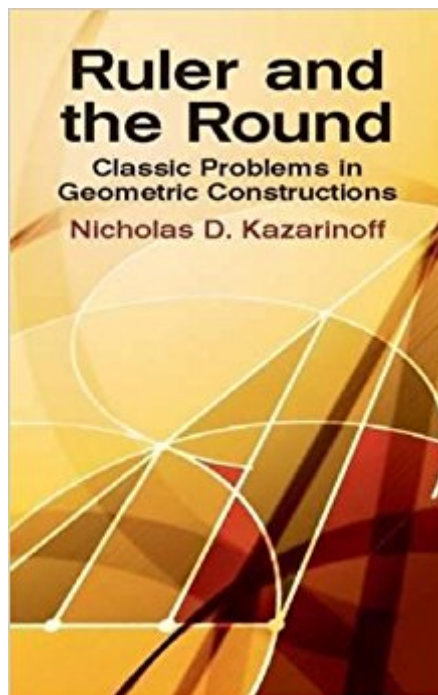




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# Ruler And The Round: Classic Problems In Geometric Constructions



## Synopsis

Although easy to comprehend and fun to do, many geometric constructions defy completion with just a ruler and a compass. This book takes an intriguing look at the most famous of these "impossible" constructions. In exploring ground rules, history, and angle trisection, the first part considers angle trisection and bird migration, constructed points, analytic geometry, algebraic classification of constructible numbers, fields of real numbers, cubic equations, and marked ruler, quadratrix, and hyperbola (among other subjects). The second part treats nonconstructible regular polygons and the algebra associated with them; specifically, irreducibility and factorization, unique factorization of quadratic integers, finite dimensional vector spaces, algebraic fields, and nonconstructible regular polygons. High school and college students as well as amateur mathematicians will appreciate this stimulating and provocative book, and its glimpses into the crucial role geometry plays in a wide range of mathematical applications.

## Book Information

Paperback: 160 pages

Publisher: Dover Publications (October 20, 2011)

Language: English

ISBN-10: 0486425150

ISBN-13: 978-0486425153

Product Dimensions: 1.5 x 0.3 x 9.2 inches

Shipping Weight: 12.6 ounces (View shipping rates and policies)

Average Customer Review: 4.2 out of 5 stars 4 customer reviews

Best Sellers Rank: #655,283 in Books (See Top 100 in Books) #93 in [Books > Science & Math > Mathematics > Applied > Graph Theory](#) #726 in [Books > Science & Math > Mathematics > Geometry & Topology](#)

## Customer Reviews

Excellent book

Save your money if you simply need to learn how to do a particular geometric construction by Googling "geometric construction" and you'll find many informative sites, some with animated constructions. This book is impressive, well written and will be a good read over the summer when I have more time. I was in a pinch tutoring Honors Geometry and needed to quickly learn how to construct a regular pentagon. This books gives the proof and is pretty clear (once I'm not in a

panic), but I googled and found a one-paragraph explanation which solved my immediate construction need.

This thoroughly readable and enjoyable book for a general audience was written by an accomplished and respected mathematician, former Professor and Chair at two of the world's best Departments of Mathematics, the University of Michigan and the University of Buffalo. Unlike many other writers of popular mathematics books, Kazarinoff does not betray his beloved field by over-simplification, pontification, or dogmatism. On the contrary, Kazarinoff has deep faith in the intelligence and critical abilities of his readers and he makes every effort to help them to become genuine participants in a small, but richly fascinating and beautiful corner of mathematics. His aim is to help the readers to gain personal knowledge of several mathematically, philosophically, historically and culturally important mathematical facts. Although these facts can be stated in short simple sentences, they were discovered to be facts only after centuries of intense mathematical research by some of the world's greatest minds. The simplest example is the fact that it is impossible to trisect the angle, i.e. there exists no general construction method or algorithm using only straight-edge and compass for trisecting an arbitrarily given angle. "RULER" in the title refers to the straight-edge; "ROUND" refers to the compass. The Kazarinoff book, again contrary to the vast majority of popular mathematics books, carefully explains the nature of the mathematical facts to be proved: the relevant fundamentals of geometry, what a construction is, exactly what can and can not be done with the straight-edge, exactly what can and can not be done with the compass. It has an intriguing and pedagogically effective discussion of the differences between what I call the collapsing compass and the non-collapsing compass. With the collapsing compass one draws a circle given the center and a point on the circumference, but one can not carry the length of the radius to other points to make copies of the circle, the compass "collapses". But with the non-collapsing compass, once one circle has been drawn it can be copied over and over wherever a center is given. An appendix presents the reader with enough practice using the straight-edge and collapsing compass that there will be no confusion or uncertainty about which facts are being proved. The practice is not just exercise: it is used to give a cogent and accessible proof of the fact, justifiably called astounding by Kazarinoff, that any figure constructible from given points by means of the straight-edge and non-collapsing compass can be done with the straight-edge supplemented only by a collapsing compass. Moreover, and here, as far as I know, RULER AND THE ROUND is absolutely unique: it provides a brief but informative discussion of exactly what a mathematical proof is. In each case, Kazarinoff wants the readers to know exactly which fact is being argued for and

exactly what a proof of it would be like -- so that the readers can make their own judgments of whether Kazarinoff has actually proved it. On page 5, at the end of the section called "PROOF" he says to the reader concerning the arguments to be presented: "I hope they convince you too". In what other popular mathematics book have you seen such respect for the reader, such openness, such modesty? In what other popular mathematics book have you seen concern for the reader's opinion? This book is an implicit insult to the elitist high-priests of popularization with their breezy enthusiasm, their hocus-pocus "proofs", their mumbo-jumbo, their scientific dogmatism. Ironically, it is Kazarinoff's openness that leads him to temper his realism with what to my mind seems to be an unacceptable level of cultural relativism and to temper his egalitarianism with a sometimes hard-edged elitism. Nevertheless, his frankness and independence are truly refreshing and his sincere effort to share with non-experts his profound mastery of the material can only evoke gratitude. Of course, there is room for disagreement about the details and about how well he fulfilled his goals. Judgments on these issues are to some extent subjective and will depend on the background of the person making the judgment. I first read a library copy of this book in 1970 when it first appeared. A few months later, when I decided to reread it, the library copy was on-loan with a long waiting list. I tried to buy a copy but by then it was out of print. Recently, I went to .com to try to get a used copy and was thrilled to learn that it is back in print with a 2003 date. Who should read this book? Mathematics majors should look at this short 130-page book as early as possible because it might reveal to them what subject they have chosen; or at the very least it will reveal to them what a serious, accomplished mathematician thinks the subject is. Mathematics teachers, especially those who complain that their students do not know what a proof is, might pick up a pointer or two from reading it. Logicians might learn something from it, especially from the section on pages 5 and 6 about what proofs are. Historians and philosophers of mathematics will find many original and thought-provoking perspectives in this book. Kazarinoff does not belong to any of the identifiable "schools" of philosophy of mathematics-he gives no signs in this book of having paid any of them the slightest attention. He is not selling anything and he is not spinning anything. I can not think of a better book for people curious about mathematics. - Frango Nabrasa, Manatee FL

This review is meant to supplement the interesting and informative review by Professor Frango Nabrasa. I agree with Nabrasa's favorable assessment of the book, but I find his review to be excessively polite or insufficiently critical (I cannot tell which). Either way, I find his review potentially misleading. It will be impossible to follow this review without having read Nabrasa's, which appears on the same webpage. Although I agree with Nabrasa's substitution of the expression `collapsing

compass' for Kazarinoff's unfortunate 'collapsible compass', I find the entire discussion of "ruler and compass constructions" to be ahistorical and anachronistic. The Greeks were perfectly clear that geometrical objects were abstract or ideal and that they are in no sense constructed. The constructivistic language used in Euclid must be understood as metaphorical or as referring to an ideal geometer. The idea that an actual geometer could literally construct a line from, say, the center of earth to the center of sun is too absurd. Moreover in the whole of Euclid's ELEMENTS there is no mention of a compass of any kind, nor for that matter of a straightedge. Incidentally, Nabrasa nowhere mentions that Kazarinoff uses the word 'ruler' to mean "straightedge" while the majority of writers in the field take a ruler to be a measuring device having graduations--something straightedges lack--even though Kazarinoff mentions on page 59 Archimedes's simple trisection of an arbitrary angle using a "marked ruler". Nabrasa wrote: "It [the book] has an intriguing and pedagogically effective discussion of the differences between a rather strange idealized device that I call the collapsing compass and the device familiar from high-school geometry that I call the non-collapsing compass. With the collapsing compass one draws a circle given the center and a point on the circumference, but one can not carry the length of the radius to other points to make copies of the circle -- the compass "collapses". But with the non-collapsing compass, once one circle has been drawn it can be copied over and over wherever a center is given. It is not that the collapsing compass can be collapsed or closed after used (as is implied by the word 'collapsible' which Kazarinoff uses); rather it must be collapsed, it cannot be kept open any longer than needed to draw one circle. An appendix presents the reader with enough practice using the straightedge and collapsing compass that there will be no uncertainty about which facts are being proved. The practice is not just exercise: it is used to give a cogent and accessible proof of the fact, justifiably called astounding by Kazarinoff, that any figure constructible from given points by means of the straightedge and non-collapsing compass can be constructed with the straightedge supplemented only by a collapsing compass. Moreover, as far as I know, RULER AND THE ROUND is absolutely unique in that it provides a brief but informative discussion of exactly what a mathematical proof is." In the first place Nabrasa misspoke slightly when he said: "With the collapsing compass one draws a circle given the center and a point on the circumference, but one can not carry the length of the radius to other points to make copies of the circle -- the compass 'collapses'." Later on he praises Kazarinoff's proof that indeed this can be done. The problem of course is that instead of "one can not carry the length" he should have said "one can not simply carry the length ... as with the non-collapsing compass". In the second place Nabrasa gives the impression that Kazarinoff is or might be the first to prove the astounding fact. But everything needed for knowledge of that fact

goes back at least to Euclid: the gist of it is in Euclid's proof of Proposition 2 of Book I, as was pointed out to me by Prof. Martin Davis. The only reason I can think of to explain why neither Kazarinoff nor Nabrasa mention this historical point is that they did not know it. The idea that Kazarinoff would risk seeming to take credit he knew was due to Euclid is so contrary to Kazarinoff's character as to be absurd. Incidentally, to be historically accurate, Euclid did not say a word about proving that what could be constructed in one way could or could not be constructed in some other way: there is no comparison of different kinds of constructability anywhere in Euclid's ELEMENTS. Thus, even attributing awareness of the issue to Euclid would be unwarranted. In the third place Nabrasa is being somewhat less than candid when he says that the Kazarinoff book "is absolutely unique in that it provides a brief but informative discussion of exactly what a mathematical proof is". For one thing "absolutely unique" is an exaggeration: "rare" would be more appropriate. For example, see Durfee 1963, 9. For another, Nabrasa himself thoroughly disagrees with the peculiarly elitist and subjectivist theory of proof espoused by Kazarinoff in the book (per. comm.). In fact, I cannot believe that even Kazarinoff himself would continue to espouse it once its fundamentally unscientific implications were made clear to him. (The reviewer was an admiring colleague and friend of Kazarinoff both at Ann Arbor and at Buffalo.) The postulate that is most germane to the discussion, Euclid's third, is often translated: "To describe a circle with any center and distance". There are two standard non-constructive ways of interpreting this. First it can be taken in a strong sense as saying that given any point  $P$  and any line  $AB$ , there is a circle having  $P$  as center and having radius equal to  $AB$ . This corresponds to "postulating" a non-collapsing compass. Second it can be read in a much weaker sense: given any point  $P$  and given any point  $Q$  at any distance from  $P$  there is a circle having  $P$  as center and having radius equal to  $PQ$ . This corresponds to "postulating" a collapsing compass. If it is interpreted in the first or strong sense then (augmented by the first two postulates) Euclid's Proposition 2 follows almost immediately and Euclid's proof looks like the work of a puristic and prolix amateur. However, if it is read in the second weak sense then Proposition 2 is far from obvious and Euclid's proof becomes clean and "elegant". The weak reading follows immediately from the strong. I would say that it is obvious that the strong reading does not follow from the weak. -- John Corcoran.

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