The ARRL

Ham Radio License Manual

All you need to become an Amateur Radio Operator

Second Edition

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This book may be used for Technician license exams given beginning July 1, 2010.

QST and the ARRL Web site (**www.arrl.org**) will have news about any rules changes affecting the Technician class license or any of the material in this book.

We strive to produce books without errors. Sometimes mistakes do occur, however. When we become aware of problems in our books (other than obvious typographical errors), we post corrections on the ARRL Web site. If you think you have found an error, please check **www.arrl.org/ham-radio-license-manual** for corrections. If you don't find a correction there, please let us know, either using the Feedback Form at the back of this book or by sending e-mail to **pubsfdbk@arrl.org**.

Contents

Foreword

Welcome to the diverse group of individuals who make up Amateur Radio! There are nearly 700,000 amateurs, or "hams," in the United States alone and 3,000,000 around the world. Hams come from all walks of life, all ages and every continent. Hams are busily communicating without regard to the geographic and political barriers that often separate humanity. This is the power of Amateur Radio — to communicate with each other directly, without any other commercial or government systems.

Amateur Radio was born along with radio itself. Marconi, the father of radio, considered himself "an amateur" and many of the wireless technologies and systems we take for granted today had their origins in the workshops and imaginations of amateurs. Governments make room for Amateur Radio when valuable radio spectrum is allocated because they know and respect the flexibility and inventiveness of hams, as well as the amateur's legendary ability to innovate and adapt in the face of emergencies and disasters.

Hams came to Amateur Radio from many walks of life and many interests. Perhaps you intend to provide emergency communications for yourself and your community. Technical experimentation might be your interest or you might be one of the burgeoning "do-it-yourself" community, discovering the pleasures of building, testing, using and learning. Making new friends via the radio, keeping in touch as you travel or exploring where a wireless signal can take you — these are all valuable and valued parts of the Amateur service.

A time-honored ham tradition is that of helping newcomers learn about the ways and skills of Amateur Radio. These helpers — known as "Elmers" by other hams — are everywhere. You are almost certainly near another ham and probably an entire ham radio club! They'll gladly help you get started. There's more information in Chapter 1 about connecting with them. If you need assistance, the staff here at ARRL Headquarters will be more than happy to help, too.

As you read this book, getting ready to pass your first ham radio licensing exam, you will find that there is a lot more material than just the answers to exam questions. That's the ARRL way of going the extra mile to help you learn about Amateur Radio. "Of, By and For the Amateur" is the ARRL's motto. By providing this extra information, we help you learn the "why" behind each question so that you are prepared when ready to get on the air. Keep this book handy as a reference to help you understand how ham radio "works" and you'll have more fun and be a more effective operator.

Most active radio amateurs in the United States are ARRL members. They realize that since 1914, the ARRL's training, sponsorship of activities and representation both nationally and internationally are second to none. The book you're reading now, *The ARRL Ham Radio License Manual* is just one of many publications for all levels and interests in Amateur Radio. You don't need a license to join the ARRL — just be interested in Amateur Radio and we are interested in you. It's as simple as that!

David Sumner, K1ZZ
Chief Executive Officer
Newington, Connecticut
March 2010

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(860) 594-0200

Prospective new amateurs call:
800-32-NEW-HAM (800-326-3942)
You can also contact us via e-mail: **newham@arrl.org**
or check out **ARRLWeb: www.arrl.org**

The Adventure Begins!

Congratulations! You've taken your first step into a hobby—and a service—that knows no limits. Amateur Radio is a worldwide network of people from various cultures, united by a common love of wireless communication. Amateur Radio is as old as radio itself, and its future is no less fantastic than its past.

For most people, Amateur Radio is a lifelong pursuit. We want to make sure you get a good start, which is why we've published this book. But first, who are "we" ?

ARRL The National Association for Amateur Radio: What's in it for You?

♦ **Help for New Hams**: Are you a beginning ham looking for help in getting started? The hams at ARRL HQ in Newington, Connecticut, will be glad to assist you. Call 800-32-NEWHAM. ARRL maintains a computer data base of ham clubs and ham radio "helpers" from across the country who've told us they're interested in helping beginning hams. There are probably several clubs in your area! Contact us for more information.

♦ **Licensing Classes**: If you're going to become a ham, you'll need to find a local license exam opportunity sooner or later. ARRL Registered Instructors teach licensing classes all around the country, and ARRL-sponsored Volunteer Examiners are right there to administer your exams. To find the locations and dates of Amateur Radio Licensing classes and test sessions in your area, call the New Ham Desk at 800-32-NEWHAM.

♦ **Clubs**: As a beginning ham, one of the best moves you can make is to join a local ham club. Whether you join an all-around group or a special-interest club (repeaters, DXing, and so on), you'll make new friends, have a lot of fun, and you can tap into a ready reserve of ham radio knowledge and experience. To find the ham clubs in your area, call HQ's New Ham Desk at 800-32-NEWHAM.

♦ **Technical Information Service**: Do you have a question of a technical nature? (What new ham doesn't?) Contact the Technical Information Service (TIS) at HQ. Our resident technical experts will help you over the phone, send you specific information on your question (antennas, interference and so on) or refer you to your local ARRL Technical Coordinator or Technical Specialist. It's expert information—and it doesn't cost Members an extra cent!

♦ **Regulatory Information**: Need help with a thorny antenna zoning problem? Having trouble understanding an FCC regulation? Vacationing in a faraway place and want to know how to get permission to operate your ham radio there? HQ's Regulatory Information Branch has the answers you need!

♦ **Operating Awards**: Like to collect "wallpaper"? The ARRL sponsors a wide variety of certificates and Amateur Radio achievement awards. For information on awards you can qualify for, contact the Membership Services Department at HQ.

♦ **Equipment Insurance**: Insurance is available to protect you from loss or damage to your amateur station, antennas and mobile equipment by lightening, theft, accident, fire, flood, tornado and other natural disasters.

♦ **Amateur Radio Emergency Service**: If you're interested in providing public service and emergency communications for your community, you can join more than 25,000 other hams who have registered their communications capabilities with local Emergency Coordinators. Your EC will call on you and other ARES members for vital assistance if disaster should strike your community. Contact the Field Services Department at HQ for information.

With your membership you also receive the monthly journal *QST*, the source for ham radio information, clever technical tips, equipment reviews, projects, Public Service, Happenings and more.

The ARRL also publishes newsletters and dozens of books covering all aspects of Amateur Radio. Our Headquarters station, W1AW, transmits bulletins of interest to radio amateurs and Morse Code practice sessions.

When it comes to representing Amateur Radio's best interests in our nation's capital, ARRL's team in Washington, DC, is constantly working with the FCC, Congress and industry to protect and foster your privileges as a ham operator.

Regardless of your Amateur Radio interests, ARRL Membership is relevant and important. We will be happy to welcome you as a Member. Use the Invitation to Membership in this book to **join today**. And don't hesitate to contact us if you have any questions!

When to Expect New Books

A Question Pool Committee (QPC) consisting of representatives from the various Volunteer Examiner Coordinators (VECs) prepares the license question pools. The QPC establishes a schedule for revising and implementing new Question Pools. The current Question Pool revision schedule is as follows:

Question Pool	***Current Study Guides***	***Valid Through***
Technician (Element 2)	*The ARRL Ham Radio License Manual,* 2nd edition *ARRL's Tech Q&A*, 5th Edition	**June 30, 2014**
General (Element 3)	*The ARRL General Class License Manual,* 6th edition *ARRL's General Q&A,* 3rd Edition	**June 30, 2011**
Amateur Extra (Element 4)	*The ARRL Extra Class License Manual*, 9th edition *ARRL's Extra Q&A,* 2nd Edition	**June 30, 2012**

As new question pools are released, ARRL will produce new study materials before the effective date of the new Pools. Until then, the current Question Pools will remain in use, and current ARRL study materials, including this book, will help you prepare for your exam.

As the new Question Pool schedules are confirmed, the information will be published in *QST* and on the ARRL Web site at **www.arrl.org**.

How to Use this Book

The ARRL Ham Radio License Manual is designed to help you learn about every topic in the Technician exam question pool. Every page presents information you'll need to pass the exam and become an effective operator. This book goes well beyond the answers to exam questions — it also contains explanations, guidelines and information to help you remember and use what you learn on the air.

The book is organized to help you learn about radio and operating in easy-to-understand, bite-sized steps. You'll begin by learning about the basics of radio signals and simple ham radio equipment. The next steps cover the principles of electricity and an introduction to electrical components. You'll then learn how a simple station is assembled and some basic operating procedures. At that point, you'll be ready to understand the rules and regulations of ham radio. The final section is all about ham radio safety.

At the back of this book you'll also find a large glossary of ham radio words, a supplement to help you choose a radio and a selection of advertisements from some vendors of ham radio equipment and supplies.

Conventions

Throughout your studies keep a sharp eye out for words in *italics*. These words are important so be sure you understand them. Many of them are included in the glossary. Another thing to look for is the Web mouse symbol, indicating that there is supplemental information on the *Ham Radio License Manual* Web site (**www.arrl.org/ham-radio-license-manual**) to accelerate and broaden your understanding. If a Web or email address is included, it will be printed in **boldface type**.

As you read the book, you will see question designators in square brackets, such as [T1A01]. These are references to the question ID in the exam's question pool. This will help you find the material that addresses a specific question. The question pool also includes a page reference where each topic is discussed.

The Exam Question Pool

The complete Technician exam question pool is included at the back of this book. The 35 questions you'll answer on the exam will be drawn from this question pool. Yes, these are the actual questions on the exam, but resist the temptation to just memorize the answers! Memorizing without learning the subject is likely to leave you "high and dry" when you begin using your new operating privileges. Do yourself a favor and take the time to understand the material.

A *Study Guide* version of the question pool has been prepared by the ARRL in which each question is presented in the order it is covered in this book. The *Study Guide* version can be downloaded from the *Ham Radio License Manual* Web site.

When using the question pool for exam practice, each question also includes a cross-reference back to the page of the book covering that topic. If you don't completely understand the question or answer, please go back and review that material.

Self-Study and Classroom Tips

For self-study students, the material in the book is designed to be studied in order from beginning to end. Read the material and then test your understanding by answering the questions at the end of each section. Use the supplemental material on the *Ham Radio License Manual* Web site if you need extra help.

The ARRL's *New Ham Desk* can answer questions emailed to **newham@arrl.org**. Your question may be answered directly or you might be directed to more instruction material. The *New Ham Desk* can also help you find a local ham to answer questions. Studying with a friend makes learning the material more fun as you help each other over the rough spots and you'll have someone to celebrate with after passing the exam!

If you are taking a licensing class, the instructors will guide you through the material. Help your instructors by letting them know where you need more assistance. They want you to learn as thoroughly and quickly as possible, so don't hold back your questions. Similarly, if you find their explanations particularly clear or helpful, tell them that, so it can be used in the next class!

At the end of each section is a short list of exam questions covered in that section. This is a good time to pause for a short review session. Be sure you understand the material by answering the questions before moving to the next section. It is a lot easier to learn the material section-by-section than by rushing ahead and you'll remember it more clearly. For a focused discussion on each exam question, pick up a copy of the *ARRL's Tech Q&A*. Every question is included with the correct answer and a short explanation.

To make the best use of the on-line reference material:

- Bookmark the *Ham Radio License Manual* Web site to use as an on-line reference while you study.
- Download the *Study Guide* version of the question pool from the Web site.

The *Ham Radio License Manual* Web page lists other resources organized by section and chapter to follow the book. Browse these links for extra information about the topics in this book.

Chapter 1

Welcome to Amateur Radio

In this chapter, you'll learn about:

- **What makes Amateur Radio unique**
- **Why the FCC makes the rules**
- **What activities you'll find in Amateur Radio**
- **Where you can find other hams**
- **The Technician license — what it is and how to get it**
- **Ready? Set? Go!**

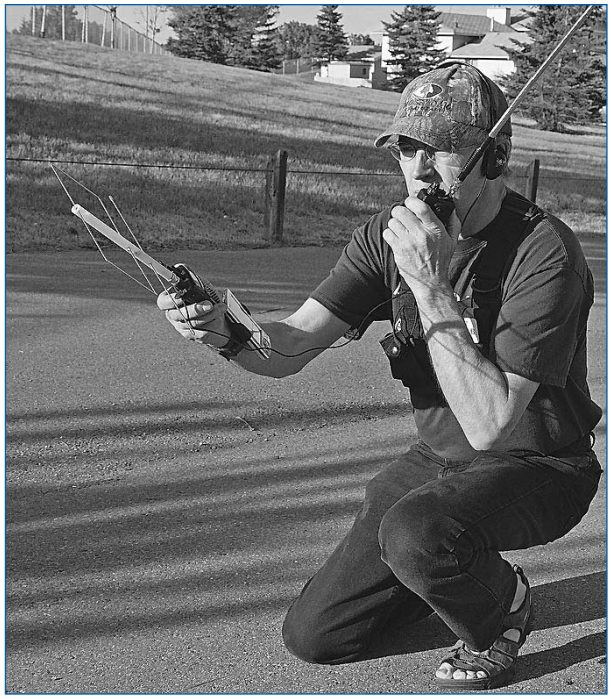
When you see the mouse, you'll find more information at www.arrl.org/ham-radio-license-manual

Welcome to the *Ham Radio License Manual*, the most popular introduction to Amateur Radio of all! In this study guide, not only will you learn enough to pass your Technician license exam, you'll also learn what ham radio is all about and how to jump right in once you're ready to get on the air.

If you want to know more about amateur or "ham" radio before you start preparing to get a license, you'll find your answers in sections beginning with "What Is Amateur Radio?" If you already know about ham radio and are anxious to get started, you're in good company — there are thousands of other folks getting ready to become a "ham" radio operator. Jump ahead to section 1.4 — "Getting Your Ham Radio License" and get started!

1.1 What is Amateur Radio?

Amateur Radio will surprise you with all its different activities. If you've encountered Amateur Radio in a public service role, or if someone you know has a ham radio in their home or car, then you already have some ideas. Maybe you have seen ham radio in a movie or read about it in a book. Are you a part of the growing "do-it-yourself" community? If so, you'll really enjoy getting involved with one of the most "hands-on" hobbies of all! Amateur Radio is the most powerful communications service available to



Jerry Clement, VE6AB demonstrates that you don't need much equipment to make contacts through a ham radio satellite.

Who Made the "Ham"?

How did "amateur" become "ham"? The real answer is unknown! Even before radio, telegraphers referred to a poor operator as a ham. Perhaps this was derived from a poor operator being "ham-fisted" on the telegraph key — an operator's "fist" referred to his or her distinctive style over the wires. With all radio stations sharing the same radio spectrum in the early days, commercial and military operators would sometimes refer to amateurs as hams when there was interference. Regardless, amateurs adopted the term as a badge of honor and proudly refer to each other as "hams" today.

the private citizen anywhere on Earth — or even above it!

Amateur Radio is a recognized national asset, providing trained operators, technical specialists and emergency communications in time of need. It was created to give a home to people just like you who have an interest in radio communications. Some hams prefer to focus on the technology and science of radio. Competitive events and award programs hold the interest of others. Some train to use radio in support of emergency relief efforts or to keep in touch with family. There are many hams who just like to talk with other hams, too! This introductory section of the *Ham Radio License Manual* will give you a broad overview of Amateur Radio so you can understand how radio works and why hams do what they do. Let's start at the beginning, shall we?

BEGINNINGS OF HAM RADIO

Amateur Radio has been around since the beginning of radio communications. It wasn't long after Marconi spanned the Atlantic in 1901 before curious folks began experimenting with "wireless." Amateur Radio more or less invented itself, right along with broadcasting and wireless telegraphy. The very first amateur licenses were granted back in 1912 and the number of "hams" grew rapidly. Early stations used "spark," literally a vigorous and noisy electrical arc, to generate radio waves. Inefficient and hazardous, spark was soon replaced by far more effective vacuum tube transmitters. By the end of the 1920s both voice and Morse code could be heard on the airwaves. Radio became very popular, instantly connecting communities and individuals as they had never been before.

Paul Dallavia, KCØWDQ, prepares for a training exercise with the Arrowhead Amateur Radio Club of Duluth, Minnesota.

As radio communication became widespread, the Federal Communications Commission (FCC) was created to regulate the competing radio users, including broadcasters, commercial message and news services, military and public safety. The Amateur service (the legal name for Amateur Radio) was created in 1934 and has expanded in size and capability ever since. Amateurs, skilled in the ways of radio, played crucial roles during World War II as operators and radio engineers.

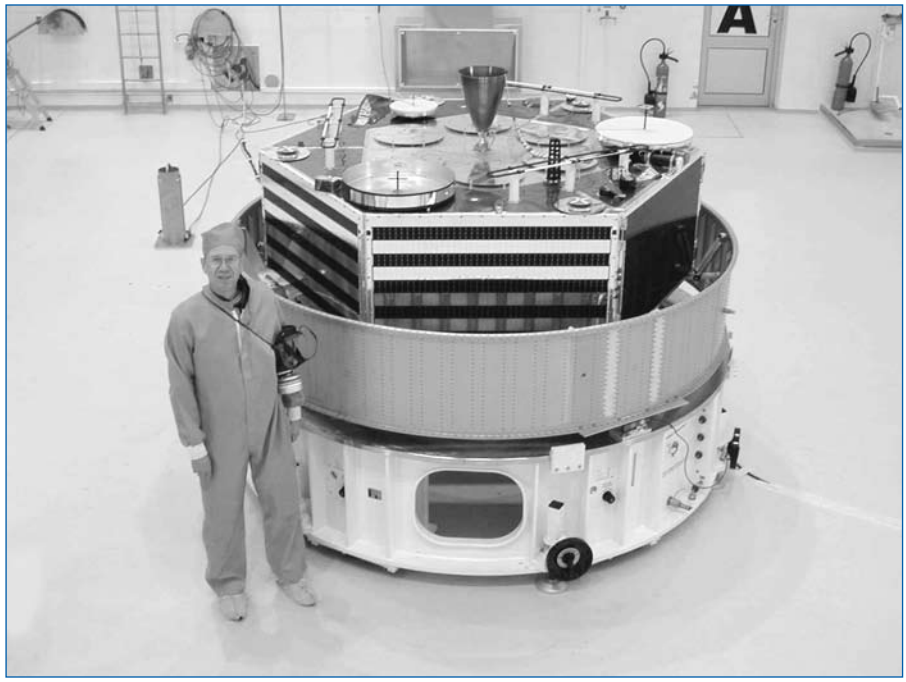
After the war, thousands of hams turned to radio and electronics as a profession, fueling the rapid advances in communications during the 1950s and 60s. Amateur Radio evolved right along with industry — spanning the globe was commonplace! With Morse code as

An On-Line Mentor

The ARRL's *Ham Radio License Manual* (HRLM) Web page **www.arrl.org/ham-radio-license-manual** contains useful additional or tutorial information organized in the same way as this book. There are also links to other Web resources that provide more detail about the book's topics. Look for the mouse symbol in the margin of the text — it indicates that there is more information on the HRLM Web site to help you.

The HRLM Web site also provides in-depth guidance on technical topics. For example, if you need help with your math skills, there are links to online math tutorials and articles. For the handful of exam questions that involve calculations, the Web page shows exactly how to work out each problem.

The Web page also includes helpful links for finding licensing classes, study materials, background information, asking questions and more. You'll find it a good introduction to the ARRL Web site, the most complete and resource for amateurs in the world.



Hams have been building "OSCAR" satellites, such as AO-51 shown in this photo, for decades. OSCAR stands for Orbiting Satellite Carrying Amateur Radio. The first OSCAR was launched in 1961!

That's Why It's Called "Amateur" Radio

In order to keep businesses or municipalities from unfairly exploiting the amateur bands, amateurs are strictly forbidden from receiving compensation for their activities. That means you can't talk with a co-worker about an assignment, for example. If you provide communications for a parade or charity activity, you can't accept a fee. This keeps Amateur Radio free to explore and improve and train. It's worked well for many years!

popular as ever, the amateur airwaves were also filling with voice and radioteletype signals. Hams even invented a new form of picture transmission called slow-scan television that could be performed with regular voice equipment. The first satellite built by amateurs, called OSCAR-1, was launched in 1961, transmitting a simple Morse message back to Earth for several weeks.

Through the 1970s amateurs built an extensive network of relay "repeater" stations, providing regional communications with low-power mobile and handheld radios. In the 1980s and 1990s, microprocessors were quickly applied to radio, greatly increasing the capabilities of amateur equipment and ushering in a new era of digital communications. Packet radio, an adaptation of computer networks, was developed by hams and is now widely used for commercial and public safety.

The personal computer, as in many other fields, gave amateurs a powerful new tool for design, modeling, station automation and recordkeeping, as well as making Amateur Radio computer networks a reality. Finally, the Internet arrived and hams quickly adapted the new technology to their own uses just as they had many times before. At each step in the development of today's communication-intensive world, hams have contributed either as part of their profession or as individuals pursuing a personal passion.

HAM RADIO TODAY

Here we are a century later and wireless is still very much at the forefront of communications technology. Far from being eclipsed by the Internet, ham radio continues its tradition of innovation by combining the Internet with radio technologies in new ways. Hams have created their own wireless data networks, position reporting systems, and even a radio-based email network that enables the most solitary ham to "log in" from anywhere in the world. Voice communications hop between Internet and radio links to connect hams on the opposite sides of the globe using only handheld transmitters less powerful than a flashlight!

Don't let anyone tell you that Morse code is finished! It's still very much alive in

The Goldfarb Scholarship winner for 2009 was Dean LaBarba, KI6CUX, who is part of the only high school Amateur Radio Emergency Service team in Long Beach, California.

Former Youth Editors Brian Mileshosky, N5ZGT (left), and Andrea Hartlage, KG4IUM meet current ARRL Youth Editor Duncan MacLachlan, KUØDM at the 2009 Dayton Hamvention. Brian is now the ARRL Rocky Mountain Division Director.

Christopher Palm, KC9JTL, and dad David, W9HQ, entered their first-ever VHF contest and earned fifth place Limited Multioperator honors in the Central Division.

Gabrielle Kaili-May Liu, KJ4MXC, passed her Technician exam in second grade, shown receiving her Certificate of Successful Completion of Examination (CSCE) from Volunteer Examiner Butch Smith, N4TK.

Amateur Radio where its simplicity and efficiency continue to make it popular. Amateurs also speak to each other directly using sophisticated radios that are grown-up versions of the Citizen's Band (CB) and Family Radio Service (FRS) radios available at the local electronics stores. Computers are a big part of ham radio today as hams chat "keyboard-to-keyboard" or send pictures via radio. You'll even find some hams assembling their own TV stations and transmitting professional-quality video!

In step with the telecommunications industry, hams also look to the skies for their communications. There are more than a dozen active Amateur Radio satellites whirling through orbit, connecting hams on the ground by voice, Morse code and data signals. There is even a ham station on the International Space Station used by astronauts (most astronauts have ham licenses) and ground-based hams alike. Ham-written software allows signals to be bounced off the moon and even meteor trails in the Earth's atmosphere.

When disaster strikes, you find hams responding quickly and capably in support of public safety agencies and relief organizations such as the Red Cross. Amateur Radio is an important part of many disaster relief efforts. Between emergencies, hams turn out in great numbers to provide communications for parades, sporting events, festivals and other public occasions.

While Amateur Radio got its start long ago as a collection of tinkerers in basements and backyard "shacks," it has grown to become a worldwide communications service for millions of licensees. The tinkerers are very much still with us, of course, creating new and