

# Solutions

## Twentieth International Olympiad, 1978

**1978/1.** Since  $1978^n$  and  $1978^m$  agree in their last three digits, the difference

$$1978^n - 1978^m = 1978^m(1978^{n-m} - 1)$$

is divisible by  $10^3 = 2^3 \cdot 5^3$ ; and since the second factor above is odd,  $2^3$  divides the first. Also

$$1978^m = 2^m \cdot 989^m,$$

so  $m \geq 3$ .

We can write  $m + n = (n - m) + 2m$ ; to minimize this sum, we take  $m = 3$  and seek the smallest value of  $d = n - m$ , such that  $1978^d - 1$  is divisible by  $5^3 = 125$ , i.e.

$$1978^d \equiv 1 \pmod{125}.$$

We shall twice make use of the following

**LEMMA.** *Let  $d$  be the smallest exponent such that  $a^d \equiv 1 \pmod{N}$ . Then any other exponent  $g$  for which  $a^g \equiv 1 \pmod{N}$  is a multiple of  $d$ .*

**PROOF:** If  $d$  does not divide  $g$ , then  $g = qd + r$  with  $0 < r < d$ , and  $a^g \equiv a^{qd}a^r \equiv 1 \pmod{N}$  implies  $a^r \equiv 1 \pmod{N}$  with  $0 < r < d$ , contradicting the minimality of  $d$ . So  $d|g$ .

Fermat's theorem states:† For any prime  $p$  and any integer  $a$  not divisible by  $p$ ,

$$(1) \quad a^{p-1} \equiv 1 \pmod{p}.$$

For example,

$$1978^4 \equiv 1 \pmod{5}.$$

†For a proof, see e.g. p. 126 of S. L. Greitzer, *The International Mathematical Olympiads*, vol. 27 in this NML series.

# Math Olympiad Problems And Solutions

**Jin-Ying Zhang**



## **Math Olympiad Problems And Solutions:**

**Problems And Solutions In Mathematical Olympiad (Secondary 2)** Xiong-hui Zhao,2024-07-02 The series is edited by the head coaches of China's IMO National Team Each volume catering to different grades is contributed by the senior coaches of the IMO National Team The Chinese edition has won the award of Top 50 Most Influential Educational Brands in China The series is created in line with the mathematics cognition and intellectual development levels of the students in the corresponding grades All hot mathematics topics of the competition are included in the volumes and are organized into chapters where concepts and methods are gradually introduced to equip the students with necessary knowledge until they can finally reach the competition level In each chapter well designed problems including those collected from real competitions are provided so that the students can apply the skills and strategies they have learned to solve these problems Detailed solutions are provided selectively As a feature of the series we also include some solutions generously offered by the members of Chinese national team and national training team      *Problems And Solutions In Mathematical Olympiad (High School 3)* Hong-bing Yu,2022-03-16 The series is edited by the head coaches of China's IMO National Team Each volume catering to different grades is contributed by the senior coaches of the IMO National Team The Chinese edition has won the award of Top 50 Most Influential Educational Brands in China The series is created in line with the mathematics cognition and intellectual development levels of the students in the corresponding grades All hot mathematics topics of the competition are included in the volumes and are organized into chapters where concepts and methods are gradually introduced to equip the students with necessary knowledge until they can finally reach the competition level In each chapter well designed problems including those collected from real competitions are provided so that the students can apply the skills and strategies they have learned to solve these problems Detailed solutions are provided selectively As a feature of the series we also include some solutions generously offered by the members of Chinese national team and national training team

**Problems And Solutions In Mathematical Olympiad (Secondary 1)** Zun Shan,2024-05-28 The series is edited by the head coaches of China's IMO National Team Each volume catering to different grades is contributed by the senior coaches of the IMO National Team The Chinese edition has won the award of Top 50 Most Influential Educational Brands in China The series is created in line with the mathematics cognition and intellectual development levels of the students in the corresponding grades All hot mathematics topics of the competition are included in the volumes and are organized into chapters where concepts and methods are gradually introduced to equip the students with necessary knowledge until they can finally reach the competition level In each chapter well designed problems including those collected from real competitions are provided so that the students can apply the skills and strategies they have learned to solve these problems Detailed solutions are provided selectively As a feature of the series we also include some solutions generously offered by the members of Chinese national team and national training team      Mathematical Olympiads 2000-2001 Titu

Andreescu, Zuming Feng, George Lee, 2003-10-16 Problems and solutions from Mathematical Olympiad Ideal for anyone interested in mathematical problem solving      *Mathematical Olympiads 1998-1999* Titu Andreescu, Zuming Feng, 2000-11-02 A large range of problems drawn from mathematics olympiads from around the world      *Mathematical Olympiad Challenges* Titu Andreescu, Razvan Gelca, 2008-12-04 Hundreds of beautiful challenging and instructive problems from algebra geometry trigonometry combinatorics and number theory Historical insights and asides are presented to stimulate further inquiry Emphasis is on creative solutions to open ended problems Many examples problems and solutions with a user friendly and accessible style Enhanced motivation References      *The Hard Mathematical Olympiad Problems and Their Solutions* Steve Dinh, 2011 This book shows the approaches to solving many difficult Mathematical Olympiad and other international problems posted at the [www.mathlinks.ro](http://www.mathlinks.ro) the largest mathematical webpage that has most of the problems used to select the talented students of the world At the time of this book's publication the solutions to many of these problems are not yet available This book is not only as much about methods of solving mathematical problems as it is about various approaches to solving the difficult problems in general It is a first step in examining the creativity that goes into problem solving The real points of the book are the enumeration of problem solving strategies and the tricks applied to solve the problems The approaches in the book build understanding and not just methods in solving problems This book is a must read for many math students and is useful for many teachers around the world      [USA and International Mathematical Olympiads, 2005](#) Zuming Feng, Cecil Rousseau, Melanie Matchett Wood, 2006 The Mathematical Olympiad examinations covering the USA Mathematical Olympiad USAMO and the International Mathematical Olympiad IMO have been published annually by the MAA American Mathematics Competitions since 1976 This collection of excellent problems and beautiful solutions is a valuable companion for students who wish to develop their interest in mathematics      [The Mathematical Olympiad Handbook](#) Anthony Gardiner, 1997 Mathematical Olympiad competitions started in Hungary at the end of the nineteenth century and are now held internationally They bring together able secondary school pupils who attempt to solve problems which develop their mathematical skills Olympiad problems are unpredictable and have no obvious starting point and although they require only the skills learnt in ordinary school problems they can seem much harder The Mathematical Olympiad Handbook introduces readers to these challenging problems and aims to convince them that Olympiads are not just for a select minority The book contains problems from the first 32 British Mathematical Olympiad BMO papers 1965-96 and gives hints and outline solutions to each problem from 1975 onwards An overview is given of the basic mathematical skills needed and a list of books for further reading is provided Working through the exercises provides a valuable source of extension and enrichment for all pupils and adults interested in mathematics      [Puzzle and Proof](#) Samuel Dittmer, Hiram Golze, Grant Molnar, Caleb Stanford, 2024-08-13 *Puzzle and Proof* A Decade of Problems from the Utah Math Olympiad is a compilation of the problems and solutions for the first 10 years of the Utah Math Olympiad The problems are challenging but

should be understandable at a high school level Besides putting all problems in one place 70 in total which have not previously appeared in print the book provides additional inspiration for many of the problems and will contain the first published solutions for 10 problems that were originally published on the contest flyer The book will be a fantastic resource for anyone who enjoys mathematical and or logic puzzles or is interested in studying for mathematics competitions Features 70 carefully designed high quality high school level math proof problems with full solutions Detailed pictures and diagrams throughout to aid understanding Suitable for anyone with high school level mathematics skills with an interest in furthering their understanding or just enjoying the puzzles Solutions in the back of the book sorting the problems by difficulty and topic

*Index to Mathematical Problems, 1980-1984* Stanley Rabinowitz,1992 A compendium of over 5 000 problems with subject keyword author and citation indexes

**Mathematical Olympiad In China (2011-2014): Problems And Solutions** Bin Xiong,Peng Yee Lee,2018-03-22 The International Mathematical Olympiad IMO is a very important competition for high school students China has taken part in the IMO 31 times since 1985 and has won the top ranking for countries 19 times with a multitude of gold medals for individual students The six students China has sent every year were selected from 60 students among approximately 300 students who took part in the annual China Mathematical Competition during the winter months This book includes the problems and solutions of the most important mathematical competitions from 2010 to 2014 in China such as China Mathematical Competition China Mathematical Olympiad China Girls Mathematical Olympiad These problems are almost exclusively created by the experts who are engaged in mathematical competition teaching and researching Some of the solutions are from national training team and national team members their wonderful solutions being the feature of this book This book is useful to mathematics fans middle school students engaged in mathematical competition coaches in mathematics teaching and teachers setting up math elective courses

*A First Step To Mathematical Olympiad Problems* Derek Allan Holton,2009-07-30 See also A SECOND STEP TO MATHEMATICAL OLYMPIAD PROBLEMS The International Mathematical Olympiad IMO is an annual international mathematics competition held for pre collegiate students It is also the oldest of the international science olympiads and competition for places is particularly fierce This book is an amalgamation of the first 8 of 15 booklets originally produced to guide students intending to contend for placement on their country s IMO team The material contained in this book provides an introduction to the main mathematical topics covered in the IMO which are Combinatorics Geometry and Number Theory In addition there is a special emphasis on how to approach unseen questions in Mathematics and model the writing of proofs Full answers are given to all questions Though A First Step to Mathematical Olympiad Problems is written from the perspective of a mathematician it is written in a way that makes it easily comprehensible to adolescents This book is also a must read for coaches and instructors of mathematical competitions

**Mathematical Olympiads 1999-2000** Titu Andreescu,Zuming Feng,2002-05-16 Challenging problems in maths plus solutions to those featured in the earlier Olympiad book

The IMO Compendium Dušan Djukić,Vladimir Janković,Ivan

Matić,Nikola Petrović,2011-05-05 The IMO Compendium is the ultimate collection of challenging high school level mathematics problems and is an invaluable resource not only for high school students preparing for mathematics competitions but for anyone who loves and appreciates mathematics The International Mathematical Olympiad IMO nearing its 50th anniversary has become the most popular and prestigious competition for high school students interested in mathematics Only six students from each participating country are given the honor of participating in this competition every year The IMO represents not only a great opportunity to tackle interesting and challenging mathematics problems it also offers a way for high school students to measure up with students from the rest of the world Until the first edition of this book appearing in 2006 it has been almost impossible to obtain a complete collection of the problems proposed at the IMO in book form The IMO Compendium is the result of a collaboration between four former IMO participants from Yugoslavia now Serbia and Montenegro to rescue these problems from old and scattered manuscripts and produce the ultimate source of IMO practice problems This book attempts to gather all the problems and solutions appearing on the IMO through 2009 This second edition contains 143 new problems picking up where the 1959 2004 edition has left off

**Introduction to Math Olympiad Problems** Michael A. Radin,2021-06-24 Introduction to Math Olympiad Problems aims to introduce high school students to all the necessary topics that frequently emerge in international Math Olympiad competitions In addition to introducing the topics the book will also provide several repetitive type guided problems to help develop vital techniques in solving problems correctly and efficiently The techniques employed in the book will help prepare students for the topics they will typically face in an Olympiad style event but also for future college mathematics courses in Discrete Mathematics Graph Theory Differential Equations Number Theory and Abstract Algebra Features Numerous problems designed to embed good practice in readers and build underlying reasoning analysis and problem solving skills Suitable for advanced high school students preparing for Math Olympiad competitions

**Index to Mathematical Problems, 1975-1979** Stanley Rabinowitz,Mark Bowron,1999 *Mathematical Olympiad in China (2007-2008)* Xiong Bin,2009 The International Mathematical Olympiad IMO is a competition for high school students China has taken part in the IMO 21 times since 1985 and has won the top ranking for countries 14 times with a multitude of golds for individual students The six students China has sent every year were selected from 20 to 30 students among approximately 130 students who took part in the annual China Mathematical Competition during the winter months This volume comprises a collection of original problems with solutions that China used to train their Olympiad team in the years from 2006 to 2008 Mathematical Olympiad problems with solutions for the years 2002OC02006 appear in an earlier volume Mathematical Olympiad in China

**The Colorado Mathematical Olympiad and Further Explorations** Alexander Soifer,2011-04-11 Over the past two decades the once small local Colorado Springs Mathematics Olympiad founded by the author himself has now become an annual state wide competition hosting over one thousand high school contenders each year This updated printing of the first edition of

Colorado Mathematical Olympiad the First Twenty Years and Further Explorations offers an interesting history of the competition as well as an outline of all the problems and solutions that have been a part of the contest over the years. Many of the essay problems were inspired by Russian mathematical folklore and written to suit the young audience; for example, the 1989 Sugar problem was written as a pleasant Lewis Carroll like story. Some other entertaining problems involve old Victorian map colorings, King Arthur and the knights of the round table, rooks in space, Santa Claus and his elves painting planes, football for 23, and even the Colorado Springs subway system. The book is more than just problems, their solutions, and event statistics; it tells a compelling story involving the lives of those who have been part of the Olympiad from every perspective.

**Mathematical Olympiad Challenges** Titu Andreescu, Razvan Gelca, 2013-12-01

Mathematical Olympiad Challenges is a rich collection of problems put together by two experienced and well known professors and coaches of the U.S. International Mathematical Olympiad Team. Hundreds of beautiful challenging and instructive problems from algebra, geometry, trigonometry, combinatorics, and number theory were selected from numerous mathematical competitions and journals. An important feature of the work is the comprehensive background material provided with each grouping of problems. The problems are clustered by topic into self contained sections with solutions provided separately. All sections start with an essay discussing basic facts and one or two representative examples. A list of carefully chosen problems follows and the reader is invited to take them on. Additionally, historical insights and asides are presented to stimulate further inquiry. The emphasis throughout is on encouraging readers to move away from routine exercises and memorized algorithms toward creative solutions to open ended problems. Aimed at motivated high school and beginning college students and instructors, this work can be used as a text for advanced problem solving courses for self study or as a resource for teachers and students training for mathematical competitions and for teacher professional development seminars and workshops.

## **Math Olympiad Problems And Solutions** Book Review: Unveiling the Power of Words

In some sort of driven by information and connectivity, the energy of words has be more evident than ever. They have the capacity to inspire, provoke, and ignite change. Such may be the essence of the book **Math Olympiad Problems And Solutions**, a literary masterpiece that delves deep to the significance of words and their effect on our lives. Written by a renowned author, this captivating work takes readers on a transformative journey, unraveling the secrets and potential behind every word. In this review, we will explore the book is key themes, examine its writing style, and analyze its overall impact on readers.

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