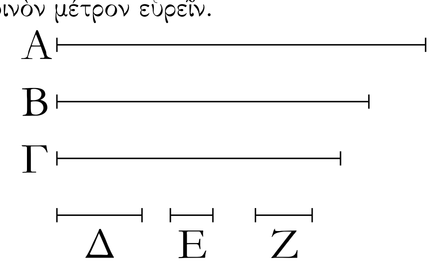
Ἐκ δὴ τούτου φανερόν, ὅτι, ἐὰν μέγεθος δύο μεγέθη μετρῇ, καὶ τὸ μέγιστον αὐτῶν κοινὸν μέτρον μετρήσει.

Corollary

So (it is) clear, from this, that if a magnitude measures two magnitudes then it will also measure their greatest common measure.

δʹ.

Τριῶν μεγεθῶν συμμέτρων δοθέντων τὸ μέγιστον αὐτῶν κοινὸν μέτρον εὑρεῖν.

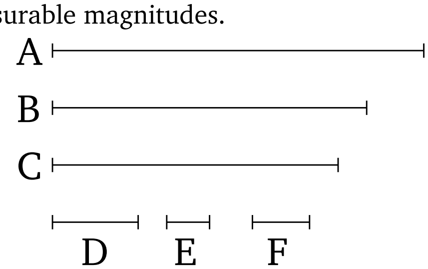


Ἔστω τὰ δοθέντα τρία μεγέθη σύμμετρα τὰ Α, Β, Γ· δεῖ δὴ τῶν Α, Β, Γ τὸ μέγιστον κοινὸν μέτρον εὑρεῖν.

Εἰλήφθω γὰρ δύο τῶν Α, Β τὸ μέγιστον κοινὸν μέτρον, καὶ ἔστω τὸ Δ· τὸ δὴ Δ τὸ Γ ἤτοι μετρεῖ ἢ οὔ [μετρεῖ]. μετρείτω πρότερον. ἐπεὶ οὖν τὸ Δ τὸ Γ μετρεῖ, μετρεῖ δὲ

Proposition 4

To find the greatest common measure of three given commensurable magnitudes.



Let A, B, C be the three given commensurable magnitudes. So it is required to find the greatest common measure of A, B, C.

For let the greatest common measure of the two (magnitudes) A and B have been taken [Prop. 10.3], and let it καὶ τὰ Α, Β, τὸ Δ ἄρα τὰ Α, Β, Γ μετρεῖ· τὸ Δ ἄρα τῶν Α, Β, Γ κοινὸν μέτρον ἐστίν. καὶ φανερόν, ὅτι καὶ μέγιστον· μεῖζον γὰρ τοῦ Δ μεγέθους τὰ Α, Β οὐ μετρεῖ.

Μὴ μετρείτω δὴ τὸ Δ τὸ Γ. λέγω πρῶτον, ὅτι σύμμετρά ἐστι τὰ Γ, Δ. ἐπεὶ γὰρ σύμμετρά ἐστι τὰ Α, Β, Γ, μετρήσει τι αὐτὰ μέγεθος, ὃ δηλαδὴ καὶ τὰ Α, Β μετρήσει· ὥστε καὶ τὸ τῶν Α, Β μέγιστον κοινὸν μέτρον τὸ Δ μετρήσει. μετρεῖ δὲ καὶ τὸ Γ· ὥστε τὸ εἰρημένον μέγεθος μετρήσει τὰ Γ, Δ· σύμμετρα ἄρα ἐστὶ τὰ Γ, Δ. εἰλήφθω οὖν αὐτῶν τὸ μέγιστον κοινὸν μέτρον, καὶ ἔστω τὸ Ε. ἐπεὶ οὖν τὸ Ε τὸ Δ μετρεῖ, ἀλλὰ τὸ Δ τὰ Α, Β μετρεῖ, καὶ τὸ Ε ἄρα τὰ Α, Β μετρήσει. μετρεῖ δὲ καὶ τὸ Γ. τὸ Ε ἄρα τὰ Α, Β, Γ μετρεῖ· τὸ Ε ἄρα τῶν Α, Β, Γ κοινόν ἐστι μέτρον. λέγω δή, ὅτι καὶ μέγιστον. εἰ γὰρ δυνατόν, ἔστω τι τοῦ Ε μεῖζον μέγεθος τὸ Ζ, καὶ μετρείτω τὰ Α, Β, Γ. καὶ ἐπεὶ τὸ Ζ τὰ Α, Β, Γ μετρεῖ, καὶ τὰ Α, Β ἄρα μετρήσει καὶ τὸ τῶν Α, Β μέγιστον κοινὸν μέτρον μετρήσει. τὸ δὲ τῶν Α, Β μέγιστον κοινὸν μέτρον ἐστὶ τὸ Δ· τὸ Ζ ἄρα τὸ Δ μετρεῖ. μετρεῖ δὲ καὶ τὸ Γ· τὸ Ζ ἄρα τὰ Γ, Δ μετρεῖ· καὶ τὸ τῶν Γ, Δ ἄρα μέγιστον κοινὸν μέτρον μετρήσει τὸ Ζ. ἔστι δὲ τὸ Ε· τὸ Ζ ἄρα τὸ Ε μετρήσει, τὸ μεῖζον τὸ ἔλασσον· ὅπερ ἐστὶν ἀδύνατον. οὐκ ἄρα μεῖζόν τι τοῦ Ε μεγέθους [μέγεθος] τὰ Α, Β, Γ μετρεῖ· τὸ Ε ἄρα τῶν Α, Β, Γ τὸ μέγιστον κοινὸν μέτρον ἐστίν, ἐὰν μὴ μετρῇ τὸ Δ τὸ Γ, ἐὰν δὲ μετρῇ, αὐτὸ τὸ Δ.

Τριῶν ἄρα μεγεθῶν συμμέτρων δοθέντων τὸ μέγιστον κοινὸν μέτρον ηὕρηται [ὅπερ ἔδει δεῖξαι].

be D. So D either measures, or [does] not [measure], C. Let it, first of all, measure (C). Therefore, since D measures C, and it also measures A and B, D thus measures A, B, C. Thus, D is a common measure of A, B, C. And (it is) clear that (it is) also (the) greatest (common measure). For no magnitude larger than D measures (both) A and B.

So let D not measure C. I say, first, that C and D are commensurable. For if A, B, C are commensurable then some magnitude will measure them which will clearly also measure A and B. Hence, it will also measure D, the greatest common measure of A and B [Prop. 10.3 corr.]. And it also measures C. Hence, the aforementioned magnitude will measure (both) C and D. Thus, C and D are commensurable [Def. 10.1]. Therefore, let their greatest common measure have been taken [Prop. 10.3], and let it be E. Therefore, since E measures D, but D measures (both) A and B, E will thus also measure A and B. And it also measures C. Thus, E measures A, B, C. Thus, E is a common measure of A, B, C. So I say that (it is) also (the) greatest (common measure). For, if possible, let F be some magnitude greater than E, and let it measure A, B, C. And since F measures A, B, C, it will thus also measure A and B, and will (thus) measure the greatest common measure of A and B [Prop. 10.3 corr.]. And D is the greatest common measure of A and B. Thus, F measures D. And it also measures C. Thus, F measures (both) C and D. Thus, F will also measure the greatest common measure of C and D [Prop. 10.3 corr.]. And it is E. Thus, F will measure E, the greater (measuring) the lesser. The very thing is impossible. Thus, some [magnitude] greater than the magnitude E cannot measure A, B, C. Thus, if D does not measure C then E is the greatest common measure of A, B, C. And if it does measure (C) then D itself (is the greatest common measure).

Thus, the greatest common measure of three given commensurable magnitudes has been found. [(Which is) the very thing it was required to show.]

Πόρισμα.

Ἐκ δὴ τούτου φανερόν, ὅτι, ἐὰν μέγεθος τρία μεγέθη μετρῇ, καὶ τὸ μέγιστον αὐτῶν κοινὸν μέτρον μετρήσει.

Ὁμοίως δὴ καὶ ἐπὶ πλειόνων τὸ μέγιστον κοινὸν μέτρον ληφθήσεται, καὶ τὸ πόρισμα προχωρήσει. ὅπερ ἔδει δεῖξαι.

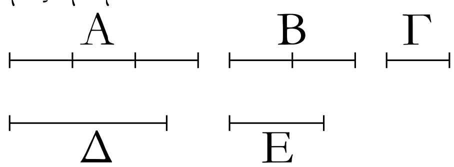
Corollary

So (it is) clear, from this, that if a magnitude measures three magnitudes then it will also measure their greatest common measure.

So, similarly, the greatest common measure of more (magnitudes) can also be taken, and the (above) corollary will go forward. (Which is) the very thing it was required to show.

ε΄.

Τὰ σύμμετρα μεγέθη πρὸς ἄλληλα λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν.



Ἔστω σύμμετρα μεγέθη τὰ Α, Β· λέγω, ὅτι τὸ Α πρὸς τὸ Β λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν.

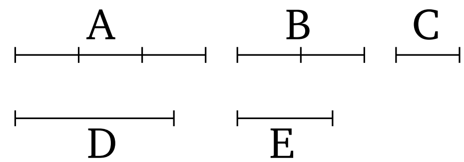
Ἐπεὶ γὰρ σύμμετρά ἐστι τὰ Α, Β, μετρήσει τι αὐτὰ μέγεθος. μετρείτω, καὶ ἔστω τὸ Γ. καὶ ὁσάκις τὸ Γ τὸ Α μετρεῖ, τοσαῦται μονάδες ἔστωσαν ἐν τῷ Δ, ὁσάκις δὲ τὸ Γ τὸ Β μετρεῖ, τοσαῦται μονάδες ἔστωσαν ἐν τῷ Ε.

Ἐπεὶ οὖν τὸ Γ τὸ Α μετρεῖ κατὰ τὰς ἐν τῷ Δ μονάδας, μετρεῖ δὲ καὶ ἡ μονὰς τὸν Δ κατὰ τὰς ἐν αὐτῷ μονάδας, ἰσάκις ἄρα ἡ μονὰς τὸν Δ μετρεῖ ἀριθμὸν καὶ τὸ Γ μέγεθος τὸ Α· ἔστιν ἄρα ὡς τὸ Γ πρὸς τὸ Α, οὕτως ἡ μονὰς πρὸς τὸν Δ· ἀνάπαλιν ἄρα, ὡς τὸ Α πρὸς τὸ Γ, οὕτως ὁ Δ πρὸς τὴν μονάδα. πάλιν ἐπεὶ τὸ Γ τὸ Β μετρεῖ κατὰ τὰς ἐν τῷ Ε μονάδας, μετρεῖ δὲ καὶ ἡ μονὰς τὸν Ε κατὰ τὰς ἐν αὐτῷ μονάδας, ἰσάκις ἄρα ἡ μονὰς τὸν Ε μετρεῖ καὶ τὸ Γ τὸ Β· ἔστιν ἄρα ὡς τὸ Γ πρὸς τὸ Β, οὕτως ἡ μονὰς πρὸς τὸν Ε. ἐδείχθη δὲ καὶ ὡς τὸ Α πρὸς τὸ Γ, ὁ Δ πρὸς τὴν μονάδα· δι᾿ ἴσου ἄρα ἐστὶν ὡς τὸ Α πρὸς τὸ Β, οὕτως ὁ Δ ἀριθμὸς πρὸς τὸν Ε.

Τὰ ἄρα σύμμετρα μεγέθη τὰ Α, Β πρὸς ἄλληλα λόγον ἔχει, ὃν ἀριθμὸς ὁ Δ πρὸς ἀριθμὸν τὸν Ε· ὅπερ ἔδει δεῖξαι.

Proposition 5

Commensurable magnitudes have to one another the ratio which (some) number (has) to (some) number.



Let A and B be commensurable magnitudes. I say that A has to B the ratio which (some) number (has) to (some) number.

For if A and B are commensurable (magnitudes) then some magnitude will measure them. Let it (so) measure (them), and let it be C. And as many times as C measures A, so many units let there be in D. And as many times as C measures B, so many units let there be in E.

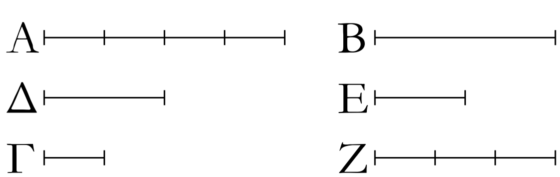
Therefore, since C measures A according to the units in D, and a unit also measures D according to the units in it, a unit thus measures the number D as many times as the magnitude C (measures) A. Thus, as C is to A, so a unit (is) to D [Def. 7.20].† Thus, inversely, as A (is) to C, so D (is) to a unit [Prop. 5.7 corr.]. Again, since C measures B according to the units in E, and a unit also measures E according to the units in it, a unit thus measures E the same number of times that C (measures) B. Thus, as C is to B, so a unit (is) to E [Def. 7.20]. And it was also shown that as A (is) to C, so D (is) to a unit. Thus, via equality, as A is to B, so the number D (is) to the (number) E [Prop. 5.22].

Thus, the commensurable magnitudes A and B have to one another the ratio which the number D (has) to the number E. (Which is) the very thing it was required to show.

† There is a slight logical gap here, since Def. 7.20 applies to four numbers, rather than two number and two magnitudes.

ϛ΄.

Ἐὰν δύο μεγέθη πρὸς ἄλληλα λόγον ἔχῃ, ὃν ἀριθμὸς πρὸς ἀριθμόν, σύμμετρα ἔσται τὰ μεγέθη.

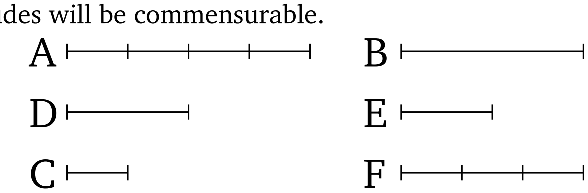


Δύο γὰρ μεγέθη τὰ Α, Β πρὸς ἄλληλα λόγον ἐχέτω, ὃν ἀριθμὸς ὁ Δ πρὸς ἀριθμὸν τὸν Ε· λέγω, ὅτι σύμμετρά ἐστι τὰ Α, Β μεγέθη.

Ὅσαι γάρ εἰσιν ἐν τῷ Δ μονάδες, εἰς τοσαῦτα ἴσα

Proposition 6

If two magnitudes have to one another the ratio which (some) number (has) to (some) number then the magnitudes will be commensurable.



For let the two magnitudes A and B have to one another the ratio which the number D (has) to the number E. I say that the magnitudes A and B are commensurable.

διῃρήσθω τὸ Α, καὶ ἑνὶ αὐτῶν ἴσον ἔστω τὸ Γ· ὅσαι δέ εἰσιν ἐν τῷ Ε μονάδες, ἐκ τοσούτων μεγεθῶν ἴσων τῷ Γ συγκείσθω τὸ Ζ.

Ἐπεὶ οὖν, ὅσαι εἰσὶν ἐν τῷ Δ μονάδες, τοσαῦτά εἰσι καὶ ἐν τῷ Α μεγέθη ἴσα τῷ Γ, ὃ ἄρα μέρος ἐστὶν ἡ μονὰς τοῦ Δ, τὸ αὐτὸ μέρος ἐστὶ καὶ τὸ Γ τοῦ Α· ἔστιν ἄρα ὡς τὸ Γ πρὸς τὸ Α, οὕτως ἡ μονὰς πρὸς τὸν Δ. μετρεῖ δὲ ἡ μονὰς τὸν Δ ἀριθμόν· μετρεῖ ἄρα καὶ τὸ Γ τὸ Α. καὶ ἐπεί ἐστιν ὡς τὸ Γ πρὸς τὸ Α, οὕτως ἡ μονὰς πρὸς τὸν Δ [ἀριθμόν], ἀνάπαλιν ἄρα ὡς τὸ Α πρὸς τὸ Γ, οὕτως ὁ Δ ἀριθμὸς πρὸς τὴν μονάδα. πάλιν ἐπεί, ὅσαι εἰσὶν ἐν τῷ Ε μονάδες, τοσαῦτά εἰσι καὶ ἐν τῷ Ζ ἴσα τῷ Γ, ἔστιν ἄρα ὡς τὸ Γ πρὸς τὸ Ζ, οὕτως ἡ μονὰς πρὸς τὸν Ε [ἀριθμόν]. ἐδείχθη δὲ καὶ ὡς τὸ Α πρὸς τὸ Γ, οὕτως ὁ Δ πρὸς τὴν μονάδα· δι᾿ ἴσου ἄρα ἐστὶν ὡς τὸ Α πρὸς τὸ Ζ, οὕτως ὁ Δ πρὸς τὸν Ε. ἀλλ᾿ ὡς ὁ Δ πρὸς τὸν Ε, οὕτως ἐστὶ τὸ Α πρὸς τὸ Β· καὶ ὡς ἄρα τὸ Α πρὸς τὸ Β, οὕτως καὶ πρὸς τὸ Ζ. τὸ Α ἄρα πρὸς ἑκάτερον τῶν Β, Ζ τὸν αὐτὸν ἔχει λόγον· ἴσον ἄρα ἐστὶ τὸ Β τῷ Ζ. μετρεῖ δὲ τὸ Γ τὸ Ζ· μετρεῖ ἄρα καὶ τὸ Β. ἀλλὰ μὴν καὶ τὸ Α· τὸ Γ ἄρα τὰ Α, Β μετρεῖ. σύμμετρον ἄρα ἐστὶ τὸ Α τῷ Β.

Ἐὰν ἄρα δύο μεγέθη πρὸς ἄλληλα, καὶ τὰ ἑξῆς.

For, as many units as there are in D, let A have been divided into so many equal (divisions). And let C be equal to one of them. And as many units as there are in E, let F be the sum of so many magnitudes equal to C.

Therefore, since as many units as there are in D, so many magnitudes equal to C are also in A, therefore whichever part a unit is of D, C is also the same part of A. Thus, as C is to A, so a unit (is) to D [Def. 7.20]. And a unit measures the number D. Thus, C also measures A. And since as C is to A, so a unit (is) to the [number] D, thus, inversely, as A (is) to C, so the number D (is) to a unit [Prop. 5.7 corr.]. Again, since as many units as there are in E, so many (magnitudes) equal to C are also in F, thus as C is to F, so a unit (is) to the [number] E [Def. 7.20]. And it was also shown that as A (is) to C, so D (is) to a unit. Thus, via equality, as A is to F, so D (is) to E [Prop. 5.22]. But, as D (is) to E, so A is to B. And thus as A (is) to B, so (it) also is to F [Prop. 5.11]. Thus, A has the same ratio to each of B and F. Thus, B is equal to F [Prop. 5.9]. And C measures F. Thus, it also measures B. But, in fact, (it) also (measures) A. Thus, C measures (both) A and B. Thus, A is commensurable with B [Def. 10.1].

Thus, if two magnitudes … to one another, and so on ….

Πόρισμα.

Ἐκ δὴ τούτου φανερόν, ὅτι, ἐὰν ὦσι δύο ἀριθμοί, ὡς οἱ Δ, Ε, καὶ εὐθεῖα, ὡς ἡ Α, δύνατόν ἐστι ποιῆσαι ὡς ὁ Δ ἀριθμὸς πρὸς τὸν Ε ἀριθμόν, οὕτως τὴν εὐθεῖαν πρὸς εὐθεῖαν. ἐὰν δὲ καὶ τῶν Α, Ζ μέση ἀνάλογον ληφθῇ, ὡς ἡ Β, ἔσται ὡς ἡ Α πρὸς τὴν Ζ, οὕτως τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς Β, τουτέστιν ὡς ἡ πρώτη πρὸς τὴν τρίτην, οὕτως τὸ ἀπὸ τῆς πρώτης πρὸς τὸ ἀπὸ τῆς δευτέρας τὸ ὅμοιον καὶ ὁμοίως ἀναγραφόμενον. ἀλλ᾿ ὡς ἡ Α πρὸς τὴν Ζ, οὕτως ἐστὶν ὁ Δ ἀριθμος πρὸς τὸν Ε ἀριθμόν· γέγονεν ἄρα καὶ ὡς ὁ Δ ἀριθμὸς πρὸς τὸν Ε ἀριθμόν, οὕτως τὸ ἀπὸ τῆς Α εὐθείας πρὸς τὸ ἀπὸ τῆς Β εὐθείας· ὅπερ ἔδει δεῖξαι.

Corollary

So it is clear, from this, that if there are two numbers, like D and E, and a straight-line, like A, then it is possible to contrive that as the number D (is) to the number E, so the straight-line (is) to (another) straight-line (*i.e.,* F). And if the mean proportion, (say) B, is taken of A and F, then as A is to F, so the (square) on A (will be) to the (square) on B. That is to say, as the first (is) to the third, so the (figure) on the first (is) to the similar, and similarly described, (figure) on the second [Prop. 6.19 corr.]. But, as A (is) to F, so the number D is to the number E. Thus, it has also been contrived that as the number D (is) to the number E, so the (figure) on the straight-line A (is) to the (similar figure) on the straight-line B. (Which is) the very thing it was required to show.

ζ΄.

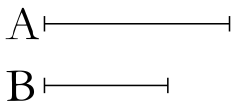
Τὰ ἀσύμμετρα μεγέθη πρὸς ἄλληλα λόγον οὐκ ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν.

Ἔστω ἀσύμμετρα μεγέθη τὰ Α, Β· λέγω, ὅτι τὸ Α πρὸς τὸ Β λόγον οὐκ ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν.

Proposition 7

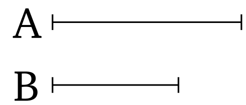
Incommensurable magnitudes do not have to one another the ratio which (some) number (has) to (some) number.

Let A and B be incommensurable magnitudes. I say that A does not have to B the ratio which (some) number (has) to (some) number.



Εἰ γὰρ ἔχει τὸ Α πρὸς τὸ Β λόγον, ὃν ἀριθμὸς πρὸς ἀριθμόν, σύμμετρον ἔσται τὸ Α τῷ Β. οὐκ ἔστι δέ· οὐκ ἄρα τὸ Α πρὸς τὸ Β λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν.

Τὰ ἄρα ἀσύμμετρα μεγέθη πρὸς ἄλληλα λόγον οὐκ ἔχει, καὶ τὰ ἑξῆς.

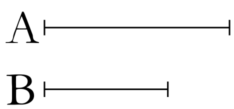


For if A has to B the ratio which (some) number (has) to (some) number then A will be commensurable with B [Prop. 10.6]. But it is not. Thus, A does not have to B the ratio which (some) number (has) to (some) number.

Thus, incommensurable numbers do not have to one another, and so on ....

η´.

Ἐὰν δύο μεγέθη πρὸς ἄλληλα λόγον μὴ ἔχῃ, ὃν ἀριθμὸς πρὸς ἀριθμόν, ἀσύμμετρα ἔσται τὰ μεγέθη.



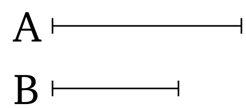
Δύο γὰρ μεγέθη τὰ Α, Β πρὸς ἄλληλα λόγον μὴ ἐχέτω, ὃν ἀριθμὸς πρὸς ἀριθμόν· λέγω, ὅτι ἀσύμμετρά ἐστι τὰ Α, Β μεγέθη.

Εἰ γὰρ ἔσται σύμμετρα, τὸ Α πρὸς τὸ Β λόγον ἕξει, ὃν ἀριθμὸς πρὸς ἀριθμόν. οὐκ ἔχει δέ. ἀσύμμετρα ἄρα ἐστὶ τὰ Α, Β μεγέθη.

Ἐὰν ἄρα δύο μεγέθη πρὸς ἄλληλα, καὶ τὰ ἑξῆς.

Proposition 8

If two magnitudes do not have to one another the ratio which (some) number (has) to (some) number then the magnitudes will be incommensurable.



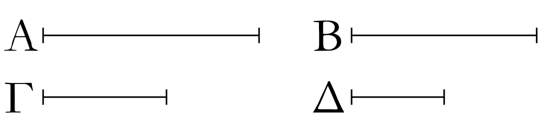
For let the two magnitudes A and B not have to one another the ratio which (some) number (has) to (some) number. I say that the magnitudes A and B are incommensurable.

For if they are commensurable, A will have to B the ratio which (some) number (has) to (some) number [Prop. 10.5]. But it does not have (such a ratio). Thus, the magnitudes A and B are incommensurable.

Thus, if two magnitudes ... to one another, and so on ....

θ´.

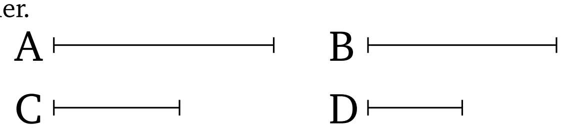
Τὰ ἀπὸ τῶν μήκει συμμέτρων εὐθειῶν τετράγωνα πρὸς ἄλληλα λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· καὶ τὰ τετράγωνα τὰ πρὸς ἄλληλα λόγον ἔχοντα, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, καὶ τὰς πλευρὰς ἕξει μήκει συμμέτρους. τὰ δὲ ἀπὸ τῶν μήκει ἀσυμμέτρων εὐθειῶν τετράγωνα πρὸς ἄλληλα λόγον οὐκ ἔχει, ὅνπερ τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· καὶ τὰ τετράγωνα τὰ πρὸς ἄλληλα λόγον μὴ ἔχοντα, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδὲ τὰς πλευρὰς ἕξει μήκει συμμέτρους.



Ἔστωσαν γὰρ αἱ Α, Β μήκει σύμμετροι· λέγω, ὅτι τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς Β τετράγωνον λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν.

Proposition 9

Squares on straight-lines (which are) commensurable in length have to one another the ratio which (some) square number (has) to (some) square number. And squares having to one another the ratio which (some) square number (has) to (some) square number will also have sides (which are) commensurable in length. But squares on straight-lines (which are) incommensurable in length do not have to one another the ratio which (some) square number (has) to (some) square number. And squares not having to one another the ratio which (some) square number (has) to (some) square number will not have sides (which are) commensurable in length either.



For let A and B be (straight-lines which are) commensurable in length. I say that the square on A has to the square on B the ratio which (some) square number (has) to (some) square number.

Ἐπεὶ γὰρ σύμμετρός ἐστιν ἡ Α τῇ Β μήκει, ἡ Α ἄρα πρὸς τὴν Β λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν. ἐχέτω, ὃν ὁ Γ πρὸς τὸν Δ. ἐπεὶ οὖν ἐστιν ὡς ἡ Α πρὸς τὴν Β, οὕτως ὁ Γ πρὸς τὸν Δ, ἀλλὰ τοῦ μὲν τῆς Α πρὸς τὴν Β λόγου διπλασίων ἐστὶν ὁ τοῦ ἀπὸ τῆς Α τετραγώνου πρὸς τὸ ἀπὸ τῆς Β τετράγωνον· τὰ γὰρ ὅμοια σχήματα ἐν διπλασίονι λόγῳ ἐστὶ τῶν ὁμολόγων πλευρῶν· τοῦ δὲ τοῦ Γ [ἀριθμοῦ] πρὸς τὸν Δ [ἀριθμὸν] λόγου διπλασίων ἐστὶν ὁ τοῦ ἀπὸ τοῦ Γ τετραγώνου πρὸς τὸν ἀπὸ τοῦ Δ τετράγωνον· δύο γὰρ τετραγώνων ἀριθμῶν εἷς μέσος ἀνάλογόν ἐστιν ἀριθμός, καί ὁ τετράγωνος πρὸς τὸν τετράγωνον [ἀριθμὸν] διπλασίονα λόγον ἔχει, ἤπερ ἡ πλευρὰ πρὸς τὴν πλευράν· ἔστιν ἄρα καὶ ὡς τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς Β τετράγωνον, οὕτως ὁ ἀπὸ τοῦ Γ τετράγωνος [ἀριθμὸς] πρὸς τὸν ἀπὸ τοῦ Δ [ἀριθμοῦ] τετράγωνον [ἀριθμόν].

Ἀλλὰ δὴ ἔστω ὡς τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς Β, οὕτως ὁ ἀπὸ τοῦ Γ τετράγωνος πρὸς τὸν ἀπὸ τοῦ Δ [τετράγωνον]· λέγω, ὅτι σύμμετρός ἐστιν ἡ Α τῇ Β μήκει.

Ἐπεὶ γάρ ἐστιν ὡς τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς Β [τετράγωνον], οὕτως ὁ ἀπὸ τοῦ Γ τετράγωνος πρὸς τὸν ἀπὸ τοῦ Δ [τετράγωνον], ἀλλ᾽ ὁ μὲν τοῦ ἀπὸ τῆς Α τετραγώνου πρὸς τὸ ἀπὸ τῆς Β [τετράγωνον] λόγος διπλασίων ἐστὶ τοῦ τῆς Α πρὸς τὴν Β λόγου, ὁ δὲ τοῦ ἀπὸ τοῦ Γ [ἀριθμοῦ] τετραγώνου [ἀριθμοῦ] πρὸς τὸν ἀπὸ τοῦ Δ [ἀριθμοῦ] τετράγωνον [ἀριθμὸν] λόγος διπλασίων ἐστὶ τοῦ τοῦ Γ [ἀριθμοῦ] πρὸς τὸν Δ [ἀριθμὸν] λόγου, ἔστιν ἄρα καὶ ὡς ἡ Α πρὸς τὴν Β, οὕτως ὁ Γ [ἀριθμὸς] πρὸς τὸν Δ [ἀριθμόν]. ἡ Α ἄρα πρὸς τὴν Β λόγον ἔχει, ὃν ἀριθμὸς ὁ Γ πρὸς ἀριθμὸν τὸν Δ· σύμμετρος ἄρα ἐστὶν ἡ Α τῇ Β μήκει.

Ἀλλὰ δὴ ἀσύμμετρος ἔστω ἡ Α τῇ Β μήκει· λέγω, ὅτι τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς Β [τετράγωνον] λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν.

Εἰ γὰρ ἔχει τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς Β [τετράγωνον] λόγον, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, σύμμετρος ἔσται ἡ Α τῇ Β. οὐκ ἔστι δέ· οὐκ ἄρα τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς Β [τετράγωνον] λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν.

Πάλιν δὴ τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς Β [τετράγωνον] λόγον μὴ ἐχέτω, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· λέγω, ὅτι ἀσύμμετρός ἐστιν ἡ Α τῇ Β μήκει.

Εἰ γάρ ἐστι σύμμετρος ἡ Α τῇ Β, ἕξει τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς Β λόγον, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. οὐκ ἔχει δέ· οὐκ ἄρα σύμμετρός ἐστιν ἡ Α τῇ Β μήκει.

Τὰ ἄρα ἀπὸ τῶν μήκει συμμέτρων, καὶ τὰ ἑξῆς.

For since A is commensurable in length with B, A thus has to B the ratio which (some) number (has) to (some) number [Prop. 10.5]. Let it have (that) which C (has) to D. Therefore, since as A is to B, so C (is) to D. But the (ratio) of the square on A to the square on B is the square of the ratio of A to B. For similar figures are in the squared ratio of (their) corresponding sides [Prop. 6.20 corr.]. And the (ratio) of the square on C to the square on D is the square of the ratio of the [number] C to the [number] D. For there exits one number in mean proportion to two square numbers, and (one) square (number) has to the (other) square [number] a squared ratio with respect to (that) the side (of the former has) to the side (of the latter) [Prop. 8.11]. And, thus, as the square on A is to the square on B, so the square [number] on the (number) C (is) to the square [number] on the [number] D.†

And so let the square on A be to the (square) on B as the square (number) on C (is) to the [square] (number) on D. I say that A is commensurable in length with B.

For since as the square on A is to the [square] on B, so the square (number) on C (is) to the [square] (number) on D. But, the ratio of the square on A to the (square) on B is the square of the (ratio) of A to B [Prop. 6.20 corr.]. And the (ratio) of the square [number] on the [number] C to the square [number] on the [number] D is the square of the ratio of the [number] C to the [number] D [Prop. 8.11]. Thus, as A is to B, so the [number] C also (is) to the [number] D. A, thus, has to B the ratio which the number C has to the number D. Thus, A is commensurable in length with B [Prop. 10.6].‡

And so let A be incommensurable in length with B. I say that the square on A does not have to the [square] on B the ratio which (some) square number (has) to (some) square number.

For if the square on A has to the [square] on B the ratio which (some) square number (has) to (some) square number then A will be commensurable (in length) with B. But it is not. Thus, the square on A does not have to the [square] on the B the ratio which (some) square number (has) to (some) square number.

So, again, let the square on A not have to the [square] on B the ratio which (some) square number (has) to (some) square number. I say that A is incommensurable in length with B.

For if A is commensurable (in length) with B then the (square) on A will have to the (square) on B the ratio which (some) square number (has) to (some) square number. But it does not have (such a ratio). Thus, A is not commensurable in length with B.

Thus, (squares) on (straight-lines which are) commensurable in length, and so on ....

Πόρισμα.

Καὶ φανερὸν ἐκ τῶν δεδειγμένων ἔσται, ὅτι αἱ μήκει σύμμετροι πάντως καὶ δυνάμει, αἱ δὲ δυνάμει οὐ πάντως καὶ μήκει.

Corollary

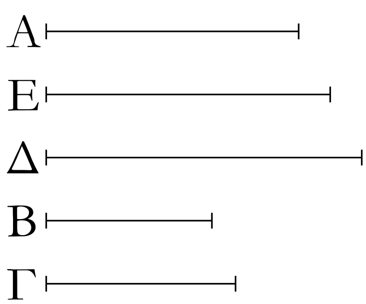
And it will be clear, from (what) has been demonstrated, that (straight-lines) commensurable in length (are) always also (commensurable) in square, but (straight-lines commensurable) in square (are) not always also (commensurable) in length.

† There is an unstated assumption here that if $\alpha : \beta :: \gamma : \delta$ then $\alpha^2 : \beta^2 :: \gamma^2 : \delta^2$.

‡ There is an unstated assumption here that if $\alpha^2 : \beta^2 :: \gamma^2 : \delta^2$ then $\alpha : \beta :: \gamma : \delta$.

ι′.

Τῇ προτεθείσῃ εὐθείᾳ προσευρεῖν δύο εὐθείας ἀσυμμέτρους, τὴν μὲν μήκει μόνον, τὴν δὲ καὶ δυνάμει.



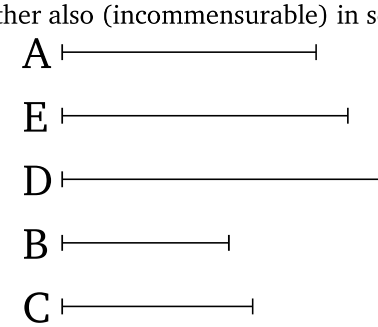
Ἔστω ἡ προτεθεῖσα εὐθεῖα ἡ Α· δεῖ δὴ τῇ Α προσευρεῖν δύο εὐθείας ἀσυμμέτρους, τὴν μὲν μήκει μόνον, τὴν δὲ καὶ δυνάμει.

Ἐκκείσθωσαν γὰρ δύο αριθμοὶ οἱ Β, Γ πρὸς ἀλλήλους λόγον μὴ ἔχοντες, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, τουτέστι μὴ ὅμοιοι ἐπίπεδοι, καὶ γεγονέτω ὡς ὁ Β πρὸς τὸν Γ, οὕτως τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς Δ τετράγωνον· ἐμάθομεν γάρ· σύμμετρον ἄρα τὸ ἀπὸ τῆς Α τῷ ἀπὸ τῆς Δ. καὶ ἐπεὶ ὁ Β πρὸς τὸν Γ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδ᾽ ἄρα τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς Δ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ Α τῇ Δ μήκει. εἰλήφθω τῶν Α, Δ μέση ἀνάλογον ἡ Ε· ἔστιν ἄρα ὡς ἡ Α πρὸς τὴν Δ, οὕτως τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς Ε. ἀσύμμετρος δέ ἐστιν ἡ Α τῇ Δ μήκει· ἀσύμμετρον ἄρα ἐστὶ καὶ τὸ ἀπὸ τῆς Α τετράγωνον τῷ ἀπὸ τῆς Ε τετραγώνῳ· ἀσύμμετρος ἄρα ἐστὶν ἡ Α τῇ Ε δυνάμει.

Τῇ ἄρα προτεθείσῃ εὐθείᾳ τῇ Α προσεύρηνται δύο εὐθεῖαι ἀσύμμετροι αἱ Δ, Ε, μήκει μὲν μόνον ἡ Δ, δυνάμει δὲ καὶ μήκει δηλαδὴ ἡ Ε [ὅπερ ἔδει δεῖξαι].

Proposition 10†

To find two straight-lines incommensurable with a given straight-line, the one (incommensurable) in length only, the other also (incommensurable) in square.



Let A be the given straight-line. So it is required to find two straight-lines incommensurable with A, the one (incommensurable) in length only, the other also (incommensurable) in square.

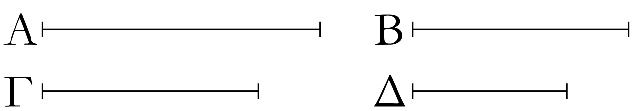
For let two numbers, B and C, not having to one another the ratio which (some) square number (has) to (some) square number—that is to say, not (being) similar plane (numbers)—have been taken. And let it be contrived that as B (is) to C, so the square on A (is) to the square on D. For we learned (how to do this) [Prop. 10.6 corr.]. Thus, the (square) on A (is) commensurable with the (square) on D [Prop. 10.6]. And since B does not have to C the ratio which (some) square number (has) to (some) square number, the (square) on A thus does not have to the (square) on D the ratio which (some) square number (has) to (some) square number either. Thus, A is incommensurable in length with D [Prop. 10.9]. Let the (straight-line) E (which is) in mean proportion to A and D have been taken [Prop. 6.13]. Thus, as A is to D, so the square on A (is) to the (square) on E [Def. 5.9]. And A is incommensurable in length with D. Thus, the square on A is also incommensurble with the square on E [Prop. 10.11]. Thus, A is incommensurable in square with E.

Thus, two straight-lines, D and E, (which are) incommensurable with the given straight-line A, have been found, the one, D, (incommensurable) in length only, the other, E, (incommensurable) in square, and, clearly, also in length. [(Which is) the very thing it was required to show.]

† This whole proposition is regarded by Heiberg as an interpolation into the original text.

ια´.

Ἐὰν τέσσαρα μεγέθη ἀνάλογον ᾖ, τὸ δὲ πρῶτον τῷ δευτέρῳ σύμμετρον ᾖ, καὶ τὸ τρίτον τῷ τετάρτῳ σύμμετρον ἔσται· κἂν τὸ πρῶτον τῷ δευτέρῳ ἀσύμμετρον ᾖ, καὶ τὸ τρίτον τῷ τετάρτῳ ἀσύμμετρον ἔσται.



Ἔστωσαν τέσσαρα μεγέθη ἀνάλογον τὰ Α, Β, Γ, Δ, ὡς τὸ Α πρὸς τὸ Β, οὕτως τὸ Γ πρὸς τὸ Δ, τὸ Α δὲ τῷ Β σύμμετρον ἔστω· λέγω, ὅτι καὶ τὸ Γ τῷ Δ σύμμετρον ἔσται.

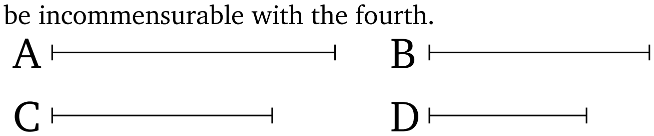
Ἐπεὶ γὰρ σύμμετρόν ἐστι τὸ Α τῷ Β, τὸ Α ἄρα πρὸς τὸ Β λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν. καί ἐστιν ὡς τὸ Α πρὸς τὸ Β, οὕτως τὸ Γ πρὸς τὸ Δ· καὶ τὸ Γ ἄρα πρὸς τὸ Δ λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν· σύμμετρον ἄρα ἐστὶ τὸ Γ τῷ Δ.

Ἀλλὰ δὴ τὸ Α τῷ Β ἀσύμμετρον ἔστω· λέγω, ὅτι καὶ τὸ Γ τῷ Δ ἀσύμμετρον ἔσται. ἐπεὶ γὰρ ἀσύμμετρόν ἐστι τὸ Α τῷ Β, τὸ Α ἄρα πρὸς τὸ Β λόγον οὐκ ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν. καί ἐστιν ὡς τὸ Α πρὸς τὸ Β, οὕτως τὸ Γ πρὸς τὸ Δ· οὐδὲ τὸ Γ ἄρα πρὸς τὸ Δ λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν· ἀσύμμετρον ἄρα ἐστὶ τὸ Γ τῷ Δ.

Ἐὰν ἄρα τέσσαρα μεγέθη, καὶ τὰ ἑξῆς.

Proposition 11

If four magnitudes are proportional, and the first is commensurable with the second, then the third will also be commensurable with the fourth. And if the first is incommensurable with the second, then the third will also be incommensurable with the fourth.



Let A, B, C, D be four proportional magnitudes, (such that) as A (is) to B, so C (is) to D. And let A be commensurable with B. I say that C will also be commensurable with D.

For since A is commensurable with B, A thus has to B the ratio which (some) number (has) to (some) number [Prop. 10.5]. And as A is to B, so C (is) to D. Thus, C also has to D the ratio which (some) number (has) to (some) number. Thus, C is commensurable with D [Prop. 10.6].

And so let A be incommensurable with B. I say that C will also be incommensurable with D. For since A is incommensurable with B, A thus does not have to B the ratio which (some) number (has) to (some) number [Prop. 10.7]. And as A is to B, so C (is) to D. Thus, C does not have to D the ratio which (some) number (has) to (some) number either. Thus, C is incommensurable with D [Prop. 10.8].

Thus, if four magnitudes, and so on ....

ιβ´.

Τὰ τῷ αὐτῷ μεγέθει σύμμετρα καὶ ἀλλήλοις ἐστὶ σύμμετρα.

Ἑκάτερον γὰρ τῶν Α, Β τῷ Γ ἔστω σύμμετρον. λέγω, ὅτι καὶ τὸ Α τῷ Β ἐστι σύμμετρον.

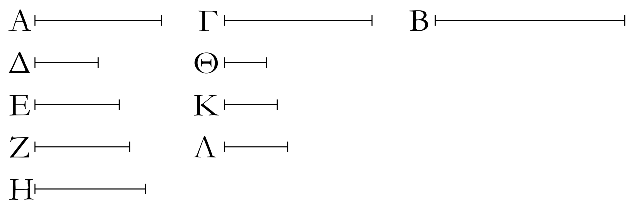
Ἐπεὶ γὰρ σύμμετρόν ἐστι τὸ Α τῷ Γ, τὸ Α ἄρα πρὸς τὸ Γ λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν. ἐχέτω, ὃν ὁ Δ πρὸς τὸν Ε. πάλιν, ἐπεὶ σύμμετρόν ἐστι τὸ Γ τῷ Β, τὸ Γ ἄρα πρὸς τὸ Β λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν. ἐχέτω, ὃν ὁ Ζ πρὸς τὸν Η. καὶ λόγων δοθέντων ὁποσωνοῦν τοῦ τε, ὃν ἔχει ὁ Δ πρὸς τὸν Ε, καὶ ὁ Ζ πρὸς τὸν Η εἰλήφθωσαν ἀριθμοὶ ἑξῆς ἐν τοῖς δοθεῖσι λόγοις οἱ Θ, Κ, Λ· ὥστε εἶναι

Proposition 12

(Magnitudes) commensurable with the same magnitude are also commensurable with one another.

For let A and B each be commensurable with C. I say that A is also commensurable with B.

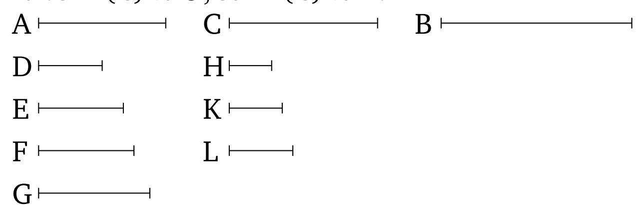
For since A is commensurable with C, A thus has to C the ratio which (some) number (has) to (some) number [Prop. 10.5]. Let it have (the ratio) which D (has) to E. Again, since C is commensurable with B, C thus has to B the ratio which (some) number (has) to (some) number [Prop. 10.5]. Let it have (the ratio) which F (has) to G. And for any multitude whatsoever ὡς μὲν τὸν Δ πρὸς τὸν Ε, οὕτως τὸν Θ πρὸς τὸν Κ, ὡς δὲ τὸν Ζ πρὸς τὸν Η, οὕτως τὸν Κ πρὸς τὸν Λ.



Ἐπεὶ οὖν ἐστιν ὡς τὸ Α πρὸς τὸ Γ, οὕτως ὁ Δ πρὸς τὸν Ε, ἀλλ᾽ ὡς ὁ Δ πρὸς τὸν Ε, οὕτως ὁ Θ πρὸς τὸν Κ, ἔστιν ἄρα καὶ ὡς τὸ Α πρὸς τὸ Γ, οὕτως ὁ Θ πρὸς τὸν Κ. πάλιν, ἐπεί ἐστιν ὡς τὸ Γ πρὸς τὸ Β, οὕτως ὁ Ζ πρὸς τὸν Η, ἀλλ᾽ ὡς ὁ Ζ πρὸς τὸν Η, [οὕτως] ὁ Κ πρὸς τὸν Λ, καὶ ὡς ἄρα τὸ Γ πρὸς τὸ Β, οὕτως ὁ Κ πρὸς τὸν Λ. ἔστι δὲ καὶ ὡς τὸ Α πρὸς τὸ Γ, οὕτως ὁ Θ πρὸς τὸν Κ· δι᾽ ἴσου ἄρα ἐστὶν ὡς τὸ Α πρὸς τὸ Β, οὕτως ὁ Θ πρὸς τὸν Λ. τὸ Α ἄρα πρὸς τὸ Β λόγον ἔχει, ὃν ἀριθμὸς ὁ Θ πρὸς ἀριθμὸν τὸν Λ· σύμμετρον ἄρα ἐστὶ τὸ Α τῷ Β.

Τὰ ἄρα τῷ αὐτῷ μεγέθει σύμμετρα καὶ ἀλλήλοις ἐστὶ σύμμετρα· ὅπερ ἔδει δεῖξαι.

of given ratios—(namely,) those which D has to E, and F to G—let the numbers H, K, L (which are) continuously (proportional) in the(se) given ratios have been taken [Prop. 8.4]. Hence, as D is to E, so H (is) to K, and as F (is) to G, so K (is) to L.

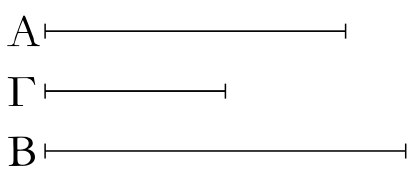


Therefore, since as A is to C, so D (is) to E, but as D (is) to E, so H (is) to K, thus also as A is to C, so H (is) to K [Prop. 5.11]. Again, since as C is to B, so F (is) to G, but as F (is) to G, [so] K (is) to L, thus also as C (is) to B, so K (is) to L [Prop. 5.11]. And also as A is to C, so H (is) to K. Thus, via equality, as A is to B, so H (is) to L [Prop. 5.22]. Thus, A has to B the ratio which the number H (has) to the number L. Thus, A is commensurable with B [Prop. 10.6].

Thus, (magnitudes) commensurable with the same magnitude are also commensurable with one another. (Which is) the very thing it was required to show.

ιγ΄.

Ἐὰν ᾖ δύο μεγέθη σύμμετρα, τὸ δὲ ἕτερον αὐτῶν μεγέθει τινὶ ἀσύμμετρον ᾖ, καὶ τὸ λοιπὸν τῷ αὐτῷ ἀσύμμετρον ἔσται.



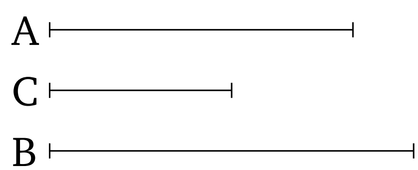
Ἔστω δύο μεγέθη σύμμετρα τὰ Α, Β, τὸ δὲ ἕτερον αὐτῶν τὸ Α ἄλλῳ τινὶ τῷ Γ ἀσύμμετρον ἔστω· λέγω, ὅτι καὶ τὸ λοιπὸν τὸ Β τῷ Γ ἀσύμμετρόν ἐστιν.

Εἰ γάρ ἐστι σύμμετρον τὸ Β τῷ Γ, ἀλλὰ καὶ τὸ Α τῷ Β σύμμετρόν ἐστιν, καὶ τὸ Α ἄρα τῷ Γ σύμμετρόν ἐστιν. ἀλλὰ καὶ ἀσύμμετρον· ὅπερ ἀδύνατον. οὐκ ἄρα σύμμετρόν ἐστι τὸ Β τῷ Γ· ἀσύμμετρον ἄρα.

Ἐὰν ἄρα ᾖ δύο μεγέθη σύμμετρα, καὶ τὰ ἑξῆς.

Proposition 13

If two magnitudes are commensurable, and one of them is incommensurable with some magnitude, then the remaining (magnitude) will also be incommensurable with it.



Let A and B be two commensurable magnitudes, and let one of them, A, be incommensurable with some other (magnitude), C. I say that the remaining (magnitude), B, is also incommensurable with C.

For if B is commensurable with C, but A is also commensurable with B, A is thus also commensurable with C [Prop. 10.12]. But, (it is) also incommensurable (with C). The very thing (is) impossible. Thus, B is not commensurable with C. Thus, (it is) incommensurable.

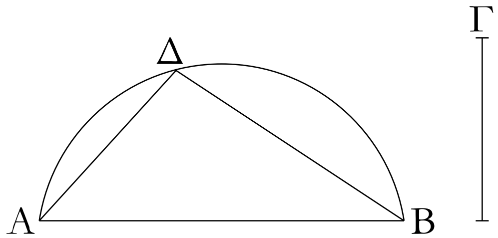
Thus, if two magnitudes are commensurable, and so on ....

Λῆμμα.

Δύο δοθεισῶν εὐθειῶν ἀνίσων εὑρεῖν, τίνι μεῖζον δύναται ἡ μείζων τῆς ἐλάσσονος.

Lemma

For two given unequal straight-lines, to find by (the square on) which (straight-line) the square on the greater



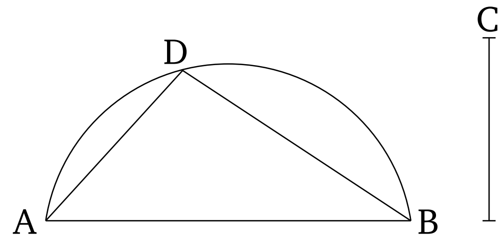
Ἔστωσαν αἱ δοθεῖσαι δύο ἄνισοι εὐθεῖαι αἱ ΑΒ, Γ, ὧν μείζων ἔστω ἡ ΑΒ· δεῖ δὴ εὑρεῖν, τίνι μεῖζον δύναται ἡ ΑΒ τῆς Γ.

Γεγράφθω ἐπὶ τῆς ΑΒ ἡμικύκλιον τὸ ΑΔΒ, καὶ εἰς αὐτὸ ἐνηρμόσθω τῇ Γ ἴση ἡ ΑΔ, καὶ ἐπεζεύχθω ἡ ΔΒ. φανερὸν δή, ὅτι ὀρθή ἐστιν ἡ ὑπὸ ΑΔΒ γωνία, καὶ ὅτι ἡ ΑΒ τῆς ΑΔ, τουτέστι τῆς Γ, μεῖζον δύναται τῇ ΔΒ.

Ὁμοίως δὲ καὶ δύο δοθεισῶν εὐθειῶν ἡ δυναμένη αὐτὰς εὑρίσκεται οὕτως.

Ἔστωσαν αἱ δοθεῖσαι δύο εὐθεῖαι αἱ ΑΔ, ΔΒ, καὶ δέον ἔστω εὑρεῖν τὴν δυναμένην αὐτάς. κείσθωσαν γάρ, ὥστε ὀρθὴν γωνίαν περιέχειν τὴν ὑπὸ ΑΔ, ΔΒ, καὶ ἐπεζεύχθω ἡ ΑΒ· φανερὸν πάλιν, ὅτι ἡ τὰς ΑΔ, ΔΒ δυναμένη ἐστὶν ἡ ΑΒ· ὅπερ ἔδει δεῖξαι.

(straight-line is) larger than (the square on) the lesser.†



Let AB and C be the two given unequal straight-lines, and let AB be the greater of them. So it is required to find by (the square on) which (straight-line) the square on AB (is) greater than (the square on) C.

Let the semi-circle ADB have been described on AB. And let AD, equal to C, have been inserted into it [Prop. 4.1]. And let DB have been joined. So (it is) clear that the angle ADB is a right-angle [Prop. 3.31], and that the square on AB (is) greater than (the square on) AD—that is to say, (the square on) C—by (the square on) DB [Prop. 1.47].

And, similarly, the square-root of (the sum of the squares on) two given straight-lines is also found likeso.

Let AD and DB be the two given straight-lines. And let it be necessary to find the square-root of (the sum of the squares on) them. For let them have been laid down such as to encompass a right-angle—(namely), that (angle encompassed) by AD and DB. And let AB have been joined. (It is) again clear that AB is the square-root of (the sum of the squares on) AD and DB [Prop. 1.47]. (Which is) the very thing it was required to show.

† That is, if α and β are the lengths of two given straight-lines, with α being greater than β, to find a straight-line of length γ such that $\alpha^2 = \beta^2 + \gamma^2$. Similarly, we can also find γ such that $\gamma^2 = \alpha^2 + \beta^2$.

ιδʹ.

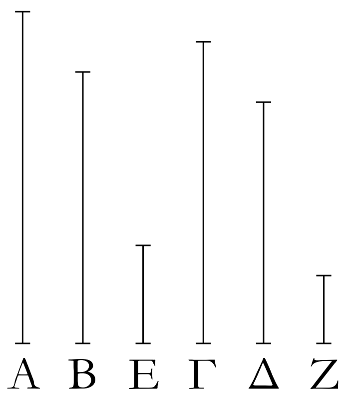
Ἐὰν τέσσαρες εὐθεῖαι ἀνάλογον ὦσιν, δύνηται δὲ ἡ πρώτη τῆς δευτέρας μεῖζον τῷ ἀπὸ συμμέτρου ἑαυτῇ [μήκει], καὶ ἡ τρίτη τῆς τετάρτης μεῖζον δυνήσεται τῷ ἀπὸ συμμέτρου ἑαυτῇ [μήκει]. καὶ ἐὰν ἡ πρώτη τῆς δευτέρας μεῖζον δύνηται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ [μήκει], καὶ ἡ τρίτη τῆς τετάρτης μεῖζον δυνήσεται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ [μήκει].

Ἔστωσαν τέσσαρες εὐθεῖαι ἀνάλογον αἱ Α, Β, Γ, Δ, ὡς ἡ Α πρὸς τὴν Β, οὕτως ἡ Γ πρὸς τὴν Δ, καὶ ἡ Α μὲν τῆς Β μεῖζον δυνάσθω τῷ ἀπὸ τῆς Ε, ἡ δὲ Γ τῆς Δ μεῖζον δυνάσθω τῷ ἀπὸ τῆς Ζ· λέγω, ὅτι, εἴτε σύμμετρός ἐστιν ἡ Α τῇ Ε, σύμμετρός ἐστι καὶ ἡ Γ τῇ Ζ, εἴτε ἀσύμμετρός ἐστιν ἡ Α τῇ Ε, ἀσύμμετρός ἐστι καὶ ὁ Γ τῇ Ζ.

Proposition 14

If four straight-lines are proportional, and the square on the first is greater than (the square on) the second by the (square) on (some straight-line) commensurable [in length] with the first, then the square on the third will also be greater than (the square on) the fourth by the (square) on (some straight-line) commensurable [in length] with the third. And if the square on the first is greater than (the square on) the second by the (square) on (some straight-line) incommensurable [in length] with the first, then the square on the third will also be greater than (the square on) the fourth by the (square) on (some straight-line) incommensurable [in length] with the third.

Let A, B, C, D be four proportional straight-lines, (such that) as A (is) to B, so C (is) to D. And let the square on A be greater than (the square on) B by the



Ἐπεὶ γάρ ἐστιν ὡς ἡ Α πρὸς τὴν Β, οὕτως ἡ Γ πρὸς τὴν Δ, ἔστιν ἄρα καὶ ὡς τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς Β, οὕτως τὸ ἀπὸ τῆς Γ πρὸς τὸ ἀπὸ τῆς Δ. ἀλλὰ τῷ μὲν ἀπὸ τῆς Α ἴσα ἐστὶ τὰ ἀπὸ τῶν Ε, Β, τῷ δὲ ἀπὸ τῆς Γ ἴσα ἐστὶ τὰ ἀπὸ τῶν Δ, Ζ. ἔστιν ἄρα ὡς τὰ ἀπὸ τῶν Ε, Β πρὸς τὸ ἀπὸ τῆς Β, οὕτως τὰ ἀπὸ τῶν Δ, Ζ πρὸς τὸ ἀπὸ τῆς Δ· διελόντι ἄρα ἐστὶν ὡς τὸ ἀπὸ τῆς Ε πρὸς τὸ ἀπὸ τῆς Β, οὕτως τὸ ἀπὸ τῆς Ζ πρὸς τὸ ἀπὸ τῆς Δ· ἔστιν ἄρα καὶ ὡς ἡ Ε πρὸς τὴν Β, οὕτως ἡ Ζ πρὸς τὴν Δ· ἀνάπαλιν ἄρα ἐστὶν ὡς ἡ Β πρὸς τὴν Ε, οὕτως ἡ Δ πρὸς τὴν Ζ. ἔστι δὲ καὶ ὡς ἡ Α πρὸς τὴν Β, οὕτως ἡ Γ πρὸς τὴν Δ· δι᾿ ἴσου ἄρα ἐστὶν ὡς ἡ Α πρὸς τὴν Ε, οὕτως ἡ Γ πρὸς τὴν Ζ. εἴτε οὖν σύμμετρός ἐστιν ἡ Α τῇ Ε, συμμετρός ἐστι καὶ ἡ Γ τῇ Ζ, εἴτε ἀσύμμετρός ἐστιν ἡ Α τῇ Ε, ἀσύμμετρός ἐστι καὶ ἡ Γ τῇ Ζ.

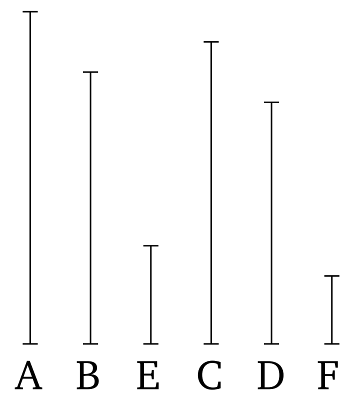
Ἐὰν ἄρα, καὶ τὰ ἑξῆς.

ιεʹ.

Ἐὰν δύο μεγέθη σύμμετρα συντεθῇ, καὶ τὸ ὅλον ἑκατέρῳ αὐτῶν σύμμετρον ἔσται· κἂν τὸ ὅλον ἑνὶ αὐτῶν σύμμετρον ᾖ, καὶ τὰ ἐξ ἀρχῆς μεγέθη σύμμετρα ἔσται.

Συγκείσθω γὰρ δύο μεγέθη σύμμετρα τὰ ΑΒ, ΒΓ· λέγω, ὅτι καὶ ὅλον τὸ ΑΓ ἑκατέρῳ τῶν ΑΒ, ΒΓ ἐστι σύμμετρον.

(square) on E, and let the square on C be greater than (the square on) D by the (square) on F. I say that A is either commensurable (in length) with E, and C is also commensurable with F, or A is incommensurable (in length) with E, and C is also incommensurable with F.



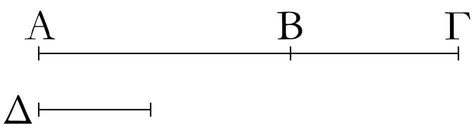
For since as A is to B, so C (is) to D, thus as the (square) on A is to the (square) on B, so the (square) on C (is) to the (square) on D [Prop. 6.22]. But the (sum of the squares) on E and B is equal to the (square) on A, and the (sum of the squares) on D and F is equal to the (square) on C. Thus, as the (sum of the squares) on E and B is to the (square) on B, so the (sum of the squares) on D and F (is) to the (square) on D. Thus, via separation, as the (square) on E is to the (square) on B, so the (square) on F (is) to the (square) on D [Prop. 5.17]. Thus, also, as E is to B, so F (is) to D [Prop. 6.22]. Thus, inversely, as B is to E, so D (is) to F [Prop. 5.7 corr.]. But, as A is to B, so C also (is) to D. Thus, via equality, as A is to E, so C (is) to F [Prop. 5.22]. Therefore, A is either commensurable (in length) with E, and C is also commensurable with F, or A is incommensurable (in length) with E, and C is also incommensurable with F [Prop. 10.11].

Thus, if, and so on ….

Proposition 15

If two commensurable magnitudes are added together then the whole will also be commensurable with each of them. And if the whole is commensurable with one of them then the original magnitudes will also be commensurable (with one another).

For let the two commensurable magnitudes AB and BC be laid down together. I say that the whole AC is also commensurable with each of AB and BC.

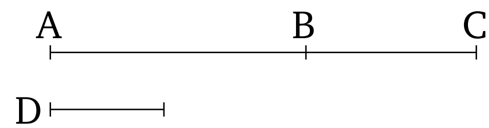


Ἐπεὶ γὰρ σύμμετρά ἐστι τὰ ΑΒ, ΒΓ, μετρήσει τι αὐτὰ μέγεθος. μετρείτω, καὶ ἔστω τὸ Δ. ἐπεὶ οὖν τὸ Δ τὰ ΑΒ, ΒΓ μετρεῖ, καὶ ὅλον τὸ ΑΓ μετρήσει. μετρεῖ δὲ καὶ τὰ ΑΒ, ΒΓ. τὸ Δ ἄρα τὰ ΑΒ, ΒΓ, ΑΓ μετρεῖ· σύμμετρον ἄρα ἐστὶ τὸ ΑΓ ἑκατέρῳ τῶν ΑΒ, ΒΓ.

Ἀλλὰ δὴ τὸ ΑΓ ἔστω σύμμετρον τῷ ΑΒ· λέγω δή, ὅτι καὶ τὰ ΑΒ, ΒΓ σύμμετρά ἐστιν.

Ἐπεὶ γὰρ σύμμετρά ἐστι τὰ ΑΓ, ΑΒ, μετρήσει τι αὐτὰ μέγεθος. μετρείτω, καὶ ἔστω τὸ Δ. ἐπεὶ οὖν τὸ Δ τὰ ΓΑ, ΑΒ μετρεῖ, καὶ λοιπὸν ἄρα τὸ ΒΓ μετρήσει. μετρεῖ δὲ καὶ τὸ ΑΒ· τὸ Δ ἄρα τὰ ΑΒ, ΒΓ μετρήσει· σύμμετρα ἄρα ἐστὶ τὰ ΑΒ, ΒΓ.

Ἐὰν ἄρα δύο μεγέθη, καὶ τὰ ἑξῆς.



For since AB and BC are commensurable, some magnitude will measure them. Let it (so) measure (them), and let it be D. Therefore, since D measures (both) AB and BC, it will also measure the whole AC. And it also measures AB and BC. Thus, D measures AB, BC, and AC. Thus, AC is commensurable with each of AB and BC [Def. 10.1].

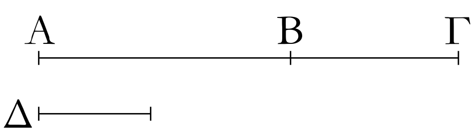
And so let AC be commensurable with AB. I say that AB and BC are also commensurable.

For since AC and AB are commensurable, some magnitude will measure them. Let it (so) measure (them), and let it be D. Therefore, since D measures (both) CA and AB, it will thus also measure the remainder BC. And it also measures AB. Thus, D will measure (both) AB and BC. Thus, AB and BC are commensurable [Def. 10.1].

Thus, if two magnitudes, and so on ....

ιϛʹ.

Ἐὰν δύο μεγέθη ἀσύμμετρα συντεθῇ, καὶ τὸ ὅλον ἑκατέρῳ αὐτῶν ἀσύμμετρον ἔσται· κἂν τὸ ὅλον ἑνὶ αὐτῶν ἀσύμμετρον ᾖ, καὶ τὰ ἐξ ἀρχῆς μεγέθη ἀσύμμετρα ἔσται.



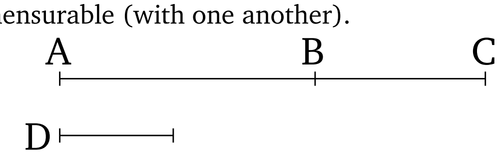
Συγκείσθω γὰρ δύο μεγέθη ἀσύμμετρα τὰ ΑΒ, ΒΓ· λέγω, ὅτι καὶ ὅλον τὸ ΑΓ ἑκατέρῳ τῶν ΑΒ, ΒΓ ἀσύμμετρόν ἐστιν.

Εἰ γὰρ μή ἐστιν ἀσύμμετρα τὰ ΓΑ, ΑΒ, μετρήσει τι [αὐτὰ] μέγεθος. μετρείτω, εἰ δυνατόν, καὶ ἔστω τὸ Δ. ἐπεὶ οὖν τὸ Δ τὰ ΓΑ, ΑΒ μετρεῖ, καὶ λοιπὸν ἄρα τὸ ΒΓ μετρήσει. μετρεῖ δὲ καὶ τὸ ΑΒ· τὸ Δ ἄρα τὰ ΑΒ, ΒΓ μετρεῖ. σύμμετρα ἄρα ἐστὶ τὰ ΑΒ, ΒΓ· ὑπέκειντο δὲ καὶ ἀσύμμετρα· ὅπερ ἐστὶν ἀδύνατον. οὐκ ἄρα τὰ ΓΑ, ΑΒ μετρήσει τι μέγεθος· ἀσύμμετρα ἄρα ἐστὶ τὰ ΓΑ, ΑΒ. ὁμοίως δὴ δείξομεν, ὅτι καὶ τὰ ΑΓ, ΓΒ ἀσύμμετρά ἐστιν. τὸ ΑΓ ἄρα ἑκατέρῳ τῶν ΑΒ, ΒΓ ἀσύμμετρόν ἐστιν.

Ἀλλὰ δὴ τὸ ΑΓ ἑνὶ τῶν ΑΒ, ΒΓ ἀσύμμετρον ἔστω. ἔστω δὴ πρότερον τῷ ΑΒ· λέγω, ὅτι καὶ τὰ ΑΒ, ΒΓ ἀσύμμετρά ἐστιν. εἰ γὰρ ἔσται σύμμετρα, μετρήσει τι αὐτὰ μέγεθος. μετρείτω, καὶ ἔστω τὸ Δ. ἐπεὶ οὖν τὸ Δ τὰ ΑΒ, ΒΓ μετρεῖ, καὶ ὅλον ἄρα τὸ ΑΓ μετρήσει. μετρεῖ δὲ καὶ τὸ ΑΒ· τὸ Δ ἄρα τὰ ΓΑ, ΑΒ μετρεῖ. σύμμετρα ἄρα ἐστὶ τὰ

Proposition 16

If two incommensurable magnitudes are added together then the whole will also be incommensurable with each of them. And if the whole is incommensurable with one of them then the original magnitudes will also be incommensurable (with one another).



For let the two incommensurable magnitudes AB and BC be laid down together. I say that that the whole AC is also incommensurable with each of AB and BC.

For if CA and AB are not incommensurable then some magnitude will measure [them]. If possible, let it (so) measure (them), and let it be D. Therefore, since D measures (both) CA and AB, it will thus also measure the remainder BC. And it also measures AB. Thus, D measures (both) AB and BC. Thus, AB and BC are commensurable [Def. 10.1]. But they were also assumed (to be) incommensurable. The very thing is impossible. Thus, some magnitude cannot measure (both) CA and AB. Thus, CA and AB are incommensurable [Def. 10.1]. So, similarly, we can show that AC and CB are also incommensurable. Thus, AC is incommensurable with each of AB and BC.

And so let AC be incommensurable with one of AB and BC. So let it, first of all, be incommensurable with

ΓΑ, ΑΒ· ὑπέκειτο δὲ καὶ ἀσύμμετρα· ὅπερ ἐστὶν ἀδύνατον. οὐκ ἄρα τὰ ΑΒ, ΒΓ μετρήσει τι μέγεθος· ἀσύμμετρα ἄρα ἐστὶ τὰ ΑΒ, ΒΓ.

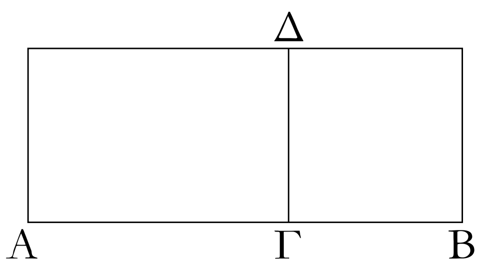
Ἐὰν ἄρα δύο μεγέθη, καὶ τὰ ἑξῆς.

AB. I say that AB and BC are also incommensurable. For if they are commensurable then some magnitude will measure them. Let it (so) measure (them), and let it be D. Therefore, since D measures (both) AB and BC, it will thus also measure the whole AC. And it also measures AB. Thus, D measures (both) CA and AB. Thus, CA and AB are commensurable [Def. 10.1]. But they were also assumed (to be) incommensurable. The very thing is impossible. Thus, some magnitude cannot measure (both) AB and BC. Thus, AB and BC are incommensurable [Def. 10.1].

Thus, if two... magnitudes, and so on ....

Λῆμμα.

Ἐὰν παρά τινα εὐθεῖαν παραβληθῇ παραλληλόγραμμον ἐλλεῖπον εἴδει τετραγώνῳ, τὸ παραβληθὲν ἴσον ἐστὶ τῷ ὑπὸ τῶν ἐκ τῆς παραβολῆς γενομένων τμημάτων τῆς εὐθείας.



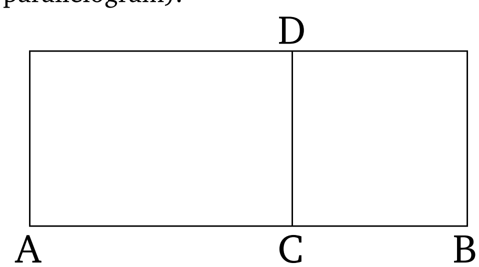
Παρὰ γὰρ εὐθεῖαν τὴν ΑΒ παραβεβλήσθω παραλληλόγραμμον τὸ ΑΔ ἐλλεῖπον εἴδει τετραγώνῳ τῷ ΔΒ· λέγω, ὅτι ἴσον ἐστὶ τὸ ΑΔ τῷ ὑπὸ τῶν ΑΓ, ΓΒ.

Καί ἐστιν αὐτόθεν φανερόν· ἐπεὶ γὰρ τετράγωνόν ἐστι τὸ ΔΒ, ἴση ἐστὶν ἡ ΔΓ τῇ ΓΒ, καί ἐστι τὸ ΑΔ τὸ ὑπὸ τῶν ΑΓ, ΓΔ, τουτέστι τὸ ὑπὸ τῶν ΑΓ, ΓΒ.

Ἐὰν ἄρα παρά τινα εὐθεῖαν, καὶ τὰ ἑξῆς.

Lemma

If a parallelogram,† falling short by a square figure, is applied to some straight-line then the applied (parallelogram) is equal (in area) to the (rectangle contained) by the pieces of the straight-line created via the application (of the parallelogram).



For let the parallelogram AD, falling short by the square figure DB, have been applied to the straight-line AB. I say that AD is equal to the (rectangle contained) by AC and CB.

And it is immediately obvious. For since DB is a square, DC is equal to CB. And AD is the (rectangle contained) by AC and CD—that is to say, by AC and CB.

Thus, if ... to some straight-line, and so on ....

† Note that this lemma only applies to rectangular parallelograms.

ιζʹ.

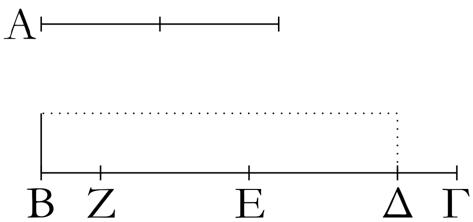
Ἐὰν ὦσι δύο εὐθεῖαι ἄνισοι, τῷ δὲ τετράτῳ μέρει τοῦ ἀπὸ τῆς ἐλάσσονος ἴσον παρὰ τὴν μείζονα παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ καὶ εἰς σύμμετρα αὐτὴν διαιρῇ μήκει, ἡ μείζων τῆς ἐλάσσονος μεῖζον δυνήσεται τῷ ἀπὸ συμμέτου ἑαυτῇ [μήκει]. καὶ ἐὰν ἡ μείζων τῆς ἐλάσσονος μεῖζον δύνηται τῷ ἀπὸ συμμέτρου ἑαυτῇ [μήκει], τῷ δὲ τετράρτῳ τοῦ ἀπὸ τῆς ἐλάσσονος ἴσον παρὰ τὴν μείζονα παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ, εἰς σύμμετρα αὐτὴν διαιρεῖ μήκει.

Ἔστωσαν δύο εὐθεῖαι ἄνισοι αἱ Α, ΒΓ, ὧν μείζων ἡ

Proposition 17†

If there are two unequal straight-lines, and a (rectangle) equal to the fourth part of the (square) on the lesser, falling short by a square figure, is applied to the greater, and divides it into (parts which are) commensurable in length, then the square on the greater will be larger than (the square on) the lesser by the (square) on (some straight-line) commensurable [in length] with the greater. And if the square on the greater is larger than (the square on) the lesser by the (square) on (some straight-line) commensurable [in length] with the

ΒΓ, τῷ δὲ τετάρτῳ μέρει τοῦ ἀπὸ ἐλάσσονος τῆς Α, τουτέστι τῷ ἀπὸ τῆς ἡμισείας τῆς Α, ἴσον παρὰ τὴν ΒΓ παραβεβλήσθω ἐλλεῖπον εἴδει τετραγώνῳ, καὶ ἔστω τὸ ὑπὸ τῶν ΒΔ, ΔΓ, σύμμετρος δὲ ἔστω ἡ ΒΔ τῇ ΔΓ μήκει· λέγω, ὅτι ἡ ΒΓ τῆς Α μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ.



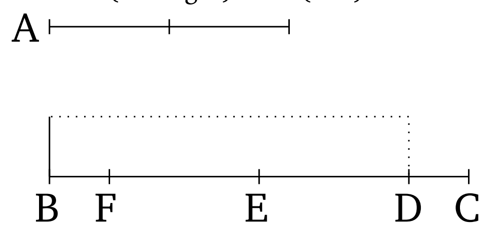
Τετμήσθω γὰρ ἡ ΒΓ δίχα κατὰ τὸ Ε σημεῖον, καὶ κείσθω τῇ ΔΕ ἴση ἡ ΕΖ. λοιπὴ ἄρα ἡ ΔΓ ἴση ἐστὶ τῇ ΒΖ. καὶ ἐπεὶ εὐθεῖα ἡ ΒΓ τέτμηται εἰς μὲν ἴσα κατὰ τὸ Ε, εἰς δὲ ἄνισα κατὰ τὸ Δ, τὸ ἄρα ὑπὸ ΒΔ, ΔΓ περειχόμενον ὀρθογώνιον μετὰ τοῦ ἀπὸ τῆς ΕΔ τετραγώνου ἴσον ἐστὶ τῷ ἀπὸ τῆς ΕΓ τετραγώνῳ· καὶ τὰ τετραπλάσια· τὸ ἄρα τετράκις ὑπὸ τῶν ΒΔ, ΔΓ μετὰ τοῦ τετραπλασίου τοῦ ἀπὸ τῆς ΔΕ ἴσον ἐστὶ τῷ τετράκις ἀπὸ τῆς ΕΓ τετραγώνῳ. ἀλλὰ τῷ μὲν τετραπλασίῳ τοῦ ὑπὸ τῶν ΒΔ, ΔΓ ἴσον ἐστὶ τὸ ἀπὸ τῆς Α τετράγωνον, τῷ δὲ τετραπλασίῳ τοῦ ἀπὸ τῆς ΔΕ ἴσον ἐστὶ τὸ ἀπὸ τῆς ΔΖ τετράγωνον· διπλασίων γάρ ἐστιν ἡ ΔΖ τῆς ΔΕ. τῷ δὲ τετραπλασίῳ τοῦ ἀπὸ τῆς ΕΓ ἴσον ἐστὶ τὸ ἀπὸ τῆς ΒΓ τετράγωνον· διπλασίων γάρ ἐστι πάλιν ἡ ΒΓ τῆς ΓΕ. τὰ ἄρα ἀπὸ τῶν Α, ΔΖ τετράγωνα ἴσα ἐστὶ τῷ ἀπὸ τῆς ΒΓ τετράγωνῳ· ὥστε τὸ ἀπὸ τῆς ΒΓ τοῦ ἀπὸ τῆς Α μεῖζόν ἐστι τῷ ἀπὸ τῆς ΔΖ· ἡ ΒΓ ἄρα τῆς Α μεῖζον δύναται τῇ ΔΖ. δεικτέον, ὅτι καὶ σύμμετρός ἐστιν ἡ ΒΓ τῇ ΔΖ. ἐπεὶ γὰρ σύμμετρός ἐστιν ἡ ΒΔ τῇ ΔΓ μήκει, σύμμετρος ἄρα ἐστὶ καὶ ἡ ΒΓ τῇ ΓΔ μήκει. ἀλλὰ ἡ ΓΔ ταῖς ΓΔ, ΒΖ ἐστι σύμμετρος μήκει· ἴση γάρ ἐστιν ἡ ΓΔ τῇ ΒΖ. καὶ ἡ ΒΓ ἄρα σύμμετρός ἐστι ταῖς ΒΖ, ΓΔ μήκει· ὥστε καὶ λοιπῇ τῇ ΖΔ σύμμετρός ἐστιν ἡ ΒΓ μήκει· ἡ ΒΓ ἄρα τῆς Α μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ.

Ἀλλὰ δὴ ἡ ΒΓ τῆς Α μεῖζον δυνάσθω τῷ ἀπὸ συμμέτρου ἑαυτῇ, τῷ δὲ τετάτρῳ τοῦ ἀπὸ τῆς Α ἴσον παρὰ τὴν ΒΓ παραβεβλήσθω ἐλλεῖπον εἴδει τετραγώνῳ, καὶ ἔστω τὸ ὑπὸ τῶν ΒΔ, ΔΓ. δεικτέον, ὅτι σύμμετρός ἐστιν ἡ ΒΔ τῇ ΔΓ μήκει.

Τῶν γὰρ αὐτῶν κατασκευασθέντων ὁμοίως δείξομεν, ὅτι ἡ ΒΓ τῆς Α μεῖζον δύναται τῷ ἀπὸ τῆς ΖΔ. δύναται δὲ ἡ

greater, and a (rectangle) equal to the fourth (part) of the (square) on the lesser, falling short by a square figure, is applied to the greater, then it divides it into (parts which are) commensurable in length.

Let A and BC be two unequal straight-lines, of which (let) BC (be) the greater. And let a (rectangle) equal to the fourth part of the (square) on the lesser, A—that is, (equal) to the (square) on half of A—falling short by a square figure, have been applied to BC. And let it be the (rectangle contained) by BD and DC [see previous lemma]. And let BD be commensurable in length with DC. I say that that the square on BC is greater than the (square on) A by (the square on some straight-line) commensurable (in length) with (BC).



For let BC have been cut in half at the point E [Prop. 1.10]. And let EF be made equal to DE [Prop. 1.3]. Thus, the remainder DC is equal to BF. And since the straight-line BC has been cut into equal (pieces) at E, and into unequal (pieces) at D, the rectangle contained by BD and DC, plus the square on ED, is thus equal to the square on EC [Prop. 2.5]. (The same) also (for) the quadruples. Thus, four times the (rectangle contained) by BD and DC, plus the quadruple of the (square) on DE, is equal to four times the square on EC. But, the square on A is equal to the quadruple of the (rectangle contained) by BD and DC, and the square on DF is equal to the quadruple of the (square) on DE. For DF is double DE. And the square on BC is equal to the quadruple of the (square) on EC. For, again, BC is double CE. Thus, the (sum of the) squares on A and DF is equal to the square on BC. Hence, the (square) on BC is greater than the (square) on A by the (square) on DF. Thus, BC is greater in square than A by DF. It must also be shown that BC is commensurable (in length) with DF. For since BD is commensurable in length with DC, BC is thus also commensurable in length with CD [Prop. 10.15]. But, CD is commensurable in length with CD plus BF. For CD is equal to BF [Prop. 10.6]. Thus, BC is also commensurable in length with BF plus CD [Prop. 10.12]. Hence, BC is also commensurable in length with the remainder FD [Prop. 10.15]. Thus, the square on BC is greater than (the square on) A by the (square) on (some straight-line) commensurable (in length) with (BC).

ΒΓ τῆς Α μεῖζον τῷ ἀπὸ συμμέτρου ἑαυτῇ. σύμμετρος ἄρα ἐστὶν ἡ ΒΓ τῇ ΖΔ μήκει· ὥστε καὶ λοιπῇ συναμφοτέρῳ τῇ ΒΖ, ΔΓ σύμμετρός ἐστιν ἡ ΒΓ μήκει. ἀλλὰ συναμφότερος ἡ ΒΖ, ΔΓ σύμμετρός ἐστι τῇ ΔΓ [μήκει]. ὥστε καὶ ἡ ΒΓ τῇ ΓΔ σύμμετρός ἐστι μήκει· καὶ διελόντι ἄρα ἡ ΒΔ τῇ ΔΓ ἐστι σύμμετρος μήκει.

Ἐὰν ἄρα ὦσι δύο εὐθεῖαι ἄνισοι, καὶ τὰ ἑξῆς.

And so let the square on BC be greater than the (square on) A by the (square) on (some straight-line) commensurable (in length) with (BC). And let a (rectangle) equal to the fourth (part) of the (square) on A, falling short by a square figure, have been applied to BC. And let it be the (rectangle contained) by BD and DC. It must be shown that BD is commensurable in length with DC.

For, similarly, by the same construction, we can show that the square on BC is greater than the (square on) A by the (square) on FD. And the square on BC is greater than the (square on) A by the (square) on (some straight-line) commensurable (in length) with (BC). Thus, BC is commensurable in length with FD. Hence, BC is also commensurable in length with the remaining sum of BF and DC [Prop. 10.15]. But, the sum of BF and DC is commensurable [in length] with DC [Prop. 10.6]. Hence, BC is also commensurable in length with CD [Prop. 10.12]. Thus, via separation, BD is also commensurable in length with DC [Prop. 10.15].

Thus, if there are two unequal straight-lines, and so on . . . .

† This proposition states that if $\alpha\, x - x^2 = \beta^2/4$ (where $\alpha = BC$, $x = DC$, and $\beta = A$) then α and $\sqrt{\alpha^2 - \beta^2}$ are commensurable when $\alpha - x$ are x are commensurable, and *vice versa*.

ιη´.

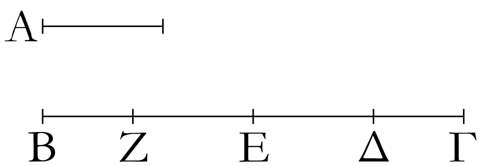
Ἐὰν ὦσι δύο εὐθεῖαι ἄνισοι, τῷ δὲ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ἐλάσσονος ἴσον παρὰ τὴν μείζονα παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ, καὶ εἰς ἀσύμμετρα αὐτὴν διαιρῇ [μήκει], ἡ μείζων τῆς ἐλάσσονος μεῖζον δυνήσεται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καὶ ἐὰν ἡ μείζων τῆς ἐλάσσονος μεῖζον δύνηται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, τῷ δὲ τετάρτῳ τοῦ ἀπὸ τῆς ἐλάσσονος ἴσον παρὰ τὴν μείζονα παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ, εἰς ἀσύμμετρα αὐτὴν διαιρεῖ [μήκει].

Ἔστωσαν δύο εὐθεῖαι ἄνισοι αἱ Α, ΒΓ, ὧν μείζων ἡ ΒΓ, τῷ δὲ τετάρτῳ [μέρει] τοῦ ἀπὸ τῆς ἐλάσσονος τῆς Α ἴσον παρὰ τὴν ΒΓ παραβεβλήσθω ἐλλεῖπον εἴδει τετραγώνῳ, καὶ ἔστω τὸ ὑπὸ τῶν ΒΔΓ, ἀσύμμετρος δὲ ἔστω ἡ ΒΔ τῇ ΔΓ μήκει· λέγω, ὅτι ἡ ΒΓ τῆς Α μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ.

Proposition 18†

If there are two unequal straight-lines, and a (rectangle) equal to the fourth part of the (square) on the lesser, falling short by a square figure, is applied to the greater, and divides it into (parts which are) incommensurable [in length], then the square on the greater will be larger than the (square on the) lesser by the (square) on (some straight-line) incommensurable (in length) with the greater. And if the square on the greater is larger than the (square on the) lesser by the (square) on (some straight-line) incommensurable (in length) with the greater, and a (rectangle) equal to the fourth (part) of the (square) on the lesser, falling short by a square figure, is applied to the greater, then it divides it into (parts which are) incommensurable [in length].

Let A and BC be two unequal straight-lines, of which (let) BC (be) the greater. And let a (rectangle) equal to the fourth [part] of the (square) on the lesser, A, falling short by a square figure, have been applied to BC. And let it be the (rectangle contained) by BDC. And let BD be incommensurable in length with DC. I say that that the square on BC is greater than the (square on) A by the (square) on (some straight-line) incommensurable (in length) with (BC).

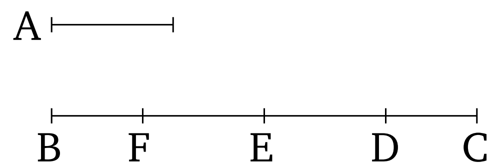


Τῶν γὰρ αὐτῶν κατασκευασθέντων τῷ πρότερον ὁμοίως δείξομεν, ὅτι ἡ ΒΓ τῆς Α μεῖζον δύναται τῷ ἀπὸ τῆς ΖΔ. δεικτέον [οὖν], ὅτι ἀσύμμετρός ἐστιν ἡ ΒΓ τῇ ΔΖ μήκει. ἐπεὶ γὰρ ἀσύμμετρός ἐστιν ἡ ΒΔ τῇ ΔΓ μήκει, ἀσύμμετρος ἄρα ἐστὶ καὶ ἡ ΒΓ τῇ ΓΔ μήκει. ἀλλὰ ἡ ΔΓ σύμμετρός ἐστι συναμφοτέραις ταῖς ΒΖ, ΔΓ· καὶ ἡ ΒΓ ἄρα ἀσύμμετρός ἐστι συναμφοτέραις ταῖς ΒΖ, ΔΓ. ὥστε καὶ λοιπῇ τῇ ΖΔ ἀσύμμετρός ἔστιν ἡ ΒΓ μήκει. καὶ ἡ ΒΓ τῆς Α μεῖζον δύναται τῷ ἀπὸ τῆς ΖΔ· ἡ ΒΓ ἄρα τῆς Α μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ.

Δυνάσθω δὴ πάλιν ἡ ΒΓ τῆς Α μεῖζον τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, τῷ δὲ τετάρτῳ τοῦ ἀπὸ τῆς Α ἴσον παρὰ τὴν ΒΓ παραβεβλήσθω ἐλλεῖπον εἴδει τετραγώνῳ, καὶ ἔστω τὸ ὑπὸ τῶν ΒΔ, ΔΓ. δεικτέον, ὅτι ἀσύμμετρός ἐστιν ἡ ΒΔ τῇ ΔΓ μήκει.

Τῶν γὰρ αὐτῶν κατασκευασθέντων ὁμοίως δείξομεν, ὅτι ἡ ΒΓ τῆς Α μεῖζον δύναται τῷ ἀπὸ τῆς ΖΔ. ἀλλὰ ἡ ΒΓ τῆς Α μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. ἀσύμμετρος ἄρα ἐστὶν ἡ ΒΓ τῇ ΖΔ μήκει· ὥστε καὶ λοιπῇ συναμφοτέρῳ τῇ ΒΖ, ΔΓ ἀσύμμετρός ἐστιν ἡ ΒΓ. ἀλλὰ συναμφότερος ἡ ΒΖ, ΔΓ τῇ ΔΓ σύμμετρός ἐστι μήκει· καὶ ἡ ΒΓ ἄρα τῇ ΔΓ ἀσύμμετρός ἐστι μήκει· ὥστε καὶ διελόντι ἡ ΒΔ τῇ ΔΓ ἀσύμμετρός ἐστι μήκει.

Ἐὰν ἄρα ὦσι δύο εὐθεῖαι, καὶ τὰ ἑξῆς.



For, similarly, by the same construction as before, we can show that the square on BC is greater than the (square on) A by the (square) on FD. [Therefore] it must be shown that BC is incommensurable in length with DF. For since BD is incommensurable in length with DC, BC is thus also incommensurable in length with CD [Prop. 10.16]. But, DC is commensurable (in length) with the sum of BF and DC [Prop. 10.6]. And, thus, BC is incommensurable (in length) with the sum of BF and DC [Prop. 10.13]. Hence, BC is also incommensurable in length with the remainder FD [Prop. 10.16]. And the square on BC is greater than the (square on) A by the (square) on FD. Thus, the square on BC is greater than the (square on) A by the (square) on (some straight-line) incommensurable (in length) with (BC).

So, again, let the square on BC be greater than the (square on) A by the (square) on (some straight-line) incommensurable (in length) with (BC). And let a (rectangle) equal to the fourth [part] of the (square) on A, falling short by a square figure, have been applied to BC. And let it be the (rectangle contained) by BD and DC. It must be shown that BD is incommensurable in length with DC.

For, similarly, by the same construction, we can show that the square on BC is greater than the (square) on A by the (square) on FD. But, the square on BC is greater than the (square) on A by the (square) on (some straight-line) incommensurable (in length) with (BC). Thus, BC is incommensurable in length with FD. Hence, BC is also incommensurable (in length) with the remaining sum of BF and DC [Prop. 10.16]. But, the sum of BF and DC is commensurable in length with DC [Prop. 10.6]. Thus, BC is also incommensurable in length with DC [Prop. 10.13]. Hence, via separation, BD is also incommensurable in length with DC [Prop. 10.16].

Thus, if there are two . . . straight-lines, and so on . . . .

† This proposition states that if $\alpha\,x - x^2 = \beta^2/4$ (where $\alpha = BC$, $x = DC$, and $\beta = A$) then α and $\sqrt{\alpha^2 - \beta^2}$ are incommensurable when $\alpha - x$ are x are incommensurable, and *vice versa*.

ιθ΄.

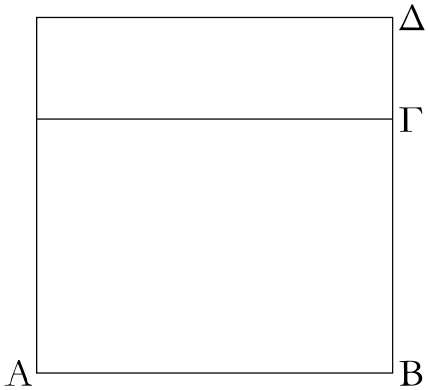
Τὸ ὑπὸ ῥητῶν μήκει συμμέτρων εὐθειῶν περιεχόμενον ὀρθογώνιον ῥητόν ἐστιν.

Ὑπὸ γὰρ ῥητῶν μήκει συμμέτρων εὐθειῶν τῶν ΑΒ, ΒΓ

Proposition 19

The rectangle contained by rational straight-lines (which are) commensurable in length is rational.

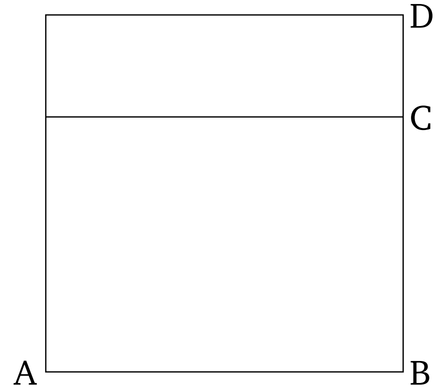
For let the rectangle AC have been enclosed by the ὀρθογώνιον περιεχέσθω τὸ ΑΓ· λέγω, ὅτι ῥητόν ἐστι τὸ ΑΓ.



Ἀναγεγράφθω γὰρ ἀπὸ τῆς ΑΒ τετράγωνον τὸ ΑΔ· ῥητὸν ἄρα ἐστὶ τὸ ΑΔ. καὶ ἐπεὶ σύμμετρός ἐστιν ἡ ΑΒ τῇ ΒΓ μήκει, ἴση δέ ἐστιν ἡ ΑΒ τῇ ΒΔ, σύμμετρος ἄρα ἐστὶν ἡ ΒΔ τῇ ΒΓ μήκει. καί ἐστιν ὡς ἡ ΒΔ πρὸς τὴν ΒΓ, οὕτως τὸ ΔΑ πρὸς τὸ ΑΓ. σύμμετρον ἄρα ἐστὶ τὸ ΔΑ τῷ ΑΓ. ῥητὸν δὲ τὸ ΔΑ· ῥητὸν ἄρα ἐστὶ καὶ τὸ ΑΓ.

Τὸ ἄρα ὑπὸ ῥητῶν μήκει συμμέτρων, καὶ τὰ ἑξῆς.

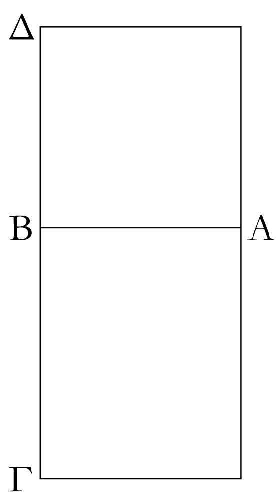
rational straight-lines AB and BC (which are) commensurable in length. I say that AC is rational.



For let the square AD have been described on AB. AD is thus rational [Def. 10.4]. And since AB is commensurable in length with BC, and AB is equal to BD, BD is thus commensurable in length with BC. And as BD is to BC, so DA (is) to AC [Prop. 6.1]. Thus, DA is commensurable with AC [Prop. 10.11]. And DA (is) rational. Thus, AC is also rational [Def. 10.4]. Thus, the ... by rational straight-lines ... commensurable, and so on ....

κ΄.

Ἐὰν ῥητὸν παρὰ ῥητὴν παραβληθῇ, πλάτος ποιεῖ ῥητὴν καὶ σύμμετρον τῇ, παρ᾽ ἣν παράκειται, μήκει.

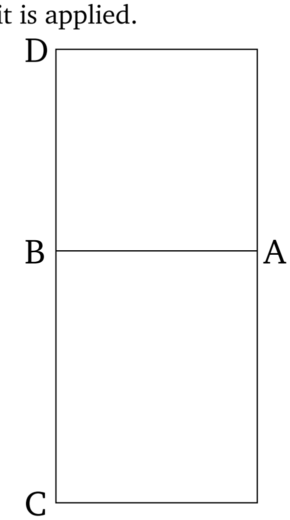


Ῥητὸν γὰρ τὸ ΑΓ παρὰ ῥητὴν τὴν ΑΒ παραβεβλήσθω πλάτος ποιοῦν τὴν ΒΓ· λέγω, ὅτι ῥητή ἐστιν ἡ ΒΓ καὶ σύμμετρος τῇ ΒΑ μήκει.

Ἀναγεγράφθω γὰρ ἀπὸ τῆς ΑΒ τετράγωνον τὸ ΑΔ· ῥητὸν ἄρα ἐστὶ τὸ ΑΔ. ῥητὸν δὲ καὶ τὸ ΑΓ· σύμμετρον ἄρα

Proposition 20

If a rational (area) is applied to a rational (straight-line) then it produces as breadth a (straight-line which is) rational, and commensurable in length with the (straight-line) to which it is applied.



For let the rational (area) AC have been applied to the rational (straight-line) AB, producing the (straight-line) BC as breadth. I say that BC is rational, and commensurable in length with BA.

For let the square AD have been described on AB.

ἐστὶ τὸ ΔΑ τῷ ΑΓ. καί ἐστιν ὡς τὸ ΔΑ πρὸς τὸ ΑΓ, οὕτως ἡ ΔΒ πρὸς τὴν ΒΓ. σύμμετρος ἄρα ἐστὶ καὶ ἡ ΔΒ τῇ ΒΓ· ἴση δὲ ἡ ΔΒ τῇ ΒΑ· σύμμετρος ἄρα καὶ ἡ ΑΒ τῇ ΒΓ. ῥητὴ δέ ἐστιν ἡ ΑΒ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΒΓ καὶ σύμμετρος τῇ ΑΒ μήκει.

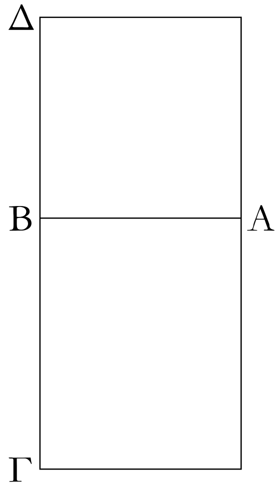
Ἐὰν ἄρα ῥητὸν παρὰ ῥητὴν παραβληθῇ, καὶ τὰ ἑξῆς.

AD is thus rational [Def. 10.4]. And AC (is) also rational. DA is thus commensurable with AC. And as DA is to AC, so DB (is) to BC [Prop. 6.1]. Thus, DB is also commensurable (in length) with BC [Prop. 10.11]. And DB (is) equal to BA. Thus, AB (is) also commensurable (in length) with BC. And AB is rational. Thus, BC is also rational, and commensurable in length with AB [Def. 10.3].

Thus, if a rational (area) is applied to a rational (straight-line), and so on ....

καʹ.

Τὸ ὑπὸ ῥητῶν δυνάμει μόνον συμμέτρων εὐθειῶν περιεχόμενον ὀρθογώνιον ἄλογόν ἐστιν, καὶ ἡ δυναμένη αὐτὸ ἄλογός ἐστιν, καλείσθω δὲ μέση.

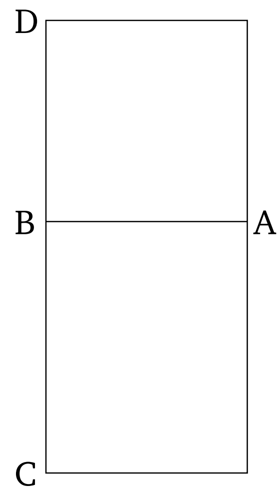


Ὑπὸ γὰρ ῥητῶν δυνάμει μόνον συμμέτρων εὐθειῶν τῶν ΑΒ, ΒΓ ὀρθογώνιον περιεχέσθω τὸ ΑΓ· λέγω, ὅτι ἄλογόν ἐστι τὸ ΑΓ, καὶ ἡ δυναμένη αὐτὸ ἄλογός ἐστιν, καλείσθω δὲ μέση.

Ἀναγεγράφθω γὰρ ἀπὸ τῆς ΑΒ τετράγωνον τὸ ΑΔ· ῥητὸν ἄρα ἐστὶ τὸ ΑΔ. καὶ ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΑΒ τῇ ΒΓ μήκει· δυνάμει γὰρ μόνον ὑπόκεινται σύμμετροι· ἴση δὲ ἡ ΑΒ τῇ ΒΔ, ἀσύμμετρος ἄρα ἐστὶ καὶ ἡ ΔΒ τῇ ΒΓ μήκει. καί ἐστιν ὡς ἡ ΔΒ πρὸς τὴν ΒΓ, οὕτως τὸ ΑΔ πρὸς τὸ ΑΓ· ἀσύμμετρον ἄρα [ἐστὶ] τὸ ΔΑ τῷ ΑΓ. ῥητὸν δὲ τὸ ΔΑ· ἄλογον ἄρα ἐστὶ τὸ ΑΓ· ὥστε καὶ ἡ δυναμένη τὸ ΑΓ [τουτέστιν ἡ ἴσον αὐτῷ τετράγωνον δυναμένη] ἄλογός ἐστιν, καλείσθω δε μέση· ὅπερ ἔδει δεῖξαι.

Proposition 21

The rectangle contained by rational straight-lines (which are) commensurable in square only is irrational, and its square-root is irrational—let it be called medial.[†]



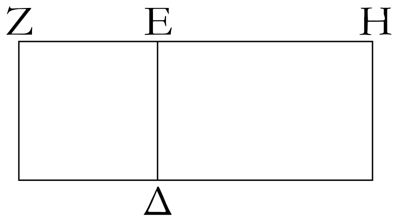
For let the rectangle AC be contained by the rational straight-lines AB and BC (which are) commensurable in square only. I say that AC is irrational, and its square-root is irrational—let it be called medial.

For let the square AD have been described on AB. AD is thus rational [Def. 10.4]. And since AB is incommensurable in length with BC. For they were assumed to be commensurable in square only. And AB (is) equal to BD. DB is thus also incommensurable in length with BC. And as DB is to BC, so AD (is) to AC [Prop. 6.1]. Thus, DA [is] incommensurable with AC [Prop. 10.11]. And DA (is) rational. Thus, AC is irrational [Def. 10.4]. Hence, its square-root [that is to say, the square-root of the square equal to it] is also irrational [Def. 10.4]—let it be called medial. (Which is) the very thing it was required to show.

[†] Thus, a medial straight-line has a length expressible as $k^{1/4}$.

Λῆμμα.

Ἐὰν ὦσι δύο εὐθεῖαι, ἔστιν ὡς ἡ πρώτη πρὸς τὴν δευτέραν, οὕτως τὸ ἀπὸ τῆς πρώτης πρὸς τὸ ὑπὸ τῶν δύο εὐθειῶν.

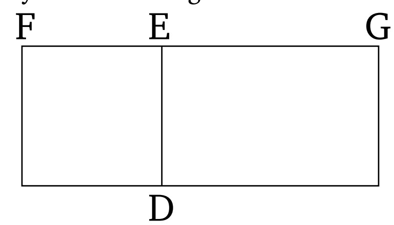


Ἔστωσαν δύο εὐθεῖαι αἱ ΖΕ, ΕΗ. λέγω, ὅτι ἐστὶν ὡς ἡ ΖΕ πρὸς τὴν ΕΗ, οὕτως τὸ ἀπὸ τῆς ΖΕ πρὸς τὸ ὑπὸ τῶν ΖΕ, ΕΗ.

Ἀναγεγράφθω γὰρ ἀπὸ τῆς ΖΕ τετράγωνον τὸ ΔΖ, καὶ συμπεπληρώσθω τὸ ΗΔ. ἐπεὶ οὖν ἐστιν ὡς ἡ ΖΕ πρὸς τὴν ΕΗ, οὕτως τὸ ΖΔ πρὸς τὸ ΔΗ, καί ἐστι τὸ μὲν ΖΔ τὸ ἀπὸ τῆς ΖΕ, τὸ δὲ ΔΗ τὸ ὑπὸ τῶν ΔΕ, ΕΗ, τουτέστι τὸ ὑπὸ τῶν ΖΕ, ΕΗ, ἔστιν ἄρα ὡς ἡ ΖΕ πρὸς τὴν ΕΗ, οὕτως τὸ ἀπὸ τῆς ΖΕ πρὸς τὸ ὑπὸ τῶν ΖΕ, ΕΗ. ὁμοίως δὲ καὶ ὡς τὸ ὑπὸ τῶν ΗΕ, ΕΖ πρὸς τὸ ἀπὸ τῆς ΕΖ, τουτέστιν ὡς τὸ ΗΔ πρὸς τὸ ΖΔ, οὕτως ἡ ΗΕ πρὸς τὴν ΕΖ· ὅπερ ἔδει δεῖξαι.

Lemma

If there are two straight-lines then as the first is to the second, so the (square) on the first (is) to the (rectangle contained) by the two straight-lines.

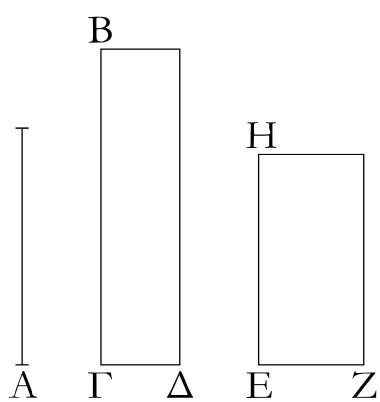


Let FE and EG be two straight-lines. I say that as FE is to EG, so the (square) on FE (is) to the (rectangle contained) by FE and EG.

For let the square DF have been described on FE. And let GD have been completed. Therefore, since as FE is to EG, so FD (is) to DG [Prop. 6.1], and FD is the (square) on FE, and DG the (rectangle contained) by DE and EG—that is to say, the (rectangle contained) by FE and EG—thus as FE is to EG, so the (square) on FE (is) to the (rectangle contained) by FE and EG. And also, similarly, as the (rectangle contained) by GE and EF is to the (square on) EF—that is to say, as GD (is) to FD—so GE (is) to EF. (Which is) the very thing it was required to show.

κβ´.

Τὸ ἀπὸ μέσης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ῥητὴν καὶ ἀσύμμετρον τῇ, παρ᾽ ἣν παράκειται, μήκει.

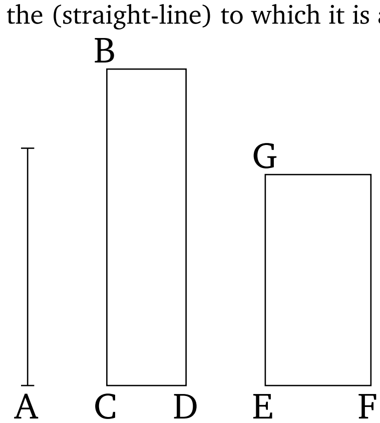


Ἔστω μέση μὲν ἡ Α, ῥητὴ δὲ ἡ ΓΒ, καὶ τῷ ἀπὸ τῆς Α ἴσον παρὰ τὴν ΒΓ παραβεβλήσθω χωρίον ὀρθογώνιον τὸ ΒΔ πλάτος ποιοῦν τὴν ΓΔ· λέγω, ὅτι ῥητή ἐστιν ἡ ΓΔ καὶ ἀσύμμετρος τῇ ΓΒ μήκει.

Ἐπεὶ γὰρ μέση ἐστὶν ἡ Α, δύναται χωρίον περιεχόμενον ὑπὸ ῥητῶν δυνάμει μόνον συμμέτρων. δυνάσθω τὸ ΗΖ.

Proposition 22

The square on a medial (straight-line), being applied to a rational (straight-line), produces as breadth a (straight-line which is) rational, and incommensurable in length with the (straight-line) to which it is applied.



Let A be a medial (straight-line), and CB a rational (straight-line), and let the rectangular area BD, equal to the (square) on A, have been applied to BC, producing CD as breadth. I say that CD is rational, and incommensurable in length with CB.

For since A is medial, the square on it is equal to a δύναται δὲ καὶ τὸ ΒΔ· ἴσον ἄρα ἐστὶ τὸ ΒΔ τῷ ΗΖ. ἔστι δὲ αὐτῷ καὶ ἰσογώνιον· τῶν δὲ ἴσων τε καὶ ἰσογωνίων παραλληλογράμμων ἀντιπεπόνθασιν αἱ πλευραὶ αἱ περὶ τὰς ἴσας γωνίας· ἀνάλογον ἄρα ἐστὶν ὡς ἡ ΒΓ πρὸς τὴν ΕΗ, οὕτως ἡ ΕΖ πρὸς τὴν ΓΔ. ἔστιν ἄρα καὶ ὡς τὸ ἀπὸ τῆς ΒΓ πρὸς τὸ ἀπὸ τῆς ΕΗ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς ΓΔ. σύμμετρον δέ ἐστι τὸ ἀπὸ τῆς ΓΒ τῷ ἀπὸ τῆς ΕΗ· ῥητὴ γάρ ἐστιν ἑκατέρα αὐτῶν· σύμμετρον ἄρα ἐστὶ καὶ τὸ ἀπὸ τῆς ΕΖ τῷ ἀπὸ τῆς ΓΔ. ῥητὸν δέ ἐστι τὸ ἀπὸ τῆς ΕΖ· ῥητὸν ἄρα ἐστὶ καὶ τὸ ἀπὸ τῆς ΓΔ· ῥητὴ ἄρα ἐστὶν ἡ ΓΔ. καὶ ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΕΖ τῇ ΕΗ μήκει· δυνάμει γὰρ μόνον εἰσὶ σύμμετροι· ὡς δὲ ἡ ΕΖ πρὸς τὴν ΕΗ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ὑπὸ τῶν ΖΕ, ΕΗ, ἀσύμμετρον ἄρα [ἐστὶ] τὸ ἀπὸ τῆς ΕΖ τῷ ὑπὸ τῶν ΖΕ, ΕΗ. ἀλλὰ τῷ μὲν ἀπὸ τῆς ΕΖ σύμμετρόν ἐστι τὸ ἀπὸ τῆς ΓΔ· ῥηταὶ γάρ εἰσι δυνάμει· τῷ δὲ ὑπὸ τῶν ΖΕ, ΕΗ σύμμετρόν ἐστι τὸ ὑπὸ τῶν ΔΓ, ΓΒ· ἴσα γάρ ἐστι τῷ ἀπὸ τῆς Α· ἀσύμμετρον ἄρα ἐστὶ καὶ τὸ ἀπὸ τῆς ΓΔ τῷ ὑπὸ τῶν ΔΓ, ΓΒ. ὡς δὲ τὸ ἀπὸ τῆς ΓΔ πρὸς τὸ ὑπὸ τῶν ΔΓ, ΓΒ, οὕτως ἐστὶν ἡ ΔΓ πρὸς τὴν ΓΒ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΔΓ τῇ ΓΒ μήκει. ῥητὴ ἄρα ἐστὶν ἡ ΓΔ καὶ ἀσύμμετρος τῇ ΓΒ μήκει· ὅπερ ἔδει δεῖξαι.

(rectangular) area contained by rational (straight-lines which are) commensurable in square only [Prop. 10.21]. Let the square on (A) be equal to GF. And the square on (A) is also equal to BD. Thus, BD is equal to GF. And (BD) is also equiangular with (GF). And for equal and equiangular parallelograms, the sides about the equal angles are reciprocally proportional [Prop. 6.14]. Thus, proportionally, as BC is to EG, so EF (is) to CD. And, also, as the (square) on BC is to the (square) on EG, so the (square) on EF (is) to the (square) on CD [Prop. 6.22]. And the (square) on CB is commensurable with the (square) on EG. For they are each rational. Thus, the (square) on EF is also commensurable with the (square) on CD [Prop. 10.11]. And the (square) on EF is rational. Thus, the (square) on CD is also rational [Def. 10.4]. Thus, CD is rational. And since EF is incommensurable in length with EG. For they are commensurable in square only. And as EF (is) to EG, so the (square) on EF (is) to the (rectangle contained) by FE and EG [see previous lemma]. The (square) on EF [is] thus incommensurable with the (rectangle contained) by FE and EG [Prop. 10.11]. But, the (square) on CD is commensurable with the (square) on EF. For they are rational in square. And the (rectangle contained) by DC and CB is commensurable with the (rectangle contained) by FE and EG. For they are (both) equal to the (square) on A. Thus, the (square) on CD is also incommensurable with the (rectangle contained) by DC and CB [Prop. 10.13]. And as the (square) on CD (is) to the (rectangle contained) by DC and CB, so DC is to CB [see previous lemma]. Thus, DC is incommensurable in length with CB [Prop. 10.11]. Thus, CD is rational, and incommensurable in length with CB. (Which is) the very thing it was required to show.

† Literally, "rational".

κγ΄.

Ἡ τῇ μέσῃ σύμμετρος μέση ἐστίν.

Ἔστω μέση ἡ Α, καὶ τῇ Α σύμμετρος ἔστω ἡ Β· λέγω, ὅτι καὶ ἡ Β μέση ἐστίν.

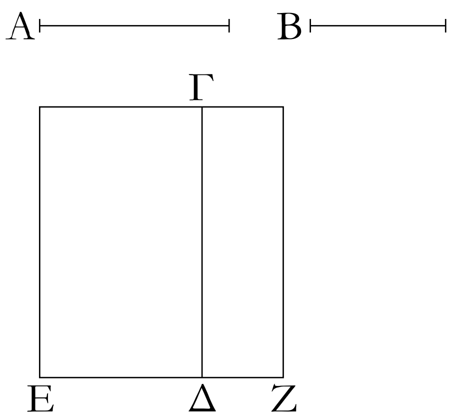
Ἐκκείσθω γὰρ ῥητὴ ἡ ΓΔ, καὶ τῷ μὲν ἀπὸ τῆς Α ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω χωρίον ὀρθογώνιον τὸ ΓΕ πλάτος ποιοῦν τὴν ΕΔ· ῥητὴ ἄρα ἐστὶν ἡ ΕΔ καὶ ἀσύμμετρος τῇ ΓΔ μήκει. τῷ δὲ ἀπὸ τῆς Β ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω χωρίον ὀρθογώνιον τὸ ΓΖ πλάτος ποιοῦν τὴν ΔΖ. ἐπεὶ οὖν σύμμετρός ἐστιν ἡ Α τῇ Β, σύμμετρόν ἐστι καὶ τὸ ἀπὸ τῆς Α τῷ ἀπὸ τῆς Β. ἀλλὰ τῷ μὲν ἀπὸ τῆς Α ἴσον ἐστὶ τὸ ΕΓ, τῷ δὲ ἀπὸ τῆς Β ἴσον ἐστὶ τὸ ΓΖ· σύμμετρον ἄρα ἐστὶ τὸ ΕΓ τῷ ΓΖ. καί ἐστιν ὡς τὸ ΕΓ πρὸς τὸ ΓΖ, οὕτως ἡ ΕΔ πρὸς τὴν ΔΖ·

Proposition 23

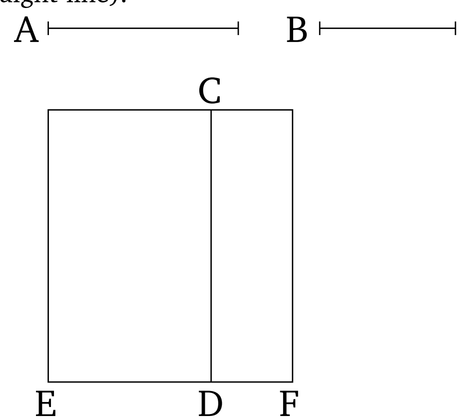
A (straight-line) commensurable with a medial (straight-line) is medial.

Let A be a medial (straight-line), and let B be commensurable with A. I say that B is also a medial (staight-line).

Let the rational (straight-line) CD be set out, and let the rectangular area CE, equal to the (square) on A, have been applied to CD, producing ED as width. ED is thus rational, and incommensurable in length with CD [Prop. 10.22]. And let the rectangular area CF, equal to the (square) on B, have been applied to CD, producing DF as width. Therefore, since A is commensurable with B, the (square) on A is also commensurable with σύμμετρος ἄρα ἐστὶν ἡ ΕΔ τῇ ΔΖ μήκει. ῥητὴ δέ ἐστιν ἡ ΕΔ καὶ ἀσύμμετρος τῇ ΔΓ μήκει· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΔΖ καὶ ἀσύμμετρος τῇ ΔΓ μήκει· αἱ ΓΔ, ΔΖ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. ἡ δὲ τὸ ὑπὸ ῥητῶν δυνάμει μόνον συμμέτρων δυναμένη μέση ἐστίν. ἡ ἄρα τὸ ὑπὸ τῶν ΓΔ, ΔΖ δυναμένη μέση ἐστίν· καὶ δύναται τὸ ὑπὸ τῶν ΓΔ, ΔΖ ἡ Β· μέση ἄρα ἐστὶν ἡ Β.



the (square) on B. But, EC is equal to the (square) on A, and CF is equal to the (square) on B. Thus, EC is commensurable with CF. And as EC is to CF, so ED (is) to DF [Prop. 6.1]. Thus, ED is commensurable in length with DF [Prop. 10.11]. And ED is rational, and incommensurable in length with CD. DF is thus also rational [Def. 10.3], and incommensurable in length with DC [Prop. 10.13]. Thus, CD and DF are rational, and commensurable in square only. And the square-root of a (rectangle contained) by rational (straight-lines which are) commensurable in square only is medial [Prop. 10.21]. Thus, the square-root of the (rectangle contained) by CD and DF is medial. And the square on B is equal to the (rectangle contained) by CD and DF. Thus, B is a medial (straight-line).



Πόρισμα.

Ἐκ δὴ τούτου φανερόν, ὅτι τὸ τῷ μέσῳ χωρίῳ σύμμετρον μέσον ἐστίν.

Corollary

And (it is) clear, from this, that an (area) commensurable with a medial area† is medial.

† A medial area is equal to the square on some medial straight-line. Hence, a medial area is expressible as $k^{1/2}$.

κδ´.

Τὸ ὑπὸ μέσων μήκει συμμέτρων εὐθειῶν περιεχόμενον ὀρθογώνιον μέσον ἐστίν.

Ὑπὸ γὰρ μέσων μήκει συμμέτρων εὐθειῶν τῶν ΑΒ, ΒΓ περιεχέσθω ὀρθογώνιον τὸ ΑΓ· λέγω, ὅτι τὸ ΑΓ μέσον ἐστίν.

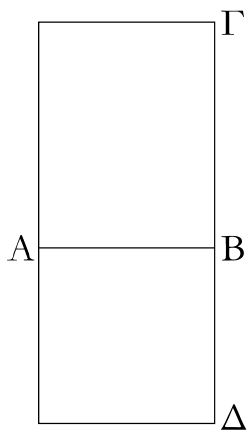
Ἀναγεγράφθω γὰρ ἀπὸ τῆς ΑΒ τετράγωνον τὸ ΑΔ· μέσον ἄρα ἐστὶ τὸ ΑΔ. καὶ ἐπεὶ σύμμετρός ἐστιν ἡ ΑΒ τῇ ΒΓ μήκει, ἴση δὲ ἡ ΑΒ τῇ ΒΔ, σύμμετρος ἄρα ἐστὶ καὶ ἡ ΔΒ τῇ ΒΓ μήκει· ὥστε καὶ τὸ ΔΑ τῷ ΑΓ σύμμετρόν ἐστιν. μέσον δὲ τὸ ΔΑ· μέσον ἄρα καὶ τὸ ΑΓ· ὅπερ ἔδει δεῖξαι.

Proposition 24

A rectangle contained by medial straight-lines (which are) commensurable in length is medial.

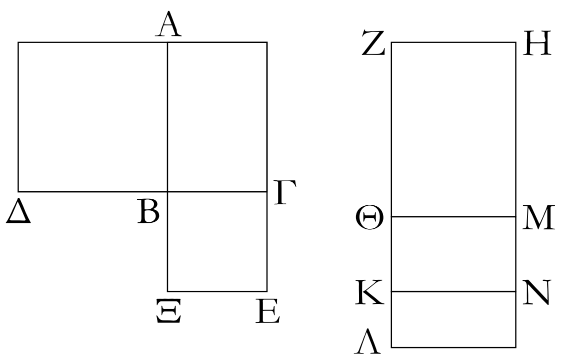
For let the rectangle AC be contained by the medial straight-lines AB and BC (which are) commensurable in length. I say that AC is medial.

For let the square AD have been described on AB. AD is thus medial [see previous footnote]. And since AB is commensurable in length with BC, and AB (is) equal to BD, DB is thus also commensurable in length with BC. Hence, DA is also commensurable with AC [Props. 6.1, 10.11]. And DA (is) medial. Thus, AC (is) also medial [Prop. 10.23 corr.]. (Which is) the very thing it was required to show.



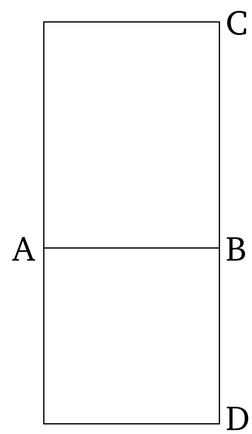
κε΄.

Τὸ ὑπὸ μέσων δυνάμει μόνον συμμέτρων εὐθειῶν περιεχόμενον ὀρθογώνιον ἤτοι ῥητὸν ἢ μέσον ἐστίν.



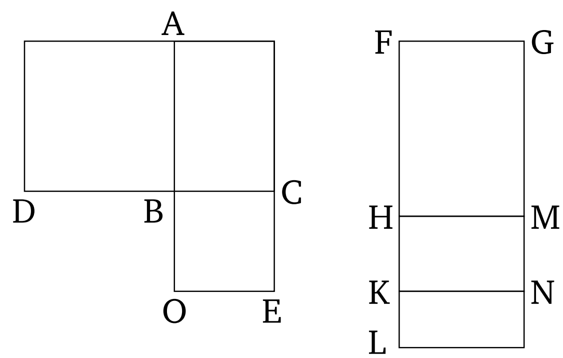
Ὑπὸ γὰρ μέσων δυνάμει μόνον συμμέτρων εὐθειῶν τῶν ΑΒ, ΒΓ ὀρθογώνιον περιεχέσθω τὸ ΑΓ· λέγω, ὅτι τὸ ΑΓ ἤτοι ῥητὸν ἢ μέσον ἐστίν.

Ἀναγεγράφθω γὰρ ἀπὸ τῶν ΑΒ, ΒΓ τετράγωνα τὰ ΑΔ, ΒΕ· μέσον ἄρα ἐστὶν ἑκάτερον τῶν ΑΔ, ΒΕ. καὶ ἐκκείσθω ῥητὴ ἡ ΖΗ, καὶ τῷ μὲν ΑΔ ἴσον παρὰ τὴν ΖΗ παραβεβλήσθω ὀρθογώνιον παραλληλόγραμμον τὸ ΗΘ πλάτος ποιοῦν τὴν ΖΘ, τῷ δὲ ΑΓ ἴσον παρὰ τὴν ΘΜ παραβεβλήσθω ὀρθογώνιον παραλληλόγραμμον τὸ ΜΚ πλάτος ποιοῦν τὴν ΘΚ, καὶ ἔτι τῷ ΒΕ ἴσον ὁμοίως παρὰ τὴν ΚΝ παραβεβλήσθω τὸ ΝΛ πλάτος ποιοῦν τὴν ΚΛ· ἐπ᾽ εὐθείας ἄρα εἰσὶν αἱ ΖΘ, ΘΚ, ΚΛ. ἐπεὶ οὖν μέσον ἐστὶν ἑκάτερον τῶν ΑΔ, ΒΕ, καί ἐστιν ἴσον τὸ μὲν ΑΔ τῷ ΗΘ, τὸ δὲ ΒΕ τῷ ΝΛ, μέσον ἄρα καὶ ἑκάτερον τῶν ΗΘ, ΝΛ. καὶ παρὰ ῥητὴν τὴν ΖΗ παράκειται· ῥητὴ ἄρα ἐστὶν ἑκατέρα τῶν ΖΘ, ΚΛ καὶ ἀσύμμετρος τῇ ΖΗ μήκει. καὶ ἐπεὶ σύμμετρόν ἐστι τὸ ΑΔ τῷ ΒΕ, σύμμετρον ἄρα ἐστὶ καὶ τὸ ΗΘ τῷ ΝΛ. καί ἐστιν ὡς τὸ ΗΘ πρὸς τὸ ΝΛ, οὕτως ἡ ΖΘ πρὸς τὴν ΚΛ· σύμμετρος ἄρα ἐστὶν ἡ ΖΘ τῇ ΚΛ μήκει. αἱ ΖΘ, ΚΛ ἄρα ῥηταί εἰσι μήκει σύμμετροι· ῥητὸν ἄρα ἐστὶ τὸ ὑπὸ τῶν ΖΘ, ΚΛ. καὶ



Proposition 25

The rectangle contained by medial straight-lines (which are) commensurable in square only is either rational or medial.



For let the rectangle AC be contained by the medial straight-lines AB and BC (which are) commensurable in square only. I say that AC is either rational or medial.

For let the squares AD and BE have been described on (the straight-lines) AB and BC (respectively). AD and BE are thus each medial. And let the rational (straight-line) FG be laid out. And let the rectangular parallelogram GH, equal to AD, have been applied to FG, producing FH as breadth. And let the rectangular parallelogram MK, equal to AC, have been applied to HM, producing HK as breadth. And, finally, let NL, equal to BE, have similarly been applied to KN, producing KL as breadth. Thus, FH, HK, and KL are in a straight-line. Therefore, since AD and BE are each medial, and AD is equal to GH, and BE to NL, GH and NL (are) thus each also medial. And they are applied to the rational (straight-line) FG. FH and KL are thus each rational, and incommensurable in length with FG [Prop. 10.22]. And since AD is commensurable with BE, GH is thus also commensurable with NL. And as ἐπεὶ ἴση ἐστὶν ἡ μὲν ΔΒ τῇ ΒΑ, ἡ δὲ ΞΒ τῇ ΒΓ, ἔστιν ἄρα ὡς ἡ ΔΒ πρὸς τὴν ΒΓ, οὕτως ἡ ΑΒ πρὸς τὴν ΒΞ. ἀλλ᾽ ὡς μὲν ἡ ΔΒ πρὸς τὴν ΒΓ, οὕτως τὸ ΔΑ πρὸς τὸ ΑΓ· ὡς δὲ ἡ ΑΒ πρὸς τὴν ΒΞ, οὕτως τὸ ΑΓ πρὸς τὸ ΓΞ· ἔστιν ἄρα ὡς τὸ ΔΑ πρὸς τὸ ΑΓ, οὕτως τὸ ΑΓ πρὸς τὸ ΓΞ. ἴσον δέ ἐστι τὸ μὲν ΑΔ τῷ ΗΘ, τὸ δὲ ΑΓ τῷ ΜΚ, τὸ δὲ ΓΞ τῷ ΝΛ· ἔστιν ἄρα ὡς τὸ ΗΘ πρὸς τὸ ΜΚ, οὕτως τὸ ΜΚ πρὸς τὸ ΝΛ· ἔστιν ἄρα καὶ ὡς ἡ ΖΘ πρὸς τὴν ΘΚ, οὕτως ἡ ΘΚ πρὸς τὴν ΚΛ· τὸ ἄρα ὑπὸ τῶν ΖΘ, ΚΛ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΘΚ. ῥητὸν δὲ τὸ ὑπὸ τῶν ΖΘ, ΚΛ· ῥητὸν ἄρα ἐστὶ καὶ τὸ ἀπὸ τῆς ΘΚ· ῥητὴ ἄρα ἐστὶν ἡ ΘΚ. καὶ εἰ μὲν σύμμετρός ἐστι τῇ ΖΗ μήκει, ῥητόν ἐστι τὸ ΘΝ· εἰ δὲ ἀσύμμετρός ἐστι τῇ ΖΗ μήκει, αἱ ΚΘ, ΘΜ ῥηταί εἰσι δυνάμει μόνον σύμμετροι· μέσον ἄρα τὸ ΘΝ. τὸ ΘΝ ἄρα ἤτοι ῥητὸν ἢ μέσον ἐστίν. ἴσον δὲ τὸ ΘΝ τῷ ΑΓ· τὸ ΑΓ ἄρα ἤτοι ῥητὸν ἢ μέσον ἐστίν.

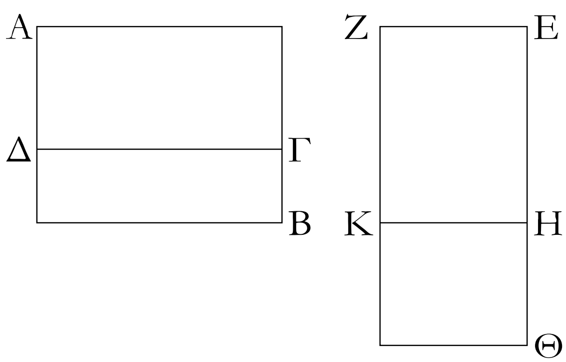
Τὸ ἄρα ὑπὸ μέσων δυνάμει μόνον συμμέτρων, καὶ τὰ εξῆς.

GH is to NL, so FH (is) to KL [Prop. 6.1]. Thus, FH is commensurable in length with KL [Prop. 10.11]. Thus, FH and KL are rational (straight-lines which are) commensurable in length. Thus, the (rectangle contained) by FH and KL is rational [Prop. 10.19]. And since DB is equal to BA, and OB to BC, thus as DB is to BC, so AB (is) to BO. But, as DB (is) to BC, so DA (is) to AC [Props. 6.1]. And as AB (is) to BO, so AC (is) to CO [Prop. 6.1]. Thus, as DA is to AC, so AC (is) to CO. And AD is equal to GH, and AC to MK, and CO to NL. Thus, as GH is to MK, so MK (is) to NL. Thus, also, as FH is to HK, so HK (is) to KL [Props. 6.1, 5.11]. Thus, the (rectangle contained) by FH and KL is equal to the (square) on HK [Prop. 6.17]. And the (rectangle contained) by FH and KL (is) rational. Thus, the (square) on HK is also rational. Thus, HK is rational. And if it is commensurable in length with FG then HN is rational [Prop. 10.19]. And if it is incommensurable in length with FG then KH and HM are rational (straight-lines which are) commensurable in square only: thus, HN is medial [Prop. 10.21]. Thus, HN is either rational or medial. And HN (is) equal to AC. Thus, AC is either rational or medial.

Thus, the . . . by medial straight-lines (which are) commensurable in square only, and so on . . . .

κϛ΄.

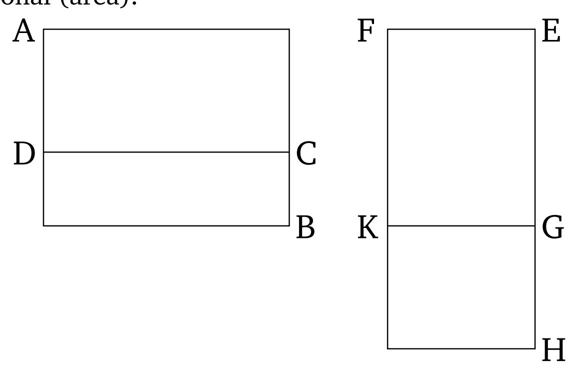
Μέσον μέσου οὐχ ὑπερέχει ῥητῷ.



Εἰ γὰρ δυνατόν, μέσον τὸ ΑΒ μέσου τοῦ ΑΓ ὑπερεχέτω ῥητῷ τῷ ΔΒ, καὶ ἐκκείσθω ῥητὴ ἡ ΕΖ, καὶ τῷ ΑΒ ἴσον παρὰ τὴν ΕΖ παραβεβλήσθω παραλληλόγραμμον ὀρθογώνιον τὸ ΖΘ πλάτος ποιοῦν τὴν ΕΘ, τῷ δὲ ΑΓ ἴσον ἀφῃρήσθω τὸ ΖΗ· λοιπὸν ἄρα τὸ ΒΔ λοιπῷ τῷ ΚΘ ἐστιν ἴσον. ῥητὸν δέ ἐστι τὸ ΔΒ· ῥητὸν ἄρα ἐστὶ καὶ τὸ ΚΘ. ἐπεὶ οὖν μέσον ἐστὶν ἑκάτερον τῶν ΑΒ, ΑΓ, καί ἐστι τὸ μὲν ΑΒ τῷ ΖΘ ἴσον, τὸ δὲ ΑΓ τῷ ΖΗ, μέσον ἄρα καὶ ἑκάτερον τῶν ΖΘ, ΖΗ. καὶ παρὰ ῥητὴν τὴν ΕΖ παράκειται· ῥητὴ ἄρα ἐστὶν ἑκατέρα τῶν ΘΕ, ΕΗ καὶ ἀσύμμετρος τῇ ΕΖ μήκει. καὶ ἐπεὶ ῥητόν ἐστι

Proposition 26

A medial (area) does not exceed a medial (area) by a rational (area).†



For, if possible, let the medial (area) AB exceed the medial (area) AC by the rational (area) DB. And let the rational (straight-line) EF be laid down. And let the rectangular parallelogram FH, equal to AB, have been applied to to EF, producing EH as breadth. And let FG, equal to AC, have been cut off (from FH). Thus, the remainder BD is equal to the remainder KH. And DB is rational. Thus, KH is also rational. Therefore, since AB and AC are each medial, and AB is equal to FH, and AC to FG, FH and FG are thus each also medial.

τὸ ΔΒ καί ἐστιν ἴσον τῷ ΚΘ, ῥητὸν ἄρα ἐστὶ καὶ τὸ ΚΘ. καὶ παρὰ ῥητὴν τὴν ΕΖ παράκειται· ῥητὴ ἄρα ἐστὶν ἡ ΗΘ καὶ σύμμετρος τῇ ΕΖ μήκει. ἀλλά καὶ ἡ ΕΗ ῥητή ἐστι καὶ ἀσύμμετρος τῇ ΕΖ μήκει· ἀσύμμετρος ἄρα ἐστὶν ἡ ΕΗ τῇ ΗΘ μήκει. καί ἐστιν ὡς ἡ ΕΗ πρὸς τὴν ΗΘ, οὕτως τὸ ἀπὸ τῆς ΕΗ πρὸς τὸ ὑπὸ τῶν ΕΗ, ΗΘ· ἀσύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΕΗ τῷ ὑπὸ τῶν ΕΗ, ΗΘ. ἀλλὰ τῷ μὲν ἀπὸ τῆς ΕΗ σύμμετρά ἐστι τὰ ἀπὸ τῶν ΕΗ, ΗΘ τετράγωνα· ῥητὰ γὰρ ἀμφότερα· τῷ δὲ ὑπὸ τῶν ΕΗ, ΗΘ σύμμετρόν ἐστι τὸ δὶς ὑπὸ τῶν ΕΗ, ΗΘ· διπλάσιον γάρ ἐστιν αὐτοῦ· ἀσύμμετρα ἄρα ἐστὶ τὰ ἀπὸ τῶν ΕΗ, ΗΘ τῷ δὶς ὑπὸ τῶν ΕΗ, ΗΘ· καὶ συναμφότερα ἄρα τά τε ἀπὸ τῶν ΕΗ, ΗΘ καὶ τὸ δὶς ὑπὸ τῶν ΕΗ, ΗΘ, ὅπερ ἐστὶ τὸ ἀπὸ τῆς ΕΘ, ἀσύμμετρόν ἐστι τοῖς ἀπὸ τῶν ΕΗ, ΗΘ. ῥητὰ δὲ τὰ ἀπὸ τῶν ΕΗ, ΗΘ· ἄλογον ἄρα τὸ ἀπὸ τῆς ΕΘ. ἄλογος ἄρα ἐστὶν ἡ ΕΘ. ἀλλὰ καὶ ῥηρή· ὅπερ ἐστὶν ἀδύνατον.

Μέσον ἄρα μέσου οὐχ ὑπερέχει ῥητῷ· ὅπερ ἔδει δεῖξαι.

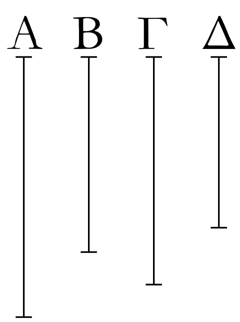
And they are applied to the rational (straight-line) EF. Thus, HE and EG are each rational, and incommensurable in length with EF [Prop. 10.22]. And since DB is rational, and is equal to KH, KH is thus also rational. And (KH) is applied to the rational (straight-line) EF. GH is thus rational, and commensurable in length with EF [Prop. 10.20]. But, EG is also rational, and incommensurable in length with EF. Thus, EG is incommensurable in length with GH [Prop. 10.13]. And as EG is to GH, so the (square) on EG (is) to the (rectangle contained) by EG and GH [Prop. 10.13 lem.]. Thus, the (square) on EG is incommensurable with the (rectangle contained) by EG and GH [Prop. 10.11]. But, the (sum of the) squares on EG and GH is commensurable with the (square) on EG. For (EG and GH are) both rational. And twice the (rectangle contained) by EG and GH is commensurable with the (rectangle contained) by EG and GH [Prop. 10.6]. For (the former) is double the latter. Thus, the (sum of the squares) on EG and GH is incommensurable with twice the (rectangle contained) by EG and GH [Prop. 10.13]. And thus the sum of the (squares) on EG and GH plus twice the (rectangle contained) by EG and GH, that is the (square) on EH [Prop. 2.4], is incommensurable with the (sum of the squares) on EG and GH [Prop. 10.16]. And the (sum of the squares) on EG and GH (is) rational. Thus, the (square) on EH is irrational [Def. 10.4]. Thus, EH is irrational [Def. 10.4]. But, (it is) also rational. The very thing is impossible.

Thus, a medial (area) does not exceed a medial (area) by a rational (area). (Which is) the very thing it was required to show.

† In other words, $\sqrt{k} - \sqrt{k'} \neq k''$.

κζ´.

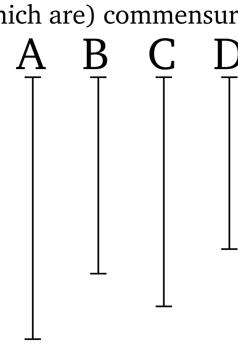
Μέσας εὑρεῖν δυνάμει μόνον συμμέτρους ῥητὸν περιεχούσας.



Ἐκκείσθωσαν δύο ῥηταὶ δυνάμει μόνον σύμμετροι αἱ Α, Β, καὶ εἰλήφθω τῶν Α, Β μέση ἀνάλογον ἡ Γ, καὶ γεγονέτω ὡς ἡ Α πρὸς τὴν Β, οὕτως ἡ Γ πρὸς τὴν Δ.

Proposition 27

To find (two) medial (straight-lines), containing a rational (area), (which are) commensurable in square only.



Let the two rational (straight-lines) A and B, (which are) commensurable in square only, be laid down. And let C—the mean proportional (straight-line) to A and B—

Καὶ ἐπεὶ αἱ Α, Β ῥηταί εἰσι δυνάμει μόνον σύμμετροι, τὸ ἄρα ὑπὸ τῶν Α, Β, τουτέστι τὸ ἀπὸ τῆς Γ, μέσον ἐστίν. μέση ἄρα ἡ Γ. καὶ ἐπεί ἐστιν ὡς ἡ Α πρὸς τὴν Β, [οὕτως] ἡ Γ πρὸς τὴν Δ, αἱ δὲ Α, Β δυνάμει μόνον [εἰσὶ] σύμμετροι, καὶ αἱ Γ, Δ ἄρα δυνάμει μόνον εἰσὶ σύμμετροι. καί ἐστι μέση ἡ Γ· μέση ἄρα καὶ ἡ Δ. αἱ Γ, Δ ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι. λέγω, ὅτι καὶ ῥητὸν περιέχουσιν. ἐπεὶ γάρ ἐστιν ὡς ἡ Α πρὸς τὴν Β, οὕτως ἡ Γ πρὸς τὴν Δ, ἐναλλὰξ ἄρα ἐστὶν ὡς ἡ Α πρὸς τὴν Γ, ἡ Β πρὸς τὴν Δ. ἀλλ᾽ ὡς ἡ Α πρὸς τὴν Γ, ἡ Γ πρὸς τὴν Β· καὶ ὡς ἄρα ἡ Γ πρὸς τὴν Β, οὕτως ἡ Β πρὸς τὴν Δ· τὸ ἄρα ὑπὸ τῶν Γ, Δ ἴσον ἐστὶ τῷ ἀπὸ τῆς Β. ῥητὸν δὲ τὸ ἀπὸ τῆς Β· ῥητὸν ἄρα [ἐστὶ] καὶ τὸ ὑπὸ τῶν Γ, Δ.

Εὕρηνται ἄρα μέσαι δυνάμει μόνον σύμμετροι ῥητὸν περιέχουσαι· ὅπερ ἔδει δεῖξαι.

have been taken [Prop. 6.13]. And let it be contrived that as A (is) to B, so C (is) to D [Prop. 6.12].

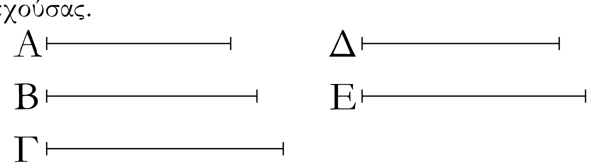
And since the rational (straight-lines) A and B are commensurable in square only, the (rectangle contained) by A and B—that is to say, the (square) on C [Prop. 6.17]—is thus medial [Prop 10.21]. Thus, C is medial [Prop. 10.21]. And since as A is to B, [so] C (is) to D, and A and B [are] commensurable in square only, C and D are thus also commensurable in square only [Prop. 10.11]. And C is medial. Thus, D is also medial [Prop. 10.23]. Thus, C and D are medial (straight-lines which are) commensurable in square only. I say that they also contain a rational (area). For since as A is to B, so C (is) to D, thus, alternately, as A is to C, so B (is) to D [Prop. 5.16]. But, as A (is) to C, (so) C (is) to B. And thus as C (is) to B, so B (is) to D [Prop. 5.11]. Thus, the (rectangle contained) by C and D is equal to the (square) on B [Prop. 6.17]. And the (square) on B (is) rational. Thus, the (rectangle contained) by C and D [is] also rational.

Thus, (two) medial (straight-lines, C and D), containing a rational (area), (which are) commensurable in square only, have been found.† (Which is) the very thing it was required to show.

† C and D have lengths $k^{1/4}$ and $k^{3/4}$ times that of A, respectively, where the length of B is $k^{1/2}$ times that of A.

κηʹ.

Μέσας εὑρεῖν δυνάμει μόνον συμμέτρους μέσον περιεχούσας.



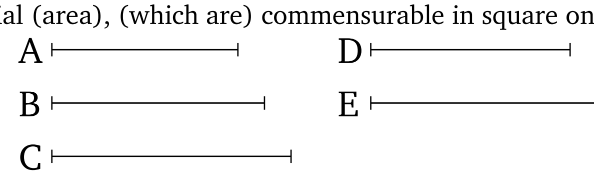
Ἐκκείσθωσαν [τρεῖς] ῥηταὶ δυνάμει μόνον σύμμετροι αἱ Α, Β, Γ, καὶ εἰλήφθω τῶν Α, Β μέση ἀνάλογον ἡ Δ, καὶ γεγονέτω ὡς ἡ Β πρὸς τὴν Γ, ἡ Δ πρὸς τὴν Ε.

Ἐπεὶ αἱ Α, Β ῥηταί εἰσι δυνάμει μόνον σύμμετροι, τὸ ἄρα ὑπὸ τῶν Α, Β, τουτέστι τὸ ἀπὸ τῆς Δ, μέσον ἐστὶν. μέση ἄρα ἡ Δ. καὶ ἐπεὶ αἱ Β, Γ δυνάμει μόνον εἰσὶ σύμμετροι, καί ἐστιν ὡς ἡ Β πρὸς τὴν Γ, ἡ Δ πρὸς τὴν Ε, καὶ αἱ Δ, Ε ἄρα δυνάμει μόνον εἰσὶ σύμμετροι. μέση δὲ ἡ Δ· μέση ἄρα καὶ ἡ Ε· αἱ Δ, Ε ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι. λέγω δή, ὅτι καὶ μέσον περιέχουσιν. ἐπεὶ γάρ ἐστιν ὡς ἡ Β πρὸς τὴν Γ, ἡ Δ πρὸς τὴν Ε, ἐναλλὰξ ἄρα ὡς ἡ Β πρὸς τὴν Δ, ἡ Γ πρὸς τὴν Ε. ὡς δὲ ἡ Β πρὸς τὴν Δ, ἡ Δ πρὸς τὴν Α· καὶ ὡς ἄρα ἡ Δ πρὸς τὴν Α, ἡ Γ πρὸς τὴν Ε· τὸ ἄρα ὑπὸ τῶν Α, Γ ἴσον ἐστὶ τῷ ὑπὸ τῶν Δ, Ε. μέσον δὲ τὸ ὑπὸ τῶν Α, Γ· μέσον ἄρα καὶ τὸ ὑπὸ τῶν Δ, Ε.

Ἐὕρηνται ἄρα μέσαι δυνάμει μόνον σύμμετροι μέσον

Proposition 28

To find (two) medial (straight-lines), containing a medial (area), (which are) commensurable in square only.



Let the [three] rational (straight-lines) A, B, and C, (which are) commensurable in square only, be laid down. And let, D, the mean proportional (straight-line) to A and B, have been taken [Prop. 6.13]. And let it be contrived that as B (is) to C, (so) D (is) to E [Prop. 6.12].

Since the rational (straight-lines) A and B are commensurable in square only, the (rectangle contained) by A and B—that is to say, the (square) on D [Prop. 6.17]—is medial [Prop. 10.21]. Thus, D (is) medial [Prop. 10.21]. And since B and C are commensurable in square only, and as B is to C, (so) D (is) to E, D and E are thus commensurable in square only [Prop. 10.11]. And D (is) medial. E (is) thus also medial [Prop. 10.23]. Thus, D and E are medial (straight-lines which are) commensurable in square only. So, I say that they also enclose a medial (area). For since as B is to C, (so) D (is) to E, thus, περιέχουσαι· ὅπερ ἔδει δεῖξαι.

alternately, as B (is) to D, (so) C (is) to E [Prop. 5.16]. And as B (is) to D, (so) D (is) to A. And thus as D (is) to A, (so) C (is) to E. Thus, the (rectangle contained) by A and C is equal to the (rectangle contained) by D and E [Prop. 6.16]. And the (rectangle contained) by A and C is medial [Prop. 10.21]. Thus, the (rectangle contained) by D and E (is) also medial.

Thus, (two) medial (straight-lines, D and E), containing a medial (area), (which are) commensurable in square only, have been found. (Which is) the very thing it was required to show.

† D and E have lengths $k^{1/4}$ and $k'^{1/2}/k^{1/4}$ times that of A, respectively, where the lengths of B and C are $k^{1/2}$ and $k'^{1/2}$ times that of A, respectively.

Λῆμμα αʹ.

Εὑρειν δύο τετραγώνους ἀριθμούς, ὥστε καὶ τὸν συγκείμενον ἐξ αὐτῶν εἶναι τετράγωνον.

Ἐκκείσθωσαν δύο ἀριθμοὶ οἱ ΑΒ, ΒΓ, ἔστωσαν δὲ ἤτοι ἄρτιοι ἢ περιττοί. καὶ ἐπεί, ἐάν τε ἀπὸ ἀρτίου ἄρτιος ἀφαιρεθῇ, ἐάν τε ἀπὸ περισσοῦ περισσός, ὁ λοιπὸς ἄρτιός ἐστιν, ὁ λοιπὸς ἄρα ὁ ΑΓ ἄρτιός ἐστιν. τετμήσθω ὁ ΑΓ δίχα κατὰ τὸ Δ. ἔστωσαν δὲ καὶ οἱ ΑΒ, ΒΓ ἤτοι ὅμοιοι ἐπίπεδοι ἢ τετράγωνοι, οἳ καὶ αὐτοὶ ὅμοιοί εἰσιν ἐπίπεδοι· ὁ ἄρα ἐκ τῶν ΑΒ, ΒΓ μετὰ τοῦ ἀπὸ [τοῦ] ΓΔ τετραγώνου ἴσος ἐστὶ τῷ ἀπὸ τοῦ ΒΔ τετραγώνῳ. καί ἐστι τετράγωνος ὁ ἐκ τῶν ΑΒ, ΒΓ, ἐπειδήπερ ἐδείχθη, ὅτι, ἐὰν δύο ὅμοιοι ἐπίπεδοι πολλαπλασιάσαντες ἀλλήλους ποιῶσι τινα, ὁ γενόμενος τετράγωνός ἐστιν. εὕρηνται ἄρα δύο τετράγωνοι ἀριθμοὶ ὅ τε ἐκ τῶν ΑΒ, ΒΓ καὶ ὁ ἀπὸ τοῦ ΓΔ, οἳ συντεθέντες ποιοῦσι τὸν ἀπὸ τοῦ ΒΔ τετράγωνον.

Καὶ φανερόν, ὅτι εὕρηνται πάλιν δύο τετράγωνοι ὅ τε ἀπὸ τοῦ ΒΔ καὶ ὁ ἀπὸ τοῦ ΓΔ, ὥστε τὴν ὑπεροχὴν αὐτῶν τὸν ὑπὸ ΑΒ, ΒΓ εἶναι τετράγωνον, ὅταν οἱ ΑΒ, ΒΓ ὅμοιοι ὦσιν ἐπίπεδοι. ὅταν δὲ μὴ ὦσιν ὅμοιοι ἐπίπεδοι, εὕρηνται δύο τετράγωνοι ὅ τε ἀπὸ τοῦ ΒΔ καὶ ὁ ἀπὸ τοῦ ΔΓ, ὧν ἡ ὑπεροχὴ ὁ ὑπὸ τῶν ΑΒ, ΒΓ οὐκ ἔστι τετράγωνος· ὅπερ ἔδει δεῖξαι.

Lemma I

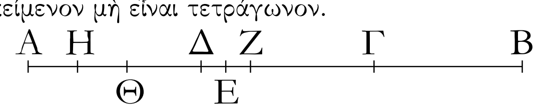
To find two square numbers such that the sum of them is also square.

Let the two numbers AB and BC be laid down. And let them be either (both) even or (both) odd. And since, if an even (number) is subtracted from an even (number), or if an odd (number is subtracted) from an odd (number), then the remainder is even [Props. 9.24, 9.26], the remainder AC is thus even. Let AC have been cut in half at D. And let AB and BC also be either similar plane (numbers), or square (numbers)—which are themselves also similar plane (numbers). Thus, the (number created) from (multiplying) AB and BC, plus the square on CD, is equal to the square on BD [Prop. 2.6]. And the (number created) from (multiplying) AB and BC is square—inasmuch as it was shown that if two similar plane (numbers) make some (number) by multiplying one another then the (number so) created is square [Prop. 9.1]. Thus, two square numbers have been found—(namely,) the (number created) from (multiplying) AB and BC, and the (square) on CD—which, (when) added (together), make the square on BD.

And (it is) clear that two square (numbers) have again been found—(namely,) the (square) on BD, and the (square) on CD—such that their difference—(namely,) the (rectangle) contained by AB and BC—is square whenever AB and BC are similar plane (numbers). But, when they are not similar plane numbers, two square (numbers) have been found—(namely,) the (square) on BD, and the (square) on DC—between which the difference—(namely,) the (rectangle) contained by AB and BC—is not square. (Which is) the very thing it was required to show.

Λῆμμα β΄.

Εὑρεῖν δύο τετραγώνους ἀριθμούς, ὥστε τὸν ἐξ αὐτῶν συγκείμενον μὴ εἶναι τετράγωνον.

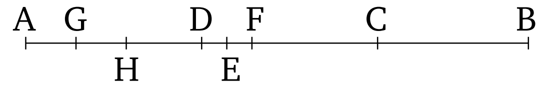


Ἔστω γὰρ ὁ ἐκ τῶν ΑΒ, ΒΓ, ὡς ἔφαμεν, τετράγωνος, καὶ ἄρτιος ὁ ΓΑ, καὶ τετμήσθω ὁ ΓΑ δίχα τῷ Δ. φανερὸν δή, ὅτι ὁ ἐκ τῶν ΑΒ, ΒΓ τετράγωνος μετὰ τοῦ ἀπὸ [τοῦ] ΓΔ τετραγώνου ἴσος ἐστὶ τῷ ἀπὸ [τοῦ] ΒΔ τετραγώνῳ. ἀφῃρήσθω μονὰς ἡ ΔΕ· ὁ ἄρα ἐκ τῶν ΑΒ, ΒΓ μετὰ τοῦ ἀπὸ [τοῦ] ΓΕ ἐλάσσων ἐστὶ τοῦ ἀπὸ [τοῦ] ΒΔ τετραγώνου. λέγω οὖν, ὅτι ὁ ἐκ τῶν ΑΒ, ΒΓ τετράγωνος μετὰ τοῦ ἀπὸ [τοῦ] ΓΕ οὐκ ἔσται τετράγωνος.

Εἰ γὰρ ἔσται τετράγωνος, ἤτοι ἴσος ἐστὶ τῷ ἀπὸ [τοῦ] ΒΕ ἢ ἐλάσσων τοῦ ἀπὸ [τοῦ] ΒΕ, οὐκέτι δὲ καὶ μείζων, ἵνα μὴ τμηθῇ ἡ μονάς. ἔστω, εἰ δυνατόν, πρότερον ὁ ἐκ τῶν ΑΒ, ΒΓ μετὰ τοῦ ἀπὸ ΓΕ ἴσος τῷ ἀπὸ ΒΕ, καὶ ἔστω τῆς ΔΕ μονάδος διπλασίων ὁ ΗΑ. ἐπεὶ οὖν ὅλος ὁ ΑΓ ὅλου τοῦ ΓΔ ἐστι διπλασίων, ὧν ὁ ΑΗ τοῦ ΔΕ ἐστι διπλασίων, καὶ λοιπὸς ἄρα ὁ ΗΓ λοιποῦ τοῦ ΕΓ ἐστι διπλασίων· δίχα ἄρα τέτμηται ὁ ΗΓ τῷ Ε. ὁ ἄρα ἐκ τῶν ΗΒ, ΒΓ μετὰ τοῦ ἀπὸ ΓΕ ἴσος ἐστὶ τῷ ἀπὸ ΒΕ τετραγώνῳ. ἀλλὰ καὶ ὁ ἐκ τῶν ΑΒ, ΒΓ μετὰ τοῦ ἀπὸ ΓΕ ἴσος ὑπόκειται τῷ ἀπὸ [τοῦ] ΒΕ τετραγώνῳ· ὁ ἄρα ἐκ τῶν ΗΒ, ΒΓ μετὰ τοῦ ἀπὸ ΓΕ ἴσος ἐστὶ τῷ ἐκ τῶν ΑΒ, ΒΓ μετὰ τοῦ ἀπὸ ΓΕ. καὶ κοινοῦ ἀφαιρεθέντος τοῦ ἀπὸ ΓΕ συνάγεται ὁ ΑΒ ἴσος τῷ ΗΒ· ὅπερ ἄτοπον. οὐκ ἄρα ὁ ἐκ τῶν ΑΒ, ΒΓ μετὰ τοῦ ἀπὸ [τοῦ] ΓΕ ἴσος ἐστὶ τῷ ἀπὸ ΒΕ. λέγω δή, ὅτι οὐδὲ ἐλάσσων τοῦ ἀπὸ ΒΕ. εἰ γὰρ δυνατόν, ἔστω τῷ ἀπὸ ΒΖ ἴσος, καὶ τοῦ ΔΖ διπλασίων ὁ ΘΑ. καὶ συναχθήσεται πάλιν διπλασίων ὁ ΘΓ τοῦ ΓΖ· ὥστε καὶ τὸν ΓΘ δίχα τετμῆσθαι κατὰ τὸ Ζ, καὶ διὰ τοῦτο τὸν ἐκ τῶν ΘΒ, ΒΓ μετὰ τοῦ ἀπὸ ΖΓ ἴσον γίνεσθαι τῷ ἀπὸ ΒΖ. ὑπόκειται δὲ καὶ ὁ ἐκ τῶν ΑΒ, ΒΓ μετὰ τοῦ ἀπὸ ΓΕ ἴσος τῷ ἀπὸ ΒΖ. ὥστε καὶ ὁ ἐκ τῶν ΘΒ, ΒΓ μετὰ τοῦ ἀπὸ ΓΖ ἴσος ἔσται τῷ ἐκ τῶν ΑΒ, ΒΓ μετὰ τοῦ ἀπὸ ΓΕ· ὅπερ ἄτοπον. οὐκ ἄρα ὁ ἐκ τῶν ΑΒ, ΒΓ μετὰ τοῦ ἀπὸ ΓΕ ἴσος ἐστὶ [τῷ] ἐλάσσονι τοῦ ἀπὸ ΒΕ. ἐδείχθη δέ, ὅτι οὐδὲ [αὐτῷ] τῷ ἀπὸ ΒΕ. οὐκ ἄρα ὁ ἐκ τῶν ΑΒ, ΒΓ μετὰ τοῦ ἀπὸ ΓΕ τετράγωνός ἐστιν. ὅπερ ἔδει δεῖξαι.

Lemma II

To find two square numbers such that the sum of them is not square.

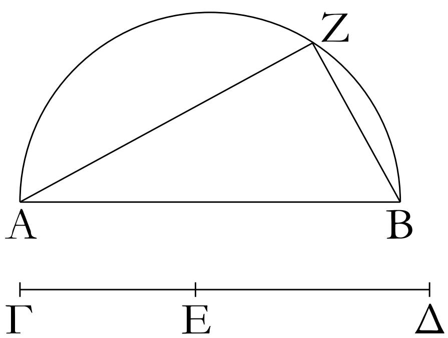


For let the (number created) from (multiplying) AB and BC, as we said, be square. And (let) CA (be) even. And let CA have been cut in half at D. So it is clear that the square (number created) from (multiplying) AB and BC, plus the square on CD, is equal to the square on BD [see previous lemma]. Let the unit DE have been subtracted (from BD). Thus, the (number created) from (multiplying) AB and BC, plus the (square) on CE, is less than the square on BD. I say, therefore, that the square (number created) from (multiplying) AB and BC, plus the (square) on CE, is not square.

For if it is square, it is either equal to the (square) on BE, or less than the (square) on BE, but cannot any more be greater (than the square on BE), lest the unit be divided. First of all, if possible, let the (number created) from (multiplying) AB and BC, plus the (square) on CE, be equal to the (square) on BE. And let GA be double the unit DE. Therefore, since the whole of AC is double the whole of CD, of which AG is double DE, the remainder GC is thus double the remainder EC. Thus, GC has been cut in half at E. Thus, the (number created) from (multiplying) GB and BC, plus the (square) on CE, is equal to the square on BE [Prop. 2.6]. But, the (number created) from (multiplying) AB and BC, plus the (square) on CE, was also assumed (to be) equal to the square on BE. Thus, the (number created) from (multiplying) GB and BC, plus the (square) on CE, is equal to the (number created) from (multiplying) AB and BC, plus the (square) on CE. And subtracting the (square) on CE from both, AB is inferred (to be) equal to GB. The very thing is absurd. Thus, the (number created) from (multiplying) AB and BC, plus the (square) on CE, is not equal to the (square) on BE. So I say that (it is) not less than the (square) on BE either. For, if possible, let it be equal to the (square) on BF. And (let) HA (be) double DF. And it can again be inferred that HC (is) double CF. Hence, CH has also been cut in half at F. And, on account of this, the (number created) from (multiplying) HB and BC, plus the (square) on FC, becomes equal to the (square) on BF [Prop. 2.6]. And the (number created) from (multiplying) AB and BC, plus the (square) on CE, was also assumed (to be) equal to the (square) on BF. Hence, the (number created) from (multiplying) HB and BC, plus the (square) on CF, will also be equal to the (number created) from (multiplying) AB and BC, plus the (square) on CE. The very thing is absurd. Thus, the (number created) from (multiplying) AB and BC, plus the (square) on CE, is not equal to less than the (square) on BE. And it was shown that (is it) not equal to the (square) on BE either. Thus, the (number created) from (multiplying) AB and BC, plus the square on CE, is not square. (Which is) the very thing it was required to show.

κθ΄.

Εὑρεῖν δύο ῥητὰς δυνάμει μόνον συμμέτρους, ὥστε τὴν μείζονα τῆς ἐλάσσονος μεῖζον δύνασθαι τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει.

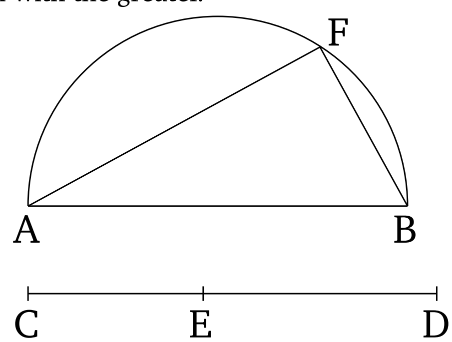


Ἐκκείσθω γάρ τις ῥητὴ ἡ ΑΒ καὶ δύο τετράγωνοι ἀριθμοὶ οἱ ΓΔ, ΔΕ, ὥστε τὴν ὑπεροχὴν αὐτῶν τὸν ΓΕ μὴ εἶναι τετράγωνον, καὶ γεγράφθω ἐπὶ τῆς ΑΒ ἡμικύκλιον τὸ ΑΖΒ, καὶ πεποιήσθω ὡς ὁ ΔΓ πρὸς τὸν ΓΕ, οὕτως τὸ ἀπὸ τῆς ΒΑ τετράγωνον πρὸς τὸ ἀπὸ τῆς ΑΖ τετράγωνον, καὶ ἐπεζεύχθω ἡ ΖΒ.

Ἐπεὶ [οὖν] ἐστιν ὡς τὸ ἀπὸ τῆς ΒΑ πρὸς τὸ ἀπὸ τῆς ΑΖ, οὕτως ὁ ΔΓ πρὸς τὸν ΓΕ, τὸ ἀπὸ τῆς ΒΑ ἄρα πρὸς τὸ ἀπὸ τῆς ΑΖ λόγον ἔχει, ὃν ἀριθμὸς ὁ ΔΓ πρὸς ἀριθμὸν τὸν ΓΕ· σύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΒΑ τῷ ἀπὸ τῆς ΑΖ. ῥητὸν δὲ τὸ ἀπὸ τῆς ΑΒ· ῥητὸν ἄρα καὶ τὸ ἀπὸ τῆς ΑΖ· ῥητὴ ἄρα καὶ ἡ ΑΖ. καὶ ἐπεὶ ὁ ΔΓ πρὸς τὸν ΓΕ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδὲ τὸ ἀπὸ τῆς ΒΑ ἄρα πρὸς τὸ ἀπὸ τῆς ΑΖ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΑΒ τῇ ΑΖ μήκει· αἱ ΒΑ, ΑΖ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. καὶ ἐπεί [ἐστιν] ὡς ὁ ΔΓ πρὸς τὸν ΓΕ, οὕτως τὸ ἀπὸ τῆς ΒΑ πρὸς τὸ ἀπὸ τῆς ΑΖ, ἀναστρέψαντι ἄρα ὡς ὁ ΓΔ πρὸς τὸν ΔΕ, οὕτως τὸ ἀπὸ τῆς ΑΒ πρὸς τὸ ἀπὸ τῆς ΒΖ. ὁ δὲ ΓΔ πρὸς τὸν ΔΕ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· καὶ τὸ ἀπὸ τῆς ΑΒ ἄρα πρὸς τὸ ἀπὸ τῆς ΒΖ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· σύμμετρος ἄρα ἐστὶν ἡ ΑΒ τῇ ΒΖ μήκει. καί ἐστι τὸ ἀπὸ τῆς ΑΒ ἴσον τοῖς ἀπὸ τῶν ΑΖ, ΖΒ· ἡ ΑΒ ἄρα τῆς ΑΖ μεῖζον δύναται τῇ ΒΖ συμμέτρῳ

Proposition 29

To find two rational (straight-lines which are) commensurable in square only, such that the square on the greater is larger than the (square on the) lesser by the (square) on (some straight-line which is) commensurable in length with the greater.



For let some rational (straight-line) AB be laid down, and two square numbers, CD and DE, such that the difference between them, CE, is not square [Prop. 10.28 lem. I]. And let the semi-circle AFB have been drawn on AB. And let it be contrived that as DC (is) to CE, so the square on BA (is) to the square on AF [Prop. 10.6 corr.]. And let FB have been joined.

[Therefore,] since as the (square) on BA is to the (square) on AF, so DC (is) to CE, the (square) on BA thus has to the (square) on AF the ratio which the number DC (has) to the number CE. Thus, the (square) on BA is commensurable with the (square) on AF [Prop. 10.6]. And the (square) on AB (is) rational [Def. 10.4]. Thus, the (square) on AF (is) also rational. Thus, AF (is) also rational. And since DC does not have to CE the ratio which (some) square number (has) to (some) square number, the (square) on BA thus does not have to the (square) on AF the ratio which (some) square number has to (some) square number either. Thus, AB is incommensurable in length with AF [Prop. 10.9]. Thus, the rational (straight-lines) BA and AF are commensurable in square only. And since as DC [is] to CE, so the (square) on BA (is) to the (square) on AF, thus, via conversion, as CD (is) to DE, so the (square) on AB (is) to the (square) on ἑαυτῇ.

Εὕρηνται ἄρα δύο ῥηταὶ δυνάμει μόνον σύμμετροι αἱ ΒΑ, ΑΖ, ὥστε τὴν μεῖζονα τὴν ΑΒ τῆς ἐλάσσονος τῆς ΑΖ μεῖζον δύνασθαι τῷ ἀπὸ τῆς ΒΖ συμμέτρου ἑαυτῇ μήκει· ὅπερ ἔδει δεῖξαι.

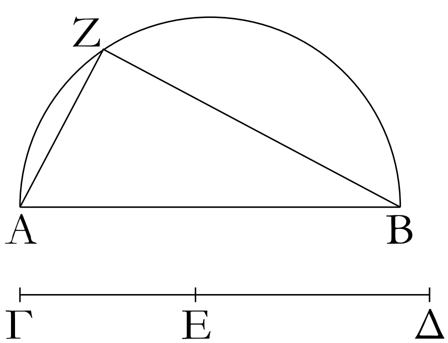
BF [Props. 5.19 corr., 3.31, 1.47]. And CD has to DE the ratio which (some) square number (has) to (some) square number. Thus, the (square) on AB also has to the (square) on BF the ratio which (some) square number has to (some) square number. AB is thus commensurable in length with BF [Prop. 10.9]. And the (square) on AB is equal to the (sum of the squares) on AF and FB [Prop. 1.47]. Thus, the square on AB is greater than (the square on) AF by (the square on) BF, (which is) commensurable (in length) with (AB).

Thus, two rational (straight-lines), BA and AF, commensurable in square only, have been found such that the square on the greater, AB, is larger than (the square on) the lesser, AF, by the (square) on BF, (which is) commensurable in length with (AB).[†] (Which is) the very thing it was required to show.

[†] BA and AF have lengths 1 and $\sqrt{1-k^2}$ times that of AB, respectively, where $k = \sqrt{DE/CD}$.

λ΄.

Εὑρεῖν δύο ῥητὰς δυνάμει μόνον συμμέτρους, ὥστε τὴν μείζονα τῆς ἐλάσσονος μεῖζον δύνασθαι τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ μήκει.

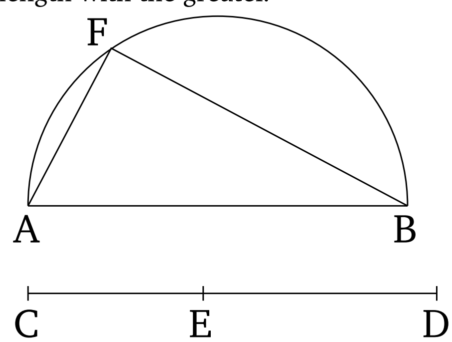


Ἐκκείσθω ῥητὴ ἡ ΑΒ καὶ δύο τετράγωνοι ἀριθμοὶ οἱ ΓΕ, ΕΔ, ὥστε τὸν συγκείμενον ἐξ αὐτῶν τὸν ΓΔ μὴ εἶναι τετράγωνον, καὶ γεγράφθω ἐπὶ τῆς ΑΒ ἡμικύκλιον τὸ ΑΖΒ, καὶ πεποιήσθω ὡς ὁ ΔΓ πρὸς τὸν ΓΕ, οὕτως τὸ ἀπὸ τῆς ΒΑ πρὸς τὸ ἀπὸ τῆς ΑΖ, καὶ ἐπεζεύχθω ἡ ΖΒ.

Ὁμοίως δὴ δείξομεν τῷ πρὸ τούτου, ὅτι αἱ ΒΑ, ΑΖ ῥηταί εἰσι δυνάμει μόνον σύμμετροι. καὶ ἐπεί ἐστιν ὡς ὁ ΔΓ πρὸς τὸν ΓΕ, οὕτως τὸ ἀπὸ τῆς ΒΑ πρὸς τὸ ἀπὸ τῆς ΑΖ, ἀναστρέψαντι ἄρα ὡς ὁ ΓΔ πρὸς τὸν ΔΕ, οὕτως τὸ ἀπὸ τῆς ΑΒ πρὸς τὸ ἀπὸ τῆς ΒΖ. ὁ δὲ ΓΔ πρὸς τὸν ΔΕ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· οὐδ᾽ ἄρα τὸ ἀπὸ τῆς ΑΒ πρὸς τὸ ἀπὸ τῆς ΒΖ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΑΒ τῇ ΒΖ μήκει. καὶ δύναται ἡ ΑΒ τῆς ΑΖ μεῖζον τῷ ἀπὸ τῆς ΖΒ ἀσυμμέτρου ἑαυτῇ.

Proposition 30

To find two rational (straight-lines which are) commensurable in square only, such that the square on the greater is larger than the (the square on) lesser by the (square) on (some straight-line which is) incommensurable in length with the greater.



Let the rational (straight-line) AB be laid out, and the two square numbers, CE and ED, such that the sum of them, CD, is not square [Prop. 10.28 lem. II]. And let the semi-circle AFB have been drawn on AB. And let it be contrived that as DC (is) to CE, so the (square) on BA (is) to the (square) on AF [Prop. 10.6 corr]. And let FB have been joined.

So, similarly to the (proposition) before this, we can show that BA and AF are rational (straight-lines which are) commensurable in square only. And since as DC is to CE, so the (square) on BA (is) to the (square) on AF, thus, via conversion, as CD (is) to DE, so the (square) on AB (is) to the (square) on BF [Props. 5.19 corr., 3.31, 1.47]. And CD does not have to DE the ratio which (some) square number (has) to (some) square number.

Αἱ ΑΒ, ΑΖ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ ἡ ΑΒ τῆς ΑΖ μεῖζον δύναται τῷ ἀπὸ τῆς ΖΒ ἀσυμμέτρου ἑαυτῇ μήκει· ὅπερ ἔδει δεῖξαι.

Thus, the (square) on AB does not have to the (square) on BF the ratio which (some) square number has to (some) square number either. Thus, AB is incommensurable in length with BF [Prop. 10.9]. And the square on AB is greater than the (square on) AF by the (square) on FB [Prop. 1.47], (which is) incommensurable (in length) with (AB).

Thus, AB and AF are rational (straight-lines which are) commensurable in square only, and the square on AB is greater than (the square on) AF by the (square) on FB, (which is) incommensurable (in length) with (AB).† (Which is) the very thing it was required to show.

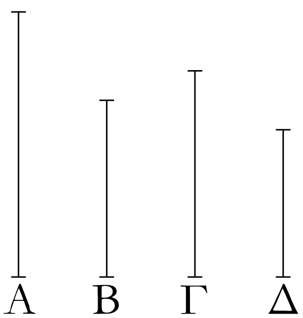
† AB and AF have lengths 1 and $1/\sqrt{1+k^2}$ times that of AB, respectively, where $k = \sqrt{DE/CE}$.

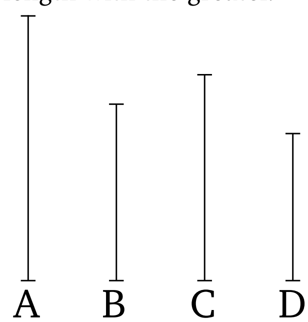
λαʹ.

Εὑρεῖν δύο μέσας δυνάμει μόνον συμμέτρους ῥητὸν περιεχούσας, ὥστε τὴν μείζονα τῆς ἐλάσσονος μεῖζον δύνασθαι τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει.

Proposition 31

To find two medial (straight-lines), commensurable in square only, (and) containing a rational (area), such that the square on the greater is larger than the (square on the) lesser by the (square) on (some straight-line) commensurable in length with the greater.





Ἐκκείσθωσαν δύο ῥηταὶ δυνάμει μόνον σύμμετροι αἱ Α, Β, ὥστε τὴν Α μείζονα οὖσαν τῆς ἐλάσσονος τῆς Β μεῖζον δύνασθαι τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει. καὶ τῷ ὑπὸ τῶν Α, Β ἴσον ἔστω τὸ ἀπὸ τῆς Γ. μέσον δὲ τὸ ὑπὸ τῶν Α, Β· μέσον ἄρα καὶ τὸ ἀπὸ τῆς Γ· μέση ἄρα καὶ ἡ Γ. τῷ δὲ ἀπὸ τῆς Β ἴσον ἔστω τὸ ὑπὸ τῶν Γ, Δ· ῥητὸν δὲ τὸ ἀπὸ τῆς Β· ῥητὸν ἄρα καὶ τὸ ὑπὸ τῶν Γ, Δ. καὶ ἐπεί ἐστιν ὡς ἡ Α πρὸς τὴν Β, οὕτως τὸ ὑπὸ τῶν Α, Β πρὸς τὸ ἀπὸ τῆς Β, ἀλλὰ τῷ μὲν ὑπὸ τῶν Α, Β ἴσον ἐστὶ τὸ ἀπὸ τῆς Γ, τῷ δὲ ἀπὸ τῆς Β ἴσον τὸ ὑπὸ τῶν Γ, Δ, ὡς ἄρα ἡ Α πρὸς τὴν Β, οὕτως τὸ ἀπὸ τῆς Γ πρὸς τὸ ὑπὸ τῶν Γ, Δ. ὡς δὲ τὸ ἀπὸ τῆς Γ πρὸς τὸ ὑπὸ τῶν Γ, Δ, οὕτως ἡ Γ πρὸς τὴν Δ· καὶ ὡς ἄρα ἡ Α πρὸς τὴν Β, οὕτως ἡ Γ πρὸς τὴν Δ. σύμμετρος δὲ ἡ Α τῇ Β δυνάμει μόνον· σύμμετρος ἄρα καὶ ἡ Γ τῇ Δ δυνάμει μόνον. καί ἐστι μέση ἡ Γ· μέση ἄρα καὶ ἡ Δ. καὶ ἐπεί ἐστιν ὡς ἡ Α πρὸς τὴν Β, ἡ Γ πρὸς τὴν Δ, ἡ δὲ Α τῆς Β μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καὶ ἡ Γ ἄρα τῆς Δ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ.

Εὕρηνται ἄρα δύο μέσαι δυνάμει μόνον σύμμετροι αἱ Γ,

Let two rational (straight-lines), A and B, commensurable in square only, be laid out, such that the square on the greater A is larger than the (square on the) lesser B by the (square) on (some straight-line) commensurable in length with (A) [Prop. 10.29]. And let the (square) on C be equal to the (rectangle contained) by A and B. And the (rectangle contained by) A and B (is) medial [Prop. 10.21]. Thus, the (square) on C (is) also medial. Thus, C (is) also medial [Prop. 10.21]. And let the (rectangle contained) by C and D be equal to the (square) on B. And the (square) on B (is) rational. Thus, the (rectangle contained) by C and D (is) also rational. And since as A is to B, so the (rectangle contained) by A and B (is) to the (square) on B [Prop. 10.21 lem.], but the (square) on C is equal to the (rectangle contained) by A and B, and the (rectangle contained) by C and D to the (square) on B, thus as A (is) to B, so the (square) on C (is) to the (rectangle contained) by C and D. And as the (square) on C (is) to the (rectangle contained) by

Δ ῥητὸν περιέχουσαι, καὶ ἡ Γ τῆς Δ μεῖζον δυνάται τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει.

Ὁμοίως δὴ δειχθήσεται καὶ τῷ ἀπὸ ἀσυμμέτρου, ὅταν ἡ Α τῆς Β μεῖζον δύνηται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ.

C and D, so C (is) to D [Prop. 10.21 lem.]. And thus as A (is) to B, so C (is) to D. And A is commensurable in square only with B. Thus, C (is) also commensurable in square only with D [Prop. 10.11]. And C is medial. Thus, D (is) also medial [Prop. 10.23]. And since as A is to B, (so) C (is) to D, and the square on A is greater than (the square on) B by the (square) on (some straight-line) commensurable (in length) with (A), the square on C is thus also greater than (the square on) D by the (square) on (some straight-line) commensurable (in length) with (C) [Prop. 10.14].

Thus, two medial (straight-lines), C and D, commensurable in square only, (and) containing a rational (area), have been found. And the square on C is greater than (the square on) D by the (square) on (some straight-line) commensurable in length with (C).†

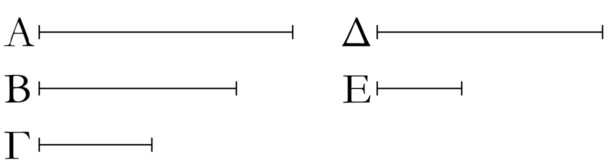
So, similarly, (the proposition) can also be demonstrated for (some straight-line) incommensurable (in length with C), provided that the square on A is greater than (the square on B) by the (square) on (some straight-line) incommensurable (in length) with (A) [Prop. 10.30].‡

† C and D have lengths $(1-k^2)^{1/4}$ and $(1-k^2)^{3/4}$ times that of A, respectively, where k is defined in the footnote to Prop. 10.29.

‡ C and D would have lengths $1/(1+k^2)^{1/4}$ and $1/(1+k^2)^{3/4}$ times that of A, respectively, where k is defined in the footnote to Prop. 10.30.

λβʹ.

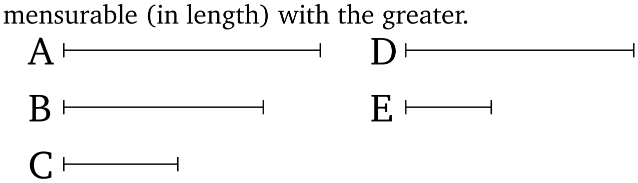
Εὑρεῖν δύο μέσας δυνάμει μόνον συμμέτρους μέσον περιεχούσας, ὥστε τὴν μείζονα τῆς ἐλάσσονος μεῖζον δύνασθαι τῷ ἀπὸ συμμέτρου ἑαυτῇ.



Ἐκκείσθωσαν τρεῖς ῥηταὶ δυνάμει μόνον σύμμετροι αἱ Α, Β, Γ, ὥστε τὴν Α τῆς Γ μεῖζον δύνασθαι τῷ ἀπὸ συμμέτρου ἑαυτῇ, καὶ τῷ μὲν ὑπὸ τῶν Α, Β ἴσον ἔστω τὸ ἀπὸ τῆς Δ. μέσον ἄρα τὸ ἀπὸ τῆς Δ· καὶ ἡ Δ ἄρα μέση ἐστίν. τῷ δὲ ὑπὸ τῶν Β, Γ ἴσον ἔστω τὸ ὑπὸ τῶν Δ, Ε. καὶ ἐπεί ἐστιν ὡς τὸ ὑπὸ τῶν Α, Β πρὸς τὸ ὑπὸ τῶν Β, Γ, οὕτως ἡ Α πρὸς τὴν Γ, ἀλλὰ τῷ μὲν ὑπὸ τῶν Α, Β ἴσον ἐστὶ τὸ ἀπὸ τῆς Δ, τῷ δὲ ὑπὸ τῶν Β, Γ ἴσον τὸ ὑπὸ τῶν Δ, Ε, ἔστιν ἄρα ὡς ἡ Α πρὸς τὴν Γ, οὕτως τὸ ἀπὸ τῆς Δ πρὸς τὸ ὑπὸ τῶν Δ, Ε. ὡς δὲ τὸ ἀπὸ τῆς Δ πρὸς τὸ ὑπὸ τῶν Δ, Ε, οὕτως ἡ Δ πρὸς τὴν Ε· καὶ ὡς ἄρα ἡ Α πρὸς τὴν Γ, οὕτως ἡ Δ πρὸς τὴν Ε. σύμμετρος δὲ ἡ Α τῇ Γ δυνάμει [μόνον]. σύμμετρος ἄρα καὶ ἡ Δ τῇ Ε δυνάμει μόνον. μέση

Proposition 32

To find two medial (straight-lines), commensurable in square only, (and) containing a medial (area), such that the square on the greater is larger than the (square on the) lesser by the (square) on (some straight-line) commensurable (in length) with the greater.



Let three rational (straight-lines), A, B and C, commensurable in square only, be laid out such that the square on A is greater than (the square on C) by the (square) on (some straight-line) commensurable (in length) with (A) [Prop. 10.29]. And let the (square) on D be equal to the (rectangle contained) by A and B. Thus, the (square) on D (is) medial. Thus, D is also medial [Prop. 10.21]. And let the (rectangle contained) by D and E be equal to the (rectangle contained) by B and C. And since as the (rectangle contained) by A and B is to the (rectangle contained) by B and C, so A (is) to C [Prop. 10.21 lem.], but the (square) on D is equal to the (rectangle contained) by A and B, and the (rectangle δὲ ἡ Δ· μέση ἄρα καὶ ἡ Ε. καὶ ἐπεί ἐστιν ὡς ἡ Α πρὸς τὴν Γ, ἡ Δ πρὸς τὴν Ε, ἡ δὲ Α τῆς Γ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καὶ ἡ Δ ἄρα τῆς Ε μεῖζον δυνήσεται τῷ ἀπὸ συμμέτρου ἑαυτῇ. λέγω δή, ὅτι καὶ μέσον ἐστὶ τὸ ὑπὸ τῶν Δ, Ε. ἐπεὶ γὰρ ἴσον ἐστὶ τὸ ὑπὸ τῶν Β, Γ τῷ ὑπὸ τῶν Δ, Ε, μέσον δὲ τὸ ὑπὸ τῶν Β, Γ [αἱ γὰρ Β, Γ ῥηταί εἰσι δυνάμει μόνον σύμμετροι], μέσον ἄρα καὶ τὸ ὑπὸ τῶν Δ, Ε.

Εὕρηνται ἄρα δύο μέσαι δυνάμει μόνον σύμμετροι αἱ Δ, Ε μέσον περιέχουσαι, ὥστε τὴν μείζονα τῆς ἐλάσσονος μεῖζον δύνασθαι τῷ ἀπὸ συμμέτρου ἑαυτῇ.

Ὁμοίως δὴ πάλιν διεχθήσεται καὶ τῷ ἀπὸ ἀσυμμέτρου, ὅταν ἡ Α τῆς Γ μεῖζον δύνηται τῷ ἀπὸ ἀσυμμέτρου ἑαυτη.

contained) by D and E to the (rectangle contained) by B and C, thus as A is to C, so the (square) on D (is) to the (rectangle contained) by D and E. And as the (square) on D (is) to the (rectangle contained) by D and E, so D (is) to E [Prop. 10.21 lem.]. And thus as A (is) to C, so D (is) to E. And A (is) commensurable in square [only] with C. Thus, D (is) also commensurable in square only with E [Prop. 10.11]. And D (is) medial. Thus, E (is) also medial [Prop. 10.23]. And since as A is to C, (so) D (is) to E, and the square on A is greater than (the square on) C by the (square) on (some straight-line) commensurable (in length) with (A), the square on D will thus also be greater than (the square on) E by the (square) on (some straight-line) commensurable (in length) with (D) [Prop. 10.14]. So, I also say that the (rectangle contained) by D and E is medial. For since the (rectangle contained) by B and C is equal to the (rectangle contained) by D and E, and the (rectangle contained) by B and C (is) medial [for B and C are rational (straight-lines which are) commensurable in square only] [Prop. 10.21], the (rectangle contained) by D and E (is) thus also medial.

Thus, two medial (straight-lines), D and E, commensurable in square only, (and) containing a medial (area), have been found such that the square on the greater is larger than the (square on the) lesser by the (square) on (some straight-line) commensurable (in length) with the greater.[†].

So, similarly, (the proposition) can again also be demonstrated for (some straight-line) incommensurable (in length with the greater), provided that the square on A is greater than (the square on) C by the (square) on (some straight-line) incommensurable (in length) with (A) [Prop. 10.30].[‡]

[†] D and E have lengths $k'^{1/4}$ and $k'^{1/4}\sqrt{1-k^2}$ times that of A, respectively, where the length of B is $k'^{1/2}$ times that of A, and k is defined in the footnote to Prop. 10.29.

[‡] D and E would have lengths $k'^{1/4}$ and $k'^{1/4}/\sqrt{1+k^2}$ times that of A, respectively, where the length of B is $k'^{1/2}$ times that of A, and k is defined in the footnote to Prop. 10.30.

Λῆμμα.

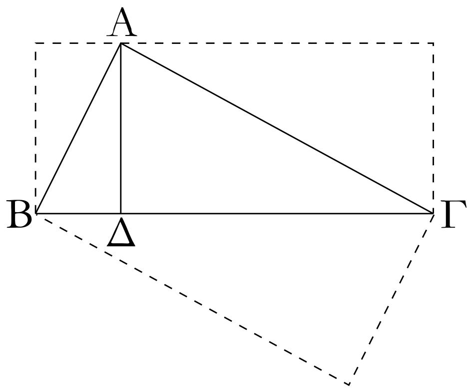
Ἔστω τρίγωνον ὀρθογώνιον τὸ ΑΒΓ ὀρθὴν ἔχον τὴν Α, καὶ ἤχθω κάθετος ἡ ΑΔ· λέγω, ὅτι τὸ μὲν ὑπὸ τῶν ΓΒΔ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΒΑ, τὸ δὲ ὑπὸ τῶν ΒΓΑ ἴσον τῷ ἀπὸ τῆς ΓΑ, καὶ τὸ ὑπὸ τῶν ΒΔ, ΔΓ ἴσον τῷ ἀπὸ τῆς ΑΔ, καὶ ἔτι τὸ ὑπὸ τῶν ΒΓ, ΑΔ ἴσον [ἐστὶ] τῷ ὑπὸ τῶν ΒΑ, ΑΓ.

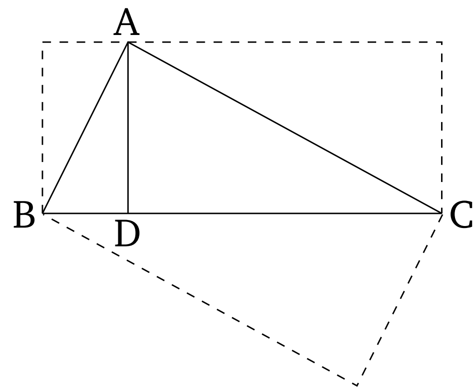
Καὶ πρῶτον, ὅτι τὸ ὑπὸ τῶν ΓΒΔ ἴσον [ἐστὶ] τῷ ἀπὸ τῆς ΒΑ.

Lemma

Let ABC be a right-angled triangle having the (angle) A a right-angle. And let the perpendicular AD have been drawn. I say that the (rectangle contained) by CBD is equal to the (square) on BA, and the (rectangle contained) by BCD (is) equal to the (square) on CA, and the (rectangle contained) by BD and DC (is) equal to the (square) on AD, and, further, the (rectangle contained) by BC and AD [is] equal to the (rectangle contained) by BA and AC.

And, first of all, (let us prove) that the (rectangle contained) by CBD [is] equal to the (square) on BA.





Ἐπεὶ γὰρ ἐν ὀρθογωνίῳ τριγώνῳ ἀπὸ τῆς ὀρθῆς γωνίας ἐπὶ τὴν βάσιν κάθετος ἦκται ἡ ΑΔ, τὰ ΑΒΔ, ΑΔΓ ἄρα τρίγωνα ὅμοιά ἐστι τῷ τε ὅλῳ τῷ ΑΒΓ καὶ ἀλλήλοις. καὶ ἐπεὶ ὅμοιόν ἐστι τὸ ΑΒΓ τρίγωνον τῷ ΑΒΔ τριγώνῳ, ἔστιν ἄρα ὡς ἡ ΓΒ πρὸς τὴν ΒΑ, οὕτως ἡ ΒΑ πρὸς τὴν ΒΔ· τὸ ἄρα ὑπὸ τῶν ΓΒΔ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΑΒ.

Διὰ τὰ αὐτὰ δὴ καὶ τὸ ὑπὸ τῶν ΒΓΔ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΑΓ.

Καὶ ἐπεί, ἐὰν ἐν ὀρθογωνίῳ τριγώνῳ ἀπὸ τῆς ὀρθῆς γωνίας ἐπὶ τὴν βάσιν κάθετος ἀχθῇ, ἡ ἀχθεῖσα τῶν τῆς βάσεως τμημάτων μέση ἀνάλογόν ἐστιν, ἔστιν ἄρα ὡς ἡ ΒΑ πρὸς τὴν ΔΑ, οὕτως ἡ ΑΔ πρὸς τὴν ΔΓ· τὸ ἄρα ὑπὸ τῶν ΒΔ, ΔΓ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΔΑ.

Λέγω, ὅτι καὶ τὸ ὑπὸ τῶν ΒΓ, ΑΔ ἴσον ἐστὶ τῷ ὑπὸ τῶν ΒΑ, ΑΓ. ἐπεὶ γάρ, ὡς ἔφαμεν, ὅμοιόν ἐστι τὸ ΑΒΓ τῷ ΑΒΔ, ἔστιν ἄρα ὡς ἡ ΒΓ πρὸς τὴν ΓΑ, οὕτως ἡ ΒΑ πρὸς τὴν ΑΔ. τὸ ἄρα ὑπὸ τῶν ΒΓ, ΑΔ ἴσον ἐστὶ τῷ ὑπὸ τῶν ΒΑ, ΑΓ· ὅπερ ἔδει δεῖξαι.

For since AD has been drawn from the right-angle in a right-angled triangle, perpendicular to the base, ABD and ADC are thus triangles (which are) similar to the whole, ABC, and to one another [Prop. 6.8]. And since triangle ABC is similar to triangle ABD, thus as CB is to BA, so BA (is) to BD [Prop. 6.4]. Thus, the (rectangle contained) by CBD is equal to the (square) on AB [Prop. 6.17].

So, for the same (reasons), the (rectangle contained) by BCD is also equal to the (square) on AC.

And since if a (straight-line) is drawn from the right-angle in a right-angled triangle, perpendicular to the base, the (straight-line so) drawn is the mean proportional to the pieces of the base [Prop. 6.8 corr.], thus as BD is to DA, so AD (is) to DC. Thus, the (rectangle contained) by BD and DC is equal to the (square) on DA [Prop. 6.17].

I also say that the (rectangle contained) by BC and AD is equal to the (rectangle contained) by BA and AC. For since, as we said, ABC is similar to ABD, thus as BC is to CA, so BA (is) to AD [Prop. 6.4]. Thus, the (rectangle contained) by BC and AD is equal to the (rectangle contained) by BA and AC [Prop. 6.16]. (Which is) the very thing it was required to show.

λγ´.

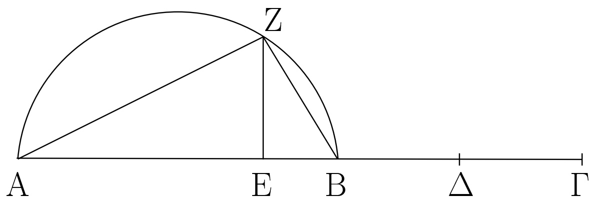
Εὑρεῖν δύο εὐθείας δυνάμει ἀσυμμέτρους ποιούσας τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾿ αὐτῶν τετραγώνων ῥητόν, τὸ δ᾿ ὑπ᾿ αὐτῶν μέσον.

Ἐκκείσθωσαν δύο ῥηταὶ δυνάμει μόνον σύμμετροι αἱ ΑΒ, ΒΓ, ὥστε τὴν μείζονα τὴν ΑΒ τῆς ἐλάσσονος τῆς ΒΓ μεῖζον δύνασθαι τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, καὶ τετμήσθω ἡ ΒΓ δίχα κατὰ τὸ Δ, καὶ τῷ ἀφ᾿ ὁποτέρας τῶν ΒΔ, ΔΓ ἴσον παρὰ τὴν ΑΒ παραβεβλήσθω παραλληλόγραμμον ἐλλεῖπον εἴδει τετραγώνῳ, καὶ ἔστω τὸ ὑπὸ τῶν ΑΕΒ, καὶ γεγράφθω ἐπὶ τῆς ΑΒ ημικύκλιον τὸ ΑΖΒ, καὶ ἤχθω τῇ ΑΒ πρὸς

Proposition 33

To find two straight-lines (which are) incommensurable in square, making the sum of the squares on them rational, and the (rectangle contained) by them medial.

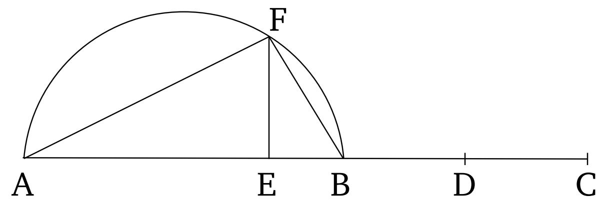
Let the two rational (straight-lines) AB and BC, (which are) commensurable in square only, be laid out such that the square on the greater, AB, is larger than (the square on) the lesser, BC, by the (square) on (some straight-line which is) incommensurable (in length) with (AB) [Prop. 10.30]. And let BC have been cut in half at D. And let a parallelogram equal to the (square) on ei-ὀρθὰς ἡ ΕΖ, καὶ ἐπεζεύχθωσαν αἱ ΑΖ, ΖΒ.



Καὶ ἐπεὶ [δύο] εὐθεῖαι ἄνισοί εἰσιν αἱ ΑΒ, ΒΓ, καὶ ἡ ΑΒ τῆς ΒΓ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, τῷ δὲ τετάρτῳ τοῦ ἀπὸ τῆς ΒΓ, τουτέστι τῷ ἀπὸ τῆς ἡμισείας αὐτῆς, ἴσον παρὰ τὴν ΑΒ παραβέβληται παραλληλόγραμμον ἐλλεῖπον εἴδει τετραγώνῳ καὶ ποιεῖ τὸ ὑπὸ τῶν ΑΕΒ, ἀσύμμετρος ἄρα ἐστὶν ἡ ΑΕ τῇ ΕΒ. καί ἐστιν ὡς ἡ ΑΕ πρὸς ΕΒ, οὕτως τὸ ὑπὸ τῶν ΒΑ, ΑΕ πρὸς τὸ ὑπὸ τῶν ΑΒ, ΒΕ, ἴσον δὲ τὸ μὲν ὑπὸ τῶν ΒΑ, ΑΕ τῷ ἀπὸ τῆς ΑΖ, τὸ δὲ ὑπὸ τῶν ΑΒ, ΒΕ τῷ ἀπὸ τῆς ΒΖ· ἀσύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΑΖ τῷ ἀπὸ τῆς ΖΒ· αἱ ΑΖ, ΖΒ ἄρα δυνάμει εἰσὶν ἀσύμμετροι. καὶ ἐπεὶ ἡ ΑΒ ῥητή ἐστιν, ῥητὸν ἄρα ἐστὶ καὶ τὸ ἀπὸ τῆς ΑΒ· ὥστε καὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΖ, ΖΒ ῥητόν ἐστιν. καὶ ἐπεὶ πάλιν τὸ ὑπὸ τῶν ΑΕ, ΕΒ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΕΖ, ὑπόκειται δὲ τὸ ὑπὸ τῶν ΑΕ, ΕΒ καὶ τῷ ἀπὸ τῆς ΒΔ ἴσον, ἴση ἄρα ἐστὶν ἡ ΖΕ τῇ ΒΔ· διπλῆ ἄρα ἡ ΒΓ τῆς ΖΕ· ὥστε καὶ τὸ ὑπὸ τῶν ΑΒ, ΒΓ σύμμετρόν ἐστι τῷ ὑπὸ τῶν ΑΒ, ΕΖ. μέσον δὲ τὸ ὑπὸ τῶν ΑΒ, ΒΓ· μέσον ἄρα καὶ τὸ ὑπὸ τῶν ΑΒ, ΕΖ. ἴσον δὲ τὸ ὑπὸ τῶν ΑΒ, ΕΖ τῷ ὑπὸ τῶν ΑΖ, ΖΒ· μέσον ἄρα καὶ τὸ ὑπὸ τῶν ΑΖ, ΖΒ. ἐδείχθη δὲ καὶ ῥητὸν τὸ συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων.

Εὕρηνται ἄρα δύο εὐθεῖαι δυνάμει ἀσύμμετροι αἱ ΑΖ, ΖΒ ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων ῥητόν, τὸ δὲ ὑπ᾽ αὐτῶν μέσον· ὅπερ ἔδει δεῖξαι.

ther of BD or DC, (and) falling short by a square figure, have been applied to AB [Prop. 6.28], and let it be the (rectangle contained) by AEB. And let the semi-circle AFB have been drawn on AB. And let EF have been drawn at right-angles to AB. And let AF and FB have been joined.



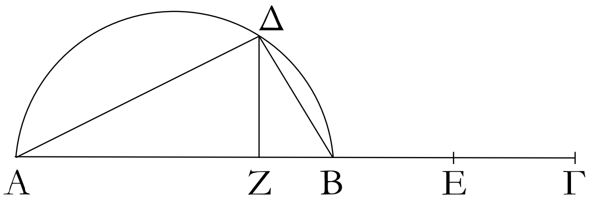
And since AB and BC are [two] unequal straight-lines, and the square on AB is greater than (the square on) BC by the (square) on (some straight-line which is) incommensurable (in length) with (AB). And a parallelogram, equal to one quarter of the (square) on BC—that is to say, (equal) to the (square) on half of it—(and) falling short by a square figure, has been applied to AB, and makes the (rectangle contained) by AEB. AE is thus incommensurable (in length) with EB [Prop. 10.18]. And as AE is to EB, so the (rectangle contained) by BA and AE (is) to the (rectangle contained) by AB and BE. And the (rectangle contained) by BA and AE (is) equal to the (square) on AF, and the (rectangle contained) by AB and BE to the (square) on BF [Prop. 10.32 lem.]. The (square) on AF is thus incommensurable with the (square) on FB [Prop. 10.11]. Thus, AF and FB are incommensurable in square. And since AB is rational, the (square) on AB is also rational. Hence, the sum of the (squares) on AF and FB is also rational [Prop. 1.47]. And, again, since the (rectangle contained) by AE and EB is equal to the (square) on EF, and the (rectangle contained) by AE and EB was assumed (to be) equal to the (square) on BD, FE is thus equal to BD. Thus, BC is double FE. And hence the (rectangle contained) by AB and BC is commensurable with the (rectangle contained) by AB and EF [Prop. 10.6]. And the (rectangle contained) by AB and BC (is) medial [Prop. 10.21]. Thus, the (rectangle contained) by AB and EF (is) also medial [Prop. 10.23 corr.]. And the (rectangle contained) by AB and EF (is) equal to the (rectangle contained) by AF and FB [Prop. 10.32 lem.]. Thus, the (rectangle contained) by AF and FB (is) also medial. And the sum of the squares on them was also shown (to be) rational.

Thus, the two straight-lines, AF and FB, (which are) incommensurable in square, have been found, making the sum of the squares on them rational, and the (rectangle contained) by them medial. (Which is) the very thing it was required to show.

† AF and FB have lengths $\sqrt{[1+k/(1+k^2)^{1/2}]/2}$ and $\sqrt{[1-k/(1+k^2)^{1/2}]/2}$ times that of AB, respectively, where k is defined in the footnote to Prop. 10.30.

λδ΄.

Εὑρεῖν δύο εὐθείας δυνάμει ἀσυμμέτρους ποιούσας τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον, τὸ δ᾽ ὑπ᾽ αὐτῶν ῥητόν.



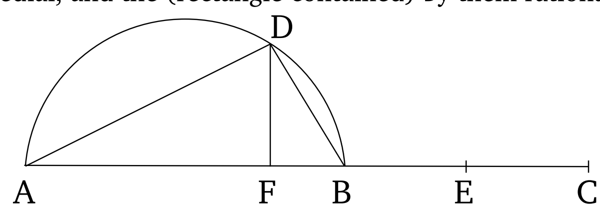
Ἐκκείσθωσαν δύο μέσαι δυνάμει μόνον σύμμετροι αἱ ΑΒ, ΒΓ ῥητὸν περιέχουσαι τὸ ὑπ᾽ αὐτῶν, ὥστε τὴν ΑΒ τῆς ΒΓ μεῖζον δύνασθαι τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, καὶ γεγράφθω ἐπὶ τῆς ΑΒ τὸ ΑΔΒ ἡμικύκλιον, καὶ τετμήσθω ἡ ΒΓ δίχα κατὰ τὸ Ε, καὶ παραβεβλήσθω παρὰ τὴν ΑΒ τῷ ἀπὸ τῆς ΒΕ ἴσον παραλληλόγραμμον ἐλλεῖπον εἴδει τετραγώνῳ τὸ ὑπὸ τῶν ΑΖΒ· ἀσύμμετρος ἄρα [ἐστὶν] ἡ ΑΖ τῇ ΖΒ μήκει. καὶ ἤχθω ἀπὸ τοῦ Ζ τῇ ΑΒ πρὸς ὀρθὰς ἡ ΖΔ, καὶ ἐπεζεύχθωσαν αἱ ΑΔ, ΔΒ.

Ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΑΖ τῇ ΖΒ, ἀσύμμετρον ἄρα ἐστὶ καὶ τὸ ὑπὸ τῶν ΒΑ, ΑΖ τῷ ὑπὸ τῶν ΑΒ, ΒΖ. ἴσον δὲ τὸ μὲν ὑπὸ τῶν ΒΑ, ΑΖ τῷ ἀπὸ τῆς ΑΔ, τὸ δὲ ὑπὸ τῶν ΑΒ, ΒΖ τῷ ἀπὸ τῆς ΔΒ· ἀσύμμετρον ἄρα ἐστὶ καὶ τὸ ἀπὸ τῆς ΑΔ τῷ ἀπὸ τῆς ΔΒ. καὶ ἐπεὶ μέσον ἐστὶ τὸ ἀπὸ τῆς ΑΒ, μέσον ἄρα καὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΔ, ΔΒ. καὶ ἐπεὶ διπλῆ ἐστιν ἡ ΒΓ τῆς ΔΖ, διπλάσιον ἄρα καὶ τὸ ὑπὸ τῶν ΑΒ, ΒΓ τοῦ ὑπὸ τῶν ΑΒ, ΖΔ. ῥητὸν δὲ τὸ ὑπὸ τῶν ΑΒ, ΒΓ· ῥητὸν ἄρα καὶ τὸ ὑπὸ τῶν ΑΒ, ΖΔ. τὸ δὲ ὑπὸ τῶν ΑΒ, ΖΔ ἴσον τῷ ὑπὸ τῶν ΑΔ, ΔΒ· ὥστε καὶ τὸ ὑπὸ τῶν ΑΔ, ΔΒ ῥητόν ἐστιν.

Εὕρηνται ἄρα δύο εὐθεῖαι δυνάμει ἀσύμμετροι αἱ ΑΔ, ΔΒ ποιοῦσαι τὸ [μὲν] συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον, τὸ δ᾽ ὑπ᾽ αὐτῶν ῥητόν· ὅπερ ἔδει δεῖξαι.

Proposition 34

To find two straight-lines (which are) incommensurable in square, making the sum of the squares on them medial, and the (rectangle contained) by them rational.



Let the two medial (straight-lines) AB and BC, (which are) commensurable in square only, be laid out having the (rectangle contained) by them rational, (and) such that the square on AB is greater than (the square on) BC by the (square) on (some straight-line) incommensurable (in length) with (AB) [Prop. 10.31]. And let the semi-circle ADB have been drawn on AB. And let BC have been cut in half at E. And let a (rectangular) parallelogram equal to the (square) on BE, (and) falling short by a square figure, have been applied to AB, (and let it be) the (rectangle contained by) AFB [Prop. 6.28]. Thus, AF [is] incommensurable in length with FB [Prop. 10.18]. And let FD have been drawn from F at right-angles to AB. And let AD and DB have been joined.

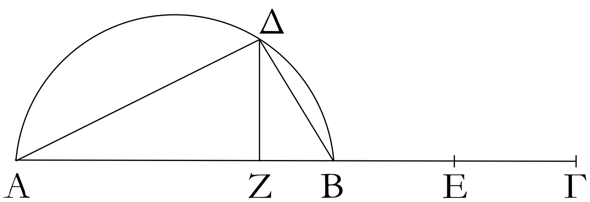
Since AF is incommensurable (in length) with FB, the (rectangle contained) by BA and AF is thus also incommensurable with the (rectangle contained) by AB and BF [Prop. 10.11]. And the (rectangle contained) by BA and AF (is) equal to the (square) on AD, and the (rectangle contained) by AB and BF to the (square) on DB [Prop. 10.32 lem.]. Thus, the (square) on AD is also incommensurable with the (square) on DB. And since the (square) on AB is medial, the sum of the (squares) on AD and DB (is) thus also medial [Props. 3.31, 1.47]. And since BC is double DF [see previous proposition], the (rectangle contained) by AB and BC (is) thus also double the (rectangle contained) by AB and FD. And the (rectangle contained) by AB and BC (is) rational. Thus, the (rectangle contained) by AB and FD (is) also rational [Prop. 10.6, Def. 10.4]. And the (rectangle contained) by AB and FD (is) equal to the (rectangle contained) by AD and DB [Prop. 10.32 lem.]. And hence the (rectangle contained) by AD and DB is rational.

Thus, two straight-lines, AD and DB, (which are) incommensurable in square, have been found, making the sum of the squares on them medial, and the (rectangle contained) by them rational.† (Which is) the very thing it was required to show.

† AD and DB have lengths $\sqrt{[(1+k^2)^{1/2}+k]/[2\,(1+k^2)]}$ and $\sqrt{[(1+k^2)^{1/2}-k]/[2\,(1+k^2)]}$ times that of AB, respectively, where k is defined in the footnote to Prop. 10.29.

λε΄.

Εὑρεῖν δύο εὐθείας δυνάμει ἀσυμμέτρους ποιούσας τό τε συγκείμενον ἐκ τῶν ἀπ᾿ αὐτῶν τετραγώνων μέσον καὶ τὸ ὑπ᾿ αὐτῶν μέσον καὶ ἔτι ἀσύμμετρον τῷ συγκειμένῳ ἐκ τῶν ἀπ᾿ αὐτῶν τετραγώνῳ.



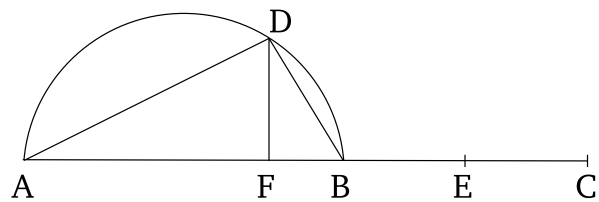
Ἐκκείσθωσαν δύο μέσαι δυνάμει μόνον σύμμετροι αἱ ΑΒ, ΒΓ μέσον περιέχουσαι, ὥστε τὴν ΑΒ τῆς ΒΓ μεῖζον δύνασθαι τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, καὶ γεγράφθω ἐπὶ τῆς ΑΒ ἡμικύκλιον τὸ ΑΔΒ, καὶ τὰ λοιπὰ γεγονέτω τοῖς ἐπάνω ὁμοίως.

Καὶ ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΑΖ τῇ ΖΒ μήκει, ἀσύμμετρός ἐστι καὶ ἡ ΑΔ τῇ ΔΒ δυνάμει. καὶ ἐπεὶ μέσον ἐστὶ τὸ ἀπὸ τῆς ΑΒ, μέσον ἄρα καὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΔ, ΔΒ. καὶ ἐπεὶ τὸ ὑπὸ τῶν ΑΖ, ΖΒ ἴσον ἐστὶ τῷ ἀφ᾿ ἑκατέρας τῶν ΒΕ, ΔΖ, ἴση ἄρα ἐστὶν ἡ ΒΕ τῇ ΔΖ· διπλῆ ἄρα ἡ ΒΓ τῆς ΖΔ· ὥστε καὶ τὸ ὑπὸ τῶν ΑΒ, ΒΓ διπλάσιόν ἐστι τοῦ ὑπὸ τῶν ΑΒ, ΖΔ. μέσον δὲ τὸ ὑπὸ τῶν ΑΒ, ΒΓ· μέσον ἄρα καὶ τὸ ὑπὸ τῶν ΑΒ, ΖΔ. καί ἐστιν ἴσον τῷ ὑπὸ τῶν ΑΔ, ΔΒ· μέσον ἄρα καὶ τὸ ὑπὸ τῶν ΑΔ, ΔΒ. καὶ ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΑΒ τῇ ΒΓ μήκει, σύμμετρος δὲ ἡ ΓΒ τῇ ΒΕ, ἀσύμμετρος ἄρα καὶ ἡ ΑΒ τῇ ΒΕ μήκει· ὥστε καὶ τὸ ἀπὸ τῆς ΑΒ τῷ ὑπὸ τῶν ΑΒ, ΒΕ ἀσύμμετρόν ἐστιν. ἀλλὰ τῷ μὲν ἀπὸ τῆς ΑΒ ἴσα ἐστὶ τὰ ἀπὸ τῶν ΑΔ, ΔΒ, τῷ δὲ ὑπὸ τῶν ΑΒ, ΒΕ ἴσον ἐστὶ τὸ ὑπὸ τῶν ΑΒ, ΖΔ, τουτέστι τὸ ὑπὸ τῶν ΑΔ, ΔΒ· ἀσύμμετρον ἄρα ἐστὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΔ, ΔΒ τῷ ὑπὸ τῶν ΑΔ, ΔΒ.

Εὕρηνται ἄρα δύο εὐθεῖαι αἱ ΑΔ, ΔΒ δυνάμει ἀσύμμετροι ποιοῦσαι τό τε συγκείμενον ἐκ τῶν ἀπ᾿ αὐτῶν μέσον καὶ τὸ ὑπ᾿ αὐτῶν μέσον καὶ ἔτι ἀσύμμετρον τῷ συγκειμένῳ ἐκ τῶν ἀπ᾿ αὐτῶν τετραγώνων· ὅπερ ἔδει δεῖξαι.

Proposition 35

To find two straight-lines (which are) incommensurable in square, making the sum of the squares on them medial, and the (rectangle contained) by them medial, and, moreover, incommensurable with the sum of the squares on them.



Let the two medial (straight-lines) AB and BC, (which are) commensurable in square only, be laid out containing a medial (area), such that the square on AB is greater than (the square on) BC by the (square) on (some straight-line) incommensurable (in length) with (AB) [Prop. 10.32]. And let the semi-circle ADB have been drawn on AB. And let the remainder (of the figure) be generated similarly to the above (proposition).

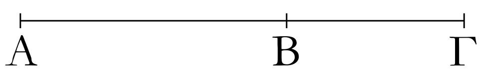
And since AF is incommensurable in length with FB [Prop. 10.18], AD is also incommensurable in square with DB [Prop. 10.11]. And since the (square) on AB is medial, the sum of the (squares) on AD and DB (is) thus also medial [Props. 3.31, 1.47]. And since the (rectangle contained) by AF and FB is equal to the (square) on each of BE and DF, BE is thus equal to DF. Thus, BC (is) double FD. And hence the (rectangle contained) by AB and BC is double the (rectangle) contained by AB and FD. And the (rectangle contained) by AB and BC (is) medial. Thus, the (rectangle contained) by AB and FD (is) also medial. And it is equal to the (rectangle contained) by AD and DB [Prop. 10.32 lem.]. Thus, the (rectangle contained) by AD and DB (is) also medial. And since AB is incommensurable in length with BC, and CB (is) commensurable (in length) with BE, AB (is) thus also incommensurable in length with BE [Prop. 10.13]. And hence the (square) on AB is also incommensurable with the (rectangle contained) by AB and BE [Prop. 10.11]. But the (sum of the squares) on AD and DB is equal to the (square) on AB [Prop. 1.47]. And the (rectangle contained) by AB and FD—that is to say, the (rectangle contained) by AD and DB—is equal to the (rectangle contained) by AB and BE. Thus, the sum of the (squares) on AD and DB is incommensurable with the (rectangle contained) by AD and DB.

Thus, two straight-lines, AD and DB, (which are) incommensurable in square, have been found, making the sum of the (squares) on them medial, and the (rectangle contained) by them medial, and, moreover, incommensurable with the sum of the squares on them.† (Which is) the very thing it was required to show.

† AD and DB have lengths $k'^{1/4}\sqrt{[1+k/(1+k^2)^{1/2}]/2}$ and $k'^{1/4}\sqrt{[1-k/(1+k^2)^{1/2}]/2}$ times that of AB, respectively, where k and k' are defined in the footnote to Prop. 10.32.

λϛ΄.

Ἐὰν δύο ῥηταὶ δυνάμει μόνον σύμμετροι συντεθῶσιν, ἡ ὅλη ἄλογός ἐστιν, καλείσθω δὲ ἐκ δύο ὀνομάτων.

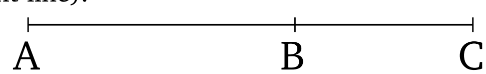


Συγκείσθωσαν γὰρ δύο ῥηταὶ δυνάμει μόνον σύμμετροι αἱ ΑΒ, ΒΓ· λέγω, ὅτι ὅλη ἡ ΑΓ ἄλογός ἐστιν.

Ἐπεὶ γὰρ ἀσύμμετρός ἐστιν ἡ ΑΒ τῇ ΒΓ μήκει· δυνάμει γὰρ μόνον εἰσὶ σύμμετροι· ὡς δὲ ἡ ΑΒ πρὸς τὴν ΒΓ, οὕτως τὸ ὑπὸ τῶν ΑΒΓ πρὸς τὸ ἀπὸ τῆς ΒΓ, ἀσύμμετρον ἄρα ἐστὶ τὸ ὑπὸ τῶν ΑΒ, ΒΓ τῷ ἀπὸ τῆς ΒΓ. ἀλλὰ τῷ μὲν ὑπὸ τῶν ΑΒ, ΒΓ σύμμετρόν ἐστι τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ, τῷ δὲ ἀπὸ τῆς ΒΓ σύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΒ, ΒΓ· αἱ γὰρ ΑΒ, ΒΓ ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀσύμμετρον ἄρα ἐστὶ τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ τοῖς ἀπὸ τῶν ΑΒ, ΒΓ. καὶ συνθέντι τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ μετὰ τῶν ἀπὸ τῶν ΑΒ, ΒΓ, τουτέστι τὸ ἀπὸ τῆς ΑΓ, ἀσύμμετρόν ἐστι τῷ συγκειμένῳ ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ· ῥητὸν δὲ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ· ἄλογον ἄρα [ἐστὶ] τὸ ἀπὸ τῆς ΑΓ· ὥστε καὶ ἡ ΑΓ ἄλογός ἐστιν, καλείσθω δὲ ἐκ δύο ὀνομάτων· ὅπερ ἔδει δεῖξαι.

Proposition 36

If two rational (straight-lines which are) commensurable in square only are added together then the whole (straight-line) is irrational—let it be called a binomial (straight-line).†



For let the two rational (straight-lines), AB and BC, (which are) commensurable in square only, be laid down together. I say that the whole (straight-line), AC, is irrational. For since AB is incommensurable in length with BC—for they are commensurable in square only—and as AB (is) to BC, so the (rectangle contained) by ABC (is) to the (square) on BC, the (rectangle contained) by AB and BC is thus incommensurable with the (square) on BC [Prop. 10.11]. But, twice the (rectangle contained) by AB and BC is commensurable with the (rectangle contained) by AB and BC [Prop. 10.6]. And (the sum of) the (squares) on AB and BC is commensurable with the (square) on BC—for the rational (straight-lines) AB and BC are commensurable in square only [Prop. 10.15]. Thus, twice the (rectangle contained) by AB and BC is incommensurable with (the sum of) the (squares) on AB and BC [Prop. 10.13]. And, via composition, twice the (rectangle contained) by AB and BC, plus (the sum of) the (squares) on AB and BC—that is to say, the (square) on AC [Prop. 2.4]—is incommensurable with the sum of the (squares) on AB and BC [Prop. 10.16]. And the sum of the (squares) on AB and BC (is) rational. Thus, the (square) on AC [is] irrational [Def. 10.4]. Hence, AC is also irrational [Def. 10.4]—let it be called a binomial (straight-line).‡ (Which is) the very thing it was required to show.

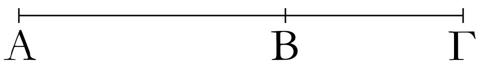
† Literally, "from two names".

‡ Thus, a binomial straight-line has a length expressible as $1+k^{1/2}$ [or, more generally, $\rho\,(1+k^{1/2})$, where ρ is rational—the same proviso applies to the definitions in the following propositions]. The binomial and the corresponding apotome, whose length is expressible as $1-k^{1/2}$

(see Prop. 10.73), are the positive roots of the quartic $x^4 - 2\,(1+k)\,x^2 + (1-k)^2 = 0$.

λζ´.

Ἐὰν δύο μέσαι δυνάμει μόνον σύμμετροι συντεθῶσι ῥητὸν περιέχουσαι, ἡ ὅλη ἄλογός ἐστιν, καλείσθω δὲ ἐκ δύο μέσων πρώτη.

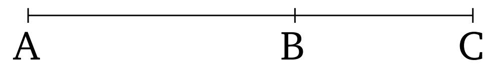


Συγκείσθωσαν γὰρ δύο μέσαι δυνάμει μόνον σύμμετροι αἱ ΑΒ, ΒΓ ῥητὸν περιέχουσαι· λέγω, ὅτι ὅλη ἡ ΑΓ ἄλογός ἐστιν.

Ἐπεὶ γὰρ ἀσύμμετρός ἐστιν ἡ ΑΒ τῇ ΒΓ μήκει, καὶ τὰ ἀπὸ τῶν ΑΒ, ΒΓ ἄρα ἀσύμμετρά ἐστι τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ· καὶ συνθέντι τὰ ἀπὸ τῶν ΑΒ, ΒΓ μετὰ τοῦ δὶς ὑπὸ τῶν ΑΒ, ΒΓ, ὅπερ ἐστὶ τὸ ἀπὸ τῆς ΑΓ, ἀσύμμετρόν ἐστι τῷ ὑπὸ τῶν ΑΒ, ΒΓ. ῥητὸν δὲ τὸ ὑπὸ τῶν ΑΒ, ΒΓ· ὑπόκεινται γὰρ αἱ ΑΒ, ΒΓ ῥητὸν περιέχουσαι· ἄλογον ἄρα τὸ ἀπὸ τῆς ΑΓ· ἄλογος ἄρα ἡ ΑΓ, καλείσθω δὲ ἐκ δύο μέσων πρώτη· ὅπερ ἔδει δεῖξαι.

Proposition 37

If two medial (straight-lines), commensurable in square only, which contain a rational (area), are added together then the whole (straight-line) is irrational—let it be called a first bimedial (straight-line).[†]



For let the two medial (straight-lines), AB and BC, commensurable in square only, (and) containing a rational (area), be laid down together. I say that the whole (straight-line), AC, is irrational.

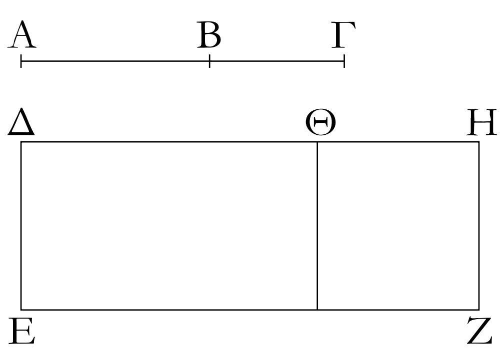
For since AB is incommensurable in length with BC, (the sum of) the (squares) on AB and BC is thus also incommensurable with twice the (rectangle contained) by AB and BC [see previous proposition]. And, via composition, (the sum of) the (squares) on AB and BC, plus twice the (rectangle contained) by AB and BC—that is, the (square) on AC [Prop. 2.4]—is incommensurable with the (rectangle contained) by AB and BC [Prop. 10.16]. And the (rectangle contained) by AB and BC (is) rational—for AB and BC were assumed to enclose a rational (area). Thus, the (square) on AC (is) irrational. Thus, AC (is) irrational [Def. 10.4]—let it be called a first bimedial (straight-line).[‡] (Which is) the very thing it was required to show.

[†] Literally, "first from two medials".

[‡] Thus, a first bimedial straight-line has a length expressible as $k^{1/4} + k^{3/4}$. The first bimedial and the corresponding first apotome of a medial, whose length is expressible as $k^{1/4} - k^{3/4}$ (see Prop. 10.74), are the positive roots of the quartic $x^4 - 2\sqrt{k}\,(1+k)\,x^2 + k\,(1-k)^2 = 0$.

λη´.

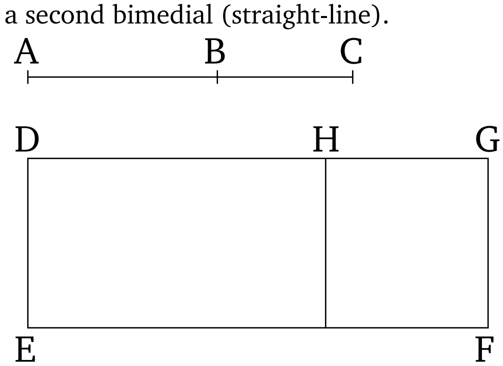
Ἐὰν δύο μέσαι δυνάμει μόνον σύμμετροι συντεθῶσι μέσον περιέχουσαι, ἡ ὅλη ἄλογός ἐστιν, καλείσθω δὲ ἐκ δύο μέσων δευτέρα.



Συγκείσθωσαν γὰρ δύο μέσαι δυνάμει μόνον σύμμετροι αἱ ΑΒ, ΒΓ μέσον περιέχουσαι· λέγω, ὅτι ἄλογός ἐστιν ἡ

Proposition 38

If two medial (straight-lines), commensurable in square only, which contain a medial (area), are added together then the whole (straight-line) is irrational—let it be called a second bimedial (straight-line).



For let the two medial (straight-lines), AB and BC, commensurable in square only, (and) containing a medial

ΑΓ.

Ἐκκείσθω γὰρ ῥητὴ ἡ ΔΕ, καὶ τῷ ἀπὸ τῆς ΑΓ ἴσον παρὰ τὴν ΔΕ παραβεβλήσθω τὸ ΔΖ πλάτος ποιοῦν τὴν ΔΗ. καὶ ἐπεὶ τὸ ἀπὸ τῆς ΑΓ ἴσον ἐστὶ τοῖς τε ἀπὸ τῶν ΑΒ, ΒΓ καὶ τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ, παραβεβλήσθω δὴ τοῖς ἀπὸ τῶν ΑΒ, ΒΓ παρὰ τὴν ΔΕ ἴσον τὸ ΕΘ· λοιπὸν ἄρα τὸ ΘΖ ἴσον ἐστὶ τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ. καὶ ἐπεὶ μέση ἐστὶν ἑκατέρα τῶν ΑΒ, ΒΓ, μέσα ἄρα ἐστὶ καὶ τὰ ἀπὸ τῶν ΑΒ, ΒΓ. μέσον δὲ ὑπόκειται καὶ τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ. καί ἐστι τοῖς μὲν ἀπὸ τῶν ΑΒ, ΒΓ ἴσον τὸ ΕΘ, τῷ δὲ δὶς ὑπὸ τῶν ΑΒ, ΒΓ ἴσον τὸ ΖΘ· μέσον ἄρα ἑκάτερον τῶν ΕΘ, ΘΖ. καὶ παρὰ ῥητὴν τὴν ΔΕ παράκειται· ῥητὴ ἄρα ἐστὶν ἑκατέρα τῶν ΔΘ, ΘΗ καὶ ἀσύμμετρος τῇ ΔΕ μήκει. ἐπεὶ οὖν ἀσύμμετρός ἐστιν ἡ ΑΒ τῇ ΒΓ μήκει, καί ἐστιν ὡς ἡ ΑΒ πρὸς τὴν ΒΓ, οὕτως τὸ ἀπὸ τῆς ΑΒ πρὸς τὸ ὑπὸ τῶν ΑΒ, ΒΓ, ἀσύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΑΒ τῷ ὑπὸ τῶν ΑΒ, ΒΓ. ἀλλὰ τῷ μὲν ἀπὸ τῆς ΑΒ σύμμετρόν ἐστι τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ τετραγώνων, τῷ δὲ ὑπὸ τῶν ΑΒ, ΒΓ σύμμετρόν ἐστι τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ. ἀσύμμετρον ἄρα ἐστὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ. ἀλλὰ τοῖς μὲν ἀπὸ τῶν ΑΒ, ΒΓ ἴσον ἐστὶ τὸ ΕΘ, τῷ δὲ δὶς ὑπὸ τῶν ΑΒ, ΒΓ ἴσον ἐστὶ τὸ ΘΖ. ἀσύμμετρον ἄρα ἐστὶ τὸ ΕΘ τῷ ΘΖ· ὥστε καὶ ἡ ΔΘ τῇ ΘΗ ἐστιν ἀσύμμετρος μήκει. αἱ ΔΘ, ΘΗ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. ὥστε ἡ ΔΗ ἄλογός ἐστιν. ῥητὴ δὲ ἡ ΔΕ· τὸ δὲ ὑπὸ ἀλόγου καὶ ῥητῆς περιεχόμενον ὀρθογώνιον ἄλογόν ἐστιν· ἄλογον ἄρα ἐστὶ τὸ ΔΖ χωρίον, καὶ ἡ δυναμένη [αὐτὸ] ἄλογός ἐστιν. δύναται δὲ τὸ ΔΖ ἡ ΑΓ· ἄλογος ἄρα ἐστὶν ἡ ΑΓ, καλείσθω δὲ ἐκ δύο μέσων δευτέρα. ὅπερ ἔδει δεῖξαι.

(area), be laid down together [Prop. 10.28]. I say that AC is irrational.

For let the rational (straight-line) DE be laid down, and let (the rectangle) DF, equal to the (square) on AC, have been applied to DE, making DG as breadth [Prop. 1.44]. And since the (square) on AC is equal to (the sum of) the (squares) on AB and BC, plus twice the (rectangle contained) by AB and BC [Prop. 2.4], so let (the rectangle) EH, equal to (the sum of) the squares on AB and BC, have been applied to DE. The remainder HF is thus equal to twice the (rectangle contained) by AB and BC. And since AB and BC are each medial, (the sum of) the squares on AB and BC is thus also medial.‡ And twice the (rectangle contained) by AB and BC was also assumed (to be) medial. And EH is equal to (the sum of) the squares on AB and BC, and FH (is) equal to twice the (rectangle contained) by AB and BC. Thus, EH and HF (are) each medial. And they were applied to the rational (straight-line) DE. Thus, DH and HG are each rational, and incommensurable in length with DE [Prop. 10.22]. Therefore, since AB is incommensurable in length with BC, and as AB is to BC, so the (square) on AB (is) to the (rectangle contained) by AB and BC [Prop. 10.21 lem.], the (square) on AB is thus incommensurable with the (rectangle contained) by AB and BC [Prop. 10.11]. But, the sum of the squares on AB and BC is commensurable with the (square) on AB [Prop. 10.15], and twice the (rectangle contained) by AB and BC is commensurable with the (rectangle contained) by AB and BC [Prop. 10.6]. Thus, the sum of the (squares) on AB and BC is incommensurable with twice the (rectangle contained) by AB and BC [Prop. 10.13]. But, EH is equal to (the sum of) the squares on AB and BC, and HF is equal to twice the (rectangle) contained by AB and BC. Thus, EH is incommensurable with HF. Hence, DH is also incommensurable in length with HG [Props. 6.1, 10.11]. Thus, DH and HG are rational (straight-lines which are) commensurable in square only. Hence, DG is irrational [Prop. 10.36]. And DE (is) rational. And the rectangle contained by irrational and rational (straight-lines) is irrational [Prop. 10.20]. The area DF is thus irrational, and (so) the square-root [of it] is irrational [Def. 10.4]. And AC is the square-root of DF. AC is thus irrational—let it be called a second bimedial (straight-line).§ (Which is) the very thing it was required to show.

† Literally, "second from two medials".

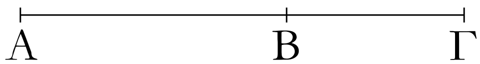
‡ Since, by hypothesis, the squares on AB and BC are commensurable—see Props. 10.15, 10.23.

§ Thus, a second bimedial straight-line has a length expressible as $k^{1/4} + k'^{1/2}/k^{1/4}$. The second bimedial and the corresponding second apotome of a medial, whose length is expressible as $k^{1/4} - k'^{1/2}/k^{1/4}$ (see Prop. 10.75), are the positive roots of the quartic $x^4 - 2\left[(k+k')/\sqrt{k}\right]x^2 +$

$[(k-k')^2/k]=0$.

λθ'.

Ἐὰν δύο εὐθεῖαι δυνάμει ἀσύμμετροι συντεθῶσι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων ῥητόν, τὸ δ᾽ ὑπ᾽ αὐτῶν μέσον, ἡ ὅλη εὐθεῖα ἄλογός ἐστιν, καλείσθω δὲ μείζων.

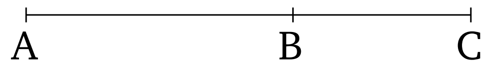


Συγκείσθωσαν γὰρ δύο εὐθεῖαι δυνάμει ἀσύμμετροι αἱ ΑΒ, ΒΓ ποιοῦσαι τὰ προκείμενα· λέγω, ὅτι ἄλογός ἐστιν ἡ ΑΓ.

Ἐπεὶ γὰρ τὸ ὑπὸ τῶν ΑΒ, ΒΓ μέσον ἐστίν, καὶ τὸ δὶς [ἄρα] ὑπὸ τῶν ΑΒ, ΒΓ μέσον ἐστίν. τὸ δὲ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ ῥητόν· ἀσύμμετρον ἄρα ἐστὶ τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ τῷ συγκειμένῳ ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ· ὥστε καὶ τὰ ἀπὸ τῶν ΑΒ, ΒΓ μετὰ τοῦ δὶς ὑπὸ τῶν ΑΒ, ΒΓ, ὅπερ ἐστὶ τὸ ἀπὸ τῆς ΑΓ, ἀσύμμετρόν ἐστι τῷ συγκειμένῳ ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ [ῥητὸν δὲ τὸ συγμείμενον ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ]· ἄλογον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΑΓ. ὥστε καὶ ἡ ΑΓ ἄλογός ἐστιν, καλείσθω δὲ μείζων. ὅπερ ἔδει δεῖξαι.

Proposition 39

If two straight-lines (which are) incommensurable in square, making the sum of the squares on them rational, and the (rectangle contained) by them medial, are added together then the whole straight-line is irrational—let it be called a major (straight-line).



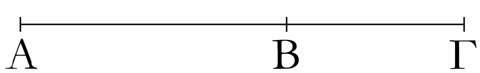
For let the two straight-lines, AB and BC, incommensurable in square, and fulfilling the prescribed (conditions), be laid down together [Prop. 10.33]. I say that AC is irrational.

For since the (rectangle contained) by AB and BC is medial, twice the (rectangle contained) by AB and BC is [thus] also medial [Props. 10.6, 10.23 corr.]. And the sum of the (squares) on AB and BC (is) rational. Thus, twice the (rectangle contained) by AB and BC is incommensurable with the sum of the (squares) on AB and BC [Def. 10.4]. Hence, (the sum of) the squares on AB and BC, plus twice the (rectangle contained) by AB and BC—that is, the (square) on AC [Prop. 2.4]—is also incommensurable with the sum of the (squares) on AB and BC [Prop. 10.16] [and the sum of the (squares) on AB and BC (is) rational]. Thus, the (square) on AC is irrational. Hence, AC is also irrational [Def. 10.4]—let it be called a major (straight-line).† (Which is) the very thing it was required to show.

† Thus, a major straight-line has a length expressible as $\sqrt{[1+k/(1+k^2)^{1/2}]/2}+\sqrt{[1-k/(1+k^2)^{1/2}]/2}$. The major and the corresponding minor, whose length is expressible as $\sqrt{[1+k/(1+k^2)^{1/2}]/2}-\sqrt{[1-k/(1+k^2)^{1/2}]/2}$ (see Prop. 10.76), are the positive roots of the quartic $x^4-2\,x^2+k^2/(1+k^2)=0$.

μ'.

Ἐὰν δύο εὐθεῖαι δυνάμει ἀσύμμετροι συντεθῶσι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον, τὸ δ᾽ ὑπ᾽ αὐτῶν ῥητόν, ἡ ὅλη εὐθεῖα ἄλογός ἐστιν, καλείσθω δὲ ῥητὸν καὶ μέσον δυναμένη.



Συγκείσθωσαν γὰρ δύο εὐθεῖαι δυνάμει ἀσύμμετροι αἱ ΑΒ, ΒΓ ποιοῦσαι τὰ προκείμενα· λέγω, ὅτι ἄλογός ἐστιν ἡ ΑΓ.

Ἐπεὶ γὰρ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ μέσον ἐστίν, τὸ δὲ δὶς ὑπὸ τῶν ΑΒ, ΒΓ ῥητόν, ἀσύμμετρον ἄρα ἐστὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ τῷ δὶς

Proposition 40

If two straight-lines (which are) incommensurable in square, making the sum of the squares on them medial, and the (rectangle contained) by them rational, are added together then the whole straight-line is irrational—let it be called the square-root of a rational plus a medial (area).

For let the two straight-lines, AB and BC, incommensurable in square, (and) fulfilling the prescribed (conditions), be laid down together [Prop. 10.34]. I say that AC is irrational.

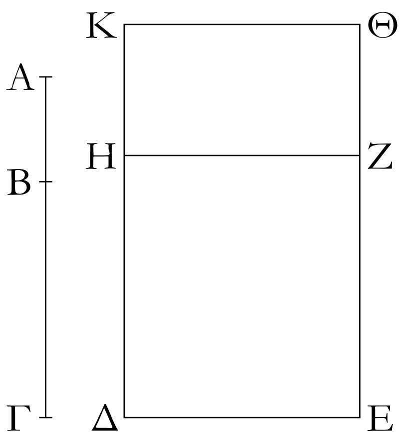
For since the sum of the (squares) on AB and BC is medial, and twice the (rectangle contained) by AB and ὑπὸ τῶν ΑΒ, ΒΓ· ὥστε καὶ τὸ ἀπὸ τῆς ΑΓ ἀσύμμετρόν ἐστι τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ. ῥητὸν δὲ τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ· ἄλογον ἄρα τὸ ἀπὸ τῆς ΑΓ. ἄλογος ἄρα ἡ ΑΓ, καλείσθω δὲ ῥητὸν καὶ μέσον δυναμένη. ὅπερ ἔδει δεῖξαι.

BC (is) rational, the sum of the (squares) on AB and BC is thus incommensurable with twice the (rectangle contained) by AB and BC. Hence, the (square) on AC is also incommensurable with twice the (rectangle contained) by AB and BC [Prop. 10.16]. And twice the (rectangle contained) by AB and BC (is) rational. The (square) on AC (is) thus irrational. Thus, AC (is) irrational [Def. 10.4]—let it be called the square-root of a rational plus a medial (area).† (Which is) the very thing it was required to show.

† Thus, the square-root of a rational plus a medial (area) has a length expressible as $\sqrt{[(1+k^2)^{1/2}+k]/[2\,(1+k^2)]}+\sqrt{[(1+k^2)^{1/2}-k]/[2\,(1+k^2)]}$. This and the corresponding irrational with a minus sign, whose length is expressible as $\sqrt{[(1+k^2)^{1/2}+k]/[2\,(1+k^2)]}-\sqrt{[(1+k^2)^{1/2}-k]/[2\,(1+k^2)]}$ (see Prop. 10.77), are the positive roots of the quartic $x^4-(2/\sqrt{1+k^2})\,x^2+k^2/(1+k^2)^2=0$.

μαʹ.

Ἐὰν δύο εὐθεῖαι δυνάμει ἀσύμμετροι συντεθῶσι ποιοῦσαι τό τε συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον καὶ τὸ ὑπ᾽ αὐτῶν μέσον καὶ ἔτι ἀσύμμετρον τῷ συγκειμένῳ ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων, ἡ ὅλη εὐθεῖα ἄλογός ἐστιν, καλείσθω δὲ δύο μέσα δυναμένη.

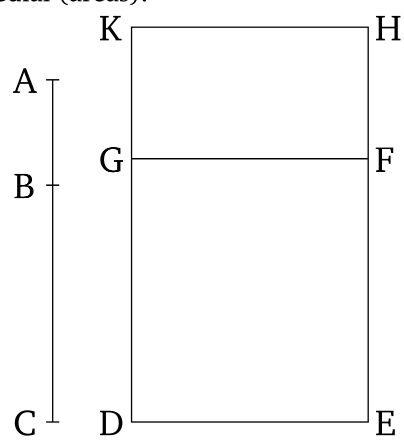


Συγκείσθωσαν γὰρ δύο εὐθεῖαι δυνάμει ἀσύμμετροι αἱ ΑΒ, ΒΓ ποιοῦσαι τὰ προκείμενα· λέγω, ὅτι ἡ ΑΓ ἄλογός ἐστιν.

Ἐκκείσθω ῥητὴ ἡ ΔΕ, καὶ παραβεβλήσθω παρὰ τὴν ΔΕ τοῖς μὲν ἀπὸ τῶν ΑΒ, ΒΓ ἴσον τὸ ΔΖ, τῷ δὲ δὶς ὑπὸ τῶν ΑΒ, ΒΓ ἴσον τὸ ΗΘ· ὅλον ἄρα τὸ ΔΘ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΑΓ τετραγώνῳ. καὶ ἐπεὶ μέσον ἐστὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ, καί ἐστιν ἴσον τῷ ΔΖ, μέσον ἄρα ἐστὶ καὶ τὸ ΔΖ. καὶ παρὰ ῥητὴν τὴν ΔΕ παράκειται· ῥητὴ ἄρα ἐστὶν ἡ ΔΗ καὶ ἀσύμμετρος τῇ ΔΕ μήκει. διὰ τὰ αὐτὰ δὴ καὶ ἡ ΗΚ ῥητή ἐστι καὶ ἀσύμμετρος τῇ ΗΖ, τουτέστι τῇ ΔΕ, μήκει. καὶ ἐπεὶ ἀσύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΒ, ΒΓ τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ, ἀσύμμετρόν ἐστι τὸ ΔΖ τῷ ΗΘ·

Proposition 41

If two straight-lines (which are) incommensurable in square, making the sum of the squares on them medial, and the (rectangle contained) by them medial, and, moreover, incommensurable with the sum of the squares on them, are added together then the whole straight-line is irrational—let it be called the square-root of (the sum of) two medial (areas).



For let the two straight-lines, AB and BC, incommensurable in square, (and) fulfilling the prescribed (conditions), be laid down together [Prop. 10.35]. I say that AC is irrational.

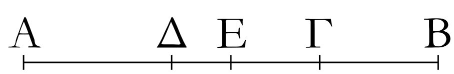
Let the rational (straight-line) DE be laid out, and let (the rectangle) DF, equal to (the sum of) the (squares) on AB and BC, and (the rectangle) GH, equal to twice the (rectangle contained) by AB and BC, have been applied to DE. Thus, the whole of DH is equal to the square on AC [Prop. 2.4]. And since the sum of the (squares) on AB and BC is medial, and is equal to DF, DF is thus also medial. And it is applied to the rational (straight-line) DE. Thus, DG is rational, and incommenὥστε καὶ ἡ ΔΗ τῇ ΗΚ ἀσύμμετρός ἐστιν. καὶ εἰσι ῥηταί· αἱ ΔΗ, ΗΚ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἄλογος ἄρα ἐστὶν ἡ ΔΚ ἡ καλουμένη ἐκ δύο ὀνομάτων. ῥητὴ δὲ ἡ ΔΕ· ἄλογον ἄρα ἐστὶ τὸ ΔΘ καὶ ἡ δυναμένη αὐτὸ ἄλογός ἐστιν. δύναται δὲ τὸ ΘΔ ἡ ΑΓ· ἄλογος ἄρα ἐστὶν ἡ ΑΓ, καλείσθω δὲ δύο μέσα δυναμένη. ὅπερ ἔδει δεῖξαι.

surable in length with DE [Prop. 10.22]. So, for the same (reasons), GK is also rational, and incommensurable in length with GF—that is to say, DE. And since (the sum of) the (squares) on AB and BC is incommensurable with twice the (rectangle contained) by AB and BC, DF is incommensurable with GH. Hence, DG is also incommensurable (in length) with GK [Props. 6.1, 10.11]. And they are rational. Thus, DG and GK are rational (straight-lines which are) commensurable in square only. Thus, DK is irrational, and that (straight-line which is) called binomial [Prop. 10.36]. And DE (is) rational. Thus, DH is irrational, and its square-root is irrational [Def. 10.4]. And AC (is) the square-root of HD. Thus, AC is irrational—let it be called the square-root of (the sum of) two medial (areas).† (Which is) the very thing it was required to show.

† Thus, the square-root of (the sum of) two medial (areas) has a length expressible as $k'^{1/4}\left(\sqrt{[1+k/(1+k^2)^{1/2}]/2}+\sqrt{[1-k/(1+k^2)^{1/2}]/2}\right)$. This and the corresponding irrational with a minus sign, whose length is expressible as $k'^{1/4}\left(\sqrt{[1+k/(1+k^2)^{1/2}]/2}-\sqrt{[1-k/(1+k^2)^{1/2}]/2}\right)$ (see Prop. 10.78), are the positive roots of the quartic $x^4 - 2\,k'^{1/2}\,x^2 + k'\,k^2/(1+k^2) = 0$.

Λῆμμα.

Ὅτι δὲ αἱ εἰρημέναι ἄλογοι μοναχῶς διαιροῦνται εἰς τὰς εὐθείας, ἐξ ὧν σύγκεινται ποιουσῶν τὰ προκείμενα εἴδη, δείξομεν ἤδη προεκθέμενοι λημμάτιον τοιοῦτον·

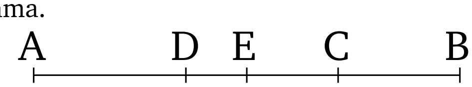


Ἐκκείσθω εὐθεῖα ἡ ΑΒ καὶ τετμήσθω ἡ ὅλη εἰς ἄνισα καθ᾿ ἑκάτερον τῶν Γ, Δ, ὑποκείσθω δὲ μείζων ἡ ΑΓ τῆς ΔΒ· λέγω, ὅτι τὰ ἀπὸ τῶν ΑΓ, ΓΒ μείζονά ἐστι τῶν ἀπὸ τῶν ΑΔ, ΔΒ.

Τετμήσθω γὰρ ἡ ΑΒ δίχα κατὰ τὸ Ε. καὶ ἐπεὶ μείζων ἐστὶν ἡ ΑΓ τῆς ΔΒ, κοινὴ ἀφῃρήσθω ἡ ΔΓ· λοιπὴ ἄρα ἡ ΑΔ λοιπῆς τῆς ΓΒ μείζων ἐστίν. ἴση δὲ ἡ ΑΕ τῇ ΕΒ· ἐλάττων ἄρα ἡ ΔΕ τῆς ΕΓ· τὰ Γ, Δ ἄρα σημεῖα οὐκ ἴσον ἀπέχουσι τῆς διχοτομίας. καὶ ἐπεὶ τὸ ὑπὸ τῶν ΑΓ, ΓΒ μετὰ τοῦ ἀπὸ τῆς ΕΓ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΕΒ, ἀλλὰ μὴν καὶ τὸ ὑπὸ τῶν ΑΔ, ΔΒ μετὰ τοῦ ἀπὸ ΔΕ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΕΒ, τὸ ἄρα ὑπὸ τῶν ΑΓ, ΓΒ μετὰ τοῦ ἀπὸ τῆς ΕΓ ἴσον ἐστὶ τῷ ὑπὸ τῶν ΑΔ, ΔΒ μετὰ τοῦ ἀπὸ τῆς ΔΕ· ὧν τὸ ἀπὸ τῆς ΔΕ ἔλασσόν ἐστι τοῦ ἀπὸ τῆς ΕΓ· καὶ λοιπὸν ἄρα τὸ ὑπὸ τῶν ΑΓ, ΓΒ ἔλασσόν ἐστι τοῦ ὑπὸ τῶν ΑΔ, ΔΒ. ὥστε καὶ τὸ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ἔλασσόν ἐστι τοῦ δὶς ὑπὸ τῶν ΑΔ, ΔΒ. καὶ λοιπὸν ἄρα τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ μεῖζόν ἐστι τοῦ συγκειμένου ἐκ τῶν ἀπὸ τῶν ΑΔ, ΔΒ. ὅπερ ἔδει δεῖξαι.

Lemma

We will now demonstrate that the aforementioned irrational (straight-lines) are uniquely divided into the straight-lines of which they are the sum, and which produce the prescribed types, (after) setting forth the following lemma.



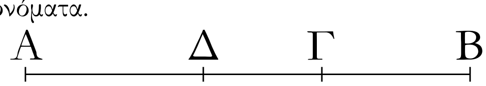
Let the straight-line AB be laid out, and let the whole (straight-line) have been cut into unequal parts at each of the (points) C and D. And let AC be assumed (to be) greater than DB. I say that (the sum of) the (squares) on AC and CB is greater than (the sum of) the (squares) on AD and DB.

For let AB have been cut in half at E. And since AC is greater than DB, let DC have been subtracted from both. Thus, the remainder AD is greater than the remainder CB. And AE (is) equal to EB. Thus, DE (is) less than EC. Thus, points C and D are not equally far from the point of bisection. And since the (rectangle contained) by AC and CB, plus the (square) on EC, is equal to the (square) on EB [Prop. 2.5], but, moreover, the (rectangle contained) by AD and DB, plus the (square) on DE, is also equal to the (square) on EB [Prop. 2.5], the (rectangle contained) by AC and CB, plus the (square) on EC, is thus equal to the (rectangle contained) by AD and DB, plus the (square) on DE. And, of these, the (square) on DE is less than the (square) on EC. And, thus, the remaining (rectangle contained) by AC and CB is less than the (rectangle contained) by AD and DB. And, hence, twice the (rectangle contained) by AC and CB is less than twice the (rectangle contained) by AD and DB. And thus the remaining sum of the (squares) on AC and CB is greater than the sum of the (squares) on AD and DB.† (Which is) the very thing it was required to show.

† Since, $AC^2 + CB^2 + 2\,AC\,CB = AD^2 + DB^2 + 2\,AD\,DB = AB^2$.

μβʹ.

Ἡ ἐκ δύο ὀνομάτων κατὰ ἓν μόνον σημεῖον διαιρεῖται εἰς τὰ ὀνόματα.



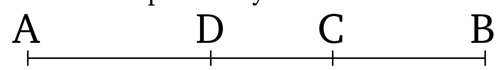
Ἔστω ἐκ δύο ὀνομάτων ἡ ΑΒ διῃρημένη εἰς τὰ ὀνόματα κατὰ τὸ Γ· αἱ ΑΓ, ΓΒ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. λέγω, ὅτι ἡ ΑΒ κατ᾽ ἄλλο σημεῖον οὐ διαιρεῖται εἰς δύο ῥητὰς δυνάμει μόνον συμμέτρους.

Εἰ γὰρ δυνατόν, διῃρήσθω καὶ κατὰ τὸ Δ, ὥστε καὶ τὰς ΑΔ, ΔΒ ῥητὰς εἶναι δυνάμει μόνον συμμέτρους. φανερὸν δή, ὅτι ἡ ΑΓ τῇ ΔΒ οὐκ ἔστιν ἡ αὐτή. εἰ γὰρ δυνατόν, ἔστω. ἔσται δὴ καὶ ἡ ΑΔ τῇ ΓΒ ἡ αὐτή· καὶ ἔσται ὡς ἡ ΑΓ πρὸς τὴν ΓΒ, οὕτως ἡ ΒΔ πρὸς τὴν ΔΑ, καὶ ἔσται ἡ ΑΒ κατὰ τὸ αὐτὸ τῇ κατὰ τὸ Γ διαιρέσει διαιρεθεῖσα καὶ κατὰ τὸ Δ· ὅπερ οὐχ ὑπόκειται. οὐκ ἄρα ἡ ΑΓ τῇ ΔΒ ἐστιν ἡ αὐτή. διὰ δὴ τοῦτο καὶ τὰ Γ, Δ σημεῖα οὐκ ἴσον ἀπέχουσι τῆς διχοτομίας. ᾧ ἄρα διαφέρει τὰ ἀπὸ τῶν ΑΓ, ΓΒ τῶν ἀπὸ τῶν ΑΔ, ΔΒ, τούτῳ διαφέρει καὶ τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ διὰ τὸ καὶ τὰ ἀπὸ τῶν ΑΓ, ΓΒ μετὰ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ καὶ τὰ ἀπὸ τῶν ΑΔ, ΔΒ μετὰ τοῦ δὶς ὑπὸ τῶν ΑΔ, ΔΒ ἴσα εἶναι τῷ ἀπὸ τῆς ΑΒ. ἀλλὰ τὰ ἀπὸ τῶν ΑΓ, ΓΒ τῶν ἀπὸ τῶν ΑΔ, ΔΒ διαφέρει ῥητῷ· ῥητὰ γὰρ ἀμφότερα· καὶ τὸ δὶς ἄρα ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ διαφέρει ῥητῷ μέσα ὄντα· ὅπερ ἄτοπον· μέσον γὰρ μέσου οὐχ ὑπερέχει ῥητῷ.

Οὐχ ἄρα ἡ ἐκ δύο ὀνομάτων κατ᾽ ἄλλο καὶ ἄλλο σημεῖον διαιρεῖται· καθ᾽ ἓν ἄρα μόνον· ὅπερ ἔδει δεῖξαι.

Proposition 42

A binomial (straight-line) can be divided into its (component) terms at one point only.†



Let AB be a binomial (straight-line) which has been divided into its (component) terms at C. AC and CB are thus rational (straight-lines which are) commensurable in square only [Prop. 10.36]. I say that AB cannot be divided at another point into two rational (straight-lines which are) commensurable in square only.

For, if possible, let it also have been divided at D, such that AD and DB are also rational (straight-lines which are) commensurable in square only. So, (it is) clear that AC is not the same as DB. For, if possible, let it be (the same). So, AD will also be the same as CB. And as AC will be to CB, so BD (will be) to DA. And AB will (thus) also be divided at D in the same (manner) as the division at C. The very opposite was assumed. Thus, AC is not the same as DB. So, on account of this, points C and D are not equally far from the point of bisection. Thus, by whatever (amount the sum of) the (squares) on AC and CB differs from (the sum of) the (squares) on AD and DB, twice the (rectangle contained) by AD and DB also differs from twice the (rectangle contained) by AC and CB by this (same amount)—on account of both (the sum of) the (squares) on AC and CB, plus twice the (rectangle contained) by AC and CB, and (the sum of) the (squares) on AD and DB, plus twice the (rectangle contained) by AD and DB, being equal to the (square) on AB [Prop. 2.4]. But, (the sum of) the (squares) on AC and CB differs from (the sum of) the (squares) on AD and DB by a rational (area). For (they are) both rational (areas). Thus, twice the (rectangle contained) by AD and DB also differs from twice the (rectangle contained) by AC and CB by a rational (area, despite both) being medial (areas) [Prop. 10.21]. The very thing is absurd. For a medial (area) cannot exceed a medial (area) by a rational (area) [Prop. 10.26].

Thus, a binomial (straight-line) cannot be divided (into its component terms) at different points. Thus, (it can be so divided) at one point only. (Which is) the very thing it was required to show.

† In other words, $k + k'^{1/2} = k'' + k'''^{1/2}$ has only one solution: *i.e.*, $k'' = k$ and $k''' = k'$. Likewise, $k^{1/2} + k'^{1/2} = k''^{1/2} + k'''^{1/2}$ has only one solution: *i.e.*, $k'' = k$ and $k''' = k'$ (or, equivalently, $k'' = k'$ and $k''' = k$).

μγ΄.

Ἡ ἐκ δύο μέσων πρώτη καθ᾿ ἓν μόνον σημεῖον διαιρεῖται.

Ἔστω ἐκ δύο μέσων πρώτη ἡ ΑΒ διῃρημένη κατὰ τὸ Γ, ὥστε τὰς ΑΓ, ΓΒ μέσας εἶναι δυνάμει μόνον συμμέτρους ῥητὸν περιεχούσας· λέγω, ὅτι ἡ ΑΒ κατ᾿ ἄλλο σημεῖον οὐ διαιρεῖται.

Εἰ γὰρ δυνατὸν διῃρήσθω καὶ κατὰ τὸ Δ, ὥστε καὶ τὰς ΑΔ, ΔΒ μέσας εἶναι δυνάμει μόνον συμμέτρους ῥητὸν περιεχούσας. ἐπεὶ οὖν, ᾧ διαφέρει τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ, τούτῳ διαφέρει τὰ ἀπὸ τῶν ΑΓ, ΓΒ τῶν ἀπὸ τῶν ΑΔ, ΔΒ, ῥητῷ δὲ διαφέρει τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ· ῥητὰ γὰρ ἀμφότερα· ῥητῷ ἄρα διαφέρει καὶ τὰ ἀπὸ τῶν ΑΓ, ΓΒ τῶν ἀπὸ τῶν ΑΔ, ΔΒ μέσα ὄντα· ὅπερ ἄτοπον.

Οὐκ ἄρα ἡ ἐκ δύο μέσων πρώτη κατ᾿ ἄλλο καὶ ἄλλο σημεῖον διαιρεῖται εἰς τὰ ὀνόματα· καθ᾿ ἓν ἄρα μόνον· ὅπερ ἔδει δεῖξαι.

Proposition 43

A first bimedial (straight-line) can be divided (into its component terms) at one point only.†

Let AB be a first bimedial (straight-line) which has been divided at C, such that AC and CB are medial (straight-lines), commensurable in square only, (and) containing a rational (area) [Prop. 10.37]. I say that AB cannot be (so) divided at another point.

For, if possible, let it also have been divided at D, such that AD and DB are also medial (straight-lines), commensurable in square only, (and) containing a rational (area). Since, therefore, by whatever (amount) twice the (rectangle contained) by AD and DB differs from twice the (rectangle contained) by AC and CB, (the sum of) the (squares) on AC and CB differs from (the sum of) the (squares) on AD and DB by this (same amount) [Prop. 10.41 lem.]. And twice the (rectangle contained) by AD and DB differs from twice the (rectangle contained) by AC and CB by a rational (area). For (they are) both rational (areas). (The sum of) the (squares) on AC and CB thus differs from (the sum of) the (squares) on AD and DB by a rational (area, despite both) being medial (areas). The very thing is absurd [Prop. 10.26].

Thus, a first bimedial (straight-line) cannot be divided into its (component) terms at different points. Thus, (it can be so divided) at one point only. (Which is) the very thing it was required to show.

† In other words, $k^{1/4} + k^{3/4} = k'^{1/4} + k'^{3/4}$ has only one solution: *i.e.*, $k' = k$.

μδ΄.

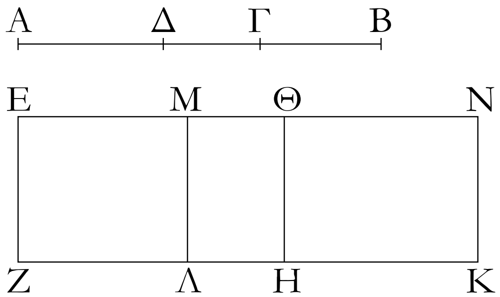
Ἡ ἐκ δύο μέσων δευτέρα καθ᾿ ἓν μόνον σημεῖον διαιρεῖται.

Ἔστω ἐκ δύο μέσων δευτέρα ἡ ΑΒ διῃρημένη κατὰ τὸ Γ, ὥστε τὰς ΑΓ, ΓΒ μέσας εἶναι δυνάμει μόνον συμμέτρους μέσον περιεχούσας· φανερὸν δή, ὅτι τὸ Γ οὐκ ἔστι κατὰ τῆς διχοτομίας, ὅτι οὐκ εἰσὶ μήκει σύμμετροι. λέγω, ὅτι ἡ ΑΒ κατ᾿ ἄλλο σημεῖον οὐ διαιρεῖται.

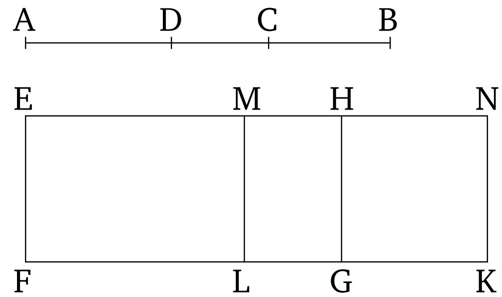
Proposition 44

A second bimedial (straight-line) can be divided (into its component terms) at one point only.†

Let AB be a second bimedial (straight-line) which has been divided at C, so that AC and BC are medial (straight-lines), commensurable in square only, (and) containing a medial (area) [Prop. 10.38]. So, (it is) clear that C is not (located) at the point of bisection, since (AC and BC) are not commensurable in length. I say that AB cannot be (so) divided at another point.



Εἰ γὰρ δυνατόν, διῃρήσθω καὶ κατὰ τὸ Δ, ὥστε τὴν ΑΓ τῇ ΔΒ μὴ εἶναι τὴν αὐτήν, ἀλλὰ μείζονα καθ᾿ ὑπόθεσιν τὴν ΑΓ· δῆλον δή, ὅτι καὶ τὰ ἀπὸ τῶν ΑΔ, ΔΒ, ὡς ἐπάνω ἐδείξαμεν, ἐλάσσονα τῶν ἀπὸ τῶν ΑΓ, ΓΒ· καὶ τὰς ΑΔ, ΔΒ μέσας εἶναι δυνάμει μόνον συμμέτρους μέσον περιεχούσας. καὶ ἐκκείσθω ῥητὴ ἡ ΕΖ, καὶ τῷ μὲν ἀπὸ τῆς ΑΒ ἴσον παρὰ τὴν ΕΖ παραλληλόγραμμον ὀρθογώνιον παραβεβλήσθω τὸ ΕΚ, τοῖς δὲ ἀπὸ τῶν ΑΓ, ΓΒ ἴσον ἀφῃρήσθω τὸ ΕΗ· λοιπὸν ἄρα τὸ ΘΚ ἴσον ἐστὶ τῷ δὶς ὑπὸ τῶν ΑΓ, ΓΒ. πάλιν δὴ τοῖς ἀπὸ τῶν ΑΔ, ΔΒ, ἅπερ ἐλάσσονα ἐδείχθη τῶν ἀπὸ τῶν ΑΓ, ΓΒ, ἴσον ἀφῃρήσθω τὸ ΕΛ· καὶ λοιπὸν ἄρα τὸ ΜΚ ἴσον τῷ δὶς ὑπὸ τῶν ΑΔ, ΔΒ. καὶ ἐπεὶ μέσα ἐστὶ τὰ ἀπὸ τῶν ΑΓ, ΓΒ, μέσον ἄρα [καὶ] τὸ ΕΗ. καὶ παρὰ ῥητὴν τὴν ΕΖ παράκειται· ῥητὴ ἄρα ἐστὶν ἡ ΕΘ καὶ ἀσύμμετρος τῇ ΕΖ μήκει. διὰ τὰ αὐτὰ δὴ καὶ ἡ ΘΝ ῥητή ἐστι καὶ ἀσύμμετρος τῇ ΕΖ μήκει. καὶ ἐπεὶ αἱ ΑΓ, ΓΒ μέσαι εἰσὶ δυνάμει μόνον σύμμετροι, ἀσύμμετρος ἄρα ἐστὶν ἡ ΑΓ τῇ ΓΒ μήκει. ὡς δὲ ἡ ΑΓ πρὸς τὴν ΓΒ, οὕτως τὸ ἀπὸ τῆς ΑΓ πρὸς τὸ ὑπὸ τῶν ΑΓ, ΓΒ· ἀσύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΑΓ τῷ ὑπὸ τῶν ΑΓ, ΓΒ. ἀλλὰ τῷ μὲν ἀπὸ τῆς ΑΓ σύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΓ, ΓΒ· δυνάμει γάρ εἰσι σύμμετροι αἱ ΑΓ, ΓΒ. τῷ δὲ ὑπὸ τῶν ΑΓ, ΓΒ σύμμετρόν ἐστι τὸ δὶς ὑπὸ τῶν ΑΓ, ΓΒ. καὶ τὰ ἀπὸ τῶν ΑΓ, ΓΒ ἄρα ἀσύμμετρά ἐστι τῷ δὶς ὑπὸ τῶν ΑΓ, ΓΒ. ἀλλὰ τοῖς μὲν ἀπὸ τῶν ΑΓ, ΓΒ ἴσον ἐστὶ τὸ ΕΗ, τῷ δὲ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ἴσον τὸ ΘΚ· ἀσύμμετρον ἄρα ἐστὶ τὸ ΕΗ τῷ ΘΚ· ὥστε καὶ ἡ ΕΘ τῇ ΘΝ ἀσύμμετρός ἐστι μήκει. καί εἰσι ῥηταί· αἱ ΕΘ, ΘΝ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. ἐὰν δὲ δύο ῥηταὶ δυνάμει μόνον σύμμετροι συντεθῶσιν, ἡ ὅλη ἄλογός ἐστιν ἡ καλουμένη ἐκ δύο ὀνομάτων· ἡ ΕΝ ἄρα ἐκ δύο ὀνομάτων ἐστὶ διῃρημένη κατὰ τὸ Θ. κατὰ τὰ αὐτὰ δὴ δειχθήσονται καὶ αἱ ΕΜ, ΜΝ ῥηταὶ δυνάμει μόνον σύμμετροι· καὶ ἔσται ἡ ΕΝ ἐκ δύο ὀνομάτων κατ᾿ ἄλλο καὶ ἄλλο διῃρημένη τό τε Θ καὶ τὸ Μ, καὶ οὐκ ἔστιν ἡ ΕΘ τῇ ΜΝ ἡ αὐτή, ὅτι τὰ ἀπὸ τῶν ΑΓ, ΓΒ μείζονά ἐστι τῶν ἀπὸ τῶν ΑΔ, ΔΒ. ἀλλὰ τὰ ἀπὸ τῶν ΑΔ, ΔΒ μείζονά ἐστι τοῦ δὶς ὑπὸ ΑΔ, ΔΒ· πολλῷ ἄρα καὶ τὰ ἀπὸ τῶν ΑΓ, ΓΒ, τουτέστι τὸ ΕΗ, μεῖζόν ἐστι τοῦ δὶς ὑπὸ τῶν ΑΔ, ΔΒ, τουτέστι τοῦ ΜΚ· ὥστε καὶ ἡ ΕΘ τῆς ΜΝ μείζων ἐστίν. ἡ ἄρα ΕΘ τῇ ΜΝ οὐκ ἔστιν ἡ αὐτή· ὅπερ ἔδει δεῖξαι.



For, if possible, let it also have been (so) divided at D, so that AC is not the same as DB, but AC (is), by hypothesis, greater. So, (it is) clear that (the sum of) the (squares) on AD and DB is also less than (the sum of) the (squares) on AC and CB, as we showed above [Prop. 10.41 lem.]. And AD and DB are medial (straight-lines), commensurable in square only, (and) containing a medial (area). And let the rational (straight-line) EF be laid down. And let the rectangular parallelogram EK, equal to the (square) on AB, have been applied to EF. And let EG, equal to (the sum of) the (squares) on AC and CB, have been cut off (from EK). Thus, the remainder, HK, is equal to twice the (rectangle contained) by AC and CB [Prop. 2.4]. So, again, let EL, equal to (the sum of) the (squares) on AD and DB—which was shown (to be) less than (the sum of) the (squares) on AC and CB—have been cut off (from EK). And, thus, the remainder, MK, (is) equal to twice the (rectangle contained) by AD and DB. And since (the sum of) the (squares) on AC and CB is medial, EG (is) thus [also] medial. And it is applied to the rational (straight-line) EF. Thus, EH is rational, and incommensurable in length with EF [Prop. 10.22]. So, for the same (reasons), HN is also rational, and incommensurable in length with EF. And since AC and CB are medial (straight-lines which are) commensurable in square only, AC is thus incommensurable in length with CB. And as AC (is) to CB, so the (square) on AC (is) to the (rectangle contained) by AC and CB [Prop. 10.21 lem.]. Thus, the (square) on AC is incommensurable with the (rectangle contained) by AC and CB [Prop. 10.11]. But, (the sum of) the (squares) on AC and CB is commensurable with the (square) on AC. For, AC and CB are commensurable in square [Prop. 10.15]. And twice the (rectangle contained) by AC and CB is commensurable with the (rectangle contained) by AC and CB [Prop. 10.6]. And thus (the sum of) the squares on AC and CB is incommensurable with twice the (rectangle contained) by AC and CB [Prop. 10.13]. But, EG is equal to (the sum of) the (squares) on AC and CB, and HK equal to twice the (rectangle contained) by AC and CB. Thus, EG is incommensurable with HK. Hence, EH is also incommensurable in length with HN [Props. 6.1, 10.11]. And (they are) rational (straight-lines). Thus, EH and HN are rational (straight-lines which are) commensurable in square only. And if two rational (straight-lines which are) commensurable in square only are added together then the whole (straight-line) is that irrational called binomial [Prop. 10.36]. Thus, EN is a binomial (straight-line) which has been divided (into its component terms) at H. So, according to the same (reasoning), EM and MN can be shown (to be) rational (straight-lines which are) commensurable in square only. And EN will (thus) be a binomial (straight-line) which has been divided (into its component terms) at the different (points) H and M (which is absurd [Prop. 10.42]). And EH is not the same as MN, since (the sum of) the (squares) on AC and CB is greater than (the sum of) the (squares) on AD and DB. But, (the sum of) the (squares) on AD and DB is greater than twice the (rectangle contained) by AD and DB [Prop. 10.59 lem.]. Thus, (the sum of) the (squares) on AC and CB—that is to say, EG—is also much greater than twice the (rectangle contained) by AD and DB—that is to say, MK. Hence, EH is also greater than MN [Prop. 6.1]. Thus, EH is not the same as MN. (Which is) the very thing it was required to show.

† In other words, $k^{1/4} + k'^{1/2}/k^{1/4} = k''^{1/4} + k'''^{1/2}/k''^{1/4}$ has only one solution: *i.e.*, $k'' = k$ and $k''' = k'$.

με΄.

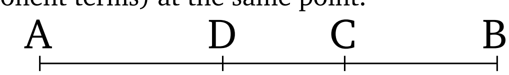
῾Η μείζων κατὰ τὸ αὐτὸ μόνον σημεῖον διαιρεῖται.

῎Εστω μείζων ἡ ΑΒ διῃρημένη κατὰ τὸ Γ, ὥστε τὰς ΑΓ, ΓΒ δυνάμει ἀσυμμέτρους εἶναι ποιούσας τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ τετραγώνων ῥητόν, τὸ δ᾿ ὑπὸ τῶν ΑΓ, ΓΒ μέσον· λέγω, ὅτι ἡ ΑΒ κατ᾿ ἄλλο σημεῖον οὐ διαιρεῖται.

Εἰ γὰρ δυνατόν, διῃρήσθω καὶ κατὰ τὸ Δ, ὥστε καὶ τὰς ΑΔ, ΔΒ δυνάμει ἀσυμμέτρους εἶναι ποιούσας τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΔ, ΔΒ ῥητόν, τὸ δ᾿ ὑπ᾿ αὐτῶν μέσον. καὶ ἐπεί, ᾧ διαφέρει τὰ ἀπὸ τῶν ΑΓ, ΓΒ τῶν ἀπὸ τῶν ΑΔ, ΔΒ, τούτῳ διαφέρει καὶ τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ, ἀλλὰ τὰ ἀπὸ τῶν ΑΓ, ΓΒ τῶν ἀπὸ τῶν ΑΔ, ΔΒ ὑπερέχει ῥητῷ· ῥητὰ γὰρ ἀμφότερα· καὶ τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ ἄρα τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ὑπερέχει ῥητῷ μέσα ὄντα· ὅπερ ἐστὶν ἀδύνατον. οὐκ ἄρα ἡ μείζων κατ᾿ ἄλλο καὶ ἄλλο σημεῖον διαιρεῖται· κατὰ τὸ αὐτὸ ἄρα μόνον διαιρεῖται· ὅπερ ἔδει δεῖξαι.

Proposition 45

A major (straight-line) can only be divided (into its component terms) at the same point.†



Let AB be a major (straight-line) which has been divided at C, so that AC and CB are incommensurable in square, making the sum of the squares on AC and CB rational, and the (rectangle contained) by AC and CD medial [Prop. 10.39]. I say that AB cannot be (so) divided at another point.

For, if possible, let it also have been divided at D, such that AD and DB are also incommensurable in square, making the sum of the (squares) on AD and DB rational, and the (rectangle contained) by them medial. And since, by whatever (amount the sum of) the (squares) on AC and CB differs from (the sum of) the (squares) on AD and DB, twice the (rectangle contained) by AD and DB also differs from twice the (rectangle contained) by AC and CB by this (same amount). But, (the sum of) the (squares) on AC and CB exceeds (the sum of) the (squares) on AD and DB by a rational (area). For (they are) both rational (areas). Thus, twice the (rectangle contained) by AD and DB also exceeds twice the (rectangle contained) by AC and CB by a rational (area), (despite both) being medial (areas). The very thing is impossible [Prop. 10.26]. Thus, a major (straight-line) cannot be divided (into its component terms) at different points. Thus, it can only be (so) divided at the same (point). (Which is) the very thing it was required to show.

† In other words, $\sqrt{[1+k/(1+k^2)^{1/2}]/2}+\sqrt{[1-k/(1+k^2)^{1/2}]/2}=\sqrt{[1+k'/(1+k'^2)^{1/2}]/2}+\sqrt{[1-k'/(1+k'^2)^{1/2}]/2}$ has only one solution: *i.e.*, $k'=k$.

μϛ΄.

Ἡ ῥητὸν καὶ μέσον δυναμένη καθ᾽ ἓν μόνον σημεῖον διαιρεῖται.

Ἔστω ῥητὸν καὶ μέσον δυναμένη ἡ ΑΒ διῃρημένη κατὰ τὸ Γ, ὥστε τὰς ΑΓ, ΓΒ δυνάμει ἀσυμμέτρους εἶναι ποιούσας τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ μέσον, τὸ δὲ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ῥητόν· λέγω, ὅτι ἡ ΑΒ κατ᾽ ἄλλο σημεῖον οὐ διαιρεῖται.

Εἰ γὰρ δυνατόν, διῃρήσθω καὶ κατὰ τὸ Δ, ὥστε καὶ τὰς ΑΔ, ΔΒ δυνάμει ἀσυμμέτρους εἶναι ποιούσας τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΔ, ΔΒ μέσον, τὸ δὲ δὶς ὑπὸ τῶν ΑΔ, ΔΒ ῥητόν. ἐπεὶ οὖν, ᾧ διαφέρει τὸ δὶς ὑπὸ τῶν ΑΓ, ΓΒ τοῦ δὶς ὑπὸ τῶν ΑΔ, ΔΒ, τούτῳ διαφέρει καὶ τὰ ἀπὸ τῶν ΑΔ, ΔΒ τῶν ἀπὸ τῶν ΑΓ, ΓΒ, τὸ δὲ δὶς ὑπὸ τῶν ΑΓ, ΓΒ τοῦ δὶς ὑπὸ τῶν ΑΔ, ΔΒ ὑπερέχει ῥητῷ, καὶ τὰ ἀπὸ τῶν ΑΔ, ΔΒ ἄρα τῶν ἀπὸ τῶν ΑΓ, ΓΒ ὑπερέχει ῥητῷ μέσα ὄντα· ὅπερ ἐστὶν ἀδύνατον. οὐκ ἄρα ἡ ῥητὸν καὶ μέσον δυναμένη κατ᾽ ἄλλο καὶ ἄλλο σημεῖον διαιρεῖται. κατὰ ἓν ἄρα σημεῖον διαιρεῖται· ὅπερ ἔδει δεῖξαι.

Proposition 46

The square-root of a rational plus a medial (area) can be divided (into its component terms) at one point only.†

Let AB be the square-root of a rational plus a medial (area) which has been divided at C, so that AC and CB are incommensurable in square, making the sum of the (squares) on AC and CB medial, and twice the (rectangle contained) by AC and CB rational [Prop. 10.40]. I say that AB cannot be (so) divided at another point.

For, if possible, let it also have been divided at D, so that AD and DB are also incommensurable in square, making the sum of the (squares) on AD and DB medial, and twice the (rectangle contained) by AD and DB rational. Therefore, since by whatever (amount) twice the (rectangle contained) by AC and CB differs from twice the (rectangle contained) by AD and DB, (the sum of) the (squares) on AD and DB also differs from (the sum of) the (squares) on AC and CB by this (same amount). And twice the (rectangle contained) by AC and CB exceeds twice the (rectangle contained) by AD and DB by a rational (area). (The sum of) the (squares) on AD and DB thus also exceeds (the sum of) the (squares) on AC and CB by a rational (area), (despite both) being medial (areas). The very thing is impossible [Prop. 10.26]. Thus, the square-root of a rational plus a medial (area) cannot be divided (into its component terms) at different points. Thus, it can be (so) divided at one point (only). (Which is) the very thing it was required to show.

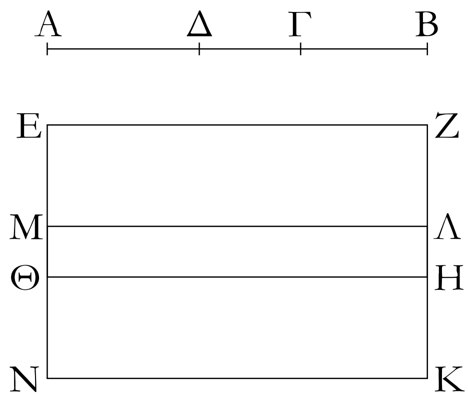
† In other words, $\sqrt{[(1+k^2)^{1/2}+k]/[2\,(1+k^2)]}+\sqrt{[(1+k^2)^{1/2}-k]/[2\,(1+k^2)]}=\sqrt{[(1+k'^2)^{1/2}+k']/[2\,(1+k'^2)]}$ $+\sqrt{[(1+k'^2)^{1/2}-k']/[2\,(1+k'^2)]}$ has only one solution: *i.e.*, $k'=k$.

μζ΄.

Ἡ δύο μέσα δυναμένη καθ᾽ ἓν μόνον σημεῖον διαιρεῖται.

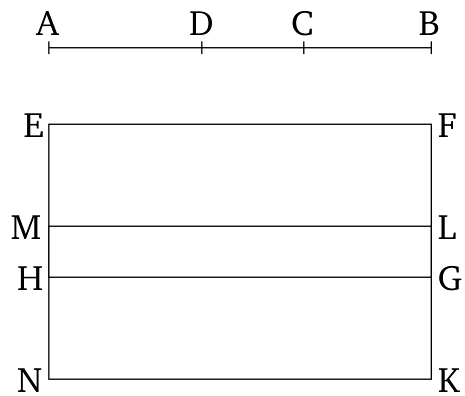
Proposition 47

The square-root of (the sum of) two medial (areas) can be divided (into its component terms) at one point only.†



Ἔστω [δύο μέσα δυναμένη] ἡ ΑΒ διῃρημένη κατὰ τὸ Γ, ὥστε τὰς ΑΓ, ΓΒ δυνάμει ἀσυμμέτρους εἶναι ποιούσας τό τε συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ μέσον καὶ τὸ ὑπὸ τῶν ΑΓ, ΓΒ μέσον καὶ ἔτι ἀσύμμετρον τῷ συγκειμένῳ ἐκ τῶν ἀπ᾽ αὐτῶν. λέγω, ὅτι ἡ ΑΒ κατ᾽ ἄλλο σημεῖον οὐ διαιρεῖται ποιοῦσα τὰ προκείμενα.

Εἰ γὰρ δυνατόν, διῃρήσθω κατὰ τὸ Δ, ὥστε πάλιν δηλονότι τὴν ΑΓ τῇ ΔΒ μὴ εἶναι τὴν αὐτήν, ἀλλὰ μείζονα καθ᾽ ὑπόθεσιν τὴν ΑΓ, καὶ ἐκκείσθω ῥητὴ ἡ ΕΖ, καὶ παραβεβλήσθω παρὰ τὴν ΕΖ τοῖς μὲν ἀπὸ τῶν ΑΓ, ΓΒ ἴσον τὸ ΕΗ, τῷ δὲ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ἴσον τὸ ΘΚ· ὅλον ἄρα τὸ ΕΚ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΑΒ τετραγώνῳ. πάλιν δὴ παραβεβλήσθω παρὰ τὴν ΕΖ τοῖς ἀπὸ τῶν ΑΔ, ΔΒ ἴσον τὸ ΕΛ· λοιπὸν ἄρα τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ λοιπῷ τῷ ΜΚ ἴσον ἐστίν. καὶ ἐπεὶ μέσον ὑπόκειται τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ, μέσον ἄρα ἐστὶ καὶ τὸ ΕΗ. καὶ παρὰ ῥητὴν τὴν ΕΖ παράκειται· ῥητὴ ἄρα ἐστὶν ἡ ΘΕ καὶ ἀσύμμετρος τῇ ΕΖ μήκει. διὰ τὰ αὐτὰ δὴ καὶ ἡ ΘΝ ῥητή ἐστι καὶ ἀσύμμετρος τῇ ΕΖ μήκει. καὶ ἐπεὶ ἀσύμμετρόν ἐστι τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ τῷ δὶς ὑπὸ τῶν ΑΓ, ΓΒ, καὶ τὸ ΕΗ ἄρα τῷ ΗΝ ἀσύμμετρόν ἐστιν· ὥστε καὶ ἡ ΕΘ τῇ ΘΝ ἀσύμμετρός ἐστιν. καί εἰσι ῥηταί· αἱ ΕΘ, ΘΝ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἡ ΕΝ ἄρα ἐκ δύο ὀνομάτων ἐστὶ διῃρημένη κατὰ τὸ Θ. ὁμοίως δὴ δείξομεν, ὅτι καὶ κατὰ τὸ Μ διῄρηται. καὶ οὐκ ἔστιν ἡ ΕΘ τῇ ΜΝ ἡ αὐτή· ἡ ἄρα ἐκ δύο ὀνομάτων κατ᾽ ἄλλο καὶ ἄλλο σημεῖον διῄρηται· ὅπερ ἐστὶν ἄτοπον. οὐκ ἄρα ἡ δύο μέσα δυναμένη κατ᾽ ἄλλο καὶ ἄλλο σημεῖον διαιρεῖται· καθ᾽ ἓν ἄρα μόνον [σημεῖον] διαιρεῖται.



Let AB be [the square-root of (the sum of) two medial (areas)] which has been divided at C, such that AC and CB are incommensurable in square, making the sum of the (squares) on AC and CB medial, and the (rectangle contained) by AC and CB medial, and, moreover, incommensurable with the sum of the (squares) on (AC and CB) [Prop. 10.41]. I say that AB cannot be divided at another point fulfilling the prescribed (conditions).

For, if possible, let it have been divided at D, such that AC is again manifestly not the same as DB, but AC (is), by hypothesis, greater. And let the rational (straight-line) EF be laid down. And let EG, equal to (the sum of) the (squares) on AC and CB, and HK, equal to twice the (rectangle contained) by AC and CB, have been applied to EF. Thus, the whole of EK is equal to the square on AB [Prop. 2.4]. So, again, let EL, equal to (the sum of) the (squares) on AD and DB, have been applied to EF. Thus, the remainder—twice the (rectangle contained) by AD and DB—is equal to the remainder, MK. And since the sum of the (squares) on AC and CB was assumed (to be) medial, EG is also medial. And it is applied to the rational (straight-line) EF. HE is thus rational, and incommensurable in length with EF [Prop. 10.22]. So, for the same (reasons), HN is also rational, and incommensurable in length with EF. And since the sum of the (squares) on AC and CB is incommensurable with twice the (rectangle contained) by AC and CB, EG is thus also incommensurable with GN. Hence, EH is also incommensurable with HN [Props. 6.1, 10.11]. And they are (both) rational (straight-lines). Thus, EH and HN are rational (straight-lines which are) commensurable in square only. Thus, EN is a binomial (straight-line) which has been divided (into its component terms) at H [Prop. 10.36]. So, similarly, we can show that it has also been (so) divided at M. And EH is not the same as MN. Thus, a binomial (straight-line) has been divided (into its component terms) at different points. The very thing is absurd [Prop. 10.42]. Thus, the square-root of (the sum of) two medial (areas) cannot be divided (into its component terms) at different points. Thus, it can be (so) divided at one [point] only.

† In other words, $k'^{1/4}\sqrt{[1+k/(1+k^2)^{1/2}]/2}+k'^{1/4}\sqrt{[1-k/(1+k^2)^{1/2}]/2}=k'''^{1/4}\sqrt{[1+k''/(1+k''^2)^{1/2}]/2}$ $+k'''^{1/4}\sqrt{[1-k''/(1+k''^2)^{1/2}]/2}$ has only one solution: *i.e.*, $k''=k$ and $k'''=k'$.

Ὅροι δεύτεροι.

ε'. Ὑποκειμένης ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων διῃρημένης εἰς τὰ ὀνόματα, ἧς τὸ μεῖζον ὄνομα τοῦ ἐλάσσονος μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει, ἐὰν μὲν τὸ μεῖζον ὄνομα σύμμετρον ᾖ μήκει τῇ ἐκκειμένῃ ῥητῇ, καλείσθω [ἡ ὅλη] ἐκ δύο ὀνομάτων πρώτη.

ϛ'. Ἐὰν δὲ τὸ ἐλάσσον ὄνομα σύμμετρον ᾖ μήκει τῇ ἐκκειμένῃ ῥητῇ, καλείσθω ἐκ δύο ὀνομάτων δευτέρα.

ζ'. Ἐὰν δὲ μηδέτερον τῶν ὀνομάτων σύμμετρον ᾖ μήκει τῇ ἐκκειμένῃ ῥητῇ, καλείσθω ἐκ δύο ὀνομάτων τρίτη.

η'. Πάλιν δὴ ἐὰν τὸ μεῖζον ὄνομα [τοῦ ἐλάσσονος] μεῖζον δύνηται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ μήκει, ἐὰν μὲν τὸ μεῖζον ὄνομα σύμμετρον ᾖ μήκει τῇ ἐκκειμένῃ ῥητῇ, καλείσθω ἐκ δύο ὀνομάτων τετάρτη.

ϑ'. Ἐὰν δὲ τὸ ἔλασσον, πέμπτη.

ι'. Ἐὰν δὲ μηδέτερον, ἕκτη.

Definitions II

5. Given a rational (straight-line), and a binomial (straight-line) which has been divided into its (component) terms, of which the square on the greater term is larger than (the square on) the lesser by the (square) on (some straight-line) commensurable in length with (the greater) then, if the greater term is commensurable in length with the rational (straight-line previously) laid out, let [the whole] (straight-line) be called a first binomial (straight-line).

6. And if the lesser term is commensurable in length with the rational (straight-line previously) laid out then let (the whole straight-line) be called a second binomial (straight-line).

7. And if neither of the terms is commensurable in length with the rational (straight-line previously) laid out then let (the whole straight-line) be called a third binomial (straight-line).

8. So, again, if the square on the greater term is larger than (the square on) [the lesser] by the (square) on (some straight-line) incommensurable in length with (the greater) then, if the greater term is commensurable in length with the rational (straight-line previously) laid out, let (the whole straight-line) be called a fourth binomial (straight-line).

9. And if the lesser (term is commensurable), a fifth (binomial straight-line).

10. And if neither (term is commensurable), a sixth (binomial straight-line).

μη'.

Εὑρεῖν τὴν ἐκ δύο ὀνομάτων πρώτην.

Ἐκκείσθωσαν δύο ἀριθμοὶ οἱ ΑΓ, ΓΒ, ὥστε τὸν συγκείμενον ἐξ αὐτῶν τὸν ΑΒ πρὸς μὲν τὸν ΒΓ λόγον ἔχειν, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, πρὸς δὲ τὸν ΓΑ λόγον μὴ ἔχειν, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, καὶ ἐκκείσθω τις ῥητὴ ἡ Δ, καὶ τῇ Δ σύμμετρος ἔστω μήκει ἡ ΕΖ. ῥητὴ ἄρα ἐστὶ καὶ ἡ ΕΖ. καὶ γεγονέτω ὡς ὁ ΒΑ ἀριθμὸς πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς ΖΗ. ὁ δὲ ΑΒ πρὸς τὸν ΑΓ λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν· καὶ τὸ ἀπὸ τῆς ΕΖ ἄρα πρὸς τὸ ἀπὸ τῆς ΖΗ λόγον ἔχει, ὃν ἀριθμὸς πρὸς ἀριθμόν· ὥστε σύμμετρόν ἐστι τὸ ἀπὸ τῆς ΕΖ τῷ ἀπὸ τῆς

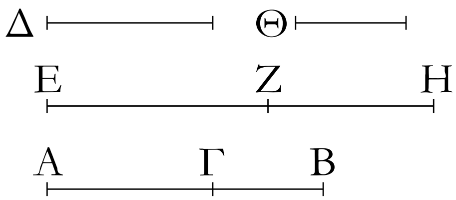
Proposition 48

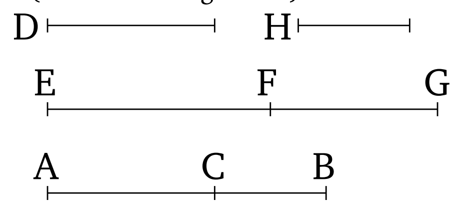
To find a first binomial (straight-line).

Let two numbers AC and CB be laid down such that their sum AB has to BC the ratio which (some) square number (has) to (some) square number, and does not have to CA the ratio which (some) square number (has) to (some) square number [Prop. 10.28 lem. I]. And let some rational (straight-line) D be laid down. And let EF be commensurable in length with D. EF is thus also rational [Def. 10.3]. And let it have been contrived that as the number BA (is) to AC, so the (square) on EF (is) to the (square) on FG [Prop. 10.6 corr.]. And AB has to AC the ratio which (some) number (has) to (some) num-

ΖΗ. καὶ ἔστι ῥητὴ ἡ ΕΖ· ῥητὴ ἄρα καὶ ἡ ΖΗ. καὶ ἐπεὶ ὁ ΒΑ πρὸς τὸν ΑΓ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδὲ τὸ ἀπὸ τῆς ΕΖ ἄρα πρὸς τὸ ἀπὸ τῆς ΖΗ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΕΖ τῇ ΖΗ μήκει. αἱ ΕΖ, ΖΗ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΕΗ. λέγω, ὅτι καὶ πρώτη.

ber. Thus, the (square) on EF also has to the (square) on FG the ratio which (some) number (has) to (some) number. Hence, the (square) on EF is commensurable with the (square) on FG [Prop. 10.6]. And EF is rational. Thus, FG (is) also rational. And since BA does not have to AC the ratio which (some) square number (has) to (some) square number, thus the (square) on EF does not have to the (square) on FG the ratio which (some) square number (has) to (some) square number either. Thus, EF is incommensurable in length with FG [Prop 10.9]. EF and FG are thus rational (straight-lines which are) commensurable in square only. Thus, EG is a binomial (straight-line) [Prop. 10.36]. I say that (it is) also a first (binomial straight-line).





Ἐπεὶ γάρ ἐστιν ὡς ὁ ΒΑ ἀριθμὸς πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς ΖΗ, μείζων δὲ ὁ ΒΑ τοῦ ΑΓ, μεῖζον ἄρα καὶ τὸ ἀπὸ τῆς ΕΖ τοῦ ἀπὸ τῆς ΖΗ. ἔστω οὖν τῷ ἀπὸ τῆς ΕΖ ἴσα τὰ ἀπὸ τῶν ΖΗ, Θ. καὶ ἐπεί ἐστιν ὡς ὁ ΒΑ πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς ΖΗ, ἀναστρέψαντι ἄρα ἐστὶν ὡς ὁ ΑΒ πρὸς τὸν ΒΓ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς Θ. ὁ δὲ ΑΒ πρὸς τὸν ΒΓ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. καὶ τὸ ἀπὸ τῆς ΕΖ ἄρα πρὸς τὸ ἀπὸ τῆς Θ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. σύμμετρος ἄρα ἐστὶν ἡ ΕΖ τῇ Θ μήκει· ἡ ΕΖ ἄρα τῆς ΖΗ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ. καί εἰσι ῥηταὶ αἱ ΕΖ, ΖΗ, καὶ σύμμετρος ἡ ΕΖ τῇ Δ μήκει.

Ἡ ΕΗ ἄρα ἐκ δύο ὀνομάτων ἐστὶ πρώτη· ὅπερ ἔδει δεῖξαι.

For since as the number BA is to AC, so the (square) on EF (is) to the (square) on FG, and BA (is) greater than AC, the (square) on EF (is) thus also greater than the (square) on FG [Prop. 5.14]. Therefore, let (the sum of) the (squares) on FG and H be equal to the (square) on EF. And since as BA is to AC, so the (square) on EF (is) to the (square) on FG, thus, via conversion, as AB is to BC, so the (square) on EF (is) to the (square) on H [Prop. 5.19 corr.]. And AB has to BC the ratio which (some) square number (has) to (some) square number. Thus, the (square) on EF also has to the (square) on H the ratio which (some) square number (has) to (some) square number. Thus, EF is commensurable in length with H [Prop. 10.9]. Thus, the square on EF is greater than (the square on) FG by the (square) on (some straight-line) commensurable (in length) with (EF). And EF and FG are rational (straight-lines). And EF (is) commensurable in length with D.

Thus, EG is a first binomial (straight-line) [Def. 10.5].† (Which is) the very thing it was required to show.

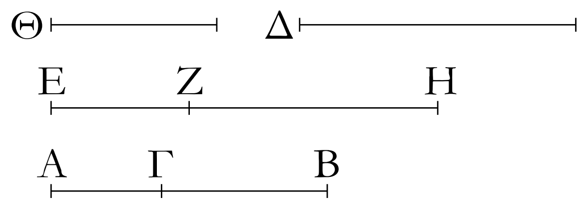
† If the rational straight-line has unit length then the length of a first binomial straight-line is $k + k\sqrt{1-k'^2}$. This, and the first apotome, whose length is $k - k\sqrt{1-k'^2}$ [Prop. 10.85], are the roots of $x^2 - 2\,k\,x + k^2\,k'^2 = 0$.

μθʹ.

Εὑρεῖν τὴν ἐκ δύο ὀνομάτων δευτέραν.

Proposition 49

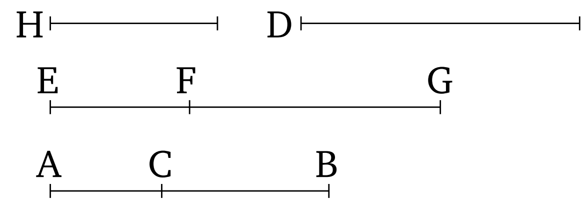
To find a second binomial (straight-line).



Ἐκκείσθωσαν δύο ἀριθμοὶ οἱ ΑΓ, ΓΒ, ὥστε τὸν συγκείμενον ἐξ αὐτῶν τὸν ΑΒ πρὸς μὲν τὸν ΒΓ λόγον ἔχειν, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, πρὸς δὲ τὸν ΑΓ λόγον μὴ ἔχειν, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, καὶ ἐκκείσθω ῥητὴ ἡ Δ, καὶ τῇ Δ σύμμετρος ἔστω ἡ ΕΖ μήκει· ῥητὴ ἄρα ἐστὶν ἡ ΕΖ. γεγονέτω δὴ καὶ ὡς ὁ ΓΑ ἀριθμὸς πρὸς τὸν ΑΒ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς ΖΗ· σύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΕΖ τῷ ἀπὸ τῆς ΖΗ. ῥητὴ ἄρα ἐστὶ καὶ ἡ ΖΗ. καὶ ἐπεὶ ὁ ΓΑ ἀριθμὸς πρὸς τὸν ΑΒ λὸγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδὲ τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς ΖΗ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. ἀσύμμετρος ἄρα ἐστὶν ἡ ΕΖ τῇ ΖΗ μήκει· αἱ ΕΖ, ΖΗ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΕΗ. δεικτέον δή, ὅτι καὶ δευτέρα.

Ἐπεὶ γὰρ ἀνάπαλίν ἐστιν ὡς ὁ ΒΑ ἀριθμὸς πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΗΖ πρὸς τὸ ἀπὸ τῆς ΖΕ, μείζων δὲ ὁ ΒΑ τοῦ ΑΓ, μεῖζον ἄρα [καὶ] τὸ ἀπὸ τῆς ΗΖ τοῦ ἀπὸ τῆς ΖΕ. ἔστω τῷ ἀπὸ τῆς ΗΖ ἴσα τὰ ἀπὸ τῶν ΕΖ, Θ· ἀναστρέψαντι ἄρα ἐστὶν ὡς ὁ ΑΒ πρὸς τὸν ΒΓ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς Θ. ἀλλ᾽ ὁ ΑΒ πρὸς τὸν ΒΓ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· καὶ τὸ ἀπὸ τῆς ΖΗ ἄρα πρὸς τὸ ἀπὸ τῆς Θ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. σύμμετρος ἄρα ἐστὶν ἡ ΖΗ τῇ Θ μήκει· ὥστε ἡ ΖΗ τῆς ΖΕ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ. καί εἰσι ῥηταὶ αἱ ΖΗ, ΖΕ δυνάμει μόνον σύμμετροι, καὶ τὸ ΕΖ ἔλασσον ὄνομα τῇ ἐκκειμένῃ ῥητῇ σύμμετρόν ἐστι τῇ Δ μήκει.

Ἡ ΕΗ ἄρα ἐκ δύο ὀνομάτων ἐστὶ δευτέρα· ὅπερ ἔδει δεῖξαι.



Let the two numbers AC and CB be laid down such that their sum AB has to BC the ratio which (some) square number (has) to (some) square number, and does not have to AC the ratio which (some) square number (has) to (some) square number [Prop. 10.28 lem. I]. And let the rational (straight-line) D be laid down. And let EF be commensurable in length with D. EF is thus a rational (straight-line). So, let it also have been contrived that as the number CA (is) to AB, so the (square) on EF (is) to the (square) on FG [Prop. 10.6 corr.]. Thus, the (square) on EF is commensurable with the (square) on FG [Prop. 10.6]. Thus, FG is also a rational (straight-line). And since the number CA does not have to AB the ratio which (some) square number (has) to (some) square number, the (square) on EF does not have to the (square) on FG the ratio which (some) square number (has) to (some) square number either. Thus, EF is incommensurable in length with FG [Prop. 10.9]. EF and FG are thus rational (straight-lines which are) commensurable in square only. Thus, EG is a binomial (straight-line) [Prop. 10.36]. So, we must show that (it is) also a second (binomial straight-line).

For since, inversely, as the number BA is to AC, so the (square) on GF (is) to the (square) on FE [Prop. 5.7 corr.], and BA (is) greater than AC, the (square) on GF (is) thus [also] greater than the (square) on FE [Prop. 5.14]. Let (the sum of) the (squares) on EF and H be equal to the (square) on GF. Thus, via conversion, as AB is to BC, so the (square) on FG (is) to the (square) on H [Prop. 5.19 corr.]. But, AB has to BC the ratio which (some) square number (has) to (some) square number. Thus, the (square) on FG also has to the (square) on H the ratio which (some) square number (has) to (some) square number. Thus, FG is commensurable in length with H [Prop. 10.9]. Hence, the square on FG is greater than (the square on) FE by the (square) on (some straight-line) commensurable in length with (FG). And FG and FE are rational (straight-lines which are) commensurable in square only. And the lesser term EF is commensurable in length with the rational (straight-line) D (previously) laid down.

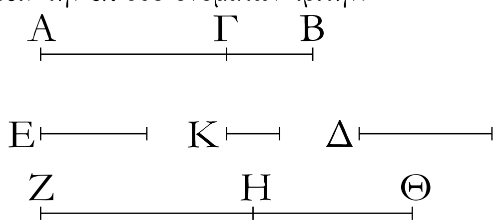
Thus, EG is a second binomial (straight-line) [Def. 10.6].† (Which is) the very thing it was required to show.

† If the rational straight-line has unit length then the length of a second binomial straight-line is $k/\sqrt{1-k'^2}+k$. This, and the second apotome,

whose length is $k/\sqrt{1-k'^{\,2}} - k$ [Prop. 10.86], are the roots of $x^2 - (2\,k/\sqrt{1-k'^{\,2}})\,x + k^2\,[k'^{\,2}/(1-k'^{\,2})] = 0$.

ν΄.

Εὑρεῖν τὴν ἐκ δύο ὀνομάτων τρίτην.

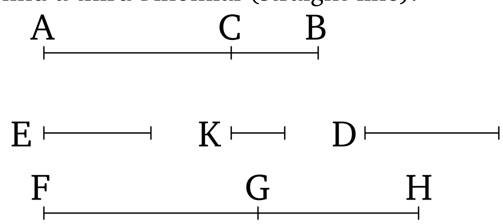


Ἐκκείσθωσαν δύο ἀριθμοὶ οἱ ΑΓ, ΓΒ, ὥστε τὸν συγκείμενον ἐξ αὐτῶν τὸν ΑΒ πρὸς μὲν τὸν ΒΓ λόγον ἔχειν, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, πρὸς δὲ τὸν ΑΓ λόγον μὴ ἔχειν, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. ἐκκείσθω δέ τις καὶ ἄλλος μὴ τετράγωνος ἀριθμὸς ὁ Δ, καὶ πρὸς ἑκάτερον τῶν ΒΑ, ΑΓ λόγον μὴ ἐχέτω, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· καὶ ἐκκείσθω τις ῥητὴ εὐθεῖα ἡ Ε, καὶ γεγονέτω ὡς ὁ Δ πρὸς τὸν ΑΒ, οὕτως τὸ ἀπὸ τῆς Ε πρὸς τὸ ἀπὸ τῆς ΖΗ· σύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς Ε τῷ ἀπὸ τῆς ΖΗ. καί ἐστι ῥητὴ ἡ Ε· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΖΗ. καὶ ἐπεὶ ὁ Δ πρὸς τὸν ΑΒ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδὲ τὸ ἀπὸ τῆς Ε πρὸς τὸ ἀπὸ τῆς ΖΗ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ Ε τῇ ΖΗ μήκει. γεγονέτω δὴ πάλιν ὡς ἡ ΒΑ ἀριθμὸς πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ· σύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΖΗ τῷ ἀπὸ τῆς ΗΘ. ῥητὴ δὲ ἡ ΖΗ· ῥητὴ ἄρα καὶ ἡ ΗΘ. καὶ ἐπεὶ ὁ ΒΑ πρὸς τὸν ΑΓ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδὲ τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΘΗ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΖΗ τῇ ΗΘ μήκει. αἱ ΖΗ, ΗΘ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἡ ΖΘ ἄρα ἐκ δύο ὀνομάτων ἐστίν. λέγω δή, ὅτι καὶ τρίτη.

Ἐπεὶ γάρ ἐστιν ὡς ὁ Δ πρὸς τὸν ΑΒ, οὕτως τὸ ἀπὸ τῆς Ε πρὸς τὸ ἀπὸ τῆς ΖΗ, ὡς δὲ ὁ ΒΑ πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ, δι᾿ ἴσου ἄρα ἐστὶν ὡς ὁ Δ πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς Ε πρὸς τὸ ἀπὸ τῆς ΗΘ. ὁ δὲ Δ πρὸς τὸν ΑΓ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· οὐδὲ τὸ ἀπὸ τῆς Ε ἄρα πρὸς τὸ ἀπὸ τῆς ΗΘ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ Ε τῇ ΗΘ μήκει. καὶ ἐπεί ἐστιν ὡς ὁ ΒΑ πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ, μεῖζον ἄρα τὸ ἀπὸ τῆς ΖΗ τοῦ ἀπὸ τῆς ΗΘ. ἔστω οὖν τῷ ἀπὸ τῆς ΖΗ ἴσα τὰ ἀπὸ τῶν ΗΘ, Κ· ἀναστρέψαντι ἄρα [ἐστὶν] ὡς ὁ ΑΒ πρὸς τὸν ΒΓ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς Κ. ὁ δὲ ΑΒ πρὸς τὸν ΒΓ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς

Proposition 50

To find a third binomial (straight-line).



Let the two numbers AC and CB be laid down such that their sum AB has to BC the ratio which (some) square number (has) to (some) square number, and does not have to AC the ratio which (some) square number (has) to (some) square number. And let some other non-square number D also be laid down, and let it not have to each of BA and AC the ratio which (some) square number (has) to (some) square number. And let some rational straight-line E be laid down, and let it have been contrived that as D (is) to AB, so the (square) on E (is) to the (square) on FG [Prop. 10.6 corr.]. Thus, the (square) on E is commensurable with the (square) on FG [Prop. 10.6]. And E is a rational (straight-line). Thus, FG is also a rational (straight-line). And since D does not have to AB the ratio which (some) square number has to (some) square number, the (square) on E does not have to the (square) on FG the ratio which (some) square number (has) to (some) square number either. E is thus incommensurable in length with FG [Prop. 10.9]. So, again, let it have been contrived that as the number BA (is) to AC, so the (square) on FG (is) to the (square) on GH [Prop. 10.6 corr.]. Thus, the (square) on FG is commensurable with the (square) on GH [Prop. 10.6]. And FG (is) a rational (straight-line). Thus, GH (is) also a rational (straight-line). And since BA does not have to AC the ratio which (some) square number (has) to (some) square number, the (square) on FG does not have to the (square) on HG the ratio which (some) square number (has) to (some) square number either. Thus, FG is incommensurable in length with GH [Prop. 10.9]. FG and GH are thus rational (straight-lines which are) commensurable in square only. Thus, FH is a binomial (straight-line) [Prop. 10.36]. So, I say that (it is) also a third (binomial straight-line).

For since as D is to AB, so the (square) on E (is) to the (square) on FG, and as BA (is) to AC, so the (square) on FG (is) to the (square) on GH, thus, via equality, as D (is) to AC, so the (square) on E (is) to the (square) on GH [Prop. 5.22]. And D does not τετράγωνον ἀριθμόν· καὶ τὸ ἀπὸ τῆς ΖΗ ἄρα πρὸς τὸ ἀπὸ τῆς Κ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· σύμμετρος ἄρα [ἐστὶν] ἡ ΖΗ τῇ Κ μήκει. ἡ ΖΗ ἄρα τῆς ΗΘ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ. καί εἰσιν αἱ ΖΗ, ΗΘ ῥηταὶ δυνάμει μόνον σύμμετροι, καὶ οὐδετέρα αὐτῶν σύμμετρός ἐστι τῇ Ε μήκει.

Ἡ ΖΘ ἄρα ἐκ δύο ὀνομάτων ἐστὶ τρίτη· ὅπερ ἔδει δεῖξαι.

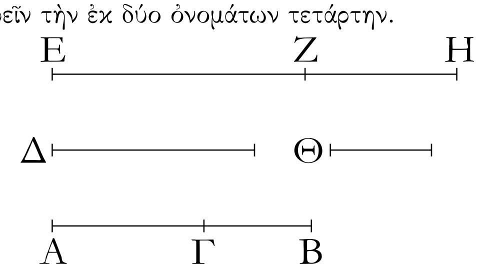
have to AC the ratio which (some) square number (has) to (some) square number. Thus, the (square) on E does not have to the (square) on GH the ratio which (some) square number (has) to (some) square number either. Thus, E is incommensurable in length with GH [Prop. 10.9]. And since as BA is to AC, so the (square) on FG (is) to the (square) on GH, the (square) on FG (is) thus greater than the (square) on GH [Prop. 5.14]. Therefore, let (the sum of) the (squares) on GH and K be equal to the (square) on FG. Thus, via conversion, as AB [is] to BC, so the (square) on FG (is) to the (square) on K [Prop. 5.19 corr.]. And AB has to BC the ratio which (some) square number (has) to (some) square number. Thus, the (square) on FG also has to the (square) on K the ratio which (some) square number (has) to (some) square number. Thus, FG [is] commensurable in length with K [Prop. 10.9]. Thus, the square on FG is greater than (the square on) GH by the (square) on (some straight-line) commensurable (in length) with (FG). And FG and GH are rational (straight-lines which are) commensurable in square only, and neither of them is commensurable in length with E.

Thus, FH is a third binomial (straight-line) [Def. 10.7].† (Which is) the very thing it was required to show.

† If the rational straight-line has unit length then the length of a third binomial straight-line is $k^{1/2}\,(1+\sqrt{1-k'^{\,2}})$. This, and the third apotome, whose length is $k^{1/2}\,(1-\sqrt{1-k'^{\,2}})$ [Prop. 10.87], are the roots of $x^2-2\,k^{1/2}\,x+k\,k'^{\,2}=0$.

να΄.

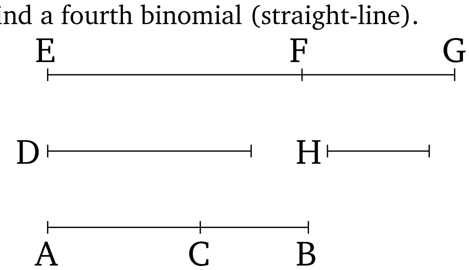
Εὑρεῖν τὴν ἐκ δύο ὀνομάτων τετάρτην.



Ἐκκείσθωσαν δύο ἀριθμοὶ οἱ ΑΓ, ΓΒ, ὥστε τὸν ΑΒ πρὸς τὸν ΒΓ λόγον μὴ ἔχειν μήτε μὴν πρὸς τὸν ΑΓ, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. καὶ ἐκκείσθω ῥητὴ ἡ Δ, καὶ τῇ Δ σύμμετρος ἔστω μήκει ἡ ΕΖ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΕΖ. καὶ γεγονέτω ὡς ὁ ΒΑ ἀριθμὸς πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς ΖΗ· σύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΕΖ τῷ ἀπὸ τῆς ΖΗ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΖΗ. καὶ ἐπεὶ ὁ ΒΑ πρὸς τὸν ΑΓ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδὲ τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς ΖΗ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΕΖ τῇ ΖΗ μήκει. αἱ ΕΖ, ΖΗ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ὥστε ἡ ΕΗ ἐκ δύο ὀνομάτων ἐστίν. λέγω δή,

Proposition 51

To find a fourth binomial (straight-line).



Let the two numbers AC and CB be laid down such that AB does not have to BC, or to AC either, the ratio which (some) square number (has) to (some) square number [Prop. 10.28 lem. I]. And let the rational (straight-line) D be laid down. And let EF be commensurable in length with D. Thus, EF is also a rational (straight-line). And let it have been contrived that as the number BA (is) to AC, so the (square) on EF (is) to the (square) on FG [Prop. 10.6 corr.]. Thus, the (square) on EF is commensurable with the (square) on FG [Prop. 10.6]. Thus, FG is also a rational (straight-line). And since BA does not have to AC the ratio which (some) square number (has) to (some) square number, ὅτι καὶ τετάρτη.

Ἐπεὶ γάρ ἐστιν ὡς ὁ ΒΑ πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς ΖΗ [μείζων δὲ ὁ ΒΑ τοῦ ΑΓ], μεῖζον ἄρα τὸ ἀπὸ τῆς ΕΖ τοῦ ἀπὸ τῆς ΖΗ. ἔστω οὖν τῷ ἀπὸ τῆς ΕΖ ἴσα τὰ ἀπὸ τῶν ΖΗ, Θ· ἀναστρέψαντι ἄρα ὡς ὁ ΑΒ ἀριθμὸς πρὸς τὸν ΒΓ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς Θ. ὁ δὲ ΑΒ πρὸς τὸν ΒΓ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· οὐδ᾿ ἄρα τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς Θ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. ἀσύμμετρος ἄρα ἐστὶν ἡ ΕΖ τῇ Θ μήκει· ἡ ΕΖ ἄρα τῆς ΗΖ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καί εἰσιν αἱ ΕΖ, ΖΗ ῥηταὶ δυνάμει μόνον σύμμετροι, καὶ ἡ ΕΖ τῇ Δ σύμμετρός ἐστι μήκει.

Ἡ ΕΗ ἄρα ἐκ δύο ὀνομάτων ἐστὶ τετάρτη· ὅπερ ἔδει δεῖξαι.

the (square) on EF does not have to the (square) on FG the ratio which (some) square number (has) to (some) square number either. Thus, EF is incommensurable in length with FG [Prop. 10.9]. Thus, EF and FG are rational (straight-lines which are) commensurable in square only. Hence, EG is a binomial (straight-line) [Prop. 10.36]. So, I say that (it is) also a fourth (binomial straight-line).

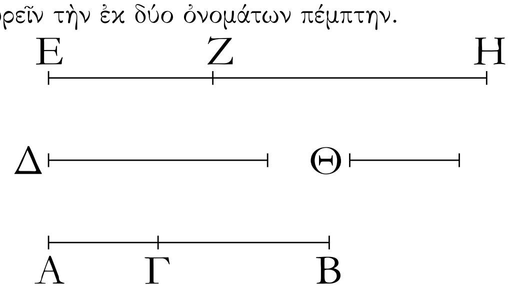
For since as BA is to AC, so the (square) on EF (is) to the (square) on FG [and BA (is) greater than AC], the (square) on EF (is) thus greater than the (square) on FG [Prop. 5.14]. Therefore, let (the sum of) the squares on FG and H be equal to the (square) on EF. Thus, via conversion, as the number AB (is) to BC, so the (square) on EF (is) to the (square) on H [Prop. 5.19 corr.]. And AB does not have to BC the ratio which (some) square number (has) to (some) square number. Thus, the (square) on EF does not have to the (square) on H the ratio which (some) square number (has) to (some) square number either. Thus, EF is incommensurable in length with H [Prop. 10.9]. Thus, the square on EF is greater than (the square on) GF by the (square) on (some straight-line) incommensurable (in length) with (EF). And EF and FG are rational (straight-lines which are) commensurable in square only. And EF is commensurable in length with D.

Thus, EG is a fourth binomial (straight-line) [Def. 10.8].† (Which is) the very thing it was required to show.

† If the rational straight-line has unit length then the length of a fourth binomial straight-line is $k\,(1+1/\sqrt{1+k'})$. This, and the fourth apotome, whose length is $k\,(1-1/\sqrt{1+k'})$ [Prop. 10.88], are the roots of $x^2 - 2\,k\,x + k^2\,k'/(1+k') = 0$.

νβ΄.

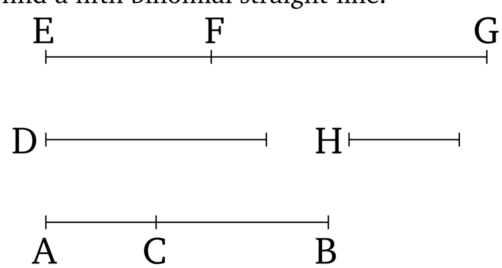
Εὑρεῖν τὴν ἐκ δύο ὀνομάτων πέμπτην.



Ἐκκείσθωσαν δύο ἀριθμοὶ οἱ ΑΓ, ΓΒ, ὥστε τὸν ΑΒ πρὸς ἑκάτερον αὐτῶν λόγον μὴ ἔχειν, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, καὶ ἐκκείσθω ῥητή τις εὐθεῖα ἡ Δ, καὶ τῇ Δ σύμμετρος ἔστω [μήκει] ἡ ΕΖ· ῥητὴ ἄρα ἡ ΕΖ. καὶ γεγονέτω ὡς ὁ ΓΑ πρὸς τὸν ΑΒ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς ΖΗ. ὁ δὲ ΓΑ πρὸς τὸν ΑΒ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· οὐδὲ τὸ ἀπὸ τῆς ΕΖ ἄρα πρὸς τὸ ἀπὸ τῆς ΖΗ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. αἱ

Proposition 52

To find a fifth binomial straight-line.



Let the two numbers AC and CB be laid down such that AB does not have to either of them the ratio which (some) square number (has) to (some) square number [Prop. 10.38 lem.]. And let some rational straight-line D be laid down. And let EF be commensurable [in length] with D. Thus, EF (is) a rational (straight-line). And let it have been contrived that as CA (is) to AB, so the (square) on EF (is) to the (square) on FG [Prop. 10.6 corr.]. And CA does not have to AB the ra-

ΕΖ, ΖΗ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΕΗ. λέγω δή, ὅτι καὶ πέμπτη.

Ἐπεὶ γάρ ἐστιν ὡς ὁ ΓΑ πρὸς τὸν ΑΒ, οὕτως τὸ ἀπὸ τῆς ΕΖ πρὸς τὸ ἀπὸ τῆς ΖΗ, ἀνάπαλιν ὡς ὁ ΒΑ πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΖΕ· μεῖζον ἄρα τὸ ἀπὸ τῆς ΗΖ τοῦ ἀπὸ τῆς ΖΕ. ἔστω οὖν τῷ ἀπὸ τῆς ΗΖ ἴσα τὰ ἀπὸ τῶν ΕΖ, Θ· ἀναστρέψαντι ἄρα ἐστὶν ὡς ὁ ΑΒ ἀριθμὸς πρὸς τὸν ΒΓ, οὕτως τὸ ἀπὸ τῆς ΗΖ πρὸς τὸ ἀπὸ τῆς Θ. ὁ δὲ ΑΒ πρὸς τὸν ΒΓ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· οὐδ᾽ ἄρα τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς Θ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. ἀσύμμετρος ἄρα ἐστὶν ἡ ΖΗ τῇ Θ μήκει· ὥστε ἡ ΖΗ τῆς ΖΕ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καί εἰσιν αἱ ΗΖ, ΖΕ ῥηταὶ δυνάμει μόνον σύμμετροι, καὶ τὸ ΕΖ ἔλαττον ὄνομα σύμμετρόν ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ Δ μήκει.

Ἡ ΕΗ ἄρα ἐκ δύο ὀνομάτων ἐστὶ πέμπτη· ὅπερ ἔδει δεῖξαι.

tio which (some) square number (has) to (some) square number. Thus, the (square) on EF does not have to the (square) on FG the ratio which (some) square number (has) to (some) square number either. Thus, EF and FG are rational (straight-lines which are) commensurable in square only [Prop. 10.9]. Thus, EG is a binomial (straight-line) [Prop. 10.36]. So, I say that (it is) also a fifth (binomial straight-line).

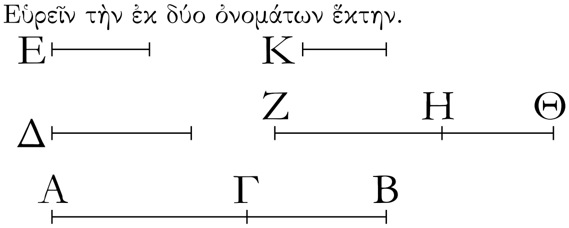
For since as CA is to AB, so the (square) on EF (is) to the (square) on FG, inversely, as BA (is) to AC, so the (square) on FG (is) to the (square) on FE [Prop. 5.7 corr.]. Thus, the (square) on GF (is) greater than the (square) on FE [Prop. 5.14]. Therefore, let (the sum of) the (squares) on EF and H be equal to the (square) on GF. Thus, via conversion, as the number AB is to BC, so the (square) on GF (is) to the (square) on H [Prop. 5.19 corr.]. And AB does not have to BC the ratio which (some) square number (has) to (some) square number. Thus, the (square) on FG does not have to the (square) on H the ratio which (some) square number (has) to (some) square number either. Thus, FG is incommensurable in length with H [Prop. 10.9]. Hence, the square on FG is greater than (the square on) FE by the (square) on (some straight-line) incommensurable (in length) with (FG). And GF and FE are rational (straight-lines which are) commensurable in square only. And the lesser term EF is commensurable in length with the rational (straight-line previously) laid down, D.

Thus, EG is a fifth binomial (straight-line).† (Which is) the very thing it was required to show.

† If the rational straight-line has unit length then the length of a fifth binomial straight-line is $k\,(\sqrt{1+k'}+1)$. This, and the fifth apotome, whose length is $k\,(\sqrt{1+k'}-1)$ [Prop. 10.89], are the roots of $x^2 - 2\,k\,\sqrt{1+k'}\,x + k^2\,k' = 0$.

νγʹ.

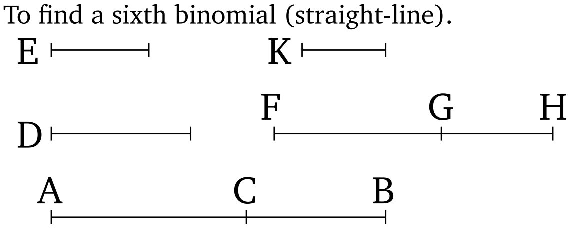
Εὑρεῖν τὴν ἐκ δύο ὀνομάτων ἕκτην.



Ἐκκείσθωσαν δύο ἀριθμοὶ οἱ ΑΓ, ΓΒ, ὥστε τὸν ΑΒ πρὸς ἑκάτερον αὐτῶν λόγον μὴ ἔχειν, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἔστω δὲ καὶ ἕτερος ἀριθμὸς ὁ Δ μὴ τετράγωνος ὢν μηδὲ πρὸς ἑκάτερον τῶν ΒΑ, ΑΓ λόγον ἔχων, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· καὶ ἐκκείσθω τις ῥητὴ εὐθεῖα ἡ Ε, καὶ γεγονέτω ὡς ὁ Δ πρὸς τὸν ΑΒ, οὕτως τὸ ἀπὸ τῆς Ε πρὸς τὸ ἀπὸ τῆς ΖΗ· σύμμετρον ἄρα τὸ ἀπὸ τῆς Ε τῷ ἀπὸ

Proposition 53

To find a sixth binomial (straight-line).



Let the two numbers AC and CB be laid down such that AB does not have to each of them the ratio which (some) square number (has) to (some) square number. And let D also be another number, which is not square, and does not have to each of BA and AC the ratio which (some) square number (has) to (some) square number either [Prop. 10.28 lem. I]. And let some rational straight-line E be laid down. And let it have been contrived that τῆς ΖΗ. καί ἐστι ῥητὴ ἡ Ε· ῥητὴ ἄρα καὶ ἡ ΖΗ. καὶ ἐπεὶ οὐκ ἔχει ὁ Δ πρὸς τὸν ΑΒ λόγον, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδὲ τὸ ἀπὸ τῆς Ε ἄρα πρὸς τὸ ἀπὸ τῆς ΖΗ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἡ Ε τῇ ΖΗ μήκει. γεγονέτω δὴ πάλιν ὡς ὁ ΒΑ πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ. σύμμετρον ἄρα τὸ ἀπὸ τῆς ΖΗ τῷ ἀπὸ τῆς ΘΗ. ῥητὸν ἄρα τὸ ἀπὸ τῆς ΘΗ· ῥητὴ ἄρα ἡ ΘΗ. καὶ ἐπεὶ ὁ ΒΑ πρὸς τὸν ΑΓ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδὲ τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΖΗ τῇ ΗΘ μήκει. αἱ ΖΗ, ΗΘ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΖΘ. δεικτέον δή, ὅτι καὶ ἕκτη.

Ἐπεὶ γάρ ἐστιν ὡς ὁ Δ πρὸς τὸν ΑΒ, οὕτως τὸ ἀπὸ τῆς Ε πρὸς τὸ ἀπὸ τῆς ΖΗ, ἔστι δὲ καὶ ὡς ὁ ΒΑ πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ, δι᾽ ἴσου ἄρα ἐστὶν ὡς ὁ Δ πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς Ε πρὸς τὸ ἀπὸ τῆς ΗΘ. ὁ δὲ Δ πρὸς τὸν ΑΓ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· οὐδὲ τὸ ἀπὸ τῆς Ε ἄρα πρὸς τὸ ἀπὸ τῆς ΗΘ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ Ε τῇ ΗΘ μήκει. ἐδείχθη δὲ καὶ τῇ ΖΗ ἀσύμμετρος· ἑκατέρα ἄρα τῶν ΖΗ, ΗΘ ἀσύμμετρός ἐστι τῇ Ε μήκει. καὶ ἐπεί ἐστιν ὡς ὁ ΒΑ πρὸς τὸν ΑΓ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ, μεῖζον ἄρα τὸ ἀπὸ τῆς ΖΗ τοῦ ἀπὸ τῆς ΗΘ. ἔστω οὖν τῷ ἀπὸ [τῆς] ΖΗ ἴσα τὰ ἀπὸ τῶν ΗΘ, Κ· ἀναστρέψαντι ἄρα ὡς ὁ ΑΒ πρὸς ΒΓ, οὕτως τὸ ἀπὸ ΖΗ πρὸς τὸ ἀπὸ τῆς Κ. ὁ δὲ ΑΒ πρὸς τὸν ΒΓ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ὥστε οὐδὲ τὸ ἀπὸ ΖΗ πρὸς τὸ ἀπὸ τῆς Κ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. ἀσύμμετρος ἄρα ἐστὶν ἡ ΖΗ τῇ Κ μήκει· ἡ ΖΗ ἄρα τῆς ΗΘ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καί εἰσιν αἱ ΖΗ, ΗΘ ῥηταὶ δυνάμει μόνον σύμμετροι, καὶ οὐδετέρα αὐτῶν σύμμετρός ἐστι μήκει τῇ ἐκκειμένῃ ῥητῇ τῇ Ε.

Ἡ ΖΘ ἄρα ἐκ δύο ὀνομάτων ἐστὶν ἕκτη· ὅπερ ἔδει δεῖξαι.

as D (is) to AB, so the (square) on E (is) to the (square) on FG [Prop. 10.6 corr.]. Thus, the (square) on E (is) commensurable with the (square) on FG [Prop. 10.6]. And E is rational. Thus, FG (is) also rational. And since D does not have to AB the ratio which (some) square number (has) to (some) square number, the (square) on E thus does not have to the (square) on FG the ratio which (some) square number (has) to (some) square number either. Thus, E (is) incommensurable in length with FG [Prop. 10.9]. So, again, let it have be contrived that as BA (is) to AC, so the (square) on FG (is) to the (square) on GH [Prop. 10.6 corr.]. The (square) on FG (is) thus commensurable with the (square) on HG [Prop. 10.6]. The (square) on HG (is) thus rational. Thus, HG (is) rational. And since BA does not have to AC the ratio which (some) square number (has) to (some) square number, the (square) on FG does not have to the (square) on GH the ratio which (some) square number (has) to (some) square number either. Thus, FG is incommensurable in length with GH [Prop. 10.9]. Thus, FG and GH are rational (straight-lines which are) commensurable in square only. Thus, FH is a binomial (straight-line) [Prop. 10.36]. So, we must show that (it is) also a sixth (binomial straight-line).

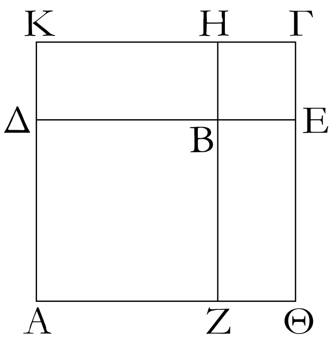
For since as D is to AB, so the (square) on E (is) to the (square) on FG, and also as BA is to AC, so the (square) on FG (is) to the (square) on GH, thus, via equality, as D is to AC, so the (square) on E (is) to the (square) on GH [Prop. 5.22]. And D does not have to AC the ratio which (some) square number (has) to (some) square number. Thus, the (square) on E does not have to the (square) on GH the ratio which (some) square number (has) to (some) square number either. E is thus incommensurable in length with GH [Prop. 10.9]. And (E) was also shown (to be) incommensurable (in length) with FG. Thus, FG and GH are each incommensurable in length with E. And since as BA is to AC, so the (square) on FG (is) to the (square) on GH, the (square) on FG (is) thus greater than the (square) on GH [Prop. 5.14]. Therefore, let (the sum of) the (squares) on GH and K be equal to the (square) on FG. Thus, via conversion, as AB (is) to BC, so the (square) on FG (is) to the (square) on K [Prop. 5.19 corr.]. And AB does not have to BC the ratio which (some) square number (has) to (some) square number. Hence, the (square) on FG does not have to the (square) on K the ratio which (some) square number (has) to (some) square number either. Thus, FG is incommensurable in length with K [Prop. 10.9]. The square on FG is thus greater than (the square on) GH by the (square) on (some straight-line which is) incommensurable (in length) with (FG). And FG and GH are rational (straight-lines which are) commensurable in square only, and neither of them is commensurable in length with the rational (straight-line) E (previously) laid down.

Thus, FH is a sixth binomial (straight-line) [Def. 10.10].† (Which is) the very thing it was required to show.

† If the rational straight-line has unit length then the length of a sixth binomial straight-line is $\sqrt{k} + \sqrt{k'}$. This, and the sixth apotome, whose length is $\sqrt{k} - \sqrt{k'}$ [Prop. 10.90], are the roots of $x^2 - 2\sqrt{k}\,x + (k - k') = 0$.

Λῆμμα.

Ἔστω δύο τετράγωνα τὰ ΑΒ, ΒΓ καὶ κείσθωσαν ὥστε ἐπ᾿ εὐθείας εἶναι τὴν ΔΒ τῇ ΒΕ· ἐπ᾿ εὐθείας ἄρα ἐστὶ καὶ ἡ ΖΒ τῇ ΒΗ. καὶ συμπεπληρώσθω τὸ ΑΓ παραλληλόγραμμον· λέγω, ὅτι τετράγωνόν ἐστι τὸ ΑΓ, καὶ ὅτι τῶν ΑΒ, ΒΓ μέσον ἀνάλογόν ἐστι τὸ ΔΗ, καὶ ἔτι τῶν ΑΓ, ΓΒ μέσον ἀνάλογόν ἐστι τὸ ΔΓ.



Ἐπεὶ γὰρ ἴση ἐστὶν ἡ μὲν ΔΒ τῇ ΒΖ, ἡ δὲ ΒΕ τῇ ΒΗ, ὅλη ἄρα ἡ ΔΕ ὅλῃ τῇ ΖΗ ἐστιν ἴση. ἀλλ᾿ ἡ μὲν ΔΕ ἑκατέρᾳ τῶν ΑΘ, ΚΓ ἐστιν ἴση, ἡ δὲ ΖΗ ἑκατέρᾳ τῶν ΑΚ, ΘΓ ἐστιν ἴση· καὶ ἑκατέρα ἄρα τῶν ΑΘ, ΚΓ ἑκατέρᾳ τῶν ΑΚ, ΘΓ ἐστιν ἴση. ἰσόπλευρον ἄρα ἐστὶ τὸ ΑΓ παραλληλόγραμμον· ἔστι δὲ καὶ ὀρθογώνιον· τετράγωνον ἄρα ἐστὶ τὸ ΑΓ.

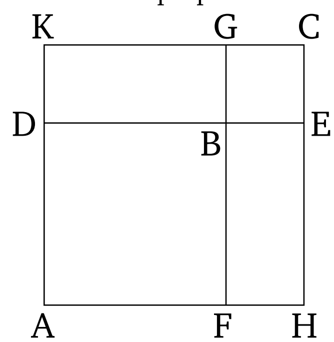
Καὶ ἐπεὶ ἐστιν ὡς ἡ ΖΒ πρὸς τὴν ΒΗ, οὕτως ἡ ΔΒ πρὸς τὴν ΒΕ, ἀλλ᾿ ὡς μὲν ἡ ΖΒ πρὸς τὴν ΒΗ, οὕτως τὸ ΑΒ πρὸς τὸ ΔΗ, ὡς δὲ ἡ ΔΒ πρὸς τὴν ΒΕ, οὕτως τὸ ΔΗ πρὸς τὸ ΒΓ, καὶ ὡς ἄρα τὸ ΑΒ πρὸς τὸ ΔΗ, οὕτως τὸ ΔΗ πρὸς τὸ ΒΓ. τῶν ΑΒ, ΒΓ ἄρα μέσον ἀνάλογόν ἐστι τὸ ΔΗ.

Λέγω δή, ὅτι καὶ τῶν ΑΓ, ΓΒ μέσον ἀνάλογόν [ἐστι] τὸ ΔΓ.

Ἐπεὶ γάρ ἐστιν ὡς ἡ ΑΔ πρὸς τὴν ΔΚ, οὕτως ἡ ΚΗ πρὸς τὴν ΗΓ· ἴση γάρ [ἐστιν] ἑκατέρα ἑκατέρᾳ· καὶ συνθέντι ὡς ἡ ΑΚ πρὸς ΚΔ, οὕτως ἡ ΚΓ πρὸς ΓΗ, ἀλλ᾿ ὡς μὲν ἡ ΑΚ πρὸς ΚΔ, οὕτως τὸ ΑΓ πρὸς τὸ ΓΔ, ὡς δὲ ἡ ΚΓ πρὸς ΓΗ, οὕτως τὸ ΔΓ πρὸς ΓΒ, καὶ ὡς ἄρα τὸ ΑΓ πρὸς ΔΓ, οὕτως τὸ ΔΓ πρὸς τὸ ΒΓ. τῶν ΑΓ, ΓΒ ἄρα μέσον ἀνάλογόν ἐστι τὸ ΔΓ· ἃ προέκειτο δεῖξαι.

Lemma

Let AB and BC be two squares, and let them be laid down such that DB is straight-on to BE. FB is, thus, also straight-on to BG. And let the parallelogram AC have been completed. I say that AC is a square, and that DG is the mean proportional to AB and BC, and, moreover, DC is the mean proportional to AC and CB.



For since DB is equal to BF, and BE to BG, the whole of DE is thus equal to the whole of FG. But DE is equal to each of AH and KC, and FG is equal to each of AK and HC [Prop. 1.34]. Thus, AH and KC are also equal to AK and HC, respectively. Thus, the parallelogram AC is equilateral. And (it is) also right-angled. Thus, AC is a square.

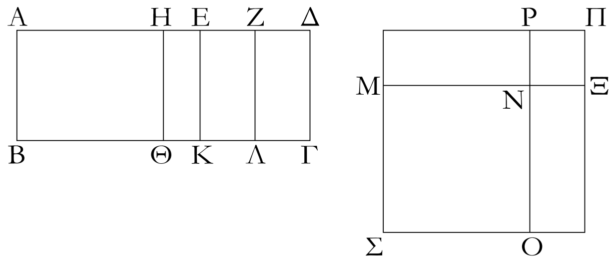
And since as FB is to BG, so DB (is) to BE, but as FB (is) to BG, so AB (is) to DG, and as DB (is) to BE, so DG (is) to BC [Prop. 6.1], thus also as AB (is) to DG, so DG (is) to BC [Prop. 5.11]. Thus, DG is the mean proportional to AB and BC.

So I also say that DC [is] the mean proportional to AC and CB.

For since as AD is to DK, so KG (is) to GC. For [they are] respectively equal. And, via composition, as AK (is) to KD, so KC (is) to CG [Prop. 5.18]. But as AK (is) to KD, so AC (is) to CD, and as KC (is) to CG, so DC (is) to CB [Prop. 6.1]. Thus, also, as AC (is) to DC, so DC (is) to BC [Prop. 5.11]. Thus, DC is the mean proportional to AC and CB. Which (is the very thing) it

νδ΄.

Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων πρώτης, ἡ τὸ χωρίον δυναμένη ἄλογός ἐστιν ἡ καλουμένη ἐκ δύο ὀνομάτων.



Χωρίον γὰρ τὸ ΑΓ περιεχέσθω ὑπὸ ῥητῆς τῆς ΑΒ καὶ τῆς ἐκ δύο ὀνομάτων πρώτης τῆς ΑΔ· λέγω, ὅτι ἡ τὸ ΑΓ χωρίον δυναμένη ἄλογός ἐστιν ἡ καλουμένη ἐκ δύο ὀνομάτων.

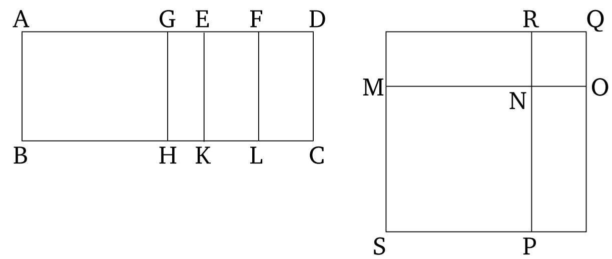
Ἐπεὶ γὰρ ἐκ δύο ὀνομάτων ἐστὶ πρώτη ἡ ΑΔ, διῃρήσθω εἰς τὰ ὀνόματα κατὰ τὸ Ε, καὶ ἔστω τὸ μεῖζον ὄνομα τὸ ΑΕ. φανερὸν δή, ὅτι αἱ ΑΕ, ΕΔ ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ ἡ ΑΕ τῆς ΕΔ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτη, καὶ ἡ ΑΕ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ ΑΒ μήκει. τετμήσθω δὴ ἡ ΕΔ δίχα κατὰ τὸ Ζ σημεῖον. καὶ ἐπεὶ ἡ ΑΕ τῆς ΕΔ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, ἐὰν ἄρα τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ἐλάσσονος, τουτέστι τῷ ἀπὸ τῆς ΕΖ, ἴσον παρὰ τὴν μείζονα τὴν ΑΕ παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ, εἰς σύμμετρα αὐτὴν διαιρεῖ. παραβεβλήσθω οὖν παρὰ τὴν ΑΕ τῷ ἀπὸ τῆς ΕΖ ἴσον τὸ ὑπὸ ΑΗ, ΗΕ· σύμμετρος ἄρα ἐστὶν ἡ ΑΗ τῇ ΕΗ μήκει. καὶ ἤχθωσαν ἀπὸ τῶν Η, Ε, Ζ ὁποτέρᾳ τῶν ΑΒ, ΓΔ παράλληλοι αἱ ΗΘ, ΕΚ, ΖΛ· καὶ τῷ μὲν ΑΘ παραλληλογράμμῳ ἴσον τετράγωνον συνεστάτω τὸ ΣΝ, τῷ δὲ ΗΚ ἴσον τὸ ΝΠ, καὶ κείσθω ὥστε ἐπ᾽ εὐθείας εἶναι τὴν ΜΝ τῇ ΝΞ· ἐπ᾽ εὐθείας ἄρα ἐστὶ καὶ ἡ ΡΝ τῇ ΝΟ. καὶ συμπεπληρώσθω τὸ ΣΠ παραλληλόγραμμον· τετράγωνον ἄρα ἐστὶ τὸ ΣΠ. καὶ ἐπεὶ τὸ ὑπὸ τῶν ΑΗ, ΗΕ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΕΖ, ἔστιν ἄρα ὡς ἡ ΑΗ πρὸς ΕΖ, οὕτως ἡ ΖΕ πρὸς ΕΗ· καὶ ὡς ἄρα τὸ ΑΘ πρὸς ΕΛ, τὸ ΕΛ πρὸς ΚΗ· τῶν ΑΘ, ΗΚ ἄρα μέσον ἀνάλογόν ἐστι τὸ ΕΛ. ἀλλὰ τὸ μὲν ΑΘ ἴσον ἐστὶ τῷ ΣΝ, τὸ δὲ ΗΚ ἴσον τῷ ΝΠ· τῶν ΣΝ, ΝΠ ἄρα μέσον ἀνάλογόν ἐστι τὸ ΕΛ. ἔστι δὲ τῶν αὐτῶν τῶν ΣΝ, ΝΠ μέσον ἀνάλογον καὶ τὸ ΜΡ· ἴσον ἄρα ἐστὶ τὸ ΕΛ τῷ ΜΡ· ὥστε καὶ τῷ ΟΞ ἴσον ἐστίν. ἔστι δὲ καὶ τὰ ΑΘ, ΗΚ τοῖς ΣΝ, ΝΠ ἴσα· ὅλον ἄρα τὸ ΑΓ ἴσον ἐστὶν ὅλῳ τῷ ΣΠ, τουτέστι τῷ ἀπὸ τῆς ΜΞ τετραγώνῳ· τὸ ΑΓ ἄρα δύναται ἡ ΜΞ. λέγω, ὅτι ἡ ΜΞ ἐκ δύο ὀνομάτων ἐστίν.

Ἐπεὶ γὰρ σύμμετρός ἐστιν ἡ ΑΗ τῇ ΗΕ, σύμμετρός ἐστι καὶ ἡ ΑΕ ἑκατέρᾳ τῶν ΑΗ, ΗΕ. ὑπόκειται δὲ καὶ ἡ ΑΕ τῇ

was prescribed to show.

Proposition 54

If an area is contained by a rational (straight-line) and a first binomial (straight-line) then the square-root of the area is the irrational (straight-line which is) called binomial.†



For let the area AC be contained by the rational (straight-line) AB and by the first binomial (straight-line) AD. I say that square-root of area AC is the irrational (straight-line which is) called binomial.

For since AD is a first binomial (straight-line), let it have been divided into its (component) terms at E, and let AE be the greater term. So, (it is) clear that AE and ED are rational (straight-lines which are) commensurable in square only, and that the square on AE is greater than (the square on) ED by the (square) on (some straight-line) commensurable (in length) with (AE), and that AE is commensurable (in length) with the rational (straight-line) AB (first) laid out [Def. 10.5]. So, let ED have been cut in half at point F. And since the square on AE is greater than (the square on) ED by the (square) on (some straight-line) commensurable (in length) with (AE), thus if a (rectangle) equal to the fourth part of the (square) on the lesser (term)—that is to say, the (square) on EF—falling short by a square figure, is applied to the greater (term) AE, then it divides it into (terms which are) commensurable (in length) [Prop 10.17]. Therefore, let the (rectangle contained) by AG and GE, equal to the (square) on EF, have been applied to AE. AG is thus commensurable in length with EG. And let GH, EK, and FL have been drawn from (points) G, E, and F (respectively), parallel to either of AB or CD. And let the square SN, equal to the parallelogram AH, have been constructed, and (the square) NQ, equal to (the parallelogram) GK [Prop. 2.14]. And let MN be laid down so as to be straight-on to NO. RN is thus also straight-on to NP. And let the parallelogram SQ have been completed. SQ is thus a square [Prop. 10.53 lem.]. And since the (rectangle contained) by AG and GE is equal to the (square) on EF, thus as AG is to EF, so FE (is) to EG [Prop. 6.17]. And thus as AH (is) to EL, (so) EL (is)

ΑΒ σύμμετρος· καὶ αἱ ΑΗ, ΗΕ ἄρα τῇ ΑΒ σύμμετροί εἰσιν. καί ἐστι ῥητὴ ἡ ΑΒ· ῥητὴ ἄρα ἐστὶ καὶ ἑκατέρα τῶν ΑΗ, ΗΕ· ῥητὸν ἄρα ἐστὶν ἑκάτερον τῶν ΑΘ, ΗΚ, καί ἐστι σύμμετρον τὸ ΑΘ τῷ ΗΚ. ἀλλὰ τὸ μὲν ΑΘ τῷ ΣΝ ἴσον ἐστίν, τὸ δὲ ΗΚ τῷ ΝΠ· καὶ τὰ ΣΝ, ΝΠ ἄρα, τουτέστι τὰ ἀπὸ τῶν ΜΝ, ΝΞ, ῥητά ἐστι καὶ σύμμετρα. καὶ ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΑΕ τῇ ΕΔ μήκει, ἀλλ᾿ ἡ μὲν ΑΕ τῇ ΑΗ ἐστι σύμμετρος, ἡ δὲ ΔΕ τῇ ΕΖ σύμμετρος, ἀσύμμετρος ἄρα καὶ ἡ ΑΗ τῇ ΕΖ· ὥστε καὶ τὸ ΑΘ τῷ ΕΛ ἀσύμμετρόν ἐστιν. ἀλλὰ τὸ μὲν ΑΘ τῷ ΣΝ ἐστιν ἴσον, τὸ δὲ ΕΛ τῷ ΜΡ· καὶ τὸ ΣΝ ἄρα τῷ ΜΡ ἀσύμμετρόν ἐστιν. ἀλλ᾿ ὡς τὸ ΣΝ πρὸς ΜΡ, ἡ ΟΝ πρὸς τὴν ΝΡ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΟΝ τῇ ΝΡ. ἴση δὲ ἡ μὲν ΟΝ τῇ ΜΝ, ἡ δὲ ΝΡ τῇ ΝΞ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΜΝ τῇ ΝΞ. καί ἐστι τὸ ἀπὸ τῆς ΜΝ σύμμετρον τῷ ἀπὸ τῆς ΝΞ, καὶ ῥητὸν ἑκάτερον· αἱ ΜΝ, ΝΞ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι.

Ἡ ΜΞ ἄρα ἐκ δύο ὀνομάτων ἐστὶ καὶ δύναται τὸ ΑΓ· ὅπερ ἔδει δεῖξαι.

to KG [Prop. 6.1]. Thus, EL is the mean proportional to AH and GK. But, AH is equal to SN, and GK (is) equal to NQ. EL is thus the mean proportional to SN and NQ. And MR is also the mean proportional to the same—(namely), SN and NQ [Prop. 10.53 lem.]. EL is thus equal to MR. Hence, it is also equal to PO [Prop. 1.43]. And AH plus GK is equal to SN plus NQ. Thus, the whole of AC is equal to the whole of SQ—that is to say, to the square on MO. Thus, MO (is) the square-root of (area) AC. I say that MO is a binomial (straight-line).

For since AG is commensurable (in length) with GE, AE is also commensurable (in length) with each of AG and GE [Prop. 10.15]. And AE was also assumed (to be) commensurable (in length) with AB. Thus, AG and GE are also commensurable (in length) with AB [Prop. 10.12]. And AB is rational. AG and GE are thus each also rational. Thus, AH and GK are each rational (areas), and AH is commensurable with GK [Prop. 10.19]. But, AH is equal to SN, and GK to NQ. SN and NQ—that is to say, the (squares) on MN and NO (respectively)—are thus also rational and commensurable. And since AE is incommensurable in length with ED, but AE is commensurable (in length) with AG, and DE (is) commensurable (in length) with EF, AG (is) thus also incommensurable (in length) with EF [Prop. 10.13]. Hence, AH is also incommensurable with EL [Props. 6.1, 10.11]. But, AH is equal to SN, and EL to MR. Thus, SN is also incommensurable with MR. But, as SN (is) to MR, (so) PN (is) to NR [Prop. 6.1]. PN is thus incommensurable (in length) with NR [Prop. 10.11]. And PN (is) equal to MN, and NR to NO. Thus, MN is incommensurable (in length) with NO. And the (square) on MN is commensurable with the (square) on NO, and each (is) rational. MN and NO are thus rational (straight-lines which are) commensurable in square only.

Thus, MO is (both) a binomial (straight-line) [Prop. 10.36], and the square-root of AC. (Which is) the very thing it was required to show.

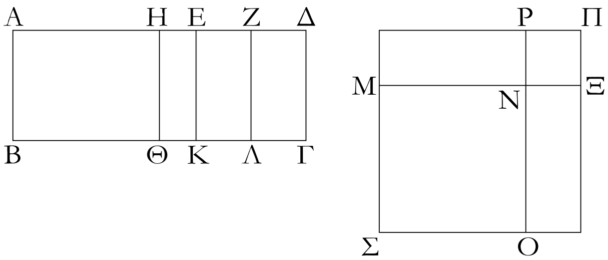
† If the rational straight-line has unit length then this proposition states that the square-root of a first binomial straight-line is a binomial straight-line: *i.e.*, a first binomial straight-line has a length $k + k\sqrt{1-k'^2}$ whose square-root can be written $\rho\,(1+\sqrt{k''})$, where $\rho = \sqrt{k\,(1+k')/2}$ and $k'' = (1-k')/(1+k')$. This is the length of a binomial straight-line (see Prop. 10.36), since ρ is rational.

νε΄.

Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων δευτέρας, ἡ τὸ χωρίον δυναμένη ἄλογός ἐστιν ἡ καλουμένη ἐκ δύο μέσων πρώτη.

Proposition 55

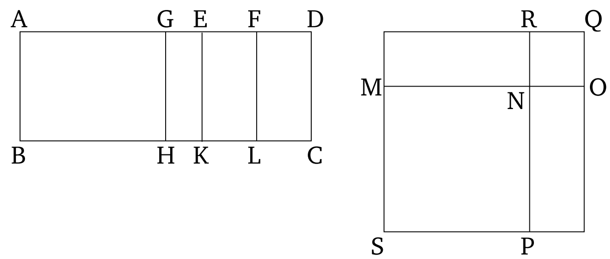
If an area is contained by a rational (straight-line) and a second binomial (straight-line) then the square-root of the area is the irrational (straight-line which is) called first bimedial.†



Περιεχέσθω γὰρ χωρίον τὸ ΑΒΓΔ ὑπὸ ῥητῆς τῆς ΑΒ καὶ τῆς ἐκ δύο ὀνομάτων δυετέρας τῆς ΑΔ· λέγω, ὅτι ἡ τὸ ΑΓ χωρίον δυναμένη ἐκ δύο μέσων πρώτη ἐστίν.

Ἐπεὶ γὰρ ἐκ δύο ὀνομάτων δευτέρα ἐστὶν ἡ ΑΔ, διῃρήσθω εἰς τὰ ὀνόματα κατὰ τὸ Ε, ὥστε τὸ μεῖζον ὄνομα εἶναι τὸ ΑΕ· αἱ ΑΕ, ΕΔ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ ἡ ΑΕ τῆς ΕΔ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καὶ τὸ ἔλαττον ὄνομα ἡ ΕΔ σύμμετρόν ἐστι τῇ ΑΒ μήκει. τετμήσθω ἡ ΕΔ δίχα κατὰ τὸ Ζ, καὶ τῷ ἀπὸ τῆς ΕΖ ἴσον παρὰ τὴν ΑΕ παραβεβλήσθω ἐλλεῖπον εἴδει τετραγώνῳ τὸ ὑπὸ τῶν ΑΗΕ· σύμμετρος ἄρα ἡ ΑΗ τῇ ΗΕ μήκει. καὶ διὰ τῶν Η, Ε, Ζ παράλληλοι ἤχθωσαν ταῖς ΑΒ, ΓΔ αἱ ΗΘ, ΕΚ, ΖΛ, καὶ τῷ μὲν ΑΘ παραλληλογράμμῳ ἴσον τετράγωνον συνεστάτω τὸ ΣΝ, τῷ δὲ ΗΚ ἴσον τετράγωνον τὸ ΝΠ, καὶ κείσθω ὥστε ἐπ᾽ εὐθείας εἶναι τὴν ΜΝ τῇ ΝΞ· ἐπ᾽ εὐθείας ἄρα [ἐστὶ] καὶ ἡ ΡΝ τῇ ΝΟ. καὶ συμπεπληρώσθω τὸ ΣΠ τετράγωνον· φανερὸν δὴ ἐκ τοῦ προδεδειγμένου, ὅτι τὸ ΜΡ μέσον ἀνάλογόν ἐστι τῶν ΣΝ, ΝΠ, καὶ ἴσον τῷ ΕΛ, καὶ ὅτι τὸ ΑΓ χωρίον δύναται ἡ ΜΞ. δεικτέον δή, ὅτι ἡ ΜΞ ἐκ δύο μέσων ἐστὶ πρώτη.

Ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΑΕ τῇ ΕΔ μήκει, σύμμετρος δὲ ἡ ΕΔ τῇ ΑΒ, ἀσύμμετρος ἄρα ἡ ΑΕ τῇ ΑΒ. καὶ ἐπεὶ σύμμετρός ἐστιν ἡ ΑΗ τῇ ΕΗ, σύμμετρός ἐστι καὶ ἡ ΑΕ ἑκατέρᾳ τῶν ΑΗ, ΗΕ. ἀλλὰ ἡ ΑΕ ἀσύμμετρος τῇ ΑΒ μήκει· καὶ αἱ ΑΗ, ΗΕ ἄρα ἀσύμμετροί εἰσι τῇ ΑΒ. αἱ ΒΑ, ΑΗ, ΗΕ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ὥστε μέσον ἐστὶν ἑκάτερον τῶν ΑΘ, ΗΚ. ὥστε καὶ ἑκάτερον τῶν ΣΝ, ΝΠ μέσον ἐστίν. καὶ αἱ ΜΝ, ΝΞ ἄρα μέσαι εἰσίν. καὶ ἐπεὶ σύμμετρος ἡ ΑΗ τῇ ΗΕ μήκει, σύμμετρόν ἐστι καὶ τὸ ΑΘ τῷ ΗΚ, τουτέστι τὸ ΣΝ τῷ ΝΠ, τουτέστι τὸ ἀπὸ τῆς ΜΝ τῷ ἀπὸ τῆς ΝΞ [ὥστε δυνάμει εἰσὶ σύμμετροι αἱ ΜΝ, ΝΞ]. καὶ ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΑΕ τῇ ΕΔ μήκει, ἀλλ᾽ ἡ μὲν ΑΕ σύμμετρός ἐστι τῇ ΑΗ, ἡ δὲ ΕΔ τῇ ΕΖ σύμμετρος, ἀσύμμετρος ἄρα ἡ ΑΗ τῇ ΕΖ· ὥστε καὶ τὸ ΑΘ τῷ ΕΛ ἀσύμμετρόν ἐστιν, τουτέστι τὸ ΣΝ τῷ ΜΡ, τουτέστιν ὁ ΟΝ τῇ ΝΡ, τουτέστιν ἡ ΜΝ τῇ ΝΞ ἀσύμμετρός ἐστι μήκει. ἐδείχθησαν δὲ αἱ ΜΝ, ΝΞ καὶ μέσαι οὖσαι καὶ δυνάμει σύμμετροι· αἱ ΜΝ, ΝΞ ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι. λέγω δή, ὅτι καὶ ῥητὸν περιέχουσιν. ἐπεὶ γὰρ ἡ ΔΕ ὑπόκειται ἑκατέρᾳ τῶν ΑΒ, ΕΖ σύμμετρος, σύμμετρος ἄρα καὶ ἡ ΕΖ τῇ ΕΚ. καὶ ῥητὴ ἑκατέρα αὐτῶν· ῥητὸν ἄρα τὸ ΕΛ, τουτέστι τὸ ΜΡ· τὸ δὲ ΜΡ ἐστι τὸ ὑπὸ τῶν ΜΝΞ. ἐὰν δὲ δύο μέσαι δυνάμει μόνον σύμμετροι συντεθῶσι ῥητὸν



For let the area $ABCD$ be contained by the rational (straight-line) AB and by the second binomial (straight-line) AD. I say that the square-root of area AC is a first bimedial (straight-line).

For since AD is a second binomial (straight-line), let it have been divided into its (component) terms at E, such that AE is the greater term. Thus, AE and ED are rational (straight-lines which are) commensurable in square only, and the square on AE is greater than (the square on) ED by the (square) on (some straight-line) commensurable (in length) with (AE), and the lesser term ED is commensurable in length with AB [Def. 10.6]. Let ED have been cut in half at F. And let the (rectangle contained) by AGE, equal to the (square) on EF, have been applied to AE, falling short by a square figure. AG (is) thus commensurable in length with GE [Prop. 10.17]. And let GH, EK, and FL have been drawn through (points) G, E, and F (respectively), parallel to AB and CD. And let the square SN, equal to the parallelogram AH, have been constructed, and the square NQ, equal to GK. And let MN be laid down so as to be straight-on to NO. Thus, RN [is] also straight-on to NP. And let the square SQ have been completed. So, (it is) clear from what has been previously demonstrated [Prop. 10.53 lem.] that MR is the mean proportional to SN and NQ, and (is) equal to EL, and that MO is the square-root of the area AC. So, we must show that MO is a first bimedial (straight-line).

Since AE is incommensurable in length with ED, and ED (is) commensurable (in length) with AB, AE (is) thus incommensurable (in length) with AB [Prop. 10.13]. And since AG is commensurable (in length) with EG, AE is also commensurable (in length) with each of AG and GE [Prop. 10.15]. But, AE is incommensurable in length with AB. Thus, AG and GE are also (both) incommensurable (in length) with AB [Prop. 10.13]. Thus, BA, AG, and (BA, and) GE are (pairs of) rational (straight-lines which are) commensurable in square only. And, hence, each of AH and GK is a medial (area) [Prop. 10.21]. Hence, each of SN and NQ is also a medial (area). Thus, MN and NO are medial (straight-lines). And since AG (is) commensurable in length with GE, AH is also commensurable περιέχουσαι, ἡ ὅλη ἄλογός ἐστιν, καλεῖται δὲ ἐκ δύο μέσων πρώτη.

Ἡ ἄρα ΜΞ ἐκ δύο μέσων ἐστὶ πρώτη· ὅπερ ἔδει δεῖξαι.

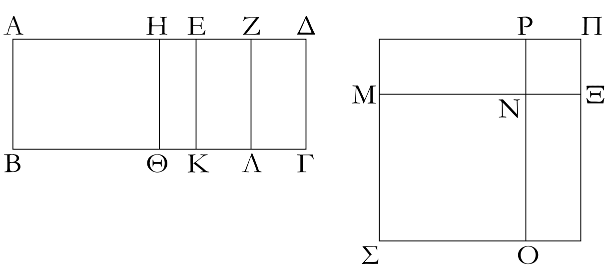
with GK—that is to say, SN with NQ—that is to say, the (square) on MN with the (square) on NO [hence, MN and NO are commensurable in square] [Props. 6.1, 10.11]. And since AE is incommensurable in length with ED, but AE is commensurable (in length) with AG, and ED commensurable (in length) with EF, AG (is) thus incommensurable (in length) with EF [Prop. 10.13]. Hence, AH is also incommensurable with EL—that is to say, SN with MR—that is to say, PN with NR—that is to say, MN is incommensurable in length with NO [Props. 6.1, 10.11]. But MN and NO have also been shown to be medial (straight-lines) which are commensurable in square. Thus, MN and NO are medial (straight-lines which are) commensurable in square only. So, I say that they also contain a rational (area). For since DE was assumed (to be) commensurable (in length) with each of AB and EF, EF (is) thus also commensurable with EK [Prop. 10.12]. And they (are) each rational. Thus, EL—that is to say, MR—(is) rational [Prop. 10.19]. And MR is the (rectangle contained) by MNO. And if two medial (straight-lines), commensurable in square only, which contain a rational (area), are added together, then the whole is (that) irrational (straight-line which is) called first bimedial [Prop. 10.37].

Thus, MO is a first bimedial (straight-line). (Which is) the very thing it was required to show.

† If the rational straight-line has unit length then this proposition states that the square-root of a second binomial straight-line is a first bimedial straight-line: *i.e.*, a second binomial straight-line has a length $k/\sqrt{1-k'^2}+k$ whose square-root can be written $\rho\,(k''^{1/4}+k''^{3/4})$, where $\rho=\sqrt{(k/2)\,(1+k')/(1-k')}$ and $k''=(1-k')/(1+k')$. This is the length of a first bimedial straight-line (see Prop. 10.37), since ρ is rational.

νϛ΄.

Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων τρίτης, ἡ τὸ χωρίον δυναμένη ἄλογός ἐστιν ἡ καλουμένη ἐκ δύο μέσων δευτέρα.

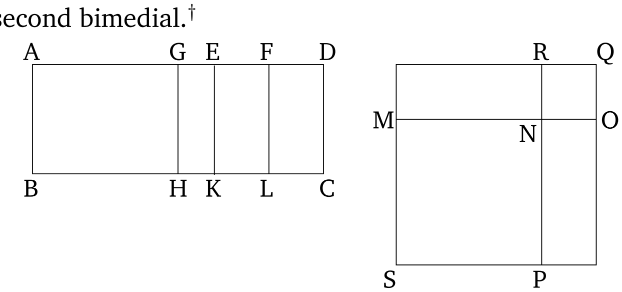


Χωρίον γὰρ τὸ ΑΒΓΔ περιεχέσθω ὑπὸ ῥητῆς τῆς ΑΒ καὶ τῆς ἐκ δύο ὀνομάτων τρίτης τῆς ΑΔ διῃρημένης εἰς τὰ ὀνόματα κατὰ τὸ Ε, ὧν μεῖζόν ἐστι τὸ ΑΕ· λέγω, ὅτι ἡ τὸ ΑΓ χωρίον δυναμένη ἄλογός ἐστιν ἡ καλουμένη ἐκ δύο μέσων δευτέρα.

Κατεσκευάσθω γὰρ τὰ αὐτὰ τοῖς πρότερον. καὶ ἐπεὶ

Proposition 56

If an area is contained by a rational (straight-line) and a third binomial (straight-line) then the square-root of the area is the irrational (straight-line which is) called second bimedial.†



For let the area $ABCD$ be contained by the rational (straight-line) AB and by the third binomial (straight-line) AD, which has been divided into its (component) terms at E, of which AE is the greater. I say that the square-root of area AC is the irrational (straight-line which is) called second bimedial.

ἐκ δύο ὀνομάτων ἐστὶ τρίτη ἡ ΑΔ, αἱ ΑΕ, ΕΔ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ ἡ ΑΕ τῆς ΕΔ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καὶ οὐδετέρα τῶν ΑΕ, ΕΔ σύμμετρός [ἐστι] τῇ ΑΒ μήκει. ὁμοίως δὴ τοῖς προδεδειγμένοις δείξομεν, ὅτι ἡ ΜΞ ἐστιν ἡ τὸ ΑΓ χωρίον δυναμένη, καὶ αἱ ΜΝ, ΝΞ μέσαι εἰσὶ δυνάμει μόνον σύμμετροι· ὥστε ἡ ΜΞ ἐκ δύο μέσων ἐστίν. δεικτέον δή, ὅτι καὶ δευτέρα.

[Καὶ] ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΔΕ τῇ ΑΒ μήκει, τουτέστι τῇ ΕΚ, σύμμετρος δὲ ἡ ΔΕ τῇ ΕΖ, ἀσύμμετρος ἄρα ἐστὶν ἡ ΕΖ τῇ ΕΚ μήκει. καί εἰσι ῥηταί· αἱ ΖΕ, ΕΚ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. μέσον ἄρα [ἐστὶ] τὸ ΕΛ, τουτέστι τὸ ΜΡ· καὶ περιέχεται ὑπὸ τῶν ΜΝΞ· μέσον ἄρα ἐστὶ τὸ ὑπὸ τῶν ΜΝΞ.

Ἡ ΜΞ ἄρα ἐκ δύο μέσων ἐστὶ δευτέρα· ὅπερ ἔδει δεῖξαι.

For let the same construction be made as previously. And since AD is a third binomial (straight-line), AE and ED are thus rational (straight-lines which are) commensurable in square only, and the square on AE is greater than (the square on) ED by the (square) on (some straight-line) commensurable (in length) with (AE), and neither of AE and ED [is] commensurable in length with AB [Def. 10.7]. So, similarly to that which has been previously demonstrated, we can show that MO is the square-root of area AC, and MN and NO are medial (straight-lines which are) commensurable in square only. Hence, MO is bimedial. So, we must show that (it is) also second (bimedial).

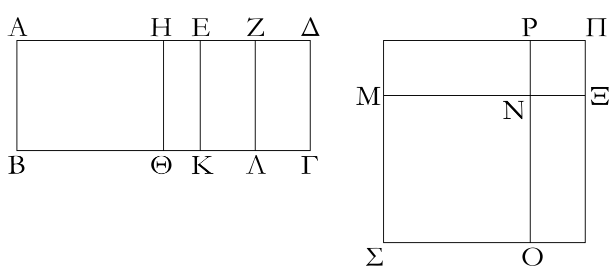
[And] since DE is incommensurable in length with AB—that is to say, with EK—and DE (is) commensurable (in length) with EF, EF is thus incommensurable in length with EK [Prop. 10.13]. And they are (both) rational (straight-lines). Thus, FE and EK are rational (straight-lines which are) commensurable in square only. EL—that is to say, MR—[is] thus medial [Prop. 10.21]. And it is contained by MNO. Thus, the (rectangle contained) by MNO is medial.

Thus, MO is a second bimedial (straight-line) [Prop. 10.38]. (Which is) the very thing it was required to show.

† If the rational straight-line has unit length then this proposition states that the square-root of a third binomial straight-line is a second bimedial straight-line: *i.e.*, a third binomial straight-line has a length $k^{1/2}\,(1+\sqrt{1-k'^2})$ whose square-root can be written $\rho\,(k^{1/4}+k''^{1/2}/k^{1/4})$, where $\rho=\sqrt{(1+k')/2}$ and $k''=k\,(1-k')/(1+k')$. This is the length of a second bimedial straight-line (see Prop. 10.38), since ρ is rational.

νζʹ.

Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων τετάρτης, ἡ τὸ χωρίον δυναμένη ἄλογός ἐστιν ἡ καλουμένη μείζων.

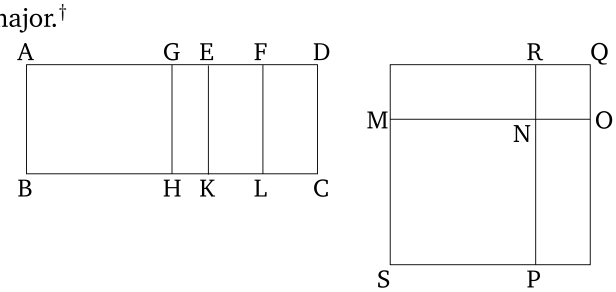


Χωρίον γὰρ τὸ ΑΓ περιεχέσθω ὑπὸ ῥητῆς τῆς ΑΒ καὶ τῆς ἐκ δύο ὀνομάτων τετάρτης τῆς ΑΔ διῃρημένης εἰς τὰ ὀνόματα κατὰ τὸ Ε, ὧν μεῖζον ἔστω τὸ ΑΕ· λέγω, ὅτι ἡ τὸ ΑΓ χωρίον δυναμένη ἄλογός ἐστιν ἡ καλουμένη μείζων.

Ἐπεὶ γὰρ ἡ ΑΔ ἐκ δύο ὀνομάτων ἐστὶ τετάρτη, αἱ ΑΕ, ΕΔ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ ἡ ΑΕ τῆς ΕΔ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, καὶ ἡ ΑΕ τῇ ΑΒ σύμμετρός [ἐστι] μήκει. τετμήσθω ἡ ΔΕ δίχα κατὰ

Proposition 57

If an area is contained by a rational (straight-line) and a fourth binomial (straight-line) then the square-root of the area is the irrational (straight-line which is) called major.†



For let the area AC be contained by the rational (straight-line) AB and the fourth binomial (straight-line) AD, which has been divided into its (component) terms at E, of which let AE be the greater. I say that the square-root of AC is the irrational (straight-line which is) called major.

For since AD is a fourth binomial (straight-line), AE and ED are thus rational (straight-lines which are) comτὸ Ζ, καὶ τῷ ἀπὸ τῆς ΕΖ ἴσον παρὰ τὴν ΑΕ παραβεβλήσθω παραλληλόγραμμον τὸ ὑπὸ ΑΗ, ΗΕ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΑΗ τῇ ΗΕ μήκει. ἤχθωσαν παράλληλοι τῇ ΑΒ αἱ ΗΘ, ΕΚ, ΖΛ, καὶ τὰ λοιπὰ τὰ αὐτὰ τοῖς πρὸ τούτου γεγονέτω· φανερὸν δή, ὅτι ἡ τὸ ΑΓ χωρίον δυναμένη ἐστὶν ἡ ΜΞ. δεικτέον δή, ὅτι ἡ ΜΞ ἄλογός ἐστιν ἡ καλουμένη μείζων.

Ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΑΗ τῇ ΕΗ μήκει, ἀσύμμετρόν ἐστι καὶ τὸ ΑΘ τῷ ΗΚ, τουτέστι τὸ ΣΝ τῷ ΝΠ· αἱ ΜΝ, ΝΞ ἄρα δυνάμει εἰσὶν ἀσύμμετροι. καὶ ἐπεὶ σύμμετρός ἐστιν ἡ ΑΕ τῇ ΑΒ μήκει, ῥητόν ἐστι τὸ ΑΚ· καί ἐστιν ἴσον τοῖς ἀπὸ τῶν ΜΝ, ΝΞ· ῥητὸν ἄρα [ἐστὶ] καὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΜΝ, ΝΞ. καὶ ἐπεὶ ἀσύμμετρός [ἐστιν] ἡ ΔΕ τῇ ΑΒ μήκει, τουτέστι τῇ ΕΚ, ἀλλὰ ἡ ΔΕ σύμμετρός ἐστι τῇ ΕΖ, ἀσύμμετρος ἄρα ἡ ΕΖ τῇ ΕΚ μήκει. αἱ ΕΚ, ΕΖ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· μέσον ἄρα τὸ ΛΕ, τουτέστι τὸ ΜΡ. καὶ περιέχεται ὑπὸ τῶν ΜΝ, ΝΞ· μέσον ἄρα ἐστὶ τὸ ὑπὸ τῶν ΜΝ, ΝΞ. καὶ ῥητὸν τὸ [συγκείμενον] ἐκ τῶν ἀπὸ τῶν ΜΝ, ΝΞ, καί εἰσιν ἀσύμμετροι αἱ ΜΝ, ΝΞ δυνάμει. ἐὰν δὲ δύο εὐθεῖαι δυνάμει ἀσύμμετροι συντεθῶσι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾿ αὐτῶν τετραγώνων ῥητόν, τὸ δ᾿ ὑπ᾿ αὐτῶν μέσον, ἡ ὅλη ἄλογός ἐστιν, καλεῖται δὲ μείζων.

Ἡ ΜΞ ἄρα ἄλογός ἐστιν ἡ καλουμένη μείζων, καὶ δύναται τὸ ΑΓ χωρίον· ὅπερ ἔδει δεῖξαι.

mensurable in square only, and the square on AE is greater than (the square on) ED by the (square) on (some straight-line) incommensurable (in length) with (AE), and AE [is] commensurable in length with AB [Def. 10.8]. Let DE have been cut in half at F, and let the parallelogram (contained by) AG and GE, equal to the (square) on EF, (and falling short by a square figure) have been applied to AE. AG is thus incommensurable in length with GE [Prop. 10.18]. Let GH, EK, and FL have been drawn parallel to AB, and let the rest (of the construction) have been made the same as the (proposition) before this. So, it is clear that MO is the square-root of area AC. So, we must show that MO is the irrational (straight-line which is) called major.

Since AG is incommensurable in length with EG, AH is also incommensurable with GK—that is to say, SN with NQ [Props. 6.1, 10.11]. Thus, MN and NO are incommensurable in square. And since AE is commensurable in length with AB, AK is rational [Prop. 10.19]. And it is equal to the (sum of the squares) on MN and NO. Thus, the sum of the (squares) on MN and NO [is] also rational. And since DE [is] incommensurable in length with AB [Prop. 10.13]—that is to say, with EK—but DE is commensurable (in length) with EF, EF (is) thus incommensurable in length with EK [Prop. 10.13]. Thus, EK and EF are rational (straight-lines which are) commensurable in square only. LE—that is to say, MR—(is) thus medial [Prop. 10.21]. And it is contained by MN and NO. The (rectangle contained) by MN and NO is thus medial. And the [sum] of the (squares) on MN and NO (is) rational, and MN and NO are incommensurable in square. And if two straight-lines (which are) incommensurable in square, making the sum of the squares on them rational, and the (rectangle contained) by them medial, are added together, then the whole is the irrational (straight-line which is) called major [Prop. 10.39].

Thus, MO is the irrational (straight-line which is) called major. And (it is) the square-root of area AC. (Which is) the very thing it was required to show.

† If the rational straight-line has unit length then this proposition states that the square-root of a fourth binomial straight-line is a major straight-line: *i.e.*, a fourth binomial straight-line has a length $k\,(1 + 1/\sqrt{1+k'})$ whose square-root can be written $\rho\,\sqrt{[1 + k''/(1+k''^{\,2})^{1/2}]/2} + \rho\,\sqrt{[1 - k''/(1+k''^{\,2})^{1/2}]/2}$, where $\rho = \sqrt{k}$ and $k''^{\,2} = k'$. This is the length of a major straight-line (see Prop. 10.39), since ρ is rational.

νηʹ.

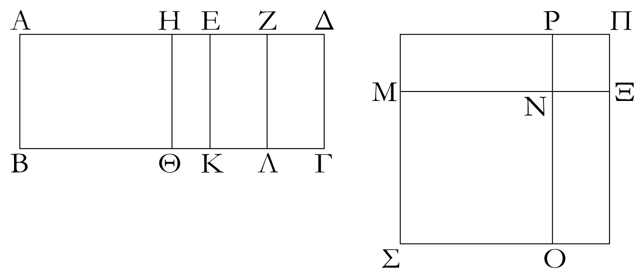
Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων πέμπτης, ἡ τὸ χωρίον δυναμένη ἄλογός ἐστιν ἡ καλουμένη ῥητὸν καὶ μέσον δυναμένη.

Χωρίον γὰρ τὸ ΑΓ περιεχέσθω ὑπὸ ῥητῆς τῆς ΑΒ καὶ

Proposition 58

If an area is contained by a rational (straight-line) and a fifth binomial (straight-line) then the square-root of the area is the irrational (straight-line which is) called the square-root of a rational plus a medial (area).†

τῆς ἐκ δύο ὀνομάτων πέμπτης τῆς ΑΔ διῃρημένης εἰς τὰ ὀνόματα κατὰ τὸ Ε, ὥστε τὸ μεῖζον ὄνομα εἶναι τὸ ΑΕ· λέγω [δή], ὅτι ἡ τὸ ΑΓ χωρίον δυναμένη ἄλογός ἐστιν ἡ καλουμένη ῥητὸν καὶ μέσον δυναμένη.

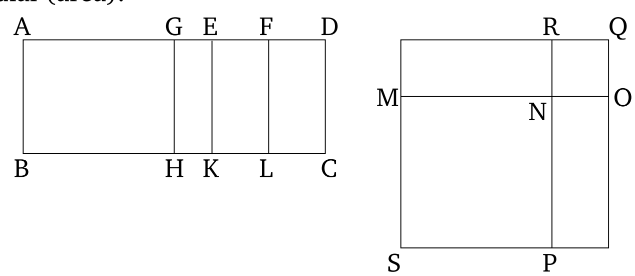


Κατεσκευάσθω γὰρ τὰ αὐτὰ τοῖς πρότερον δεδειγμένοις· φανερὸν δή, ὅτι ἡ τὸ ΑΓ χωρίον δυναμένη ἐστὶν ἡ ΜΞ. δεικτέον δή, ὅτι ἡ ΜΞ ἐστιν ἡ ῥητὸν καὶ μέσον δυναμένη.

Ἐπεὶ γὰρ ἀσύμμετρός ἐστιν ἡ ΑΗ τῇ ΗΕ, ἀσύμμετρον ἄρα ἐστὶ καὶ τὸ ΑΘ τῷ ΘΕ, τουτέστι τὸ ἀπὸ τῆς ΜΝ τῷ ἀπὸ τῆς ΝΞ· αἱ ΜΝ, ΝΞ ἄρα δυνάμει εἰσὶν ἀσύμμετροι. καὶ ἐπεὶ ἡ ΑΔ ἐκ δύο ὀνομάτων ἐστὶ πέμπτη, καί [ἐστιν] ἔλασσον αὐτῆς τμῆμα τὸ ΕΔ, σύμμετρος ἄρα ἡ ΕΔ τῇ ΑΒ μήκει. ἀλλὰ ἡ ΑΕ τῇ ΕΔ ἐστιν ἀσύμμετρος· καὶ ἡ ΑΒ ἄρα τῇ ΑΕ ἐστιν ἀσύμμετρος μήκει [αἱ ΒΑ, ΑΕ ῥηταί εἰσι δυνάμει μόνον σύμμετροι]· μέσον ἄρα ἐστὶ τὸ ΑΚ, τουτέστι τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΜΝ, ΝΞ. καὶ ἐπεὶ σύμμετρός ἐστιν ἡ ΔΕ τῇ ΑΒ μήκει, τουτέστι τῇ ΕΚ, ἀλλὰ ἡ ΔΕ τῇ ΕΖ σύμμετρός ἐστιν, καὶ ἡ ΕΖ ἄρα τῇ ΕΚ σύμμετρός ἐστιν. καὶ ῥητὴ ἡ ΕΚ· ῥητὸν ἄρα καὶ τὸ ΕΛ, τουτέστι τὸ ΜΡ, τουτέστι τὸ ὑπὸ ΜΝΞ· αἱ ΜΝ, ΝΞ ἄρα δυνάμει ἀσύμμετροί εἰσι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον, τὸ δ᾽ ὑπ᾽ αὐτῶν ῥητόν.

Ἡ ΜΞ ἄρα ῥητὸν καὶ μέσον δυναμένη ἐστὶ καὶ δύναται τὸ ΑΓ χωρίον· ὅπερ ἔδει δεῖξαι.

For let the area AC be contained by the rational (straight-line) AB and the fifth binomial (straight-line) AD, which has been divided into its (component) terms at E, such that AE is the greater term. [So] I say that the square-root of area AC is the irrational (straight-line which is) called the square-root of a rational plus a medial (area).



For let the same construction be made as that shown previously. So, (it is) clear that MO is the square-root of area AC. So, we must show that MO is the square-root of a rational plus a medial (area).

For since AG is incommensurable (in length) with GE [Prop. 10.18], AH is thus also incommensurable with HE—that is to say, the (square) on MN with the (square) on NO [Props. 6.1, 10.11]. Thus, MN and NO are incommensurable in square. And since AD is a fifth binomial (straight-line), and ED [is] its lesser segment, ED (is) thus commensurable in length with AB [Def. 10.9]. But, AE is incommensurable (in length) with ED. Thus, AB is also incommensurable in length with AE [BA and AE are rational (straight-lines which are) commensurable in square only] [Prop. 10.13]. Thus, AK—that is to say, the sum of the (squares) on MN and NO—is medial [Prop. 10.21]. And since DE is commensurable in length with AB—that is to say, with EK—but, DE is commensurable (in length) with EF, EF is thus also commensurable (in length) with EK [Prop. 10.12]. And EK (is) rational. Thus, EL—that is to say, MR—that is to say, the (rectangle contained) by MNO—(is) also rational [Prop. 10.19]. MN and NO are thus (straight-lines which are) incommensurable in square, making the sum of the squares on them medial, and the (rectangle contained) by them rational.

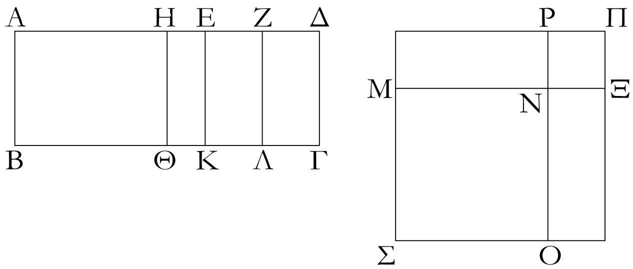
Thus, MO is the square-root of a rational plus a medial (area) [Prop. 10.40]. And (it is) the square-root of area AC. (Which is) the very thing it was required to show.

† If the rational straight-line has unit length then this proposition states that the square-root of a fifth binomial straight-line is the square root of a rational plus a medial area: *i.e.*, a fifth binomial straight-line has a length $k\,(\sqrt{1+k'}+1)$ whose square-root can be written $\rho\,\sqrt{[(1+k''^{\,2})^{1/2}+k'']/[2\,(1+k''^{\,2})]}+\rho\,\sqrt{[(1+k''^{\,2})^{1/2}-k'']/[2\,(1+k''^{\,2})]}$, where $\rho=\sqrt{k\,(1+k''^{\,2})}$ and $k''^{\,2}=k'$. This is the length of

the square root of a rational plus a medial area (see Prop. 10.40), since ρ is rational.

νθ´.

Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων ἕκτης, ἡ τὸ χωρίον δυναμένη ἄλογός ἐστιν ἡ καλουμένη δύο μέσα δυναμένη.



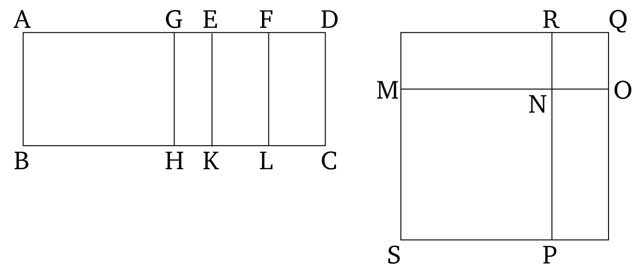
Χωρίον γὰρ τὸ ΑΒΓΔ περιεχέσθω ὑπὸ ῥητῆς τῆς ΑΒ καὶ τῆς ἐκ δύο ὀνομάτων ἕκτης τῆς ΑΔ διῃρημένης εἰς τὰ ὀνόματα κατὰ τὸ Ε, ὥστε τὸ μεῖζον ὄνομα εἶναι τὸ ΑΕ· λέγω, ὅτι ἡ τὸ ΑΓ δυναμένη ἡ δύο μέσα δυναμένη ἐστίν.

Κατεσκευάσθω [γὰρ] τὰ αὐτὰ τοῖς προδεδειγμένοις. φανερὸν δή, ὅτι [ἡ] τὸ ΑΓ δυναμένη ἐστὶν ἡ ΜΞ, καὶ ὅτι ἀσύμμετρός ἐστιν ἡ ΜΝ τῇ ΝΞ δυνάμει. καὶ ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΕΑ τῇ ΑΒ μήκει, αἱ ΕΑ, ΑΒ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· μέσον ἄρα ἐστὶ τὸ ΑΚ, τουτέστι τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΜΝ, ΝΞ. πάλιν, ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΕΔ τῇ ΑΒ μήκει, ἀσύμμετρος ἄρα ἐστὶ καὶ ἡ ΖΕ τῇ ΕΚ· αἱ ΖΕ, ΕΚ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· μέσον ἄρα ἐστὶ τὸ ΕΛ, τουτέστι τὸ ΜΡ, τουτέστι τὸ ὑπὸ τῶν ΜΝΞ. καὶ ἐπεὶ ἀσύμμετρος ἡ ΑΕ τῇ ΕΖ, καὶ τὸ ΑΚ τῷ ΕΛ ἀσύμμετρόν ἐστιν. ἀλλὰ τὸ μὲν ΑΚ ἐστι τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΜΝ, ΝΞ, τὸ δὲ ΕΛ ἐστι τὸ ὑπὸ τῶν ΜΝΞ· ἀσύμμετρον ἄρα ἐστὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΜΝΞ τῷ ὑπὸ τῶν ΜΝΞ. καί ἐστι μέσον ἑκάτερον αὐτῶν, καὶ αἱ ΜΝ, ΝΞ δυνάμει εἰσὶν ἀσύμμετροι.

Ἡ ΜΞ ἄρα δύο μέσα δυναμένη ἐστὶ καὶ δύναται τὸ ΑΓ· ὅπερ ἔδει δεῖξαι.

Proposition 59

If an area is contained by a rational (straight-line) and a sixth binomial (straight-line) then the square-root of the area is the irrational (straight-line which is) called the square-root of (the sum of) two medial (areas).†



For let the area $ABCD$ be contained by the rational (straight-line) AB and the sixth binomial (straight-line) AD, which has been divided into its (component) terms at E, such that AE is the greater term. So, I say that the square-root of AC is the square-root of (the sum of) two medial (areas).

[For] let the same construction be made as that shown previously. So, (it is) clear that MO is the square-root of AC, and that MN is incommensurable in square with NO. And since EA is incommensurable in length with AB [Def. 10.10], EA and AB are thus rational (straight-lines which are) commensurable in square only. Thus, AK—that is to say, the sum of the (squares) on MN and NO—is medial [Prop. 10.21]. Again, since ED is incommensurable in length with AB [Def. 10.10], FE is thus also incommensurable (in length) with EK [Prop. 10.13]. Thus, FE and EK are rational (straight-lines which are) commensurable in square only. Thus, EL—that is to say, MR—that is to say, the (rectangle contained) by MNO—is medial [Prop. 10.21]. And since AE is incommensurable (in length) with EF, AK is also incommensurable with EL [Props. 6.1, 10.11]. But, AK is the sum of the (squares) on MN and NO, and EL is the (rectangle contained) by MNO. Thus, the sum of the (squares) on MNO is incommensurable with the (rectangle contained) by MNO. And each of them is medial. And MN and NO are incommensurable in square.

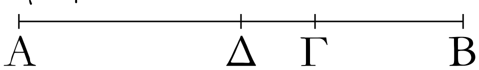
Thus, MO is the square-root of (the sum of) two medial (areas) [Prop. 10.41]. And (it is) the square-root of AC. (Which is) the very thing it was required to show.

† If the rational straight-line has unit length then this proposition states that the square-root of a sixth binomial straight-line is the square root of the sum of two medial areas: *i.e.*, a sixth binomial straight-line has a length $\sqrt{k}+\sqrt{k'}$ whose square-root can be written $k^{1/4}\left(\sqrt{[1+k''/(1+k''^2)^{1/2}]/2}+\sqrt{[1-k''/(1+k''^2)^{1/2}]/2}\right)$, where $k''^2=(k-k')/k'$. This is the length of the square-root of the sum of

two medial areas (see Prop. 10.41).

Λῆμμα.

Ἐὰν εὐθεῖα γραμμὴ τμηθῇ εἰς ἄνισα, τὰ ἀπὸ τῶν ἀνίσων τετράγωνα μείζονά ἐστι τοῦ δὶς ὑπὸ τῶν ἀνίσων περιεχομένου ὀρθογωνίου.

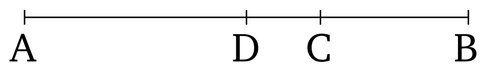


Ἔστω εὐθεῖα ἡ ΑΒ καὶ τετμήσθω εἰς ἄνισα κατὰ τὸ Γ, καὶ ἔστω μείζων ἡ ΑΓ· λέγω, ὅτι τὰ ἀπὸ τῶν ΑΓ, ΓΒ μείζονά ἐστι τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ.

Τετμήσθω γὰρ ἡ ΑΒ δίχα κατὰ τὸ Δ. ἐπεὶ οὖν εὐθεῖα γραμμὴ τέτμηται εἰς μὲν ἴσα κατὰ τὸ Δ, εἰς δὲ ἄνισα κατὰ τὸ Γ, τὸ ἄρα ὑπὸ τῶν ΑΓ, ΓΒ μετὰ τοῦ ἀπὸ ΓΔ ἴσον ἐστὶ τῷ ἀπὸ ΑΔ· ὥστε τὸ ὑπὸ τῶν ΑΓ, ΓΒ ἔλαττόν ἐστι τοῦ ἀπὸ ΑΔ· τὸ ἄρα δὶς ὑπὸ τῶν ΑΓ, ΓΒ ἔλαττον ἢ διπλάσιόν ἐστι τοῦ ἀπὸ ΑΔ. ἀλλὰ τὰ ἀπὸ τῶν ΑΓ, ΓΒ διπλάσιά [ἐστι] τῶν ἀπὸ τῶν ΑΔ, ΔΓ· τὰ ἄρα ἀπὸ τῶν ΑΓ, ΓΒ μείζονά ἐστι τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ· ὅπερ ἔδει δεῖξαι.

Lemma

If a straight-line is cut unequally then (the sum of) the squares on the unequal (parts) is greater than twice the rectangle contained by the unequal (parts).

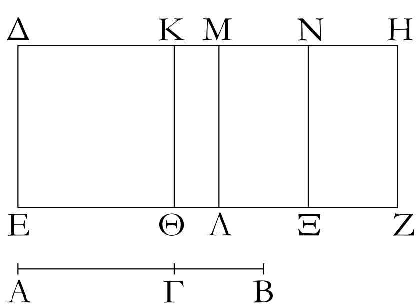


Let AB be a straight-line, and let it have been cut unequally at C, and let AC be greater (than CB). I say that (the sum of) the (squares) on AC and CB is greater than twice the (rectangle contained) by AC and CB.

For let AB have been cut in half at D. Therefore, since a straight-line has been cut into equal (parts) at D, and into unequal (parts) at C, the (rectangle contained) by AC and CB, plus the (square) on CD, is thus equal to the (square) on AD [Prop. 2.5]. Hence, the (rectangle contained) by AC and CB is less than the (square) on AD. Thus, twice the (rectangle contained) by AC and CB is less than double the (square) on AD. But, (the sum of) the (squares) on AC and CB [is] double (the sum of) the (squares) on AD and DC [Prop. 2.9]. Thus, (the sum of) the (squares) on AC and CB is greater than twice the (rectangle contained) by AC and CB. (Which is) the very thing it was required to show.

ξ'.

Τὸ ἀπὸ τῆς ἐκ δύο ὀνομάτων παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων πρώτην.

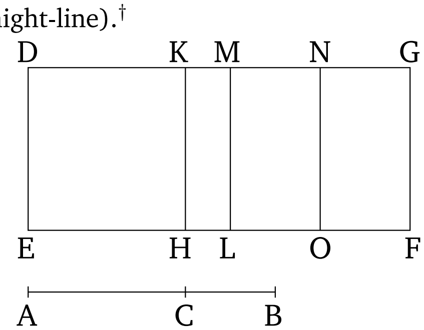


Ἔστω ἐκ δύο ὀνομάτων ἡ ΑΒ διῃρημένη εἰς τὰ ὀνόματα κατὰ τὸ Γ, ὥστε τὸ μεῖζον ὄνομα εἶναι τὸ ΑΓ, καὶ ἐκκείσθω ῥητὴ ἡ ΔΕ, καὶ τῷ ἀπὸ τῆς ΑΒ ἴσον παρὰ τὴν ΔΕ παραβεβλήσθω τὸ ΔΕΖΗ πλάτος ποιοῦν τὴν ΔΗ· λέγω, ὅτι ἡ ΔΗ ἐκ δύο ὀνομάτων ἐστὶ πρώτη.

Παραβεβλήσθω γὰρ παρὰ τὴν ΔΕ τῷ μὲν ἀπὸ τῆς ΑΓ ἴσον τὸ ΔΘ, τῷ δὲ ἀπὸ τῆς ΒΓ ἴσον τὸ ΚΛ· λοιπὸν ἄρα τὸ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ἴσον ἐστὶ τῷ ΜΖ. τετμήσθω ἡ ΜΗ δίχα κατὰ τὸ Ν, καὶ παράλληλος ἤχθω ἡ ΝΞ [ἑκατέρᾳ

Proposition 60

The square on a binomial (straight-line) applied to a rational (straight-line) produces as breadth a first binomial (straight-line).†



Let AB be a binomial (straight-line), having been divided into its (component) terms at C, such that AC is the greater term. And let the rational (straight-line) DE be laid down. And let the (rectangle) $DEFG$, equal to the (square) on AB, have been applied to DE, producing DG as breadth. I say that DG is a first binomial (straight-line).

For let DH, equal to the (square) on AC, and KL, equal to the (square) on BC, have been applied to DE.

τῶν ΜΛ, ΗΖ]. ἑκάτερον ἄρα τῶν ΜΞ, ΝΖ ἴσον ἐστὶ τῷ ἅπαξ ὑπὸ τῶν ΑΓΒ. καὶ ἐπεὶ ἐκ δύο ὀνομάτων ἐστὶν ἡ ΑΒ διῃρημένη εἰς τὰ ὀνόματα κατὰ τὸ Γ, αἱ ΑΓ, ΓΒ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· τὰ ἄρα ἀπὸ τῶν ΑΓ, ΓΒ ῥητά ἐστι καὶ σύμμετρα ἀλλήλοις· ὥστε καὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ. καί ἐστιν ἴσον τῷ ΔΛ· ῥητὸν ἄρα ἐστὶ τὸ ΔΛ. καὶ παρὰ ῥητὴν τὴν ΔΕ παράκειται· ῥητὴ ἄρα ἐστὶν ἡ ΔΜ καὶ σύμμετρος τῇ ΔΕ μήκει. πάλιν, ἐπεὶ αἱ ΑΓ, ΓΒ ῥηταί εἰσι δυνάμει μόνον σύμμετροι, μέσον ἄρα ἐστὶ τὸ δὶς ὑπὸ τῶν ΑΓ, ΓΒ, τουτέστι τὸ ΜΖ. καὶ παρὰ ῥητὴν τὴν ΜΛ παράκειται· ῥητὴ ἄρα καὶ ἡ ΜΗ καὶ ἀσύμμετρος τῇ ΜΛ, τουτέστι τῇ ΔΕ, μήκει. ἔστι δὲ καὶ ἡ ΜΔ ῥητὴ καὶ τῇ ΔΕ μήκει σύμμετρος· ἀσύμμετρος ἄρα ἐστὶν ἡ ΔΜ τῇ ΜΗ μήκει. καί εἰσι ῥηταί· αἱ ΔΜ, ΜΗ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΔΗ. δεικτέον δή, ὅτι καὶ πρώτη.

Ἐπεὶ τῶν ἀπὸ τῶν ΑΓ, ΓΒ μέσον ἀνάλογόν ἐστι τὸ ὑπὸ τῶν ΑΓΒ, καὶ τῶν ΔΘ, ΚΛ ἄρα μέσον ἀνάλογόν ἐστι τὸ ΜΞ. ἔστιν ἄρα ὡς τὸ ΔΘ πρὸς τὸ ΜΞ, οὕτως τὸ ΜΞ πρὸς τὸ ΚΛ, τουτέστιν ὡς ἡ ΔΚ πρὸς τὴν ΜΝ, ἡ ΜΝ πρὸς τὴν ΜΚ· τὸ ἄρα ὑπὸ τῶν ΔΚ, ΚΜ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΜΝ. καὶ ἐπεὶ σύμμετρόν ἐστι τὸ ἀπὸ τῆς ΑΓ τῷ ἀπὸ τῆς ΓΒ, σύμμετρόν ἐστι καὶ τὸ ΔΘ τῷ ΚΛ· ὥστε καὶ ἡ ΔΚ τῇ ΚΜ σύμμετρός ἐστιν. καὶ ἐπεὶ μείζονά ἐστι τὰ ἀπὸ τῶν ΑΓ, ΓΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ, μεῖζον ἄρα καὶ τὸ ΔΛ τοῦ ΜΖ· ὥστε καὶ ἡ ΔΜ τῆς ΜΗ μείζων ἐστίν. καί ἐστιν ἴσον τὸ ὑπὸ τῶν ΔΚ, ΚΜ τῷ ἀπὸ τῆς ΜΝ, τουτέστι τῷ τετάρτῳ τοῦ ἀπὸ τῆς ΜΗ, καὶ σύμμετρος ἡ ΔΚ τῇ ΚΜ. ἐὰν δὲ ὦσι δύο εὐθεῖαι ἄνισοι, τῷ δὲ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ἐλάσσονος ἴσον παρὰ τὴν μείζονα παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ καὶ εἰς σύμμετρα αὐτὴν διαιρῇ, ἡ μείζων τῆς ἐλάσσονος μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ· ἡ ΔΜ ἄρα τῆς ΜΗ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ. καί εἰσι ῥηταὶ αἱ ΔΜ, ΜΗ, καὶ ἡ ΔΜ μεῖζον ὄνομα οὖσα σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ ΔΕ μήκει.

Ἡ ΔΗ ἄρα ἐκ δύο ὀνομάτων ἐστὶ πρώτη· ὅπερ ἔδει δεῖξαι.

Thus, the remaining twice the (rectangle contained) by AC and CB is equal to MF [Prop. 2.4]. Let MG have been cut in half at N, and let NO have been drawn parallel [to each of ML and GF]. MO and NF are thus each equal to once the (rectangle contained) by ACB. And since AB is a binomial (straight-line), having been divided into its (component) terms at C, AC and CB are thus rational (straight-lines which are) commensurable in square only [Prop. 10.36]. Thus, the (squares) on AC and CB are rational, and commensurable with one another. And hence the sum of the (squares) on AC and CB (is rational) [Prop. 10.15], and is equal to DL. Thus, DL is rational. And it is applied to the rational (straight-line) DE. DM is thus rational, and commensurable in length with DE [Prop. 10.20]. Again, since AC and CB are rational (straight-lines which are) commensurable in square only, twice the (rectangle contained) by AC and CB—that is to say, MF—is thus medial [Prop. 10.21]. And it is applied to the rational (straight-line) ML. MG is thus also rational, and incommensurable in length with ML—that is to say, with DE [Prop. 10.22]. And MD is also rational, and commensurable in length with DE. Thus, DM is incommensurable in length with MG [Prop. 10.13]. And they are rational. DM and MG are thus rational (straight-lines which are) commensurable in square only. Thus, DG is a binomial (straight-line) [Prop. 10.36]. So, we must show that (it is) also a first (binomial straight-line).

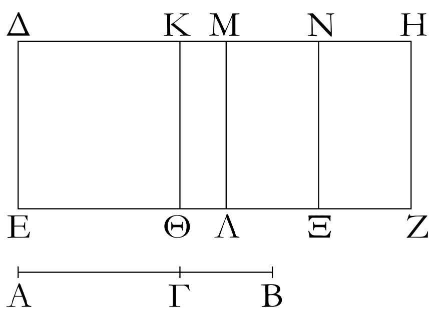
Since the (rectangle contained) by ACB is the mean proportional to the squares on AC and CB [Prop. 10.53 lem.], MO is thus also the mean proportional to DH and KL. Thus, as DH is to MO, so MO (is) to KL—that is to say, as DK (is) to MN, (so) MN (is) to MK [Prop. 6.1]. Thus, the (rectangle contained) by DK and KM is equal to the (square) on MN [Prop. 6.17]. And since the (square) on AC is commensurable with the (square) on CB, DH is also commensurable with KL. Hence, DK is also commensurable with KM [Props. 6.1, 10.11]. And since (the sum of) the squares on AC and CB is greater than twice the (rectangle contained) by AC and CB [Prop. 10.59 lem.], DL (is) thus also greater than MF. Hence, DM is also greater than MG [Props. 6.1, 5.14]. And the (rectangle contained) by DK and KM is equal to the (square) on MN—that is to say, to one quarter the (square) on MG. And DK (is) commensurable (in length) with KM. And if there are two unequal straight-lines, and a (rectangle) equal to the fourth part of the (square) on the lesser, falling short by a square figure, is applied to the greater, and divides it into (parts which are) commensurable (in length), then the square on the greater is larger than (the square on) the lesser by the (square) on (some straight-line) commensurable (in length) with the greater [Prop. 10.17]. Thus, the square on DM is greater than (the square on) MG by the (square) on (some straight-line) commensurable (in length) with (DM). And DM and MG are rational. And DM, which is the greater term, is commensurable in length with the (previously) laid down rational (straight-line) DE.

Thus, DG is a first binomial (straight-line) [Def. 10.5]. (Which is) the very thing it was required to show.

† In other words, the square of a binomial is a first binomial. See Prop. 10.54.

ξα΄.

Τὸ ἀπὸ τῆς ἐκ δύο μέσων πρώτης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων δευτέραν.



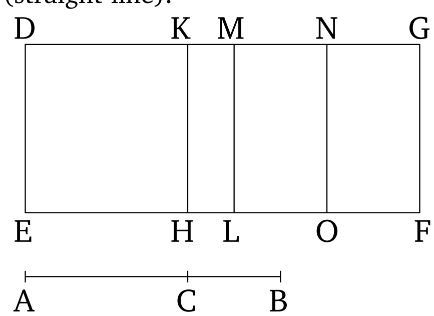
Ἔστω ἐκ δύο μέσων πρώτη ἡ ΑΒ διῃρημένη εἰς τὰς μέσας κατὰ τὸ Γ, ὧν μείζων ἡ ΑΓ, καὶ ἐκκείσθω ῥητὴ ἡ ΔΕ, καὶ παραβεβλήσθω παρὰ τὴν ΔΕ τῷ ἀπὸ τῆς ΑΒ ἴσον παραλληλόγραμμον τὸ ΔΖ πλάτος ποιοῦν τὴν ΔΗ· λέγω, ὅτι ἡ ΔΗ ἐκ δύο ὀνομάτων ἐστὶ δευτέρα.

Κατεσκευάσθω γὰρ τὰ αὐτὰ τοῖς πρὸ τούτου. καὶ ἐπεὶ ἡ ΑΒ ἐκ δύο μέσων ἐστὶ πρώτη διῃρημένη κατὰ τὸ Γ, αἱ ΑΓ, ΓΒ ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι ῥητὸν περιέχουσαι· ὥστε καὶ τὰ ἀπὸ τῶν ΑΓ, ΓΒ μέσα ἐστίν. μέσον ἄρα ἐστὶ τὸ ΔΛ. καὶ παρὰ ῥητὴν τὴν ΔΕ παραβέβληται· ῥητὴ ἄρα ἐστίν ἡ ΜΔ καὶ ἀσύμμετρος τῇ ΔΕ μήκει. πάλιν, ἐπεὶ ῥητόν ἐστι τὸ δὶς ὑπὸ τῶν ΑΓ, ΓΒ, ῥητόν ἐστι καὶ τὸ ΜΖ. καὶ παρὰ ῥητὴν τὴν ΜΛ παράκειται· ῥητὴ ἄρα [ἐστὶ] καὶ ἡ ΜΗ καὶ μήκει σύμμετρος τῇ ΜΛ, τουτέστι τῇ ΔΕ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΔΜ τῇ ΜΗ μήκει. καί εἰσι ῥηταί· αἱ ΔΜ, ΜΗ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΔΗ. δεικτέον δή, ὅτι καὶ δευτέρα.

Ἐπεὶ γὰρ τὰ ἀπὸ τῶν ΑΓ, ΓΒ μείζονά ἐστι τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ, μεῖζον ἄρα καὶ τὸ ΔΛ τοῦ ΜΖ· ὥστε καὶ ἡ ΔΜ τῆς ΜΗ. καὶ ἐπεὶ σύμμετρόν ἐστι τὸ ἀπὸ τῆς ΑΓ τῷ ἀπὸ τῆς ΓΒ, σύμμετρόν ἐστι καὶ τὸ ΔΘ τῷ ΚΛ· ὥστε καὶ ἡ ΔΚ τῇ ΚΜ σύμμετρός ἐστιν. καί ἐστι τὸ ὑπὸ τῶν ΔΚΜ ἴσον τῷ ἀπὸ τῆς ΜΝ· ἡ ΔΜ ἄρα τῆς ΜΗ μεῖζον δύναται τῷ

Proposition 61

The square on a first bimedial (straight-line) applied to a rational (straight-line) produces as breadth a second binomial (straight-line).†



Let AB be a first bimedial (straight-line) having been divided into its (component) medial (straight-lines) at C, of which AC (is) the greater. And let the rational (straight-line) DE be laid down. And let the parallelogram DF, equal to the (square) on AB, have been applied to DE, producing DG as breadth. I say that DG is a second binomial (straight-line).

For let the same construction have been made as in the (proposition) before this. And since AB is a first bimedial (straight-line), having been divided at C, AC and CB are thus medial (straight-lines) commensurable in square only, and containing a rational (area) [Prop. 10.37]. Hence, the (squares) on AC and CB are also medial [Prop. 10.21]. Thus, DL is medial [Props. 10.15, 10.23 corr.]. And it has been applied to the rational (straight-line) DE. MD is thus rational, and incommensurable in length with DE [Prop. 10.22]. Again, since twice the (rectangle contained) by AC and CB is rational, MF is also rational. And it is applied to the rational (straight-line) ML. Thus, MG [is] also rational, and commensurable in length with ML—that is to say, with DE [Prop. 10.20]. DM is thus incommensurable in length with MG [Prop. 10.13]. And they are rational. DM and MG are thus rational, and commensuἀπὸ συμμέτρου ἑαυτῇ. καί ἐστιν ἡ ΜΗ σύμμετρος τῇ ΔΕ μήκει.

Ἡ ΔΗ ἄρα ἐκ δύο ὀνομάτων ἐστὶ δευτέρα.

rable in square only. DG is thus a binomial (straight-line) [Prop. 10.36]. So, we must show that (it is) also a second (binomial straight-line).

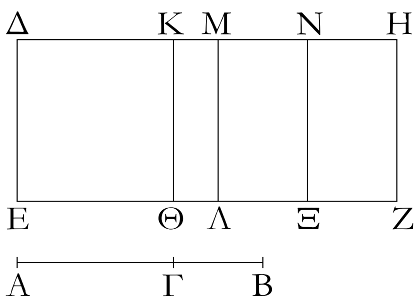
For since (the sum of) the squares on AC and CB is greater than twice the (rectangle contained) by AC and CB [Prop. 10.59], DL (is) thus also greater than MF. Hence, DM (is) also (greater) than MG [Prop. 6.1]. And since the (square) on AC is commensurable with the (square) on CB, DH is also commensurable with KL. Hence, DK is also commensurable (in length) with KM [Props. 6.1, 10.11]. And the (rectangle contained) by DKM is equal to the (square) on MN. Thus, the square on DM is greater than (the square on) MG by the (square) on (some straight-line) commensurable (in length) with (DM) [Prop. 10.17]. And MG is commensurable in length with DE.

Thus, DG is a second binomial (straight-line) [Def. 10.6].

† In other words, the square of a first bimedial is a second binomial. See Prop. 10.55.

ξβʹ.

Τὸ ἀπὸ τῆς ἐκ δύο μέσων δευτέρας παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων τρίτην.

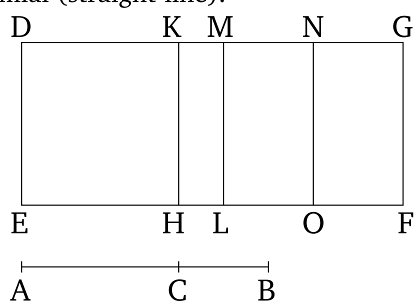


Ἔστω ἐκ δύο μέσων δευτέρα ἡ ΑΒ διῃρημένη εἰς τὰς μέσας κατὰ τὸ Γ, ὥστε τὸ μεῖζον τμῆμα εἶναι τὸ ΑΓ, ῥητὴ δέ τις ἔστω ἡ ΔΕ, καὶ παρὰ τὴν ΔΕ τῷ ἀπὸ τῆς ΑΒ ἴσον παραλληλόγραμμον παραβεβλήσθω τὸ ΔΖ πλάτος ποιοῦν τὴν ΔΗ· λέγω, ὅτι ἡ ΔΗ ἐκ δύο ὀνομάτων ἐστὶ τρίτη.

Κατεσκευάσθω τὰ αὐτὰ τοῖς προδεδειγμένοις. καὶ ἐπεὶ ἐκ δύο μέσων δευτέρα ἐστὶν ἡ ΑΒ διῃρημένη κατὰ τὸ Γ, αἱ ΑΓ, ΓΒ ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι μέσον περιέχουσαι· ὥστε καὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ μέσον ἐστίν. καί ἐστιν ἴσον τῷ ΔΛ· μέσον ἄρα καὶ τὸ ΔΛ. καὶ παράκειται παρὰ ῥητὴν τὴν ΔΕ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΜΔ καὶ ἀσύμμετρος τῇ ΔΕ μήκει. διὰ τὰ αὐτὰ δὴ καὶ ἡ ΜΗ ῥητή ἐστι καὶ ἀσύμμετρος τῇ ΜΛ, τουτέστι τῇ ΔΕ, μήκει· ῥητὴ ἄρα ἐστὶν ἑκατέρα τῶν ΔΜ, ΜΗ καὶ ἀσύμμετρος τῇ ΔΕ μήκει. καὶ ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΑΓ τῇ ΓΒ μήκει, ὡς δὲ ἡ ΑΓ πρὸς τὴν ΓΒ, οὕτως τὸ ἀπὸ τῆς ΑΓ πρὸς τὸ

Proposition 62

The square on a second bimedial (straight-line) applied to a rational (straight-line) produces as breadth a third binomial (straight-line).†



Let AB be a second bimedial (straight-line) having been divided into its (component) medial (straight-lines) at C, such that AC is the greater segment. And let DE be some rational (straight-line). And let the parallelogram DF, equal to the (square) on AB, have been applied to DE, producing DG as breadth. I say that DG is a third binomial (straight-line).

Let the same construction be made as that shown previously. And since AB is a second bimedial (straight-line), having been divided at C, AC and CB are thus medial (straight-lines) commensurable in square only, and containing a medial (area) [Prop. 10.38]. Hence, the sum of the (squares) on AC and CB is also medial [Props. 10.15, 10.23 corr.]. And it is equal to DL. Thus, DL (is) also medial. And it is applied to the rational (straight-line) DE. MD is thus also rational, and in-ὑπὸ τῶν ΑΓΒ, ἀσύμμετρον ἄρα καὶ τὸ ἀπὸ τῆς ΑΓ τῷ ὑπὸ τῶν ΑΓΒ. ὥστε καὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ τῷ δὶς ὑπὸ τῶν ΑΓΒ ἀσύμμετρόν ἐστιν, τουτέστι τὸ ΔΛ τῷ ΜΖ· ὥστε καὶ ἡ ΔΜ τῷ ΜΗ ἀσύμμετρός ἐστιν. καί εἰσι ῥηταί· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΔΗ. δεικτέον [δή], ὅτι καὶ τρίτη.

Ὁμοίως δὴ τοῖς προτέροις ἐπιλογιούμεθα, ὅτι μείζων ἐστὶν ἡ ΔΜ τῆς ΜΗ, καὶ σύμμετρος ἡ ΔΚ τῇ ΚΜ. καί ἐστι τὸ ὑπὸ τῶν ΔΚΜ ἴσον τῷ ἀπὸ τῆς ΜΝ· ἡ ΔΜ ἄρα τῆς ΜΗ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ. καὶ οὐδετέρα τῶν ΔΜ, ΜΗ σύμμετρός ἐστι τῇ ΔΕ μήκει.

Ἡ ΔΗ ἄρα ἐκ δύο ὀνομάτων ἐστὶ τρίτη· ὅπερ ἔδει δεῖξαι.

commensurable in length with DE [Prop. 10.22]. So, for the same (reasons), MG is also rational, and incommensurable in length with ML—that is to say, with DE. Thus, DM and MG are each rational, and incommensurable in length with DE. And since AC is incommensurable in length with CB, and as AC (is) to CB, so the (square) on AC (is) to the (rectangle contained) by ACB [Prop. 10.21 lem.], the (square) on AC (is) also incommensurable with the (rectangle contained) by ACB [Prop. 10.11]. And hence the sum of the (squares) on AC and CB is incommensurable with twice the (rectangle contained) by ACB—that is to say, DL with MF [Props. 10.12, 10.13]. Hence, DM is also incommensurable (in length) with MG [Props. 6.1, 10.11]. And they are rational. DG is thus a binomial (straight-line) [Prop. 10.36]. [So] we must show that (it is) also a third (binomial straight-line).

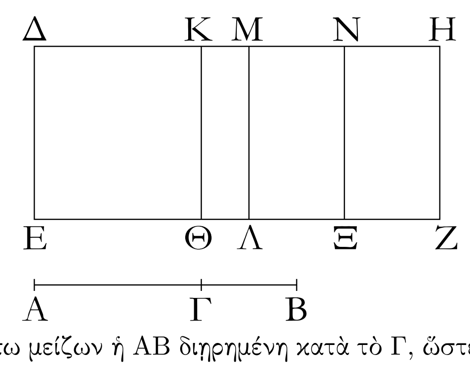
So, similarly to the previous (propositions), we can conclude that DM is greater than MG, and DK (is) commensurable (in length) with KM. And the (rectangle contained) by DKM is equal to the (square) on MN. Thus, the square on DM is greater than (the square on) MG by the (square) on (some straight-line) commensurable (in length) with (DM) [Prop. 10.17]. And neither of DM and MG is commensurable in length with DE.

Thus, DG is a third binomial (straight-line) [Def. 10.7]. (Which is) the very thing it was required to show.

† In other words, the square of a second bimedial is a third binomial. See Prop. 10.56.

ξγʹ.

Τὸ ἀπὸ τῆς μείζονος παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων τετάρτην.

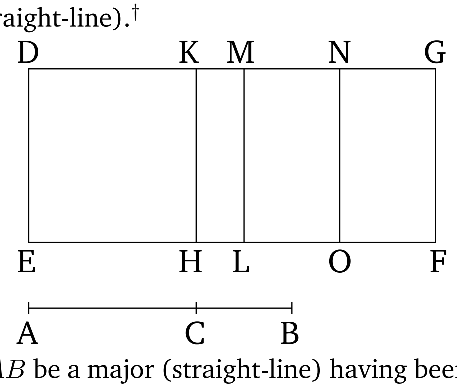


Ἔστω μείζων ἡ ΑΒ διῃρημένη κατὰ τὸ Γ, ὥστε μείζονα εἶναι τὴν ΑΓ τῆς ΓΒ, ῥητὴ δὲ ἡ ΔΕ, καὶ τῷ ἀπὸ τῆς ΑΒ ἴσον παρὰ τὴν ΔΕ παραβεβλήσθω τὸ ΔΖ παραλληλόγραμμον πλάτος ποιοῦν τὴν ΔΗ· λέγω, ὅτι ἡ ΔΗ ἐκ δύο ὀνομάτων ἐστὶ τετάρτη.

Κατεσκευάσθω τὰ αὐτὰ τοῖς προδεδειγμένοις. καὶ ἐπεὶ μείζων ἐστὶν ἡ ΑΒ διῃρημένη κατὰ τὸ Γ, αἱ ΑΓ, ΓΒ δυνάμει

Proposition 63

The square on a major (straight-line) applied to a rational (straight-line) produces as breadth a fourth binomial (straight-line).†



Let AB be a major (straight-line) having been divided at C, such that AC is greater than CB, and (let) DE (be) a rational (straight-line). And let the parallelogram DF, equal to the (square) on AB, have been applied to DE, producing DG as breadth. I say that DG is a fourth binomial (straight-line).

Let the same construction be made as that shown preεἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ' αὐτῶν τετραγώνων ῥητόν, τὸ δὲ ὑπ' αὐτῶν μέσον. ἐπεὶ οὖν ῥητόν ἐστι τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ, ῥητὸν ἄρα ἐστὶ τὸ ΔΛ· ῥητὴ ἄρα καὶ ἡ ΔΜ καὶ σύμμετρος τῇ ΔΕ μήκει. πάλιν, ἐπεὶ μέσον ἐστὶ τὸ δὶς ὑπὸ τῶν ΑΓ, ΓΒ, τουτέστι τὸ ΜΖ, καὶ παρὰ ῥητήν ἐστι τὴν ΜΛ, ῥητὴ ἄρα ἐστὶ καὶ ἡ ΜΗ καὶ ἀσύμμετρος τῇ ΔΕ μήκει· ἀσύμμετρος ἄρα ἐστὶ καὶ ἡ ΔΜ τῇ ΜΗ μήκει. αἱ ΔΜ, ΜΗ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΔΗ. δεικτέον [δή], ὅτι καὶ τετάρτη.

Ὁμοίως δὴ δείξομεν τοῖς πρότερον, ὅτι μείζων ἐστὶν ἡ ΔΜ τῆς ΜΗ, καὶ ὅτι τὸ ὑπὸ ΔΚΜ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΜΝ. ἐπεὶ οὖν ἀσύμμετρόν ἐστι τὸ ἀπὸ τῆς ΑΓ τῷ ἀπὸ τῆς ΓΒ, ἀσύμμετρον ἄρα ἐστὶ καὶ τὸ ΔΘ τῷ ΚΛ· ὥστε ἀσύμμετρος καὶ ἡ ΔΚ τῇ ΚΜ ἐστιν. ἐὰν δὲ ὦσι δύο εὐθεῖαι ἄνισοι, τῷ δὲ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ἐλάσσονος ἴσον παραλληλόγραμμον παρὰ τὴν μείζονα παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ καὶ εἰς ἀσύμμετρα αὐτὴν διαιρῇ, ἡ μείζων τῆς ἐλάσσονος μεῖζον δυνήσεται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ μήκει· ἡ ΔΜ ἄρα τῆς ΜΗ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καί εἰσιν αἱ ΔΜ, ΜΗ ῥηταὶ δυνάμει μόνον σύμμετροι, καὶ ἡ ΔΜ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ ΔΕ.

Ἡ ΔΗ ἄρα ἐκ δύο ὀνομάτων ἐστὶ τετάρτη· ὅπερ ἔδει δεῖξαι.

viously. And since AB is a major (straight-line), having been divided at C, AC and CB are incommensurable in square, making the sum of the squares on them rational, and the (rectangle contained) by them medial [Prop. 10.39]. Therefore, since the sum of the (squares) on AC and CB is rational, DL is thus rational. Thus, DM (is) also rational, and commensurable in length with DE [Prop. 10.20]. Again, since twice the (rectangle contained) by AC and CB—that is to say, MF—is medial, and is (applied to) the rational (straight-line) ML, MG is thus also rational, and incommensurable in length with DE [Prop. 10.22]. DM is thus also incommensurable in length with MG [Prop. 10.13]. DM and MG are thus rational (straight-lines which are) commensurable in square only. Thus, DG is a binomial (straight-line) [Prop. 10.36]. [So] we must show that (it is) also a fourth (binomial straight-line).

So, similarly to the previous (propositions), we can show that DM is greater than MG, and that the (rectangle contained) by DKM is equal to the (square) on MN. Therefore, since the (square) on AC is incommensurable with the (square) on CB, DH is also incommensurable with KL. Hence, DK is also incommensurable with KM [Props. 6.1, 10.11]. And if there are two unequal straight-lines, and a parallelogram equal to the fourth part of the (square) on the lesser, falling short by a square figure, is applied to the greater, and divides it into (parts which are) incommensurable (in length), then the square on the greater will be larger than (the square on) the lesser by the (square) on (some straight-line) incommensurable in length with the greater [Prop. 10.18]. Thus, the square on DM is greater than (the square on) MG by the (square) on (some straight-line) incommensurable (in length) with (DM). And DM and MG are rational (straight-lines which are) commensurable in square only. And DM is commensurable (in length) with the (previously) laid down rational (straight-line) DE.

Thus, DG is a fourth binomial (straight-line) [Def. 10.8]. (Which is) the very thing it was required to show.

† In other words, the square of a major is a fourth binomial. See Prop. 10.57.

ξδ'.

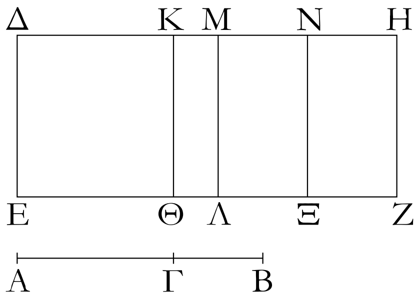
Τὸ ἀπὸ τῆς ῥητὸν καὶ μέσον δυναμένης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων πέμπτην.

Ἔστω ῥητὸν καὶ μέσον δυναμένη ἡ ΑΒ διῃρημένη εἰς τὰς εὐθείας κατὰ τὸ Γ, ὥστε μείζονα εἶναι τὴν ΑΓ, καὶ ἐκκείσθω ῥητὴ ἡ ΔΕ, καὶ τῷ ἀπὸ τῆς ΑΒ ἴσον παρὰ τὴν ΔΕ παραβεβλήσθω τὸ ΔΖ πλάτος ποιοῦν τὴν ΔΗ· λέγω, ὅτι ἡ ΔΗ ἐκ δύο ὀνομάτων ἐστὶ πέμπτη.

Proposition 64

The square on the square-root of a rational plus a medial (area) applied to a rational (straight-line) produces as breadth a fifth binomial (straight-line).†

Let AB be the square-root of a rational plus a medial (area) having been divided into its (component) straight-lines at C, such that AC is greater. And let the rational (straight-line) DE be laid down. And let the (parallelogram) DF, equal to the (square) on AB, have been ap-

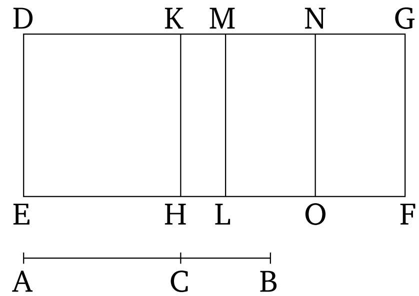


Κατεσκευάσθω τὰ αὐτα τοῖς πρὸ τούτου. ἐπεὶ οὖν ῥητὸν καὶ μέσον δυναμένη ἐστὶν ἡ ΑΒ διῃρημένη κατὰ τὸ Γ, αἱ ΑΓ, ΓΒ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον, τὸ δ᾽ ὑπ᾽ αὐτῶν ῥητόν. ἐπεὶ οὖν μέσον ἐστὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ, μέσον ἄρα ἐστὶ τὸ ΔΛ· ὥστε ῥητή ἐστιν ἡ ΔΜ καὶ μήκει ἀσύμμετρος τῇ ΔΕ. πάλιν, ἐπεὶ ῥητόν ἐστι τὸ δὶς ὑπὸ τῶν ΑΓΒ, τουτέστι τὸ ΜΖ, ῥητὴ ἄρα ἡ ΜΗ καὶ σύμμετρος τῇ ΔΕ. ἀσύμμετρος ἄρα ἡ ΔΜ τῇ ΜΗ· αἱ ΔΜ, ΜΗ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΔΗ. λέγω δή, ὅτι καὶ πέμπτη.

Ὁμοίως γὰρ διεχθήσεται, ὅτι τὸ ὑπὸ τῶν ΔΚΜ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΜΝ, καὶ ἀσύμμετρος ἡ ΔΚ τῇ ΚΜ μήκει· ἡ ΔΜ ἄρα τῆς ΜΗ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καί εἰσιν αἱ ΔΜ, ΜΗ [ῥηταὶ] δυνάμει μόνον σύμμετροι, καὶ ἡ ἐλάσσων ἡ ΜΗ σύμμετρος τῇ ΔΕ μήκει.

Ἡ ΔΗ ἄρα ἐκ δύο ὀνομάτων ἐστὶ πέμπτη· ὅπερ ἔδει δεῖξαι.

plied to DE, producing DG as breadth. I say that DG is a fifth binomial straight-line.



Let the same construction be made as in the (propositions) before this. Therefore, since AB is the square-root of a rational plus a medial (area), having been divided at C, AC and CB are thus incommensurable in square, making the sum of the squares on them medial, and the (rectangle contained) by them rational [Prop. 10.40]. Therefore, since the sum of the (squares) on AC and CB is medial, DL is thus medial. Hence, DM is rational and incommensurable in length with DE [Prop. 10.22]. Again, since twice the (rectangle contained) by ACB—that is to say, MF—is rational, MG (is) thus rational and commensurable (in length) with DE [Prop. 10.20]. DM (is) thus incommensurable (in length) with MG [Prop. 10.13]. Thus, DM and MG are rational (straight-lines which are) commensurable in square only. Thus, DG is a binomial (straight-line) [Prop. 10.36]. So, I say that (it is) also a fifth (binomial straight-line).

For, similarly (to the previous propositions), it can be shown that the (rectangle contained) by DKM is equal to the (square) on MN, and DK (is) incommensurable in length with KM. Thus, the square on DM is greater than (the square on) MG by the (square) on (some straight-line) incommensurable (in length) with (DM) [Prop. 10.18]. And DM and MG are [rational] (straight-lines which are) commensurable in square only, and the lesser MG is commensurable in length with DE.

Thus, DG is a fifth binomial (straight-line) [Def. 10.9]. (Which is) the very thing it was required to show.

† In other words, the square of the square-root of a rational plus medial is a fifth binomial. See Prop. 10.58.

ξεʹ.

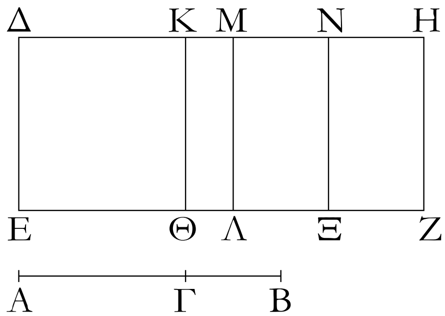
Τὸ ἀπὸ τῆς δύο μέσα δυναμένης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων ἕκτην.

Ἔστω δύο μέσα δυναμένη ἡ ΑΒ διῃρημένη κατὰ τὸ Γ, ῥητὴ δὲ ἔστω ἡ ΔΕ, καὶ παρὰ τὴν ΔΕ τῷ ἀπὸ τῆς ΑΒ ἴσον παραβεβλήσθω τὸ ΔΖ πλάτος ποιοῦν τὴν ΔΗ· λέγω, ὅτι ἡ ΔΗ ἐκ δύο ὀνομάτων ἐστὶν ἕκτη.

Proposition 65

The square on the square-root of (the sum of) two medial (areas) applied to a rational (straight-line) produces as breadth a sixth binomial (straight-line).†

Let AB be the square-root of (the sum of) two medial (areas), having been divided at C. And let DE be a rational (straight-line). And let the (parallelogram) DF, equal to the (square) on AB, have been applied to DE,

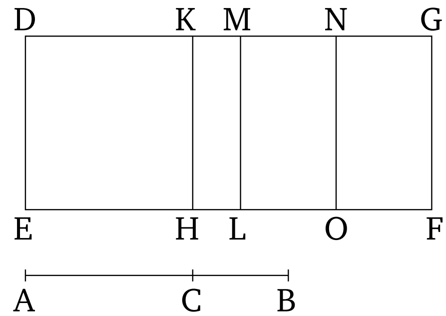


Κατεσκευάσθω γὰρ τὰ αὐτὰ τοῖς πρότερον. καὶ ἐπεὶ ἡ ΑΒ δύο μέσα δυναμένη ἐστὶ διῃρημένη κατὰ τὸ Γ, αἱ ΑΓ, ΓΒ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τό τε συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον καὶ τὸ ὑπ᾽ αὐτῶν μέσον καὶ ἔτι ἀσύμμετρον τὸ ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων συγκείμενον τῷ ὑπ᾽ αὐτῶν· ὥστε κατὰ τὰ προδεδειγμένα μέσον ἐστὶν ἑκάτερον τῶν ΔΛ, ΜΖ. καὶ παρὰ ῥητὴν τὴν ΔΕ παράκειται· ῥητὴ ἄρα ἐστὶν ἑκατέρα τῶν ΔΜ, ΜΗ καὶ ἀσύμμετρος τῇ ΔΕ μήκει. καὶ ἐπεὶ ἀσύμμετρόν ἐστι τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ τῷ δὶς ὑπὸ τῶν ΑΓ, ΓΒ, ἀσύμμετρον ἄρα ἐστὶ τὸ ΔΛ τῷ ΜΖ. ἀσύμμετρος ἄρα καὶ ἡ ΔΜ τῇ ΜΗ· αἱ ΔΜ, ΜΗ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΔΗ. λέγω δή, ὅτι καὶ ἕκτη.

Ὁμοίως δὴ πάλιν δείξομεν, ὅτι τὸ ὑπὸ τῶν ΔΚΜ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΜΝ, καὶ ὅτι ἡ ΔΚ τῇ ΚΜ μήκει ἐστὶν ἀσύμμετρος· καὶ διὰ τὰ αὐτὰ δὴ ἡ ΔΜ τῆς ΜΗ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ μήκει. καὶ οὐδετέρα τῶν ΔΜ, ΜΗ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ ΔΕ μήκει.

Ἡ ΔΗ ἄρα ἐκ δύο ὀνομάτων ἐστὶν ἕκτη· ὅπερ ἔδει δεῖξαι.

producing DG as breadth. I say that DG is a sixth binomial (straight-line).



For let the same construction be made as in the previous (propositions). And since AB is the square-root of (the sum of) two medial (areas), having been divided at C, AC and CB are thus incommensurable in square, making the sum of the squares on them medial, and the (rectangle contained) by them medial, and, moreover, the sum of the squares on them incommensurable with the (rectangle contained) by them [Prop. 10.41]. Hence, according to what has been previously demonstrated, DL and MF are each medial. And they are applied to the rational (straight-line) DE. Thus, DM and MG are each rational, and incommensurable in length with DE [Prop. 10.22]. And since the sum of the (squares) on AC and CB is incommensurable with twice the (rectangle contained) by AC and CB, DL is thus incommensurable with MF. Thus, DM (is) also incommensurable (in length) with MG [Props. 6.1, 10.11]. DM and MG are thus rational (straight-lines which are) commensurable in square only. Thus, DG is a binomial (straight-line) [Prop. 10.36]. So, I say that (it is) also a sixth (binomial straight-line).

So, similarly (to the previous propositions), we can again show that the (rectangle contained) by DKM is equal to the (square) on MN, and that DK is incommensurable in length with KM. And so, for the same (reasons), the square on DM is greater than (the square on) MG by the (square) on (some straight-line) incommensurable in length with (DM) [Prop. 10.18]. And neither of DM and MG is commensurable in length with the (previously) laid down rational (straight-line) DE.

Thus, DG is a sixth binomial (straight-line) [Def. 10.10]. (Which is) the very thing it was required to show.

† In other words, the square of the square-root of two medials is a sixth binomial. See Prop. 10.59.

ξϛʹ.

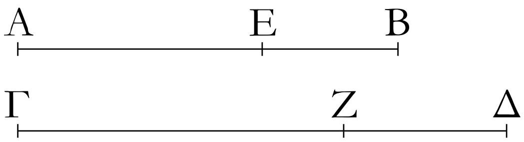
Ἡ τῇ ἐκ δύο ὀνομάτων μήκει σύμμετρος καὶ αὐτὴ ἐκ δύο ὀνομάτων ἐστὶ καὶ τῇ τάξει ἡ αὐτή.

Ἔστω ἐκ δύο ὀνομάτων ἡ ΑΒ, καὶ τῇ ΑΒ μήκει

Proposition 66

A (straight-line) commensurable in length with a binomial (straight-line) is itself also binomial, and the same in order.

σύμμετρος ἔστω ἡ ΓΔ· λέγω, ὅτι ἡ ΓΔ ἐκ δύο ὀνομάτων ἐστὶ καὶ τῇ τάξει ἡ αὐτὴ τῇ ΑΒ.

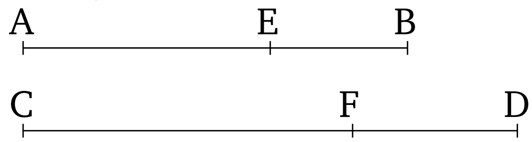


Ἐπεὶ γὰρ ἐκ δύο ὀνομάτων ἐστὶν ἡ ΑΒ, διῃρήσθω εἰς τὰ ὀνόματα κατὰ τὸ Ε, καὶ ἔστω μεῖζον ὄνομα τὸ ΑΕ· αἱ ΑΕ, ΕΒ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. γεγονέτω ὡς ἡ ΑΒ πρὸς τὴν ΓΔ, οὕτως ἡ ΑΕ πρὸς τὴν ΓΖ· καὶ λοιπὴ ἄρα ἡ ΕΒ πρὸς λοιπὴν τὴν ΖΔ ἐστιν, ὡς ἡ ΑΒ πρὸς τὴν ΓΔ. σύμμετρος δὲ ἡ ΑΒ τῇ ΓΔ μήκει· σύμμετρος ἄρα ἐστὶ καὶ ἡ μὲν ΑΕ τῇ ΓΖ, ἡ δὲ ΕΒ τῇ ΖΔ. καί εἰσι ῥηταὶ αἱ ΑΕ, ΕΒ· ῥηταὶ ἄρα εἰσὶ καὶ αἱ ΓΖ, ΖΔ. καὶ ἐστιν ὡς ἡ ΑΕ πρὸς ΓΖ, ἡ ΕΒ πρὸς ΖΔ. ἐναλλὰξ ἄρα ἐστὶν ὡς ἡ ΑΕ πρὸς ΕΒ, ἡ ΓΖ πρὸς ΖΔ. αἱ δὲ ΑΕ, ΕΒ δυνάμει μόνον [εἰσὶ] σύμμετροι· καὶ αἱ ΓΖ, ΖΔ ἄρα δυνάμει μόνον εἰσὶ σύμμετροι. καί εἰσι ῥηταί· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΓΔ. λέγω δή, ὅτι τῇ τάξει ἐστὶν ἡ αὐτὴ τῇ ΑΒ.

Ἡ γὰρ ΑΕ τῆς ΕΒ μεῖζον δύναται ἤτοι τῷ ἀπὸ συμμέτρου ἑαυτῇ ἢ τῷ ἀπὸ ἀσυμμέτρου. εἰ μὲν οὖν ἡ ΑΕ τῆς ΕΒ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καὶ ἡ ΓΖ τῆς ΖΔ μεῖζον δυνήσεται τῷ ἀπὸ συμμέτρου ἑαυτῇ. καὶ εἰ μὲν σύμμετρός ἐστιν ἡ ΑΕ τῇ ἐκκειμένῃ ῥητῇ, καὶ ἡ ΓΖ σύμμετρος αὐτῇ ἔσται, καὶ διὰ τοῦτο ἑκατέρα τῶν ΑΒ, ΓΔ ἐκ δύο ὀνομάτων ἐστὶ πρώτη, τουτέστι τῇ τάξει ἡ αὐτή. εἰ δὲ ἡ ΕΒ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ, καὶ ἡ ΖΔ σύμμετρός ἐστιν αὐτῇ, καὶ διὰ τοῦτο πάλιν τῇ τάξει ἡ αὐτὴ ἔσται τῇ ΑΒ· ἑκατέρα γὰρ αὐτῶν ἔσται ἐκ δύο ὀνομάτων δευτέρα. εἰ δὲ οὐδετέρα τῶν ΑΕ, ΕΒ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ, οὐδετέρα τῶν ΓΖ, ΖΔ σύμμετρος αὐτῇ ἔσται, καί ἐστιν ἑκατέρα τρίτη. εἰ δὲ ἡ ΑΕ τῆς ΕΒ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, καὶ ἡ ΓΖ τῆς ΖΔ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καὶ εἰ μὲν ἡ ΑΕ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῃ, καὶ ἡ ΓΖ σύμμετρός ἐστιν αὐτῇ, καὶ ἐστιν ἑκατέρα τετάρτη. εἰ δὲ ἡ ΕΒ, καὶ ἡ ΖΔ, καὶ ἔσται ἑκατέρα πέμπτη. εἰ δὲ οὐδετέρα τῶν ΑΕ, ΕΒ, καὶ τῶν ΓΖ, ΖΔ οὐδετέρα σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ, καὶ ἔσται ἑκατέρα ἕκτη.

Ὥστε ἡ τῇ ἐκ δύο ὀνομάτων μήκει σύμμετρος ἐκ δύο ὀνομάτων ἐστὶ καὶ τῇ τάξει ἡ αὐτή· ὅπερ ἔδει δεῖξαι.

Let AB be a binomial (straight-line), and let CD be commensurable in length with AB. I say that CD is a binomial (straight-line), and (is) the same in order as AB.



For since AB is a binomial (straight-line), let it have been divided into its (component) terms at E, and let AE be the greater term. AE and EB are thus rational (straight-lines which are) commensurable in square only [Prop. 10.36]. Let it have been contrived that as AB (is) to CD, so AE (is) to CF [Prop. 6.12]. Thus, the remainder EB is also to the remainder FD, as AB (is) to CD [Props. 6.16, 5.19 corr.]. And AB (is) commensurable in length with CD. Thus, AE is also commensurable (in length) with CF, and EB with FD [Prop. 10.11]. And AE and EB are rational. Thus, CF and FD are also rational. And as AE is to CF, (so) EB (is) to FD [Prop. 5.11]. Thus, alternately, as AE is to EB, (so) CF (is) to FD [Prop. 5.16]. And AE and EB [are] commensurable in square only. Thus, CF and FD are also commensurable in square only [Prop. 10.11]. And they are rational. CD is thus a binomial (straight-line) [Prop. 10.36]. So, I say that it is the same in order as AB.

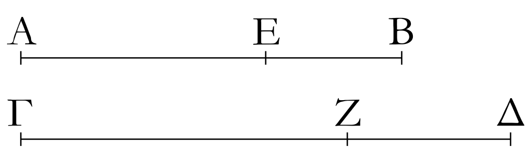
For the square on AE is greater than (the square on) EB by the (square) on (some straight-line) either commensurable or incommensurable (in length) with (AE). Therefore, if the square on AE is greater than (the square on) EB by the (square) on (some straight-line) commensurable (in length) with (AE) then the square on CF will also be greater than (the square on) FD by the (square) on (some straight-line) commensurable (in length) with (CF) [Prop. 10.14]. And if AE is commensurable (in length) with (some previously) laid down rational (straight-line) then CF will also be commensurable (in length) with it [Prop. 10.12]. And, on account of this, AB and CD are each first binomial (straight-lines) [Def. 10.5]—that is to say, the same in order. And if EB is commensurable (in length) with the (previously) laid down rational (straight-line) then FD is also commensurable (in length) with it [Prop. 10.12], and, again, on account of this, (CD) will be the same in order as AB. For each of them will be second binomial (straight-lines) [Def. 10.6]. And if neither of AE and EB is commensurable (in length) with the (previously) laid down rational (straight-line) then neither of CF and FD will be commensurable (in length) with it [Prop. 10.13], and each (of AB and CD) is a third (binomial straight-line)

[Def. 10.7]. And if the square on AE is greater than (the square on) EB by the (square) on (some straight-line) incommensurable (in length) with (AE) then the square on CF is also greater than (the square on) FD by the (square) on (some straight-line) incommensurable (in length) with (CF) [Prop. 10.14]. And if AE is commensurable (in length) with the (previously) laid down rational (straight-line) then CF is also commensurable (in length) with it [Prop. 10.12], and each (of AB and CD) is a fourth (binomial straight-line) [Def. 10.8]. And if EB (is commensurable in length with the previously laid down rational straight-line) then FD (is) also (commensurable in length with it), and each (of AB and CD) will be a fifth (binomial straight-line) [Def. 10.9]. And if neither of AE and EB (is commensurable in length with the previously laid down rational straight-line) then also neither of CF and FD is commensurable (in length) with the laid down rational (straight-line), and each (of AB and CD) will be a sixth (binomial straight-line) [Def. 10.10].

Hence, a (straight-line) commensurable in length with a binomial (straight-line) is a binomial (straight-line), and the same in order. (Which is) the very thing it was required to show.

ξζ΄.

Ἡ τῇ ἐκ δύο μέσων μήκει σύμμετρος καὶ αὐτὴ ἐκ δύο μέσων ἐστὶ καὶ τῇ τάξει ἡ αὐτή.



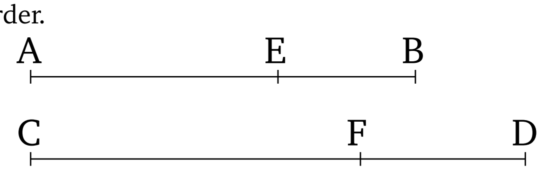
Ἔστω ἐκ δύο μέσων ἡ ΑΒ, καὶ τῇ ΑΒ σύμμετρος ἔστω μήκει ἡ ΓΔ· λέγω, ὅτι ἡ ΓΔ ἐκ δύο μέσων ἐστὶ καὶ τῇ τάξει ἡ αὐτὴ τῇ ΑΒ.

Ἐπεὶ γὰρ ἐκ δύο μέσων ἐστὶν ἡ ΑΒ, διῃρήσθω εἰς τὰς μέσας κατὰ τὸ Ε· αἱ ΑΕ, ΕΒ ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι. καὶ γεγονέτω ὡς ἡ ΑΒ πρὸς ΓΔ, ἡ ΑΕ πρὸς ΓΖ· καὶ λοιπὴ ἄρα ἡ ΕΒ πρὸς λοιπὴν τὴν ΖΔ ἐστιν, ὡς ἡ ΑΒ πρὸς ΓΔ. σύμμετρος δὲ ἡ ΑΒ τῇ ΓΔ μήκει· σύμμετρος ἄρα καὶ ἑκατέρα τῶν ΑΕ, ΕΒ ἑκατέρᾳ τῶν ΓΖ, ΖΔ. μέσαι δὲ αἱ ΑΕ, ΕΒ· μέσαι ἄρα καὶ αἱ ΓΖ, ΖΔ. καὶ ἐπεί ἐστιν ὡς ἡ ΑΕ πρὸς ΕΒ, ἡ ΓΖ πρὸς ΖΔ, αἱ δὲ ΑΕ, ΕΒ δυνάμει μόνον σύμμετροί εἰσιν, καὶ αἱ ΓΖ, ΖΔ [ἄρα] δυνάμει μόνον σύμμετροί εἰσιν, ἐδείχθησαν δὲ καὶ μέσαι· ἡ ΓΔ ἄρα ἐκ δύο μέσων ἐστίν. λέγω δή, ὅτι καὶ τῇ τάξει ἡ αὐτή ἐστι τῇ ΑΒ.

Ἐπεὶ γάρ ἐστιν ὡς ἡ ΑΕ πρὸς ΕΒ, ἡ ΓΖ πρὸς ΖΔ, καὶ ὡς ἄρα τὸ ἀπὸ τῆς ΑΕ πρὸς τὸ ὑπὸ τῶν ΑΕΒ, οὕτως τὸ ἀπὸ τῆς ΓΖ πρὸς τὸ ὑπὸ τῶν ΓΖΔ· ἐναλλὰξ ὡς τὸ ἀπὸ τῆς

Proposition 67

A (straight-line) commensurable in length with a bimedial (straight-line) is itself also bimedial, and the same in order.



Let AB be a bimedial (straight-line), and let CD be commensurable in length with AB. I say that CD is bimedial, and the same in order as AB.

For since AB is a bimedial (straight-line), let it have been divided into its (component) medial (straight-lines) at E. Thus, AE and EB are medial (straight-lines which are) commensurable in square only [Props. 10.37, 10.38]. And let it have been contrived that as AB (is) to CD, (so) AE (is) to CF [Prop. 6.12]. And thus as the remainder EB is to the remainder FD, so AB (is) to CD [Props. 5.19 corr., 6.16]. And AB (is) commensurable in length with CD. Thus, AE and EB are also commensurable (in length) with CF and FD, respectively [Prop. 10.11]. And AE and EB (are) medial. Thus, CF and FD (are) also medial [Prop. 10.23]. And since as AE is to EB, (so) CF (is) to FD, and AE and EB are commensurable in square only, CF and FD are [thus]

ΑΕ πρὸς τὸ ἀπὸ τῆς ΓΖ, οὕτως τὸ ὑπὸ τῶν ΑΕΒ πρὸς τὸ ὑπὸ τῶν ΓΖΔ. σύμμετρον δὲ τὸ ἀπὸ τῆς ΑΕ τῷ ἀπὸ τῆς ΓΖ· σύμμετρον ἄρα καὶ τὸ ὑπὸ τῶν ΑΕΒ τῷ ὑπὸ τῶν ΓΖΔ. εἴτε οὖν ῥητόν ἐστι τὸ ὑπὸ τῶν ΑΕΒ, καὶ τὸ ὑπὸ τῶν ΓΖΔ ῥητόν ἐστιν [καὶ διὰ τοῦτό ἐστιν ἐκ δύο μέσων πρώτη]. εἴτε μέσον, μέσον, καί ἐστιν ἑκατέρα δευτέρα.

Καὶ διὰ τοῦτο ἔσται ἡ ΓΔ τῇ ΑΒ τῇ τάξει ἡ αὐτή· ὅπερ ἔδει δεῖξαι.

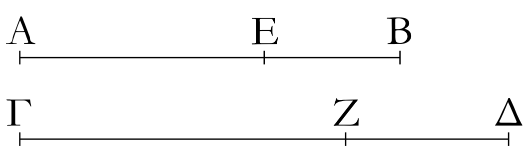
also commensurable in square only [Prop. 10.11]. And they were also shown (to be) medial. Thus, CD is a bimedial (straight-line). So, I say that it is also the same in order as AB.

For since as AE is to EB, (so) CF (is) to FD, thus also as the (square) on AE (is) to the (rectangle contained) by AEB, so the (square) on CF (is) to the (rectangle contained) by CFD [Prop. 10.21 lem.]. Alternately, as the (square) on AE (is) to the (square) on CF, so the (rectangle contained) by AEB (is) to the (rectangle contained) by CFD [Prop. 5.16]. And the (square) on AE (is) commensurable with the (square) on CF. Thus, the (rectangle contained) by AEB (is) also commensurable with the (rectangle contained) by CFD [Prop. 10.11]. Therefore, either the (rectangle contained) by AEB is rational, and the (rectangle contained) by CFD is rational [and, on account of this, (AE and CD) are first bimedial (straight-lines)], or (the rectangle contained by AEB is) medial, and (the rectangle contained by CFD is) medial, and (AB and CD) are each second (bimedial straight-lines) [Props. 10.23, 10.37, 10.38].

And, on account of this, CD will be the same in order as AB. (Which is) the very thing it was required to show.

ξη΄.

Ἡ τῇ μείζονι σύμμετρος καὶ αὐτὴ μείζων ἐστίν.

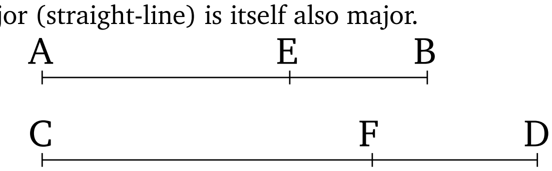


Ἔστω μείζων ἡ ΑΒ, καὶ τῇ ΑΒ σύμμετρος ἔστω ἡ ΓΔ· λέγω, ὅτι ἡ ΓΔ μείζων ἐστίν.

Διῃρήσθω ἡ ΑΒ κατὰ τὸ Ε· αἱ ΑΕ, ΕΒ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων ῥητόν, τὸ δ᾽ ὑπ᾽ αὐτῶν μέσον· καὶ γεγονέτω τὰ αὐτὰ τοῖς πρότερον. καὶ ἐπεί ἐστιν ὡς ἡ ΑΒ πρὸς τὴν ΓΔ, οὕτως ἥ τε ΑΕ πρὸς τὴν ΓΖ καὶ ἡ ΕΒ πρὸς τὴν ΖΔ, καὶ ὡς ἄρα ἡ ΑΕ πρὸς τὴν ΓΖ, οὕτως ἡ ΕΒ πρὸς τὴν ΖΔ. σύμμετρος δὲ ἡ ΑΒ τῇ ΓΔ· σύμμετρος ἄρα καὶ ἑκατέρα τῶν ΑΕ, ΕΒ ἑκατέρᾳ τῶν ΓΖ, ΖΔ. καὶ ἐπεὶ ἐστιν ὡς ἡ ΑΕ πρὸς τὴν ΓΖ, οὕτως ἡ ΕΒ πρὸς τὴν ΖΔ, καὶ ἐναλλὰξ ὡς ἡ ΑΕ πρὸς ΕΒ, οὕτως ἡ ΓΖ πρὸς ΖΔ, καὶ συνθέντι ἄρα ἐστὶν ὡς ἡ ΑΒ πρὸς τὴν ΒΕ, οὕτως ἡ ΓΔ πρὸς τὴν ΔΖ· καὶ ὡς ἄρα τὸ ἀπὸ τῆς ΑΒ πρὸς τὸ ἀπὸ τῆς ΒΕ, οὕτως τὸ ἀπὸ τῆς ΓΔ πρὸς τὸ ἀπὸ τῆς ΔΖ. ὁμοίως δὴ δείξομεν, ὅτι καὶ ὡς τὸ ἀπὸ τῆς ΑΒ πρὸς τὸ ἀπὸ τῆς ΑΕ, οὕτως τὸ ἀπὸ τῆς ΓΔ πρὸς τὸ ἀπὸ τῆς ΓΖ. καὶ ὡς ἄρα τὸ ἀπὸ τῆς ΑΒ πρὸς τὰ ἀπὸ τῶν ΑΕ, ΕΒ, οὕτως τὸ ἀπὸ τῆς ΓΔ πρὸς τὰ ἀπὸ τῶν ΓΖ, ΖΔ·

Proposition 68

A (straight-line) commensurable (in length) with a major (straight-line) is itself also major.



Let AB be a major (straight-line), and let CD be commensurable (in length) with AB. I say that CD is a major (straight-line).

Let AB have been divided (into its component terms) at E. AE and EB are thus incommensurable in square, making the sum of the squares on them rational, and the (rectangle contained) by them medial [Prop. 10.39]. And let (the) same (things) have been contrived as in the previous (propositions). And since as AB is to CD, so AE (is) to CF and EB to FD, thus also as AE (is) to CF, so EB (is) to FD [Prop. 5.11]. And AB (is) commensurable (in length) with CD. Thus, AE and EB (are) also commensurable (in length) with CF and FD, respectively [Prop. 10.11]. And since as AE is to CF, so EB (is) to FD, also, alternately, as AE (is) to EB, so CF (is) to FD [Prop. 5.16], and thus, via composition, as AB is to BE, so CD (is) to DF [Prop. 5.18]. And thus as the (square) on AB (is) to the (square) on BE, so the καὶ ἐναλλὰξ ἄρα ἐστὶν ὡς τὸ ἀπὸ τῆς ΑΒ πρὸς τὸ ἀπὸ τῆς ΓΔ, οὕτως τὰ ἀπὸ τῶν ΑΕ, ΕΒ πρὸς τὰ ἀπὸ τῶν ΓΖ, ΖΔ. σύμμετρον δὲ τὸ ἀπὸ τῆς ΑΒ τῷ ἀπὸ τῆς ΓΔ· σύμμετρα ἄρα καὶ τὰ ἀπὸ τῶν ΑΕ, ΕΒ τοῖς ἀπὸ τῶν ΓΖ, ΖΔ. καί ἐστι τὰ ἀπὸ τῶν ΑΕ, ΕΒ ἅμα ῥητόν, καὶ τὰ ἀπὸ τῶν ΓΖ, ΖΔ ἅμα ῥητόν ἐστιν. ὁμοίως δὲ καὶ τὸ δὶς ὑπὸ τῶν ΑΕ, ΕΒ σύμμετρόν ἐστι τῷ δὶς ὑπὸ τῶν ΓΖ, ΖΔ. καί ἐστι μέσον τὸ δὶς ὑπὸ τῶν ΑΕ, ΕΒ· μέσον ἄρα καὶ τὸ δὶς ὑπὸ τῶν ΓΖ, ΖΔ. αἱ ΓΖ, ΖΔ ἄρα δυνάμει ἀσύμμετροί εἰσι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων ἅμα ῥητόν, τὸ δὲ δὶς ὑπ᾽ αὐτῶν μέσον· ὅλη ἄρα ἡ ΓΔ ἄλογός ἐστιν ἡ καλουμένη μείζων.

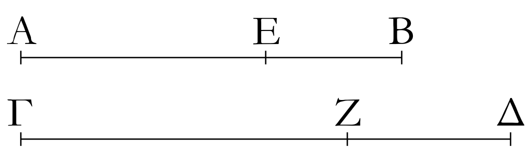
Ἡ ἄρα τῇ μείζονι σύμμετρος μείζων ἐστίν· ὅπερ ἔδει δεῖξαι.

(square) on CD (is) to the (square) on DF [Prop. 6.20]. So, similarly, we can also show that as the (square) on AB (is) to the (square) on AE, so the (square) on CD (is) to the (square) on CF. And thus as the (square) on AB (is) to (the sum of) the (squares) on AE and EB, so the (square) on CD (is) to (the sum of) the (squares) on CF and FD. And thus, alternately, as the (square) on AB is to the (square) on CD, so (the sum of) the (squares) on AE and EB (is) to (the sum of) the (squares) on CF and FD [Prop. 5.16]. And the (square) on AB (is) commensurable with the (square) on CD. Thus, (the sum of) the (squares) on AE and EB (is) also commensurable with (the sum of) the (squares) on CF and FD [Prop. 10.11]. And the (squares) on AE and EB (added) together are rational. The (squares) on CF and FD (added) together (are) thus also rational. So, similarly, twice the (rectangle contained) by AE and EB is also commensurable with twice the (rectangle contained) by CF and FD. And twice the (rectangle contained) by AE and EB is medial. Therefore, twice the (rectangle contained) by CF and FD (is) also medial [Prop. 10.23 corr.]. CF and FD are thus (straight-lines which are) incommensurable in square [Prop 10.13], simultaneously making the sum of the squares on them rational, and twice the (rectangle contained) by them medial. The whole, CD, is thus that irrational (straight-line) called major [Prop. 10.39].

Thus, a (straight-line) commensurable (in length) with a major (straight-line) is major. (Which is) the very thing it was required to show.

ξθʹ.

Ἡ τῇ ῥητὸν καὶ μέσον δυναμένῃ σύμμετρος [καὶ αὐτὴ] ῥητὸν καὶ μέσον δυναμένη ἐστίν.

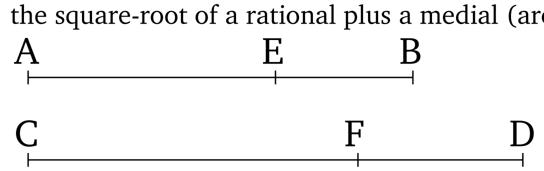


Ἔστω ῥητὸν καὶ μέσον δυναμένη ἡ ΑΒ, καὶ τῇ ΑΒ σύμμετρος ἔστω ἡ ΓΔ· δεικτέον, ὅτι καὶ ἡ ΓΔ ῥητὸν καὶ μέσον δυναμένη ἐστίν.

Διῃρήσθω ἡ ΑΒ εἰς τὰς εὐθείας κατὰ τὸ Ε· αἱ ΑΕ, ΕΒ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον, τὸ δ᾽ ὑπ᾽ αὐτῶν ῥητόν· καὶ τὰ αὐτὰ κατεσκευάσθω τοῖς πρότερον. ὁμοίως δὴ δείξομεν, ὅτι καὶ αἱ ΓΖ, ΖΔ δυνάμει εἰσὶν ἀσύμμετροι, καὶ σύμμετρον τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΕ, ΕΒ τῷ συγκειμένῳ ἐκ τῶν ἀπὸ τῶν ΓΖ, ΖΔ, τὸ δὲ ὑπὸ ΑΕ, ΕΒ τῷ ὑπὸ ΓΖ, ΖΔ· ὥστε καὶ τὸ [μὲν] συγκείμενον ἐκ τῶν ἀπὸ τῶν ΓΖ, ΖΔ τετραγώνων ἐστὶ μέσον, τὸ δ᾽ ὑπὸ τῶν ΓΖ,

Proposition 69

A (straight-line) commensurable (in length) with the square-root of a rational plus a medial (area) is [itself also] the square-root of a rational plus a medial (area).



Let AB be the square-root of a rational plus a medial (area), and let CD be commensurable (in length) with AB. We must show that CD is also the square-root of a rational plus a medial (area).

Let AB have been divided into its (component) straight-lines at E. AE and EB are thus incommensurable in square, making the sum of the squares on them medial, and the (rectangle contained) by them rational [Prop. 10.40]. And let the same construction have been made as in the previous (propositions). So, similarly, we can show that CF and FD are also incommensurable in square, and that the sum of the (squares) on AE and

ΖΔ ῥητόν.

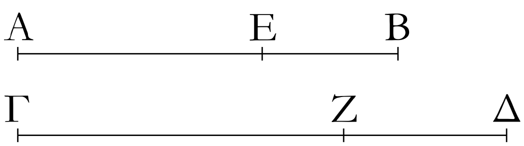
Ῥητὸν ἄρα καὶ μέσον δυναμένη ἐστὶν ἡ ΓΔ· ὅπερ ἔδει δεῖξαι.

EB (is) commensurable with the sum of the (squares) on CF and FD, and the (rectangle contained) by AE and EB with the (rectangle contained) by CF and FD. And hence the sum of the squares on CF and FD is medial, and the (rectangle contained) by CF and FD (is) rational.

Thus, CD is the square-root of a rational plus a medial (area) [Prop. 10.40]. (Which is) the very thing it was required to show.

ο´.

Ἡ τῇ δύο μέσα δυναμένῃ σύμμετρος δύο μέσα δυναμένη ἐστίν.



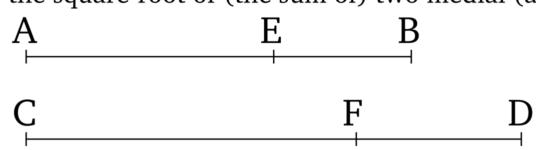
Ἔστω δύο μέσα δυναμένη ἡ ΑΒ, καὶ τῇ ΑΒ σύμμετρος ἡ ΓΔ· δεικτέον, ὅτι καὶ ἡ ΓΔ δύο μέσα δυναμένη ἐστίν.

Ἐπεὶ γὰρ δύο μέσα δυναμένη ἐστὶν ἡ ΑΒ, διῃρήσθω εἰς τὰς εὐθείας κατὰ τὸ Ε· αἱ ΑΕ, ΕΒ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τό τε συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν [τετραγώνων] μέσον καὶ τὸ ὑπ᾽ αὐτῶν μέσον καὶ ἔτι ἀσύμμετρον τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΕ, ΕΒ τετραγώνων τῷ ὑπὸ τῶν ΑΕ, ΕΒ· καὶ κατεσκευάσθω τὰ αὐτὰ τοῖς πρότερον. ὁμοίως δὴ δείξομεν, ὅτι καὶ αἱ ΓΖ, ΖΔ δυνάμει εἰσὶν ἀσύμμετροι καὶ σύμμετρον τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΕ, ΕΒ τῷ συγκειμένῳ ἐκ τῶν ἀπὸ τῶν ΓΖ, ΖΔ, τὸ δὲ ὑπὸ τῶν ΑΕ, ΕΒ τῷ ὑπὸ τῶν ΓΖ, ΖΔ· ὥστε καὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΓΖ, ΖΔ τετραγώνων μέσον ἐστὶ καὶ τὸ ὑπὸ τῶν ΓΖ, ΖΔ μέσον καὶ ἔτι ἀσύμμετρον τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΓΖ, ΖΔ τετραγώνων τῷ ὑπὸ τῶν ΓΖ, ΖΔ.

Ἡ ἄρα ΓΔ δύο μέσα δυναμένη ἐστίν· ὅπερ ἔδει δεῖξαι.

Proposition 70

A (straight-line) commensurable (in length) with the square-root of (the sum of) two medial (areas) is (itself also) the square-root of (the sum of) two medial (areas).



Let AB be the square-root of (the sum of) two medial (areas), and (let) CD (be) commensurable (in length) with AB. We must show that CD is also the square-root of (the sum of) two medial (areas).

For since AB is the square-root of (the sum of) two medial (areas), let it have been divided into its (component) straight-lines at E. Thus, AE and EB are incommensurable in square, making the sum of the [squares] on them medial, and the (rectangle contained) by them medial, and, moreover, the sum of the (squares) on AE and EB incommensurable with the (rectangle) contained by AE and EB [Prop. 10.41]. And let the same construction have been made as in the previous (propositions). So, similarly, we can show that CF and FD are also incommensurable in square, and (that) the sum of the (squares) on AE and EB (is) commensurable with the sum of the (squares) on CF and FD, and the (rectangle contained) by AE and EB with the (rectangle contained) by CF and FD. Hence, the sum of the squares on CF and FD is also medial, and the (rectangle contained) by CF and FD (is) medial, and, moreover, the sum of the squares on CF and FD (is) incommensurable with the (rectangle contained) by CF and FD.

Thus, CD is the square-root of (the sum of) two medial (areas) [Prop. 10.41]. (Which is) the very thing it was required to show.

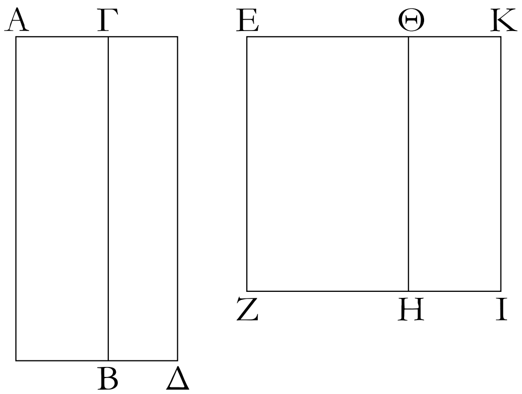
οα´.

Ῥητοῦ καὶ μέσου συντιθεμένου τέσσαρες ἄλογοι γίγνονται ἤτοι ἐκ δύο ὀνομάτων ἢ ἐκ δύο μέσων πρώτη ἢ μείζων ἢ ῥητὸν καὶ μέσον δυναμένη.

Proposition 71

When a rational and a medial (area) are added together, four irrational (straight-lines) arise (as the square-roots of the total area)—either a binomial, or a first bi-

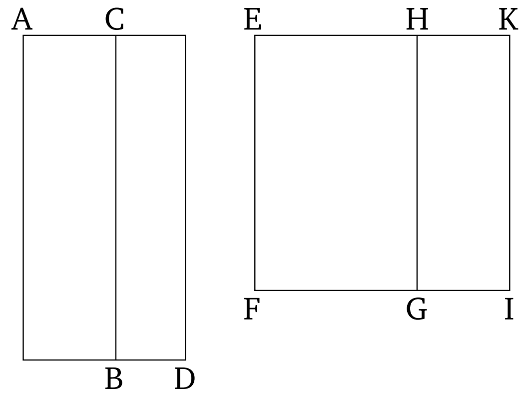
Ἔστω ῥητὸν μὲν τὸ ΑΒ, μέσον δὲ τὸ ΓΔ· λέγω, ὅτι ἡ τὸ ΑΔ χωρίον δυναμένη ἤτοι ἐκ δύο ὀνομάτων ἐστὶν ἢ ἐκ δύο μέσων πρώτη ἢ μείζων ἢ ῥητὸν καὶ μέσον δυναμένη.



Τὸ γὰρ ΑΒ τοῦ ΓΔ ἤτοι μεῖζόν ἐστιν ἢ ἔλασσον. ἔστω πρότερον μεῖζον· καὶ ἐκκείσθω ῥητὴ ἡ ΕΖ, καὶ παραβεβλήσθω παρὰ τὴν ΕΖ τῷ ΑΒ ἴσον τὸ ΕΗ πλάτος ποιοῦν τὴν ΕΘ· τῷ δὲ ΔΓ ἴσον παρὰ τὴν ΕΖ παραβεβλήσθω τὸ ΘΙ πλάτος ποιοῦν τὴν ΘΚ. καὶ ἐπεὶ ῥητόν ἐστι τὸ ΑΒ καί ἐστιν ἴσον τῷ ΕΗ, ῥητὸν ἄρα καὶ τὸ ΕΗ. καὶ παρὰ [ῥητὴν] τὴν ΕΖ παραβέβληται πλάτος ποιοῦν τὴν ΕΘ· ἡ ΕΘ ἄρα ῥητή ἐστι καὶ σύμμετρος τῇ ΕΖ μήκει. πάλιν, ἐπεὶ μέσον ἐστὶ τὸ ΓΔ καί ἐστιν ἴσον τῷ ΘΙ, μέσον ἄρα ἐστὶ καὶ τὸ ΘΙ. καὶ παρὰ ῥητὴν τὴν ΕΖ παράκειται πλάτος ποιοῦν τὴν ΘΚ· ῥητὴ ἄρα ἐστὶν ἡ ΘΚ καὶ ἀσύμμετρος τῇ ΕΖ μήκει. καὶ ἐπεὶ μέσον ἐστὶ τὸ ΓΔ, ῥητὸν δὲ τὸ ΑΒ, ἀσύμμετρον ἄρα ἐστὶ τὸ ΑΒ τῷ ΓΔ· ὥστε καὶ τὸ ΕΗ ἀσύμμετρόν ἐστι τῷ ΘΙ. ὡς δὲ τὸ ΕΗ πρὸς τὸ ΘΙ, οὕτως ἐστὶν ἡ ΕΘ πρὸς τὴν ΘΚ· ἀσύμμετρος ἄρα ἐστὶ καὶ ἡ ΕΘ τῇ ΘΚ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ΕΘ, ΘΚ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΕΚ διῃρημένη κατὰ τὸ Θ. καὶ ἐπεὶ μεῖζόν ἐστι τὸ ΑΒ τοῦ ΓΔ, ἴσον δὲ τὸ μὲν ΑΒ τῷ ΕΗ, τὸ δὲ ΓΔ τῷ ΘΙ, μεῖζον ἄρα καὶ τὸ ΕΗ τοῦ ΘΙ· καὶ ἡ ΕΘ ἄρα μείζων ἐστὶ τῆς ΘΚ. ἤτοι οὖν ἡ ΕΘ τῆς ΘΚ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει ἢ τῷ ἀπὸ ἀσυμμέτρου. δυνάσθω πρότερον τῷ ἀπὸ συμμέτρου ἑαυτῇ· καί ἐστιν ἡ μείζων ἡ ΘΕ σύμμετρος τῇ ἐκκειμένῃ ῥητῃ τῇ ΕΖ· ἡ ἄρα ΕΚ ἐκ δύο ὀνομάτων ἐστὶ πρώτη. ῥητὴ δὲ ἡ ΕΖ· ἐὰν δὲ χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων πρώτης, ἡ τὸ χωρίον δυναμένη ἐκ δύο ὀνομάτων ἐστίν. ἡ ἄρα τὸ ΕΙ δυναμένη ἐκ δύο ὀνομάτων ἐστίν· ὥστε καὶ ἡ τὸ ΑΔ δυναμένη ἐκ δύο ὀνομάτων ἐστίν. ἀλλὰ δὴ δυνάσθω ἡ ΕΘ τῆς ΘΚ μεῖζον τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ· καί ἐστιν ἡ μείζων ἡ ΕΘ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ τῇ ΕΖ μήκει· ἡ ἄρα ΕΚ ἐκ δύο ὀνομάτων ἐστὶ τετάρτη. ῥητὴ δὲ ἡ ΕΖ· ἐὰν δὲ χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο

medial, or a major, or the square-root of a rational plus a medial (area).

Let AB be a rational (area), and CD a medial (area). I say that the square-root of area AD is either binomial, or first bimedial, or major, or the square-root of a rational plus a medial (area).



For AB is either greater or less than CD. Let it, first of all, be greater. And let the rational (straight-line) EF be laid down. And let (the rectangle) EG, equal to AB, have been applied to EF, producing EH as breadth. And let (the recatangle) HI, equal to DC, have been applied to EF, producing HK as breadth. And since AB is rational, and is equal to EG, EG is thus also rational. And it has been applied to the [rational] (straight-line) EF, producing EH as breadth. EH is thus rational, and commensurable in length with EF [Prop. 10.20]. Again, since CD is medial, and is equal to HI, HI is thus also medial. And it is applied to the rational (straight-line) EF, producing HK as breadth. HK is thus rational, and incommensurable in length with EF [Prop. 10.22]. And since CD is medial, and AB rational, AB is thus incommensurable with CD. Hence, EG is also incommensurable with HI. And as EG (is) to HI, so EH is to HK [Prop. 6.1]. Thus, EH is also incommensurable in length with HK [Prop. 10.11]. And they are both rational. Thus, EH and HK are rational (straight-lines which are) commensurable in square only. EK is thus a binomial (straight-line), having been divided (into its component terms) at H [Prop. 10.36]. And since AB is greater than CD, and AB (is) equal to EG, and CD to HI, EG (is) thus also greater than HI. Thus, EH is also greater than HK [Prop. 5.14]. Therefore, the square on EH is greater than (the square on) HK either by the (square) on (some straight-line) commensurable in length with (EH), or by the (square) on (some straight-line) incommensurable (in length with EH). Let it, first of all, be greater by the (square) on (some straight-line) commensurable (in length with EH). And the greater ὀνομάτων τετάρτης, ἡ τὸ χωρίον δυναμένη ἄλογός ἐστιν ἡ καλουμένη μείζων. ἡ ἄρα τὸ ΕΙ χωρίον δυναμένη μείζων ἐστίν· ὥστε καὶ ἡ τὸ ΑΔ δυναμένη μείζων ἐστίν.

Ἀλλὰ δὴ ἔστω ἔλασσον τὸ ΑΒ τοῦ ΓΔ· καὶ τὸ ΕΗ ἄρα ἔλασσόν ἐστι τοῦ ΘΙ· ὥστε καὶ ἡ ΕΘ ἐλάσσων ἐστὶ τῆς ΘΚ. ἤτοι δὲ ἡ ΘΚ τῆς ΕΘ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ ἢ τῷ ἀπὸ ἀσυμμέτρου. δυνάσθω πρότερον τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει· καί ἐστιν ἡ ἐλάσσων ἡ ΕΘ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ τῇ ΕΖ μήκει· ἡ ἄρα ΕΚ ἐκ δύο ὀνομάτων ἐστὶ δευτέρα. ῥητὴ δὲ ἡ ΕΖ· ἐὰν δὲ χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων δευτέρας, ἡ τὸ χωρίον δυναμένη ἐκ δύο μέσων ἐστὶ πρώτη. ἡ ἄρα τὸ ΕΙ χωρίον δυναμένη ἐκ δύο μέσων ἐστὶ πρώτη· ὥστε καὶ ἡ τὸ ΑΔ δυναμένη ἐκ δύο μέσων ἐστὶ πρώτη. ἀλλὰ δὴ ἡ ΘΚ τῆς ΘΕ μεῖζον δυνάσθω τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καί ἐστιν ἡ ἐλάσσων ἡ ΕΘ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ τῇ ΕΖ· ἡ ἄρα ΕΚ ἐκ δύο ὀνομάτων ἐστὶ πέμπτη. ῥητὴ δὲ ἡ ΕΖ· ἐὰν δὲ χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων πέμπτης, ἡ τὸ χωρίον δυναμένη ῥητὸν καὶ μέσον δυναμένη ἐστίν. ἡ ἄρα τὸ ΕΙ χωρίον δυναμένη ῥητὸν καὶ μέσον δυναμένη ἐστίν· ὥστε καὶ ἡ τὸ ΑΔ χωρίον δυναμένη ῥητὸν καὶ μέσον δυναμένη ἐστίν.

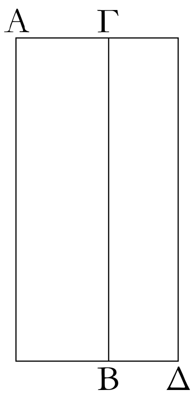
Ῥητοῦ ἄρα καὶ μέσου συντιθεμένου τέσσαρες ἄλογοι γίγνονται ἤτοι ἐκ δύο ὀνομάτων ἢ ἐκ δύο μέσων πρώτη ἢ μείζων ἢ ῥητὸν καὶ μέσον δυναμένη· ὅπερ ἔδει δεῖξαι.

(of the two components of EK) HE is commensurable (in length) with the (previously) laid down (straight-line) EF. EK is thus a first binomial (straight-line) [Def. 10.5]. And EF (is) rational. And if an area is contained by a rational (straight-line) and a first binomial (straight-line) then the square-root of the area is a binomial (straight-line) [Prop. 10.54]. Thus, the square-root of EI is a binomial (straight-line). Hence the square-root of AD is also a binomial (straight-line). And, so, let the square on EH be greater than (the square on) HK by the (square) on (some straight-line) incommensurable (in length) with (EH). And the greater (of the two components of EK) EH is commensurable in length with the (previously) laid down rational (straight-line) EF. Thus, EK is a fourth binomial (straight-line) [Def. 10.8]. And EF (is) rational. And if an area is contained by a rational (straight-line) and a fourth binomial (straight-line) then the square-root of the area is the irrational (straight-line) called major [Prop. 10.57]. Thus, the square-root of area EI is a major (straight-line). Hence, the square-root of AD is also major.

And so, let AB be less than CD. Thus, EG is also less than HI. Hence, EH is also less than HK [Props. 6.1, 5.14]. And the square on HK is greater than (the square on) EH either by the (square) on (some straight-line) commensurable (in length) with (HK), or by the (square) on (some straight-line) incommensurable (in length) with (HK). Let it, first of all, be greater by the square on (some straight-line) commensurable in length with (HK). And the lesser (of the two components of EK) EH is commensurable in length with the (previously) laid down rational (straight-line) EF. Thus, EK is a second binomial (straight-line) [Def. 10.6]. And EF (is) rational. And if an area is contained by a rational (straight-line) and a second binomial (straight-line) then the square-root of the area is a first bimedial (straight-line) [Prop. 10.55]. Thus, the square-root of area EI is a first bimedial (straight-line). Hence, the square-root of AD is also a first bimedial (straight-line). And so, let the square on HK be greater than (the square on) HE by the (square) on (some straight-line) incommensurable (in length) with (HK). And the lesser (of the two components of EK) EH is commensurable (in length) with the (previously) laid down rational (straight-line) EF. Thus, EK is a fifth binomial (straight-line) [Def. 10.9]. And EF (is) rational. And if an area is contained by a rational (straight-line) and a fifth binomial (straight-line) then the square-root of the area is the square-root of a rational plus a medial (area) [Prop. 10.58]. Thus, the square-root of area EI is the square-root of a rational plus a medial (area). Hence, the square-root of area AD is also the

ξβ΄.

Δύο μέσων ἀσυμμέτρων ἀλλήλοις συντιθεμένων αἱ λοιπαὶ δύο ἄλογοι γίγνονται ἤτοι ἐκ δύο μέσων δευτέρα ἢ [ἡ] δύο μέσα δυναμένη.



Συγκείσθω γὰρ δύο μέσα ἀσύμμετρα ἀλλήλοις τὰ ΑΒ, ΓΔ· λέγω, ὅτι ἡ τὸ ΑΔ χωρίον δυναμένη ἤτοι ἐκ δύο μέσων ἐστὶ δευτέρα ἢ δύο μέσα δυναμένη.

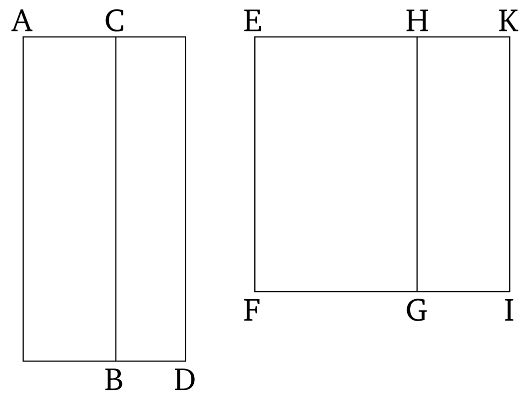
Τὸ γὰρ ΑΒ τοῦ ΓΔ ἤτοι μεῖζόν ἐστιν ἢ ἔλασσον. ἔστω, εἰ τύχον, πρότερον μεῖζον τὸ ΑΒ τοῦ ΓΔ· καὶ ἐκκείσθω ῥητὴ ἡ ΕΖ, καὶ τῷ μὲν ΑΒ ἴσον παρὰ τὴν ΕΖ παραβεβλήσθω τὸ ΕΗ πλάτος ποιοῦν τὴν ΕΘ, τῷ δὲ ΓΔ ἴσον τὸ ΘΙ πλάτος ποιοῦν τὴν ΘΚ. καὶ ἐπεὶ μέσον ἐστὶν ἑκάτερον τῶν ΑΒ, ΓΔ, μέσον ἄρα καὶ ἑκάτερον τῶν ΕΗ, ΘΙ. καὶ παρὰ ῥητὴν τὴν ΖΕ παράκειται πλάτος ποιοῦν τὰς ΕΘ, ΘΚ· ἑκατέρα ἄρα τῶν ΕΘ, ΘΚ ῥητή ἐστι καὶ ἀσύμμετρος τῇ ΕΖ μήκει. καὶ ἐπεὶ ἀσύμμετρόν ἐστι τὸ ΑΒ τῷ ΓΔ, καί ἐστιν ἴσον τὸ μὲν ΑΒ τῷ ΕΗ, τὸ δὲ ΓΔ τῷ ΘΙ, ἀσύμμετρον ἄρα ἐστὶ καὶ τὸ ΕΗ τῷ ΘΙ. ὡς δὲ τὸ ΕΗ πρὸς τὸ ΘΙ, οὕτως ἐστὶν ἡ ΕΘ πρὸς ΘΚ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΕΘ τῇ ΘΚ μήκει. αἱ ΕΘ, ΘΚ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΕΚ. ἤτοι δὲ ἡ ΕΘ τῆς ΘΚ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ ἢ τῷ ἀπὸ ἀσυμμέτρου. δυνάσθω πρότερον τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει· καὶ οὐδετέρα τῶν ΕΘ, ΘΚ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ ΕΖ μήκει· ἡ ΕΚ ἄρα ἐκ δύο ὀνομάτων ἐστὶ τρίτη. ῥητὴ δὲ ἡ ΕΖ· ἐὰν δὲ χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων τρίτης, ἡ τὸ χωρίον δυναμένη ἐκ δύο μέσων ἐστὶ δευτέρα· ἡ ἄρα τὸ ΕΙ, τουτέστι τὸ ΑΔ, δυναμένη ἐκ δύο μέσων ἐστὶ δευτέρα.

square-root of a rational plus a medial (area).

Thus, when a rational and a medial area are added together, four irrational (straight-lines) arise (as the square-roots of the total area)—either a binomial, or a first bimedial, or a major, or the square-root of a rational plus a medial (area). (Which is) the very thing it was required to show.

Proposition 72

When two medial (areas which are) incommensurable with one another are added together, the remaining two irrational (straight-lines) arise (as the square-roots of the total area)—either a second bimedial, or the square-root of (the sum of) two medial (areas).



For let the two medial (areas) AB and CD, (which are) incommensurable with one another, have been added together. I say that the square-root of area AD is either a second bimedial, or the square-root of (the sum of) two medial (areas).

For AB is either greater than or less than CD. By chance, let AB, first of all, be greater than CD. And let the rational (straight-line) EF be laid down. And let EG, equal to AB, have been applied to EF, producing EH as breadth, and HI, equal to CD, producing HK as breadth. And since AB and CD are each medial, EG and HI (are) thus also each medial. And they are applied to the rational straight-line FE, producing EH and HK (respectively) as breadth. Thus, EH and HK are each rational (straight-lines which are) incommensurable in length with EF [Prop. 10.22]. And since AB is incommensurable with CD, and AB is equal to EG, and CD to HI, EG is thus also incommensurable with HI. And as EG (is) to HI, so EH is to HK [Prop. 6.1]. EH is thus incommensurable in length with HK [Prop. 10.11]. Thus, EH and HK are rational (straight-lines which are) commensurable in square only. EK is thus a binomial (straight-line) [Prop. 10.36]. And the square on EH is greater than (the square on) HK either by the (square) ἀλλα δὴ ἡ ΕΘ τῆς ΘΚ μεῖζον δυνάσθω τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ μήκει· καὶ ἀσύμμετρός ἐστιν ἑκατέρα τῶν ΕΘ, ΘΚ τῇ ΕΖ μήκει· ἡ ἄρα ΕΚ ἐκ δύο ὀνομάτων ἐστὶν ἕκτη. ἐὰν δὲ χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τῆς ἐκ δύο ὀνομάτων ἕκτης, ἡ τὸ χωρίον δυναμένη ἡ δύο μέσα δυναμένη ἐστίν· ὥστε καὶ ἡ τὸ ΑΔ χωρίον δυναμένη ἡ δύο μέσα δυναμένη ἐστίν.

[Ὁμοίως δὴ δείξομεν, ὅτι κἂν ἔλαττον ᾖ τὸ ΑΒ τοῦ ΓΔ, ἡ τὸ ΑΔ χωρίον δυναμένη ἢ ἐκ δύο μέσων δευτέρα ἐστὶν ἤτοι δύο μέσα δυναμένη].

Δύο ἄρα μέσων ἀσυμμέτρων ἀλλήλοις συντιθεμένων αἱ λοιπαὶ δύο ἄλογοι γίγνονται ἤτοι ἐκ δύο μέσων δευτέρα ἢ δύο μέσα δυναμένη.

Ἡ ἐκ δύο ὀνομάτων καὶ αἱ μετ᾽ αὐτὴν ἄλογοι οὔτε τῇ μέσῃ οὔτε ἀλλήλαις εἰσὶν αἱ αὐταί. τὸ μὲν γὰρ ἀπὸ μέσης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ῥητὴν καὶ ἀσύμμετρον τῇ παρ᾽ ἣν παράκειται μήκει. τὸ δὲ ἀπὸ τῆς ἐκ δύο ὀνομάτων παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων πρώτην. τὸ δὲ ἀπὸ τῆς ἐκ δύο μέσων πρώτης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων δευτέραν. τὸ δὲ ἀπὸ τῆς ἐκ δύο μέσων δευτέρας παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων τρίτην. τὸ δὲ ἀπὸ τῆς μείζονος παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων τετάρτην. τὸ δὲ ἀπὸ τῆς ῥητὸν καὶ μέσον δυναμένης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων πέμπτην. τὸ δὲ ἀπὸ τῆς δύο μέσα δυναμένης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων ἕκτην. τὰ δ᾽ εἰρημένα πλάτη διαφέρει τοῦ τε πρώτου καὶ ἀλλήλων, τοῦ μὲν πρώτου, ὅτι ῥητή ἐστιν, ἀλλήλων δέ, ὅτι τῇ τάξει οὐκ εἰσὶν αἱ αὐταί· ὥστε καὶ αὐταὶ αἱ ἄλογοι διαφέρουσιν ἀλλήλων.

on (some straight-line) commensurable (in length) with (EH), or by the (square) on (some straight-line) incommensurable (in length with EH). Let it, first of all, be greater by the square on (some straight-line) commensurable in length with (EH). And neither of EH or HK is commensurable in length with the (previously) laid down rational (straight-line) EF. Thus, EK is a third binomial (straight-line) [Def. 10.7]. And EF (is) rational. And if an area is contained by a rational (straight-line) and a third binomial (straight-line) then the square-root of the area is a second bimedial (straight-line) [Prop. 10.56]. Thus, the square-root of EI—that is to say, of AD—is a second bimedial. And so, let the square on EH be greater than (the square) on HK by the (square) on (some straight-line) incommensurable in length with (EH). And EH and HK are each incommensurable in length with EF. Thus, EK is a sixth binomial (straight-line) [Def. 10.10]. And if an area is contained by a rational (straight-line) and a sixth binomial (straight-line) then the square-root of the area is the square-root of (the sum of) two medial (areas) [Prop. 10.59]. Hence, the square-root of area AD is also the square-root of (the sum of) two medial (areas).

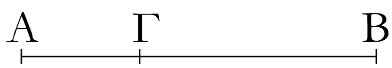
[So, similarly, we can show that, even if AB is less than CD, the square-root of area AD is either a second bimedial or the square-root of (the sum of) two medial (areas).]

Thus, when two medial (areas which are) incommensurable with one another are added together, the remaining two irrational (straight-lines) arise (as the square-roots of the total area)—either a second bimedial, or the square-root of (the sum of) two medial (areas).

A binomial (straight-line), and the (other) irrational (straight-lines) after it, are neither the same as a medial (straight-line) nor (the same) as one another. For the (square) on a medial (straight-line), applied to a rational (straight-line), produces as breadth a rational (straight-line which is) also incommensurable in length with (the straight-line) to which it is applied [Prop. 10.22]. And the (square) on a binomial (straight-line), applied to a rational (straight-line), produces as breadth a first binomial [Prop. 10.60]. And the (square) on a first bimedial (straight-line), applied to a rational (straight-line), produces as breadth a second binomial [Prop. 10.61]. And the (square) on a second bimedial (straight-line), applied to a rational (straight-line), produces as breadth a third binomial [Prop. 10.62]. And the (square) on a major (straight-line), applied to a rational (straight-line), produces as breadth a fourth binomial [Prop. 10.63]. And the (square) on the square-root of a rational plus a medial (area), applied to a rational (straight-line), produces as breadth a fifth binomial [Prop. 10.64]. And the (square) on the square-root of (the sum of) two medial (areas), applied to a rational (straight-line), produces as breadth a sixth binomial [Prop. 10.65]. And the aforementioned breadths differ from the first (breadth), and from one another—from the first, because it is rational—and from one another, because they are not the same in order. Hence, the (previously mentioned) irrational (straight-lines) themselves also differ from one another.

ογʹ.

Ἐὰν ἀπὸ ῥητῆς ῥητὴ ἀφαιρεθῇ δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ, ἡ λοιπὴ ἄλογός ἐστιν· καλείσθω δὲ ἀποτομή.

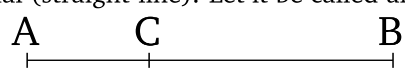


Ἀπὸ γὰρ ῥητῆς τῆς ΑΒ ῥητὴ ἀφῃρήσθω ἡ ΒΓ δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ· λέγω, ὅτι ἡ λοιπὴ ἡ ΑΓ ἄλογός ἐστιν ἡ καλουμένη ἀποτομή.

Ἐπεὶ γὰρ ἀσύμμετρός ἐστιν ἡ ΑΒ τῇ ΒΓ μήκει, καί ἐστιν ὡς ἡ ΑΒ πρὸς τὴν ΒΓ, οὕτως τὸ ἀπὸ τῆς ΑΒ πρὸς τὸ ὑπὸ τῶν ΑΒ, ΒΓ, ἀσύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΑΒ τῷ ὑπὸ τῶν ΑΒ, ΒΓ. ἀλλὰ τῷ μὲν ἀπὸ τῆς ΑΒ σύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΒ, ΒΓ τετράγωνα, τῷ δὲ ὑπὸ τῶν ΑΒ, ΒΓ σύμμετρόν ἐστι τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ. καὶ ἐπειδήπερ τὰ ἀπὸ τῶν ΑΒ, ΒΓ ἴσα ἐστὶ τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ μετὰ τοῦ ἀπὸ ΓΑ, καὶ λοιπῷ ἄρα τῷ ἀπὸ τῆς ΑΓ ἀσύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΒ, ΒΓ. ῥητὰ δὲ τὰ ἀπὸ τῶν ΑΒ, ΒΓ· ἄλογος ἄρα ἐστὶν ἡ ΑΓ· καλείσθω δὲ ἀποτομή. ὅπερ ἔδει δεῖξαι.

Proposition 73

If a rational (straight-line), which is commensurable in square only with the whole, is subtracted from a(nother) rational (straight-line) then the remainder is an irrational (straight-line). Let it be called an apotome.



For let the rational (straight-line) BC, which commensurable in square only with the whole, have been subtracted from the rational (straight-line) AB. I say that the remainder AC is that irrational (straight-line) called an apotome.

For since AB is incommensurable in length with BC, and as AB is to BC, so the (square) on AB (is) to the (rectangle contained) by AB and BC [Prop. 10.21 lem.], the (square) on AB is thus incommensurable with the (rectangle contained) by AB and BC [Prop. 10.11]. But, the (sum of the) squares on AB and BC is commensurable with the (square) on AB [Prop. 10.15], and twice the (rectangle contained) by AB and BC is commensurable with the (rectangle contained) by AB and BC [Prop. 10.6]. And, inasmuch as the (sum of the squares) on AB and BC is equal to twice the (rectangle contained) by AB and BC plus the (square) on CA [Prop. 2.7], the (sum of the squares) on AB and BC is thus also incommensurable with the remaining (square) on AC [Props. 10.13, 10.16]. And the (sum of the squares) on AB and BC is rational. AC is thus an irrational (straight-line) [Def. 10.4]. And let it be called an apotome.† (Which is) the very thing it was required to show.

† See footnote to Prop. 10.36.

οδʹ.

Ἐὰν ἀπὸ μέσης μέση ἀφαιρεθῇ δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης ῥητὸν περιέχουσα, ἡ λοιπὴ ἄλογός ἐστιν· καλείσθω δὲ μέσης ἀποτομὴ πρώτη.

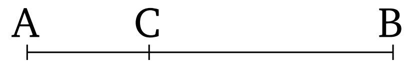
Proposition 74

If a medial (straight-line), which is commensurable in square only with the whole, and which contains a rational (area) with the whole, is subtracted from a(nother) medial (straight-line) then the remainder is an irrational

Ἀπὸ γὰρ μέσης τῆς ΑΒ μέση ἀφῃρήσθω ἡ ΒΓ δυνάμει μόνον σύμμετρος οὖσα τῇ ΑΒ, μετὰ δὲ τῆς ΑΒ ῥητὸν ποιοῦσα τὸ ὑπὸ τῶν ΑΒ, ΒΓ· λέγω, ὅτι ἡ λοιπὴ ἡ ΑΓ ἄλογός ἐστιν· καλείσθω δὲ μέσης ἀποτομὴ πρώτη.

Ἐπεὶ γὰρ αἱ ΑΒ, ΒΓ μέσαι εἰσίν, μέσα ἐστὶ καὶ τὰ ἀπὸ τῶν ΑΒ, ΒΓ. ῥητὸν δὲ τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ· ἀσύμμετρα ἄρα τὰ ἀπὸ τῶν ΑΒ, ΒΓ τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ· καὶ λοιπῷ ἄρα τῷ ἀπὸ τῆς ΑΓ ἀσύμμετρόν ἐστι τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ, ἐπεὶ κἂν τὸ ὅλον ἑνὶ αὐτῶν ἀσύμμετρον ᾖ, καὶ τὰ ἐξ ἀρχῆς μεγέθη ἀσύμμετρα ἔσται. ῥητὸν δὲ τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ· ἄλογον ἄρα τὸ ἀπὸ τῆς ΑΓ· ἄλογος ἄρα ἐστὶν ἡ ΑΓ· καλείσθω δὲ μέσης ἀποτομὴ πρώτη.

(straight-line). Let it be called a first apotome of a medial (straight-line).



For let the medial (straight-line) BC, which is commensurable in square only with AB, and which makes with AB the rational (rectangle contained) by AB and BC, have been subtracted from the medial (straight-line) AB [Prop. 10.27]. I say that the remainder AC is an irrational (straight-line). Let it be called the first apotome of a medial (straight-line).

For since AB and BC are medial (straight-lines), the (sum of the squares) on AB and BC is also medial. And twice the (rectangle contained) by AB and BC (is) rational. The (sum of the squares) on AB and BC (is) thus incommensurable with twice the (rectangle contained) by AB and BC. Thus, twice the (rectangle contained) by AB and BC is also incommensurable with the remaining (square) on AC [Prop. 2.7], since if the whole is incommensurable with one of the (constituent magnitudes) then the original magnitudes will also be incommensurable (with one another) [Prop. 10.16]. And twice the (rectangle contained) by AB and BC (is) rational. Thus, the (square) on AC is irrational. Thus, AC is an irrational (straight-line) [Def. 10.4]. Let it be called a first apotome of a medial (straight-line).†

† See footnote to Prop. 10.37.

οε΄.

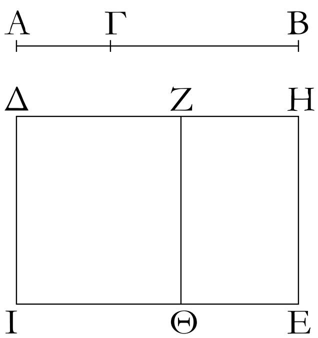
Ἐὰν ἀπὸ μέσης μέση ἀφαιρεθῇ δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης μέσον περιέχουσα, ἡ λοιπὴ ἄλογός ἐστιν· καλείσθω δὲ μέσης ἀποτομὴ δευτέρα.

Ἀπὸ γὰρ μέσης τῆς ΑΒ μέση ἀφῃρήσθω ἡ ΓΒ δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ τῇ ΑΒ, μετὰ δὲ τῆς ὅλης τῆς ΑΒ μέσον περιέχουσα τὸ ὑπὸ τῶν ΑΒ, ΒΓ· λέγω, ὅτι ἡ λοιπὴ ἡ ΑΓ ἄλογός ἐστιν· καλείσθω δὲ μέσης ἀποτομὴ δευτέρα.

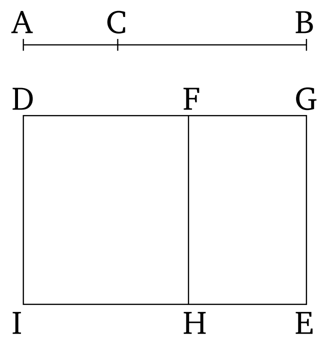
Proposition 75

If a medial (straight-line), which is commensurable in square only with the whole, and which contains a medial (area) with the whole, is subtracted from a(nother) medial (straight-line) then the remainder is an irrational (straight-line). Let it be called a second apotome of a medial (straight-line).

For let the medial (straight-line) CB, which is commensurable in square only with the whole, AB, and which contains with the whole, AB, the medial (rectangle contained) by AB and BC, have been subtracted from the medial (straight-line) AB [Prop. 10.28]. I say that the remainder AC is an irrational (straight-line). Let it be called a second apotome of a medial (straight-line).



Ἐκκείσθω γὰρ ῥητὴ ἡ ΔΙ, καὶ τοῖς μὲν ἀπὸ τῶν ΑΒ, ΒΓ ἴσον παρὰ τὴν ΔΙ παραβεβλήσθω τὸ ΔΕ πλάτος ποιοῦν τὴν ΔΗ, τῷ δὲ δὶς ὑπὸ τῶν ΑΒ, ΒΓ ἴσον παρὰ τὴν ΔΙ παραβεβλήσθω τὸ ΔΘ πλάτος ποιοῦν τὴν ΔΖ· λοιπὸν ἄρα τὸ ΖΕ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΑΓ. καὶ ἐπεὶ μέσα καὶ σύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΒ, ΒΓ, μέσον ἄρα καὶ τὸ ΔΕ. καὶ παρὰ ῥητὴν τὴν ΔΙ παράκειται πλάτος ποιοῦν τὴν ΔΗ· ῥητὴ ἄρα ἐστὶν ἡ ΔΗ καὶ ἀσύμμετρος τῇ ΔΙ μήκει. πάλιν, ἐπεὶ μέσον ἐστὶ τὸ ὑπὸ τῶν ΑΒ, ΒΓ, καὶ τὸ δὶς ἄρα ὑπὸ τῶν ΑΒ, ΒΓ μέσον ἐστίν. καί ἐστιν ἴσον τῷ ΔΘ· καὶ τὸ ΔΘ ἄρα μέσον ἐστίν. καὶ παρὰ ῥητὴν τὴν ΔΙ παραβέβληται πλάτος ποιοῦν τὴν ΔΖ· ῥητὴ ἄρα ἐστὶν ἡ ΔΖ καὶ ἀσύμμετρος τῇ ΔΙ μήκει. καὶ ἐπεὶ αἱ ΑΒ, ΒΓ δυνάμει μόνον σύμμετροί εἰσιν, ἀσύμμετρος ἄρα ἐστὶν ἡ ΑΒ τῇ ΒΓ μήκει· ἀσύμμετρον ἄρα καὶ τὸ ἀπὸ τῆς ΑΒ τετράγωνον τῷ ὑπὸ τῶν ΑΒ, ΒΓ. ἀλλὰ τῷ μὲν ἀπὸ τῆς ΑΒ σύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΒ, ΒΓ, τῷ δὲ ὑπὸ τῶν ΑΒ, ΒΓ σύμμετρόν ἐστι τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ· ἀσύμμετρον ἄρα ἐστὶ τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ τοῖς ἀπὸ τῶν ΑΒ, ΒΓ. ἴσον δὲ τοῖς μὲν ἀπὸ τῶν ΑΒ, ΒΓ τὸ ΔΕ, τῷ δὲ δὶς ὑπὸ τῶν ΑΒ, ΒΓ τὸ ΔΘ· ἀσύμμετρον ἄρα [ἐστὶ] τὸ ΔΕ τῷ ΔΘ. ὡς δὲ τὸ ΔΕ πρὸς τὸ ΔΘ, οὕτως ἡ ΗΔ πρὸς τὴν ΔΖ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΗΔ τῇ ΔΖ. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ἄρα ΗΔ, ΔΖ ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἡ ΖΗ ἄρα ἀποτομή ἐστιν. ῥητὴ δὲ ἡ ΔΙ· τὸ δὲ ὑπὸ ῥητῆς καὶ ἀλόγου περιεχόμενον ἄλογόν ἐστιν, καὶ ἡ δυναμένη αὐτὸ ἄλογός ἐστιν. καὶ δύναται τὸ ΖΕ ἡ ΑΓ· ἡ ΑΓ ἄρα ἄλογός ἐστιν· καλείσθω δὲ μέσης ἀποτομὴ δευτέρα. ὅπερ ἔδει δεῖξαι.



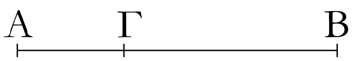
For let the rational (straight-line) DI be laid down. And let DE, equal to the (sum of the squares) on AB and BC, have been applied to DI, producing DG as breadth. And let DH, equal to twice the (rectangle contained) by AB and BC, have been applied to DI, producing DF as breadth. The remainder FE is thus equal to the (square) on AC [Prop. 2.7]. And since the (squares) on AB and BC are medial and commensurable (with one another), DE (is) thus also medial [Props. 10.15, 10.23 corr.]. And it is applied to the rational (straight-line) DI, producing DG as breadth. Thus, DG is rational, and incommensurable in length with DI [Prop. 10.22]. Again, since the (rectangle contained) by AB and BC is medial, twice the (rectangle contained) by AB and BC is thus also medial [Prop. 10.23 corr.]. And it is equal to DH. Thus, DH is also medial. And it has been applied to the rational (straight-line) DI, producing DF as breadth. DF is thus rational, and incommensurable in length with DI [Prop. 10.22]. And since AB and BC are commensurable in square only, AB is thus incommensurable in length with BC. Thus, the square on AB (is) also incommensurable with the (rectangle contained) by AB and BC [Props. 10.21 lem., 10.11]. But, the (sum of the squares) on AB and BC is commensurable with the (square) on AB [Prop. 10.15], and twice the (rectangle contained) by AB and BC is commensurable with the (rectangle contained) by AB and BC [Prop. 10.6]. Thus, twice the (rectangle contained) by AB and BC is incommensurable with the (sum of the squares) on AB and BC [Prop. 10.13]. And DE is equal to the (sum of the squares) on AB and BC, and DH to twice the (rectangle contained) by AB and BC. Thus, DE [is] incommensurable with DH. And as DE (is) to DH, so GD (is) to DF [Prop. 6.1]. Thus, GD is incommensurable with DF [Prop. 10.11]. And they are both rational (straight-lines). Thus, GD and DF are rational (straight-lines which are) commensurable in square only. Thus, FG is an apotome [Prop. 10.73]. And DI (is) rational. And the (area) contained by a rational and an irrational (straight-line) is irrational [Prop. 10.20], and its square-root is irrational.

And AC is the square-root of FE. Thus, AC is an irrational (straight-line) [Def. 10.4]. And let it be called the second apotome of a medial (straight-line).† (Which is) the very thing it was required to show.

† See footnote to Prop. 10.38.

οϛʹ.

Ἐὰν ἀπὸ εὐθείας εὐθεῖα ἀφαιρεθῇ δυνάμει ἀσύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης ποιοῦσα τὰ μὲν ἀπ᾿ αὐτῶν ἅμα ῥητόν, τὸ δ᾿ ὑπ᾿ αὐτῶν μέσον, ἡ λοιπὴ ἄλογός ἐστιν· καλείσθω δὲ ἐλάσσων.



Ἀπὸ γὰρ εὐθείας τῆς ΑΒ εὐθεῖα ἀφῃρήσθω ἡ ΒΓ δυνάμει ἀσύμμετρος οὖσα τῇ ὅλῃ ποιοῦσα τὰ προκείμενα. λέγω, ὅτι ἡ λοιπὴ ἡ ΑΓ ἄλογός ἐστιν ἡ καλουμένη ἐλάσσων.

Ἐπεὶ γὰρ τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ τετραγώνων ῥητόν ἐστιν, τὸ δὲ δὶς ὑπὸ τῶν ΑΒ, ΒΓ μέσον, ἀσύμμετρα ἄρα ἐστὶ τὰ ἀπὸ τῶν ΑΒ, ΒΓ τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ· καὶ ἀναστρέψαντι λοιπῷ τῷ ἀπὸ τῆς ΑΓ ἀσύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΒ, ΒΓ. ῥητὰ δὲ τὰ ἀπὸ τῶν ΑΒ, ΒΓ· ἄλογον ἄρα τὸ ἀπὸ τῆς ΑΓ· ἄλογος ἄρα ἡ ΑΓ· καλείσθω δὲ ἐλάσσων. ὅπερ ἔδει δεῖξαι.

Proposition 76

If a straight-line, which is incommensurable in square with the whole, and with the whole makes the (squares) on them (added) together rational, and the (rectangle contained) by them medial, is subtracted from a(nother) straight-line then the remainder is an irrational (straight-line). Let it be called a minor (straight-line).

For let the straight-line BC, which is incommensurable in square with the whole, and fulfils the (other) prescribed (conditions), have been subtracted from the straight-line AB [Prop. 10.33]. I say that the remainder AC is that irrational (straight-line) called minor.

For since the sum of the squares on AB and BC is rational, and twice the (rectangle contained) by AB and BC (is) medial, the (sum of the squares) on AB and BC is thus incommensurable with twice the (rectangle contained) by AB and BC. And, via conversion, the (sum of the squares) on AB and BC is incommensurable with the remaining (square) on AC [Props. 2.7, 10.16]. And the (sum of the squares) on AB and BC (is) rational. The (square) on AC (is) thus irrational. Thus, AC (is) an irrational (straight-line) [Def. 10.4]. Let it be called a minor (straight-line).† (Which is) the very thing it was required to show.

† See footnote to Prop. 10.39.

οζʹ.

Ἐὰν ἀπὸ εὐθείας εὐθεῖα ἀφαιρεθῇ δυνάμει ἀσύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης ποιοῦσα τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾿ αὐτῶν τετραγώνων μέσον, τὸ δὲ δὶς ὑπ᾿ αὐτῶν ῥητόν, ἡ λοιπὴ ἄλογός ἐστιν· καλείσθω δὲ ἡ μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσα.

Ἀπὸ γὰρ εὐθείας τῆς ΑΒ εὐθεῖα ἀφῃρήσθω ἡ ΒΓ δυνάμει ἀσύμμετος οὖσα τῇ ΑΒ ποιοῦσα τὰ προκείμενα· λέγω, ὅτι ἡ λοιπὴ ἡ ΑΓ ἄλογός ἐστιν ἡ προειρημένη.

Ἐπεὶ γὰρ τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ

Proposition 77

If a straight-line, which is incommensurable in square with the whole, and with the whole makes the sum of the squares on them medial, and twice the (rectangle contained) by them rational, is subtracted from a(nother) straight-line then the remainder is an irrational (straight-line). Let it be called that which makes with a rational (area) a medial whole.

For let the straight-line BC, which is incommensurable in square with AB, and fulfils the (other) prescribed (conditions), have been subtracted from the straight-line AB [Prop. 10.34]. I say that the remainder AC is the τετραγώνων μέσον ἐστίν, τὸ δὲ δὶς ὑπὸ τῶν ΑΒ, ΒΓ ῥητόν, ἀσύμμετρα ἄρα ἐστὶ τὰ ἀπὸ τῶν ΑΒ, ΒΓ τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ· καὶ λοιπὸν ἄρα τὸ ἀπὸ τῆς ΑΓ ἀσύμμετρόν ἐστι τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ. καί ἐστι τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ ῥητόν· τὸ ἄρα ἀπὸ τῆς ΑΓ ἄλογόν ἐστιν· ἄλογος ἄρα ἐστὶν ἡ ΑΓ· καλείσθω δὲ ἡ μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσα. ὅπερ ἔδει δεῖξαι.

aforementioned irrational (straight-line).

For since the sum of the squares on AB and BC is medial, and twice the (rectangle contained) by AB and BC rational, the (sum of the squares) on AB and BC is thus incommensurable with twice the (rectangle contained) by AB and BC. Thus, the remaining (square) on AC is also incommensurable with twice the (rectangle contained) by AB and BC [Props. 2.7, 10.16]. And twice the (rectangle contained) by AB and BC is rational. Thus, the (square) on AC is irrational. Thus, AC is an irrational (straight-line) [Def. 10.4]. And let it be called that which makes with a rational (area) a medial whole.† (Which is) the very thing it was required to show.

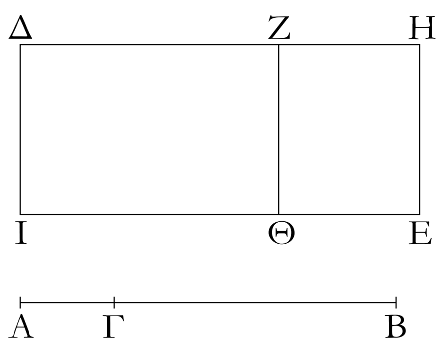
† See footnote to Prop. 10.40.

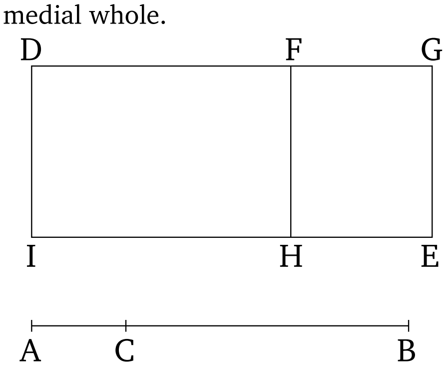
οη΄.

Ἐὰν ἀπὸ εὐθείας εὐθεῖα ἀφαιρεθῇ δυνάμει ἀσύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης ποιοῦσα τό τε συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον τό τε δὶς ὑπ᾽ αὐτῶν μέσον καὶ ἔτι τὰ ἀπ᾽ αὐτῶν τετράγωνα ἀσύμμετρα τῷ δὶς ὑπ᾽ αὐτῶν, ἡ λοιπὴ ἄλογός ἐστιν· καλείσθω δὲ ἡ μετὰ μέσου μέσον τὸ ὅλον ποιοῦσα.

Proposition 78

If a straight-line, which is incommensurable in square with the whole, and with the whole makes the sum of the squares on them medial, and twice the (rectangle contained) by them medial, and, moreover, the (sum of the) squares on them incommensurable with twice the (rectangle contained) by them, is subtracted from a(nother) straight-line then the remainder is an irrational (straight-line). Let it be called that which makes with a medial (area) a medial whole.





Ἀπὸ γὰρ εὐθείας τῆς ΑΒ εὐθεῖα ἀφῃρήσθω ἡ ΒΓ δυνάμει ἀσύμμετρος οὖσα τῇ ΑΒ ποιοῦσα τὰ προκείμενα· λέγω, ὅτι ἡ λοιπὴ ἡ ΑΓ ἄλογός ἐστιν ἡ καλουμένη ἡ μετὰ μέσου μέσον τὸ ὅλον ποιοῦσα.

Ἐκκείσθω γὰρ ῥητὴ ἡ ΔΙ, καὶ τοῖς μὲν ἀπὸ τῶν ΑΒ, ΒΓ ἴσον παρὰ τὴν ΔΙ παραβεβλήσθω τὸ ΔΕ πλάτος ποιοῦν τὴν ΔΗ, τῷ δὲ δὶς ὑπὸ τῶν ΑΒ, ΒΓ ἴσον ἀφῃρήσθω τὸ ΔΘ [πλάτος ποιοῦν τὴν ΔΖ]. λοιπὸν ἄρα τὸ ΖΕ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΑΓ· ὥστε ἡ ΑΓ δύναται τὸ ΖΕ. καὶ ἐπεὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΒ, ΒΓ τετραγώνων μέσον ἐστὶ καί ἐστιν ἴσον τῷ ΔΕ, μέσον ἄρα [ἐστὶ] τὸ ΔΕ. καὶ παρὰ ῥητὴν τὴν ΔΙ παράκειται πλάτος ποιοῦν τὴν ΔΗ· ῥητὴ ἄρα ἐστὶν ἡ ΔΗ καὶ ἀσύμμετρος τῇ ΔΙ μήκει. πάλιν, ἐπεὶ τὸ δὶς ὑπὸ τῶν ΑΒ, ΒΓ μέσον ἐστὶ καί ἐστιν ἴσον τῷ ΔΘ, τὸ ἄρα

For let the straight-line BC, which is incommensurable in square AB, and fulfils the (other) prescribed (conditions), have been subtracted from the (straight-line) AB [Prop. 10.35]. I say that the remainder AC is the irrational (straight-line) called that which makes with a medial (area) a medial whole.

For let the rational (straight-line) DI be laid down. And let DE, equal to the (sum of the squares) on AB and BC, have been applied to DI, producing DG as breadth. And let DH, equal to twice the (rectangle contained) by AB and BC, have been subtracted (from DE) [producing DF as breadth]. Thus, the remainder FE is equal to the (square) on AC [Prop. 2.7]. Hence, AC is the square-root of FE. And since the sum of the squares on

ΔΘ μέσον ἐστίν. καὶ παρὰ ῥητὴν τὴν ΔΙ παράκειται πλάτος ποιοῦν τὴν ΔΖ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΔΖ καὶ ἀσύμμετρος τῇ ΔΙ μήκει. καὶ ἐπεὶ ἀσύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΒ, ΒΓ τῷ δὶς ὑπὸ τῶν ΑΒ, ΒΓ, ἀσύμμετρον ἄρα καὶ τὸ ΔΕ τῷ ΔΘ. ὡς δὲ τὸ ΔΕ πρὸς τὸ ΔΘ, οὕτως ἐστὶ καὶ ἡ ΔΗ πρὸς τὴν ΔΖ· ἀσύμμετρος ἄρα ἡ ΔΗ τῇ ΔΖ. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ΗΔ, ΔΖ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. ἀποτομὴ ἄρα ἐστίν ἡ ΖΗ· ῥητὴ δὲ ἡ ΖΘ. τὸ δὲ ὑπὸ ῥητῆς καὶ ἀποτομῆς περιεχόμενον [ὀρθογώνιον] ἄλογόν ἐστιν, καὶ ἡ δυναμένη αὐτὸ ἄλογός ἐστιν· καὶ δύναται τὸ ΖΕ ἡ ΑΓ· ἡ ΑΓ ἄρα ἄλογός ἐστιν· καλείσθω δὲ ἡ μετὰ μέσου μέσον τὸ ὅλον ποιοῦσα. ὅπερ ἔδει δεῖξαι.

AB and BC is medial, and is equal to DE, DE [is] thus medial. And it is applied to the rational (straight-line) DI, producing DG as breadth. Thus, DG is rational, and incommensurable in length with DI [Prop 10.22]. Again, since twice the (rectangle contained) by AB and BC is medial, and is equal to DH, DH is thus medial. And it is applied to the rational (straight-line) DI, producing DF as breadth. Thus, DF is also rational, and incommensurable in length with DI [Prop. 10.22]. And since the (sum of the squares) on AB and BC is incommensurable with twice the (rectangle contained) by AB and BC, DE (is) also incommensurable with DH. And as DE (is) to DH, so DG also is to DF [Prop. 6.1]. Thus, DG (is) incommensurable (in length) with DF [Prop. 10.11]. And they are both rational. Thus, GD and DF are rational (straight-lines which are) commensurable in square only. Thus, FG is an apotome [Prop. 10.73]. And FH (is) rational. And the [rectangle] contained by a rational (straight-line) and an apotome is irrational [Prop. 10.20], and its square-root is irrational. And AC is the square-root of FE. Thus, AC is irrational. Let it be called that which makes with a medial (area) a medial whole.† (Which is) the very thing it was required to show.

† See footnote to Prop. 10.41.

οθ΄.

Τῇ ἀποτομῇ μία [μόνον] προσαρμόζει εὐθεῖα ῥητὴ δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ.

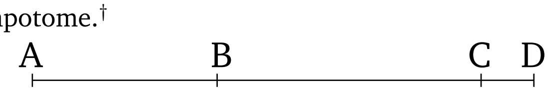
Ἔστω ἀποτομὴ ἡ ΑΒ, προσαρμόζουσα δὲ αὐτῇ ἡ ΒΓ· αἱ ΑΓ, ΓΒ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· λέγω, ὅτι τῇ ΑΒ ἑτέρα οὐ προσαρμόζει ῥητὴ δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ.

Εἰ γὰρ δυνατόν, προσαρμοζέτω ἡ ΒΔ· καὶ αἱ ΑΔ, ΔΒ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. καὶ ἐπεί, ᾧ ὑπερέχει τὰ ἀπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΔ, ΔΒ, τούτῳ ὑπερέχει καὶ τὰ ἀπὸ τῶν ΑΓ, ΓΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ· τῷ γὰρ αὐτῷ τῷ ἀπὸ τῆς ΑΒ ἀμφότερα ὑπερέχει· ἐναλλὰξ ἄρα, ᾧ ὑπερέχει τὰ ἀπὸ τῶν ΑΔ, ΔΒ τῶν ἀπὸ τῶν ΑΓ, ΓΒ, τούτῳ ὑπερέχει [καὶ] τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ. τὰ δὲ ἀπὸ τῶν ΑΔ, ΔΒ τῶν ἀπὸ τῶν ΑΓ, ΓΒ ὑπερέχει ῥητῷ· ῥητὰ γὰρ ἀμφότερα. καὶ τὸ δὶς ἄρα ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ὑπερέχει ῥητῷ· ὅπερ ἐστὶν ἀδύνατον· μέσα γὰρ ἀμφότερα, μέσον δὲ μέσου οὐχ ὑπερέχει ῥητῷ. τῇ ἄρα ΑΒ ἑτέρα οὐ προσαρμόζει ῥητὴ δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ.

Μία ἄρα μόνη τῇ ἀποτομῇ προσαρμόζει ῥητὴ δυνάμει

Proposition 79

[Only] one rational straight-line, which is commensurable in square only with the whole, can be attached to an apotome.†



Let AB be an apotome, with BC (so) attached to it. AC and CB are thus rational (straight-lines which are) commensurable in square only [Prop. 10.73]. I say that another rational (straight-line), which is commensurable in square only with the whole, cannot be attached to AB.

For, if possible, let BD be (so) attached (to AB). Thus, AD and DB are also rational (straight-lines which are) commensurable in square only [Prop. 10.73]. And since by whatever (area) the (sum of the squares) on AD and DB exceeds twice the (rectangle contained) by AD and DB, the (sum of the squares) on AC and CB also exceeds twice the (rectangle contained) by AC and CB by this (same area). For both exceed by the same (area)—(namely), the (square) on AB [Prop. 2.7]. Thus, alternately, by whatever (area) the (sum of the squares) on AD and DB exceeds the (sum of the squares) on AC and CB, twice the (rectangle contained) by AD and DB [also] exceeds twice the (rectangle contained) by AC and μόνον σύμμετρος οὖσα τῇ ὅλῃ· ὅπερ ἔδει δεῖξαι.

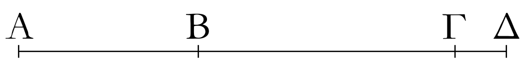
CB by this (same area). And the (sum of the squares) on AD and DB exceeds the (sum of the squares) on AC and CB by a rational (area). For both (are) rational (areas). Thus, twice the (rectangle contained) by AD and DB also exceeds twice the (rectangle contained) by AC and CB by a rational (area). The very thing is impossible. For both are medial (areas) [Prop. 10.21], and a medial (area) cannot exceed a(nother) medial (area) by a rational (area) [Prop. 10.26]. Thus, another rational (straight-line), which is commensurable in square only with the whole, cannot be attached to AB.

Thus, only one rational (straight-line), which is commensurable in square only with the whole, can be attached to an apotome. (Which is) the very thing it was required to show.

† This proposition is equivalent to Prop. 10.42, with minus signs instead of plus signs.

πʹ.

Τῇ μέσης ἀποτομῇ πρώτῃ μία μόνον προσαρμόζει εὐθεῖα μέση δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης ῥητὸν περιέχουσα.



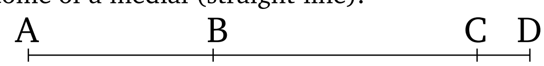
Ἔστω γὰρ μέσης ἀποτομὴ πρώτη ἡ ΑΒ, καὶ τῇ ΑΒ προσαρμοζέτω ἡ ΒΓ· αἱ ΑΓ, ΓΒ ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι ῥητὸν περιέχουσαι τὸ ὑπὸ τῶν ΑΓ, ΓΒ· λέγω, ὅτι τῇ ΑΒ ἑτέρα οὐ προσαρμόζει μέση δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης ῥητὸν περιέχουσα.

Εἰ γὰρ δυνατόν, προσαρμοζέτω καὶ ἡ ΔΒ· αἱ ἄρα ΑΔ, ΔΒ μέσαι εἰσὶ δυνάμει μόνον σύμμετροι ῥητὸν περιέχουσαι τὸ ὑπὸ τῶν ΑΔ, ΔΒ. καὶ ἐπεί, ᾧ ὑπερέχει τὰ ἀπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΔ, ΔΒ, τούτῳ ὑπερέχει καὶ τὰ ἀπὸ τῶν ΑΓ, ΓΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ· τῷ γὰρ αὐτῷ [πάλιν] ὑπερέχουσι τῷ ἀπὸ τῆς ΑΒ· ἐναλλὰξ ἄρα, ᾧ ὑπερέχει τὰ ἀπὸ τῶν ΑΔ, ΔΒ τῶν ἀπὸ τῶν ΑΓ, ΓΒ, τούτῳ ὑπερέχει καὶ τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ. τὸ δὲ δὶς ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ὑπερέχει ῥητῷ· ῥητὰ γὰρ ἀμφότερα. καὶ τὰ ἀπὸ τῶν ΑΔ, ΔΒ ἄρα τῶν ἀπὸ τῶν ΑΓ, ΓΒ [τετραγώνων] ὑπερέχει ῥητῷ· ὅπερ ἐστὶν ἀδύνατον· μέσα γάρ ἐστιν ἀμφότερα, μέσον δὲ μέσου οὐχ ὑπερέχει ῥητῷ.

Τῇ ἄρα μέσης ἀποτομῇ πρώτῃ μία μόνον προσαρμόζει εὐθεῖα μέση δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης ῥητὸν περιέχουσα· ὅπερ ἔδει δεῖξαι.

Proposition 80

Only one medial straight-line, which is commensurable in square only with the whole, and contains a rational (area) with the whole, can be attached to a first apotome of a medial (straight-line).†



For let AB be a first apotome of a medial (straight-line), and let BC be (so) attached to AB. Thus, AC and CB are medial (straight-lines which are) commensurable in square only, containing a rational (area)—(namely, that contained) by AC and CB [Prop. 10.74]. I say that a(nother) medial (straight-line), which is commensurable in square only with the whole, and contains a rational (area) with the whole, cannot be attached to AB.

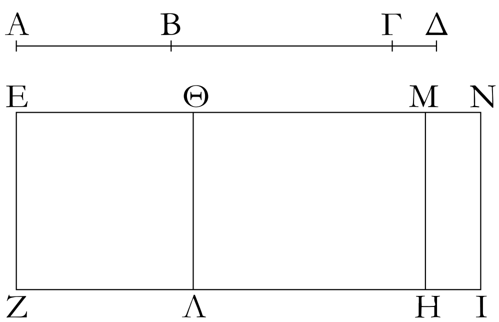
For, if possible, let DB also be (so) attached to AB. Thus, AD and DB are medial (straight-lines which are) commensurable in square only, containing a rational (area)—(namely, that) contained by AD and DB [Prop. 10.74]. And since by whatever (area) the (sum of the squares) on AD and DB exceeds twice the (rectangle contained) by AD and DB, the (sum of the squares) on AC and CB also exceeds twice the (rectangle contained) by AC and CB by this (same area). For [again] both exceed by the same (area)—(namely), the (square) on AB [Prop. 2.7]. Thus, alternately, by whatever (area) the (sum of the squares) on AD and DB exceeds the (sum of the squares) on AC and CB, twice the (rectangle contained) by AD and DB also exceeds twice the (rectangle contained) by AC and CB by this (same area). And twice the (rectangle contained) by AD and DB exceeds twice the (rectangle contained) by AC and CB by a rational (area). For both (are) rational (areas). Thus, the (sum of the squares) on AD and DB also exceeds the (sum of the) [squares] on AC and CB by a rational (area). The very thing is impossible. For both are medial (areas) [Props. 10.15, 10.23 corr.], and a medial (area) cannot exceed a(nother) medial (area) by a rational (area) [Prop. 10.26].

Thus, only one medial (straight-line), which is commensurable in square only with the whole, and contains a rational (area) with the whole, can be attached to a first apotome of a medial (straight-line). (Which is) the very thing it was required to show.

† This proposition is equivalent to Prop. 10.43, with minus signs instead of plus signs.

πα΄.

Τῇ μέσης ἀποτομῇ δευτέρᾳ μία μόνον προσαρμόζει εὐθεῖα μέση δυνάμει μόνον σύμμετρος τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης μέσον περιέχουσα.

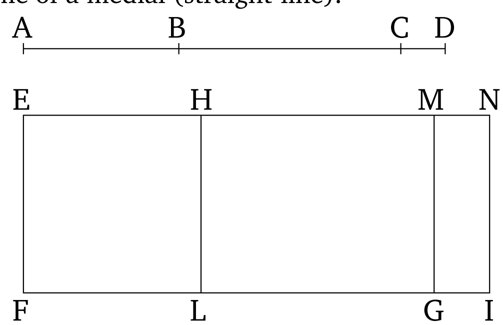


Ἔστω μέσης ἀποτομὴ δευτέρα ἡ ΑΒ καὶ τῇ ΑΒ προσαρμόζουσα ἡ ΒΓ· αἱ ἄρα ΑΓ, ΓΒ μέσαι εἰσὶ δυνάμει μόνον σύμμετροι μέσον περιέχουσαι τὸ ὑπὸ τῶν ΑΓ, ΓΒ· λέγω, ὅτι τῇ ΑΒ ἑτέρα οὐ προσαρμόσει εὐθεῖα μέση δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης μέσον περιέχουσα.

Εἰ γὰρ δυνατόν, προσαρμοζέτω ἡ ΒΔ· καὶ αἱ ΑΔ, ΔΒ ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι μέσον περιέχουσαι τὸ ὑπὸ τῶν ΑΔ, ΔΒ. καὶ ἐκκείσθω ῥητὴ ἡ ΕΖ, καὶ τοῖς μὲν ἀπὸ τῶν ΑΓ, ΓΒ ἴσον παρὰ τὴν ΕΖ παραβεβλήσθω τὸ ΕΗ πλάτος ποιοῦν τὴν ΕΜ· τῷ δὲ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ἴσον ἀφῃρήσθω τὸ ΘΗ πλάτος ποιοῦν τὴν ΘΜ· λοιπὸν ἄρα τὸ ΕΛ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΑΒ· ὥστε ἡ ΑΒ δύναται τὸ ΕΛ. πάλιν δὴ τοῖς ἀπὸ τῶν ΑΔ, ΔΒ ἴσον παρὰ τὴν ΕΖ παραβεβλήσθω τὸ ΕΙ πλάτος ποιοῦν τὴν ΕΝ· ἔστι δὲ καὶ τὸ ΕΛ ἴσον τῷ ἀπὸ τῆς ΑΒ τετραγώνῳ· λοιπὸν ἄρα τὸ ΘΙ ἴσον ἐστὶ τῷ δὶς ὑπὸ τῶν ΑΔ, ΔΒ. καὶ ἐπεὶ μέσαι εἰσὶν αἱ ΑΓ, ΓΒ, μέσα ἄρα ἐστὶ καὶ τὰ ἀπὸ τῶν ΑΓ, ΓΒ. καί ἐστιν ἴσα τῷ ΕΗ· μέσον ἄρα καὶ τὸ ΕΗ. καὶ παρὰ ῥητὴν τὴν ΕΖ παράκειται πλάτος ποιοῦν

Proposition 81

Only one medial straight-line, which is commensurable in square only with the whole, and contains a medial (area) with the whole, can be attached to a second apotome of a medial (straight-line).†



Let AB be a second apotome of a medial (straight-line), with BC (so) attached to AB. Thus, AC and CB are medial (straight-lines which are) commensurable in square only, containing a medial (area)—(namely, that contained) by AC and CB [Prop. 10.75]. I say that a(nother) medial straight-line, which is commensurable in square only with the whole, and contains a medial (area) with the whole, cannot be attached to AB.

For, if possible, let BD be (so) attached. Thus, AD and DB are also medial (straight-lines which are) commensurable in square only, containing a medial (area)—(namely, that contained) by AD and DB [Prop. 10.75]. And let the rational (straight-line) EF be laid down. And let EG, equal to the (sum of the squares) on AC and CB, have been applied to EF, producing EM as breadth. And let HG, equal to twice the (rectangle contained) by AC and CB, have been subtracted (from EG), producing HM as breadth. The remainder EL is thus equal to the (square) on AB [Prop. 2.7]. Hence, AB is the τὴν ΕΜ· ῥητὴ ἄρα ἐστὶν ἡ ΕΜ καὶ ἀσύμμετρος τῇ ΕΖ μήκει. πάλιν, ἐπεὶ μέσον ἐστὶ τὸ ὑπὸ τῶν ΑΓ, ΓΒ, καὶ τὸ δὶς ὑπὸ τῶν ΑΓ, ΓΒ μέσον ἐστίν. καί ἐστιν ἴσον τῷ ΘΗ· καὶ τὸ ΘΗ ἄρα μέσον ἐστίν. καὶ παρὰ ῥητὴν τὴν ΕΖ παράκειται πλάτος ποιοῦν τὴν ΘΜ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΘΜ καὶ ἀσύμμετρος τῇ ΕΖ μήκει. καὶ ἐπεὶ αἱ ΑΓ, ΓΒ δυνάμει μόνον σύμμετροί εἰσιν, ἀσύμμετρος ἄρα ἐστὶν ἡ ΑΓ τῇ ΓΒ μήκει. ὡς δὲ ἡ ΑΓ πρὸς τὴν ΓΒ, οὕτως ἐστὶ τὸ ἀπὸ τῆς ΑΓ πρὸς τὸ ὑπὸ τῶν ΑΓ, ΓΒ· ἀσύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΑΓ τῷ ὑπὸ τῶν ΑΓ, ΓΒ. ἀλλὰ τῷ μὲν ἀπὸ τῆς ΑΓ σύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΓ, ΓΒ, τῷ δὲ ὑπὸ τῶν ΑΓ, ΓΒ σύμμετρόν ἐστι τὸ δὶς ὑπὸ τῶν ΑΓ, ΓΒ· ἀσύμμετρα ἄρα ἐστὶ τὰ ἀπὸ τῶν ΑΓ, ΓΒ τῷ δὶς ὑπὸ τῶν ΑΓ, ΓΒ. καί ἐστι τοῖς μὲν ἀπὸ τῶν ΑΓ, ΓΒ ἴσον τὸ ΕΗ, τῷ δὲ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ἴσον τὸ ΗΘ· ἀσύμμετρον ἄρα ἐστὶ τὸ ΕΗ τῷ ΘΗ. ὡς δὲ τὸ ΕΗ πρὸς τὸ ΘΗ, οὕτως ἐστὶν ἡ ΕΜ πρὸς τὴν ΘΜ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΕΜ τῇ ΜΘ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ΕΜ, ΜΘ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΕΘ, προσαρμόζουσα δὲ αὐτῇ ἡ ΘΜ. ὁμοίως δὴ δείξομεν, ὅτι καὶ ἡ ΘΝ αὐτῇ προσαρμόζει· τῇ ἄρα ἀποτομῇ ἄλλη καὶ ἄλλη προσαρμόζει εὐθεῖα δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ· ὅπερ ἐστὶν ἀδύνατον.

Τῇ ἄρα μέσης ἀποτομῇ δευτέρᾳ μία μόνον προσαρμόζει εὐθεῖα μέση δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης μέσον περιέχουσα· ὅπερ ἔδει δεῖξαι.

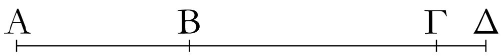
square-root of EL. So, again, let EI, equal to the (sum of the squares) on AD and DB have been applied to EF, producing EN as breadth. And EL is also equal to the square on AB. Thus, the remainder HI is equal to twice the (rectangle contained) by AD and DB [Prop. 2.7]. And since AC and CB are (both) medial (straight-lines), the (sum of the squares) on AC and CB is also medial. And it is equal to EG. Thus, EG is also medial [Props. 10.15, 10.23 corr.]. And it is applied to the rational (straight-line) EF, producing EM as breadth. Thus, EM is rational, and incommensurable in length with EF [Prop. 10.22]. Again, since the (rectangle contained) by AC and CB is medial, twice the (rectangle contained) by AC and CB is also medial [Prop. 10.23 corr.]. And it is equal to HG. Thus, HG is also medial. And it is applied to the rational (straight-line) EF, producing HM as breadth. Thus, HM is also rational, and incommensurable in length with EF [Prop. 10.22]. And since AC and CB are commensurable in square only, AC is thus incommensurable in length with CB. And as AC (is) to CB, so the (square) on AC is to the (rectangle contained) by AC and CB [Prop. 10.21 corr.]. Thus, the (square) on AC is incommensurable with the (rectangle contained) by AC and CB [Prop. 10.11]. But, the (sum of the squares) on AC and CB is commensurable with the (square) on AC, and twice the (rectangle contained) by AC and CB is commensurable with the (rectangle contained) by AC and CB [Prop. 10.6]. Thus, the (sum of the squares) on AC and CB is incommensurable with twice the (rectangle contained) by AC and CB [Prop. 10.13]. And EG is equal to the (sum of the squares) on AC and CB. And GH is equal to twice the (rectangle contained) by AC and CB. Thus, EG is incommensurable with HG. And as EG (is) to HG, so EM is to HM [Prop. 6.1]. Thus, EM is incommensurable in length with MH [Prop. 10.11]. And they are both rational (straight-lines). Thus, EM and MH are rational (straight-lines which are) commensurable in square only. Thus, EH is an apotome [Prop. 10.73], and HM (is) attached to it. So, similarly, we can show that HN (is) also (commensurable in square only with EN and is) attached to (EH). Thus, different straight-lines, which are commensurable in square only with the whole, are attached to an apotome. The very thing is impossible [Prop. 10.79].

Thus, only one medial straight-line, which is commensurable in square only with the whole, and contains a medial (area) with the whole, can be attached to a second apotome of a medial (straight-line). (Which is) the very thing it was required to show.

† This proposition is equivalent to Prop. 10.44, with minus signs instead of plus signs.

πβ΄.

Τῇ ἐλάσσονι μία μόνον προσαρμόζει εὐθεῖα δυνάμει ἀσύμμετρος οὖσα τῇ ὅλῃ ποιοῦσα μετὰ τῆς ὅλης τὸ μὲν ἐκ τῶν ἀπ᾿ αὐτῶν τετραγώνων ῥητόν, τὸ δὲ δὶς ὑπ᾿ αὐτῶν μέσον.



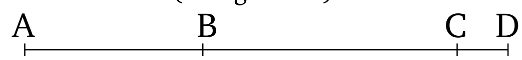
Ἔστω ἡ ἐλάσσων ἡ ΑΒ, καὶ τῇ ΑΒ προσαρμόζουσα ἔστω ἡ ΒΓ· αἱ ἄρα ΑΓ, ΓΒ δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾿ αὐτῶν τετραγώνων ῥητόν, τὸ δὲ δὶς ὑπ᾿ αὐτῶν μέσον· λέγω, ὅτι τῇ ΑΒ ἑτέρα εὐθεῖα οὐ προσαρμόσει τὰ αὐτὰ ποιοῦσα.

Εἰ γὰρ δυνατόν, προσαρμοζέτω ἡ ΒΔ· καὶ αἱ ΑΔ, ΔΒ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὰ προειρημένα. καὶ ἐπεί, ᾧ ὑπερέχει τὰ ἀπὸ τῶν ΑΔ, ΔΒ τῶν ἀπὸ τῶν ΑΓ, ΓΒ, τούτῳ ὑπερέχει καὶ τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ, τὰ δὲ ἀπὸ τῶν ΑΔ, ΔΒ τετράγωνα τῶν ἀπὸ τῶν ΑΓ, ΓΒ τετραγώνων ὑπερέχει ῥητῷ· ῥητὰ γάρ ἐστιν ἀμφότερα· καὶ τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ ἄρα τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ὑπερέχει ῥητῷ· ὅπερ ἐστὶν ἀδύνατον· μέσα γάρ ἐστιν ἀμφότερα.

Τῇ ἄρα ἐλάσσονι μία μόνον προσαρμόζει εὐθεῖα δυνάμει ἀσύμμετρος οὖσα τῇ ὅλῃ καὶ ποιοῦσα τὰ μὲν ἀπ᾿ αὐτῶν τετράγωνα ἅμα ῥητόν, τὸ δὲ δὶς ὑπ᾿ αὐτῶν μέσον· ὅπερ ἔδει δεῖξαι.

Proposition 82

Only one straight-line, which is incommensurable in square with the whole, and (together) with the whole makes the (sum of the) squares on them rational, and twice the (rectangle contained) by them medial, can be attached to a minor (straight-line).



Let AB be a minor (straight-line), and let BC be (so) attached to AB. Thus, AC and CB are (straight-lines which are) incommensurable in square, making the sum of the squares on them rational, and twice the (rectangle contained) by them medial [Prop. 10.76]. I say that another another straight-line fulfilling the same (conditions) cannot be attached to AB.

For, if possible, let BD be (so) attached (to AB). Thus, AD and DB are also (straight-lines which are) incommensurable in square, fulfilling the (other) aforementioned (conditions) [Prop. 10.76]. And since by whatever (area) the (sum of the squares) on AD and DB exceeds the (sum of the squares) on AC and CB, twice the (rectangle contained) by AD and DB also exceeds twice the (rectangle contained) by AC and CB by this (same area) [Prop. 2.7]. And the (sum of the) squares on AD and DB exceeds the (sum of the) squares on AC and CB by a rational (area). For both are rational (areas). Thus, twice the (rectangle contained) by AD and DB also exceeds twice the (rectangle contained) by AC and CB by a rational (area). The very thing is impossible. For both are medial (areas) [Prop. 10.26].

Thus, only one straight-line, which is incommensurable in square with the whole, and (with the whole) makes the squares on them (added) together rational, and twice the (rectangle contained) by them medial, can be attached to a minor (straight-line). (Which is) the very thing it was required to show.

† This proposition is equivalent to Prop. 10.45, with minus signs instead of plus signs.

πγ΄.

Τῇ μετὰ ῥητοῦ μέσον τὸ ὅλον ποιούσῃ μία μόνον προσαρμόζει εὐθεῖα δυνάμει ἀσύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης ποιοῦσα τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾿ αὐτῶν τετραγώνων μέσον, τὸ δὲ δὶς ὑπ᾿ αὐτῶν ῥητόν.

Proposition 83

Only one straight-line, which is incommensurable in square with the whole, and (together) with the whole makes the sum of the squares on them medial, and twice the (rectangle contained) by them rational, can be attached to that (straight-line) which with a rational (area) makes a medial whole.†

Ἔστω ἡ μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσα ἡ ΑΒ, καὶ τῇ ΑΒ προσαρμοζέτω ἡ ΒΓ· αἱ ἄρα ΑΓ, ΓΒ δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὰ προκείμενα· λέγω, ὅτι τῇ ΑΒ ἑτέρα οὐ προσαρμόσει τὰ αὐτὰ ποιοῦσα.

Εἰ γὰρ δυνατόν, προσαρμοζέτω ἡ ΒΔ· καὶ αἱ ΑΔ, ΔΒ ἄρα εὐθεῖαι δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὰ προκείμενα. ἐπεὶ οὐν, ᾧ ὑπερέχει τὰ ἀπὸ τῶν ΑΔ, ΔΒ τῶν ἀπὸ τῶν ΑΓ, ΓΒ, τούτῳ ὑπερέχει καὶ τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ἀκολούθως τοῖς πρὸ αὐτοῦ, τὸ δὲ δὶς ὑπὸ τῶν ΑΔ, ΔΒ τοῦ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ὑπερέχει ῥητῷ· ῥητὰ γάρ ἐστιν ἀμφότερα· καὶ τὰ ἀπὸ τῶν ΑΔ, ΔΒ ἄρα τῶν ἀπὸ τῶν ΑΓ, ΓΒ ὑπερέχει ῥητῷ· ὅπερ ἐστὶν ἀδύνατον· μέσα γάρ ἐστιν ἀμφότερα.

Οὐκ ἄρα τῇ ΑΒ ἑτέρα προσαρμόσει εὐθεῖα δυνάμει ἀσύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης ποιοῦσα τὰ προειρημένα· μία ἄρα μόνον προσαρμόσει· ὅπερ ἔδει δεῖξαι.

Let AB be a (straight-line) which with a rational (area) makes a medial whole, and let BC be (so) attached to AB. Thus, AC and CB are (straight-lines which are) incommensurable in square, fulfilling the (other) proscribed (conditions) [Prop. 10.77]. I say that another (straight-line) fulfilling the same (conditions) cannot be attached to AB.

For, if possible, let BD be (so) attached (to AB). Thus, AD and DB are also straight-lines (which are) incommensurable in square, fulfilling the (other) prescribed (conditions) [Prop. 10.77]. Therefore, analogously to the (propositions) before this, since by whatever (area) the (sum of the squares) on AD and DB exceeds the (sum of the squares) on AC and CB, twice the (rectangle contained) by AD and DB also exceeds twice the (rectangle contained) by AC and CB by this (same area). And twice the (rectangle contained) by AD and DB exceeds twice the (rectangle contained) by AC and CB by a rational (area). For they are (both) rational (areas). Thus, the (sum of the squares) on AD and DB also exceeds the (sum of the squares) on AC and CB by a rational (area). The very thing is impossible. For both are medial (areas) [Prop. 10.26].

Thus, another straight-line cannot be attached to AB, which is incommensurable in square with the whole, and fulfills the (other) aforementioned (conditions) with the whole. Thus, only one (such straight-line) can be (so) attached. (Which is) the very thing it was required to show.

† This proposition is equivalent to Prop. 10.46, with minus signs instead of plus signs.

πδʹ.

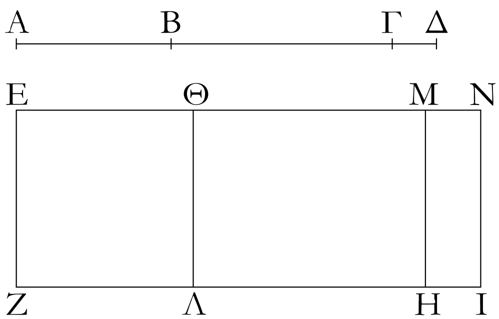
Τῇ μετὰ μέσου μέσον τὸ ὅλον ποιούσῃ μία μόνη προσαρμόζει εὐθεῖα δυνάμει ἀσύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης ποιοῦσα τό τε συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον τό τε δὶς ὑπ᾽ αὐτῶν μέσον καὶ ἔτι ἀσύμμετρον τῷ συγκειμένῳ ἐκ τῶν ἀπ᾽ αὐτῶν.

Ἔστω ἡ μετὰ μέσου μέσον τὸ ὅλον ποιοῦσα ἡ ΑΒ, προσαρμόζουσα δὲ αὐτῇ ἡ ΒΓ· αἱ ἄρα ΑΓ, ΓΒ δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὰ προειρημένα. λέγω, ὅτι τῇ ΑΒ ἑτέρα οὐ προσαρμόσει ποιοῦσα προειρημένα.

Proposition 84

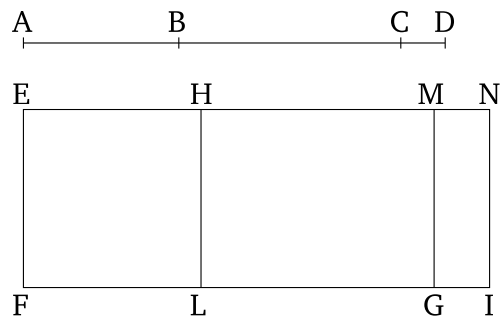
Only one straight-line, which is incommensurable in square with the whole, and (together) with the whole makes the sum of the squares on them medial, and twice the (rectangle contained) by them medial, and, moreover, incommensurable with the sum of the (squares) on them, can be attached to that (straight-line) which with a medial (area) makes a medial whole.†

Let AB be a (straight-line) which with a medial (area) makes a medial whole, BC being (so) attached to it. Thus, AC and CB are incommensurable in square, fulfilling the (other) aforementioned (conditions) [Prop. 10.78]. I say that a(nother) (straight-line) fulfilling the aforementioned (conditions) cannot be attached to AB.



Εἰ γὰρ δυνατόν, προσαρμοζέτω ἡ ΒΔ, ὥστε καὶ τὰς ΑΔ, ΔΒ δυνάμει ἀσυμμέτρους εἶναι ποιούσας τά τε ἀπὸ τῶν ΑΔ, ΔΒ τετράγωνα ἅμα μέσον καὶ τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ μέσον καὶ ἔτι τὰ ἀπὸ τῶν ΑΔ, ΔΒ ἀσύμμετρα τῷ δὶς ὑπὸ τῶν ΑΔ, ΔΒ· καὶ ἐκκείσθω ῥητὴ ἡ ΕΖ, καὶ τοῖς μὲν ἀπὸ τῶν ΑΓ, ΓΒ ἴσον παρὰ τὴν ΕΖ παραβεβλήσθω τὸ ΕΗ πλάτος ποιοῦν τὴν ΕΜ, τῷ δὲ δὶς ὑπὸ τῶν ΑΓ, ΓΒ ἴσον παρὰ τὴν ΕΖ παραβεβλήσθω τὸ ΘΗ πλάτος ποιοῦν τὴν ΘΜ· λοιπὸν ἄρα τὸ ἀπὸ τῆς ΑΒ ἴσον ἐστὶ τῷ ΕΛ· ἡ ἄρα ΑΒ δύναται τὸ ΕΛ. πάλιν τοῖς ἀπὸ τῶν ΑΔ, ΔΒ ἴσον παρὰ τὴν ΕΖ παραβεβλήσθω τὸ ΕΙ πλάτος ποιοῦν τὴν ΕΝ. ἔστι δὲ καὶ τὸ ἀπὸ τῆς ΑΒ ἴσον τῷ ΕΛ· λοιπὸν ἄρα τὸ δὶς ὑπὸ τῶν ΑΔ, ΔΒ ἴσον [ἐστὶ] τῷ ΘΙ. καὶ ἐπεὶ μέσον ἐστὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΓ, ΓΒ καί ἐστιν ἴσον τῷ ΕΗ, μέσον ἄρα ἐστὶ καὶ τὸ ΕΗ. καὶ παρὰ ῥητὴν τὴν ΕΖ παράκειται πλάτος ποιοῦν τὴν ΕΜ· ῥητὴ ἄρα ἐστὶν ἡ ΕΜ καὶ ἀσύμμετρος τῇ ΕΖ μήκει. πάλιν, ἐπεὶ μέσον ἐστὶ τὸ δὶς ὑπὸ τῶν ΑΓ, ΓΒ καί ἐστιν ἴσον τῷ ΘΗ, μέσον ἄρα καὶ τὸ ΘΗ. καὶ παρὰ ῥητὴν τὴν ΕΖ παράκειται πλάτος ποιοῦν τὴν ΘΜ· ῥητὴ ἄρα ἐστὶν ἡ ΘΜ καὶ ἀσύμμετρος τῇ ΕΖ μήκει. καὶ ἐπεὶ ἀσύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΓ, ΓΒ τῷ δὶς ὑπὸ τῶν ΑΓ, ΓΒ, ἀσύμμετρόν ἐστι καὶ τὸ ΕΗ τῷ ΘΗ· ἀσύμμετρος ἄρα ἐστὶ καὶ ἡ ΕΜ τῇ ΜΘ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ἄρα ΕΜ, ΜΘ ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΕΘ, προσαρμόζουσα δὲ αὐτῇ ἡ ΘΜ. ὁμοίως δὴ δείξομεν, ὅτι ἡ ΕΘ πάλιν ἀποτομή ἐστιν, προσαρμόζουσα δὲ αὐτῇ ἡ ΘΝ. τῇ ἄρα ἀποτομῇ ἄλλη καὶ ἄλλη προσαρμόζει ῥητὴ δυνάμει μόνον σύμμετρος οὖσα τῇ ὅλῃ· ὅπερ ἐδείχθη ἀδύνατον. οὐκ ἄρα τῇ ΑΒ ἑτέρα προσαρμόσει εὐθεῖα.

Τῇ ἄρα ΑΒ μία μόνον προσαρμόζει εὐθεῖα δυνάμει ἀσύμμετρος οὖσα τῇ ὅλῃ, μετὰ δὲ τῆς ὅλης ποιοῦσα τά τε ἀπ᾽ αὐτῶν τετράγωνα ἅμα μέσον καὶ τὸ δὶς ὑπ᾽ αὐτῶν μέσον καὶ ἔτι τὰ ἀπ᾽ αὐτῶν τετράγωνα ἀσύμμετρα τῷ δὶς ὑπ᾽ αὐτῶν· ὅπερ ἔδει δεῖξαι.



For, if possible, let BD be (so) attached. Hence, AD and DB are also (straight-lines which are) incommensurable in square, making the squares on AD and DB (added) together medial, and twice the (rectangle contained) by AD and DB medial, and, moreover, the (sum of the squares) on AD and DB incommensurable with twice the (rectangle contained) by AD and DB [Prop. 10.78]. And let the rational (straight-line) EF be laid down. And let EG, equal to the (sum of the squares) on AC and CB, have been applied to EF, producing EM as breadth. And let HG, equal to twice the (rectangle contained) by AC and CB, have been applied to EF, producing HM as breadth. Thus, the remaining (square) on AB is equal to EL [Prop. 2.7]. Thus, AB is the square-root of EL. Again, let EI, equal to the (sum of the squares) on AD and DB, have been applied to EF, producing EN as breadth. And the (square) on AB is also equal to EL. Thus, the remaining twice the (rectangle contained) by AD and DB [is] equal to HI [Prop. 2.7]. And since the sum of the (squares) on AC and CB is medial, and is equal to EG, EG is thus also medial. And it is applied to the rational (straight-line) EF, producing EM as breadth. EM is thus rational, and incommensurable in length with EF [Prop. 10.22]. Again, since twice the (rectangle contained) by AC and CB is medial, and is equal to HG, HG is thus also medial. And it is applied to the rational (straight-line) EF, producing HM as breadth. HM is thus rational, and incommensurable in length with EF [Prop. 10.22]. And since the (sum of the squares) on AC and CB is incommensurable with twice the (rectangle contained) by AC and CB, EG is also incommensurable with HG. Thus, EM is also incommensurable in length with MH [Props. 6.1, 10.11]. And they are both rational (straight-lines). Thus, EM and MH are rational (straight-lines which are) commensurable in square only. Thus, EH is an apotome [Prop. 10.73], with HM attached to it. So, similarly, we can show that EH is again an apotome, with HN attached to it. Thus, different rational (straight-lines), which are commensurable in square only with the whole, are attached to an apotome. The very thing was shown (to be) impossible [Prop. 10.79]. Thus, another straight-line cannot be (so) attached to AB.

Thus, only one straight-line, which is incommensurable in square with the whole, and (together) with the whole makes the squares on them (added) together medial, and twice the (rectangle contained) by them medial, and, moreover, the (sum of the) squares on them incommensurable with the (rectangle contained) by them, can be attached to AB. (Which is) the very thing it was required to show.

† This proposition is equivalent to Prop. 10.47, with minus signs instead of plus signs.

Ὅροι τρίτοι.

ια΄. Ὑποκειμένης ῥητῆς καὶ ἀποτομῆς, ἐὰν μὲν ἡ ὅλη τῆς προσαρμοζούσης μεῖζον δύνηται τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει, καὶ ἡ ὅλη σύμμετρος ᾖ τῇ ἐκκειμένῃ ῥητῇ μήκει, καλείσθω ἀποτομὴ πρώτη.

ιβ΄. Ἐὰν δὲ ἡ προσαρμόζουσα σύμμετρος ᾖ τῇ ἐκκειμένῃ ῥητῇ μήκει, καὶ ἡ ὅλη τῆς προσαρμοζούσης μεῖζον δύνηται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καλείσθω ἀποτομὴ δευτέρα.

ιγ΄. Ἐὰν δὲ μηδετέρα σύμμετρος ᾖ τῇ ἐκκειμένῃ ῥητῇ μήκει, ἡ δὲ ὅλη τῆς προσαρμοζούσης μεῖζον δύνηται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καλείσθω ἀποτομὴ τρίτη.

ιδ΄. Πάλιν, ἐὰν ἡ ὅλη τῆς προσαρμοζούσης μεῖζον δύνηται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ [μήκει], ἐὰν μὲν ἡ ὅλη σύμμετρος ᾖ τῇ ἐκκειμένῃ ῥητῇ μήκει, καλείσθω ἀποτομὴ τετάρτη.

ιε΄. Ἐὰν δὲ ἡ προσαρμόζουσα, πέμπτη.

ιϛ΄. Ἐὰν δὲ μηδετέρα, ἕκτη.

Definitions III

11. Given a rational (straight-line) and an apotome, if the square on the whole is greater than the (square on a straight-line) attached (to the apotome) by the (square) on (some straight-line) commensurable in length with (the whole), and the whole is commensurable in length with the (previously) laid down rational (straight-line), then let the (apotome) be called a first apotome.

12. And if the attached (straight-line) is commensurable in length with the (previously) laid down rational (straight-line), and the square on the whole is greater than (the square on) the attached (straight-line) by the (square) on (some straight-line) commensurable (in length) with (the whole), then let the (apotome) be called a second apotome.

13. And if neither of (the whole or the attached straight-line) is commensurable in length with the (previously) laid down rational (straight-line), and the square on the whole is greater than (the square on) the attached (straight-line) by the (square) on (some straight-line) commensurable (in length) with (the whole), then let the (apotome) be called a third apotome.

14. Again, if the square on the whole is greater than (the square on) the attached (straight-line) by the (square) on (some straight-line) incommensurable [in length] with (the whole), and the whole is commensurable in length with the (previously) laid down rational (straight-line), then let the (apotome) be called a fourth apotome.

15. And if the attached (straight-line is commensurable), a fifth (apotome).

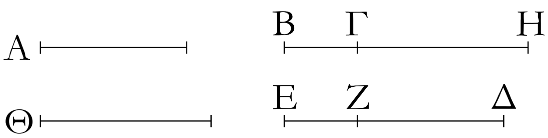
16. And if neither (the whole nor the attached straight-line is commensurable), a sixth (apotome).

πε΄.

Εὑρεῖν τὴν πρώτην ἀποτομήν.

Proposition 85

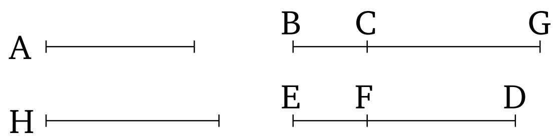
To find a first apotome.



Ἐκκείσθω ῥητὴ ἡ Α, καὶ τῇ Α μήκει σύμμετρος ἔστω ἡ ΒΗ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΒΗ. καὶ ἐκκείσθωσαν δύο τετράγωνοι ἀριθμοὶ οἱ ΔΕ, ΕΖ, ὧν ἡ ὑπεροχὴ ὁ ΖΔ μὴ ἔστω τετράγωνος· οὐδ᾽ ἄρα ὁ ΕΔ πρὸς τὸν ΔΖ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. καὶ πεποιήσθω ὡς ὁ ΕΔ πρὸς τὸν ΔΖ, οὕτως τὸ ἀπὸ τῆς ΒΗ τετράγωνον πρὸς τὸ ἀπὸ τὴς ΗΓ τετράγωνον· σύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΒΗ τῷ ἀπὸ τῆς ΗΓ. ῥητὸν δὲ τὸ ἀπὸ τῆς ΒΗ· ῥητὸν ἄρα καὶ τὸ ἀπὸ τῆς ΗΓ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΗΓ. καὶ ἐπεὶ ὁ ΕΔ πρὸς τὸν ΔΖ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδ᾽ ἄρα τὸ ἀπὸ τῆς ΒΗ πρὸς τὸ ἀπὸ τῆς ΗΓ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΒΗ τῇ ΗΓ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ΒΗ, ΗΓ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἡ ἄρα ΒΓ ἀποτομή ἐστιν. λέγω δή, ὅτι καὶ πρώτη.

Ὧι γὰρ μεῖζόν ἐστι τὸ ἀπὸ τῆς ΒΗ τοῦ ἀπὸ τῆς ΗΓ, ἔστω τὸ ἀπὸ τῆς Θ. καὶ ἐπεί ἐστιν ὡς ὁ ΕΔ πρὸς τὸν ΖΔ, οὕτως τὸ ἀπὸ τῆς ΒΗ πρὸς τὸ ἀπὸ τῆς ΗΓ, καὶ ἀναστρέψαντι ἄρα ἐστὶν ὡς ὁ ΔΕ πρὸς τὸν ΕΖ, οὕτως τὸ ἀπὸ τῆς ΗΒ πρὸς τὸ ἀπὸ τῆς Θ. ὁ δὲ ΔΕ πρὸς τὸν ΕΖ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἑκάτερος γὰρ τετράγωνός ἐστιν· καὶ τὸ ἀπὸ τῆς ΗΒ ἄρα πρὸς τὸ ἀπὸ τῆς Θ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· σύμμετρος ἄρα ἐστὶν ἡ ΒΗ τῇ Θ μήκει. καὶ δύναται ἡ ΒΗ τῆς ΗΓ μεῖζον τῷ ἀπὸ τῆς Θ· ἡ ΒΗ ἄρα τῆς ΗΓ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει. καί ἐστιν ἡ ὅλη ἡ ΒΗ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ μήκει τῇ Α. ἡ ΒΓ ἄρα ἀποτομή ἐστι πρώτη.

Εὕρηται ἄρα ἡ πρώτη ἀποτομὴ ἡ ΒΓ· ὅπερ ἔδει εὑρεῖν.



Let the rational (straight-line) A be laid down. And let BG be commensurable in length with A. BG is thus also a rational (straight-line). And let two square numbers DE and EF be laid down, and let their difference FD be not square [Prop. 10.28 lem. I]. Thus, ED does not have to DF the ratio which (some) square number (has) to (some) square number. And let it have been contrived that as ED (is) to DF, so the square on BG (is) to the square on GC [Prop. 10.6. corr.]. Thus, the (square) on BG is commensurable with the (square) on GC [Prop. 10.6]. And the (square) on BG (is) rational. Thus, the (square) on GC (is) also rational. Thus, GC is also rational. And since ED does not have to DF the ratio which (some) square number (has) to (some) square number, the (square) on BG thus does not have to the (square) on GC the ratio which (some) square number (has) to (some) square number either. Thus, BG is incommensurable in length with GC [Prop. 10.9]. And they are both rational (straight-lines). Thus, BG and GC are rational (straight-lines which are) commensurable in square only. Thus, BC is an apotome [Prop. 10.73]. So, I say that (it is) also a first (apotome).

Let the (square) on H be that (area) by which the (square) on BG is greater than the (square) on GC [Prop. 10.13 lem.]. And since as ED is to FD, so the (square) on BG (is) to the (square) on GC, thus, via conversion, as DE is to EF, so the (square) on GB (is) to the (square) on H [Prop. 5.19 corr.]. And DE has to EF the ratio which (some) square-number (has) to (some) square-number. For each is a square (number). Thus, the (square) on GB also has to the (square) on H the ratio which (some) square number (has) to (some) square number. Thus, BG is commensurable in length with H [Prop. 10.9]. And the square on BG is greater than (the square on) GC by the (square) on H. Thus, the square on BG is greater than (the square on) GC by the (square) on (some straight-line) commensurable in length with (BG). And the whole, BG, is commensurable in length with the (previously) laid down rational (straight-line) A. Thus, BC is a first apotome [Def. 10.11].

Thus, the first apotome BC has been found. (Which is) the very thing it was required to find.

† See footnote to Prop. 10.48.

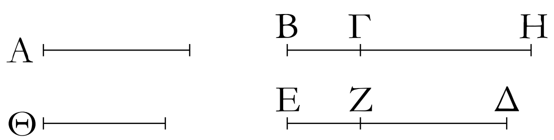
πϛʹ.

Proposition 86

Εὑρεῖν τὴν δευτέραν ἀποτομήν.

To find a second apotome.

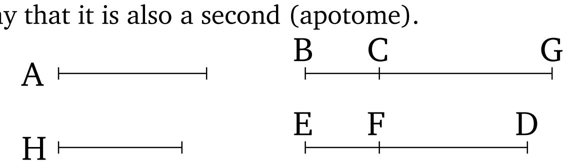
Ἐκκείσθω ῥητὴ ἡ Α καὶ τῇ Α σύμμετρος μήκει ἡ ΗΓ. ῥητὴ ἄρα ἐστὶν ἡ ΗΓ. καὶ ἐκκείσθωσαν δύο τετράγωνοι ἀριθμοὶ οἱ ΔΕ, ΕΖ, ὧν ἡ ὑπεροχὴ ὁ ΔΖ μὴ ἔστω τετράγωνος. καὶ πεποιήσθω ὡς ὁ ΖΔ πρὸς τὸν ΔΕ, οὕτως τὸ ἀπὸ τῆς ΓΗ τετράγωνον πρὸς τὸ ἀπὸ τῆς ΗΒ τετράγωνον. σύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΓΗ τετράγωνον τῷ ἀπὸ τῆς ΗΒ τετραγώνῳ. ῥητὸν δὲ τὸ ἀπὸ τῆς ΓΗ. ῥητὸν ἄρα [ἐστὶ] καὶ τὸ ἀπὸ τῆς ΗΒ· ῥητὴ ἄρα ἐστὶν ἡ ΒΗ. καὶ ἐπεὶ τὸ ἀπὸ τῆς ΗΓ τετράγωνον πρὸς τὸ ἀπὸ τῆς ΗΒ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, ἀσύμμετρός ἐστιν ἡ ΓΗ τῇ ΗΒ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ΓΗ, ΗΒ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἡ ΒΓ ἄρα ἀποτομή ἐστιν. λέγω δή, ὅτι καὶ δευτέρα.



Ὧι γὰρ μεῖζόν ἐστι τὸ ἀπὸ τῆς ΒΗ τοῦ ἀπὸ τῆς ΗΓ, ἔστω τὸ ἀπὸ τῆς Θ. ἐπεὶ οὖν ἐστιν ὡς τὸ ἀπὸ τῆς ΒΗ πρὸς τὸ ἀπὸ τῆς ΗΓ, οὕτως ὁ ΕΔ ἀριθμὸς πρὸς τὸν ΔΖ ἀριθμόν, ἀναστρέψαντι ἄρα ἐστὶν ὡς τὸ ἀπὸ τῆς ΒΗ πρὸς τὸ ἀπὸ τῆς Θ, οὕτως ὁ ΔΕ πρὸς τὸν ΕΖ. καί ἐστιν ἑκάτερος τῶν ΔΕ, ΕΖ τετράγωνος· τὸ ἄρα ἀπὸ τῆς ΒΗ πρὸς τὸ ἀπὸ τῆς Θ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· σύμμετρος ἄρα ἐστὶν ἡ ΒΗ τῇ Θ μήκει. καὶ δύναται ἡ ΒΗ τῆς ΗΓ μεῖζον τῷ ἀπὸ τῆς Θ· ἡ ΒΗ ἄρα τῆς ΗΓ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει. καί ἐστιν ἡ προσαρμόζουσα ἡ ΓΗ τῇ ἐκκειμένῃ ῥητῇ σύμμετρος τῇ Α. ἡ ΒΓ ἄρα ἀποτομή ἐστι δευτέτα.

Εὕρηται ἄρα δευτέρα ἀποτομὴ ἡ ΒΓ· ὅπερ ἔδει δεῖξαι.

Let the rational (straight-line) A, and GC (which is) commensurable in length with A, be laid down. Thus, GC is a rational (straight-line). And let the two square numbers DE and EF be laid down, and let their difference DF be not square [Prop. 10.28 lem. I]. And let it have been contrived that as FD (is) to DE, so the square on CG (is) to the square on GB [Prop. 10.6 corr.]. Thus, the square on CG is commensurable with the square on GB [Prop. 10.6]. And the (square) on CG (is) rational. Thus, the (square) on GB [is] also rational. Thus, BG is a rational (straight-line). And since the square on GC does not have to the (square) on GB the ratio which (some) square number (has) to (some) square number, CG is incommensurable in length with GB [Prop. 10.9]. And they are both rational (straight-lines). Thus, CG and GB are rational (straight-lines which are) commensurable in square only. Thus, BC is an apotome [Prop. 10.73]. So, I say that it is also a second (apotome).



For let the (square) on H be that (area) by which the (square) on BG is greater than the (square) on GC [Prop. 10.13 lem.]. Therefore, since as the (square) on BG is to the (square) on GC, so the number ED (is) to the number DF, thus, also, via conversion, as the (square) on BG is to the (square) on H, so DE (is) to EF [Prop. 5.19 corr.]. And DE and EF are each square (numbers). Thus, the (square) on BG has to the (square) on H the ratio which (some) square number (has) to (some) square number. Thus, BG is commensurable in length with H [Prop. 10.9]. And the square on BG is greater than (the square on) GC by the (square) on H. Thus, the square on BG is greater than (the square on) GC by the (square) on (some straight-line) commensurable in length with (BG). And the attachment CG is commensurable (in length) with the (prevously) laid down rational (straight-line) A. Thus, BC is a second apotome [Def. 10.12].†

Thus, the second apotome BC has been found. (Which is) the very thing it was required to show.

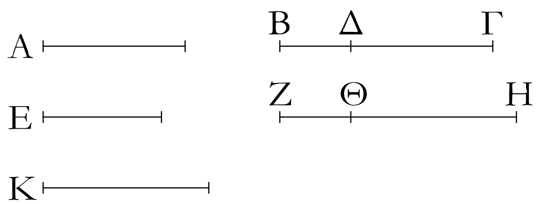
† See footnote to Prop. 10.49.

πζ´.

Εὑρεῖν τὴν τρίτην ἀποτομήν.

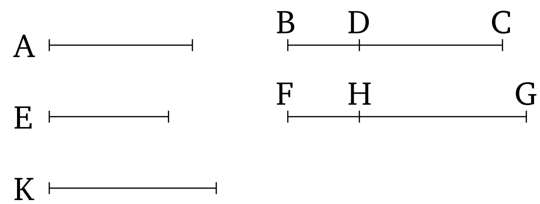
Proposition 87

To find a third apotome.



Ἐκκείσθω ῥητὴ ἡ Α, καὶ ἐκκείσθωσαν τρεῖς ἀριθμοὶ οἱ Ε, ΒΓ, ΓΔ λόγον μὴ ἔχοντες πρὸς ἀλλήλους, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, ὁ δὲ ΓΒ πρὸς τὸν ΒΔ λόγον ἐχέτω, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, καὶ πεποιήσθω ὡς μὲν ὁ Ε πρὸς τὸν ΒΓ, οὕτως τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς ΖΗ τετράγωνον, ὡς δὲ ὁ ΒΓ πρὸς τὸν ΓΔ, οὕτως τὸ ἀπὸ τῆς ΖΗ τετράγωνον πρὸς τὸ ἀπὸ τὴς ΗΘ. ἐπεὶ οὖν ἐστιν ὡς ὁ Ε πρὸς τὸν ΒΓ, οὕτως τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς ΖΗ τετράγωνον, σύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς Α τετράγωνον τῷ ἀπὸ τῆς ΖΗ τετραγώνῳ. ῥητὸν δὲ τὸ ἀπὸ τῆς Α τετράγωνον. ῥητὸν ἄρα καὶ τὸ ἀπὸ τῆς ΖΗ· ῥητὴ ἄρα ἐστὶν ἡ ΖΗ. καὶ ἐπεὶ ὁ Ε πρὸς τὸν ΒΓ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδ᾽ ἄρα τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς ΖΗ [τετράγωνον] λόγον ἔχει, ὅν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ Α τῇ ΖΗ μήκει. πάλιν, ἐπεί ἐστιν ὡς ὁ ΒΓ πρὸς τὸν ΓΔ, οὕτως τὸ ἀπὸ τῆς ΖΗ τετράγωνον πρὸς τὸ ἀπὸ τῆς ΗΘ, σύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΖΗ τῷ ἀπὸ τῆς ΗΘ. ῥητὸν δὲ τὸ ἀπὸ τῆς ΖΗ· ῥητὸν ἄρα καὶ τὸ ἀπὸ τῆς ΗΘ· ῥητὴ ἄρα ἐστὶν ἡ ΗΘ. καὶ ἐπεὶ ὁ ΒΓ πρὸς τὸν ΓΔ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδ᾽ ἄρα τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΖΗ τῇ ΗΘ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ΖΗ, ΗΘ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΖΘ. λέγω δή, ὅτι καὶ τρίτη.

Ἐπεὶ γάρ ἐστιν ὡς μὲν ὁ Ε πρὸς τὸν ΒΓ, οὕτως τὸ ἀπὸ τῆς Α τετράγωνον πρὸς τὸ ἀπὸ τῆς ΖΗ, ὡς δὲ ὁ ΒΓ πρὸς τὸν ΓΔ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΘΗ, δι᾽ ἴσου ἄρα ἐστὶν ὡς ὁ Ε πρὸς τὸν ΓΔ, οὕτως τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς ΘΗ. ὁ δὲ Ε πρὸς τὸν ΓΔ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· οὐδ᾽ ἄρα τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς ΗΘ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἡ Α τῇ ΗΘ μήκει. οὐδετέρα ἄρα τῶν ΖΗ, ΗΘ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ Α μήκει. ᾧ οὖν μεῖζόν ἐστι τὸ ἀπὸ τῆς ΖΗ τοῦ ἀπὸ τῆς ΗΘ, ἔστω τὸ ἀπὸ τῆς Κ. ἐπεὶ οὖν ἐστιν ὡς ὁ ΒΓ πρὸς τὸν ΓΔ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ, ἀναστρέψαντι ἄρα ἐστὶν ὡς ὁ ΒΓ πρὸς τὸν ΒΔ, οὕτως τὸ ἀπὸ τῆς ΖΗ τετράγωνον πρὸς τὸ ἀπὸ τῆς Κ. ὁ δὲ ΒΓ πρὸς τὸν ΒΔ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. καὶ τὸ ἀπὸ τῆς ΖΗ ἄρα πρὸς τὸ ἀπὸ τῆς Κ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον



Let the rational (straight-line) A be laid down. And let the three numbers, E, BC, and CD, not having to one another the ratio which (some) square number (has) to (some) square number, be laid down. And let CB have to BD the ratio which (some) square number (has) to (some) square number. And let it have been contrived that as E (is) to BC, so the square on A (is) to the square on FG, and as BC (is) to CD, so the square on FG (is) to the (square) on GH [Prop. 10.6 corr.]. Therefore, since as E is to BC, so the square on A (is) to the square on FG, the square on A is thus commensurable with the square on FG [Prop. 10.6]. And the square on A (is) rational. Thus, the (square) on FG (is) also rational. Thus, FG is a rational (straight-line). And since E does not have to BC the ratio which (some) square number (has) to (some) square number, the square on A thus does not have to the [square] on FG the ratio which (some) square number (has) to (some) square number either. Thus, A is incommensurable in length with FG [Prop. 10.9]. Again, since as BC is to CD, so the square on FG is to the (square) on GH, the square on FG is thus commensurable with the (square) on GH [Prop. 10.6]. And the (square) on FG (is) rational. Thus, the (square) on GH (is) also rational. Thus, GH is a rational (straight-line). And since BC does not have to CD the ratio which (some) square number (has) to (some) square number, the (square) on FG thus does not have to the (square) on GH the ratio which (some) square number (has) to (some) square number either. Thus, FG is incommensurable in length with GH [Prop. 10.9]. And both are rational (straight-lines). FG and GH are thus rational (straight-lines which are) commensurable in square only. Thus, FH is an apotome [Prop. 10.73]. So, I say that (it is) also a third (apotome).

For since as E is to BC, so the square on A (is) to the (square) on FG, and as BC (is) to CD, so the (square) on FG (is) to the (square) on HG, thus, via equality, as E is to CD, so the (square) on A (is) to the (square) on HG [Prop. 5.22]. And E does not have to CD the ratio which (some) square number (has) to (some) square number. Thus, the (square) on A does not have to the (square) on GH the ratio which (some) square number (has) to (some) square number either. A (is) thus incommensurable in length with GH [Prop. 10.9]. Thus, neither of FG and GH is commensurable in length with the ἀριθμόν. σύμμετρός ἄρα ἐστὶν ἡ ΖΗ τῇ Κ μήκει, καὶ δύναται ἡ ΖΗ τῆς ΗΘ μεῖζον τῷ ἀπὸ συμμέτρου ἑαυτῇ. καὶ οὐδετέρα τῶν ΖΗ, ΗΘ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ Α μήκει· ἡ ΖΘ ἄρα ἀποτομή ἐστι τρίτη.

Εὕρηται ἄρα ἡ τρίτη ἀποτομὴ ἡ ΖΘ· ὅπερ ἔδει δεῖξαι.

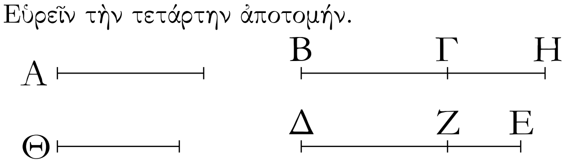
(previously) laid down rational (straight-line) A. Therefore, let the (square) on K be that (area) by which the (square) on FG is greater than the (square) on GH [Prop. 10.13 lem.]. Therefore, since as BC is to CD, so the (square) on FG (is) to the (square) on GH, thus, via conversion, as BC is to BD, so the square on FG (is) to the square on K [Prop. 5.19 corr.]. And BC has to BD the ratio which (some) square number (has) to (some) square number. Thus, the (square) on FG also has to the (square) on K the ratio which (some) square number (has) to (some) square number. FG is thus commensurable in length with K [Prop. 10.9]. And the square on FG is (thus) greater than (the square on) GH by the (square) on (some straight-line) commensurable (in length) with (FG). And neither of FG and GH is commensurable in length with the (previously) laid down rational (straight-line) A. Thus, FH is a third apotome [Def. 10.13].

Thus, the third apotome FH has been found. (Which is) very thing it was required to show.

† See footnote to Prop. 10.50.

πη´.

Εὑρεῖν τὴν τετάρτην ἀποτομήν.

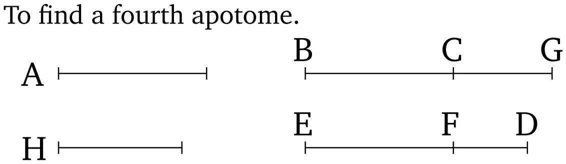


Ἐκκείσθω ῥητὴ ἡ Α καὶ τῇ Α μήκει σύμμετρος ἡ ΒΗ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΒΗ. καὶ ἐκκείσθωσαν δύο ἀριθμοὶ οἱ ΔΖ, ΖΕ, ὥστε τὸν ΔΕ ὅλον πρὸς ἑκάτερον τῶν ΔΖ, ΕΖ λόγον μὴ ἔχειν, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν. καὶ πεποιήσθω ὡς ὁ ΔΕ πρὸς τὸν ΕΖ, οὕτως τὸ ἀπὸ τῆς ΒΗ τετράγωνον πρὸς τὸ ἀπὸ τῆς ΗΓ· σύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΒΗ τῷ ἀπὸ τῆς ΗΓ. ῥητὸν δὲ τὸ ἀπὸ τῆς ΒΗ· ῥητὸν ἄρα καὶ τὸ ἀπὸ τῆς ΗΓ· ῥητὴ ἄρα ἐστὶν ἡ ΗΓ. καὶ ἐπεὶ ὁ ΔΕ πρὸς τὸν ΕΖ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδ᾽ ἄρα τὸ ἀπὸ τῆς ΒΗ πρὸς τὸ ἀπὸ τῆς ΗΓ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΒΗ τῇ ΗΓ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ΒΗ, ΗΓ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΒΓ. [λέγω δή, ὅτι καὶ τετάρτη.]

Ὧι οὖν μεῖζόν ἐστι τὸ ἀπὸ τῆς ΒΗ τοῦ ἀπὸ τῆς ΗΓ, ἔστω τὸ ἀπὸ τῆς Θ. ἐπεὶ οὖν ἐστιν ὡς ὁ ΔΕ πρὸς τὸν ΕΖ, οὕτως τὸ ἀπὸ τῆς ΒΗ πρὸς τὸ ἀπὸ τῆς ΗΓ, καὶ ἀναστρέψαντι ἄρα ἐστὶν ὡς ὁ ΕΔ πρὸς τὸν ΔΖ, οὕτως τὸ ἀπὸ τῆς ΗΒ πρὸς τὸ ἀπὸ τῆς Θ. ὁ δὲ ΕΔ πρὸς τὸν ΔΖ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον

Proposition 88

To find a fourth apotome.



Let the rational (straight-line) A, and BG (which is) commensurable in length with A, be laid down. Thus, BG is also a rational (straight-line). And let the two numbers DF and FE be laid down such that the whole, DE, does not have to each of DF and EF the ratio which (some) square number (has) to (some) square number. And let it have been contrived that as DE (is) to EF, so the square on BG (is) to the (square) on GC [Prop. 10.6 corr.]. The (square) on BG is thus commensurable with the (square) on GC [Prop. 10.6]. And the (square) on BG (is) rational. Thus, the (square) on GC (is) also rational. Thus, GC (is) a rational (straight-line). And since DE does not have to EF the ratio which (some) square number (has) to (some) square number, the (square) on BG thus does not have to the (square) on GC the ratio which (some) square number (has) to (some) square number either. Thus, BG is incommensurable in length with GC [Prop. 10.9]. And they are both rational (straight-lines). Thus, BG and GC are rational (straight-lines which are) commensurable in square only. Thus, BC is an apotome [Prop. 10.73]. [So, I say that (it ἀριθμόν· οὐδ᾽ ἄρα τὸ ἀπὸ τῆς ΗΒ πρὸς τὸ ἀπὸ τῆς Θ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΒΗ τῇ Θ μήκει. καὶ δύναται ἡ ΒΗ τῆς ΗΓ μεῖζον τῷ ἀπὸ τῆς Θ· ἡ ἄρα ΒΗ τῆς ΗΓ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καὶ ἐστιν ὅλη ἡ ΒΗ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ μήκει τῇ Α. ἡ ἄρα ΒΓ ἀποτομή ἐστι τετάρτη.

Εὕρηται ἄρα ἡ τετάρτη ἀποτομή· ὅπερ ἔδει δεῖξαι.

is) also a fourth (apotome).]

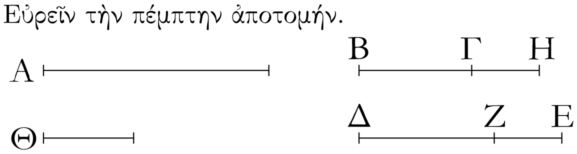
Now, let the (square) on H be that (area) by which the (square) on BG is greater than the (square) on GC [Prop. 10.13 lem.]. Therefore, since as DE is to EF, so the (square) on BG (is) to the (square) on GC, thus, also, via conversion, as ED is to DF, so the (square) on GB (is) to the (square) on H [Prop. 5.19 corr.]. And ED does not have to DF the ratio which (some) square number (has) to (some) square number. Thus, the (square) on GB does not have to the (square) on H the ratio which (some) square number (has) to (some) square number either. Thus, BG is incommensurable in length with H [Prop. 10.9]. And the square on BG is greater than (the square on) GC by the (square) on H. Thus, the square on BG is greater than (the square) on GC by the (square) on (some straight-line) incommensurable (in length) with (BG). And the whole, BG, is commensurable in length with the the (previously) laid down rational (straight-line) A. Thus, BC is a fourth apotome [Def. 10.14].[†]

Thus, a fourth apotome has been found. (Which is) the very thing it was required to show.

[†] See footnote to Prop. 10.51.

πθ´.

Εὑρεῖν τὴν πέμπτην ἀποτομήν.

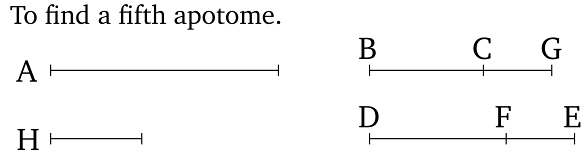


Ἐκκείσθω ῥητὴ ἡ Α, καὶ τῇ Α μήκει σύμμετρος ἔστω ἡ ΓΗ· ῥητὴ ἄρα [ἐστὶν] ἡ ΓΗ. καὶ ἐκκείσθωσαν δύο ἀριθμοὶ οἱ ΔΖ, ΖΕ, ὥστε τὸν ΔΕ πρὸς ἑκάτερον τῶν ΔΖ, ΖΕ λόγον πάλιν μὴ ἔχειν, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· καὶ πεποιήσθω ὡς ὁ ΖΕ πρὸς τὸν ΕΔ, οὕτως τὸ ἀπὸ τῆς ΓΗ πρὸς τὸ ἀπὸ τῆς ΗΒ. ῥητὸν ἄρα καὶ τὸ ἀπὸ τῆς ΗΒ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΒΗ. καὶ ἐπεί ἐστιν ὡς ὁ ΔΕ πρὸς τὸν ΕΖ, οὕτως τὸ ἀπὸ τῆς ΒΗ πρὸς τὸ ἀπὸ τῆς ΗΓ, ὁ δὲ ΔΕ πρὸς τὸν ΕΖ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδ᾽ ἄρα τὸ ἀπὸ τῆς ΒΗ πρὸς τὸ ἀπὸ τῆς ΗΓ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΒΗ τῇ ΗΓ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ΒΗ, ΗΓ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἡ ΒΓ ἄρα ἀποτομή ἐστιν. λέγω δή, ὅτι καὶ πέμπτη.

Ὧι γὰρ μεῖζόν ἐστι τὸ ἀπὸ τῆς ΒΗ τοῦ ἀπὸ τῆς ΗΓ, ἔστω τὸ ἀπὸ τῆς Θ. ἐπεὶ οὖν ἐστιν ὡς τὸ ἀπὸ τὴς ΒΗ πρὸς τὸ ἀπὸ τῆς ΗΓ, οὕτως ὁ ΔΕ πρὸς τὸν ΕΖ, ἀναστρέψαντι ἄρα ἐστὶν ὡς ὁ ΕΔ πρὸς τὸν ΔΖ, οὕτως τὸ ἀπὸ τῆς ΒΗ πρὸς τὸ ἀπὸ τῆς Θ, ὁ δὲ ΕΔ πρὸς τὸν ΔΖ λόγον οὐκ ἔχει, ὃν

Proposition 89

To find a fifth apotome.



Let the rational (straight-line) A be laid down, and let CG be commensurable in length with A. Thus, CG [is] a rational (straight-line). And let the two numbers DF and FE be laid down such that DE again does not have to each of DF and FE the ratio which (some) square number (has) to (some) square number. And let it have been contrived that as FE (is) to ED, so the (square) on CG (is) to the (square) on GB. Thus, the (square) on GB (is) also rational [Prop. 10.6]. Thus, BG is also rational. And since as DE is to EF, so the (square) on BG (is) to the (square) on GC. And DE does not have to EF the ratio which (some) square number (has) to (some) square number. The (square) on BG thus does not have to the (square) on GC the ratio which (some) square number (has) to (some) square number either. Thus, BG is incommensurable in length with GC [Prop. 10.9]. And they are both rational (straight-lines). BG and GC are thus rational (straight-lines which are) commensurable in square only. Thus, BC is an apotome [Prop. 10.73]. So, I say that (it is) also a fifth (apotome).

τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· οὐδ᾽ ἄρα τὸ ἀπὸ τῆς ΒΗ πρὸς τὸ ἀπὸ τῆς Θ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΒΗ τῇ Θ μήκει. καὶ δύναται ἡ ΒΗ τῆς ΗΓ μεῖζον τῷ ἀπὸ τῆς Θ· ἡ ΗΒ ἄρα τῆς ΗΓ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ μήκει. καί ἐστιν ἡ προσαρμόζουσα ἡ ΓΗ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ τῇ Α μήκει· ἡ ἄρα ΒΓ ἀποτομή ἐστι πέμπτη.

Εὕρηται ἄρα ἡ πέμπτη ἀποτομὴ ἡ ΒΓ· ὅπερ ἔδει δεῖξαι.

For, let the (square) on H be that (area) by which the (square) on BG is greater than the (square) on GC [Prop. 10.13 lem.]. Therefore, since as the (square) on BG (is) to the (square) on GC, so DE (is) to EF, thus, via conversion, as ED is to DF, so the (square) on BG (is) to the (square) on H [Prop. 5.19 corr.]. And ED does not have to DF the ratio which (some) square number (has) to (some) square number. Thus, the (square) on BG does not have to the (square) on H the ratio which (some) square number (has) to (some) square number either. Thus, BG is incommensurable in length with H [Prop. 10.9]. And the square on BG is greater than (the square on) GC by the (square) on H. Thus, the square on GB is greater than (the square on) GC by the (square) on (some straight-line) incommensurable in length with (GB). And the attachment CG is commensurable in length with the (previously) laid down rational (straight-line) A. Thus, BC is a fifth apotome [Def. 10.15].†

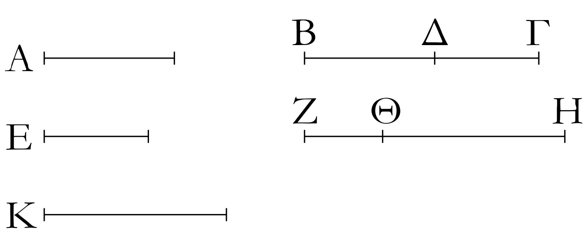
Thus, the fifth apotome BC has been found. (Which is) the very thing it was required to show.

† See footnote to Prop. 10.52.

ϛ´.

Εὑρεῖν τὴν ἕκτην ἀποτομήν.

Ἐκκείσθω ῥητὴ ἡ Α καὶ τρεῖς ἀριθμοὶ οἱ Ε, ΒΓ, ΓΔ λόγον μὴ ἔχοντες πρὸς ἀλλήλους, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἔτι δὲ καὶ ὁ ΓΒ πρὸς τὸν ΒΔ λόγον μὴ ἐχετώ, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· καὶ πεποιήσθω ὡς μὲν ὁ Ε πρὸς τὸν ΒΓ, οὕτως τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς ΖΗ, ὡς δὲ ὁ ΒΓ πρὸς τὸν ΓΔ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ.

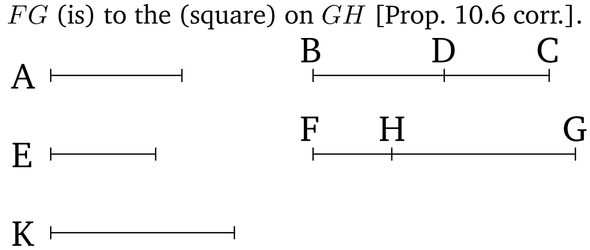


Ἐπεὶ οὖν ἐστιν ὡς ὁ Ε πρὸς τὸν ΒΓ, οὕτως τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς ΖΗ, σύμμετρον ἄρα τὸ ἀπὸ τῆς Α τῷ ἀπὸ τῆς ΖΗ. ῥητὸν δὲ τὸ ἀπὸ τῆς Α· ῥητὸν ἄρα καὶ τὸ ἀπὸ τῆς ΖΗ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΖΗ. καὶ ἐπεὶ ὁ Ε πρὸς τὸν ΒΓ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδ᾽ ἄρα τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς ΖΗ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ Α τῇ ΖΗ μήκει. πάλιν, ἐπεί ἐστιν ὡς ὁ ΒΓ πρὸς τὸν ΓΔ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ, σύμμετρον ἄρα τὸ ἀπὸ τῆς ΖΗ τῷ ἀπὸ τῆς ΗΘ. ῥητὸν

Proposition 90

To find a sixth apotome.

Let the rational (straight-line) A, and the three numbers E, BC, and CD, not having to one another the ratio which (some) square number (has) to (some) square number, be laid down. Furthermore, let CB also not have to BD the ratio which (some) square number (has) to (some) square number. And let it have been contrived that as E (is) to BC, so the (square) on A (is) to the (square) on FG, and as BC (is) to CD, so the (square) on FG (is) to the (square) on GH [Prop. 10.6 corr.].



Therefore, since as E is to BC, so the (square) on A (is) to the (square) on FG, the (square) on A (is) thus commensurable with the (square) on FG [Prop. 10.6]. And the (square) on A (is) rational. Thus, the (square) on FG (is) also rational. Thus, FG is also a rational (straight-line). And since E does not have to BC the ratio which (some) square number (has) to (some) square number, the (square) on A thus does not have to the (square) on FG the ratio which (some) square number (has) to (some) square number either. Thus, A is in-δὲ τὸ ἀπὸ τῆς ΖΗ· ῥητὸν ἄρα καὶ τὸ ἀπὸ τῆς ΗΘ· ῥητὴ ἄρα καὶ ἡ ΗΘ. καὶ ἐπεὶ ὁ ΒΓ πρὸς τὸν ΓΔ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν, οὐδ᾽ ἄρα τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΖΗ τῇ ΗΘ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ΖΗ, ΗΘ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἡ ἄρα ΖΘ ἀποτομή ἐστιν. λέγω δή, ὅτι καὶ ἕκτη.

Ἐπεὶ γάρ ἐστιν ὡς μὲν ὁ Ε πρὸς τὸν ΒΓ, οὕτως τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς ΖΗ, ὡς δὲ ὁ ΒΓ πρὸς τὸν ΓΔ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ, δι᾽ ἴσου ἄρα ἐστὶν ὡς ὁ Ε πρὸς τὸν ΓΔ, οὕτως τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς ΗΘ. ὁ δὲ Ε πρὸς τὸν ΓΔ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· οὐδ᾽ ἄρα τὸ ἀπὸ τῆς Α πρὸς τὸ ἀπὸ τῆς ΗΘ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ Α τῇ ΗΘ μήκει· οὐδετέρα ἄρα τῶν ΖΗ, ΗΘ σύμμετρός ἐστι τῇ Α ῥητῇ μήκει. ᾧ οὖν μεῖζόν ἐστι τὸ ἀπὸ τῆς ΖΗ τοῦ ἀπὸ τῆς ΗΘ, ἔστω τὸ ἀπὸ τῆς Κ. ἐπεὶ οὖν ἐστιν ὡς ὁ ΒΓ πρὸς τὸν ΓΔ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς ΗΘ, ἀναστρέψαντι ἄρα ἐστὶν ὡς ὁ ΓΒ πρὸς τὸν ΒΔ, οὕτως τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς Κ. ὁ δὲ ΓΒ πρὸς τὸν ΒΔ λόγον οὐκ ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· οὐδ᾽ ἄρα τὸ ἀπὸ τῆς ΖΗ πρὸς τὸ ἀπὸ τῆς Κ λόγον ἔχει, ὃν τετράγωνος ἀριθμὸς πρὸς τετράγωνον ἀριθμόν· ἀσύμμετρος ἄρα ἐστὶν ἡ ΖΗ τῇ Κ μήκει. καὶ δύναται ἡ ΖΗ τῆς ΗΘ μεῖζον τῷ ἀπὸ τῆς Κ· ἡ ΖΗ ἄρα τῆς ΗΘ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ μήκει. καὶ οὐδετέρα τῶν ΖΗ, ΗΘ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ μήκει τῇ Α. ἡ ἄρα ΖΘ ἀποτομή ἐστιν ἕκτη.

Εὕρηται ἄρα ἡ ἕκτη ἀποτομὴ ἡ ΖΘ· ὅπερ ἔδει δεῖξαι.

commensurable in length with FG [Prop. 10.9]. Again, since as BC is to CD, so the (square) on FG (is) to the (square) on GH, the (square) on FG (is) thus commensurable with the (square) on GH [Prop. 10.6]. And the (square) on FG (is) rational. Thus, the (square) on GH (is) also rational. Thus, GH (is) also rational. And since BC does not have to CD the ratio which (some) square number (has) to (some) square number, the (square) on FG thus does not have to the (square) on GH the ratio which (some) square (number) has to (some) square (number) either. Thus, FG is incommensurable in length with GH [Prop. 10.9]. And both are rational (straight-lines). Thus, FG and GH are rational (straight-lines which are) commensurable in square only. Thus, FH is an apotome [Prop. 10.73]. So, I say that (it is) also a sixth (apotome).

For since as E is to BC, so the (square) on A (is) to the (square) on FG, and as BC (is) to CD, so the (square) on FG (is) to the (square) on GH, thus, via equality, as E is to CD, so the (square) on A (is) to the (square) on GH [Prop. 5.22]. And E does not have to CD the ratio which (some) square number (has) to (some) square number. Thus, the (square) on A does not have to the (square) GH the ratio which (some) square number (has) to (some) square number either. A is thus incommensurable in length with GH [Prop. 10.9]. Thus, neither of FG and GH is commensurable in length with the rational (straight-line) A. Therefore, let the (square) on K be that (area) by which the (square) on FG is greater than the (square) on GH [Prop. 10.13 lem.]. Therefore, since as BC is to CD, so the (square) on FG (is) to the (square) on GH, thus, via conversion, as CB is to BD, so the (square) on FG (is) to the (square) on K [Prop. 5.19 corr.]. And CB does not have to BD the ratio which (some) square number (has) to (some) square number. Thus, the (square) on FG does not have to the (square) on K the ratio which (some) square number (has) to (some) square number either. FG is thus incommensurable in length with K [Prop. 10.9]. And the square on FG is greater than (the square on) GH by the (square) on K. Thus, the square on FG is greater than (the square on) GH by the (square) on (some straight-line) incommensurable in length with (FG). And neither of FG and GH is commensurable in length with the (previously) laid down rational (straight-line) A. Thus, FH is a sixth apotome [Def. 10.16].

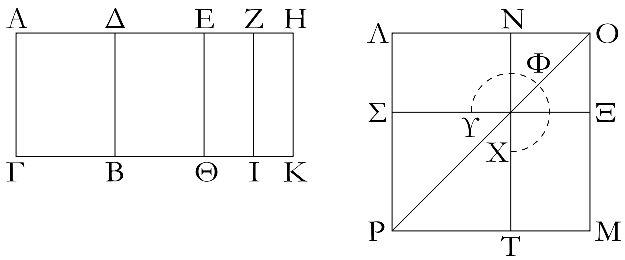
Thus, the sixth apotome FH has been found. (Which is) the very thing it was required to show.

† See footnote to Prop. 10.53.

ϟαʹ.

Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ ἀποτομῆς πρώτης, ἡ τὸ χωρίον δυναμένη ἀπορομή ἐστιν.

Περιεχέσθω γὰρ χωρίον τὸ ΑΒ ὑπὸ ῥητῆς τῆς ΑΓ καὶ ἀποτομῆς πρώτης τῆς ΑΔ· λέγω, ὅτι ἡ τὸ ΑΒ χωρίον δυναμένη ἀποτομή ἐστιν.



Ἐπεὶ γὰρ ἀποτομή ἐστι πρώτη ἡ ΑΔ, ἔστω αὐτῇ προσαρμόζουσα ἡ ΔΗ· αἱ ΑΗ, ΗΔ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. καὶ ὅλη ἡ ΑΗ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ ΑΓ, καὶ ἡ ΑΗ τῆς ΗΔ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει· ἐὰν ἄρα τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΔΗ ἴσον παρὰ τὴν ΑΗ παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ, εἰς σύμμετρα αὐτὴν διαιρεῖ. τετμήσθω ἡ ΔΗ δίχα κατὰ τὸ Ε, καὶ τῷ ἀπὸ τῆς ΕΗ ἴσον παρὰ τὴν ΑΗ παραβεβλήσθω ἐλλεῖπον εἴδει τετραγώνῳ, καὶ ἔστω τὸ ὑπὸ τῶν ΑΖ, ΖΗ· σύμμετρος ἄρα ἐστὶν ἡ ΑΖ τῇ ΖΗ. καὶ διὰ τῶν Ε, Ζ, Η σημείων τῇ ΑΓ παράλληλοι ἤχθωσαν αἱ ΕΘ, ΖΙ, ΗΚ.

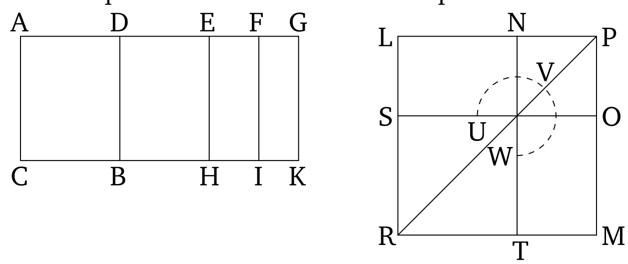
Καὶ ἐπεὶ σύμμετρός ἐστιν ἡ ΑΖ τῇ ΖΗ μήκει, καὶ ἡ ΑΗ ἄρα ἑκατέρᾳ τῶν ΑΖ, ΖΗ σύμμετρός ἐστι μήκει. ἀλλὰ ἡ ΑΗ σύμμετρός ἐστι τῇ ΑΓ· καὶ ἑκατέρα ἄρα τῶν ΑΖ, ΖΗ σύμμετρός ἐστι τῇ ΑΓ μήκει. καί ἐστι ῥητὴ ἡ ΑΓ· ῥητὴ ἄρα καὶ ἑκατέρα τῶν ΑΖ, ΖΗ· ὥστε καὶ ἑκάτερον τῶν ΑΙ, ΖΚ ῥητόν ἐστιν. καὶ ἐπεὶ σύμμετρός ἐστιν ἡ ΔΕ τῇ ΕΗ μήκει, καὶ ἡ ΔΗ ἄρα ἑκατέρᾳ τῶν ΔΕ, ΕΗ σύμμετρός ἐστι μήκει. ῥητὴ δὲ ἡ ΔΗ καὶ ἀσύμμετρος τῇ ΑΓ μήκει· ῥητὴ ἄρα καὶ ἑκατέρα τῶν ΔΕ, ΕΗ καὶ ἀσύμμετρος τῇ ΑΓ μήκει· ἑκάτερον ἄρα τῶν ΔΘ, ΕΚ μέσον ἐστίν.

Κείσθω δὴ τῷ μὲν ΑΙ ἴσον τετράγωνον τὸ ΛΜ, τῷ δὲ ΖΚ ἴσον τετράγωνον ἀφῃρήσθω κοινὴν γωνίαν ἔχον αὐτῷ τὴν ὑπὸ ΛΟΜ τὸ ΝΞ· περὶ τὴν αὐτὴν ἄρα διάμετρόν ἐστι τὰ ΛΜ, ΝΞ τετράγωνα. ἔστω αὐτῶν διάμετρος ἡ ΟΡ, καὶ καταγεγράφθω τὸ σχῆμα. ἐπεὶ οὖν ἴσον ἐστὶ τὸ ὑπὸ τῶν ΑΖ, ΖΗ περιεχόμενον ὀρθογώνιον τῷ ἀπὸ τῆς ΕΗ τετραγώνῳ, ἔστιν ἄρα ὡς ἡ ΑΖ πρὸς τὴν ΕΗ, οὕτως ἡ ΕΗ πρὸς τὴν ΖΗ. ἀλλ᾽ ὡς μὲν ἡ ΑΖ πρὸς τὴν ΕΗ, οὕτως τὸ ΑΙ πρὸς τὸ ΕΚ, ὡς δὲ ἡ ΕΗ πρὸς τὴν ΖΗ, οὕτως ἐστὶ τὸ ΕΚ πρὸς τὸ ΚΖ· τῶν ἄρα ΑΙ, ΚΖ μέσον ἀνάλογόν ἐστι τὸ ΕΚ. ἔστι δὲ καὶ τῶν ΛΜ, ΝΞ μέσον ἀνάλογον τὸ ΜΝ, ὡς ἐν τοῖς ἔμπροσθεν ἐδείχθη, καί ἐστι τὸ [μὲν] ΑΙ τῷ ΛΜ τετραγώνῳ ἴσον, τὸ δὲ ΚΖ τῷ ΝΞ· καὶ τὸ ΜΝ ἄρα τῷ ΕΚ ἴσον ἐστίν. ἀλλὰ τὸ μὲν ΕΚ τῷ ΔΘ ἐστιν ἴσον, τὸ δὲ ΜΝ τῷ ΛΞ· τὸ ἄρα

Proposition 91

If an area is contained by a rational (straight-line) and a first apotome then the square-root of the area is an apotome.

For let the area AB have been contained by the rational (straight-line) AC and the first apotome AD. I say that the square-root of area AB is an apotome.



For since AD is a first apotome, let DG be its attachment. Thus, AG and DG are rational (straight-lines which are) commensurable in square only [Prop. 10.73]. And the whole, AG, is commensurable (in length) with the (previously) laid down rational (straight-line) AC, and the square on AG is greater than (the square on) GD by the (square) on (some straight-line) commensurable in length with (AG) [Def. 10.11]. Thus, if (an area) equal to the fourth part of the (square) on DG is applied to AG, falling short by a square figure, then it divides (AG) into (parts which are) commensurable (in length) [Prop. 10.17]. Let DG have been cut in half at E. And let (an area) equal to the (square) on EG have been applied to AG, falling short by a square figure. And let it be the (rectangle contained) by AF and FG. AF is thus commensurable (in length) with FG. And let EH, FI, and GK have been drawn through points E, F, and G (respectively), parallel to AC.

And since AF is commensurable in length with FG, AG is thus also commensurable in length with each of AF and FG [Prop. 10.15]. But AG is commensurable (in length) with AC. Thus, each of AF and FG is also commensurable in length with AC [Prop. 10.12]. And AC is a rational (straight-line). Thus, AF and FG (are) each also rational (straight-lines). Hence, AI and FK are also each rational (areas) [Prop. 10.19]. And since DE is commensurable in length with EG, DG is thus also commensurable in length with each of DE and EG [Prop. 10.15]. And DG (is) rational, and incommensurable in length with AC. DE and EG (are) thus each rational, and incommensurable in length with AC [Prop. 10.13]. Thus, DH and EK are each medial (areas) [Prop. 10.21].

So let the square LM, equal to AI, be laid down. And let the square NO, equal to FK, have been sub-

ΔΚ ἴσον ἐστὶ τῷ ΥΦΧ γνώμονι καὶ τῷ ΝΞ. ἔστι δὲ καὶ τὸ ΑΚ ἴσον τοῖς ΛΜ, ΝΞ τετραγώνοις· λοιπὸν ἄρα τὸ ΑΒ ἴσον ἐστὶ τῷ ΣΤ. τὸ δὲ ΣΤ τὸ ἀπὸ τῆς ΛΝ ἐστι τετράγωνον· τὸ ἄρα ἀπὸ τῆς ΛΝ τετράγωνον ἴσον ἐστὶ τῷ ΑΒ· ἡ ΛΝ ἄρα δύναται τὸ ΑΒ. λέγω δή, ὅτι ἡ ΛΝ ἀποτομή ἐστιν.

Ἐπεὶ γὰρ ῥητόν ἐστιν ἑκάτερον τῶν ΑΙ, ΖΚ, καί ἐστιν ἴσον τοῖς ΛΜ, ΝΞ, καὶ ἑκάτερον ἄρα τῶν ΛΜ, ΝΞ ῥητόν ἐστιν, τουτέστι τὸ ἀπὸ ἑκατέρας τῶν ΛΟ, ΟΝ· καὶ ἑκατέρα ἄρα τῶν ΛΟ, ΟΝ ῥητή ἐστιν. πάλιν, ἐπεὶ μέσον ἐστὶ τὸ ΔΘ καί ἐστιν ἴσον τῷ ΛΞ, μέσον ἄρα ἐστὶ καὶ τὸ ΛΞ. ἐπεὶ οὖν τὸ μὲν ΛΞ μέσον ἐστίν, τὸ δὲ ΝΞ ῥητόν, ἀσύμμετρον ἄρα ἐστὶ τὸ ΛΞ τῷ ΝΞ· ὡς δὲ τὸ ΛΞ πρὸς τὸ ΝΞ, οὕτως ἐστὶν ἡ ΛΟ πρὸς τὴν ΟΝ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΛΟ τῇ ΟΝ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ΛΟ, ΟΝ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΛΝ. καὶ δύναται τὸ ΑΒ χωρίον· ἡ ἄρα τὸ ΑΒ χωρίον δυναμένη ἀποτομή ἐστιν.

Ἐὰν ἄρα χωρίον περιέχηται ὑπὸ ῥητῆς καὶ τὰ ἑξῆς.

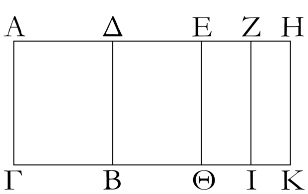
tracted (from LM), having with it the common angle LPM. Thus, the squares LM and NO are about the same diagonal [Prop. 6.26]. Let PR be their (common) diagonal, and let the (rest of the) figure have been drawn. Therefore, since the rectangle contained by AF and FG is equal to the square EG, thus as AF is to EG, so EG (is) to FG [Prop. 6.17]. But, as AF (is) to EG, so AI (is) to EK, and as EG (is) to FG, so EK is to KF [Prop. 6.1]. Thus, EK is the mean proportional to AI and KF [Prop. 5.11]. And MN is also the mean proportional to LM and NO, as shown before [Prop. 10.53 lem.]. And AI is equal to the square LM, and KF to NO. Thus, MN is also equal to EK. But, EK is equal to DH, and MN to LO [Prop. 1.43]. Thus, DK is equal to the gnomon UVW and NO. And AK is also equal to (the sum of) the squares LM and NO. Thus, the remainder AB is equal to ST. And ST is the square on LN. Thus, the square on LN is equal to AB. Thus, LN is the square-root of AB. So, I say that LN is an apotome.

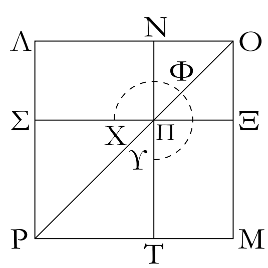
For since AI and FK are each rational (areas), and are equal to LM and NO (respectively), thus LM and NO—that is to say, the (squares) on each of LP and PN (respectively)—are also each rational (areas). Thus, LP and PN are also each rational (straight-lines). Again, since DH is a medial (area), and is equal to LO, LO is thus also a medial (area). Therefore, since LO is medial, and NO rational, LO is thus incommensurable with NO. And as LO (is) to NO, so LP is to PN [Prop. 6.1]. LP is thus incommensurable in length with PN [Prop. 10.11]. And they are both rational (straight-lines). Thus, LP and PN are rational (straight-lines which are) commensurable in square only. Thus, LN is an apotome [Prop. 10.73]. And it is the square-root of area AB. Thus, the square-root of area AB is an apotome.

Thus, if an area is contained by a rational (straight-line), and so on ....

ϙβʹ.

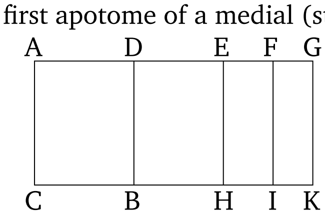
Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ ἀποτομῆς δευτέρας, ἡ τὸ χωρίον δυναμένη μέσης ἀποτομή ἐστι πρώτη.

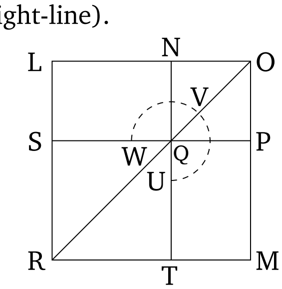




Proposition 92

If an area is contained by a rational (straight-line) and a second apotome then the square-root of the area is a first apotome of a medial (straight-line).





Χωρίον γὰρ τὸ ΑΒ περιεχέσθω ὑπὸ ῥητῆς τῆς ΑΓ καὶ ἀποτομῆς δευτέρας τῆς ΑΔ· λέγω, ὅτι ἡ τὸ ΑΒ χωρίον δυναμένη μέσης ἀποτομή ἐστι πρώτη.

Ἔστω γὰρ τῇ ΑΔ προσαρμόζουσα ἡ ΔΗ· αἱ ἄρα ΑΗ, ΗΔ ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ ἡ προσαρμόζουσα ἡ ΔΗ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ ΑΓ, ἡ δὲ ὅλη ἡ ΑΗ τῆς προσαρμοζούσης τῆς ΗΔ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει. ἐπεὶ οὖν ἡ ΑΗ τῆς ΗΔ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, ἐὰν ἄρα τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΗΔ ἴσον παρὰ τὴν ΑΗ παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ, εἰς σύμμετρα αὐτὴν διαιρεῖ. τετμήσθω οὖν ἡ ΔΗ δίχα κατὰ τὸ Ε· καὶ τῷ ἀπὸ τῆς ΕΗ ἴσον παρὰ τὴν ΑΗ παραβεβλήσθω ἐλλεῖπον εἴδει τετραγώνῳ, καὶ ἔστω τὸ ὑπὸ τῶν ΑΖ, ΖΗ· σύμμετρος ἄρα ἐστὶν ἡ ΑΖ τῇ ΖΗ μήκει. καὶ ἡ ΑΗ ἄρα ἑκατέρᾳ τῶν ΑΖ, ΖΗ σύμμετρός ἐστι μήκει. ῥητὴ δὲ ἡ ΑΗ καὶ ἀσύμμετρος τῇ ΑΓ μήκει· καὶ ἑκατέρα ἄρα τῶν ΑΖ, ΖΗ ῥητή ἐστι καὶ ἀσύμμετρος τῇ ΑΓ μήκει· ἑκάτερον ἄρα τῶν ΑΙ, ΖΚ μέσον ἐστίν. πάλιν, ἐπεὶ σύμμετρός ἐστιν ἡ ΔΕ τῇ ΕΗ, καὶ ἡ ΔΗ ἄρα ἑκατέρᾳ τῶν ΔΕ, ΕΗ σύμμετρός ἐστιν. ἀλλ᾽ ἡ ΔΗ σύμμετρός ἐστι τῇ ΑΓ μήκει [ῥητὴ ἄρα καὶ ἑκατέρα τῶν ΔΕ, ΕΗ καὶ σύμμετρος τῇ ΑΓ μήκει]. ἑκάτερον ἄρα τῶν ΔΘ, ΕΚ ῥητόν ἐστιν.

Συνεστάτω οὖν τῷ μὲν ΑΙ ἴσον τετράγωνον τὸ ΛΜ, τῷ δὲ ΖΚ ἴσον ἀφῃρήσθω τὸ ΝΞ περὶ τὴν αὐτὴν γωνίαν ὂν τῷ ΛΜ τὴν ὑπὸ τῶν ΛΟΜ· περὶ τὴν αὐτὴν ἄρα ἐστὶ διάμετρον τὰ ΛΜ, ΝΞ τετράγωνα. ἔστω αὐτῶν διάμετρος ἡ ΟΡ, καὶ καταγεγράφθω τὸ σχῆμα. ἐπεὶ οὖν τὰ ΑΙ, ΖΚ μέσα ἐστὶ καί ἐστιν ἴσα τοῖς ἀπὸ τῶν ΛΟ, ΟΝ, καὶ τὰ ἀπὸ τῶν ΛΟ, ΟΝ [ἄρα] μέσα ἐστίν· καὶ αἱ ΛΟ, ΟΝ ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι. καὶ ἐπεὶ τὸ ὑπὸ τῶν ΑΖ, ΖΗ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΕΗ, ἔστιν ἄρα ὡς ἡ ΑΖ πρὸς τὴν ΕΗ, οὕτως ἡ ΕΗ πρὸς τὴν ΖΗ· ἀλλ᾽ ὡς μὲν ἡ ΑΖ πρὸς τὴν ΕΗ, οὕτως τὸ ΑΙ πρὸς τὸ ΕΚ· ὡς δὲ ἡ ΕΗ πρὸς τὴν ΖΗ, οὕτως [ἐστὶ] τὸ ΕΚ πρὸς τὸ ΖΚ· τῶν ἄρα ΑΙ, ΖΚ μέσον ἀνάλογόν ἐστι τὸ ΕΚ. ἔστι δὲ καὶ τῶν ΛΜ, ΝΞ τετραγώνων μέσον ἀνάλογον τὸ ΜΝ· καί ἐστιν ἴσον τὸ μὲν ΑΙ τῷ ΛΜ, τὸ δὲ ΖΚ τῷ ΝΞ· καὶ τὸ ΜΝ ἄρα ἴσον ἐστὶ τῷ ΕΚ. ἀλλὰ τῷ μὲν ΕΚ ἴσον [ἐστὶ] τὸ ΔΘ, τῷ δὲ ΜΝ ἴσον τὸ ΛΞ· ὅλον ἄρα τὸ ΔΚ ἴσον ἐστὶ τῷ ΥΦΧ γνώμονι καὶ τῷ ΝΞ. ἐπεὶ οὖν ὅλον τὸ ΑΚ ἴσον ἐστὶ τοῖς ΛΜ, ΝΞ, ὧν τὸ ΔΚ ἴσον ἐστὶ τῷ ΥΦΧ γνώμονι καὶ τῷ ΝΞ, λοιπὸν ἄρα τὸ ΑΒ ἴσον ἐστὶ τῷ ΤΣ. τὸ δὲ ΤΣ ἐστι τὸ ἀπὸ τῆς ΛΝ· τὸ ἀπὸ τῆς ΛΝ ἄρα ἴσον ἐστὶ τῷ ΑΒ χωρίῳ· ἡ ΛΝ ἄρα δύναται τὸ ΑΒ χωρίον. λέγω [δή], ὅτι ἡ ΛΝ μέσης ἀποτομή ἐστι πρώτη.

Ἐπεὶ γὰρ ῥητόν ἐστι τὸ ΕΚ καί ἐστιν ἴσον τῷ ΛΞ, ῥητὸν ἄρα ἐστὶ τὸ ΛΞ, τουτέστι τὸ ὑπὸ τῶν ΛΟ, ΟΝ. μέσον δὲ ἐδείχθη τὸ ΝΞ· ἀσύμμετρον ἄρα ἐστὶ τὸ ΛΞ τῷ ΝΞ· ὡς δὲ τὸ ΛΞ πρὸς τὸ ΝΞ, οὕτως ἐστὶν ἡ ΛΟ πρὸς ΟΝ· αἱ ΛΟ, ΟΝ ἄρα ἀσύμμετροί εἰσι μήκει. αἱ ἄρα ΛΟ, ΟΝ μέσαι εἰσὶ δυνάμει μόνον σύμμετροι ῥητὸν περιέχουσαι· ἡ ΛΝ ἄρα

For let the area AB have been contained by the rational (straight-line) AC and the second apotome AD. I say that the square-root of area AB is the first apotome of a medial (straight-line).

For let DG be an attachment to AD. Thus, AG and GD are rational (straight-lines which are) commensurable in square only [Prop. 10.73], and the attachment DG is commensurable (in length) with the (previously) laid down rational (straight-line) AC, and the square on the whole, AG, is greater than (the square on) the attachment, GD, by the (square) on (some straight-line) commensurable in length with (AG) [Def. 10.12]. Therefore, since the square on AG is greater than (the square on) GD by the (square) on (some straight-line) commensurable (in length) with (AG), thus if (an area) equal to the fourth part of the (square) on GD is applied to AG, falling short by a square figure, then it divides (AG) into (parts which are) commensurable (in length) [Prop. 10.17]. Therefore, let DG have been cut in half at E. And let (an area) equal to the (square) on EG have been applied to AG, falling short by a square figure. And let it be the (rectangle contained) by AF and FG. Thus, AF is commensurable in length with FG. AG is thus also commensurable in length with each of AF and FG [Prop. 10.15]. And AG (is) a rational (straight-line), and incommensurable in length with AC. AF and FG are thus also each rational (straight-lines), and incommensurable in length with AC [Prop. 10.13]. Thus, AI and FK are each medial (areas) [Prop. 10.21]. Again, since DE is commensurable (in length) with EG, thus DG is also commensurable (in length) with each of DE and EG [Prop. 10.15]. But, DG is commensurable in length with AC [thus, DE and EG are also each rational, and commensurable in length with AC]. Thus, DH and EK are each rational (areas) [Prop. 10.19].

Therefore, let the square LM, equal to AI, have been constructed. And let NO, equal to FK, which is about the same angle LPM as LM, have been subtracted (from LM). Thus, the squares LM and NO are about the same diagonal [Prop. 6.26]. Let PR be their (common) diagonal, and let the (rest of the) figure have been drawn. Therefore, since AI and FK are medial (areas), and are equal to the (squares) on LP and PN (respectively), [thus] the (squares) on LP and PN are also medial. Thus, LP and PN are also medial (straight-lines which are) commensurable in square only.† And since the (rectangle contained) by AF and FG is equal to the (square) on EG, thus as AF is to EG, so EG (is) to FG [Prop. 10.17]. But, as AF (is) to EG, so AI (is) to EK. And as EG (is) to FG, so EK [is] to FK [Prop. 6.1]. Thus, EK is the mean proportional to AI

μέσης ἀποτομή ἐστι πρώτη· καὶ δύναται τὸ ΑΒ χωρίον.

Ἡ ἄρα τὸ ΑΒ χωρίον δυναμένη μέσης ἀποτομή ἐστι πρώτη· ὅπερ ἔδει δεῖξαι.

and FK [Prop. 5.11]. And MN is also the mean proportional to the squares LM and NO [Prop. 10.53 lem.]. And AI is equal to LM, and FK to NO. Thus, MN is also equal to EK. But, DH [is] equal to EK, and LO equal to MN [Prop. 1.43]. Thus, the whole (of) DK is equal to the gnomon UVW and NO. Therefore, since the whole (of) AK is equal to LM and NO, of which DK is equal to the gnomon UVW and NO, the remainder AB is thus equal to TS. And TS is the (square) on LN. Thus, the (square) on LN is equal to the area AB. LN is thus the square-root of area AB. [So], I say that LN is the first apotome of a medial (straight-line).

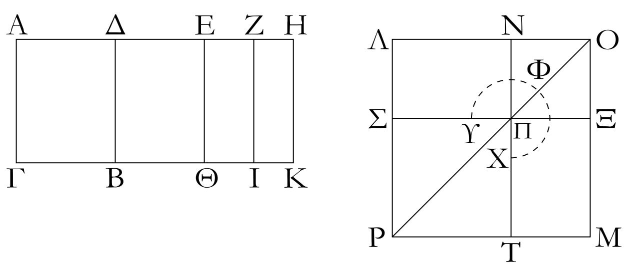
For since EK is a rational (area), and is equal to LO, LO—that is to say, the (rectangle contained) by LP and PN—is thus a rational (area). And NO was shown (to be) a medial (area). Thus, LO is incommensurable with NO. And as LO (is) to NO, so LP is to PN [Prop. 6.1]. Thus, LP and PN are incommensurable in length [Prop. 10.11]. LP and PN are thus medial (straight-lines which are) commensurable in square only, and which contain a rational (area). Thus, LN is the first apotome of a medial (straight-line) [Prop. 10.74]. And it is the square-root of area AB.

Thus, the square root of area AB is the first apotome of a medial (straight-line). (Which is) the very thing it was required to show.

† There is an error in the argument here. It should just say that LP and PN are commensurable in square, rather than in square only, since LP and PN are only shown to be incommensurable in length later on.

ϟγʹ.

Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ ἀποτομῆς τρίτης, ἡ τὸ χωρίον δυναμένη μέσης ἀποτομή ἐστι δευτέρα.

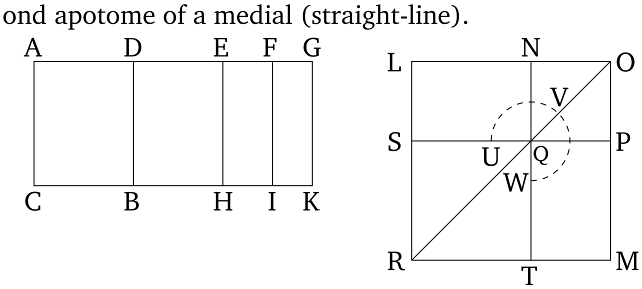


Χωρίον γὰρ τὸ ΑΒ περιεχέσθω ὑπὸ ῥητῆς τῆς ΑΓ καὶ ἀποτομῆς τρίτης τῆς ΑΔ· λέγω, ὅτι ἡ τὸ ΑΒ χωρίον δυναμένη μέσης ἀποτομή ἐστι δευτέρα.

Ἔστω γὰρ τῇ ΑΔ προσαρμόζουσα ἡ ΔΗ· αἱ ΑΗ, ΗΔ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ οὐδετέρα τῶν ΑΗ, ΗΔ σύμμετρός ἐστι μήκει τῇ ἐκκειμένῃ ῥητῇ τῇ ΑΓ, ἡ δὲ ὅλη ἡ ΑΗ τῆς προσαρμοζούσης τῆς ΔΗ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ. ἐπεὶ οὖν ἡ ΑΗ τῆς ΗΔ μεῖζον

Proposition 93

If an area is contained by a rational (straight-line) and a third apotome then the square-root of the area is a second apotome of a medial (straight-line).



For let the area AB have been contained by the rational (straight-line) AC and the third apotome AD. I say that the square-root of area AB is the second apotome of a medial (straight-line).

For let DG be an attachment to AD. Thus, AG and GD are rational (straight-lines which are) commensurable in square only [Prop. 10.73], and neither of AG and GD is commensurable in length with the (previδύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, ἐὰν ἄρα τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΔΗ ἴσον παρὰ τὴν ΑΗ παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ, εἰς σύμμετρα αὐτὴν διελεῖ. τετμήσθω οὖν ἡ ΔΗ δίχα κατὰ τὸ Ε, καὶ τῷ ἀπὸ τῆς ΕΗ ἴσον παρὰ τὴν ΑΗ παραβεβλήσθω ἐλλεῖπον εἴδει τετραγώνῳ, καὶ ἔστω τὸ ὑπὸ τῶν ΑΖ, ΖΗ. καὶ ἤχθωσαν διὰ τῶν Ε, Ζ, Η σημείων τῇ ΑΓ παράλληλοι αἱ ΕΘ, ΖΙ, ΗΚ· σύμμετροι ἄρα εἰσὶν αἱ ΑΖ, ΖΗ· σύμμετρον ἄρα καὶ τὸ ΑΙ τῷ ΖΚ. καὶ ἐπεὶ αἱ ΑΖ, ΖΗ σύμμετροί εἰσι μήκει, καὶ ἡ ΑΗ ἄρα ἑκατέρᾳ τῶν ΑΖ, ΖΗ σύμμετρός ἐστι μήκει. ῥητὴ δὲ ἡ ΑΗ καὶ ἀσύμμετρος τῇ ΑΓ μήκει· ὥστε καὶ αἱ ΑΖ, ΖΗ. ἑκάτερον ἄρα τῶν ΑΙ, ΖΚ μέσον ἐστίν. πάλιν, ἐπεὶ σύμμετρός ἐστιν ἡ ΔΕ τῇ ΕΗ μήκει, καὶ ἡ ΔΗ ἄρα ἑκατέρᾳ τῶν ΔΕ, ΕΗ σύμμετρός ἐστι μήκει. ῥητὴ δὲ ἡ ΗΔ καὶ ἀσύμμετρος τῇ ΑΓ μήκει· ῥητὴ ἄρα καὶ ἑκατέρα τῶν ΔΕ, ΕΗ καὶ ἀσύμμετρος τῇ ΑΓ μήκει· ἑκάτερον ἄρα τῶν ΔΘ, ΕΚ μέσον ἐστίν. καὶ ἐπεὶ αἱ ΑΗ, ΗΔ δυνάμει μόνον σύμμετροί εἰσιν, ἀσύμμετρος ἄρα ἐστὶ μήκει ἡ ΑΗ τῇ ΗΔ. ἀλλ᾽ ἡ μὲν ΑΗ τῇ ΑΖ σύμμετρός ἐστι μήκει ἡ δὲ ΔΗ τῇ ΕΗ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΑΖ τῇ ΕΗ μήκει. ὡς δὲ ἡ ΑΖ πρὸς τὴν ΕΗ, οὕτως ἐστὶ τὸ ΑΙ πρὸς τὸ ΕΚ· ἀσύμμετρον ἄρα ἐστὶ τὸ ΑΙ τῷ ΕΚ.

Συνεστάτω οὖν τῷ μὲν ΑΙ ἴσον τετράγωνον τὸ ΛΜ, τῷ δὲ ΖΚ ἴσον ἀφῃρήσθω τὸ ΝΞ περὶ τὴν αὐτὴν γωνίαν ὂν τῷ ΛΜ· περὶ τὴν αὐτὴν ἄρα διάμετρόν ἐστι τὰ ΛΜ, ΝΞ. ἔστω αὐτῶν διάμετρος ἡ ΟΡ, καὶ καταγεγράφθω τὸ σχῆμα. ἐπεὶ οὖν τὸ ὑπὸ τῶν ΑΖ, ΖΗ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΕΗ, ἔστιν ἄρα ὡς ἡ ΑΖ πρὸς τὴν ΕΗ, οὕτως ἡ ΕΗ πρὸς τὴν ΖΗ. ἀλλ᾽ ὡς μὲν ἡ ΑΖ πρὸς τὴν ΕΗ, οὕτως ἐστὶ τὸ ΑΙ πρὸς τὸ ΕΚ· ὡς δὲ ἡ ΕΗ πρὸς τὴν ΖΗ, οὕτως ἐστὶ τὸ ΕΚ πρὸς τὸ ΖΚ· καὶ ὡς ἄρα τὸ ΑΙ πρὸς τὸ ΕΚ, οὕτως τὸ ΕΚ πρὸς τὸ ΖΚ· τῶν ἄρα ΑΙ, ΖΚ μέσον ἀνάλογόν ἐστι τὸ ΕΚ. ἔστι δὲ καὶ τῶν ΛΜ, ΝΞ τετραγώνων μέσον ἀνάλογον τὸ ΜΝ· καί ἐστιν ἴσον τὸ μὲν ΑΙ τῷ ΛΜ, τὸ δὲ ΖΚ τῷ ΝΞ· καὶ τὸ ΕΚ ἄρα ἴσον ἐστὶ τῷ ΜΝ. ἀλλὰ τὸ μὲν ΜΝ ἴσον ἐστὶ τῷ ΛΞ, τὸ δὲ ΕΚ ἴσον [ἐστὶ] τῷ ΔΘ· καὶ ὅλον ἄρα τὸ ΔΚ ἴσον ἐστὶ τῷ ΥΦΧ γνώμονι καὶ τῷ ΝΞ. ἔστι δὲ καὶ τὸ ΑΚ ἴσον τοῖς ΛΜ, ΝΞ· λοιπὸν ἄρα τὸ ΑΒ ἴσον ἐστὶ τῷ ΣΤ, τουτέστι τῷ ἀπὸ τῆς ΛΝ τετραγώνῳ· ἡ ΛΝ ἄρα δύναται τὸ ΑΒ χωρίον. λέγω, ὅτι ἡ ΛΝ μέσης ἀποτομή ἐστι δευτέρα.

Ἐπεὶ γὰρ μέσα ἐδείχθη τὰ ΑΙ, ΖΚ καί ἐστιν ἴσα τοῖς ἀπὸ τῶν ΛΟ, ΟΝ, μέσον ἄρα καὶ ἑκάτερον τῶν ἀπὸ τῶν ΛΟ, ΟΝ· μέση ἄρα ἑκατέρα τῶν ΛΟ, ΟΝ. καὶ ἐπεὶ σύμμετρόν ἐστι τὸ ΑΙ τῷ ΖΚ, σύμμετρον ἄρα καὶ τὸ ἀπὸ τῆς ΛΟ τῷ ἀπὸ τῆς ΟΝ. πάλιν, ἐπεὶ ἀσύμμετρον ἐδείχθη τὸ ΑΙ τῷ ΕΚ, ἀσύμμετρον ἄρα ἐστὶ καὶ τὸ ΛΜ τῷ ΜΝ, τουτέστι τὸ ἀπὸ τῆς ΛΟ τῷ ὑπὸ τῶν ΛΟ, ΟΝ· ὥστε καὶ ἡ ΛΟ ἀσύμμετρός ἐστι μήκει τῇ ΟΝ· αἱ ΛΟ, ΟΝ ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι. λέγω δή, ὅτι καὶ μέσον περιέχουσιν.

Ἐπεὶ γὰρ μέσον ἐδείχθη τὸ ΕΚ καί ἐστιν ἴσον τῷ ὑπὸ τῶν ΛΟ, ΟΝ, μέσον ἄρα ἐστὶ καὶ τὸ ὑπὸ τῶν ΛΟ, ΟΝ· ὥστε αἱ ΛΟ, ΟΝ μέσαι εἰσὶ δυνάμει μόνον σύμμετροι μέσον

ously) laid down rational (straight-line) AC, and the square on the whole, AG, is greater than (the square on) the attachment, DG, by the (square) on (some straight-line) commensurable (in length) with (AG) [Def. 10.13]. Therefore, since the square on AG is greater than (the square on) GD by the (square) on (some straight-line) commensurable (in length) with (AG), thus if (an area) equal to the fourth part of the square on DG is applied to AG, falling short by a square figure, then it divides (AG) into (parts which are) commensurable (in length) [Prop. 10.17]. Therefore, let DG have been cut in half at E. And let (an area) equal to the (square) on EG have been applied to AG, falling short by a square figure. And let it be the (rectangle contained) by AF and FG. And let EH, FI, and GK have been drawn through points E, F, and G (respectively), parallel to AC. Thus, AF and FG are commensurable (in length). AI (is) thus also commensurable with FK [Props. 6.1, 10.11]. And since AF and FG are commensurable in length, AG is thus also commensurable in length with each of AF and FG [Prop. 10.15]. And AG (is) rational, and incommensurable in length with AC. Hence, AF and FG (are) also (rational, and incommensurable in length with AC) [Prop. 10.13]. Thus, AI and FK are each medial (areas) [Prop. 10.21]. Again, since DE is commensurable in length with EG, DG is also commensurable in length with each of DE and EG [Prop. 10.15]. And GD (is) rational, and incommensurable in length with AC. Thus, DE and EG (are) each also rational, and incommensurable in length with AC [Prop. 10.13]. DH and EK are thus each medial (areas) [Prop. 10.21]. And since AG and GD are commensurable in square only, AG is thus incommensurable in length with GD. But, AG is commensurable in length with AF, and DG with EG. Thus, AF is incommensurable in length with EG [Prop. 10.13]. And as AF (is) to EG, so AI is to EK [Prop. 6.1]. Thus, AI is incommensurable with EK [Prop. 10.11].

Therefore, let the square LM, equal to AI, have been constructed. And let NO, equal to FK, which is about the same angle as LM, have been subtracted (from LM). Thus, LM and NO are about the same diagonal [Prop. 6.26]. Let PR be their (common) diagonal, and let the (rest of the) figure have been drawn. Therefore, since the (rectangle contained) by AF and FG is equal to the (square) on EG, thus as AF is to EG, so EG (is) to FG [Prop. 6.17]. But, as AF (is) to EG, so AI is to EK [Prop. 6.1]. And as EG (is) to FG, so EK is to FK [Prop. 6.1]. And thus as AI (is) to EK, so EK (is) to FK [Prop. 5.11]. Thus, EK is the mean proportional to AI and FK. And MN is also the mean proportional to the squares LM and NO [Prop. 10.53 lem.]. And AI is περιέχουσαι. ἡ ΛΝ ἄρα μέσης ἀποτομή ἐστι δευτέρα· καὶ δύναται τὸ ΑΒ χωρίον.

Ἡ ἄρα τὸ ΑΒ χωρίον δυναμένη μέσης ἀποτομή ἐστι δευτέρα· ὅπερ ἔδει δεῖξαι.

equal to LM, and FK to NO. Thus, EK is also equal to MN. But, MN is equal to LO, and EK [is] equal to DH [Prop. 1.43]. And thus the whole of DK is equal to the gnomon UVW and NO. And AK (is) also equal to LM and NO. Thus, the remainder AB is equal to ST—that is to say, to the square on LN. Thus, LN is the square-root of area AB. I say that LN is the second apotome of a medial (straight-line).

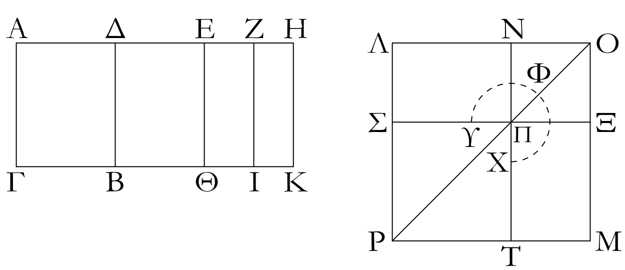
For since AI and FK were shown (to be) medial (areas), and are equal to the (squares) on LP and PN (respectively), the (squares) on each of LP and PN (are) thus also medial. Thus, LP and PN (are) each medial (straight-lines). And since AI is commensurable with FK [Props. 6.1, 10.11], the (square) on LP (is) thus also commensurable with the (square) on PN. Again, since AI was shown (to be) incommensurable with EK, LM is thus also incommensurable with MN—that is to say, the (square) on LP with the (rectangle contained) by LP and PN. Hence, LP is also incommensurable in length with PN [Props. 6.1, 10.11]. Thus, LP and PN are medial (straight-lines which are) commensurable in square only. So, I say that they also contain a medial (area).

For since EK was shown (to be) a medial (area), and is equal to the (rectangle contained) by LP and PN, the (rectangle contained) by LP and PN is thus also medial. Hence, LP and PN are medial (straight-lines which are) commensurable in square only, and which contain a medial (area). Thus, LN is the second apotome of a medial (straight-line) [Prop. 10.75]. And it is the square-root of area AB.

Thus, the square-root of area AB is the second apotome of a medial (straight-line). (Which is) the very thing it was required to show.

ϟδʹ.

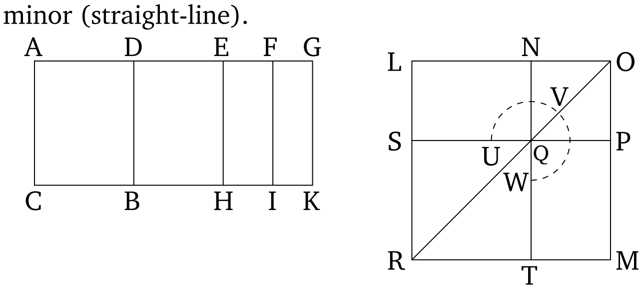
Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ ἀποτομῆς τετάρτης, ἡ τὸ χωρίον δυναμένη ἐλάσσων ἐστίν.



Χωρίον γὰρ τὸ ΑΒ περιεχέσθω ὑπὸ ῥητῆς τῆς ΑΓ καὶ ἀποτομῆς τετάρτης τῆς ΑΔ· λέγω, ὅτι ἡ τὸ ΑΒ χωρίον δυναμένη ἐλάσσων ἐστίν.

Proposition 94

If an area is contained by a rational (straight-line) and a fourth apotome then the square-root of the area is a minor (straight-line).



For let the area AB have been contained by the rational (straight-line) AC and the fourth apotome AD. I say that the square-root of area AB is a minor (straight-

Ἔστω γὰρ τῇ ΑΔ προσαρμόζουσα ἡ ΔΗ· αἱ ἄρα ΑΗ, ΗΔ ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ ἡ ΑΗ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ ΑΓ μήκει, ἡ δὲ ὅλη ἡ ΑΗ τῆς προσαρμοζούσης τῆς ΔΗ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ μήκει. ἐπεὶ οὖν ἡ ΑΗ τῆς ΗΔ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ μήκει, ἐὰν ἄρα τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΔΗ ἴσον παρὰ τὴν ΑΗ παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ, εἰς ἀσύμμετρα αὐτὴν διελεῖ. τετμήσθω οὖν ἡ ΔΗ δίχα κατὰ τὸ Ε, καὶ τῷ ἀπὸ τῆς ΕΗ ἴσον παρὰ τὴν ΑΗ παραβεβλήσθω ἐλλεῖπον εἴδει τετραγώνῳ, καὶ ἔστω τὸ ὑπὸ τῶν ΑΖ, ΖΗ· ἀσύμμετρος ἄρα ἐστὶ μήκει ἡ ΑΖ τῇ ΖΗ. ἤχθωσαν οὖν διὰ τῶν Ε, Ζ, Η παράλληλοι ταῖς ΑΓ, ΒΔ αἱ ΕΘ, ΖΙ, ΗΚ. ἐπεὶ οὖν ῥητή ἐστιν ἡ ΑΗ καὶ σύμμετρος τῇ ΑΓ μήκει, ῥητὸν ἄρα ἐστὶν ὅλον τὸ ΑΚ. πάλιν, ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΔΗ τῇ ΑΓ μήκει, καί εἰσιν ἀμφότεραι ῥηταί, μέσον ἄρα ἐστὶ τὸ ΔΚ. πάλιν, ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΑΖ τῇ ΖΗ μήκει, ἀσύμμετρον ἄρα καὶ τὸ ΑΙ τῷ ΖΚ.

Συνεστάτω οὖν τῷ μὲν ΑΙ ἴσον τετράγωνον τὸ ΛΜ, τῷ δὲ ΖΚ ἴσον ἀφῃρήσθω περὶ τὴν αὐτὴν γωνίαν τὴν ὑπὸ τῶν ΛΟΜ τὸ ΝΞ. περὶ τὴν αὐτὴν ἄρα διάμετόν ἐστι τὰ ΛΜ, ΝΞ τετράγωνα. ἔστω αὐτῶν διάμετος ἡ ΟΡ, καὶ καταγεγράφθω τὸ σχῆμα. ἐπεὶ οὖν τὸ ὑπὸ τῶν ΑΖ, ΖΗ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΕΗ, ἀνάλογον ἄρα ἐστὶν ὡς ἡ ΑΖ πρὸς τὴν ΕΗ, οὕτως ἡ ΕΗ πρὸς τὴν ΖΗ. ἀλλ᾽ ὡς μὲν ἡ ΑΖ πρὸς τὴν ΕΗ, οὕτως ἐστὶ τὸ ΑΙ πρὸς τὸ ΕΚ, ὡς δὲ ἡ ΕΗ πρὸς τὴν ΖΗ, οὕτως ἐστὶ τὸ ΕΚ πρὸς τὸ ΖΚ· τῶν ἄρα ΑΙ, ΖΚ μέσον ἀνάλογόν ἐστι τὸ ΕΚ. ἔστι δὲ καὶ τῶν ΛΜ, ΝΞ τετραγώνων μέσον ἀνάλογον τὸ ΜΝ, καί ἐστιν ἴσον τὸ μὲν ΑΙ τῷ ΛΜ, τὸ δὲ ΖΚ τῷ ΝΞ· καὶ τὸ ΕΚ ἄρα ἴσον ἐστὶ τῷ ΜΝ. ἀλλὰ τῷ μὲν ΕΚ ἴσον ἐστὶ τὸ ΔΘ, τῷ δὲ ΜΝ ἴσον ἐστὶ τὸ ΛΞ· ὅλον ἄρα τὸ ΔΚ ἴσον ἐστὶ τῷ ΥΦΧ γνώμονι καὶ τῷ ΝΞ. ἐπεὶ οὖν ὅλον τὸ ΑΚ ἴσον ἐστὶ τοῖς ΛΜ, ΝΞ τετραγώνοις, ὧν τὸ ΔΚ ἴσον ἐστὶ τῷ ΥΦΧ γνώμονι καὶ τῷ ΝΞ τετραγώνῳ, λοιπὸν ἄρα τὸ ΑΒ ἴσον ἐστὶ τῷ ΣΤ, τουτέστι τῷ ἀπὸ τῆς ΛΝ τετραγώνῳ· ἡ ΛΝ ἄρα δύναται τὸ ΑΒ χωρίον. λέγω, ὅτι ἡ ΛΝ ἄλογός ἐστιν ἡ καλουμένη ἐλάσσων.

Ἐπεὶ γὰρ ῥητόν ἐστι τὸ ΑΚ καί ἐστιν ἴσον τοῖς ἀπὸ τῶν ΛΟ, ΟΝ τετραγώνοις, τὸ ἄρα συγκείμενον ἐκ τῶν ἀπὸ τῶν ΛΟ, ΟΝ ῥητόν ἐστιν. πάλιν, ἐπεὶ τὸ ΔΚ μέσον ἐστίν, καί ἐστιν ἴσον τὸ ΔΚ τῷ δὶς ὑπὸ τῶν ΛΟ, ΟΝ, τὸ ἄρα δὶς ὑπὸ τῶν ΛΟ, ΟΝ μέσον ἐστίν. καὶ ἐπεὶ ἀσύμμετρον ἐδείχθη τὸ ΑΙ τῷ ΖΚ, ἀσύμμετρον ἄρα καὶ τὸ ἀπὸ τῆς ΛΟ τετράγωνον τῷ ἀπὸ τῆς ΟΝ τετραγώνῳ. αἱ ΛΟ, ΟΝ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων ῥητόν, τὸ δὲ δὶς ὑπ᾽ αὐτῶν μέσον. ἡ ΛΝ ἄρα ἄλογός ἐστιν ἡ καλουμένη ἐλάσσων· καὶ δύναται τὸ ΑΒ χωρίον.

Ἡ ἄρα τὸ ΑΒ χωρίον δυναμένη ἐλάσσων ἐστίν· ὅπερ ἔδει δεῖξαι.

line). For let DG be an attachment to AD. Thus, AG and DG are rational (straight-lines which are) commensurable in square only [Prop. 10.73], and AG is commensurable in length with the (previously) laid down rational (straight-line) AC, and the square on the whole, AG, is greater than (the square on) the attachment, DG, by the square on (some straight-line) incommensurable in length with (AG) [Def. 10.14]. Therefore, since the square on AG is greater than (the square on) GD by the (square) on (some straight-line) incommensurable in length with (AG), thus if (some area), equal to the fourth part of the (square) on DG, is applied to AG, falling short by a square figure, then it divides (AG) into (parts which are) incommensurable (in length) [Prop. 10.18]. Therefore, let DG have been cut in half at E, and let (some area), equal to the (square) on EG, have been applied to AG, falling short by a square figure, and let it be the (rectangle contained) by AF and FG. Thus, AF is incommensurable in length with FG. Therefore, let EH, FI, and GK have been drawn through E, F, and G (respectively), parallel to AC and BD. Therefore, since AG is rational, and commensurable in length with AC, the whole (area) AK is thus rational [Prop. 10.19]. Again, since DG is incommensurable in length with AC, and both are rational (straight-lines), DK is thus a medial (area) [Prop. 10.21]. Again, since AF is incommensurable in length with FG, AI (is) thus also incommensurable with FK [Props. 6.1, 10.11].

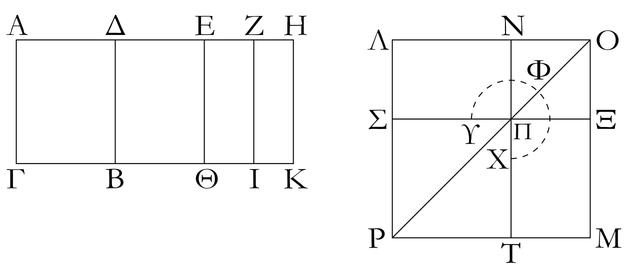
Therefore, let the square LM, equal to AI, have been constructed. And let NO, equal to FK, (and) about the same angle, LPM, have been subtracted (from LM). Thus, the squares LM and NO are about the same diagonal [Prop. 6.26]. Let PR be their (common) diagonal, and let the (rest of the) figure have been drawn. Therefore, since the (rectangle contained) by AF and FG is equal to the (square) on EG, thus, proportionally, as AF is to EG, so EG (is) to FG [Prop. 6.17]. But, as AF (is) to EG, so AI is to EK, and as EG (is) to FG, so EK is to FK [Prop. 6.1]. Thus, EK is the mean proportional to AI and FK [Prop. 5.11]. And MN is also the mean proportional to the squares LM and NO [Prop. 10.13 lem.], and AI is equal to LM, and FK to NO. EK is thus also equal to MN. But, DH is equal to EK, and LO is equal to MN [Prop. 1.43]. Thus, the whole of DK is equal to the gnomon UVW and NO. Therefore, since the whole of AK is equal to the (sum of the) squares LM and NO, of which DK is equal to the gnomon UVW and the square NO, the remainder AB is thus equal to ST—that is to say, to the square on LN. Thus, LN is the square-root of area AB. I say that LN is the irrational (straight-line which is) called minor.

For since AK is rational, and is equal to the (sum of the) squares LP and PN, the sum of the (squares) on LP and PN is thus rational. Again, since DK is medial, and DK is equal to twice the (rectangle contained) by LP and PN, thus twice the (rectangle contained) by LP and PN is medial. And since AI was shown (to be) incommensurable with FK, the square on LP (is) thus also incommensurable with the square on PN. Thus, LP and PN are (straight-lines which are) incommensurable in square, making the sum of the squares on them rational, and twice the (rectangle contained) by them medial. LN is thus the irrational (straight-line) called minor [Prop. 10.76]. And it is the square-root of area AB.

Thus, the square-root of area AB is a minor (straight-line). (Which is) the very thing it was required to show.

ϙε΄.

Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ ἀποτομῆς πέμπτης, ἡ τὸ χωρίον δυναμένη [ἡ] μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσά ἐστιν.



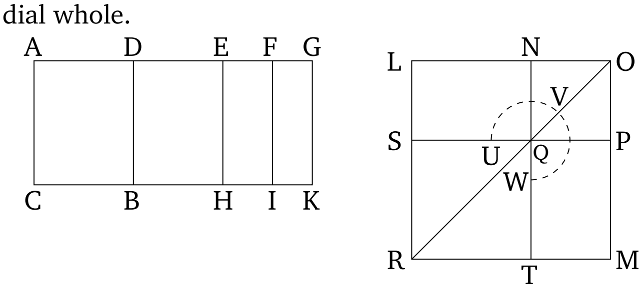
Χωρίον γὰρ τὸ ΑΒ περιεχέσθω ὑπὸ ῥητῆς τῆς ΑΓ καὶ ἀποτομῆς πέμπτης τῆς ΑΔ· λέγω, ὅτι ἡ τὸ ΑΒ χωρίον δυναμένη [ἡ] μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσά ἐστιν.

Ἔστω γὰρ τῇ ΑΔ προσαρμόζουσα ἡ ΔΗ· αἱ ἄρα ΑΗ, ΗΔ ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ ἡ προσαρμόζουσα ἡ ΗΔ σύμμετρός ἐστι μήκει τῇ ἐκκειμένῃ ῥητῇ τῇ ΑΓ, ἡ δὲ ὅλη ἡ ΑΗ τῆς προσαρμοζούσης τῆς ΔΗ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. ἐὰν ἄρα τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΔΗ ἴσον παρὰ τὴν ΑΗ παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ, εἰς ἀσύμμετρα αὐτὴν διελεῖ. τετμήσθω οὖν ἡ ΔΗ δίχα κατὰ τὸ Ε σημεῖον, καὶ τῷ ἀπὸ τῆς ΕΗ ἴσον παρὰ τὴν ΑΗ παραβεβλήσθω ἐλλεῖπον εἴδει τετραγώνῳ καὶ ἔστω τὸ ὑπὸ τῶν ΑΖ, ΖΗ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΑΖ τῇ ΖΗ μήκει. καὶ ἐπεὶ ἀσύμμετρός ἐστιν ἡ ΑΗ τῇ ΓΑ μήκει, καί εἰσιν ἀμφότεραι ῥηταί, μέσον ἄρα ἐστὶ τὸ ΑΚ. πάλιν, ἐπεὶ ῥητή ἐστιν ἡ ΔΗ καὶ σύμμετρος τῇ ΑΓ μήκει, ῥητόν ἐστι τὸ ΔΚ.

Συνεστάτω οὖν τῷ μὲν ΑΙ ἴσον τετράγωνον τὸ ΛΜ, τῷ δὲ ΖΚ ἴσον τετράγωνον ἀφῃρήσθω τὸ ΝΞ περὶ τὴν αὐτὴν γωνίαν τὴν ὑπὸ ΛΟΜ· περὶ τὴν αὐτὴν ἄρα διάμετρόν ἐστι τὰ ΛΜ, ΝΞ τετράγωνα. ἔστω αὐτῶν διάμετρος ἡ ΟΡ, καὶ

Proposition 95

If an area is contained by a rational (straight-line) and a fifth apotome then the square-root of the area is that (straight-line) which with a rational (area) makes a medial whole.



For let the area AB have been contained by the rational (straight-line) AC and the fifth apotome AD. I say that the square-root of area AB is that (straight-line) which with a rational (area) makes a medial whole.

For let DG be an attachment to AD. Thus, AG and DG are rational (straight-lines which are) commensurable in square only [Prop. 10.73], and the attachment GD is commensurable in length the the (previously) laid down rational (straight-line) AC, and the square on the whole, AG, is greater than (the square on) the attachment, DG, by the (square) on (some straight-line) incommensurable (in length) with (AG) [Def. 10.15]. Thus, if (some area), equal to the fourth part of the (square) on DG, is applied to AG, falling short by a square figure, then it divides (AG) into (parts which are) incommensurable (in length) [Prop. 10.18]. Therefore, let DG have been divided in half at point E, and let (some area), equal to the (square) on EG, have been applied to AG, falling short by a square figure, and let it be the (rectangle contained) by AF and FG. Thus, AF is incommensurable in length with FG. And since AG is incommensurable καταγεγράφθω τὸ σχῆμα. ὁμοίως δὴ δείξομεν, ὅτι ἡ ΛΝ δύναται τὸ ΑΒ χωρίον. λέγω, ὅτι ἡ ΛΝ ἡ μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσά ἐστιν.

Ἐπεὶ γὰρ μέσον ἐδείχθη τὸ ΑΚ καί ἐστιν ἴσον τοῖς ἀπὸ τῶν ΛΟ, ΟΝ, τὸ ἄρα συγκείμενον ἐκ τῶν ἀπὸ τῶν ΛΟ, ΟΝ μέσον ἐστίν. πάλιν, ἐπεὶ ῥητόν ἐστι τὸ ΔΚ καί ἐστιν ἴσον τῷ δὶς ὑπὸ τῶν ΛΟ, ΟΝ, καὶ αὐτὸ ῥητόν ἐστιν. καὶ ἐπεὶ ἀσύμμετρόν ἐστι τὸ ΑΙ τῷ ΖΚ, ἀσύμμετρον ἄρα ἐστὶ καὶ τὸ ἀπὸ τῆς ΛΟ τῷ ἀπὸ τῆς ΟΝ· αἱ ΛΟ, ΟΝ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον, τὸ δὲ δὶς ὑπ᾽ αὐτῶν ῥητόν. ἡ λοιπὴ ἄρα ἡ ΛΝ ἄλογός ἐστιν ἡ καλουμένη μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσα· καὶ δύναται τὸ ΑΒ χωρίον.

Ἡ τὸ ΑΒ ἄρα χωρίον δυναμένη μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσά ἐστιν· ὅπερ ἔδει δεῖξαι.

in length with CA, and both are rational (straight-lines), AK is thus a medial (area) [Prop. 10.21]. Again, since DG is rational, and commensurable in length with AC, DK is a rational (area) [Prop. 10.19].

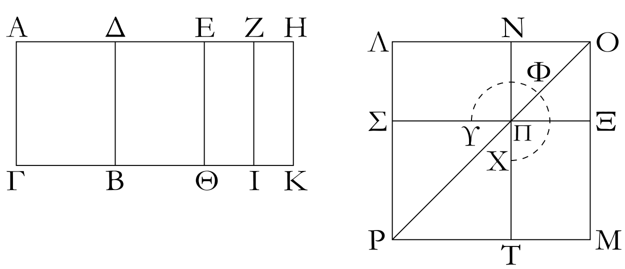
Therefore, let the square LM, equal to AI, have been constructed. And let the square NO, equal to FK, (and) about the same angle, LPM, have been subtracted (from NO). Thus, the squares LM and NO are about the same diagonal [Prop. 6.26]. Let PR be their (common) diagonal, and let (the rest of) the figure have been drawn. So, similarly (to the previous propositions), we can show that LN is the square-root of area AB. I say that LN is that (straight-line) which with a rational (area) makes a medial whole.

For since AK was shown (to be) a medial (area), and is equal to (the sum of) the squares on LP and PN, the sum of the (squares) on LP and PN is thus medial. Again, since DK is rational, and is equal to twice the (rectangle contained) by LP and PN, (the latter) is also rational. And since AI is incommensurable with FK, the (square) on LP is thus also incommensurable with the (square) on PN. Thus, LP and PN are (straight-lines which are) incommensurable in square, making the sum of the squares on them medial, and twice the (rectangle contained) by them rational. Thus, the remainder LN is the irrational (straight-line) called that which with a rational (area) makes a medial whole [Prop. 10.77]. And it is the square-root of area AB.

Thus, the square-root of area AB is that (straight-line) which with a rational (area) makes a medial whole. (Which is) the very thing it was required to show.

ϟϛ´.

Ἐὰν χωρίον περιέχηται ὑπὸ ῥητῆς καὶ ἀποτομῆς ἕκτης, ἡ τὸ χωρίον δυναμένη μετὰ μέσου μέσον τὸ ὅλον ποιοῦσά ἐστιν.

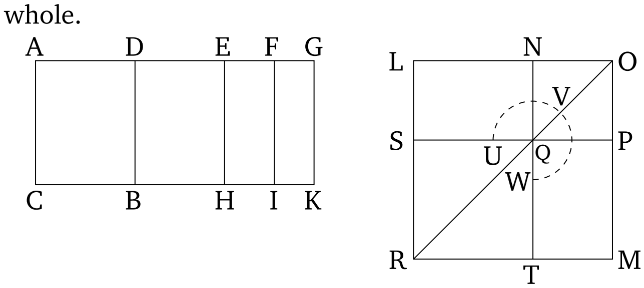


Χωρίον γὰρ τὸ ΑΒ περιεχέσθω ὑπὸ ῥητῆς τῆς ΑΓ καὶ ἀποτομῆς ἕκτης τῆς ΑΔ· λέγω, ὅτι ἡ τὸ ΑΒ χωρίον δυναμένη [ἡ] μετὰ μέσου μέσον τὸ ὅλον ποιοῦσά ἐστιν.

Ἔστω γὰρ τῇ ΑΔ προσαρμόζουσα ἡ ΔΗ· αἱ ἄρα ΑΗ, ΗΔ ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ οὐδετέρα

Proposition 96

If an area is contained by a rational (straight-line) and a sixth apotome then the square-root of the area is that (straight-line) which with a medial (area) makes a medial whole.



For let the area AB have been contained by the rational (straight-line) AC and the sixth apotome AD. I say that the square-root of area AB is that (straight-line) which with a medial (area) makes a medial whole.

For let DG be an attachment to AD. Thus, AG and αὐτῶν σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ ΑΓ μήκει, ἡ δὲ ὅλη ἡ ΑΗ τῆς προσαρμοζούσης τῆς ΔΗ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ μήκει. ἐπεὶ οὖν ἡ ΑΗ τῆς ΗΔ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ μήκει, ἐὰν ἄρα τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΔΗ ἴσον παρὰ τὴν ΑΗ παραβληθῇ ἐλλεῖπον εἴδει τετραγώνῳ, εἰς ἀσύμμετρα αὐτὴν διελεῖ. τετμήσθω οὖν ἡ ΔΗ δίχα κατὰ τὸ Ε [σημεῖον], καὶ τῷ ἀπὸ τῆς ΕΗ ἴσον παρὰ τὴν ΑΗ παραβεβλήσθω ἐλλεῖπον εἴδει τετραγώνῳ, καὶ ἔστω τὸ ὑπὸ τῶν ΑΖ, ΖΗ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΑΖ τῇ ΖΗ μήκει. ὡς δὲ ἡ ΑΖ πρὸς τὴν ΖΗ, οὕτως ἐστὶ τὸ ΑΙ πρὸς τὸ ΖΚ· ἀσύμμετρον ἄρα ἐστὶ τὸ ΑΙ τῷ ΖΚ. καὶ ἐπεὶ αἱ ΑΗ, ΑΓ ῥηταί εἰσι δυνάμει μόνον σύμμετροι, μέσον ἐστὶ τὸ ΑΚ. πάλιν, ἐπεὶ αἱ ΑΓ, ΔΗ ῥηταί εἰσι καὶ ἀσύμμετροι μήκει, μέσον ἐστὶ καὶ τὸ ΔΚ. ἐπεὶ οὖν αἱ ΑΗ, ΗΔ δυνάμει μόνον σύμμετροί εἰσιν, ἀσύμμετρος ἄρα ἐστὶν ἡ ΑΗ τῇ ΗΔ μήκει. ὡς δὲ ἡ ΑΗ πρὸς τὴν ΗΔ, οὕτως ἐστὶ τὸ ΑΚ πρὸς τὸ ΚΔ· ἀσύμμετρον ἄρα ἐστὶ τὸ ΑΚ τῷ ΚΔ.

Συνεστάτω οὖν τῷ μὲν ΑΙ ἴσον τετράγωνον τὸ ΛΜ, τῷ δὲ ΖΚ ἴσον ἀφῃρήσθω περὶ τὴν αὐτὴν γωνίαν τὸ ΝΞ· περὶ τὴν αὐτὴν ἄρα διάμετρόν ἐστι τὰ ΛΜ, ΝΞ τετράγωνα. ἔστω αὐτῶν διάμετρος ἡ ΟΡ, καὶ καταγεγράφθω τὸ σχῆμα. ὁμοίως δὴ τοῖς ἐπάνω δείξομεν, ὅτι ἡ ΛΝ δύναται τὸ ΑΒ χωρίον. λέγω, ὅτι ἡ ΛΝ [ἡ] μετὰ μέσου μέσον τὸ ὅλον ποιοῦσά ἐστιν.

Ἐπεὶ γὰρ μέσον ἐδείχθη τὸ ΑΚ καί ἐστιν ἴσον τοῖς ἀπὸ τῶν ΛΟ, ΟΝ, τὸ ἄρα συγκείμενον ἐκ τῶν ἀπὸ τῶν ΛΟ, ΟΝ μέσον ἐστίν. πάλιν, ἐπεὶ μέσον ἐδείχθη τὸ ΔΚ καί ἐστιν ἴσον τῷ δὶς ὑπὸ τῶν ΛΟ, ΟΝ, καὶ τὸ δὶς ὑπὸ τῶν ΛΟ, ΟΝ μέσον ἐστίν. καὶ ἐπεὶ ἀσύμμετρον ἐδείχθη τὸ ΑΚ τῷ ΔΚ, ἀσύμμετρα [ἄρα] ἐστὶ καὶ τὰ ἀπὸ τῶν ΛΟ, ΟΝ τετράγωνα τῷ δὶς ὑπὸ τῶν ΛΟ, ΟΝ. καὶ ἐπεὶ ἀσύμμετρόν ἐστι τὸ ΑΙ τῷ ΖΚ, ἀσύμμετρον ἄρα καὶ τὸ ἀπὸ τῆς ΛΟ τῷ ἀπὸ τῆς ΟΝ· αἱ ΛΟ, ΟΝ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τό τε συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον καὶ τὸ δὶς ὑπ᾽ αὐτῶν μέσον ἔτι τε τὰ ἀπ᾽ αὐτῶν τετράγωνα ἀσύμμετρα τῷ δὶς ὑπ᾽ αὐτῶν. ἡ ἄρα ΛΝ ἄλογός ἐστιν ἡ καλουμέμη μετὰ μέσου μέσον τὸ ὅλον ποιοῦσα· καὶ δύναται τὸ ΑΒ χωρίον.

Ἡ ἄρα τὸ χωρίον δυναμένη μετὰ μέσου μέσον τὸ ὅλον ποιοῦσά ἐστιν· ὅπερ ἔδει δεῖξαι.

GD are rational (straight-lines which are) commensurable in square only [Prop. 10.73], and neither of them is commensurable in length with the (previously) laid down rational (straight-line) AC, and the square on the whole, AG, is greater than (the square on) the attachment, DG, by the (square) on (some straight-line) incommensurable in length with (AG) [Def. 10.16]. Therefore, since the square on AG is greater than (the square on) GD by the (square) on (some straight-line) incommensurable in length with (AG), thus if (some area), equal to the fourth part of square on DG, is applied to AG, falling short by a square figure, then it divides (AG) into (parts which are) incommensurable (in length) [Prop. 10.18]. Therefore, let DG have been cut in half at [point] E. And let (some area), equal to the (square) on EG, have been applied to AG, falling short by a square figure. And let it be the (rectangle contained) by AF and FG. AF is thus incommensurable in length with FG. And as AF (is) to FG, so AI is to FK [Prop. 6.1]. Thus, AI is incommensurable with FK [Prop. 10.11]. And since AG and AC are rational (straight-lines which are) commensurable in square only, AK is a medial (area) [Prop. 10.21]. Again, since AC and DG are rational (straight-lines which are) incommensurable in length, DK is also a medial (area) [Prop. 10.21]. Therefore, since AG and GD are commensurable in square only, AG is thus incommensurable in length with GD. And as AG (is) to GD, so AK is to KD [Prop. 6.1]. Thus, AK is incommensurable with KD [Prop. 10.11].

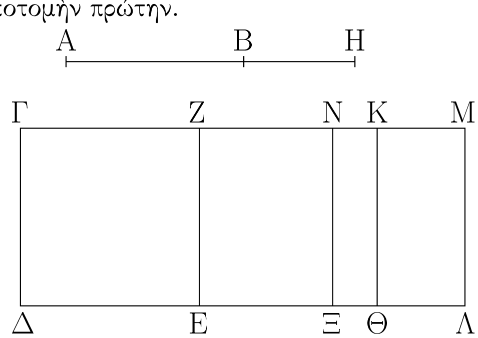
Therefore, let the square LM, equal to AI, have been constructed. And let NO, equal to FK, (and) about the same angle, have been subtracted (from LM). Thus, the squares LM and NO are about the same diagonal [Prop. 6.26]. Let PR be their (common) diagonal, and let (the rest of) the figure have been drawn. So, similarly to the above, we can show that LN is the square-root of area AB. I say that LN is that (straight-line) which with a medial (area) makes a medial whole.

For since AK was shown (to be) a medial (area), and is equal to the (sum of the) squares on LP and PN, the sum of the (squares) on LP and PN is medial. Again, since DK was shown (to be) a medial (area), and is equal to twice the (rectangle contained) by LP and PN, twice the (rectangle contained) by LP and PN is also medial. And since AK was shown (to be) incommensurable with DK, [thus] the (sum of the) squares on LP and PN is also incommensurable with twice the (rectangle contained) by LP and PN. And since AI is incommensurable with FK, the (square) on LP (is) thus also incommensurable with the (square) on PN. Thus, LP and PN are (straight-lines which are) incommensurable in square, making the sum of the squares on them medial, and twice the (rectangle contained) by medial, and, furthermore, the (sum of the) squares on them incommensurable with twice the (rectangle contained) by them. Thus, LN is the irrational (straight-line) called that which with a medial (area) makes a medial whole [Prop. 10.78]. And it is the square-root of area AB.

Thus, the square-root of area (AB) is that (straight-line) which with a medial (area) makes a medial whole. (Which is) the very thing it was required to show.

ϟζ'.

Τὸ ἀπὸ ἀποτομῆς παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν πρώτην.

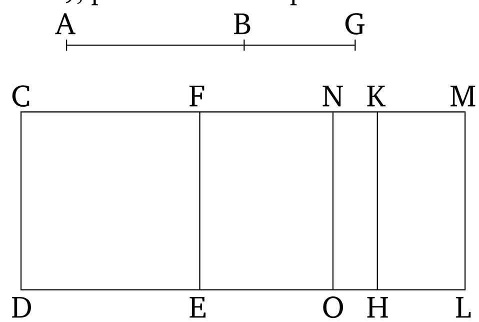


Ἔστω ἀποτομὴ ἡ ΑΒ, ῥητὴ δὲ ἡ ΓΔ, καὶ τῷ ἀπὸ τῆς ΑΒ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω τὸ ΓΕ πλάτος ποιοῦν τὴν ΓΖ· λέγω, ὅτι ἡ ΓΖ ἀποτομή ἐστι πρώτη.

Ἔστω γὰρ τῇ ΑΒ προσαρμόζουσα ἡ ΒΗ· αἱ ἄρα ΑΗ, ΗΒ ῥηταί εἰσι δυνάμει μόνον σύμμετροι. καὶ τῷ μὲν ἀπὸ τῆς ΑΗ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω τὸ ΓΘ, τῷ δὲ ἀπὸ τῆς ΒΗ τὸ ΚΛ. ὅλον ἄρα τὸ ΓΛ ἴσον ἐστὶ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ· ὧν τὸ ΓΕ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΑΒ· λοιπὸν ἄρα τὸ ΖΛ ἴσον ἐστὶ τῷ δὶς ὑπὸ τῶν ΑΗ, ΗΒ. τετμήσθω ἡ ΖΜ δίχα κατὰ τὸ Ν σημεῖον, καὶ ἤχθω διὰ τοῦ Ν τῇ ΓΔ παράλληλος ἡ ΝΞ· ἑκάτερον ἄρα τῶν ΖΞ, ΛΝ ἴσον ἐστὶ τῷ ὑπὸ τῶν ΑΗ, ΗΒ. καὶ ἐπεὶ τὰ ἀπὸ τῶν ΑΗ, ΗΒ ῥητά ἐστιν, καί ἐστι τοῖς ἀπὸ τῶν ΑΗ, ΗΒ ἴσον τὸ ΔΜ, ῥητὸν ἄρα ἐστὶ τὸ ΔΜ. καὶ παρὰ ῥητὴν τὴν ΓΔ παραβέβληται πλάτος ποιοῦν τὴν ΓΜ· ῥητὴ ἄρα ἐστὶν ἡ ΓΜ καὶ σύμμετρος τῇ ΓΔ μήκει. πάλιν, ἐπεὶ μέσον ἐστὶ τὸ δὶς ὑπὸ τῶν ΑΗ, ΗΒ, καὶ τῷ δὶς ὑπὸ τῶν ΑΗ, ΗΒ ἴσον τὸ ΖΛ, μέσον ἄρα τὸ ΖΛ. καὶ παρὰ ῥητὴν τὴν ΓΔ παράκειται πλάτος ποιοῦν τὴν ΖΜ· ῥητὴ ἄρα ἐστὶν ἡ ΖΜ καὶ ἀσύμμετρος τῇ ΓΔ μήκει. καὶ ἐπεὶ τὰ μὲν ἀπὸ τῶν ΑΗ, ΗΒ ῥητά ἐστιν, τὸ δὲ δὶς ὑπὸ τῶν ΑΗ, ΗΒ μέσον, ἀσύμμετρα ἄρα ἐστὶ τὰ ἀπὸ τῶν ΑΗ, ΗΒ τῷ δὶς ὑπὸ τῶν ΑΗ, ΗΒ. καὶ τοῖς μὲν ἀπὸ τῶν ΑΗ, ΗΒ ἴσον ἐστὶ τὸ ΓΛ, τῷ δὲ δὶς ὑπὸ τῶν ΑΗ, ΗΒ τὸ ΖΛ· ἀσύμμετρον ἄρα ἐστὶ τὸ ΔΜ τῷ ΖΛ. ὡς δὲ τὸ ΔΜ πρὸς τὸ ΖΛ, οὕτως ἐστὶν ἡ ΓΜ πρὸς τὴν ΖΜ. ἀσύμμετρος ἄρα ἐστὶν ἡ ΓΜ τῇ ΖΜ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ἄρα ΓΜ, ΜΖ ῥηταί εἰσι

Proposition 97

The (square) on an apotome, applied to a rational (straight-line), produces a first apotome as breadth.



Let AB be an apotome, and CD a rational (straight-line). And let CE, equal to the (square) on AB, have been applied to CD, producing CF as breadth. I say that CF is a first apotome.

For let BG be an attachment to AB. Thus, AG and GB are rational (straight-lines which are) commensurable in square only [Prop. 10.73]. And let CH, equal to the (square) on AG, and KL, (equal) to the (square) on BG, have been applied to CD. Thus, the whole of CL is equal to the (sum of the squares) on AG and GB, of which CE is equal to the (square) on AB. The remainder FL is thus equal to twice the (rectangle contained) by AG and GB [Prop. 2.7]. Let FM have been cut in half at point N. And let NO have been drawn through N, parallel to CD. Thus, FO and LN are each equal to the (rectangle contained) by AG and GB. And since the (sum of the squares) on AG and GB is rational, and DM is equal to the (sum of the squares) on AG and GB, DM is thus rational. And it has been applied to the rational (straight-line) CD, producing CM as breadth. Thus, CM is rational, and commensurable in length with CD [Prop. 10.20]. Again, since twice the (rectangle contained) by AG and GB is medial, and FL (is) equal to twice the (rectangle contained) by AG and GB, FL (is) thus a medial (area). And it is applied to the rational (straight-line) CD, producing FM as breadth. FM is δυνάμει μόνον σύμμετροι· ἡ ΓΖ ἄρα ἀποτομή ἐστιν. λέγω δή, ὅτι καὶ πρώτη.

Ἐπεὶ γὰρ τῶν ἀπὸ τῶν ΑΗ, ΗΒ μέσον ἀνάλογόν ἐστι τὸ ὑπὸ τῶν ΑΗ, ΗΒ, καί ἐστι τῷ μὲν ἀπὸ τῆς ΑΗ ἴσον τὸ ΓΘ, τῷ δὲ ἀπὸ τῆς ΒΗ ἴσον τὸ ΚΛ, τῷ δὲ ὑπὸ τῶν ΑΗ, ΗΒ τὸ ΝΛ, καὶ τῶν ΓΘ, ΚΛ ἄρα μέσον ἀνάλογόν ἐστι τὸ ΝΛ· ἔστιν ἄρα ὡς τὸ ΓΘ πρὸς τὸ ΝΛ, οὕτως τὸ ΝΛ πρὸς τὸ ΚΛ. ἀλλ᾽ ὡς μὲν τὸ ΓΘ πρὸς τὸ ΝΛ, οὕτως ἐστὶν ἡ ΓΚ πρὸς τὴν ΝΜ· ὡς δὲ τὸ ΝΛ πρὸς τὸ ΚΛ, οὕτως ἐστὶν ἡ ΝΜ πρὸς τὴν ΚΜ· τὸ ἄρα ὑπὸ τῶν ΓΚ, ΚΜ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΝΜ, τουτέστι τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΖΜ. καὶ επεὶ σύμμετρόν ἐστι τὸ ἀπὸ τῆς ΑΗ τῷ ἀπὸ τῆς ΗΒ, σύμμετρόν [ἐστι] καὶ τὸ ΓΘ τῷ ΚΛ. ὡς δὲ τὸ ΓΘ πρὸς τὸ ΚΛ, οὕτως ἡ ΓΚ πρὸς τὴν ΚΜ· σύμμετρος ἄρα ἐστὶν ἡ ΓΚ τῇ ΚΜ. ἐπεὶ οὖν δύο εὐθεῖαι ἄνισοί εἰσιν αἱ ΓΜ, ΜΖ, καὶ τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΖΜ ἴσον παρὰ τὴν ΓΜ παραβέβληται ἐλλεῖπον εἴδει τετραγώνῳ τὸ ὑπὸ τῶν ΓΚ, ΚΜ, καί ἐστι σύμμετρος ἡ ΓΚ τῇ ΚΜ, ἡ ἄρα ΓΜ τῆς ΜΖ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει. καί ἐστιν ἡ ΓΜ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ τῇ ΓΔ μήκει· ἡ ἄρα ΓΖ ἀποτομή ἐστι πρώτη.

Τὸ ἄρα ἀπὸ ἀποτομῆς παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν πρώτην· ὅπερ ἔδει δεῖξαι.

thus rational, and incommensurable in length with CD [Prop. 10.22]. And since the (sum of the squares) on AG and GB is rational, and twice the (rectangle contained) by AG and GB medial, the (sum of the squares) on AG and GB is thus incommensurable with twice the (rectangle contained) by AG and GB. And CL is equal to the (sum of the squares) on AG and GB, and FL to twice the (rectangle contained) by AG and GB. DM is thus incommensurable with FL. And as DM (is) to FL, so CM is to FM [Prop. 6.1]. CM is thus incommensurable in length with FM [Prop. 10.11]. And both are rational (straight-lines). Thus, CM and MF are rational (straight-lines which are) commensurable in square only. CF is thus an apotome [Prop. 10.73]. So, I say that (it is) also a first (apotome).

For since the (rectangle contained) by AG and GB is the mean proportional to the (squares) on AG and GB [Prop. 10.21 lem.], and CH is equal to the (square) on AG, and KL equal to the (square) on BG, and NL to the (rectangle contained) by AG and GB, NL is thus also the mean proportional to CH and KL. Thus, as CH is to NL, so NL (is) to KL. But, as CH (is) to NL, so CK is to NM, and as NL (is) to KL, so NM is to KM [Prop. 6.1]. Thus, the (rectangle contained) by CK and KM is equal to the (square) on NM—that is to say, to the fourth part of the (square) on FM [Prop. 6.17]. And since the (square) on AG is commensurable with the (square) on GB, CH [is] also commensurable with KL. And as CH (is) to KL, so CK (is) to KM [Prop. 6.1]. CK is thus commensurable (in length) with KM [Prop. 10.11]. Therefore, since CM and MF are two unequal straight-lines, and the (rectangle contained) by CK and KM, equal to the fourth part of the (square) on FM, has been applied to CM, falling short by a square figure, and CK is commensurable (in length) with KM, the square on CM is thus greater than (the square on) MF by the (square) on (some straight-line) commensurable in length with (CM) [Prop. 10.17]. And CM is commensurable in length with the (previously) laid down rational (straight-line) CD. Thus, CF is a first apotome [Def. 10.15].

Thus, the (square) on an apotome, applied to a rational (straight-line), produces a first apotome as breadth. (Which is) the very thing it was required to show.

ϛη´.

Τὸ ἀπὸ μέσης ἀποτομῆς πρώτης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν δευτέραν.

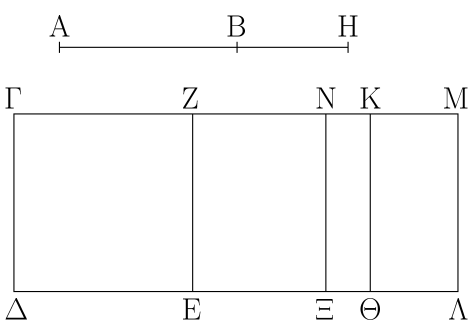
Ἔστω μέσης ἀποτομὴ πρώτη ἡ ΑΒ, ῥητὴ δὲ ἡ ΓΔ, καὶ τῷ ἀπὸ τῆς ΑΒ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω τὸ ΓΕ πλάτος

Proposition 98

The (square) on a first apotome of a medial (straight-line), applied to a rational (straight-line), produces a second apotome as breadth.

Let AB be a first apotome of a medial (straight-line), ποιοῦν τὴν ΓΖ· λέγω, ὅτι ἡ ΓΖ ἀποτομή ἐστι δευτέρα.

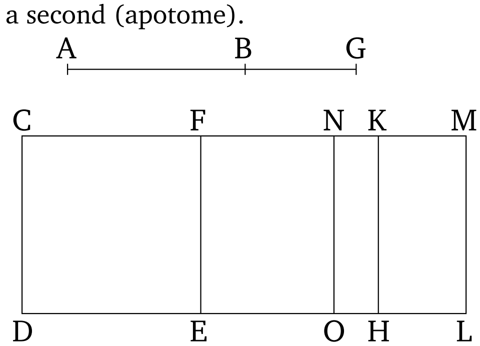
Ἔστω γὰρ τῇ ΑΒ προσαρμόζουσα ἡ ΒΗ· αἱ ἄρα ΑΗ, ΗΒ μέσαι εἰσὶ δυνάμει μόνον σύμμετροι ῥητὸν περιέχουσαι. καὶ τῷ μὲν ἀπὸ τῆς ΑΗ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω τὸ ΓΘ πλάτος ποιοῦν τὴν ΓΚ, τῷ δὲ ἀπὸ τῆς ΗΒ ἴσον τὸ ΚΛ πλάτος ποιοῦν τὴν ΚΜ· ὅλον ἄρα τὸ ΓΛ ἴσον ἐστὶ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ· μέσον ἄρα καὶ τὸ ΓΛ. καὶ παρὰ ῥητὴν τὴν ΓΔ παράκειται πλάτος ποιοῦν τὴν ΓΜ· ῥητὴ ἄρα ἐστὶν ἡ ΓΜ καὶ ἀσύμμετρος τῇ ΓΔ μήκει. καὶ ἐπεὶ τὸ ΓΛ ἴσον ἐστὶ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ, ὧν τὸ ἀπὸ τῆς ΑΒ ἴσον ἐστὶ τῷ ΓΕ, λοιπὸν ἄρα τὸ δὶς ὑπὸ τῶν ΑΗ, ΗΒ ἴσον ἐστὶ τῷ ΖΛ. ῥητὸν δέ [ἐστι] τὸ δὶς ὑπὸ τῶν ΑΗ, ΗΒ· ῥητὸν ἄρα τὸ ΖΛ. καὶ παρὰ ῥητὴν τὴν ΖΕ παράκειται πλάτος ποιοῦν τὴν ΖΜ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΖΜ καὶ σύμμετρος τῇ ΓΔ μήκει. ἐπεὶ οὖν τὰ μὲν ἀπὸ τῶν ΑΗ, ΗΒ, τουτέστι τὸ ΓΛ, μέσον ἐστίν, τὸ δὲ δὶς ὑπὸ τῶν ΑΗ, ΗΒ, τουτέστι τὸ ΖΛ, ῥητόν ἀσύμμετρον ἄρα ἐστὶ τὸ ΓΛ τῷ ΖΛ. ὡς δὲ τὸ ΓΛ πρὸς τὸ ΖΛ, οὕτως ἐστὶν ἡ ΓΜ πρὸς τὴν ΖΜ· ἀσύμμετρος ἄρα ἡ ΓΜ τῇ ΖΜ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ἄρα ΓΜ, ΜΖ ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἡ ΓΖ ἄρα ἀποτομή ἐστιν. λέγω δή, ὅτι καὶ δευτέρα.



Τετμήσθω γὰρ ἡ ΖΜ δίχα κατὰ τὸ Ν, καὶ ἤχθω διὰ τοῦ Ν τῇ ΓΔ παράλληλος ἡ ΝΞ· ἑκάτερον ἄρα τῶν ΖΞ, ΝΛ ἴσον ἐστὶ τῷ ὑπὸ τῶν ΑΗ, ΗΒ. καὶ ἐπεὶ τῶν ἀπὸ τῶν ΑΗ, ΗΒ τετραγώνων μέσον ἀνάλογόν ἐστι τὸ ὑπὸ τῶν ΑΗ, ΗΒ, καί ἐστιν ἴσον τὸ μὲν ἀπὸ τῆς ΑΗ τῷ ΓΘ, τὸ δὲ ὑπὸ τῶν ΑΗ, ΗΒ τῷ ΝΛ, τὸ δὲ ἀπὸ τῆς ΒΗ τῷ ΚΛ, καὶ τῶν ΓΘ, ΚΛ ἄρα μέσον ἀνάλογόν ἐστι τὸ ΝΛ· ἔστιν ἄρα ὡς τὸ ΓΘ πρὸς τὸ ΝΛ, οὕτως τὸ ΝΛ πρὸς τὸ ΚΛ. ἀλλ᾽ ὡς μὲν τὸ ΓΘ πρὸς

and CD a rational (straight-line). And let CE, equal to the (square) on AB, have been applied to CD, producing CF as breadth. I say that CF is a second apotome.

For let BG be an attachment to AB. Thus, AG and GB are medial (straight-lines which are) commensurable in square only, containing a rational (area) [Prop. 10.74]. And let CH, equal to the (square) on AG, have been applied to CD, producing CK as breadth, and KL, equal to the (square) on GB, producing KM as breadth. Thus, the whole of CL is equal to the (sum of the squares) on AG and GB. Thus, CL (is) also a medial (area) [Props. 10.15, 10.23 corr.]. And it is applied to the rational (straight-line) CD, producing CM as breadth. CM is thus rational, and incommensurable in length with CD [Prop. 10.22]. And since CL is equal to the (sum of the squares) on AG and GB, of which the (square) on AB is equal to CE, the remainder, twice the (rectangle contained) by AG and GB, is thus equal to FL [Prop. 2.7]. And twice the (rectangle contained) by AG and GB [is] rational. Thus, FL (is) rational. And it is applied to the rational (straight-line) FE, producing FM as breadth. FM is thus also rational, and commensurable in length with CD [Prop. 10.20]. Therefore, since the (sum of the squares) on AG and GB—that is to say, CL—is medial, and twice the (rectangle contained) by AG and GB—that is to say, FL—(is) rational, CL is thus incommensurable with FL. And as CL (is) to FL, so CM is to FM [Prop. 6.1]. Thus, CM (is) incommensurable in length with FM [Prop. 10.11]. And they are both rational (straight-lines). Thus, CM and MF are rational (straight-lines which are) commensurable in square only. CF is thus an apotome [Prop. 10.73]. So, I say that (it is) also a second (apotome).



For let FM have been cut in half at N. And let NO have been drawn through (point) N, parallel to CD. Thus, FO and NL are each equal to the (rectangle contained) by AG and GB. And since the (rectangle contained) by AG and GB is the mean proportional to the squares on AG and GB [Prop. 10.21 lem.], and the (square) on AG is equal to CH, and the (rectangle contained) by AG and GB to NL, and the (square) on τὸ ΝΛ, οὕτως ἐστὶν ἡ ΓΚ πρὸς τὴν ΝΜ, ὡς δὲ τὸ ΝΛ πρὸς τὸ ΚΛ, οὕτως ἐστὶν ἡ ΝΜ πρὸς τὴν ΜΚ· ὡς ἄρα ἡ ΓΚ πρὸς τὴν ΝΜ, οὕτως ἐστὶν ἡ ΝΜ πρὸς τὴν ΚΜ· τὸ ἄρα ὑπὸ τῶν ΓΚ, ΚΜ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΝΜ, τουτέστι τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΖΜ [καὶ ἐπεὶ σύμμετρόν ἐστι τὸ ἀπὸ τῆς ΑΗ τῷ ἀπὸ τῆς ΒΗ, σύμμετρόν ἐστι καὶ τὸ ΓΘ τῷ ΚΛ, τουτέστιν ἡ ΓΚ τῇ ΚΜ]. ἐπεὶ οὖν δύο εὐθεῖαι ἄνισοί εἰσιν αἱ ΓΜ, ΜΖ, καὶ τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΜΖ ἴσον παρὰ τὴν μείζονα τὴν ΓΜ παραβέβληται ἐλλεῖπον εἴδει τετραγώνῳ τὸ ὑπὸ τῶν ΓΚ, ΚΜ καὶ εἰς σύμμετρα αὐτὴν διαιρεῖ, ἡ ἄρα ΓΜ τῆς ΜΖ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ μήκει. καί ἐστιν ἡ προσαρμόζουσα ἡ ΖΜ σύμμετρος μήκει τῇ ἐκκειμένῃ ῥητῇ τῇ ΓΔ· ἡ ἄρα ΓΖ ἀποτομή ἐστι δευτέρα.

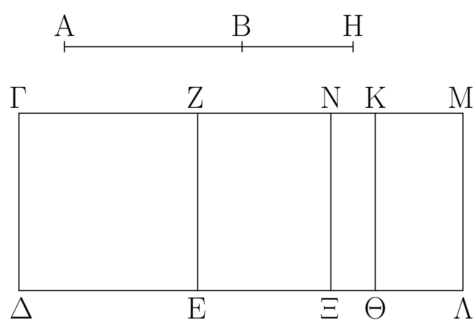
Τὸ ἄρα ἀπὸ μέσης ἀποτομῆς πρώτης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν δευτέραν· ὅπερ ἔδει δεῖξαι.

BG to KL, NL is thus also the mean proportional to CH and KL. Thus, as CH is to NL, so NL (is) to KL [Prop. 5.11]. But, as CH (is) to NL, so CK is to NM, and as NL (is) to KL, so NM is to MK [Prop. 6.1]. Thus, as CK (is) to NM, so NM is to KM [Prop. 5.11]. The (rectangle contained) by CK and KM is thus equal to the (square) on NM [Prop. 6.17]—that is to say, to the fourth part of the (square) on FM [and since the (square) on AG is commensurable with the (square) on BG, CH is also commensurable with KL—that is to say, CK with KM]. Therefore, since CM and MF are two unequal straight-lines, and the (rectangle contained) by CK and KM, equal to the fourth part of the (square) on MF, has been applied to the greater CM, falling short by a square figure, and divides it into commensurable (parts), the square on CM is thus greater than (the square on) MF by the (square) on (some straight-line) commensurable in length with (CM) [Prop. 10.17]. The attachment FM is also commensurable in length with the (previously) laid down rational (straight-line) CD. CF is thus a second apotome [Def. 10.16].

Thus, the (square) on a first apotome of a medial (straight-line), applied to a rational (straight-line), produces a second apotome as breadth. (Which is) the very thing it was required to show.

ϙϑ´.

Τὸ ἀπὸ μέσης ἀποτομῆς δευτέρας παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν τρίτην.

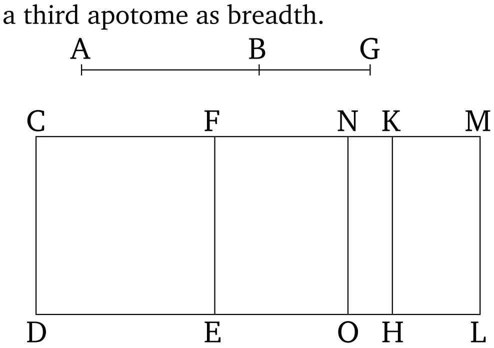


Ἔστω μέσης ἀποτομὴ δευτέρα ἡ ΑΒ, ῥητὴ δὲ ἡ ΓΔ, καὶ τῷ ἀπὸ τῆς ΑΒ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω τὸ ΓΕ πλάτος ποιοῦν τὴν ΓΖ· λέγω, ὅτι ἡ ΓΖ ἀποτομή ἐστι τρίτη.

Ἔστω γὰρ τῇ ΑΒ προσαρμόζουσα ἡ ΒΗ· αἱ ἄρα ΑΗ, ΗΒ μέσαι εἰσὶ δυνάμει μόνον σύμμετροι μέσον περιέχουσαι. καὶ τῷ μὲν ἀπὸ τῆς ΑΗ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω τὸ ΓΘ πλάτος ποιοῦν τὴν ΓΚ, τῷ δὲ ἀπὸ τῆς ΒΗ ἴσον παρὰ τὴν ΚΘ παραβεβλήσθω τὸ ΚΛ πλάτος ποιοῦν τὴν ΚΜ· ὅλον ἄρα τὸ ΓΛ ἴσον ἐστὶ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ [καί ἐστι μέσα τὰ ἀπὸ τῶν ΑΗ, ΗΒ]· μέσον ἄρα καὶ τὸ ΓΛ. καὶ παρὰ ῥητὴν τὴν

Proposition 99

The (square) on a second apotome of a medial (straight-line), applied to a rational (straight-line), produces a third apotome as breadth.



Let AB be the second apotome of a medial (straight-line), and CD a rational (straight-line). And let CE, equal to the (square) on AB, have been applied to CD, producing CF as breadth. I say that CF is a third apotome.

For let BG be an attachment to AB. Thus, AG and GB are medial (straight-lines which are) commensurable in square only, containing a medial (area) [Prop. 10.75]. And let CH, equal to the (square) on AG, have been applied to CD, producing CK as breadth. And let KL, ΓΔ παραβέβληται πλάτος ποιοῦν τὴν ΓΜ· ῥητὴ ἄρα ἐστὶν ἡ ΓΜ καὶ ἀσύμμετρος τῇ ΓΔ μήκει. καὶ ἐπεὶ ὅλον τὸ ΓΛ ἴσον ἐστὶ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ, ὧν τὸ ΓΕ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΑΒ, λοιπὸν ἄρα τὸ ΛΖ ἴσον ἐστὶ τῷ δὶς ὑπὸ τῶν ΑΗ, ΗΒ. τετμήσθω οὖν ἡ ΖΜ δίχα κατὰ τὸ Ν σημεῖον, καὶ τῇ ΓΔ παράλληλος ἤχθω ἡ ΝΞ· ἑκάτερον ἄρα τῶν ΖΞ, ΝΛ ἴσον ἐστὶ τῷ ὑπὸ τῶν ΑΗ, ΗΒ. μέσον δὲ τὸ ὑπὸ τῶν ΑΗ, ΗΒ· μέσον ἄρα ἐστὶ καὶ τὸ ΖΛ. καὶ παρὰ ῥητὴν τὴν ΕΖ παράκειται πλάτος ποιοῦν τὴν ΖΜ· ῥητὴ ἄρα καὶ ἡ ΖΜ καὶ ἀσύμμετρος τῇ ΓΔ μήκει. καὶ ἐπεὶ αἱ ΑΗ, ΗΒ δυνάμει μόνον εἰσὶ σύμμετροι, ἀσύμμετρος ἄρα [ἐστὶ] μήκει ἡ ΑΗ τῇ ΗΒ· ἀσύμμετρον ἄρα ἐστὶ καὶ τὸ ἀπὸ τῆς ΑΗ τῷ ὑπὸ τῶν ΑΗ, ΗΒ. ἀλλὰ τῷ μὲν ἀπὸ τῆς ΑΗ σύμμετρά ἐστι τὰ ἀπὸ τῶν ΑΗ, ΗΒ, τῷ δὲ ὑπὸ τῶν ΑΗ, ΗΒ τὸ δὶς ὑπὸ τῶν ΑΗ, ΗΒ· ἀσύμμετρα ἄρα ἐστὶ τὰ ἀπὸ τῶν ΑΗ, ΗΒ τῷ δὶς ὑπὸ τῶν ΑΗ, ΗΒ. ἀλλὰ τοῖς μὲν ἀπὸ τῶν ΑΗ, ΗΒ ἴσον ἐστὶ τὸ ΓΛ, τῷ δὲ δὶς ὑπὸ τῶν ΑΗ, ΗΒ ἴσον ἐστὶ τὸ ΖΛ· ἀσύμμετρον ἄρα ἐστὶ τὸ ΓΛ τῷ ΖΛ. ὡς δὲ τὸ ΓΛ πρὸς τὸ ΖΛ, οὕτως ἐστὶν ἡ ΓΜ πρὸς τὴν ΖΜ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΓΜ τῇ ΖΜ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ἄρα ΓΜ, ΜΖ ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΓΖ. λέγω δή, ὅτι καὶ τρίτη.

Ἐπεὶ γὰρ σύμμετρόν ἐστι τὸ ἀπὸ τῆς ΑΗ τῷ ἀπὸ τῆς ΗΒ, σύμμετρον ἄρα καὶ τὸ ΓΘ τῷ ΚΛ· ὥστε καὶ ἡ ΓΚ τῇ ΚΜ. καὶ ἐπεὶ τῶν ἀπὸ τῶν ΑΗ, ΗΒ μέσον ἀνάλογόν ἐστι τὸ ὑπὸ τῶν ΑΗ, ΗΒ, καί ἐστι τῷ μὲν ἀπὸ τῆς ΑΗ ἴσον τὸ ΓΘ, τῷ δὲ ἀπὸ τῆς ΗΒ ἴσον τὸ ΚΛ, τῷ δὲ ὑπὸ τῶν ΑΗ, ΗΒ ἴσον τὸ ΝΛ, καὶ τῶν ΓΘ, ΚΛ ἄρα μέσον ἀνάλογόν ἐστι τὸ ΝΛ· ἔστιν ἄρα ὡς τὸ ΓΘ πρὸς τὸ ΝΛ, οὕτως τὸ ΝΛ πρὸς τὸ ΚΛ. ἀλλ᾽ ὡς μὲν τὸ ΓΘ πρὸς τὸ ΝΛ, οὕτως ἐστὶν ἡ ΓΚ πρὸς τὴν ΝΜ, ὡς δὲ τὸ ΝΛ πρὸς τὸ ΚΛ, οὕτως ἐστὶν ἡ ΝΜ πρὸς τὴν ΚΜ· ὡς ἄρα ἡ ΓΚ πρὸς τὴν ΜΝ, οὕτως ἐστὶν ἡ ΜΝ πρὸς τὴν ΚΜ· τὸ ἄρα ὑπὸ τῶν ΓΚ, ΚΜ ἴσον ἐστὶ τῷ [ἀπὸ τῆς ΜΝ, τουτέστι τῷ] τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΖΜ. ἐπεὶ οὖν δύο εὐθεῖαι ἄνισοί εἰσιν αἱ ΓΜ, ΜΖ, καὶ τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΖΜ ἴσον παρὰ τὴν ΓΜ παραβέβληται ἐλλεῖπον εἴδει τετραγώνῳ καὶ εἰς σύμμετρα αὐτὴν διαιρεῖ, ἡ ΓΜ ἄρα τῆς ΜΖ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ. καὶ οὐδετέρα τῶν ΓΜ, ΜΖ σύμμετρός ἐστι μήκει τῇ ἐκκειμένῃ ῥητῇ τῇ ΓΔ· ἡ ἄρα ΓΖ ἀποτομή ἐστι τρίτη.

Τὸ ἄρα ἀπὸ μέσης ἀποτομῆς δευτέρας παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν τρίτην· ὅπερ ἔδει δεῖξαι.

equal to the (square) on BG, have been applied to KH, producing KM as breadth. Thus, the whole of CL is equal to the (sum of the squares) on AG and GB [and the (sum of the squares) on AG and GB is medial]. CL (is) thus also medial [Props. 10.15, 10.23 corr.]. And it has been applied to the rational (straight-line) CD, producing CM as breadth. Thus, CM is rational, and incommensurable in length with CD [Prop. 10.22]. And since the whole of CL is equal to the (sum of the squares) on AG and GB, of which CE is equal to the (square) on AB, the remainder LF is thus equal to twice the (rectangle contained) by AG and GB [Prop. 2.7]. Therefore, let FM have been cut in half at point N. And let NO have been drawn parallel to CD. Thus, FO and NL are each equal to the (rectangle contained) by AG and GB. And the (rectangle contained) by AG and GB (is) medial. Thus, FL is also medial. And it is applied to the rational (straight-line) EF, producing FM as breadth. FM is thus rational, and incommensurable in length with CD [Prop. 10.22]. And since AG and GB are commensurable in square only, AG [is] thus incommensurable in length with GB. Thus, the (square) on AG is also incommensurable with the (rectangle contained) by AG and GB [Props. 6.1, 10.11]. But, the (sum of the squares) on AG and GB is commensurable with the (square) on AG, and twice the (rectangle contained) by AG and GB with the (rectangle contained) by AG and GB. The (sum of the squares) on AG and GB is thus incommensurable with twice the (rectangle contained) by AG and GB [Prop. 10.13]. But, CL is equal to the (sum of the squares) on AG and GB, and FL is equal to twice the (rectangle contained) by AG and GB. Thus, CL is incommensurable with FL. And as CL (is) to FL, so CM is to FM [Prop. 6.1]. CM is thus incommensurable in length with FM [Prop. 10.11]. And they are both rational (straight-lines). Thus, CM and MF are rational (straight-lines which are) commensurable in square only. CF is thus an apotome [Prop. 10.73]. So, I say that (it is) also a third (apotome).

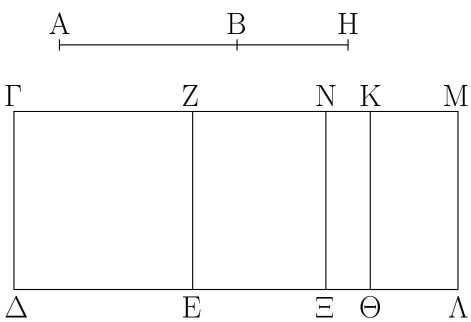
For since the (square) on AG is commensurable with the (square) on GB, CH (is) thus also commensurable with KL. Hence, CK (is) also (commensurable in length) with KM [Props. 6.1, 10.11]. And since the (rectangle contained) by AG and GB is the mean proportional to the (squares) on AG and GB [Prop. 10.21 lem.], and CH is equal to the (square) on AG, and KL equal to the (square) on GB, and NL equal to the (rectangle contained) by AG and GB, NL is thus also the mean proportional to CH and KL. Thus, as CH is to NL, so NL (is) to KL. But, as CH (is) to NL, so CK is to NM, and as NL (is) to KL, so NM (is) to KM [Prop. 6.1].

Thus, as CK (is) to MN, so MN is to KM [Prop. 5.11]. Thus, the (rectangle contained) by CK and KM is equal to the [(square) on MN—that is to say, to the] fourth part of the (square) on FM [Prop. 6.17]. Therefore, since CM and MF are two unequal straight-lines, and (some area), equal to the fourth part of the (square) on FM, has been applied to CM, falling short by a square figure, and divides it into commensurable (parts), the square on CM is thus greater than (the square on) MF by the (square) on (some straight-line) commensurable (in length) with (CM) [Prop. 10.17]. And neither of CM and MF is commensurable in length with the (previously) laid down rational (straight-line) CD. CF is thus a third apotome [Def. 10.13].

Thus, the (square) on a second apotome of a medial (straight-line), applied to a rational (straight-line), produces a third apotome as breadth. (Which is) the very thing it was required to show.

ρʹ.

Τὸ ἀπὸ ἐλάσσονος παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν τετάρτην.

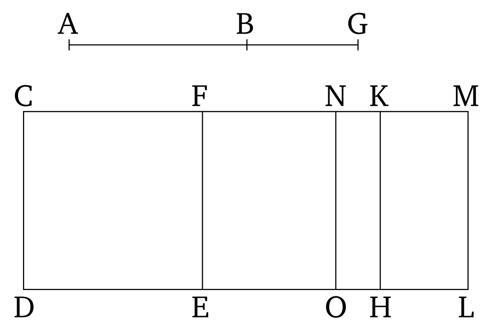


Ἔστω ἐλάσσων ἡ ΑΒ, ῥητὴ δὲ ἡ ΓΔ, καὶ τῷ ἀπὸ τῆς ΑΒ ἴσον παρὰ ῥητὴν τὴν ΓΔ παραβεβλήσθω τὸ ΓΕ πλάτος ποιοῦν τὴν ΓΖ· λέγω, ὅτι ἡ ΓΖ ἀποτομή ἐστι τετάρτη.

Ἔστω γὰρ τῇ ΑΒ προσαρμόζουσα ἡ ΒΗ· αἱ ἄρα ΑΗ, ΗΒ δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΗ, ΗΒ τετραγώνων ῥητόν, τὸ δὲ δὶς ὑπὸ τῶν ΑΗ, ΗΒ μέσον. καὶ τῷ μὲν ἀπὸ τῆς ΑΗ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω τὸ ΓΘ πλάτος ποιοῦν τὴν ΓΚ, τῷ δὲ ἀπὸ τῆς ΒΗ ἴσον τὸ ΚΛ πλάτος ποιοῦν τὴν ΚΜ· ὅλον ἄρα τὸ ΓΛ ἴσον ἐστὶ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ. καί ἐστι τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΗ, ΗΒ ῥητόν· ῥητὸν ἄρα ἐστὶ καὶ τὸ ΓΛ. καὶ παρὰ ῥητὴν τὴν ΓΔ παράκειται πλάτος ποιοῦν τὴν ΓΜ· ῥητὴ ἄρα καὶ ἡ ΓΜ καὶ σύμμετρος τῇ ΓΔ μήκει. καὶ ἐπεὶ ὅλον τὸ ΓΛ ἴσον ἐστὶ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ, ὧν τὸ ΓΕ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΑΒ, λοιπὸν ἄρα τὸ ΖΛ ἴσον ἐστὶ τῷ δὶς ὑπὸ τῶν ΑΗ, ΗΒ. τετμήσθω οὖν ἡ ΖΜ δίχα κατὰ τὸ Ν σημεῖον, καὶ ἤχθω δια τοῦ Ν ὁποτέρᾳ τῶν ΓΔ,

Proposition 100

The (square) on a minor (straight-line), applied to a rational (straight-line), produces a fourth apotome as breadth.



Let AB be a minor (straight-line), and CD a rational (straight-line). And let CE, equal to the (square) on AB, have been applied to the rational (straight-line) CD, producing CF as breadth. I say that CF is a fourth apotome.

For let BG be an attachment to AB. Thus, AG and GB are incommensurable in square, making the sum of the squares on AG and GB rational, and twice the (rectangle contained) by AG and GB medial [Prop. 10.76]. And let CH, equal to the (square) on AG, have been applied to CD, producing CK as breadth, and KL, equal to the (square) on BG, producing KM as breadth. Thus, the whole of CL is equal to the (sum of the squares) on AG and GB. And the sum of the (squares) on AG and GB is rational. CL is thus also rational. And it is applied to the rational (straight-line) CD, producing CM as breadth. Thus, CM (is) also rational, and commensurable in length with CD [Prop. 10.20]. And since the

ΜΛ παράλληλος ἡ ΝΞ· ἑκάτερον ἄρα τῶν ΖΞ, ΝΛ ἴσον ἐστὶ τῷ ὑπὸ τῶν ΑΗ, ΗΒ. καὶ ἐπεὶ τὸ δὶς ὑπὸ τῶν ΑΗ, ΗΒ μέσον ἐστὶ καί ἐστιν ἴσον τῷ ΖΛ, καὶ τὸ ΖΛ ἄρα μέσον ἐστίν. καὶ παρὰ ῥητὴν τὴν ΖΕ παράκειται πλάτος ποιοῦν τὴν ΖΜ· ῥητὴ ἄρα ἐστὶν ἡ ΖΜ καὶ ἀσύμμετρος τῇ ΓΔ μήκει. καὶ ἐπεὶ τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΗ, ΗΒ ῥητόν ἐστιν, τὸ δὲ δὶς ὑπὸ τῶν ΑΗ, ΗΒ μέσον, ἀσύμμετρα [ἄρα] ἐστὶ τὰ ἀπὸ τῶν ΑΗ, ΗΒ τῷ δὶς ὑπὸ τῶν ΑΗ, ΗΒ. ἴσον δέ [ἐστι] τὸ ΓΛ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ, τῷ δὲ δὶς ὑπὸ τῶν ΑΗ, ΗΒ ἴσον τὸ ΖΛ· ἀσύμμετρον ἄρα [ἐστὶ] τὸ ΓΛ τῷ ΖΛ. ὡς δὲ τὸ ΓΛ πρὸς τὸ ΖΛ, οὕτως ἐστὶν ἡ ΓΜ πρὸς τὴν ΜΖ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΓΜ τῇ ΜΖ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ἄρα ΓΜ, ΜΖ ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΓΖ. λέγω [δή], ὅτι καὶ τετάρτη.

Ἐπεὶ γὰρ αἱ ΑΗ, ΗΒ δυνάμει εἰσὶν ἀσύμμετροι, ἀσύμμετρον ἄρα καὶ τὸ ἀπὸ τῆς ΑΗ τῷ ἀπὸ τῆς ΗΒ. καί ἐστι τῷ μὲν ἀπὸ τῆς ΑΗ ἴσον τὸ ΓΘ, τῷ δὲ ἀπὸ τῆς ΗΒ ἴσον τὸ ΚΛ· ἀσύμμετρον ἄρα ἐστὶ τὸ ΓΘ τῷ ΚΛ. ὡς δὲ τὸ ΓΘ πρὸς τὸ ΚΛ, οὕτως ἐστὶν ἡ ΓΚ πρὸς τὴν ΚΜ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΓΚ τῇ ΚΜ μήκει. καὶ ἐπεὶ τῶν ἀπὸ τῶν ΑΗ, ΗΒ μέσον ἀνάλογόν ἐστι τὸ ὑπὸ τῶν ΑΗ, ΗΒ, καί ἐστιν ἴσον τὸ μὲν ἀπὸ τῆς ΑΗ τῷ ΓΘ, τὸ δὲ ἀπὸ τῆς ΗΒ τῷ ΚΛ, τὸ δὲ ὑπὸ τῶν ΑΗ, ΗΒ τῷ ΝΛ, τῶν ἄρα ΓΘ, ΚΛ μέσον ἀνάλογόν ἐστι τὸ ΝΛ· ἔστιν ἄρα ὡς τὸ ΓΘ πρὸς τὸ ΝΛ, οὕτως τὸ ΝΛ πρὸς τὸ ΚΛ. ἀλλʼ ὡς μὲν τὸ ΓΘ πρὸς τὸ ΝΛ, οὕτως ἐστίν ἡ ΓΚ πρὸς τὴν ΝΜ, ὡς δὲ τὸ ΝΛ πρὸς τὸ ΚΛ, οὕτως ἐστὶν ἡ ΝΜ πρὸς τὴν ΚΜ· ὡς ἄρα ἡ ΓΚ πρὸς τὴν ΜΝ, οὕτως ἐστὶν ἡ ΜΝ πρὸς τὴν ΚΜ· τὸ ἄρα ὑπὸ τῶν ΓΚ, ΚΜ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΜΝ, τουτέστι τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΖΜ. ἐπεὶ οὖν δύο εὐθεῖαι ἄνισοί εἰσιν αἱ ΓΜ, ΜΖ, καὶ τῷ τετράρτῳ μέρει τοῦ ἀπὸ τῆς ΜΖ ἴσον παρὰ τὴν ΓΜ παραβέβληται ἐλλεῖπον εἴδει τετραγώνῳ τὸ ὑπὸ τῶν ΓΚ, ΚΜ καὶ εἰς ἀσύμμετρα αὐτὴν διαιρεῖ, ἡ ἄρα ΓΜ τῆς ΜΖ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καί ἐστιν ὅλη ἡ ΓΜ σύμμετρος μήκει τῇ ἐκκειμένῃ ῥητῇ τῇ ΓΔ· ἡ ἄρα ΓΖ ἀποτομή ἐστι τετάρτη.

Τὸ ἄρα ἀπὸ ἐλάσσονος καὶ τὰ ἑξῆς.

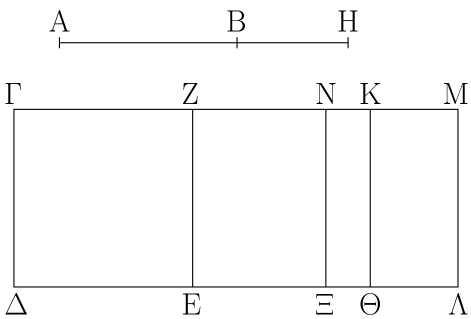
whole of CL is equal to the (sum of the squares) on AG and GB, of which CE is equal to the (square) on AB, the remainder FL is thus equal to twice the (rectangle contained) by AG and GB [Prop. 2.7]. Therefore, let FM have been cut in half at point N. And let NO have been drawn through N, parallel to either of CD or ML. Thus, FO and NL are each equal to the (rectangle contained) by AG and GB. And since twice the (rectangle contained) by AG and GB is medial, and is equal to FL, FL is thus also medial. And it is applied to the rational (straight-line) FE, producing FM as breadth. Thus, FM is rational, and incommensurable in length with CD [Prop. 10.22]. And since the sum of the (squares) on AG and GB is rational, and twice the (rectangle contained) by AG and GB medial, the (sum of the squares) on AG and GB is [thus] incommensurable with twice the (rectangle contained) by AG and GB. And CL (is) equal to the (sum of the squares) on AG and GB, and FL equal to twice the (rectangle contained) by AG and GB. CL [is] thus incommensurable with FL. And as CL (is) to FL, so CM is to MF [Prop. 6.1]. CM is thus incommensurable in length with MF [Prop. 10.11]. And both are rational (straight-lines). Thus, CM and MF are rational (straight-lines which are) commensurable in square only. CF is thus an apotome [Prop. 10.73]. [So], I say that (it is) also a fourth (apotome).

For since AG and GB are incommensurable in square, the (square) on AG (is) thus also incommensurable with the (square) on GB. And CH is equal to the (square) on AG, and KL equal to the (square) on GB. Thus, CH is incommensurable with KL. And as CH (is) to KL, so CK is to KM [Prop. 6.1]. CK is thus incommensurable in length with KM [Prop. 10.11]. And since the (rectangle contained) by AG and GB is the mean proportional to the (squares) on AG and GB [Prop. 10.21 lem.], and the (square) on AG is equal to CH, and the (square) on GB to KL, and the (rectangle contained) by AG and GB to NL, NL is thus the mean proportional to CH and KL. Thus, as CH is to NL, so NL (is) to KL. But, as CH (is) to NL, so CK is to NM, and as NL (is) to KL, so NM is to KM [Prop. 6.1]. Thus, as CK (is) to MN, so MN is to KM [Prop. 5.11]. The (rectangle contained) by CK and KM is thus equal to the (square) on MN—that is to say, to the fourth part of the (square) on FM [Prop. 6.17]. Therefore, since CM and MF are two unequal straight-lines, and the (rectangle contained) by CK and KM, equal to the fourth part of the (square) on MF, has been applied to CM, falling short by a square figure, and divides it into incommensurable (parts), the square on CM is thus greater than (the square on) MF by the (square) on (some straight-line) incommensurable (in length) with (CM) [Prop. 10.18]. And the whole of CM is commensurable in length with the (previously) laid down rational (straight-line) CD. Thus, CF is a fourth apotome [Def. 10.14].

Thus, the (square) on a minor, and so on …

ρα΄.

Τὸ ἀπὸ τῆς μετὰ ῥητοῦ μέσον τὸ ὅλον ποιούσης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν πέμπτην.



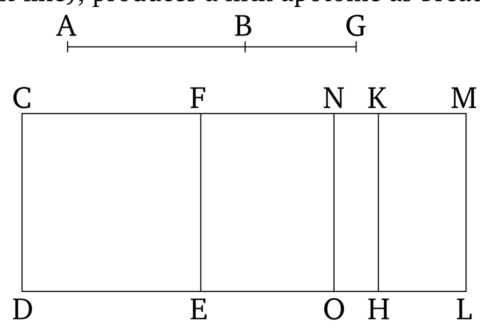
Ἔστω ἡ μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσα ἡ ΑΒ, ῥητὴ δὲ ἡ ΓΔ, καὶ τῷ ἀπὸ τῆς ΑΒ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω τὸ ΓΕ πλάτος ποιοῦν τὴν ΓΖ· λέγω, ὅτι ἡ ΓΖ ἀποτομή ἐστι πέμπτη.

Ἔστω γὰρ τῇ ΑΒ προσαρμόζουσα ἡ ΒΗ· αἱ ἄρα ΑΗ, ΗΒ εὐθεῖαι δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον, τὸ δὲ δὶς ὑπ᾽ αὐτῶν ῥητόν, καὶ τῷ μὲν ἀπὸ τῆς ΑΗ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω τὸ ΓΘ, τῷ δὲ ἀπὸ τῆς ΗΒ ἴσον τὸ ΚΛ· ὅλον ἄρα τὸ ΓΛ ἴσον ἐστὶ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ. τὸ δὲ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΗ, ΗΒ ἅμα μέσον ἐστίν· μέσον ἄρα ἐστὶ τὸ ΓΛ. καὶ παρὰ ῥητὴν τὴν ΓΔ παράκειται πλάτος ποιοῦν τὴν ΓΜ· ῥητὴ ἄρα ἐστὶν ἡ ΓΜ καὶ ἀσύμμετρος τῇ ΓΔ. καὶ ἐπεὶ ὅλον τὸ ΓΛ ἴσον ἐστὶ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ, ὧν τὸ ΓΕ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΑΒ, λοιπὸν ἄρα τὸ ΖΛ ἴσον ἐστὶ τῷ δὶς ὑπὸ τῶν ΑΗ, ΗΒ. τετμήσθω οὖν ἡ ΖΜ δίχα κατὰ τὸ Ν, καὶ ἤχθω διὰ τοῦ Ν ὁποτέρᾳ τῶν ΓΔ, ΜΛ παράλληλος ἡ ΝΞ· ἑκάτερον ἄρα τῶν ΖΞ, ΝΛ ἴσον ἐστὶ τῷ ὑπὸ τῶν ΑΗ, ΗΒ, καὶ ἐπεὶ τὸ δὶς ὑπὸ τῶν ΑΗ, ΗΒ ῥητόν ἐστι καί [ἐστιν] ἴσον τῷ ΖΛ, ῥητὸν ἄρα ἐστὶ τὸ ΖΛ. καὶ παρὰ ῥητὴν τὴν ΕΖ παράκειται πλάτος ποιοῦν τὴν ΖΜ· ῥητὴ ἄρα ἐστὶν ἡ ΖΜ καὶ σύμμετρος τῇ ΓΔ μήκει. καὶ ἐπεὶ τὸ μὲν ΓΛ μέσον ἐστίν, τὸ δὲ ΖΛ ῥητόν, ἀσύμμετρον ἄρα ἐστὶ τὸ ΓΛ τῷ ΖΛ. ὡς δὲ τὸ ΓΛ πρὸς τὸ ΖΛ, οὕτως ἡ ΓΜ πρὸς τὴν ΜΖ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΓΜ τῇ ΜΖ μήκει. καί εἰσιν ἀμφότεραι ῥηταί· αἱ ἄρα ΓΜ, ΜΖ ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΓΖ. λὲγω δή, ὅτι καὶ πέμπτη.

Ὁμοίως γὰρ δείξομεν, ὅτι τὸ ὑπὸ τῶν ΓΚΜ ἴσον ἐστὶ τῷ ἀπὸ τῆς ΝΜ, τουτέστι τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς

Proposition 101

The (square) on that (straight-line) which with a rational (area) makes a medial whole, applied to a rational (straight-line), produces a fifth apotome as breadth.



Let AB be that (straight-line) which with a rational (area) makes a medial whole, and CD a rational (straight-line). And let CE, equal to the (square) on AB, have been applied to CD, producing CF as breadth. I say that CF is a fifth apotome.

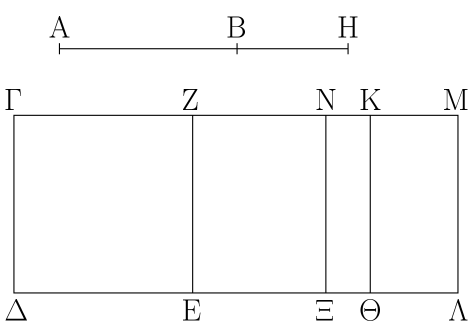
Let BG be an attachment to AB. Thus, the straight-lines AG and GB are incommensurable in square, making the sum of the squares on them medial, and twice the (rectangle contained) by them rational [Prop. 10.77]. And let CH, equal to the (square) on AG, have been applied to CD, and KL, equal to the (square) on GB. The whole of CL is thus equal to the (sum of the squares) on AG and GB. And the sum of the (squares) on AG and GB together is medial. Thus, CL is medial. And it has been applied to the rational (straight-line) CD, producing CM as breadth. CM is thus rational, and incommensurable (in length) with CD [Prop. 10.22]. And since the whole of CL is equal to the (sum of the squares) on AG and GB, of which CE is equal to the (square) on AB, the remainder FL is thus equal to twice the (rectangle contained) by AG and GB [Prop. 2.7]. Therefore, let FM have been cut in half at N. And let NO have been drawn through N, parallel to either of CD or ML. Thus, FO and NL are each equal to the (rectangle contained) by AG and GB. And since twice the (rectangle contained) by AG and GB is rational, and [is] equal to FL, FL is thus rational. And it is applied to the rational (straight-line) EF, producing FM as breadth. Thus, FM is rational, and commensurable in length with CD [Prop. 10.20]. And since CL is medial, and FL rational, ΖΜ. καὶ ἐπεὶ ἀσύμμετρόν ἐστι τὸ ἀπὸ τῆς ΑΗ τῷ ἀπὸ τῆς ΗΒ, ἴσον δὲ τὸ μὲν ἀπὸ τῆς ΑΗ τῷ ΓΘ, τὸ δὲ ἀπὸ τῆς ΗΒ τῷ ΚΛ, ἀσύμμετρον ἄρα τὸ ΓΘ τῷ ΚΛ. ὡς δὲ τὸ ΓΘ πρὸς τὸ ΚΛ, οὕτως ἡ ΓΚ πρὸς τὴν ΚΜ· ἀσύμμετρος ἄρα ἡ ΓΚ τῇ ΚΜ μήκει. ἐπεὶ οὖν δύο εὐθεῖαι ἄνισοί εἰσιν αἱ ΓΜ, ΜΖ, καὶ τῷ τετάρτῳ μέρει τοῦ ἀπὸ τῆς ΖΜ ἴσον παρὰ τὴν ΓΜ παραβέβληται ἐλλεῖπον εἴδει τετραγώνῳ καὶ εἰς ἀσύμμετρα αὐτὴν διαιρεῖ, ἡ ἄρα ΓΜ τῆς ΜΖ μεῖζον δύναται τῷ ἀπὸ ἀσύμμέτρου ἑαυτῇ. καί ἐστιν ἡ προσαρμόζουσα ἡ ΖΜ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ τῇ ΓΔ· ἡ ἄρα ΓΖ ἀποτομή ἐστι πέμπτη· ὅπερ ἔδει δεῖξαι.

CL is thus incommensurable with FL. And as CL (is) to FL, so CM (is) to MF [Prop. 6.1]. CM is thus incommensurable in length with MF [Prop. 10.11]. And both are rational. Thus, CM and MF are rational (straight-lines which are) commensurable in square only. CF is thus an apotome [Prop. 10.73]. So, I say that (it is) also a fifth (apotome).

For, similarly (to the previous propositions), we can show that the (rectangle contained) by CKM is equal to the (square) on NM—that is to say, to the fourth part of the (square) on FM. And since the (square) on AG is incommensurable with the (square) on GB, and the (square) on AG (is) equal to CH, and the (square) on GB to KL, CH (is) thus incommensurable with KL. And as CH (is) to KL, so CK (is) to KM [Prop. 6.1]. Thus, CK (is) incommensurable in length with KM [Prop. 10.11]. Therefore, since CM and MF are two unequal straight-lines, and (some area), equal to the fourth part of the (square) on FM, has been applied to CM, falling short by a square figure, and divides it into incommensurable (parts), the square on CM is thus greater than (the square on) MF by the (square) on (some straight-line) incommensurable (in length) with (CM) [Prop. 10.18]. And the attachment FM is commensurable with the (previously) laid down rational (straight-line) CD. Thus, CF is a fifth apotome [Def. 10.15]. (Which is) the very thing it was required to show.

ρβ΄.

Τὸ ἀπὸ τῆς μετὰ μέσου μέσον τὸ ὅλον ποιούσης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν ἕκτην.

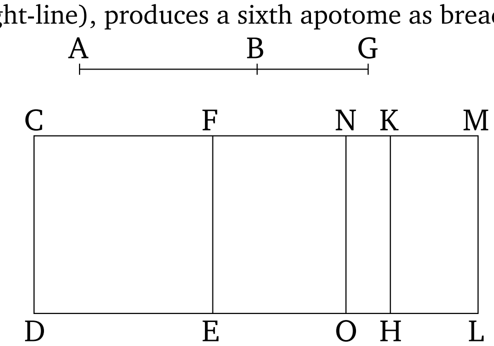


Ἔστω ἡ μετὰ μέσου μέσον τὸ ὅλον ποιοῦσα ἡ ΑΒ, ῥητὴ δὲ ἡ ΓΔ, καὶ τῷ ἀπὸ τῆς ΑΒ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω τὸ ΓΕ πλάτος ποιοῦν τὴν ΓΖ· λέγω, ὅτι ἡ ΓΖ ἀποτομή ἐστιν ἕκτη.

Ἔστω γὰρ τῇ ΑΒ προσαρμόζουσα ἡ ΒΗ· αἱ ἄρα ΑΗ, ΗΒ δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τό τε συγκείμενον ἐκ τῶν ἀπ᾿ αὐτῶν τετραγώνων μέσον καὶ τὸ δὶς ὑπὸ τῶν ΑΗ, ΗΒ μέσον καὶ ἀσύμμετρον τὰ ἀπὸ τῶν ΑΗ, ΗΒ τῷ

Proposition 102

The (square) on that (straight-line) which with a medial (area) makes a medial whole, applied to a rational (straight-line), produces a sixth apotome as breadth.



Let AB be that (straight-line) which with a medial (area) makes a medial whole, and CD a rational (straight-line). And let CE, equal to the (square) on AB, have been applied to CD, producing CF as breadth. I say that CF is a sixth apotome.

For let BG be an attachment to AB. Thus, AG and GB are incommensurable in square, making the sum of the squares on them medial, and twice the (rectangle δὶς ὑπὸ τῶν ΑΗ, ΗΒ. παραβεβλήσθω οὖν παρὰ τὴν ΓΔ τῷ μὲν ἀπὸ τῆς ΑΗ ἴσον τὸ ΓΘ πλάτος ποιοῦν τὴν ΓΚ, τῷ δὲ ἀπὸ τῆς ΒΗ τὸ ΚΛ· ὅλον ἄρα τὸ ΓΛ ἴσον ἐστὶ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ· μέσον ἄρα [ἐστὶ] καὶ τὸ ΓΛ. καὶ παρὰ ῥητὴν τὴν ΓΔ παράκειται πλάτος ποιοῦν τὴν ΓΜ· ῥητὴ ἄρα ἐστὶν ἡ ΓΜ καὶ ἀσύμμετρος τῇ ΓΔ μήκει. ἐπεὶ οὖν τὸ ΓΛ ἴσον ἐστὶ τοῖς ἀπὸ τῶν ΑΗ, ΗΒ, ὧν τὸ ΓΕ ἴσον τῷ ἀπὸ τῆς ΑΒ, λοιπὸν ἄρα τὸ ΖΛ ἴσον ἐστὶ τῷ δὶς ὑπὸ τῶν ΑΗ, ΗΒ. καί ἐστι τὸ δὶς ὑπὸ τῶν ΑΗ, ΗΒ μέσον· καὶ τὸ ΖΛ ἄρα μέσον ἐστίν. καὶ παρὰ ῥητὴν τὴν ΖΕ παράκειται πλάτος ποιοῦν τὴν ΖΜ· ῥητὴ ἄρα ἐστὶν ἡ ΖΜ καὶ ἀσύμμετρος τῇ ΓΔ μήκει. καὶ ἐπεὶ τὰ ἀπὸ τῶν ΑΗ, ΗΒ ἀσύμμετρά ἐστι τῷ δὶς ὑπὸ τῶν ΑΗ, ΗΒ, καί ἐστι τοῖς μὲν ἀπὸ τῶν ΑΗ, ΗΒ ἴσον τὸ ΓΛ, τῷ δὲ δὶς ὑπὸ τῶν ΑΗ, ΗΒ ἴσον τὸ ΖΛ, ἀσύμμετρος ἄρα [ἐστὶ] τὸ ΓΛ τῷ ΖΛ. ὡς δὲ τὸ ΓΛ πρὸς τὸ ΖΛ, οὕτως ἐστὶν ἡ ΓΜ πρὸς τὴν ΜΖ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΓΜ τῇ ΜΖ μήκει. καί εἰσιν ἀμφότεραι ῥηταί. αἱ ΓΜ, ΜΖ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΓΖ. λέγω δή, ὅτι καὶ ἕκτη.

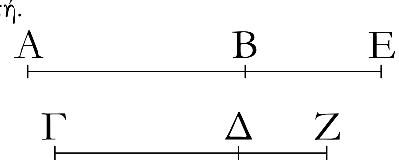
Ἐπεὶ γὰρ τὸ ΖΛ ἴσον ἐστὶ τῷ δὶς ὑπὸ τῶν ΑΗ, ΗΒ, τετμήσθω δίχα ἡ ΖΜ κατὰ τὸ Ν, καὶ ἤχθω διὰ τοῦ Ν τῇ ΓΔ παράλληλος ἡ ΝΞ· ἑκάτερον ἄρα τῶν ΖΞ, ΝΛ ἴσον ἐστὶ τῷ ὑπὸ τῶν ΑΗ, ΗΒ. καὶ ἐπεὶ αἱ ΑΗ, ΗΒ δυνάμει εἰσὶν ἀσύμμετροι, ἀσύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς ΑΗ τῷ ἀπὸ τῆς ΗΒ. ἀλλὰ τῷ μὲν ἀπὸ τῆς ΑΗ ἴσον ἐστὶ τὸ ΓΘ, τῷ δὲ ἀπὸ τῆς ΗΒ ἴσον ἐστὶ τὸ ΚΛ· ἀσύμμετρον ἄρα ἐστὶ τὸ ΓΘ τῷ ΚΛ. ὡς δὲ τὸ ΓΘ πρὸς τὸ ΚΛ, οὕτως ἐστὶν ἡ ΓΚ πρὸς τὴν ΚΜ· ἀσύμμετρος ἄρα ἐστὶν ἡ ΓΚ τῇ ΚΜ. καὶ ἐπεὶ τῶν ἀπὸ τῶν ΑΗ, ΗΒ μέσον ἀνάλογόν ἐστι τὸ ὑπὸ τῶν ΑΗ, ΗΒ, καὶ ἐστι τῷ μὲν ἀπὸ τῆς ΑΗ ἴσον τὸ ΓΘ, τῷ δὲ ἀπὸ τῆς ΗΒ ἴσον τὸ ΚΛ, τῷ δὲ ὑπὸ τῶν ΑΗ, ΗΒ ἴσον τὸ ΝΛ, καὶ τῶν ἄρα ΓΘ, ΚΛ μέσον ἀνάλογόν ἐστι τὸ ΝΛ· ἔστιν ἄρα ὡς τὸ ΓΘ πρὸς τὸ ΝΛ, οὕτως τὸ ΝΛ πρὸς τὸ ΚΛ. καὶ διὰ τὰ αὐτὰ ἡ ΓΜ τῆς ΜΖ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καὶ οὐδετέρα αὐτῶν σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ τῇ ΓΔ· ἡ ΓΖ ἄρα ἀποτομή ἐστιν ἕκτη· ὅπερ ἔδει δεῖξαι.

contained) by AG and GB medial, and the (sum of the squares) on AG and GB incommensurable with twice the (rectangle contained) by AG and GB [Prop. 10.78]. Therefore, let CH, equal to the (square) on AG, have been applied to CD, producing CK as breadth, and KL, equal to the (square) on BG. Thus, the whole of CL is equal to the (sum of the squares) on AG and GB. CL [is] thus also medial. And it is applied to the rational (straight-line) CD, producing CM as breadth. Thus, CM is rational, and incommensurable in length with CD [Prop. 10.22]. Therefore, since CL is equal to the (sum of the squares) on AG and GB, of which CE (is) equal to the (square) on AB, the remainder FL is thus equal to twice the (rectangle contained) by AG and GB [Prop. 2.7]. And twice the (rectangle contained) by AG and GB (is) medial. Thus, FL is also medial. And it is applied to the rational (straight-line) FE, producing FM as breadth. FM is thus rational, and incommensurable in length with CD [Prop. 10.22]. And since the (sum of the squares) on AG and GB is incommensurable with twice the (rectangle contained) by AG and GB, and CL equal to the (sum of the squares) on AG and GB, and FL equal to twice the (rectangle contained) by AG and GB, CL [is] thus incommensurable with FL. And as CL (is) to FL, so CM is to MF [Prop. 6.1]. Thus, CM is incommensurable in length with MF [Prop. 10.11]. And they are both rational. Thus, CM and MF are rational (straight-lines which are) commensurable in square only. CF is thus an apotome [Prop. 10.73]. So, I say that (it is) also a sixth (apotome).

For since FL is equal to twice the (rectangle contained) by AG and GB, let FM have been cut in half at N, and let NO have been drawn through N, parallel to CD. Thus, FO and NL are each equal to the (rectangle contained) by AG and GB. And since AG and GB are incommensurable in square, the (square) on AG is thus incommensurable with the (square) on GB. But, CH is equal to the (square) on AG, and KL is equal to the (square) on GB. Thus, CH is incommensurable with KL. And as CH (is) to KL, so CK is to KM [Prop. 6.1]. Thus, CK is incommensurable (in length) with KM [Prop. 10.11]. And since the (rectangle contained) by AG and GB is the mean proportional to the (squares) on AG and GB [Prop. 10.21 lem.], and CH is equal to the (square) on AG, and KL equal to the (square) on GB, and NL equal to the (rectangle contained) by AG and GB, NL is thus also the mean proportional to CH and KL. Thus, as CH is to NL, so NL (is) to KL. And for the same (reasons as the preceding propositions), the square on CM is greater than (the square on) MF by the (square) on (some straight-line) incommensurable (in length) with (CM) [Prop. 10.18]. And neither of them is commensurable with the (previously) laid down rational (straight-line) CD. Thus, CF is a sixth apotome [Def. 10.16]. (Which is) the very thing it was required to show.

ργ΄.

Ἡ τῇ ἀποτομῇ μήκει σύμμετρος ἀποτομή ἐστι καὶ τῇ τάξει ἡ αὐτή.



Ἔστω ἀποτομὴ ἡ ΑΒ, καὶ τῇ ΑΒ μήκει σύμμετρος ἔστω ἡ ΓΔ· λέγω, ὅτι καὶ ἡ ΓΔ ἀποτομή ἐστι καὶ τῇ τάξει ἡ αὐτὴ τῇ ΑΒ.

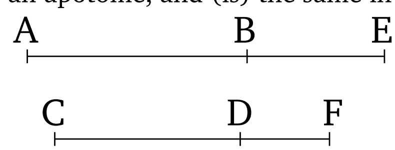
Ἐπεὶ γὰρ ἀποτομή ἐστιν ἡ ΑΒ, ἔστω αὐτῇ προσαρμόζουσα ἡ ΒΕ· αἱ ΑΕ, ΕΒ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. καὶ τῷ τῆς ΑΒ πρὸς τὴν ΓΔ λόγῳ ὁ αὐτὸς γεγονέτω ὁ τῆς ΒΕ πρὸς τὴν ΔΖ· καὶ ὡς ἓν ἄρα πρὸς ἕν, πάντα [ἐστὶ] πρὸς πάντα· ἔστιν ἄρα καὶ ὡς ὅλη ἡ ΑΕ πρὸς ὅλην τὴν ΓΖ, οὕτως ἡ ΑΒ πρὸς τὴν ΓΔ. σύμμετρος δὲ ἡ ΑΒ τῇ ΓΔ μήκει· σύμμετρος ἄρα καὶ ἡ ΑΕ μὲν τῇ ΓΖ, ἡ δὲ ΒΕ τῇ ΔΖ. καὶ αἱ ΑΕ, ΕΒ ῥηταί εἰσι δυνάμει μόνον σύμμετροι· καὶ αἱ ΓΖ, ΖΔ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι [ἀποτομὴ ἄρα ἐστὶν ἡ ΓΔ. λέγω δή, ὅτι καὶ τῇ τάξει ἡ αὐτὴ τῇ ΑΒ].

Ἐπεὶ οὖν ἐστιν ὡς ἡ ΑΕ πρὸς τὴν ΓΖ, οὕτως ἡ ΒΕ πρὸς τὴν ΔΖ, ἐναλλὰξ ἄρα ἐστὶν ὡς ἡ ΑΕ πρὸς τὴν ΕΒ, οὕτως ἡ ΓΖ πρὸς τὴν ΖΔ. ἤτοι δὴ ἡ ΑΕ τῆς ΕΒ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ ἢ τῷ ἀπὸ ἀσυμμέτρου. εἰ μὲν οὖν ἡ ΑΕ τῆς ΕΒ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καὶ ἡ ΓΖ τῆς ΖΔ μεῖζον δυνήσεται τῷ ἀπὸ συμμέτρου ἑαυτῇ. καὶ εἰ μὲν σύμμετρός ἐστιν ἡ ΑΕ τῇ ἐκκειμένῃ ῥητῇ μήκει, καὶ ἡ ΓΖ, εἰ δὲ ἡ ΒΕ, καὶ ἡ ΔΖ, εἰ δὲ οὐδετέρα τῶν ΑΕ, ΕΒ, καὶ οὐδετέρα τῶν ΓΖ, ΖΔ. εἰ δὲ ἡ ΑΕ [τῆς ΕΒ] μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, καὶ ἡ ΓΖ τῆς ΖΔ μεῖζον δυνήσεται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καὶ εἰ μὲν σύμμετρός ἐστιν ἡ ΑΕ τῇ ἐκκειμένῃ ῥητῇ μήκει, καὶ ἡ ΓΖ, εἰ δὲ ἡ ΒΕ, καὶ ἡ ΔΖ, εἰ δὲ οὐδετέρα τῶν ΑΕ, ΕΒ, οὐδετέρα τῶν ΓΖ, ΖΔ.

Ἀποτομὴ ἄρα ἐστὶν ἡ ΓΔ καὶ τῇ τάξει ἡ αὐτὴ τῇ ΑΒ· ὅπερ ἔδει δεῖξαι.

Proposition 103

A (straight-line) commensurable in length with an apotome is an apotome, and (is) the same in order.



Let AB be an apotome, and let CD be commensurable in length with AB. I say that CD is also an apotome, and (is) the same in order as AB.

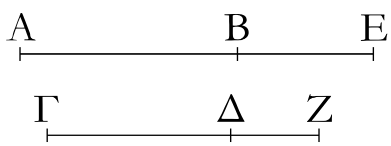
For since AB is an apotome, let BE be an attachment to it. Thus, AE and EB are rational (straight-lines which are) commensurable in square only [Prop. 10.73]. And let it have been contrived that the (ratio) of BE to DF is the same as the ratio of AB to CD [Prop. 6.12]. Thus, also, as one is to one, (so) all [are] to all [Prop. 5.12]. And thus as the whole AE is to the whole CF, so AB (is) to CD. And AB (is) commensurable in length with CD. AE (is) thus also commensurable (in length) with CF, and BE with DF [Prop. 10.11]. And AE and BE are rational (straight-lines which are) commensurable in square only. Thus, CF and FD are also rational (straight-lines which are) commensurable in square only [Prop. 10.13]. [CD is thus an apotome. So, I say that (it is) also the same in order as AB.]

Therefore, since as AE is to CF, so BE (is) to DF, thus, alternately, as AE is to EB, so CF (is) to FD [Prop. 5.16]. So, the square on AE is greater than (the square on) EB either by the (square) on (some straight-line) commensurable, or by the (square) on (some straight-line) incommensurable, (in length) with (AE). Therefore, if the (square) on AE is greater than (the square on) EB by the (square) on (some straight-line) commensurable (in length) with (AE) then the square on CF will also be greater than (the square on) FD by the (square) on (some straight-line) commensurable (in length) with (CF) [Prop. 10.14]. And if AE is commensurable in length with a (previously) laid down rational (straight-line) then so (is) CF [Prop. 10.12], and if BE (is commensurable), so (is) DF, and if neither of AE or EB (are commensurable), neither (are) either of CF or FD [Prop. 10.13]. And if the (square) on AE is greater [than (the square on) EB] by the (square) on (some straight-line) incommensurable (in length) with (AE) then the (square) on CF will also be greater than (the square on) FD by the (square) on (some straight-line) incommensurable (in length) with (CF) [Prop. 10.14]. And if AE is commensurable in length with a (previously) laid down rational (straight-line), so (is) CF [Prop. 10.12], and if BE (is commensurable), so (is) DF, and if neither of AE or EB (are commensurable), neither (are) either of CF or FD [Prop. 10.13].

Thus, CD is an apotome, and (is) the same in order as AB [Defs. 10.11—10.16]. (Which is) the very thing it was required to show.

ρδ΄.

Ἡ τῇ μέσης ἀποτομῇ σύμμετρος μέσης ἀποτομή ἐστι καὶ τῇ τάξει ἡ αὐτή.



Ἔστω μέσης ἀποτομὴ ἡ ΑΒ, καὶ τῇ ΑΒ μήκει σύμμετρος ἔστω ἡ ΓΔ· λέγω, ὅτι καὶ ἡ ΓΔ μέσης ἀποτομή ἐστι καὶ τῇ τάξει ἡ αὐτὴ τῇ ΑΒ.

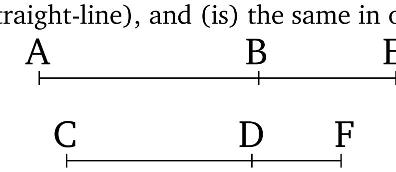
Ἐπεὶ γὰρ μέσης ἀποτομή ἐστιν ἡ ΑΒ, ἔστω αὐτῇ προσαρμόζουσα ἡ ΕΒ. αἱ ΑΕ, ΕΒ ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι. καὶ γεγονέτω ὡς ἡ ΑΒ πρὸς τὴν ΓΔ, οὕτως ἡ ΒΕ πρὸς τὴν ΔΖ· σύμμετρος ἄρα [ἐστὶ] καὶ ἡ ΑΕ τῇ ΓΖ, ἡ δὲ ΒΕ τῇ ΔΖ. αἱ δὲ ΑΕ, ΕΒ μέσαι εἰσὶ δυνάμει μόνον σύμμετροι· καὶ αἱ ΓΖ, ΖΔ ἄρα μέσαι εἰσὶ δυνάμει μόνον σύμμετροι· μέσης ἄρα ἀποτομή ἐστιν ἡ ΓΔ. λέγω δή, ὅτι καὶ τῇ τάξει ἐστὶν ἡ αὐτὴ τῇ ΑΒ.

Ἐπεὶ [γάρ] ἐστιν ὡς ἡ ΑΕ πρὸς τὴν ΕΒ, οὕτως ἡ ΓΖ πρὸς τὴν ΖΔ [ἀλλ᾽ ὡς μὲν ἡ ΑΕ πρὸς τὴν ΕΒ, οὕτως τὸ ἀπὸ τῆς ΑΕ πρὸς τὸ ὑπὸ τῶν ΑΕ, ΕΒ, ὡς δὲ ἡ ΓΖ πρὸς τὴν ΖΔ, οὕτως τὸ ἀπὸ τῆς ΓΖ πρὸς τὸ ὑπὸ τῶν ΓΖ, ΖΔ], ἔστιν ἄρα καὶ ὡς τὸ ἀπὸ τῆς ΑΕ πρὸς τὸ ὑπὸ τῶν ΑΕ, ΕΒ, οὕτως τὸ ἀπὸ τῆς ΓΖ πρὸς τὸ ὑπὸ τῶν ΓΖ, ΖΔ [καὶ ἐναλλὰξ ὡς τὸ ἀπὸ τῆς ΑΕ πρὸς τὸ ἀπὸ τῆς ΓΖ, οὕτως τὸ ὑπὸ τῶν ΑΕ, ΕΒ πρὸς τὸ ὑπὸ τῶν ΓΖ, ΖΔ]. σύμμετρον δὲ τὸ ἀπὸ τῆς ΑΕ τῷ ἀπὸ τῆς ΓΖ· σύμμετρον ἄρα ἐστὶ καὶ τὸ ὑπὸ τῶν ΑΕ, ΕΒ τῷ ὑπὸ τῶν ΓΖ, ΖΔ. εἴτε οὖν ῥητόν ἐστι τὸ ὑπὸ τῶν ΑΕ, ΕΒ, ῥητὸν ἔσται καὶ τὸ ὑπὸ τῶν ΓΖ, ΖΔ, εἴτε μέσον [ἐστὶ] τὸ ὑπὸ τῶν ΑΕ, ΕΒ, μέσον [ἐστὶ] καὶ τὸ ὑπὸ τῶν ΓΖ, ΖΔ.

Μέσης ἄρα ἀποτομή ἐστιν ἡ ΓΔ καὶ τῇ τάξει ἡ αὐτὴ τῇ ΑΒ· ὅπερ ἔδει δεῖξαι.

Proposition 104

A (straight-line) commensurable (in length) with an apotome of a medial (straight-line) is an apotome of a medial (straight-line), and (is) the same in order.



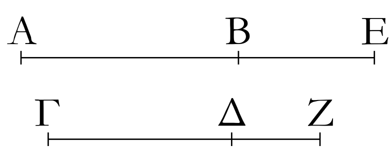
Let AB be an apotome of a medial (straight-line), and let CD be commensurable in length with AB. I say that CD is also an apotome of a medial (straight-line), and (is) the same in order as AB.

For since AB is an apotome of a medial (straight-line), let EB be an attachment to it. Thus, AE and EB are medial (straight-lines which are) commensurable in square only [Props. 10.74, 10.75]. And let it have been contrived that as AB is to CD, so BE (is) to DF [Prop. 6.12]. Thus, AE [is] also commensurable (in length) with CF, and BE with DF [Props. 5.12, 10.11]. And AE and EB are medial (straight-lines which are) commensurable in square only. CF and FD are thus also medial (straight-lines which are) commensurable in square only [Props. 10.23, 10.13]. Thus, CD is an apotome of a medial (straight-line) [Props. 10.74, 10.75]. So, I say that it is also the same in order as AB.

[For] since as AE is to EB, so CF (is) to FD [Props. 5.12, 5.16] [but as AE (is) to EB, so the (square) on AE (is) to the (rectangle contained) by AE and EB, and as CF (is) to FD, so the (square) on CF (is) to the (rectangle contained) by CF and FD], thus as the (square) on AE is to the (rectangle contained) by AE and EB, so the (square) on CF also (is) to the (rectangle contained) by CF and FD [Prop. 10.21 lem.] [and, alternately, as the (square) on AE (is) to the (square) on CF, so the (rectangle contained) by AE and EB (is) to the (rectangle contained) by CF and FD]. And the (square) on AE (is) commensurable with the (square)

ρε´.

Ἡ τῇ ἐλάσσονι σύμμετρος ἐλάσσων ἐστίν.



Ἔστω γὰρ ἐλάσσων ἡ ΑΒ καὶ τῇ ΑΒ σύμμετρος ἡ ΓΔ· λέγω, ὅτι καὶ ἡ ΓΔ ἐλάσσων ἐστίν.

Γεγονέτω γὰρ τὰ αὐτά· καὶ ἐπεὶ αἱ ΑΕ, ΕΒ δυνάμει εἰσὶν ἀσύμμετροι, καὶ αἱ ΓΖ, ΖΔ ἄρα δυνάμει εἰσὶν ἀσύμμετροι. ἐπεὶ οὖν ἐστιν ὡς ἡ ΑΕ πρὸς τὴν ΕΒ, οὕτως ἡ ΓΖ πρὸς τὴν ΖΔ, ἔστιν ἄρα καὶ ὡς τὸ ἀπὸ τῆς ΑΕ πρὸς τὸ ἀπὸ τῆς ΕΒ, οὕτως τὸ ἀπὸ τῆς ΓΖ πρὸς τὸ ἀπὸ τῆς ΖΔ. συνθέντι ἄρα ἐστὶν ὡς τὰ ἀπὸ τῶν ΑΕ, ΕΒ πρὸς τὸ ἀπὸ τῆς ΕΒ, οὕτως τὰ ἀπὸ τῶν ΓΖ, ΖΔ πρὸς τὸ ἀπὸ τῆς ΖΔ [καὶ ἐναλλάξ]· σύμμετρον δέ ἐστι τὸ ἀπὸ τῆς ΒΕ τῷ ἀπὸ τῆς ΔΖ· σύμμετρον ἄρα καὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΕ, ΕΒ τετραγώνων τῷ συγκειμένῳ ἐκ τῶν ἀπὸ τῶν ΓΖ, ΖΔ τετραγώνων. ῥητὸν δέ ἐστι τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΕ, ΕΒ τετραγώνων· ῥητὸν ἄρα ἐστὶ καὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΓΖ, ΖΔ τετραγώνων. πάλιν, ἐπεί ἐστιν ὡς τὸ ἀπὸ τῆς ΑΕ πρὸς τὸ ὑπὸ τῶν ΑΕ, ΕΒ, οὕτως τὸ ἀπὸ τῆς ΓΖ πρὸς τὸ ὑπὸ τῶν ΓΖ, ΖΔ, σύμμετρον δὲ τὸ ἀπὸ τῆς ΑΕ τετράγωνον τῷ ἀπὸ τῆς ΓΖ τετραγώνῳ, σύμμετρον ἄρα ἐστὶ καὶ τὸ ὑπὸ τῶν ΑΕ, ΕΒ τῷ ὑπὸ τῶν ΓΖ, ΖΔ. μέσον δὲ τὸ ὑπὸ τῶν ΑΕ, ΕΒ· μέσον ἄρα καὶ τὸ ὑπὸ τῶν ΓΖ, ΖΔ· αἱ ΓΖ, ΖΔ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων ῥητόν, τὸ δ᾽ ὑπ᾽ αὐτῶν μέσον.

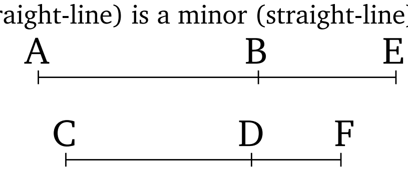
Ἐλάσσων ἄρα ἐστὶν ἡ ΓΔ· ὅπερ ἔδει δεῖξαι.

on CF. Thus, the (rectangle contained) by AE and EB is also commensurable with the (rectangle contained) by CF and FD [Props. 5.16, 10.11]. Therefore, either the (rectangle contained) by AE and EB is rational, and the (rectangle contained) by CF and FD will also be rational [Def. 10.4], or the (rectangle contained) by AE and EB [is] medial, and the (rectangle contained) by CF and FD [is] also medial [Prop. 10.23 corr.].

Therefore, CD is the apotome of a medial (straight-line), and is the same in order as AB [Props. 10.74, 10.75]. (Which is) the very thing it was required to show.

Proposition 105

A (straight-line) commensurable (in length) with a minor (straight-line) is a minor (straight-line).



For let AB be a minor (straight-line), and (let) CD (be) commensurable (in length) with AB. I say that CD is also a minor (straight-line).

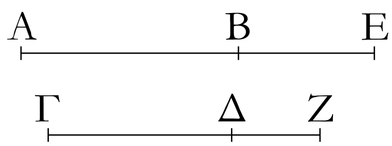
For let the same things have been contrived (as in the former proposition). And since AE and EB are (straight-lines which are) incommensurable in square [Prop. 10.76], CF and FD are thus also (straight-lines which are) incommensurable in square [Prop. 10.13]. Therefore, since as AE is to EB, so CF (is) to FD [Props. 5.12, 5.16], thus also as the (square) on AE is to the (square) on EB, so the (square) on CF (is) to the (square) on FD [Prop. 6.22]. Thus, via composition, as the (sum of the squares) on AE and EB is to the (square) on EB, so the (sum of the squares) on CF and FD (is) to the (square) on FD [Prop. 5.18], [also alternately]. And the (square) on BE is commensurable with the (square) on DF [Prop. 10.104]. The sum of the squares on AE and EB (is) thus also commensurable with the sum of the squares on CF and FD [Prop. 5.16, 10.11]. And the sum of the (squares) on AE and EB is rational [Prop. 10.76]. Thus, the sum of the (squares) on CF and FD is also rational [Def. 10.4]. Again, since as the (square) on AE is to the (rectangle contained) by AE and EB, so the (square) on CF (is) to the (rectangle contained) by CF and FD [Prop. 10.21 lem.], and the square on AE (is) commensurable with the square on CF, the (rectangle contained) by AE and EB is thus also commensurable with the (rectangle contained) by CF and FD. And the (rectangle contained) by AE and EB (is) medial [Prop. 10.76]. Thus, the (rectangle contained) by CF and FD (is) also medial [Prop. 10.23 corr.]. CF and

FD are thus (straight-lines which are) incommensurable in square, making the sum of the squares on them rational, and the (rectangle contained) by them medial.

Thus, CD is a minor (straight-line) [Prop. 10.76]. (Which is) the very thing it was required to show.

ρϛ´.

Ἡ τῇ μετὰ ῥητοῦ μέσον τὸ ὅλον ποιούσῃ σύμμετρος μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσά ἐστιν.



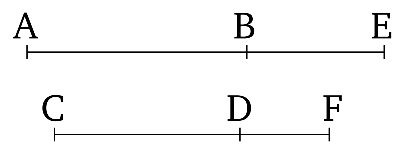
Ἔστω μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσα ἡ ΑΒ καὶ τῇ ΑΒ σύμμετρος ἡ ΓΔ· λέγω, ὅτι καὶ ἡ ΓΔ μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσά ἐστιν.

Ἔστω γὰρ τῇ ΑΒ προσαρμόζουσα ἡ ΒΕ· αἱ ΑΕ, ΕΒ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΕ, ΕΒ τετραγώνων μέσον, τὸ δ᾽ ὑπ᾽ αὐτῶν ῥητόν. καὶ τὰ αὐτὰ κατεσκευάσθω. ὁμοίως δὴ δείξομεν τοῖς πρότερον, ὅτι αἱ ΓΖ, ΖΔ ἐν τῷ αὐτῷ λόγῳ εἰσὶ ταῖς ΑΕ, ΕΒ, καὶ σύμμετρόν ἐστι τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΕ, ΕΒ τετραγώνων τῷ συγκειμένῳ ἐκ τῶν ἀπὸ τῶν ΓΖ, ΖΔ τετραγώνων, τὸ δὲ ὑπὸ τῶν ΑΕ, ΕΒ τῷ ὑπὸ τῶν ΓΖ, ΖΔ· ὥστε καὶ αἱ ΓΖ, ΖΔ δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τὸ μὲν συγκείμενον ἐκ τῶν ἀπὸ τῶν ΓΖ, ΖΔ τετραγώνων μέσον, τὸ δ᾽ ὑπ᾽ αὐτῶν ῥητόν.

Ἡ ΓΔ ἄρα μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσά ἐστιν· ὅπερ ἔδει δεῖξαι.

Proposition 106

A (straight-line) commensurable (in length) with a (straight-line) which with a rational (area) makes a medial whole is a (straight-line) which with a rational (area) makes a medial whole.



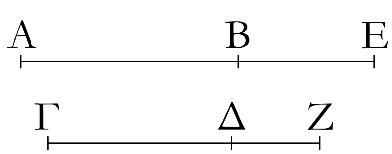
Let AB be a (straight-line) which with a rational (area) makes a medial whole, and (let) CD (be) commensurable (in length) with AB. I say that CD is also a (straight-line) which with a rational (area) makes a medial (whole).

For let BE be an attachment to AB. Thus, AE and EB are (straight-lines which are) incommensurable in square, making the sum of the squares on AE and EB medial, and the (rectangle contained) by them rational [Prop. 10.77]. And let the same construction have been made (as in the previous propositions). So, similarly to the previous (propositions), we can show that CF and FD are in the same ratio as AE and EB, and the sum of the squares on AE and EB is commensurable with the sum of the squares on CF and FD, and the (rectangle contained) by AE and EB with the (rectangle contained) by CF and FD. Hence, CF and FD are also (straight-lines which are) incommensurable in square, making the sum of the squares on CF and FD medial, and the (rectangle contained) by them rational.

CD is thus a (straight-line) which with a rational (area) makes a medial whole [Prop. 10.77]. (Which is) the very thing it was required to show.

ρζ´.

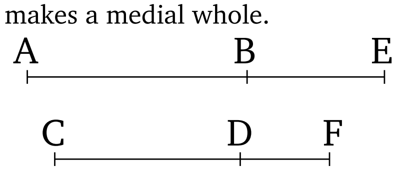
Ἡ τῇ μετὰ μέσου μέσον τὸ ὅλον ποιούσῃ σύμμετρος καὶ αὐτὴ μετὰ μέσου μέσον τὸ ὅλον ποιοῦσά ἐστιν.



Ἔστω μετὰ μέσου μέσον τὸ ὅλον ποιοῦσα ἡ ΑΒ, καὶ τῇ

Proposition 107

A (straight-line) commensurable (in length) with a (straight-line) which with a medial (area) makes a medial whole is itself also a (straight-line) which with a medial (area) makes a medial whole.



Let AB be a (straight-line) which with a medial (area)

ΑΒ ἔστω σύμμετρος ἡ ΓΔ· λέγω, ὅτι καὶ ἡ ΓΔ μετὰ μέσου μέσον τὸ ὅλον ποιοῦσά ἐστιν.

Ἔστω γὰρ τῇ ΑΒ προσαρμόζουσα ἡ ΒΕ, καὶ τὰ αὐτὰ κατεσκευάσθω· αἱ ΑΕ, ΕΒ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τό τε συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον καὶ τὸ ὑπ᾽ αὐτῶν μέσον καὶ ἔτι ἀσύμμετρον τὸ συγκέιμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων τῷ ὑπ᾽ αὐτῶν. καί εἰσιν, ὡς ἐδείχθη, αἱ ΑΕ, ΕΒ σύμμετροι ταῖς ΓΖ, ΖΔ, καὶ τὸ συγκείμενον ἐκ τῶν ἀπὸ τῶν ΑΕ, ΕΒ τετραγώνων τῷ συγκειμένῳ ἐκ τῶν ἀπὸ τῶν ΓΖ, ΖΔ, τὸ δὲ ὑπὸ τῶν ΑΕ, ΕΒ τῷ ὑπὸ τῶν ΓΖ, ΖΔ· καὶ αἱ ΓΖ, ΖΔ ἄρα δυνάμει εἰσὶν ἀσύμμετροι ποιοῦσαι τό τε συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν τετραγώνων μέσον καὶ τὸ ὑπ᾽ ἀὐτῶν μέσον καὶ ἔτι ἀσύμμετρον τὸ συγκείμενον ἐκ τῶν ἀπ᾽ αὐτῶν [τετραγώνων] τῷ ὑπ᾽ αὐτῶν.

Ἡ ΓΔ ἄρα μετὰ μέσου μέσον τὸ ὅλον ποιοῦσά ἐστιν· ὅπερ ἔδει δεῖξαι.

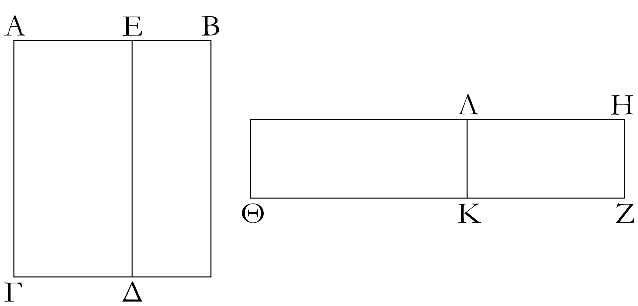
makes a medial whole, and let CD be commensurable (in length) with AB. I say that CD is also a (straight-line) which with a medial (area) makes a medial whole.

For let BE be an attachment to AB. And let the same construction have been made (as in the previous propositions). Thus, AE and EB are (straight-lines which are) incommensurable in square, making the sum of the squares on them medial, and the (rectangle contained) by them medial, and, further, the sum of the squares on them incommensurable with the (rectangle contained) by them [Prop. 10.78]. And, as was shown (previously), AE and EB are commensurable (in length) with CF and FD (respectively), and the sum of the squares on AE and EB with the sum of the squares on CF and FD, and the (rectangle contained) by AE and EB with the (rectangle contained) by CF and FD. Thus, CF and FD are also (straight-lines which are) incommensurable in square, making the sum of the squares on them medial, and the (rectangle contained) by them medial, and, further, the sum of the [squares] on them incommensurable with the (rectangle contained) by them.

Thus, CD is a (straight-line) which with a medial (area) makes a medial whole [Prop. 10.78]. (Which is) the very thing it was required to show.

ρη´.

Ἀπὸ ῥητοῦ μέσου ἀφαιρουμένου ἡ τὸ λοιπὸν χωρίον δυναμένη μία δύο ἀλόγων γίνεται ἤτοι ἀποτομὴ ἢ ἐλάσσων.

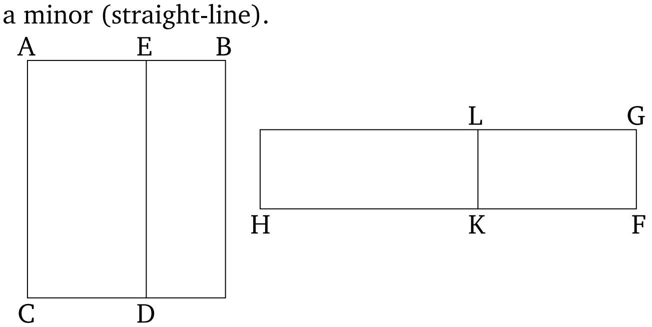


Ἀπὸ γὰρ ῥητοῦ τοῦ ΒΓ μέσον ἀφηρήσθω τὸ ΒΔ· λέγω, ὅτι ἡ τὸ λοιπὸν δυναμένη τὸ ΕΓ μία δύο ἀλόγων γίνεται ἤτοι ἀποτομὴ ἢ ἐλάσσων.

Ἐκκείσθω γὰρ ῥητὴ ἡ ΖΗ, καὶ τῷ μὲν ΒΓ ἴσον παρὰ τὴν ΖΗ παραβεβλήσθω ὀρθογώνιον παραλληλόγραμμον τὸ ΗΘ, τῷ δὲ ΔΒ ἴσον ἀφῃρήσθω τὸ ΗΚ· λοιπὸν ἄρα τὸ ΕΓ ἴσον ἐστὶ τῷ ΛΘ. ἐπεὶ οὖν ῥητὸν μέν ἐστι τὸ ΒΓ, μέσον δὲ τὸ ΒΔ, ἴσον δὲ τὸ μὲν ΒΓ τῷ ΗΘ, τὸ δὲ ΒΔ τῷ ΗΚ, ῥητὸν μὲν ἄρα ἐστὶ τὸ ΗΘ, μέσον δὲ τὸ ΗΚ. καὶ παρὰ ῥητὴν τὴν ΖΗ παράκειται· ῥητὴ μὲν ἄρα ἡ ΖΘ καὶ σύμμετρος τῇ ΖΗ μήκει, ῥητὴ δὲ ἡ ΖΚ καὶ ἀσύμμετρος τῇ ΖΗ μήκει· ἀσύμμετρος ἄρα

Proposition 108

A medial (area) being subtracted from a rational (area), one of two irrational (straight-lines) arise (as) the square-root of the remaining area—either an apotome, or a minor (straight-line).



For let the medial (area) BD have been subtracted from the rational (area) BC. I say that one of two irrational (straight-lines) arise (as) the square-root of the remaining (area), EC—either an apotome, or a minor (straight-line).

For let the rational (straight-line) FG have been laid out, and let the right-angled parallelogram GH, equal to BC, have been applied to FG, and let GK, equal to DB, have been subtracted (from GH). Thus, the remainder EC is equal to LH. Therefore, since BC is a rational (area), and BD a medial (area), and BC (is) equal to ἐστὶν ἡ ΖΘ τῇ ΖΚ μήκει. αἱ ΖΘ, ΖΚ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΚΘ, προσαρμόζουσα δὲ αὐτῇ ἡ ΚΖ. ἤτοι δὴ ἡ ΘΖ τῆς ΖΚ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἢ οὔ.

Δυνάσθω πρότερον τῷ ἀπὸ συμμέτρου. καί ἐστιν ὅλη ἡ ΘΖ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ μήκει τῇ ΖΗ· ἀποτομὴ ἄρα πρώτη ἐστὶν ἡ ΚΘ. τὸ δ᾽ ὑπὸ ῥητῆς καὶ ἀποτομῆς πρώτης περιεχόμενον ἡ δυναμένη ἀποτομή ἐστιν. ἡ ἄρα τὸ ΛΘ, τουτέστι τὸ ΕΓ, δυναμένη ἀποτομή ἐστιν.

Εἰ δὲ ἡ ΘΖ τῆς ΖΚ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, καί ἐστιν ὅλη ἡ ΖΘ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ μήκει τῇ ΖΗ, ἀποτομὴ τετάρτη ἐστὶν ἡ ΚΘ. τὸ δ᾽ ὑπὸ ῥητῆς καὶ ἀποτομῆς τετάρτης περιεχόμενον ἡ δυναμένη ἐλάσσων ἐστίν· ὅπερ ἔδει δεῖξαι.

GH, and BD to GK, GH is thus a rational (area), and GK a medial (area). And they are applied to the rational (straight-line) FG. Thus, FH (is) rational, and commensurable in length with FG [Prop. 10.20], and FK (is) also rational, and incommensurable in length with FG [Prop. 10.22]. Thus, FH is incommensurable in length with FK [Prop. 10.13]. FH and FK are thus rational (straight-lines which are) commensurable in square only. Thus, KH is an apotome [Prop. 10.73], and KF an attachment to it. So, the square on HF is greater than (the square on) FK by the (square) on (some straight-line which is) either commensurable, or not (commensurable), (in length with HF).

First, let the square (on it) be (greater) by the (square) on (some straight-line which is) commensurable (in length with HF). And the whole of HF is commensurable in length with the (previously) laid down rational (straight-line) FG. Thus, KH is a first apotome [Def. 10.1]. And the square-root of an (area) contained by a rational (straight-line) and a first apotome is an apotome [Prop. 10.91]. Thus, the square-root of LH—that is to say, (of) EC—is an apotome.

And if the square on HF is greater than (the square on) FK by the (square) on (some straight-line which is) incommensurable (in length) with (HF), and (since) the whole of FH is commensurable in length with the (previously) laid down rational (straight-line) FG, KH is a fourth apotome [Prop. 10.14]. And the square-root of an (area) contained by a rational (straight-line) and a fourth apotome is a minor (straight-line) [Prop. 10.94]. (Which is) the very thing it was required to show.

ρθ´.

Ἀπὸ μέσου ῥητοῦ ἀφαιρουμένου ἄλλαι δύο ἄλογοι γίνονται ἤτοι μέσης ἀποτομὴ πρώτη ἢ μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσα.

Ἀπὸ γὰρ μέσου τοῦ ΒΓ ῥητὸν ἀφῃρήσθω τὸ ΒΔ. λέγω, ὅτι ἡ τὸ λοιπὸν τὸ ΕΓ δυναμένη μία δύο ἀλόγων γίνεται ἤτοι μέσης ἀποτομὴ πρώτη ἢ μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσα.

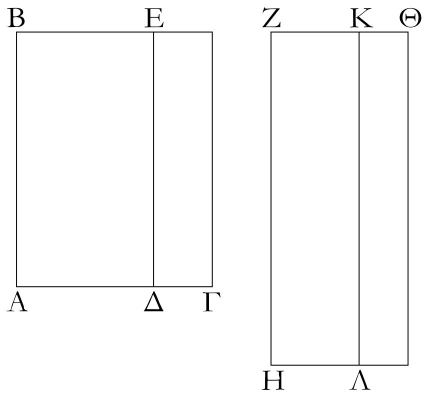
Ἐκκείσθω γὰρ ῥητὴ ἡ ΖΗ, καὶ παραβεβλήσθω ὁμοίως τὰ χωρία. ἔστι δὴ ἀκολούθως ῥητὴ μὲν ἡ ΖΘ καὶ ἀσύμμετρος τῇ ΖΗ μήκει, ῥητὴ δὲ ἡ ΚΖ καὶ σύμμετρος τῇ ΖΗ μήκει· αἱ ΖΘ, ΖΚ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΚΘ, προσαρμόζουσα δὲ ταύτῃ ἡ ΖΚ. ἤτοι δὴ ἡ ΘΖ τῆς ΖΚ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ ἢ τῷ ἀπὸ ἀσυμμέτρου.

Proposition 109

A rational (area) being subtracted from a medial (area), two other irrational (straight-lines) arise (as the square-root of the remaining area)—either a first apotome of a medial (straight-line), or that (straight-line) which with a rational (area) makes a medial whole.

For let the rational (area) BD have been subtracted from the medial (area) BC. I say that one of two irrational (straight-lines) arise (as) the square-root of the remaining (area), EC—either a first apotome of a medial (straight-line), or that (straight-line) which with a rational (area) makes a medial whole.

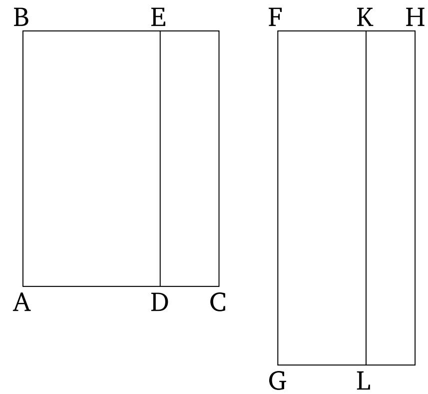
For let the rational (straight-line) FG be laid down, and let similar areas (to the preceding proposition) have been applied (to it). So, accordingly, FH is rational, and incommensurable in length with FG, and KF (is) also rational, and commensurable in length with FG. Thus, FH and FK are rational (straight-lines which are) com-



Εἰ μὲν οὖν ἡ ΘΖ τῆς ΖΚ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καί ἐστιν ἡ προσαρμόζουσα ἡ ΖΚ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ μήκει τῇ ΖΗ, ἀποτομὴ δευτέρα ἐστὶν ἡ ΚΘ. ῥητὴ δὲ ἡ ΖΗ· ὥστε ἡ τὸ ΛΘ, τουτέστι τὸ ΕΓ, δυναμένη μέσης ἀποτομὴ πρώτη ἐστίν.

Εἰ δὲ ἡ ΘΖ τῆς ΖΚ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου, καί ἐστιν ἡ προσαρμόζουσα ἡ ΖΚ σύμμετρος τῇ ἐκκειμένῃ ῥητῇ μήκει τῇ ΖΗ, ἀποτομὴ πέμπτη ἐστὶν ἡ ΚΘ· ὥστε ἡ τὸ ΕΓ δυναμένη μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσά ἐστιν· ὅπερ ἔδει δεῖξαι.

mensurable in square only [Prop. 10.13]. KH is thus an apotome [Prop. 10.73], and FK an attachment to it. So, the square on HF is greater than (the square on) FK either by the (square) on (some straight-line) commensurable (in length) with (HF), or by the (square) on (some straight-line) incommensurable (in length with HF).



Therefore, if the square on HF is greater than (the square on) FK by the (square) on (some straight-line) commensurable (in length) with (HF), and (since) the attachment FK is commensurable in length with the (previously) laid down rational (straight-line) FG, KH is a second apotome [Def. 10.12]. And FG (is) rational. Hence, the square-root of LH—that is to say, (of) EC—is a first apotome of a medial (straight-line) [Prop. 10.92].

And if the square on HF is greater than (the square on) FK by the (square) on (some straight-line) incommensurable (in length with HF), and (since) the attachment FK is commensurable in length with the (previously) laid down rational (straight-line) FG, KH is a fifth apotome [Def. 10.15]. Hence, the square-root of EC is that (straight-line) which with a rational (area) makes a medial whole [Prop. 10.95]. (Which is) the very thing it was required to show.

ρι΄.

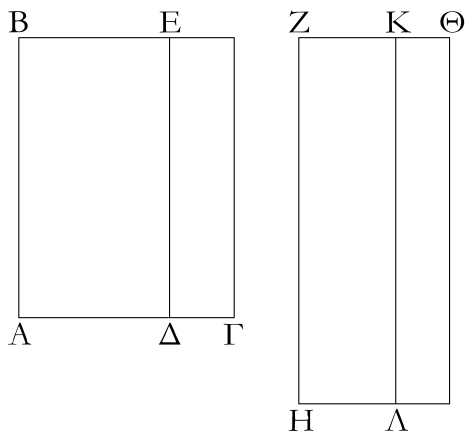
Ἀπὸ μέσου μέσου ἀφαιρουμένου ἀσυμμέτρου τῷ ὅλῳ αἱ λοιπαὶ δύο ἄλογοι γίνονται ἤτοι μέσης ἀποτομὴ δευτέρα ἢ μετὰ μέσου μέσον τὸ ὅλον ποιοῦσα.

Ἀφῃρήσθω γὰρ ὡς ἐπὶ τῶν προκειμένων καταγραφῶν ἀπὸ μέσου τοῦ ΒΓ μέσον τὸ ΒΔ ἀσύμμετρον τῷ ὅλῳ· λέγω, ὅτι ἡ τὸ ΕΓ δυναμένη μία ἐστὶ δύο ἀλόγων ἤτοι μέσης ἀποτομὴ δευτέρα ἢ μετὰ μέσου μέσον τὸ ὅλον ποιοῦσα.

Proposition 110

A medial (area), incommensurable with the whole, being subtracted from a medial (area), the two remaining irrational (straight-lines) arise (as) the (square-root of the area)—either a second apotome of a medial (straight-line), or that (straight-line) which with a medial (area) makes a medial whole.

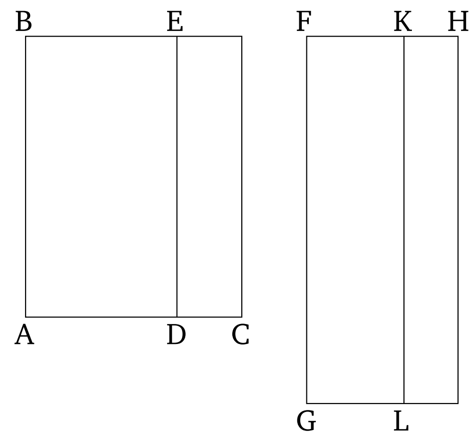
For, as in the previous figures, let the medial (area) BD, incommensurable with the whole, have been subtracted from the medial (area) BC. I say that the square-root of EC is one of two irrational (straight-lines)—either a second apotome of a medial (straight-line), or that (straight-line) which with a medial (area) makes a medial whole.



Ἐπεὶ γὰρ μέσον ἐστὶν ἑκάτερον τῶν ΒΓ, ΒΔ, καὶ ἀσύμμετρον τὸ ΒΓ τῷ ΒΔ, ἔσται ἀκολούθως ῥητὴ ἑκατέρα τῶν ΖΘ, ΖΚ καὶ ἀσύμμετρος τῇ ΖΗ μήκει. καὶ ἐπεὶ ἀσύμμετρόν ἐστι τὸ ΒΓ τῷ ΒΔ, τουτέστι τὸ ΗΘ τῷ ΗΚ, ἀσύμμετρος καὶ ἡ ΘΖ τῇ ΖΚ· αἱ ΖΘ, ΖΚ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΚΘ [προσαρμόζουσα δὲ ἡ ΖΚ. ἤτοι δὴ ἡ ΖΘ τῆς ΖΚ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἢ τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ].

Εἰ μὲν δὴ ἡ ΖΘ τῆς ΖΚ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καὶ οὐθετέρα τῶν ΖΘ, ΖΚ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ μήκει τῇ ΖΗ, ἀποτομὴ τρίτη ἐστὶν ἡ ΚΘ. ῥητὴ δὲ ἡ ΚΛ, τὸ δ᾽ ὑπὸ ῥητῆς καὶ ἀποτομῆς τρίτης περιεχόμενον ὀρθογώνιον ἄλογόν ἐστιν, καὶ ἡ δυναμένη αὐτὸ ἄλογός ἐστιν, καλεῖται δὲ μέσης ἀποτομὴ δευτέρα· ὥστε ἡ τὸ ΛΘ, τουτέστι τὸ ΕΓ, δυναμένη μέσης ἀποτομή ἐστι δευτερά.

Εἰ δὲ ἡ ΖΘ τῆς ΖΚ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ [μήκει], καὶ οὐθετέρα τῶν ΘΖ, ΖΚ σύμμετρός ἐστι τῇ ΖΗ μήκει, ἀποτομὴ ἕκτη ἐστὶν ἡ ΚΘ. τὸ δ᾽ ὑπὸ ῥητῆς καὶ ἀποτομῆς ἕκτης ἡ δυναμένη ἐστὶ μετὰ μέσου μέσον τὸ ὅλον ποιοῦσα. ἡ τὸ ΛΘ ἄρα, τουτέστι τὸ ΕΓ, δυναμένη μετὰ μέσου μέσον τὸ ὅλον ποιοῦσά ἐστιν· ὅπερ ἔδει δεῖξαι.



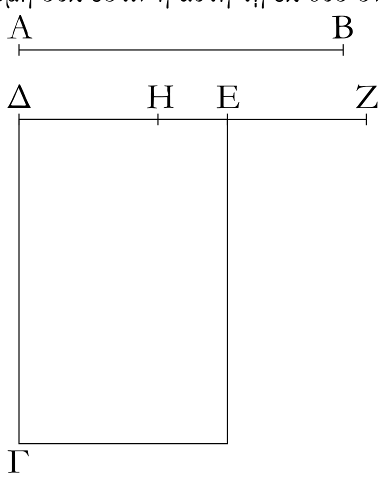
For since BC and BD are each medial (areas), and BC (is) incommensurable with BD, accordingly, FH and FK will each be rational (straight-lines), and incommensurable in length with FG [Prop. 10.22]. And since BC is incommensurable with BD—that is to say, GH with GK—HF (is) also incommensurable (in length) with FK [Props. 6.1, 10.11]. Thus, FH and FK are rational (straight-lines which are) commensurable in square only. KH is thus as apotome [Prop. 10.73], [and FK an attachment (to it). So, the square on FH is greater than (the square on) FK either by the (square) on (some straight-line) commensurable, or by the (square) on (some straight-line) incommensurable, (in length) with (FH).]

So, if the square on FH is greater than (the square on) FK by the (square) on (some straight-line) commensurable (in length) with (FH), and (since) neither of FH and FK is commensurable in length with the (previously) laid down rational (straight-line) FG, KH is a third apotome [Def. 10.3]. And KL (is) rational. And the rectangle contained by a rational (straight-line) and a third apotome is irrational, and the square-root of it is that irrational (straight-line) called a second apotome of a medial (straight-line) [Prop. 10.93]. Hence, the square-root of LH—that is to say, (of) EC—is a second apotome of a medial (straight-line).

And if the square on FH is greater than (the square on) FK by the (square) on (some straight-line) incommensurable [in length] with (FH), and (since) neither of HF and FK is commensurable in length with FG, KH is a sixth apotome [Def. 10.16]. And the square-root of the (rectangle contained) by a rational (straight-line) and a sixth apotome is that (straight-line) which with a medial (area) makes a medial whole [Prop. 10.96]. Thus, the square-root of LH—that is to say, (of) EC—is that (straight-line) which with a medial (area) makes a medial whole. (Which is) the very thing it was required to

ρια΄.

Ἡ ἀποτομὴ οὐκ ἔστιν ἡ αὐτὴ τῇ ἐκ δύο ὀνομάτων.



Ἔστω ἀποτομὴ ἡ ΑΒ· λέγω, ὅτι ἡ ΑΒ οὐκ ἔστιν ἡ αὐτὴ τῇ ἐκ δύο ὀνομάτων.

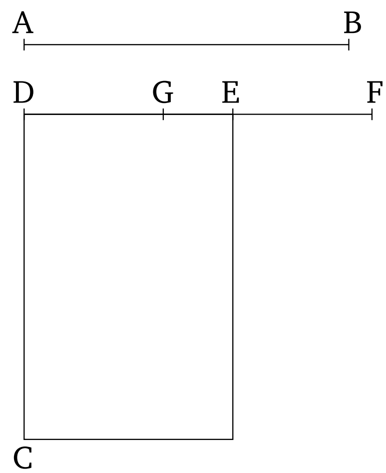
Εἰ γὰρ δυνατόν, ἔστω· καὶ ἐκκείσθω ῥητὴ ἡ ΔΓ, καὶ τῷ ἀπὸ τῆς ΑΒ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω ὀρθογώνιον τὸ ΓΕ πλάτος ποιοῦν τὴν ΔΕ. ἐπεὶ οὖν ἀποτομή ἐστιν ἡ ΑΒ, ἀποτομὴ πρώτη ἐστὶν ἡ ΔΕ. ἔστω αὐτῇ προσαρμόζουσα ἡ ΕΖ· αἱ ΔΖ, ΖΕ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ ἡ ΔΖ τῆς ΖΕ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καὶ ἡ ΔΖ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ μήκει τῇ ΔΓ. πάλιν, ἐπεὶ ἐκ δύο ὀνομάτων ἐστὶν ἡ ΑΒ, ἐκ δύο ἄρα ὀνομάτων πρώτη ἐστὶν ἡ ΔΕ. διῃρήσθω εἰς τὰ ὀνόματα κατὰ τὸ Η, καὶ ἔστω μεῖζον ὄνομα τὸ ΔΗ· αἱ ΔΗ, ΗΕ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι, καὶ ἡ ΔΗ τῆς ΗΕ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καὶ τὸ μεῖζον ἡ ΔΗ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ μήκει τῇ ΔΓ. καὶ ἡ ΔΖ ἄρα τῇ ΔΗ σύμμετρός ἐστι μήκει· καὶ λοιπὴ ἄρα ἡ ΗΖ σύμμετρός ἐστι τῇ ΔΖ μήκει. [ἐπεὶ οὖν σύμμετρός ἐστιν ἡ ΔΖ τῇ ΗΖ, ῥητὴ δέ ἐστιν ἡ ΔΖ, ῥητὴ ἄρα ἐστὶ καὶ ἡ ΗΖ. ἐπεὶ οὖν σύμμετρός ἐστιν ἡ ΔΖ τῇ ΗΖ μήκει] ἀσύμμετρος δὲ ἡ ΔΖ τῇ ΕΖ μήκει. ἀσύμμετρος ἄρα ἐστὶ καὶ ἡ ΖΗ τῇ ΕΖ μήκει. αἱ ΗΖ, ΖΕ ἄρα ῥηταί [εἰσι] δυνάμει μόνον σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΕΗ. ἀλλὰ καὶ ῥητή· ὅπερ ἐστὶν ἀδύνατον.

Ἡ ἄρα ἀποτομὴ οὐκ ἔστιν ἡ αὐτὴ τῇ ἐκ δύο ὀνομάτων· ὅπερ ἔδει δεῖξαι.

show.

Proposition 111

An apotome is not the same as a binomial.



Let AB be an apotome. I say that AB is not the same as a binomial.

For, if possible, let it be (the same). And let a rational (straight-line) DC be laid down. And let the rectangle CE, equal to the (square) on AB, have been applied to CD, producing DE as breadth. Therefore, since AB is an apotome, DE is a first apotome [Prop. 10.97]. Let EF be an attachment to it. Thus, DF and FE are rational (straight-lines which are) commensurable in square only, and the square on DF is greater than (the square on) FE by the (square) on (some straight-line) commensurable (in length) with (DF), and DF is commensurable in length with the (previously) laid down rational (straight-line) DC [Def. 10.10]. Again, since AB is a binomial, DE is thus a first binomial [Prop. 10.60]. Let (DE) have been divided into its (component) terms at G, and let DG be the greater term. Thus, DG and GE are rational (straight-lines which are) commensurable in square only, and the square on DG is greater than (the square on) GE by the (square) on (some straight-line) commensurable (in length) with (DG), and the greater (term) DG is commensurable in length with the (previously) laid down rational (straight-line) DC [Def. 10.5]. Thus, DF is also commensurable in length with DG [Prop. 10.12]. The remainder GF is thus commensurable in length with DF [Prop. 10.15]. [Therefore, since DF is commensurable with GF, and DF is rational, GF is thus also rational. Therefore, since DF is commensurable in length with GF,] DF (is) incommensurable in length with EF. Thus, FG is also incommensurable in length with EF [Prop. 10.13]. GF and FE [are] thus rational (straight-lines which are) commensurable in square only. Thus, *EG* is an apotome [Prop. 10.73]. But, (it is) also rational. The very thing is impossible.

Thus, an apotome is not the same as a binomial. (Which is) the very thing it was required to show.

[Πόρισμα.]

Ἡ ἀποτομὴ καὶ αἱ μετ᾿ αὐτὴν ἄλογοι οὔτε τῇ μέσῃ οὔτε ἀλλήλαις εἰσὶν αἱ αὐταί.

Τὸ μὲν γὰρ ἀπὸ μέσης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ῥητὴν καὶ ἀσύμμετρον τῇ, παρ᾿ ἣν παράκειται, μήκει, τὸ δὲ ἀπὸ ἀποτομῆς παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν πρώτην, τὸ δὲ ἀπὸ μέσης ἀποτομῆς πρώτης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν δευτέραν, τὸ δὲ ἀπὸ μέσης ἀποτομῆς δευτέρας παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν τρίτην, τὸ δὲ ἀπὸ ἐλάσσονος παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν τετάρτην, τὸ δὲ ἀπὸ τῆς μετὰ ῥητοῦ μέσον τὸ ὅλον ποιούσης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν πέμπτην, τὸ δὲ ἀπὸ τῆς μετὰ μέσου μέσον τὸ ὅλον ποιούσης παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ ἀποτομὴν ἕκτην. ἐπεὶ οὖν τὰ εἰρημένα πλάτη διαφέρει τοῦ τε πρώτου καὶ ἀλλήλων, τοῦ μὲν πρώτου, ὅτι ῥητή ἐστιν, ἀλλήλων δὲ, ἐπεὶ τῇ τάξει οὐκ εἰσὶν αἱ αὐταί, δῆλον, ὡς καὶ αὐταὶ αἱ ἄλογοι διαφέρουσιν ἀλλήλων. καὶ ἐπεὶ δέδεικται ἡ ἀποτομὴ οὐκ οὖσα ἡ αὐτὴ τῇ ἐκ δύο ὀνομάτων, ποιοῦσι δὲ πλάτη παρὰ ῥητὴν παραβαλλόμεναι αἱ μετὰ τὴν ἀποτομὴν ἀποτομὰς ἀκολούθως ἑκάστη τῇ τάξει τῇ καθ᾿ αὑτήν, αἱ δὲ μετὰ τὴν ἐκ δύο ὀνομάτων τὰς ἐκ δύο ὀνομάτων καὶ αὐταὶ τῇ τάξει ἀκολούθως, ἕτεραι ἄρα εἰσὶν αἱ μετὰ τὴν ἀποτομὴν καὶ ἕτεραι αἱ μετὰ τὴν ἐκ δύο ὀνομάτων, ὡς εἶναι τῇ τάξει πάσας ἀλόγους $\overline{\iota\gamma}$,

[Corollary]

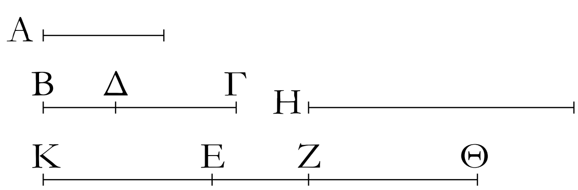
The apotome and the irrational (straight-lines) after it are neither the same as a medial (straight-line) nor (the same) as one another.

For the (square) on a medial (straight-line), applied to a rational (straight-line), produces as breadth a rational (straight-line which is) incommensurable in length with the (straight-line) to which (the area) is applied [Prop. 10.22]. And the (square) on an apotome, applied to a rational (straight-line), produces as breadth a first apotome [Prop. 10.97]. And the (square) on a first apotome of a medial (straight-line), applied to a rational (straight-line), produces as breadth a second apotome [Prop. 10.98]. And the (square) on a second apotome of a medial (straight-line), applied to a rational (straight-line), produces as breadth a third apotome [Prop. 10.99]. And (square) on a minor (straight-line), applied to a rational (straight-line), produces as breadth a fourth apotome [Prop. 10.100]. And (square) on that (straight-line) which with a rational (area) produces a medial whole, applied to a rational (straight-line), produces as breadth a fifth apotome [Prop. 10.101]. And (square) on that (straight-line) which with a medial (area) produces a medial whole, applied to a rational (straight-line), produces as breadth a sixth apotome [Prop. 10.102]. Therefore, since the aforementioned breadths differ from the first (breadth), and from one another—from the first, because it is rational, and from one another since they are not the same in order—clearly, the irrational (straight-lines) themselves also differ from one another. And since it has been shown that an apotome is not the same as a binomial [Prop. 10.111], and (that) the (irrational straight-lines) after the apotome, being applied to a rational (straight-line), produce as breadth, each according to its own (order), apotomes, and (that) the (irrational straight-lines) after the binomial themselves also (produce as breadth), according (to their) order, binomials, the (irrational straight-lines) after the apotome are thus different, and the (irrational straight-lines) after the binomial (are also) different, so that there are, in order, 13 irrational (straight-lines) in all:

Μέσην,
Ἐκ δύο ὀνομάτων,
Ἐκ δύο μέσων πρώτην,
Ἐκ δύο μέσων δευτέραν,
Μείζονα,
Ῥητὸν καὶ μέσον δυναμένην,
Δύο μέσα δυναμένην,
Ἀποτομήν,
Μέσης ἀποτομὴν πρώτην,
Μέσης ἀποτομὴν δευτέραν,
Ἐλάσσονα,
Μετὰ ῥητοῦ μέσον τὸ ὅλον ποιοῦσαν,
Μετὰ μέσου μέσον τὸ ὅλον ποιοῦσαν.

ριβ΄.

Τὸ ἀπὸ ῥητῆς παρὰ τὴν ἐκ δύο ὀνομάτων παραβαλλόμενον πλάτος ποιεῖ ἀποτομήν, ἧς τὰ ὀνόματα σύμμετρά ἐστι τοῖς τῆς ἐκ δύο ὀνομάτων ὀνόμασι καὶ ἔτι ἐν τῷ αὐτῷ λόγῳ, καὶ ἔτι ἡ γινομένη ἀποτομὴ τὴν αὐτὴν ἕξει τάξιν τῇ ἐκ δύο ὀνομάτων.



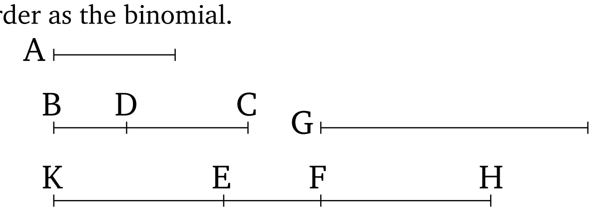
Ἔστω ῥητὴ μὲν ἡ Α, ἐκ δύο ὀνομάτων δὲ ἡ ΒΓ, ἧς μεῖζον ὄνομα ἔστω ἡ ΔΓ, καὶ τῷ ἀπὸ τῆς Α ἴσον ἔστω τὸ ὑπὸ τῶν ΒΓ, ΕΖ· λέγω, ὅτι ἡ ΕΖ ἀποτομή ἐστιν, ἧς τὰ ὀνόματα σύμμετρά ἐστι τοῖς ΓΔ, ΔΒ, καὶ ἐν τῷ αὐτῷ λόγῳ, καὶ ἔτι ἡ ΕΖ τὴν αὐτὴν ἕξει τάξιν τῇ ΒΓ.

Ἔστω γὰρ πάλιν τῷ ἀπὸ τῆς Α ἴσον τὸ ὑπὸ τῶν ΒΔ, Η. ἐπεὶ οὖν τὸ ὑπὸ τῶν ΒΓ, ΕΖ ἴσον ἐστὶ τῷ ὑπὸ τῶν ΒΔ, Η, ἔστιν ἄρα ὡς ἡ ΓΒ πρὸς τὴν ΒΔ, οὕτως ἡ Η πρὸς τὴν ΕΖ. μείζων δὲ ἡ ΓΒ τῆς ΒΔ· μείζων ἄρα ἐστὶ καὶ ἡ Η τῆς ΕΖ. ἔστω τῇ Η ἴση ἡ ΕΘ· ἔστιν ἄρα ὡς ἡ ΓΒ πρὸς τὴν ΒΔ, οὕτως ἡ ΘΕ πρὸς τὴν ΕΖ· διελόντι ἄρα ἐστὶν ὡς ἡ ΓΔ πρὸς τὴν ΒΔ, οὕτως ἡ ΘΖ πρὸς τὴν ΖΕ. γεγονέτω ὡς ἡ ΘΖ πρὸς τὴν ΖΕ, οὕτως ἡ ΖΕ πρὸς τὴν ΚΕ· καὶ ὅλη ἄρα ἡ ΘΚ πρὸς ὅλην τὴν ΚΖ ἐστιν, ὡς ἡ ΖΚ πρὸς ΚΕ· ὡς γὰρ ἓν τῶν ἡγουμένων πρὸς ἓν τῶν ἑπομένων, οὕτως ἅπαντα τὰ ἡγούμενα πρὸς ἅπαντα τὰ ἑπόμενα. ὡς δὲ ἡ ΖΚ πρὸς ΚΕ, οὕτως ἐστὶν ἡ ΓΔ πρὸς τὴν ΔΒ· καὶ ὡς ἄρα ἡ ΘΚ πρὸς ΚΖ, οὕτως ἡ ΓΔ πρὸς τὴν ΔΒ. σύμμετρον δὲ τὸ ἀπὸ τῆς ΓΔ τῷ ἀπὸ τῆς ΔΒ· σύμμετρον ἄρα ἐστὶ καὶ τὸ ἀπὸ τῆς ΘΚ τῷ

Medial,
Binomial,
First bimedial,
Second bimedial,
Major,
Square-root of a rational plus a medial (area),
Square-root of (the sum of) two medial (areas),
Apotome,
First apotome of a medial,
Second apotome of a medial,
Minor,
That which with a rational (area) produces a medial whole,
That which with a medial (area) produces a medial whole.

Proposition 112†

The (square) on a rational (straight-line), applied to a binomial (straight-line), produces as breadth an apotome whose terms are commensurable (in length) with the terms of the binomial, and, furthermore, in the same ratio. Moreover, the created apotome will have the same order as the binomial.



Let A be a rational (straight-line), and BC a binomial (straight-line), of which let DC be the greater term. And let the (rectangle contained) by BC and EF be equal to the (square) on A. I say that EF is an apotome whose terms are commensurable (in length) with CD and DB, and in the same ratio, and, moreover, that EF will have the same order as BC.

For, again, let the (rectangle contained) by BD and G be equal to the (square) on A. Therefore, since the (rectangle contained) by BC and EF is equal to the (rectangle contained) by BD and G, thus as CB is to BD, so G (is) to EF [Prop. 6.16]. And CB (is) greater than BD. Thus, G is also greater than EF [Props. 5.16, 5.14]. Let EH be equal to G. Thus, as CB is to BD, so HE (is) to EF. Thus, via separation, as CD is to BD, so HF (is) to FE [Prop. 5.17]. Let it have been contrived that as HF (is) to FE, so FK (is) to KE. And, thus, the whole HK is to the whole KF, as FK (is) to KE. For as one of the leading (proportional magnitudes is) to one of the ἀπὸ τῆς ΚΖ. καί ἐστιν ὡς τὸ ἀπὸ τῆς ΘΚ πρὸς τὸ ἀπὸ τῆς ΚΖ, οὕτως ἡ ΘΚ πρὸς τὴν ΚΕ, ἐπεὶ αἱ τρεῖς αἱ ΘΚ, ΚΖ, ΚΕ ἀνάλογόν εἰσιν. σύμμετρος ἄρα ἡ ΘΚ τῇ ΚΕ μήκει. ὥστε καὶ ἡ ΘΕ τῇ ΕΚ σύμμετρός ἐστι μήκει. καὶ ἐπεὶ τὸ ἀπὸ τῆς Α ἴσον ἐστὶ τῷ ὑπὸ τῶν ΕΘ, ΒΔ, ῥητὸν δέ ἐστι τὸ ἀπὸ τῆς Α, ῥητὸν ἄρα ἐστὶ καὶ τὸ ὑπὸ τῶν ΕΘ, ΒΔ. καὶ παρὰ ῥητὴν τὴν ΒΔ παράκειται· ῥητὴ ἄρα ἐστὶν ἡ ΕΘ καὶ σύμμετρος τῇ ΒΔ μήκει· ὥστε καὶ ἡ σύμμετρος αὐτῇ ἡ ΕΚ ῥητή ἐστι καὶ σύμμετρος τῇ ΒΔ μήκει. ἐπεὶ οὖν ἐστιν ὡς ἡ ΓΔ πρὸς ΔΒ, οὕτως ἡ ΖΚ πρὸς ΚΕ, αἱ δὲ ΓΔ, ΔΒ δυνάμει μόνον εἰσὶ σύμμετροι, καὶ αἱ ΖΚ, ΚΕ δυνάμει μόνον εἰσὶ σύμμετροι. ῥητὴ δέ ἐστιν ἡ ΚΕ· ῥητὴ ἄρα ἐστὶ καὶ ἡ ΖΚ. αἱ ΖΚ, ΚΕ ἄρα ῥηταὶ δυνάμει μόνον εἰσὶ σύμμετροι· ἀποτομὴ ἄρα ἐστὶν ἡ ΕΖ.

Ἤτοι δὲ ἡ ΓΔ τῆς ΔΒ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ ἢ τῷ ἀπὸ ἀσυμμέτρου.

Εἰ μὲν οὖν ἡ ΓΔ τῆς ΔΒ μεῖζον δύναται τῷ ἀπὸ συμμέτρου [ἑαυτῇ], καὶ ἡ ΖΚ τῆς ΚΕ μεῖζον δυνήσεται τῷ ἀπὸ συμμέτρου ἑαυτῇ. καὶ εἰ μὲν σύμμετρός ἐστιν ἡ ΓΔ τῇ ἐκκειμένῃ ῥητῇ μήκει, καὶ ἡ ΖΚ· εἰ δὲ ἡ ΒΔ, καὶ ἡ ΚΕ· εἰ δὲ οὐδετέρα τῶν ΓΔ, ΔΒ, καὶ οὐδετέρα τῶν ΖΚ, ΚΕ.

Εἰ δὲ ἡ ΓΔ τῆς ΔΒ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, καὶ ἡ ΖΚ τῆς ΚΕ μεῖζον δυνήσεται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καὶ εἰ μὲν ἡ ΓΔ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ μήκει, καὶ ἡ ΖΚ· εἰ δὲ ἡ ΒΔ, καὶ ἡ ΚΕ· εἰ δὲ οὐδετέρα τῶν ΓΔ, ΔΒ, καὶ οὐδετέρα τῶν ΖΚ, ΚΕ· ὥστε ἀποτομή ἐστιν ἡ ΖΕ, ἧς τὰ ὀνόματα τὰ ΖΚ, ΚΕ σύμμετρά ἐστι τοῖς τῆς ἐκ δύο ὀνομάτων ὀνόμασι τοῖς ΓΔ, ΔΒ καὶ ἐν τῷ αὐτῷ λόγῳ, καὶ τὴν αὐτὴν τάξιν ἔχει τῇ ΒΓ· ὅπερ ἔδει δεῖξαι.

following, so all of the leading (magnitudes) are to all of the following [Prop. 5.12]. And as FK (is) to KE, so CD is to DB [Prop. 5.11]. And, thus, as HK (is) to KF, so CD is to DB [Prop. 5.11]. And the (square) on CD (is) commensurable with the (square) on DB [Prop. 10.36]. The (square) on HK is thus also commensurable with the (square) on KF [Props. 6.22, 10.11]. And as the (square) on HK is to the (square) on KF, so HK (is) to KE, since the three (straight-lines) HK, KF, and KE are proportional [Def. 5.9]. HK is thus commensurable in length with KE [Prop. 10.11]. Hence, HE is also commensurable in length with EK [Prop. 10.15]. And since the (square) on A is equal to the (rectangle contained) by EH and BD, and the (square) on A is rational, the (rectangle contained) by EH and BD is thus also rational. And it is applied to the rational (straight-line) BD. Thus, EH is rational, and commensurable in length with BD [Prop. 10.20]. And, hence, the (straight-line) commensurable (in length) with it, EK, is also rational [Def. 10.3], and commensurable in length with BD [Prop. 10.12]. Therefore, since as CD is to DB, so FK (is) to KE, and CD and DB are (straight-lines which are) commensurable in square only, FK and KE are also commensurable in square only [Prop. 10.11]. And KE is rational. Thus, FK is also rational. FK and KE are thus rational (straight-lines which are) commensurable in square only. Thus, EF is an apotome [Prop. 10.73].

And the square on CD is greater than (the square on) DB either by the (square) on (some straight-line) commensurable, or by the (square) on (some straight-line) incommensurable, (in length) with (CD).

Therefore, if the square on CD is greater than (the square on) DB by the (square) on (some straight-line) commensurable (in length) with [CD] then the square on FK will also be greater than (the square on) KE by the (square) on (some straight-line) commensurable (in length) with (FK) [Prop. 10.14]. And if CD is commensurable in length with a (previously) laid down rational (straight-line), (so) also (is) FK [Props. 10.11, 10.12]. And if BD (is commensurable), (so) also (is) KE [Prop. 10.12]. And if neither of CD or DB (is commensurable), neither also (are) either of FK or KE.

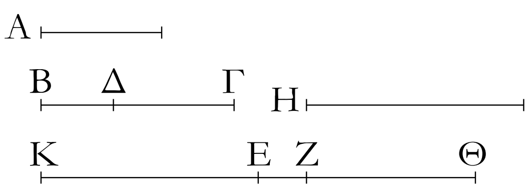
And if the square on CD is greater than (the square on) DB by the (square) on (some straight-line) incommensurable (in length) with (CD) then the square on FK will also be greater than (the square on) KE by the (square) on (some straight-line) incommensurable (in length) with (FK) [Prop. 10.14]. And if CD is commensurable in length with a (previously) laid down rational (straight-line), (so) also (is) FK [Props. 10.11, 10.12]. And if BD (is commensurable), (so) also (is) KE

[Prop. 10.12]. And if neither of CD or DB (is commensurable), neither also (are) either of FK or KE. Hence, FE is an apotome whose terms, FK and KE, are commensurable (in length) with the terms, CD and DB, of the binomial, and in the same ratio. And (FE) has the same order as BC [Defs. 10.5—10.10]. (Which is) the very thing it was required to show.

† Heiberg considers this proposition, and the succeeding ones, to be relatively early interpolations into the original text.

ριγʹ.

Τὸ ἀπὸ ῥητῆς παρὰ ἀποτομὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ἐκ δύο ὀνομάτων, ἧς τὰ ὀνόματα σύμμετρά ἐστι τοῖς τῆς ἀποτομῆς ὀνόμασι καὶ ἐν τῷ αὐτῷ λόγῳ, ἔτι δὲ ἡ γινομένη ἐκ δύο ὀνομάτων τὴν αὐτὴν τάξιν ἔχει τῇ ἀποτομῇ.

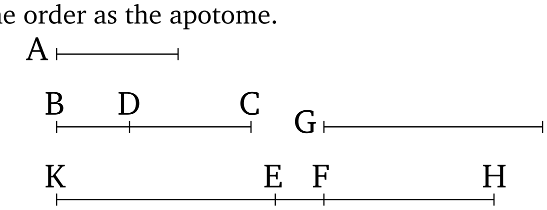


Ἔστω ῥητὴ μὲν ἡ Α, ἀποτομὴ δὲ ἡ ΒΔ, καὶ τῷ ἀπὸ τῆς Α ἴσον ἔστω τὸ ὑπὸ τῶν ΒΔ, ΚΘ, ὥστε τὸ ἀπὸ τῆς Α ῥητῆς παρὰ τὴν ΒΔ ἀποτομὴν παραβαλλόμενον πλάτος ποιεῖ τὴν ΚΘ· λέγω, ὅτι ἐκ δύο ὀνομάτων ἐστὶν ἡ ΚΘ, ἧς τὰ ὀνόματα σύμμετρά ἐστι τοῖς τῆς ΒΔ ὀνόμασι καὶ ἐν τῷ αὐτῷ λόγῳ, καὶ ἔτι ἡ ΚΘ τὴν αὐτὴν ἔχει τάξιν τῇ ΒΔ.

Ἔστω γὰρ τῇ ΒΔ προσαρμόζουσα ἡ ΔΓ· αἱ ΒΓ, ΓΔ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι. καὶ τῷ ἀπὸ τῆς Α ἴσον ἔστω καὶ τὸ ὑπὸ τῶν ΒΓ, Η. ῥητὸν δὲ τὸ ἀπὸ τῆς Α· ῥητὸν ἄρα καὶ τὸ ὑπὸ τῶν ΒΓ, Η. καὶ παρὰ ῥητὴν τὴν ΒΓ παραβέβληται· ῥητὴ ἄρα ἐστὶν ἡ Η καὶ σύμμετρος τῇ ΒΓ μήκει. ἐπεὶ οὖν τὸ ὑπὸ τῶν ΒΓ, Η ἴσον ἐστὶ τῷ ὑπὸ τῶν ΒΔ, ΚΘ, ἀνάλογον ἄρα ἐστὶν ὡς ἡ ΓΒ πρὸς ΒΔ, οὕτως ἡ ΚΘ πρὸς Η. μείζων δὲ ἡ ΒΓ τῆς ΒΔ· μείζων ἄρα καὶ ἡ ΚΘ τῆς Η. κείσθω τῇ Η ἴση ἡ ΚΕ· σύμμετρος ἄρα ἐστὶν ἡ ΚΕ τῇ ΒΓ μήκει. καὶ ἐπεί ἐστιν ὡς ἡ ΓΒ πρὸς ΒΔ, οὕτως ἡ ΘΚ πρὸς ΚΕ, ἀναστρέψαντι ἄρα ἐστὶν ὡς ἡ ΒΓ πρὸς τὴν ΓΔ, οὕτως ἡ ΚΘ πρὸς ΘΕ. γεγονέτω ὡς ἡ ΚΘ πρὸς ΘΕ, οὕτως ἡ ΘΖ πρὸς ΖΕ· καὶ λοιπὴ ἄρα ἡ ΚΖ πρὸς ΖΘ ἐστιν, ὡς ἡ ΚΘ πρὸς ΘΕ, τουτέστιν [ὡς] ἡ ΒΓ πρὸς ΓΔ. αἱ δὲ ΒΓ, ΓΔ δυνάμει μόνον [εἰσὶ] σύμμετροι· καὶ αἱ ΚΖ, ΖΘ ἄρα δυνάμει μόνον εἰσὶ σύμμετροι· καὶ ἐπεί ἐστιν ὡς ἡ ΚΘ πρὸς ΘΕ, ἡ ΚΖ πρὸς ΖΘ, ἀλλ᾽ ὡς ἡ ΚΘ πρὸς ΘΕ, ἡ ΘΖ πρὸς ΖΕ, καὶ ὡς ἄρα ἡ ΚΖ πρὸς ΖΘ, ἡ ΘΖ πρὸς ΖΕ· ὥστε καὶ ὡς ἡ πρώτη πρὸς τὴν τρίτην, τὸ ἀπὸ τῆς πρώτης πρὸς τὸ ἀπὸ τῆς δευτέρας· καὶ ὡς ἄρα ἡ ΚΖ πρὸς ΖΕ, οὕτως τὸ ἀπὸ τῆς ΚΖ πρὸς τὸ ἀπὸ τῆς ΖΘ. σύμμετρον δέ ἐστι τὸ ἀπὸ τῆς ΚΖ τῷ ἀπὸ τῆς ΖΘ· αἱ γὰρ ΚΖ, ΖΘ δυνάμει εἰσὶ σύμμετροι· σύμμετρος ἄρα ἐστὶ καὶ ἡ ΚΖ τῇ ΖΕ μήκει· ὥστε ἡ ΚΖ καὶ

Proposition 113

The (square) on a rational (straight-line), applied to an apotome, produces as breadth a binomial whose terms are commensurable with the terms of the apotome, and in the same ratio. Moreover, the created binomial has the same order as the apotome.



Let A be a rational (straight-line), and BD an apotome. And let the (rectangle contained) by BD and KH be equal to the (square) on A, such that the square on the rational (straight-line) A, applied to the apotome BD, produces KH as breadth. I say that KH is a binomial whose terms are commensurable with the terms of BD, and in the same ratio, and, moreover, that KH has the same order as BD.

For let DC be an attachment to BD. Thus, BC and CD are rational (straight-lines which are) commensurable in square only [Prop. 10.73]. And let the (rectangle contained) by BC and G also be equal to the (square) on A. And the (square) on A (is) rational. The (rectangle contained) by BC and G (is) thus also rational. And it has been applied to the rational (straight-line) BC. Thus, G is rational, and commensurable in length with BC [Prop. 10.20]. Therefore, since the (rectangle contained) by BC and G is equal to the (rectangle contained) by BD and KH, thus, proportionally, as CB is to BD, so KH (is) to G [Prop. 6.16]. And BC (is) greater than BD. Thus, KH (is) also greater than G [Prop. 5.16, 5.14]. Let KE be made equal to G. KE is thus commensurable in length with BC. And since as CB is to BD, so HK (is) to KE, thus, via conversion, as BC (is) to CD, so KH (is) to HE [Prop. 5.19 corr.]. Let it have been contrived that as KH (is) to HE, so HF (is) to FE. And thus the remainder KF is to FH, as KH (is) to HE—that is to say, [as] BC (is) to CD [Prop. 5.19]. And BC and CD [are] commensurable in square only.

τῇ ΚΕ σύμμετρός [ἐστι] μήκει. ῥητὴ δέ ἐστιν ἡ ΚΕ καὶ σύμμετρος τῇ ΒΓ μήκει. ῥητὴ ἄρα καὶ ἡ ΚΖ καὶ σύμμετρος τῇ ΒΓ μήκει. καὶ ἐπεί ἐστιν ὡς ἡ ΒΓ πρὸς ΓΔ, οὕτως ἡ ΚΖ πρὸς ΖΘ, ἐναλλὰξ ὡς ἡ ΒΓ πρὸς ΚΖ, οὕτως ἡ ΔΓ πρὸς ΖΘ. σύμμετρος δὲ ἡ ΒΓ τῇ ΚΖ· σύμμετρος ἄρα καὶ ἡ ΖΘ τῇ ΓΔ μήκει. αἱ ΒΓ, ΓΔ δὲ ῥηταί εἰσι δυνάμει μόνον σύμμετροι· καὶ αἱ ΚΖ, ΖΘ ἄρα ῥηταί εἰσι δυνάμει μόνον σύμμετροι· ἐκ δύο ὀνομάτων ἐστὶν ἄρα ἡ ΚΘ.

Εἰ μὲν οὖν ἡ ΒΓ τῆς ΓΔ μεῖζον δύναται τῷ ἀπὸ συμμέτρου ἑαυτῇ, καὶ ἡ ΚΖ τῆς ΖΘ μεῖζον δυνήσεται τῷ ἀπὸ συμμέτρου ἑαυτῇ. καὶ εἰ μὲν σύμμετρός ἐστιν ἡ ΒΓ τῇ ἐκκειμένῃ ῥητῇ μήκει, καὶ ἡ ΚΖ, εἰ δὲ ἡ ΓΔ σύμμετρός ἐστι τῇ ἐκκειμένῃ ῥητῇ μήκει, καὶ ἡ ΖΘ, εἰ δὲ οὐδετέρα τῶν ΒΓ, ΓΔ, οὐδετέρα τῶν ΚΖ, ΖΘ.

Εἰ δὲ ἡ ΒΓ τῆς ΓΔ μεῖζον δύναται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ, καὶ ἡ ΚΖ τῆς ΖΘ μεῖζον δυνήσεται τῷ ἀπὸ ἀσυμμέτρου ἑαυτῇ. καὶ εἰ μὲν σύμμετρός ἐστιν ἡ ΒΓ τῇ ἐκκειμένῃ ῥητῇ μήκει, καὶ ἡ ΚΖ, εἰ δὲ ἡ ΓΔ, καὶ ἡ ΖΘ, εἰ δὲ οὐδετέρα τῶν ΒΓ, ΓΔ, οὐδετέρα τῶν ΚΖ, ΖΘ.

Ἐκ δύο ἄρα ὀνομάτων ἐστὶν ἡ ΚΘ, ἧς τὰ ὀνόματα τὰ ΚΖ, ΖΘ σύμμετρά [ἐστι] τοῖς τῆς ἀποτομῆς ὀνόμασι τοῖς ΒΓ, ΓΔ καὶ ἐν τῷ αὐτῷ λόγῳ, καὶ ἔτι ἡ ΚΘ τῇ ΒΓ τὴν αὐτὴν ἕξει τάξιν· ὅπερ ἔδει δεῖξαι.

KF and FH are thus also commensurable in square only [Prop. 10.11]. And since as KH is to HE, (so) KF (is) to FH, but as KH (is) to HE, (so) HF (is) to FE, thus, also as KF (is) to FH, (so) HF (is) to FE [Prop. 5.11]. And hence as the first (is) to the third, so the (square) on the first (is) to the (square) on the second [Def. 5.9]. And thus as KF (is) to FE, so the (square) on KF (is) to the (square) on FH. And the (square) on KF is commensurable with the (square) on FH. For KF and FH are commensurable in square. Thus, KF is also commensurable in length with FE [Prop. 10.11]. Hence, KF [is] also commensurable in length with KE [Prop. 10.15]. And KE is rational, and commensurable in length with BC. Thus, KF (is) also rational, and commensurable in length with BC [Prop. 10.12]. And since as BC is to CD, (so) KF (is) to FH, alternately, as BC (is) to KF, so DC (is) to FH [Prop. 5.16]. And BC (is) commensurable (in length) with KF. Thus, FH (is) also commensurable in length with CD [Prop. 10.11]. And BC and CD are rational (straight-lines which are) commensurable in square only. KF and FH are thus also rational (straight-lines which are) commensurable in square only [Def. 10.3, Prop. 10.13]. Thus, KH is a binomial [Prop. 10.36].

Therefore, if the square on BC is greater than (the square on) CD by the (square) on (some straight-line) commensurable (in length) with (BC), then the square on KF will also be greater than (the square on) FH by the (square) on (some straight-line) commensurable (in length) with (KF) [Prop. 10.14]. And if BC is commensurable in length with a (previously) laid down rational (straight-line), (so) also (is) KF [Prop. 10.12]. And if CD is commensurable in length with a (previously) laid down rational (straight-line), (so) also (is) FH [Prop. 10.12]. And if neither of BC or CD (are commensurable), neither also (are) either of KF or FH [Prop. 10.13].

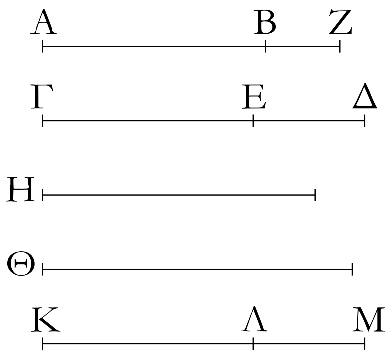
And if the square on BC is greater than (the square on) CD by the (square) on (some straight-line) incommensurable (in length) with (BC) then the square on KF will also be greater than (the square on) FH by the (square) on (some straight-line) incommensurable (in length) with (KF) [Prop. 10.14]. And if BC is commensurable in length with a (previously) laid down rational (straight-line), (so) also (is) KF [Prop. 10.12]. And if CD is commensurable, (so) also (is) FH [Prop. 10.12]. And if neither of BC or CD (are commensurable), neither also (are) either of KF or FH [Prop. 10.13].

KH is thus a binomial whose terms, KF and FH, [are] commensurable (in length) with the terms, BC and CD, of the apotome, and in the same ratio. Moreover,

KH will have the same order as BC [Defs. 10.5—10.10]. (Which is) the very thing it was required to show.

ριδ΄.

Ἐὰν χωρίον περιέχηται ὑπὸ ἀποτομῆς καὶ τῆς ἐκ δύο ὀνομάτων, ἧς τὰ ὀνόματα σύμμετρά τέ ἐστι τοῖς τῆς ἀποτομῆς ὀνόμασι καὶ ἐν τῷ αὐτῷ λόγῳ, ἡ τὸ χωρίον δυναμένη ῥητή ἐστιν.



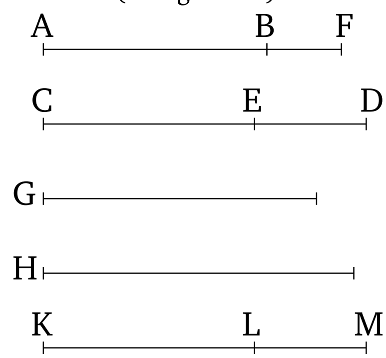
Περιεχέσθω γὰρ χωρίον τὸ ὑπὸ τῶν ΑΒ, ΓΔ ὑπὸ ἀποτομῆς τῆς ΑΒ καὶ τῆς ἐκ δύο ὀνομάτων τῆς ΓΔ, ἧς μεῖζον ὄνομα ἔστω τὸ ΓΕ, καὶ ἔστω τὰ ὀνόματα τῆς ἐκ δύο ὀνομάτων τὰ ΓΕ, ΕΔ σύμμετρά τε τοῖς τῆς ἀποτομῆς ὀνόμασι τοῖς ΑΖ, ΖΒ καὶ ἐν τῷ αὐτῷ λόγῳ, καὶ ἔστω ἡ τὸ ὑπὸ τῶν ΑΒ, ΓΔ δυναμένη ἡ Η· λέγω, ὅτι ῥητή ἐστιν ἡ Η.

Ἐκκείσθω γὰρ ῥητὴ ἡ Θ, καὶ τῷ ἀπὸ τῆς Θ ἴσον παρὰ τὴν ΓΔ παραβεβλήσθω πλάτος ποιοῦν τὴν ΚΛ· ἀποτομὴ ἄρα ἐστὶν ἡ ΚΛ, ἧς τὰ ὀνόματα ἔστω τὰ ΚΜ, ΜΛ σύμμετρα τοῖς τῆς ἐκ δύο ὀνομάτων ὀνόμασι τοῖς ΓΕ, ΕΔ καὶ ἐν τῷ αὐτῷ λόγῳ. ἀλλὰ καὶ αἱ ΓΕ, ΕΔ σύμμετροί τέ εἰσι ταῖς ΑΖ, ΖΒ καὶ ἐν τῷ αὐτῷ λόγῳ· ἔστιν ἄρα ὡς ἡ ΑΖ πρὸς τὴν ΖΒ, οὕτως ἡ ΚΜ πρὸς ΜΛ. ἐναλλὰξ ἄρα ἐστὶν ὡς ἡ ΑΖ πρὸς τὴν ΚΜ, οὕτως ἡ ΒΖ πρὸς τὴν ΛΜ· καὶ λοιπὴ ἄρα ἡ ΑΒ πρὸς λοιπὴν τὴν ΚΛ ἐστιν ὡς ἡ ΑΖ πρὸς ΚΜ. σύμμετρος δὲ ἡ ΑΖ τῇ ΚΜ· σύμμετρος ἄρα ἐστὶ καὶ ἡ ΑΒ τῇ ΚΛ. καί ἐστιν ὡς ἡ ΑΒ πρὸς ΚΛ, οὕτως τὸ ὑπὸ τῶν ΓΔ, ΑΒ πρὸς τὸ ὑπὸ τῶν ΓΔ, ΚΛ· σύμμετρον ἄρα ἐστὶ καὶ τὸ ὑπὸ τῶν ΓΔ, ΑΒ τῷ ὑπὸ τῶν ΓΔ, ΚΛ. ἴσον δὲ τὸ ὑπὸ τῶν ΓΔ, ΚΛ τῷ ἀπὸ τῆς Θ· σύμμετρον ἄρα ἐστὶ τὸ ὑπὸ τῶν ΓΔ, ΑΒ τῷ ἀπὸ τῆς Θ. τῷ δὲ ὑπὸ τῶν ΓΔ, ΑΒ ἴσον ἐστὶ τὸ ἀπὸ τῆς Η· σύμμετρον ἄρα ἐστὶ τὸ ἀπὸ τῆς Η τῷ ἀπὸ τῆς Θ. ῥητὸν δὲ τὸ ἀπὸ τῆς Θ· ῥητὸν ἄρα ἐστὶ καὶ τὸ ἀπὸ τῆς Η· ῥητὴ ἄρα ἐστὶν ἡ Η. καὶ δύναται τὸ ὑπὸ τῶν ΓΔ, ΑΒ.

Ἐὰν ἄρα χωρίον περιέχηται ὑπὸ ἀποτομῆς καὶ τῆς ἐκ δύο ὀνομάτων, ἧς τὰ ὀνόματα σύμμετρά ἐστι τοῖς τῆς ἀποτομῆς ὀνόμασι καὶ ἐν τῷ αὐτῷ λόγῳ, ἡ τὸ χωρίον δυναμένη ῥητή ἐστιν.

Proposition 114

If an area is contained by an apotome, and a binomial whose terms are commensurable with, and in the same ratio as, the terms of the apotome then the square-root of the area is a rational (straight-line).



For let an area, the (rectangle contained) by AB and CD, have been contained by the apotome AB, and the binomial CD, of which let the greater term be CE. And let the terms of the binomial, CE and ED, be commensurable with the terms of the apotome, AF and FB (respectively), and in the same ratio. And let the square-root of the (rectangle contained) by AB and CD be G. I say that G is a rational (straight-line).

For let the rational (straight-line) H be laid down. And let (some rectangle), equal to the (square) on H, have been applied to CD, producing KL as breadth. Thus, KL is an apotome, of which let the terms, KM and ML, be commensurable with the terms of the binomial, CE and ED (respectively), and in the same ratio [Prop. 10.112]. But, CE and ED are also commensurable with AF and FB (respectively), and in the same ratio. Thus, as AF is to FB, so KM (is) to ML. Thus, alternately, as AF is to KM, so BF (is) to LM [Prop. 5.16]. Thus, the remainder AB is also to the remainder KL as AF (is) to KM [Prop. 5.19]. And AF (is) commensurable with KM [Prop. 10.12]. AB is thus also commensurable with KL [Prop. 10.11]. And as AB is to KL, so the (rectangle contained) by CD and AB (is) to the (rectangle contained) by CD and KL [Prop. 6.1]. Thus, the (rectangle contained) by CD and AB is also commensurable with the (rectangle contained) by CD and KL [Prop. 10.11]. And the (rectangle contained) by CD and KL (is) equal to the (square) on H. Thus, the (rectangle contained) by CD and AB is commensurable with the (square) on H. And the (square) on G is equal to the (rectangle contained) by CD and AB. The (square) on G

is thus commensurable with the (square) on H. And the (square) on H (is) rational. Thus, the (square) on G is also rational. G is thus rational. And it is the square-root of the (rectangle contained) by CD and AB.

Thus, if an area is contained by an apotome, and a binomial whose terms are commensurable with, and in the same ratio as, the terms of the apotome, then the square-root of the area is a rational (straight-line).

Πόρισμα.

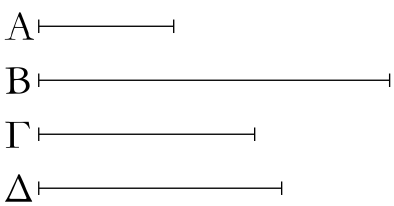
Καὶ γέγονεν ἡμῖν καὶ διὰ τούτου φανερόν, ὅτι δυνατόν ἐστι ῥητὸν χωρίον ὑπὸ ἀλόγων εὐθειῶν περιέχεσθαι. ὅπερ ἔδει δεῖξαι.

Corollary

And it has also been made clear to us, through this, that it is possible for a rational area to be contained by irrational straight-lines. (Which is) the very thing it was required to show.

ριε´.

Ἀπὸ μέσης ἄπειροι ἄλογοι γίνονται, καὶ οὐδεμία οὐδεμιᾷ τῶν πρότερον ἡ αὐτή.

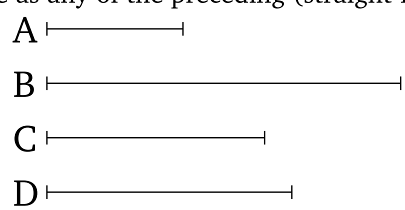


Ἔστω μέση ἡ Α· λέγω, ὅτι ἀπὸ τῆς Α ἄπειροι ἄλογοι γίνονται, καὶ οὐδεμία οὐδεμιᾷ τῶν πρότερον ἡ αὐτή.

Ἐκκείσθω ῥητὴ ἡ Β, καὶ τῷ ὑπὸ τῶν Β, Α ἴσον ἔστω τὸ ἀπὸ τῆς Γ· ἄλογος ἄρα ἐστὶν ἡ Γ· τὸ γὰρ ὑπὸ ἀλόγου καὶ ῥητῆς ἄλογόν ἐστιν. καὶ οὐδεμιᾷ τῶν πρότερον ἡ αὐτή· τὸ γὰρ ἀπ᾽ οὐδεμιᾶς τῶν πρότερον παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ μέσην. πάλιν δὴ τῷ ὑπὸ τῶν Β, Γ ἴσον ἔστω τὸ ἀπὸ τῆς Δ· ἄλογον ἄρα ἐστὶ τὸ ἀπὸ τῆς Δ. ἄλογος ἄρα ἐστὶν ἡ Δ· καὶ οὐδεμιᾷ τῶν πρότερον ἡ αὐτή· τὸ γὰρ ἀπ᾽ οὐδεμιᾶς τῶν πρότερον παρὰ ῥητὴν παραβαλλόμενον πλάτος ποιεῖ τὴν Γ. ὁμοίως δὴ τῆς τοιαύτης τάξεως ἐπ᾽ ἄπειρον προβαινούσης φανερόν, ὅτι ἀπὸ τῆς μέσης ἄπειροι ἄλογοι γίνονται, καὶ οὐδεμία οὐδεμιᾷ τῶν πρότερον ἡ αὐτή· ὅπερ ἔδει δεῖξαι.

Proposition 115

An infinite (series) of irrational (straight-lines) can be created from a medial (straight-line), and none of them is the same as any of the preceding (straight-lines).



Let A be a medial (straight-line). I say that an infinite (series) of irrational (straight-lines) can be created from A, and that none of them is the same as any of the preceding (straight-lines).

Let the rational (straight-line) B be laid down. And let the (square) on C be equal to the (rectangle contained) by B and A. Thus, C is irrational [Def. 10.4]. For an (area contained) by an irrational and a rational (straight-line) is irrational [Prop. 10.20]. And (C is) not the same as any of the preceding (straight-lines). For the (square) on none of the preceding (straight-lines), applied to a rational (straight-line), produces a medial (straight-line) as breadth. So, again, let the (square) on D be equal to the (rectangle contained) by B and C. Thus, the (square) on D is irrational [Prop. 10.20]. D is thus irrational [Def. 10.4]. And (D is) not the same as any of the preceding (straight-lines). For the (square) on none of the preceding (straight-lines), applied to a rational (straight-line), produces C as breadth. So, similarly, this arrangement being advanced to infinity, it is clear that an infinite (series) of irrational (straight-lines) can be created from a medial (straight-line), and that none of them is the same as any of the preceding (straight-lines). (Which is) the very thing it was required to show.