

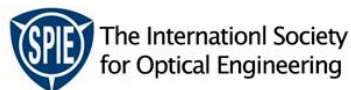


# Hands-On Optics

**How To Manual for Educators &  
Optics Resource Agents**

## **Making an Impact with Light**

An educational collaboration  
of SPIE, OSA, NOAO,  
Sponsored by the National Science Foundation



## **Hands-on Optics How-To Manual for Educators and Optics Resource Volunteers**

### **HANDS-ON OPTICS AND YOU**

Welcome to Hands-On Optics: Making an Impact with Light! This *How To Manual* is for educators, optics resource volunteers, youth group leaders, and others who teach optics to students. It contains tips and suggestions about starting and carrying out a Hands-On Optics (HOO) teacher/optics resource volunteer partnership. As a HOO partner, an optics resource volunteer agrees to make ongoing school visits, and to work with a partner teacher and a group of students over time to assist them in learning more about optics in and out of the classroom.

If you're reading this manual, you are probably either a teacher who wants an optics resource volunteer to visit your classroom, or an optics resource volunteer who wants to spend some time sharing your love of optics with teachers and young people. You may be seeking a partner optics resource volunteer or teacher, or you may already have a partner and be planning your first classroom visit together. This manual is intended to give you some ideas about how to get started, and how to develop a successful partnership over the coming months and years.

You are about to embark on a rewarding and sometimes challenging partnership to improve science education. If you're a teacher in a school or community organization, working with "your" optics resource volunteer is a way to bring new experiences and expertise to your students. If you are an optics resource volunteer, volunteering to visit a school can be as valuable to you as to the students—putting you in touch with youngsters and doing something meaningful for your community. You'll find that most students have a natural fascination with optics that can be sparked through hands-on activities and your own enthusiasm. And you'll see that you can readily integrate other sciences and subjects, from biology, to art, to history, to technology and engineering into your optics lessons.

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**Middle school students test the Hands-On Optics modules on lasers...**



**...and on kaleidoscopes....**



**...and on lenses and telescopes...**

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## HOW TO USE THIS MANUAL

The purpose of this manual is to give you guidance to help your partnership be as successful as possible. We know that such manuals have less meaning if you've never visited a classroom or worked with a visiting scientist before. Even so, we encourage you to read this manual at least once before you begin your partnership, and then return to it after you've started. We suggest that you also read the sections intended for your partner—whether teacher or optics resource volunteer—to help you understand your partner's potential concerns. See the Table of Contents for specific sections that meet your needs.

In this manual we'll give tips on:

- What makes a successful partnership?
- Finding a partner teacher or optics resource volunteer
- Partnership strategies and possibilities
- Expectations and planning
- Integrating the optics resource volunteer into the classroom
- Getting started and the first visit
- Roles and responsibilities for teachers and optics resource volunteers
- Involving the school and community
- Getting support and publicity
- Science clubs, and other good ideas

We welcome your comments and suggestions. As you read and use this manual, we hope you will make your own notes and share them with us. Please send your feedback to Constance Walker, National Optical Astronomy Observatory, 950 N. Cherry Ave., Tucson, AZ 85719, or by phone: 520.318.8535 or by email: [cwalker@noao.edu](mailto:cwalker@noao.edu).

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## 1. INTRODUCTION: What is Hands-On Optics: Making an Impact with Light (HOO)?

Hands-on Optics (HOO) is a unique, national, informal science education program that links teachers and students in grades 6-8 with optics resource volunteers. Optics resource volunteers are comprised of Optical Society of America and SPIE members and volunteers from industry, government labs and academe, including students enrolled in optical science and engineering. The overall goal of HOO is to excite students about science by actively engaging them in optics activities. Funded by the National Science Foundation, HOO was developed in 2004 by two optics societies (the International Society for Optical Engineering (SPIE) and the Optical Society of America (OSA)) in collaboration with the Mathematics, Engineering, Science Achievement Program (MESA) of California and the National Optical Astronomy Observatory (NOAO).

Because of its attractiveness for students, optics (and photonics) is an ideal entree to teach about the process of science. Many teachers recognize their students' interest in optics and want to teach more of it, but lack adequate background and training in the subject. At the same time, optics resource volunteers, concerned about the crisis in science education in the U.S., have wanted to do more to help teachers, but have often been unsure how to make a meaningful contribution. On their own, many optics resource volunteers make a one-time visit to a local classroom, but such quick interactions have only a limited impact on students.

Hands-on Optics (HOO) was developed to address these needs in optics and science education by preparing optics resource volunteers to make *multiple* visits to the same classroom (and to do meaningful activities while they are there), while at the same time, providing resource volunteer development opportunities for teachers. HOO helps teachers and optics resource volunteers form partnerships, offers them training and support, and provides a range of materials for classroom use. The focus of HOO is on grades 6-8 because it is in these grades that students' long-term attitudes about science and engineering are formed. After being trained, optics resource volunteers agree to make enough school visits to assist with 3 to 6 hands-on modular activities each year, giving talks on optics discoveries, helping with science projects and science fairs, lending a hand with curriculum development, and serving as role models. Whenever possible, teachers and optics resource volunteers together establish links with local optics institutions, science centers and colleges or universities.

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The HOO program provides the following services to support teacher/optics resource volunteer partnerships and optics education:

- Training teachers and optics resource volunteers in doing age-appropriate, hands-on optics activities
- Providing guidance, advice, and training to organizations and individuals interested in starting a HOO program or partnership in their area
- Creating and disseminating materials to support teacher/optics resource volunteer partnerships, including selections of the best activities for the classroom, and a wide range of resources about optics and teaching optics
- Conducting ongoing evaluation of HOO partnerships and materials to continue to learn what works best
- Producing a newsletter and providing electronic networking for HOO expansion sites

This *How-To Manual* draws on the experiences of teachers and astronomer partners who participated in the pilot phase in a similar science education program in astronomy called Project ASTRO, which was started in California by the Astronomical Society of the Pacific in 1993. Working with science centers, research institutions, and universities, Project ASTRO is now expanding to 13 other metropolitan areas throughout the U.S.

## **HANDS-ON OPTICS MATERIALS**

A HOO publication will be available to help you with your partnership. *Scope it Out! An Optics Activity and Resource Notebook* will contain 6 hands-on optics activity modules for grades 6-8. These activities are being created and some selected from a variety of exemplary sources by a team of science education specialists and optical science students, and pilot tested. Designed for teachers, optics professionals, and others who want to improve or increase the optics they teach, the resource notebook also contains a host of resource lists on a wide range of optics topics and optics background material. It is the essential companion to this *How To Manual* for anyone interested in teaching optics. Information about how to order *Scope it Out!* is provided at the end of this manual.

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## **ABOUT THE FOUR FOUNDING INSTITUTIONS**

The OSA, headquartered in Washington, DC, is an international scientific society dedicated to increasing and diffusing the knowledge of optics and photonics in all its branches, pure and applied, through its world-renowned publications and education forums. Founded in 1916, the OSA comprises nearly 16,000 individual and over 250 corporate members encompassing scientists, engineers, and technicians from the United States and nearly 90 other countries.

SPIE is an international technical society dedicated to providing education and information to the optical science and engineering community worldwide. It is committed to advancing scientific research and engineering applications of optical, photonic, imaging, and optoelectronic technologies through its education programs, meetings, and publications. The Society comprises more than 16,000 individual, 360 corporate, and 5,000 technical group members in more than 78 countries. A core mission of the Society is to provide a full range of continuing education, resource volunteer development, and student/educator resources and services, including the award of \$250,000 annually in scholarships and grants.

MESA is an academic enrichment program of the University of California. It was founded in 1970 to focus on educationally underserved African American, Latino, and American Indian students. MESA was designed to provide a rigorous program that supplemented the classroom and prepared students for the challenges of collegiate academics, as well as for meeting the state's need for highly skilled workers, especially engineers. MESA now serves the needs of nearly 33,000 educationally disadvantaged students through its network of 480 K–12 schools, over 30 two-year colleges, and over 20 public and independent colleges and universities at elementary, middle, high school, and college levels.

MESA was recognized in 2001 as one of the five most innovative public programs in the nation by Innovations in American Government, an award program of the Ford Foundation, Harvard University, and the Council for Excellence in Government. MESA also is the recipient of the Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring for its work in supporting underrepresented students to achieve. The MESA Schools Program has become a model for the development of programs in eleven states nationwide. The following sample of successful measurements demonstrates MESA's long-standing record of achievement:

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The National Optical Astronomy Observatory (NOAO), headquartered in Tucson, with educational projects and facilities in Arizona, New Mexico, Hawaii, and Chile, has expertise in design of instructional materials. The education group in Tucson has a strong background in astronomy, optical science, and engineering as well as a history of effectively working with schools, science centers, and teachers locally, regionally, and nationally. NOAO has partnered with the educational efforts of numerous resource volunteer technical societies such as the Astronomical Society of the Pacific, American Geophysical Union, the American Astronomical Society, and the Optical Society of America. The National Optical Astronomy Observatory manages Kitt Peak National Observatory near Tucson, Cerro Tololo Inter-American Observatory in Chile, and the National Solar Observatory with facilities at Sacramento Peak, New Mexico and Kitt Peak, Arizona. Today, NOAO also represents the US astronomical community in the International Gemini Project, with large telescopes in Hawaii and Chile.

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## 2. KIDS AND SCIENCE: THE HANDS-ON OPTICS PHILOSOPHY

"I ask my students, do scientists [and engineers] know everything? No they don't, but they are willing to find out and correct their mistakes, and try and try again. That's what I want you to do" *A Teacher Partner*

Children are born with a natural curiosity about the natural world. Like scientists, they explore, observe, experiment and classify (if you've ever taken sand out of a curious toddler's mouth, you know what we mean). Sadly, for many children as they go through school, science begins to lose its fascination—often because it is taught as a series of disconnected facts. Students don't always learn about the connection between these facts and the natural world. They may no longer experience the link between their own curiosity and the science they learn in school. They only know it seems boring (or not relevant to their lives, or too abstract to understand), and when something is boring, not relevant, or too abstract, it's tough for kids to put their minds to work. The overall purpose of Hands-On Optics (HOO), is to help students see that science can be interesting and fun while still getting them to think about the process and results of discovery. The goal of HOO is *not* to make all kids into optics resource volunteer (although some students may eventually follow this path). Rather, we want to use the wonder and fascination of optics to engage *all* students in the process of science and logical reasoning.

This means we want students to behave like "short scientists" by making observations, gathering and classifying data, drawing conclusions, and asking new questions. We want students to consider multiple explanations for a phenomenon, and use their data to reach the best conclusion. We want students to consider that sometimes there isn't one correct answer, or that people may disagree on the answer, or that we don't always know what the answer is, but that we can devise ways to find out.

Toward these ends, the focus of HOO is on helping kids learn by doing. By using hands-on, concrete activities where students make discoveries for themselves, students think more like scientists and are more likely to really learn about optics. If you are serious about involving students in optics in an active way, we encourage you to get HOO's, *Scope It Out! An Optics Activity and Resource Notebook*, or other curriculum guides that contain specific optics activities for grades 6-8.

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### **Promote hands-on student discovery experiences**

Kids learn by doing! Hands-on activities in which students discover things for themselves are the highest quality learning experiences. Students forget most of the things their teachers tell them. But when adults lead kids in experiences where they wrestle with an interesting personal observation and then figure it out "by themselves"—those things are remembered forever. Seek to be more of a guide to discovery than a conveyor of information and a provider of answers.

*From Preparing and Presenting Effective K-12 Science and Math Education Activities, Sandia National Laboratories.*

## **BEING A HANDS-ON OPTICS PARTNER: A SUGGESTED APPROACH**

One of Project HOO's main agendas is to help teachers improve their optics and science teaching by working closely with someone with special knowledge about optics. Teachers are called upon to teach many subjects. Many teachers, particularly elementary teachers, may not be comfortable teaching science and may be eager to improve their understanding of science content and processes. Even teachers who are familiar with science may not know enough optics to teach it effectively. For teachers, having a visiting optics resource volunteer in their classroom can be a valuable resource to improve and increase the optics they teach.

We use the term *partnerships* to describe HOO because the optics resource volunteers and teachers work together as equal partners to develop their own program. Together, they decide what specific activities to do, based on each partner's interests and the students' needs. In this way, teachers learn more about optics, and optics resource volunteers become more familiar with students and schools. Teachers who are inspired by learning and doing more optics can go on to share their new knowledge with colleagues and use new skills with other classes. As optics resource volunteers learn more about what teachers, kids, and schools need, they become more effective volunteers for improving science education in general and creating meaningful and lasting links between schools and the outside community.

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By making the commitment to work together in this way, some of the following things may start to happen:

- Students may ask their teacher over and over, "When is the optics person coming again?"
- A usually reserved eighth grade class may create an elaborate optics display, complete with the optics resource volunteer's picture, a box for students' optics questions, and set up for an optics experiment.
- A reluctant principal may attend a MESA period or a Saturday workshop and become so enthralled by the sight of a working telescope built by students that eager students have to push her out of the way to see "first light" through the eyepiece for themselves.
- A teacher may finally persuade her school to provide an Internet connection to her classroom so that she and her students can communicate with their optics resource volunteer.
- A busy parent may stop to look a rainbow with his child, helping to discover the real reason why it forms in the first place..
- A university optics professor may change the way she teaches college level optics, adapting activities that worked with her HOO seventh graders.
- Other teachers, optics resource volunteers, and graduate students may decide they want to become part of HOO in some way; and finally...
- It may all happen again the next year!

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### 3. KEY IDEAS ABOUT PARTNERSHIPS

#### TEN STEPS TO A SUCCESSFUL PARTNERSHIP

**1. During the academic year, plan and make at least twice as many classroom visits as the number of Hands-On Optics modules being planned, plus an extra first visit for the optics resource volunteer to observe the class anonymously. For example, if there are 3 modules being planned during the year, 7 visits would be in order.**

Make multiple visits to the school or classroom, and begin with an observation visit so that the optics resource volunteer can see what the school and classroom are like. We've found that 7 visits during the entire year are the minimum number for the optics resource volunteer and students to have time to get to know each other. With at least 7 visits, the optics resource volunteer can do longer term projects with students, and can join the teacher at key points in the curriculum. Also because each school visit may take some preparation, making more than 7 visits may not be possible for really busy optics resource volunteers. Of course, we encourage you to make more than 7 visits if possible—some Hands-On Optics resource volunteers may enjoy visiting as often as once a month for the entire school year.

**2. Visit the same classroom over time.**

When he or she works with the same students over time, the optics resource volunteer really gets to know the kids (and vice versa). We suggest that the optics resource volunteer work with at most two, self-contained middle school classrooms (e.g., “MESA” or “science periods”) or a Saturday Academy (e.g. workshop) during a visit. Go for depth rather than exposure.

#### Start small

We know that teachers who see more than one class each day ideally want to expose all of their students to the optics resource volunteer. Resist this kind impulse! This can place a great time demand on the optics resource volunteer (who is, after all, a volunteer) and make it more difficult for him or her to learn the children's names, let alone form relationships with them. Although you will initially involve a smaller group of students, these kids will benefit much more from the optics resource volunteer's multiple visits and personal contact. (In similar pilot programs, the visiting volunteers who faced many classes each time reported that they had a much less satisfying experience than those who "adopted" one class.)

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Teachers can use the new skills they develop to enhance optics with other classes. If all partners agree, you can add additional students after you have been working together for a while. To reach more students, consider inviting them to special events (e.g., the entire sixth grade to a telescope building competition), have a one-time assembly for more kids, or have your students teach other classes.

**3. The teacher should be responsible for student discipline and classroom management.**

Visiting optics resource volunteers, as volunteers in the classroom, should not be expected to manage student behavior in the classroom. Rather, teachers should stay actively involved in the classroom, both to model learning and curiosity to students and to assist the optics resource volunteer with any discipline or logistics. At the same time, optics resource volunteers need to be aware of classroom rules and routines, and use them appropriately during their visits (such as having students raise their hands before speaking). It is a good idea to clarify what these rules are before the first visit.

**4. Commitment and communication are the keys to a successful partnership.** Strong partnerships develop when everyone has a high level of enthusiasm and commitment to the project. You will need to devote enough time to communicate and plan with your partner, to get ready for visits, and of course, to be in the classroom. Be careful not to over-commit at first. But, do follow through by keeping in touch with your partner teacher or optics resource volunteer. It's also important to communicate clearly and openly about any concerns, needs, or suggestions you may have.

**5. Teachers and optics resource volunteers should enter the partnership as equal, but differently skilled, partners.**

Teachers are likely to be more knowledgeable about how students learn, what students need to know, and about how to structure and manage a classroom activity. Optics resource volunteers are likely to know more about optics and technology. Your partnership will be more successful if you enter it with respect and an expectation of equality. But don't expect your partner to know everything or to do everything perfectly the first time. Let your partnership and your own skills develop as you get to know each other's strengths.

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## **6. Provide adequate time for planning and follow-up.**

Focus on a few themes and goals and add more ambitious activities (field trips to science museums, site visits to an optics or engineering company, etc.) after you have been working together for a while. An initial planning meeting or two will help you understand each other's needs and interests. It is important for optics resource volunteers to listen and respond to teachers' needs—you will be stronger allies this way. Build from your strengths. And, check in with each other about students' reactions and how the activities went after each visit.

## **7. Children learn best when they are actively involved and engaged in learning, by observing, measuring, discussing, etc.**

The philosophy and focus of HOO is to involve students in active, hands-on optics activities, as opposed to listening to lectures (although an occasional lecture may have a place in a well-thought-out program). Doing hands-on activities may require a more cooperative approach with both partners actively engaged.

## **8. Involve school administrators, other teachers, and families.**

It's always a good idea to keep the school principal and other administrators informed about HOO. Be sure the principal meets the visiting optics resource volunteer, and invite school administrators to special events and visits. If other teachers express interest in the program, invite them as well. In addition, you'll find that optics offers great opportunities to involve families in their children's science learning. Also, make use of other resources in your community. See Sections 7 and 9 for more ideas.

## **9. Involve community resources when possible.**

Don't feel that the two of you need to do it all alone, especially if you are planning a special event. Seek out optics resources in your community, such as:

- local science or engineering clubs or optics societies
- businesses that sell microscopes, telescopes, binoculars, optical bench components
- parents with telescopes
- public or private observatories
- college or university with an optics, biology, chemistry, physics, astronomy or engineering program with access to optical instruments
- a science museum

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- a NASA facility (including one of NASA's Teacher Resource Centers or Space Grant College programs)

See the sections on finding an optics resource volunteer and involving the community for specific ideas.

**10. Create a plan that addresses both the teacher's and the optics resource volunteer's needs and interests, and don't forget to keep the students in mind!**

Sometimes, teachers and optics resource volunteers find that they want different things from the partnership. For example, the teacher may want students to learn about building telescopes, and the optics resource volunteer may want to share his or her knowledge and enthusiasm for understanding the properties of different lenses. It is important that both the teacher's and the optics resource volunteer's interests get met to some degree. You may need to clarify what the underlying issue is and make a few compromises so that the teacher's classroom needs are met and the optics resource volunteer does what he or she is most enthusiastic about. The best solutions often involve working more closely together or sharing roles.

**MORE ABOUT TIME COMMITMENT**

It's very important for the success of your partnership that you have a clear understanding of the time involved. As a HOO participant, you will need time to:

- Have an initial planning meeting (away from the school, if possible) and additional meetings or phone calls to plan as needed.
- Set aside at least two classroom visit per HOO module.
- Make or host at least a total of 6 classroom visits, plus a classroom observation before the first visit. An extra visit might be a field trip. These special activities involve additional planning.

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- Make multiple phone calls, or send faxes and e-mail to arrange visits. You should expect to play "phone tag" and to talk with your partner during the evening or on weekends.
- Follow-up each visit with a phone call or brief meeting.
- For the optics resource volunteer: prepare and practice activities before visiting the school
- For the teacher: prepare and follow up with students after the optics resource volunteer visits. Fit the visits into your overall program. Make arrangements for materials and logistics.

**To Optics resource volunteers:** If you are an optics resource volunteer, be sure you have the time to devote to the project and can take the time off during the school day as needed. Remember that school schedules are not very flexible. Many companies support their employees' involvement in community service, so check into your employer's volunteer policy. You might also make school visits early in the day or during an extended lunch hour, depending on how the time coincides with the MESA period. Sometimes a letter from the HOO coordinator or school principal can help smooth the way with your employer.

**To Teachers:** It may take some additional time and effort at first to "fit" the optics resource volunteer into your program. Once you get started, this time will decrease as the optics resource volunteer becomes more familiar with your needs. Try asking your administrator for release time to plan with your optics resource volunteer, and look into the use of funds to support your release time. Also, remember that the optics resource volunteer is volunteering his or her time, probably taking time off from work. You will likely need to be the one to handle any additional logistics or dealings with the school

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## MORE ABOUT COMMUNICATION

Communication and follow-through with your partner are essential. Sometimes partners are surprised by the problems they experience in communicating. Keep in mind that:

- Few teachers have e-mail or phones in their classrooms. Most teachers are exceedingly busy during the school day. Some schools are better than others in getting messages to teachers. So, it can be difficult to reach teachers during the day.
- Optics resource volunteers may be less available in the evenings and may travel for periods of the year. Volunteer visits may not be their top priority every day. Professional optics resource volunteers especially are used to communicating via electronic mail, and may be impatient with people who don't yet have an internet connection.
- Together you will need to figure out the best way and time to communicate (work phone, home answering machines, fax, modem, Saturday mornings). If multiple teachers are involved, designate one teacher to be the contact person.

### Communication Tips

- Initiate contact with your partner. Don't wait for him or her to call you!
- Follow through on plans. Call two days before visits. Call well in advance if you need to re-schedule.
- Return phone calls and messages promptly.
- Be flexible, listen, and expect difficulty reaching each other sometimes.

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## 4. FINDING A PARTNER

By now you've decided you want to start an HOO partnership, but you don't have a partner. Having the interest is the first step; finding a partner may require some initiative and persistence. Even if the first person you contact does not work out, he or she may be able to refer you to the perfect person.

Foremost, since HOO is a program associated with the Mathematics, Engineering, Science Achievement (MESA) program, MESA USA is the first place to inquire about finding a teacher partner. To contact its founding member, MESA of California, email [mesa@ucop.edu](mailto:mesa@ucop.edu), phone (510)987-9337 or write:

MESA Statewide Office  
300 Lakeside Drive, 7th Floor  
Oakland, CA 94612-3550

Likewise, to make initial inquiries about finding a optics resource volunteer, contact either the Optical Society of America (OSA) at

Education Outreach  
Optical Society of America  
2010 Massachusetts Ave., N.W.  
Washington, D.C. 20036.1023  
Phone: (202)416-1430 or (800)766-4672  
[member@osa.org](mailto:member@osa.org)

or the International Society for Optical Engineering (SPIE) at

SPIE  
PO Box 10  
Bellingham WA 98227-0010 USA  
Phone: (360)676-3290  
[education@spie.org](mailto:education@spie.org)

As the HOO program grows and includes science centers and other related facilities, here are some other ideas about how to find partners.

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## **FOR OPTICS RESOURCE VOLUNTEERS: FINDING A PARTNER TEACHER**

Among the other ways to find a partner teacher are:

1. Make contact with an individual teacher
2. "Network" through school personnel and other people you know
3. Publicize your availability through written material

Making contact with an individual teacher is perhaps the best approach. Information left with school administrators can get lost before it reaches interested teachers. A good way to find the names of teachers is to start with people you know (see below) because they will have a greater interest in helping you. When you contact a teacher, explain that you want to volunteer as a HOO optics resource volunteer and describe some of what you'd like to offer. Be aware that not all teachers cover optics, so it may take some persistence to find a teacher who does, or wants to. Here are some suggestions about whom to approach as a first point of contact:

- Your child's classroom teacher or science teacher. Your friends' children's teachers, especially those who are interested in science.
- Classroom or science teachers in your local area (especially a neighborhood school). The principal, school counselor, or school science coordinator (if there is one) may be able to connect you with an interested teacher.
- County or District level Science Coordinator or Volunteer Coordinator. Contact the County or District Superintendent's office for names.
- A local planetarium or science center. Teachers who are interested in optics may be involved with special programs there. Ask for the education coordinator at these organizations.
- State science teachers' association (check the phone book, ask a teacher, or contact the National Science Teachers Association, 1840 Wilson Blvd., Arlington, VA 22201 (703)243-7100). Ask the officers or staff of the state organization how to reach interested teachers. They may be able to pass your name along to people in your area.

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- Science education faculty at a local university School of Education. These faculty members may be familiar with teacher professional development programs, and may be able to steer you toward a network of interested teachers.
- Graduates of education programs for teachers that have studied optics. These teachers may be interested in working with an optics resource volunteer, or may be able to refer you to other teachers in their area. Contact the organization that runs the program that studies optics for names of teachers in your area. Organizations with experience running teacher education programs in optics include OSA, SPIE and MESA, whose contact information were given a couple of pages ago, and:

National Optical Astronomy Observatory (NOAO)'s Education Outreach Department. Contact NOAO, Education Outreach, 950 N. Cherry Ave, Tucson, AZ 85719, (520)318-8230.

Optics Education: International Directory of Degree Programs in Optics (<http://www.opticseducation.org/>) is available online, searchable by institution name, country or state, optics specialties, degrees offered, and tuition ranges.

NASA Teacher Resource Centers (located at various locations across the country). Contact NASA CORE, Lorain County JVS, 15181 Route 58 South, Oberlin, OH 44074 (216)774-1051 for a list of centers.

National Science Teachers Association, 1840 Wilson Blvd., Arlington, VA 22201 (703)243-7100

### How to Approach School Personnel

- When you call or write, communicate your desire to have an *ongoing* relationship with the school and to have an impact on optics and science education. Let the teacher, counselor, or administrator know that you would like to provide ongoing enrichment to the classroom lessons (not just a one-time lecture). Describe some of the specific ways you think you can be of help, and discuss your availability and commitment.

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- Bring a copy of the HOO *How-To Manual*, and other HOO resource materials you may have to a meeting with the school principal or classroom teacher. Summarize or photocopy the brief description of HOO at the beginning of this manual.
- Ask what ideas the teacher, counselor, or administrator has about how you can help with optics and science education. Emphasize that the focus of HOO is on optics, but the broader goal is to help students develop enthusiasm in science and logical reasoning skills.
- Follow-up with a note and phone call. Teachers and administrators get extremely busy and may have difficulty getting back to you as soon as you would like. Take it upon yourself to make follow-up contact.

(Adapted from *One Small Step...An Education Outreach Resource Guide* produced by AIAA and NASA)

## **FOR TEACHERS: FINDING A PARTNER OPTICS RESOURCE VOLUNTEER**

Because HOO encourages optics resource volunteers to visit schools, there are several avenues to pursue to find a partner optics resource volunteer.

### **1. Contact local optics societies and science clubs**

Many optics resource volunteers belong to optics societies and/or science clubs. Each society or club usually has some members who are interested in education and explaining astronomy to the public. Often, they hold special events like science fairs for the public, or go to local schools for one-time visits. You will want to find local society or club members who are interested in conveying optics to others and have at least some experience with children. Call the club or society president, attend a local meeting, or show up at a club or society special event and talk to the members. Most likely you will find someone who is enthusiastic. To find optics societies or science clubs in your area, contact OSA, SPIE or college engineering or science departments in your area.

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## **2. Contact optics educators**

Call your science center or community college or local university to find optics educators. Many of these institutions have at least one person on staff who teaches optics. Staff and faculty at these organizations can be quite busy, but may be interested in visiting your school to enhance their teaching skills and experience, and to link with the community. If the main optics educator or faculty member is not available, he or she may be able to refer you to advanced students or others in the local community.

## **3. Contact professional or research optics engineers**

The involvement of professional optics engineers in K-12 education is gaining legitimacy as scientists and other fields recognize the importance of supporting science education in the early grades. You can find professional optics engineers through local colleges and universities, research labs, NASA centers, and industry. Graduate students and postdoctoral level professionals may be particularly interested in working with schools. At the university level, the best initial contact is secretary in the optical science, engineering and physics departments. He or she should be able to give you names of faculty members or graduate students who have an interest in education. Ask if the secretary can post an announcement on electronic mail or distribute letters to all faculty and graduate students. If you need help finding optics programs and research centers in your area, contact OSA or SPIE. (See page 20.) They are both professional optics societies, which publish annual directories of its individual and organizational members.

## **4. Call the Optical Society of America (OSA) or SPIE**

We have a growing database of optics engineers and educators interested in Hands-On Optics, and can help refer you to other organizations. Contact information for SPIE and OSA is on p. 20 of this manual.

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## 5. PARTNERSHIP STRATEGIES

### POSSIBILITIES

There are many ways an optics resource volunteer can work with teachers and students, as well as a universe of possible partnership activities. Here are some ideas:

- Lead or help lead hands-on activities with students
- Lead or arrange a field trip to a science center, observatory or other engineering or science department at a college or work site
- Stimulate and guide independent research by students (such as a science fair project)
- Show students practical applications of computers in science
- Serve as a resource person for the teacher and other school faculty
- Help obtain, fix, and maintain equipment
- Serve as a tutor, mentor, and role model for individual students or small groups
- Encourage female and minority students to enter science-oriented careers
- Invite engineering colleagues at work or in SPIE or the Optical Society of America to join you for a visit
- Work with and involve parents and families
- Lead an after-school science or engineering club
- Help teachers with curriculum and activity development
- Assist with a science, math, engineering and career festivals in the school
- Bring interesting artifacts and equipment to class

### INTEGRATING THE OPTICS RESOURCE VOLUNTEER INTO THE SCHOOL PROGRAM

Before you begin your partnership, it will help to decide how you want to fit the optics resource volunteer's visits into the school program. There are two general approaches. You could:

#### 1. Link the visits closely with the curriculum

You can link each visit to ongoing classroom activities and the specific science lessons planned for class that day. This approach can be very enriching for the students and can create a great partnership. It requires planning, communication, and flexibility and the optics resource

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volunteer needs to have an interest in the specific topics that are being covered. The teacher and optics resource volunteer will need to keep in touch about what the students are doing and be prepared to reschedule if the class falls behind schedule.

## **2. Plan “stand-alone” visits by the optics resource volunteer**

The optics resource volunteer's visits can be “extra” lessons that fit generally with the science students are learning, but do not link directly to current lessons. Stand-alone visits can weave optics into the curriculum over a longer period of time, and may relate more to the optics resource volunteer's particular interest or expertise. It is still essential for partners to discuss and plan, but this approach allows you to schedule the dates of visits more definitively in advance. Most partners choose an approach somewhere between these two alternatives. They try to fit the topic and activity of the visit into the year's curriculum, while still focusing on areas of interest to the optics resource volunteer.

Below are different ways that HOO partners could integrate the optics resource volunteer's visits into the school program, based on six or more visits:

- Designate time or “MESA periods” during the school day for the students to concentrate with the optics resource volunteer on an HOO program module.
- Have students compete in hands-on math and science activities at the local and regional level MESA Day or Saturday Academies. Use the resource volunteers as advisors, mentors or judges.
- Teach optics throughout the year with the optics resource volunteer visiting 6 times or at regular intervals (such as one day each month).
- Teach a 4-8 week optics unit and have the optics resource volunteer visit 6 or more times during the unit.
- Teach an optics unit first. Then, after the unit is over, have a weekly (or monthly) optics day in your class. The optics resource volunteer can continue the visits, working with individual students or focusing on new areas of optics.

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- Create a lunchtime or after school science or engineering club with a special focus on optics either for a specific grade level or all interested students. The optics resource volunteer can visit every club meeting, or at regular intervals.
- Have students communicate with the optics resource volunteer via electronic mail. It's a good idea to combine this with "in person" contact first.
- Have the optics resource volunteer make visits or be available to the teacher on an "on-call" basis. This requires advance planning, as well as a commitment to stay in touch and respond to requests.

## **PARTNERING IN THE CLASSROOM**

Once your partnership gets underway, you'll find a way of working together that suits your skills and interests, as well as the students' needs. In some HOO partnerships, the optics resource volunteer and teacher work closely together to "team teach" the class. This means that both are equally involved in leading the class, perhaps dividing or trading off roles as the lesson moves along. In other HOO partnerships, the teacher may lead the main lesson, while the optics resource volunteer helps students in small groups, encouraging them to stretch their thinking or make more astute observations. Or, in some cases, especially when the optics resource volunteer is more comfortable with the students, the optics resource volunteer may lead the class through an activity, field questions, or give a brief lecture while the teacher remains actively involved managing student behavior. In general, we suggest that you start by sharing roles in the classroom, rather than having the optics resource volunteer lead the entire lesson or activity.

### **Keep in mind.**

The teacher is responsible for classroom management. The optics resource volunteer is not a substitute teacher, and should not be left alone to deal with student discipline. The optics resource volunteer should be able to count on the teacher for help with classroom logistics or inattentive students.

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## **What Would You Do?**

Here are some typical scenarios drawn from real teacher-volunteer partnerships. We encourage you and your partner teacher or optics resource volunteer to discuss these scenarios together: what would you do in the same situation?

### **Scenario 1: What would you do?**

David, an optics professional, is very interested in education. He's lectured college students before, and wants to try doing hands-on activities with students through HOO. David has young children of his own and feels comfortable around kids. He's very busy with his research and only has time for six or seven classroom visits during the entire school year.

David's partner, Sue, teaches sixth grade. Sue is very comfortable with hands-on science, but doesn't know much about optics. She thinks *Hands-On Optics Modules* will be a great resource. Sue wants her optics resource volunteer to serve as a resource person: to answer students' questions, show slides, talk about his work, help her understand optics better, and to work with students one-on-one. Sue is worried that David does not have the teaching skills to convey concepts to students and keep them on task (sixth graders can be tough) and she's hesitant to have him lead activities. Plus, she's worried that David may not finish activities during his visit and her class will get off schedule.

### **Scenario 2: What would you do?**

Bill is an eighth grade science teacher at a large middle school. The school, which has a very diverse student population, has a new grant to create an integrated science program. As part of this program, students work in groups doing activities and projects, and teachers do very little lecturing. Bill is very committed to this effort and believes that active learning is the best way to get students interested in science. Bill wants to focus on telescope making and have students create a small observatory on the school ground. (He has about 6 weeks to teach astronomy and optics.) He would like his partner optics resource volunteer to help him with optics concepts, to work with students in small groups during classroom visits, and to help students with projects.

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Bill's partner optics resource volunteer, Valerie, is a retired engineer and wants to get involved in a meaningful volunteer activity. Valerie has plenty of time to participate in HOO, and is very enthusiastic about sharing her love of optics with students. She'd love to volunteer all year. She's especially interested in any projects with lenses and mirrors. Over the years, she has been collecting slides and images that she is eager to share, and she has given lectures to adults that have been very well received. Valerie is most comfortable with a lecture approach using her slides, and she'd like to help students with library research projects.

### **Scenario 3: What would you do?**

Steve is an active optics engineer and an amateur astronomer. He's the education officer in his astronomy club and has helped schools with star parties for years. Steve has a naturally engaging way with children and adults and he's done optics and astronomy activities with students at summer camp, county fairs, and through scouting. He's eager to learn some new activities through HOO, and hopes to work side by side with his partner teacher to develop a creative and fun program at their school. He'd love to take the students on a special nighttime star party outside of the city.

Rita, Steve's partner, is a fourth grade teacher in an inner city school. The school is besieged by problems and is known to have the lowest test scores in the district. There are very few resources available at the school (no one knows what happened to the slide projector) and students have very few experiences outside of their own community. Rita often uses her own money to buy supplies for students. She was excited to be selected for HOO so that she could bring a real engineer/scientist into the classroom to interact with students. Rita, who does not have a lot of experience with hands-on science, is very unfamiliar with optics and astronomy. She's hoping that Steve, as a guest speaker, can lead the class during his visits so that she might learn more about optics and astronomy at the same time.

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## 6. STARTING YOUR PARTNERSHIP

### PLANNING GUIDELINES

As we've said, we found that it's critical that partners meet before starting the visits to develop a focused plan. Below are some areas partners have found it useful to discuss.

- **The school**

How is the school organized? What are the students like? What is the school culture? Are there any school politics the optics resource volunteer should know about? Will other staff or faculty be involved? Are there any new priorities or special projects? What's the principal like? Where do visitors park? Are there specific rules school visitors must follow?

- **The students**

What grade will be involved? How many students are in a class? Which students will the optics resource volunteer visit? What is the background of students (academic, language, cultural). What is their attention span? To what extent are families involved in students' schoolwork? What sorts of things are students interested in? Are there special suggestions about working with particular students? Look at examples of student work.

#### The Value of Planning

Although we were given time during our first workshop experience, we did not realize how important a firm year-long plan would be. We were so new to this that it was difficult for us to do great planning at the time. We decided to plan the first visit and take it one at a time. Looking back, it would have been better to have set dates and year-long curriculum goals (what areas would be covered at each visit, when would the star party take place, when would there be a visit to an observatory etc.). *A Teacher Partner*

- **The Optics Resource Volunteer**

How did the optics resource volunteer get into optics? Does he or she have areas of research or special interest? What are the optics resource volunteer's favorite aspects of optics? (If the optics resource volunteer specializes in lenses and mirrors, focus on this with students. If the optics

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resource volunteer studies laser technology, spend time on lasers and how we learn about them.) What areas of optics is he or she less knowledgeable about? Does the optics resource volunteer have any links with engineering societies, research organizations, or sources of materials? How could these contacts be useful? In what areas of working with kids does the optics resource volunteer need help or want to learn more?

### Attitude for a Successful Partnership

Be flexible (there might be a fire drill, etc.)

Be honest

Learn from experience, learn from mistakes

Be open about your strengths and weaknesses

Communicate your needs

Don't be discouraged

Don't expect perfection, especially the first time

Be persistent

Don't expect your partner to know everything

Appreciate the optics resource volunteer's contribution and possible sacrifice

Appreciate the existing relationships between teachers and students

Look at the big picture

Be punctual

Laugh

### • The Teacher

What is the teacher's science and teaching background? What is his or her experience with optics? What is the teacher's philosophy and teaching style? In what areas of optics does the teacher need help or want to learn more? How much optics has the teacher included in the curriculum before and how might things change as a result of the partnership?

### • The Curriculum

What are science learning objectives for your grade level? What is the curriculum? How does optics fit into the broader science curriculum? What key concepts and processes are students expected to learn this year? What main areas of optics will you focus on?

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### • **Classroom Behavior**

What are the classroom (and school) rules and norms regarding behavior? How should students address the optics resource volunteer? What "classroom management" techniques does the teacher use to quiet the class or get students' attention (for example, raising hands, or waiting until everyone is quiet before continuing)? What are the consequences of misbehavior in the classroom? Although it is primarily the teachers' responsibility to manage student behavior, it is important that the optics resource volunteer knows what is expected of students and knows a few techniques to manage discussion, noise level, and attention.

### • **Logistics and Scheduling**

When during the year will optics be taught? When during the day? Will school logistics and schedules work for both partners? How often can the optics resource volunteer visit? Is anything going on in the optics resource volunteer's or teacher's life or work that may affect availability? (If the teacher wants to teach optics during October and November, but the optics resource volunteer plans to be out of the country during those months, your partnership will have problems!)

### • **Equipment and Materials**

What audiovisual, demonstration or computer equipment is available at the school? How far in advance does it need to be ordered or reserved? What will you do if something breaks or a bulb burns out? Are there enough materials for all students? Which partner will be responsible for bringing the materials needed? What contingency plans would it be wise to have?

#### Common Concerns Partners Have

##### Teachers

Will my optics resource volunteer...

- Use appropriate vocabulary?
- Use effective teaching tools (visual aids, models)?
- Encourage girls and bilingual students?
- Learn and respect my classroom rules and routines?
- Observe student behavior?
- Fit into the crowded schedule I already have?

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Will I...

- Look ignorant compared to the optics resource volunteer?
- Not understand what the optics resource volunteer is saying?
- Be asked to spend too much time on this project?

### Optics Resource Volunteers

Will my teacher...

- Give me enough guidance?
- Want me to come to too many different classes (instead of getting to know one very well)?
- Help me to plan something that will be both of interest to the students and something I can get excited about?
- Do nothing while I have to do it all?

Will I...

- Be good enough in front of the class
- Talk over the students' heads?
- Be asked to spend too much time on this project?

### • Communication

What are good ways to stay in touch with each other? What are the best days and times to call? What is the best way to get a message to each other in an emergency? If more than one teacher is involved in the partnership, who will be the designated contact person?

Such planning is also useful because you'll see whether your personalities and interests “click” before making a visit. Be flexible and open to new perspectives. But if things look like they may not work out, it's better to find a new partner. Feel free to contact MESA for a new teacher partner or SPIE or OSA for a new optics resource volunteer partner. (See p. 20.) And perhaps you can help each other find a more suitable partner.

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## Planning Checklist

\_\_\_ Have an initial planning meeting, preferably away from school or interruptions. At the meeting, be sure to address the areas listed above and select a few themes and activities from the HOO modules to focus on first. Because unexpected situations can come up, be sure to have a back-up plan for each session, just in case.

\_\_\_ Make a date for continued planning, if needed. We suggest you try to sketch out a plan for the whole unit or semester. You can always revise the plan or make it more specific after the first visit.

\_\_\_ Set up a time for the optics resource volunteer to observe the classroom as an anonymous visitor before he or she begins making visits.

\_\_\_ Introduce the optics resource volunteer to the school principal and to any other important school personnel. The optics resource volunteer should be presented as a valued and honored visitor with expertise who is giving time to volunteer in the school.

\_\_\_ Give the optics resource volunteer a tour of the school (including the location of restrooms and parking spaces!).

\_\_\_ Exchange information about scheduling constraints or commitments. Give the optics resource volunteer a school calendar for the year.

\_\_\_ Make a communication contract: Who will call whom and when? How will you follow-up after visits? When and how often will you plan? How will you give each other feedback?

\_\_\_ “Debrief” after the optics resource volunteer’s observation and subsequent visits. If you can’t talk at school, make an agreement to talk by phone later.

\_\_\_ Divide up responsibility for any materials needed for the visits. We suggest that most materials stay at the school site, but optics resource volunteers may need some materials (such as slides) to prepare for visits. For sites with multiple teachers, you will need to make additional copies or work out a rotating system to share materials.

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## THE FIRST VISIT

The first visit provides the opportunity for the optics resource volunteer and students to get acquainted. It is also a chance for the optics resource volunteer to get a better sense of the students' interests and prior knowledge. And, you can use the first visit to interest the students in what's to come.

Most partners have a lot of fun with the first visit. By this time, partners are usually more comfortable with each other as a result of the planning they've done. Still, the first meeting with students can be somewhat nerve-wracking for the optics resource volunteer who is new to the classroom, and for the teacher who has not had a visiting scientist in the classroom before. HOO partners have come up with a number of first visit ideas that have helped them get off to a successful start. Of course, you will want the first meeting to fit with your style and what you plan to do in subsequent visits. Here are some ideas and suggestions from some teacher partners that may spark your own thinking.

### Before the Optics Resource Volunteer Arrives

- **Prepare the students**

Before the visit, the teacher should introduce new material thoroughly and build up the excitement about the optics resource volunteer. Emphasize that the optics resource volunteer is coming *especially* to see these students, that he or she knows a lot about optics, and is making a very special effort to come to their school.

- **Do an activity where students picture an engineer or scientist before the optics resource volunteer arrives**

In this activity, students picture an optics resource volunteer in their mind and draw a picture of what they think an optics resource volunteer looks like. You can also have the students write about what they think an optics resource volunteer does. Then, students compare their different images, and discuss some of the assumptions they made (do they assume the optics resource volunteer is male? Do they assume the optics resource volunteer wears glasses?). Students will be extremely interested to find out what their optics resource volunteer really looks like after this activity. After the first visit, the optics resource volunteer can give out various awards for the

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drawings (the most life like, the most "nerdy," the funniest, etc.). You can also create a great bulletin board using these drawings, including some photographs of the real optics resource volunteer, or other optics resource volunteers.

- **Have Students Make a List of Questions**

In small groups, have students come up with at least 10 questions for the optics resource volunteer. Post these questions in the classroom, and provide opportunities for the optics resource volunteer to answer some of them when he or she comes. This will also help the optics resource volunteer to see what interests students. To avoid overloading the optics resource volunteer, have each group of students or the whole class select three of their favorite questions to ask. (You may want to share the questions with the optics resource volunteer before the visit.) The optics resource volunteer can answer the questions for the class or meet with small groups. Then, keep the questions posted to refer to during the optics unit.

### **During the First Visit**

- **Talk about your work and interests**

If you are an optics resource volunteer, share yourself with students by describing your work, how you got interested in optics, what you wanted to be when you were their age, what else you like to do, etc. The students will likely have a range of questions about these topics, and will appreciate that you care enough to share your personal experience with them. It's always a good idea to bring some photos or slides.

- **Learn the students' names and get comfortable with each other**

It's helpful to have students wear nametags for the first visit (and future visits until the optics resource volunteer learns their names), and to clarify what they should call the optics resource volunteer (other than, "hey you" or "Space Guy"). Doing an "icebreaker activity" (see box) is a great way to get acquainted and learn the children's names.

- **Plan one manageable activity, if time allows**

If there is enough time, plan to do a simple hands-on activity with students. Teachers and optics resource volunteers may want to lead the first activity together. Small group activities work well because these give the optics resource volunteer a chance to interact with students on a more

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personal basis. You will probably want to do an activity that ties into what students will be learning next. For example, if students will be studying telescopes, a good first activity is to have students work in groups to predict what you might see imaging with one convex lens and then a system of two convex lenses. These activities and others can be found among the *HOO modules*.

### Optics "Icebreaker" Activities

- Brainstorm lists of everyday objects that use optics (technologies such as eyeglasses and binoculars, light-emitting diode (LED) displays of clocks, energy-saving compact fluorescent lamps, infrared remote controls, optical fibers for distributing cable television, satellite-based optical weather imaging, newspaper phototypesetting, fax machines and laser printers, super-market bar code scanners, optical data storage, laser fabric cutting in the textile industry, and optical tools for medical diagnosis). Do in teams and give a prize to the team with the longest list.
- Have each student write down three things about him or herself and one question about optics. Let each student introduce him or herself and ask their question. For added fun, the optics resource volunteer can take a Polaroid photo of each child to display at

Whatever you do during the first visit, try to relax and have fun. Be prepared for something not to go as planned, and be willing to be flexible. Most likely, things will be great! After the first visit, be sure that you meet with your partner or debrief on the phone that night. Discuss how the students responded, ask for feedback, and talk about what you might do differently next time. Then, make a date for the next time.

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## 7. GUIDELINES FOR TEACHERS

Here are some guidelines and suggestions about the teacher's role in a HOO partnership. We hope these ideas will be helpful, and encourage you to refer back to this section as your partnership develops.

### ROLES AND RESPONSIBILITIES

Before you start your partnership, and before each visit it's a good idea to be clear about roles and responsibilities. Here are some general guidelines about the teacher's role:

**The teacher is responsible for student behavior and classroom management, and should remain actively involved in the classroom by modeling learning for the students.** The optics resource volunteer is not a substitute teacher, and should not be left alone to deal with the students. He or she should be able to count on the teacher for help with classroom logistics or inattentive students. Be sure to let the optics resource volunteer know about classroom rules and routines.

**Both the teacher and optics resource volunteer are responsible for getting in touch with their partner.** Partnerships won't continue if one partner does not hear back from the other partner. Avoid this pitfall by initiating contact with your partner (even if you think it's the other's turn) and returning any calls within two days (even if it's to say, "I'm swamped and will call you back later").

**The teacher should stay engaged and involved in the classroom.** Take notes, do the activities, ask questions. This models curiosity and learning to students and helps the optics resource volunteer. For example, if it seems that students' do not understand the optics resource volunteer's explanation for something, you can help the optics resource volunteer to clarify by asking the question again yourself in a different way.

**Keep interruptions to a minimum** during the optics resource volunteer's visits (because the optics resource volunteer is only there a few times). If possible, arrange for a longer class period for the visit.

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**Keep track of time** during the visit (because optics resource volunteers can get excited and lose track).

**Coordinate logistics**, materials, and equipment before the optics resource volunteer's visits (making copies, getting a slide projector, making sure the room is dark, etc.).

**Arrange the details of any field trips** or activities away from school (although optics resource volunteers are often willing to help or even take the lead).

**Express appreciation** and thanks to the visiting optics resource volunteer. Make your optics resource volunteer feel welcome (it's great of course, to have students do this too).

**Make plans** for the next visit, or for next year.

## **TIPS FOR TEACHERS**

Here are some additional tips for teachers that can help make your partnership go more smoothly.

### **Prepare a Welcome**

Select several students to greet the visiting optics resource volunteer. Tell the optics resource volunteer where and how she/he will be greeted.

### **Understand What Your Students Are Learning**

Anticipate and identify questions they may have so you can prepare to follow-up.

### **Give Your Optics Resource Volunteer a Chance to Learn**

Remember when you first started teaching? It was a bit scary and you made mistakes. Maybe you lost the students' interest, or talked a bit too long. Let the optics resource volunteer have time to develop his or her skills and do what is interesting to him or her, but don't leave him or her floundering. You may need to strike a balance between averting a "failure" and letting your optics resource volunteer try it his or her way.

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**Let Your Optics Resource Volunteer Use His or Her Interests**

Your optics resource volunteer will be more committed to you and your students if she or he can do something that is of particular interest to her or him.

**Provide and Request Feedback**

After the visit, provide feedback to the scientist. He or she will respond to your positive reinforcement as well as constructive criticism. At the same time, ask your partner for feedback and input. He or she may have new ideas, constructive suggestions, or areas where your help is needed.

**Discuss the Visit With Your Students**

Build on their experience with follow-up activities.

**Think Interdisciplinary**

Incorporate interdisciplinary activities in writing, spelling, art, social studies, reading and math.

**Share Your Experience**

Parents, colleagues, and school administrators benefit from hearing about scientists' and engineers' visits. Publicity in the community will gain support for your efforts, and for the school.

**Keep a Portfolio**

Keep a scrapbook with photographs, student work, curriculum outlines etc. to document your HOO effort. Take videos of the optics resource volunteer's visits and special events.

**You Never Know Which Students will Like Optics**

Don't assume which students will like optics, or which students will or won't connect with the optics resource volunteer. Many teachers have found that students with behavior problems or learning difficulties have been especially turned on by science and engineering projects in optics.

**Address the Issue of Women and Minorities in Optics**

It's important to show students that there are female and minority optics resource volunteers. If your partner is a women or person of color, ask the optics resource volunteer to talk about his or her own experiences in the field of optics or science. You can also ask the visiting optics resource volunteer to talk directly about women and minorities in the field, or to help you find additional resources.

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### More Ideas for Teachers

- Create an "Ask the Optics Resource Volunteer" question box.
- Organize small group discussions with the optics resource volunteer to give quieter kids a chance to ask questions.
- Get a commitment of release days in advance for planning.
- Visit the optics resource volunteer's workplace.
- Go to an education outreach session sponsored by an optical society.
- Let optics resource volunteer know what will go on between visits.

Keep in mind that, while your partner optics resource volunteer may know more about optics than you do, he or she will not necessarily know about every aspect of optics. Most optics resource volunteers focus on one or two areas of optics, but may be able to discuss other aspects of the field if you give them notice.

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## 8. GUIDELINES FOR OPTIC RESOURCE VOLUNTEERS

We think you'll discover that visiting a school will be a rewarding experience. Teachers are grateful for the assistance and professional interaction, and most students will appreciate your time, care, and enthusiasm. At the same time, schools are unique cultures that can at times be frustrating for the newcomer. As workplaces for teachers, schools differ significantly from most offices. This means you'll need some special strategies to stay in touch with your teacher. Also, if you feel a bit nervous about the prospect of working with 30 active 13-year olds, you're not alone. Many people feel anxious before visiting a new classroom. You might have immediate rapport with the students, or it may take a few visits before you click with them. Bear in mind that students' reactions may have nothing to do with you, and could reflect something that happened earlier in school or at home, peer pressures, raging hormones (in early adolescence), and many other factors. Knowing and practicing some time-tested teaching techniques will help you connect with students and engage them in learning about optics.

Below are some tips and suggestions from a few scientist/teacher partnership projects. We hope these tips will help you navigate the school, interact with your teachers, and work with the students. You may want to return to this section after you've done a few visits to try new ideas each time.

### ROLES AND RESPONSIBILITIES

Before you start your partnership, and before each visit, we suggest that you clarify roles and responsibilities with your partner teacher. For instance:

**You are not a substitute teacher and do not need to lead the class alone.** You should count on the teacher to help you manage student activities and behavior. At the same time, it is important that optics resource volunteers learn about classroom rules and how to communicate effectively with students.

**Both the teacher and optics resource volunteer are responsible for getting in touch with each other.** Both of you have busy schedules and it can be difficult to reach teachers during the school day. Nevertheless, your partnership will be more successful if both partners take the initiative to get in touch.

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**Prepare for visits** by practicing activities and reading any guidelines thoroughly (try the activity out on your family or a friend).

**Request honest feedback** from the teacher (because teachers may be shy about giving it to you). Such feedback (even if it hurts a bit) can be invaluable in helping you to become a better resource for the students.

**Support your teacher's involvement in HOO**—let the principal know how great your partner teacher is, help your teacher attend workshops and special events, inform the community and colleagues about what the two of you are doing.

**Keep in touch** with your teacher about your schedule

**Make plans** for the next visit, or for next year.

### Reaching Teachers

One of the most obvious differences between teachers' lives and most optics resource volunteers' lives involves communicating with the "outside world" during the workday. In many workplaces, people have a cell phone or phone in their office, a fax machine down the hall, an accessible copy machine, and a computer with e-mail. Most teachers do not have an office, let alone a phone or computer of their own to use. Their workday is focused primarily on students and staff in the school. This means that reaching each other will require some persistence and creativity. What's the reality of communication for most teachers?

- Teachers may have access to a typewriter, phone, and fax but it's most likely in the main office (under the nose of the principal and office staff). Some teachers have a phone in their room, or in the science office, but can't always answer it.
- Teachers may have a computer to use, but it's probably in a computer lab or at home.

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- Many teachers do not have access to the Internet and e-mail yet.
- Most schools have few journals or optics books.
- Teachers can talk to other teachers in their school, but have less contact with teachers in other schools.
- Professional conferences are rare and special events.

*(Adapted from a list by Elizabeth Roettger, Adler Planetarium, Chicago)]*

## **TIPS FOR OPTICS RESOURCE VOLUNTEERS**

### **General Tips**

- Start simple, with smaller groups of students.
- You don't have to know the answer to everything. Model being a scientist/engineer who finds out.
- Don't assume the teacher has a strong background in optics or science. Be sensitive to concerns they may have about their own science/engineering preparation.
- Don't over-commit or you may burn out.
- You don't need to teach all of optics this year. Some students may have had some optics in a previous grade, others may have it in the next few years. It's best to help students understand a few focused concepts and to pique their interest in learning more.
- Students are at many levels of knowledge and reasoning. Be prepared not to reach everyone.
- Keep any lectures short and combine them with activities.

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- Monitor the safe use of equipment, to protect students and equipment.
- Listen to teachers and students and be flexible about your plans, based on what you hear.
- Start with an attention-getting activity.
- Always have a back-up lesson or activity, just in case. It's also helpful to have some "filler" activities or questions, in case you have extra time.
- Plan a good conclusion or wrap up. Review and emphasize how much the students have learned, and provide encouragement.

### **Don't try to cover too much**

It's easy to assume that concepts and procedures, which have become second nature to you, can be quickly learned by others—but it simply isn't true. It takes multiple exposures, active participation... and time for new concepts to become integrated into our brains. A small amount of material presented very effectively is much better than a lot covered so hurriedly it's confusing.

*(From *Preparing and Presenting Effective K-12 Science and Math Education Activities*, Sandia National Laboratories)*

### **Engage students in the process of science and engineering**

- Emphasize hands-on learning.
- Remember that process can be more important than just getting the right answer. When there are differences or unexpected results, explore the reasons why with students. Turn failures into science: "Why did your image of the lamp turn out to be inverted?" Encourage students to discover answers for themselves, or in some cases to consider that there may not be one right answer.

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- Students learn in different ways, so use a variety of approaches. Articles about student learning in science and engineering would be appropriate background reading. Also, request input from your partner teacher.
- Define what you are trying to accomplish. What is your purpose for this lesson?
- Use age-appropriate vocabulary (you'll do better by keeping your language simple).
- Take advantage of special events (e.g., new science or engineering discoveries in the news that may have to do with optics).

A teacher and her optics resource volunteer found a way to combine their interests in telescopes with teaching basic science principles. Their most successful activity was helping the students to see how a magnifying lens works, and how two lenses combine to make a usable telescope. The students were able to use the telescope to look at the sky and understood how it worked.

### **Get Feedback from Students**

When possible, use terms and analogies that the students already know. If you use a new term, define it or ask your partner teacher to help prepare students in advance. Not sure what language is appropriate? The best test is to ask the students by posing a question such as, "How many of you know what [the term] is?" "Can anyone tell me what I mean by [X]?" Look at the children's faces and behavior. Are they fidgeting or looking bored? This may mean that they do not understand you (with the exception of eighth graders who may just look bored). Also, don't forget to involve your partner teacher. Agree that the teacher will cue you if you are talking above the students, and ask your teacher for feedback after your visit. At the same time, don't worry if all students don't understand every word you say. It's likely that there will be a range of understanding, and that your teacher can help clarify any confusion later.

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### What do students know? Want to know?

It's very helpful to start by finding out what students already know. To do this, you can simply ask students to tell you everything they know about a topic, say the telescopes. As the students say their ideas, have the teacher write the ideas on the board. Another technique is to use a "KWL Chart" (What I know. What I want to know. What I learned). You or the teacher can create a big chart with these headings and list the students' responses under each heading. Keep the chart up until you're done with the unit or topic, and fill in the last part.

### Support Your Teacher

- Invite your teacher to visit your workplace. One HOO optics resource volunteer invited his teacher to his lab where they spent an afternoon trying to devise an experiment about optics for the students to do. Even though they didn't create a successful experiment, they both felt that the time they spent working together outside of the school setting made them more effective partners.
- Help your teacher find additional materials and resources.
- Let the principal know about the great things the teacher is doing.

### Help make teachers' lives simpler, not more complex

Teachers are pulled in many directions and are very busy. Seek to enhance their efforts without imposing a lot of extra demands on their already hectic schedules. Avoid becoming viewed as a time sink or just another person competing for attention. Be part of the solution, not part of the problem.

(From *Preparing and Presenting Effective K-12 Science and Math Education Activities*, Sandia National Laboratories)]

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### **Develop relationships with students**

- Be yourself. Talk about your work, your family, and how you got interested in optics.
- Validate and give positive feedback to students.
- Bring things for students: special photos, individual notes (in response to questions, perhaps).
- Hold contests with small prizes to do with optics.
- Keep in mind that not all kids will have a fascination with optics, science and engineering, but you can have a positive impact by showing you respect and care about students as people.
- If you are less experienced with kids, you may need to work harder to learn some kid-friendly techniques and language. Be patient, and let the teacher guide you.

#### **What your visits might accomplish**

"It's hard for kids who grow up in the inner city because when you're their age, that is the whole world to them. I was one of those children. I didn't know a whole world existed outside of my neighborhood. And I didn't know I was entitled to it either. You have to learn that from somebody else. And, once you learn that there's another world out there and you're entitled to it—that makes the difference." *A Teacher Partner*

### **Avoid gender and ethnic stereotyping**

Women and minorities are severely underrepresented in science. It is important to consciously avoid language, mindsets, and actions, which disenfranchise girls and minority students. Be inclusive in your language, actively involve and respond to all students (girls and boys), and use examples and materials that include women and minorities as role models and examples. Most important, have high expectations for *all* students.

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### **A Special Connection**

"There was an African American girl in my class who wasn't very involved during my first visit. As I was leaving, she walked up to me after class and asked me whether there were any African American female astronauts. I told her I didn't know, and promised to find out for her. So, I called NASA and found out that, indeed, there is an African American woman astronaut named Mae Jemison, the nation's first. A medical doctor, engineer, and accomplished dancer who majored in African American history at Stanford University, Jemison flew aboard the space shuttle Endeavor during a 1992 mission. NASA sent me a picture and the next time I visited the school, I gave the picture to the student and told her more about Mae Jemison. She was very excited and told me that her grandmother had told her not to expect to find an astronaut who was a woman and African American. During class, the girl walked up to me several times, clutching the picture and asking how to pronounce Mae Jemison's name correctly so that she could show the picture to her grandmother." *A Partner from Project ASTRO*

## **FURTHER TEACHING TIPS FOR OPTICS RESOURCE VOLUNTEERS**

### **Get Everyone Involved**

Make sure that all students have opportunities to participate and contribute (it is often easy to overlook girls or shy boys).

### **Stimulate Thinking by Asking Questions**

Questions that ask students to make a prediction, to give an explanation, to state an opinion, or to draw a conclusion are especially valuable.

### **Make Connections**

Students are more likely to understand if you can help them understand how a specific scientific concept has applications in other fields of study or relates to their own lives.

### **Leave More than a Memory Behind You**

Help set up an experiment that students can continue after you leave. Invite students to ask questions by letter or e-mail.

(From *The Science Alliance Handbook*)

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## HOW TO BE EFFECTIVE IN A CLASSROOM

**Make eye contact with the students** because they love the personal contact.

**Smile and feel comfortable telling amusing anecdotes** because kids love a good laugh.

**Organize all materials in advance** because kids sometimes have a hard time waiting.

**Use student volunteers to help you set up and distribute materials, samples, pictures and handouts** because kids love to feel important.

**Require that students raise their hands to participate** because they will probably all want to talk at once.

**Use a prearranged signal to get students' attention during activities (clapping, flipping light switch, etc.)** because it is too hard to give good directions unless students are quiet.

**Stop and wait for students to let you continue speaking if they get noisy** because they have probably heard the "cold silence" before and know that it means they need to be less noisy.

**Wait to give handouts to students until it is time to read or use them** because if the students have the handouts while you are speaking they will be distracted.

**Wait several seconds before calling on students to answer a question** because the whole class needs time to think about the question before someone answers it.

**Praise attentive or helpful behavior** because this is the behavior you want to encourage.

**Enjoy the students, their enthusiasm, and their sense of wonder** because they have a fascinating perspective on the world!

From *Sharing Science With Children: A Survival Guide for Scientists and Engineers*,  
Developed by the North Carolina Museum of Life and Science

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## **9. INVOLVING FAMILIES, COMMUNITY AND THE SCHOOL**

The HOO program provides opportunities to involve families, the community, and the entire school. Linking with families and the community can serve several purposes. Students are more likely to succeed in science (and school in general) when their families are actively engaged in learning with them. Finding ways to involve families in optics education will help support children's interest in science and engineering in and out of the classroom. And, because optics education can be fascinating for many adults, it is an excellent subject to draw families to school events and involve families in out of school activities with their children.

Linking with the community, from nearby science centers and colleges or universities to local businesses, will enhance your partnership activities by providing access to new resources and opportunities. Are there sites that you would like students to visit? Are there additional people to involve who can enhance the effectiveness of your partnership? Can a community connection provide materials or resources for the classroom? Are there local opportunities for teachers to develop their knowledge of optics? Organizations and individuals in your area may be able to meet some of these needs.

For example, a physics or engineering department visit can be a useful addition to students' learning and understanding of optics. Perhaps the local science center has optics-related activities for kids and families on the weekend. Ask a local optical society to help build or help raise money for school telescopes. Find out whether research institutions provide a summer internships for teachers, or if a program can be developed. Ask local businesses to donate materials for student projects. Developing community linkages will add to the value of your HOO program. At the same time, you can use your HOO program as a vehicle to develop ongoing links between the school and needed community resources so that the connection is not just a one-time event.

### **GETTING THE SCHOOL INVOLVED**

As you make links with community organizations, don't forget that sometimes involving the rest of the school can enrich your HOO program. For example, you can hold a brown bag lunch for the optics resource volunteer and other faculty members. Or have a mini-workshop for other teachers on a hands-on optics activity. Or involve the school librarian in doing a display of books about optics.

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## LINKING WITH OUTSIDE RESOURCES

In general, remember that students will be more engaged in science when they can *do* something that has meaning in the real world, such as participating in a real research project, writing an article that gets read by people, or demonstrating a science concept to families or other younger students. Kids will also be more motivated when they understand real world applications of what they are learning in school. Below are some examples of the types of connections you may want to make in your community:

- Colleagues, especially women or minority scientists who can serve as role models, could join you in the classroom to speak with students directly about their own experiences.
- Colleges and universities may have students willing to work with children, or faculty who can help provide access to research activities and resources.
- Your local high school may have resources you can use. Some high schools have optical benches, or more advanced equipment you can borrow.
- NASA's research centers may have educational programs relating to specific missions, or materials may be available to teachers through the much larger network of NASA Teacher Resource Centers. To get an updated list of NASA Teacher Resource Centers, contact NASA CORE, Lorain County JVS, 15181 Route 58 South, Oberlin, OH 44074 (216)774-1051.
- Businesses and industries in your area can help support your HOO partnership through cash or in-kind donations (printing, paper, supplies).
- Aerospace or other science and engineering-related companies may provide you with posters, slides, and other timely materials. Some companies sponsor teacher internships during the summer. Contact the company public information office as a first step.
- Your local media may be interested in news about your partnerships. Send out brief press releases a week before an interesting visit or event. Good public relations is always helpful for the school, and all involved will appreciate the recognition. Don't forget the school newspaper!

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### **Some Ideas to get Families and the Community Involved in HOO**

- Celebrate projects having to do with optics at a local science fair for students and families.
- Create a room at a local library or other accessible location with photographs, memorabilia, maps and books about optics. Show a lunar sample, available to educators through a training course offered by some NASA Centers.
- Have a community telescope building competition and hold a star party at the local school.
- Create special evening or weekend programs at schools for families around science and engineering events that could include optics.
- Set up a hands-on optics activities booth, staffed by children, at local fairs and events: Girl Scouts Convention, the County Fair, festivals, etc.
- Link up with a local scout troop or other youth group for joint science and engineering projects in optics.

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## 10. IDEAS FOR SUPPORT AND PUBLICITY

### GET ADMINISTRATOR OR EMPLOYER SUPPORT

Your HOO partnership will be far more likely to succeed if teachers have the support of school administrators, and optics resource volunteers have the support of their employers. We encourage you to take the time to develop the support and participation of your administrators and managers upfront and keep them informed as the visits progress.

#### At the School: Developing Administrator Support

- Inform your principal and key administrators about HOO before you begin, and keep them informed with brief updates.
- Request an initial commitment of 1-2 release days for planning and special projects (and get it in writing).
- Introduce the optics resource volunteer to the principal.
- Invite the principal and key administrators (superintendents, curriculum specialists) to visit your class during the optics resource volunteer's visits, or to attend special HOO-related events.
- Attend a school board meeting with your optics resource volunteer and involve the board members and administrators in a demonstration or hands-on optics activity that would illustrate the importance of supporting science education.
- Similarly, seek positive public relations for your program in the community and among parents.

#### The Optics Resource Volunteer's Employer: Developing Support

Some optics resource volunteers who participate in HOO may have flexible schedules or receive paid release time from their employer for school visits. Other optics resource volunteers will be making real sacrifices in order to visit classrooms by taking vacation days or working overtime later. The more support provided by the optics resource volunteer's employer, the more likely the partnership will be to continue. More and more, companies and institutions are recognizing the value of providing time for their staffs to do community service, but many companies still do not give time for employees to volunteer. HOO can help provide some legitimacy to optics resource volunteers who need a few hours off to visit classrooms. Any way that the school can recognize and reward the optics resource volunteer's employer for providing time for the visits can be helpful. However, because company policies and protocols differ, teachers should be sure to talk with their optics resource volunteer before contacting his or her employer.

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### **Some Steps You Can Take**

- Notify your employer about HOO and try to get a commitment of release time for planning and visits in advance.
- Enroll in your employer's volunteer program if there is one. The coordinator of the program will be impressed that you've arranged your own volunteer activity.
- Put news about the good work the optics resource volunteer is doing in the company (or institution) newsletter or let the public information director know about your efforts.
- Keep your employer informed about the highlights of your school visits.
- Get the name of the optics resource volunteer's employer into any publicity releases about the project. Credit the company and its generosity in contributing time and resources to improve science and engineering education.
- Teachers: Send appreciation letters on school letterhead to the optics resource volunteer's manager and to corporate officers (if appropriate).
- Build on the initial support. If the company is supportive, could it donate equipment? Other resources? More staff? Or, help with publicity?

### **GETTING PUBLICITY**

Getting publicity about your HOO activities is a great way to build support for the project and to involve the community. Positive publicity will enhance your community's awareness of optics, and the importance of science education. Publicity is also good for the school's standing in the community, as well as for the optics resource volunteer's employer. And, getting publicity is always an exciting reward for students, teachers, and optics resource volunteers involved with your project. As you develop and carry out your HOO program, think about ways you can let others know what you're doing and generate positive PR.

#### **Publicity Ideas: At School**

- Write about students' success in the school newspaper or parent newsletter.
- Videotape HOO activities.
- Take pictures and slides of your HOO program.
- Give a talk at professional teacher conferences.
- Keep a class portfolio.
- Do a display in the hall, cafeteria or library.

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**Publicity Ideas: In the Community**

- Send out press releases about your program to local papers, radio, and television stations. Think about the story you want the press to tell. Emphasize the optics resource volunteer's visits. Do this at least a week before a special event.
- Call and write the reporters who cover education, science, and family issues in your local paper, radio, and TV. Send them personalized invitations and press releases about classroom visits or special events.
- Contact your neighborhood newspapers or local cable channel.
- Write an article for the optics resource volunteer's company newsletter, or teacher publications in your area.
- If you do a collaborative community project (with a science center, for example), ask their PR department to help with publicity for your program.
- Set up a booth (with student help) at a fair, expo, or other community event.
- And please keep the OSA, SPIE, MESA and NOAO offices informed as well.

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## 11. SPECIAL EVENTS AND GOOD IDEAS

### FORMING A SCHOOL SCIENCE (or ENGINEERING) CLUB

Forming a school science (or engineering) club is an effective way to involve students in learning science. Because a club is less structured, an optics resource volunteer may have more opportunities to explore working with students directly. The science club can also give kids the chance to play an active role in deciding what they want to learn or explore. At the same time, because students join the science club voluntarily, the club activities need to be fun and engaging. You will find that many of the activities and ideas contained in this manual and in the *Scope It Out! An Optics Activity and Resource Notebook* can be very successfully adapted to a club setting.

How do you form a science club? You need to decide in advance how many students you want in the club and how you will select them. In general, it is best to work with students who join voluntarily, rather than kids who were required to participate. The club will be easier to manage if you limit the size to 10-15 students. To select kids, you might open the club to specific grades, develop a lottery system, or require students to write an essay to join. Perhaps the club can be an extension of a classroom optics or science unit for interested students. Or, you may need to put up posters to publicize the club more widely and make it seem enticing. You will also need to decide when and how often the club will meet. Science clubs can meet before school, during lunch, and after school. And, finally, you need to decide how you will structure the club. Will the optics resource volunteer and teacher plan activities in advance, or will you involve students in deciding what they want to do in the club? Will the optics resource volunteer come to every meeting, or can the teacher handle some meetings alone?

In addition, you may need to talk with the school administration about finding a space, using equipment, and any funding needs. You may want to ask students to pay dues, although in many schools this could exclude some students. Alternatively, if funds are needed, you might approach the parent-teacher council, local businesses, or the optics resource volunteer's employer for some funding.

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## USING TELECOMMUNICATIONS AND SOFTWARE

Telecommunications—particularly electronic mail and the World Wide Web—are tools you may want to use to enhance your partnership. For those teachers with access to electronic mail, this may be one way to make plans or keep in touch with your optics resource volunteer if he or she has easy access to the Internet. If your school or classroom does not currently have access to the Internet, some optics resource volunteers may be able to help you set up and use e-mail. If you have telecommunications in the classroom, you can have students communicate or share data with the optics resource volunteer via e-mail. Or, you might have students communicate with other students to share optics, engineering or general science information or data. This does not, of course, replace in-person visits by your optics resource volunteer, but can add more interest and excitement to your optics unit.

The World Wide Web contains many optics-related sites and tools, in particular visual images and data. If the optics resource volunteer is familiar with the World Wide Web, he or she can help teachers learn how to access and navigate the Web or create web pages. Science centers and school districts are getting increasingly involved with telecommunications and may provide workshops and assistance to teachers and optics resource volunteers interested in learning more about the Web.

### Telecommunications Tips

Below are some tips about using telecommunications in your HOO partnership.

(Teachers) Manage student questions: As a class, select one or two questions to send the optics resource volunteer. Don't overwhelm the optics resource volunteer with questions from all students.

(Optics Resource Volunteers) Answer with a question: Rather than give complete or direct answers to students' questions, pose a new question or ask a "what if" question to extend students' thinking, or suggest an experiment or observation that students can do on their own.

(Teachers) Display the replies: Make hard copies of the optics resource volunteer's responses to give students something tangible to look at.

(Optics Resource Volunteers) If the class has access to the World Wide Web, point the students to a site where they can find information, rather than providing it yourself.

(Adapted from the *Science Alliance Handbook*)

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## Optics Software

There is a range of optics, science and engineering software that can help students see how optics resource volunteers review actual data and draw conclusions. You may want to integrate some computer activities into your HOO program. Optics, engineering and general science software generally falls into one of several categories:

**Multimedia libraries:** database programs that store images and video clips on either optics, general science or engineering, along with text information

**Games and tutorials:** programs that teach about optics, general science or engineering through games, illustrated lectures, and on-line activities

**Software tools:** packages that allow students and teacher to use computers like scientists do—to explore new terrain and display large amounts of raw data in a usable form (e.g. image processing programs)

However you integrate technology—whether through telecommunications or software—into your activities, consider how the use of technology can engage students in active, rather than passive, learning.

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Teachers who care about giving students meaningful science experiences want and need expert support to convey the process and content of optics. Increasingly, optics resource volunteers recognize the importance of becoming resources to help schools and youth-serving organizations improve students' science literacy. Working together, teachers and optics resource volunteers can enhance the local curriculum and create new ways for students to learn about optics. As a HOO partner, you have the opportunity to make a real difference in your students' learning, as well as to affect how science is conveyed in schools and community organizations. We hope you will also be changed and enriched by participating in such a program. We applaud your efforts, large and small, and encourage you to make an ongoing commitment to bring students the wonders of optics.

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## 12. HOW TO GET THE SCIENCE EDUCATION ACTIVITY MODULES ON OPTICS

*Hands-on Optics: Making an Impact with Light*, edited by Stephen M. Pompea and Constance E. Walker, is a comprehensive and ready-to-use collection of 6 classroom modules on optics, full of activities, teaching ideas, and annotated resource lists. Developed as a result of the Hands-On Optics program, these modules focus on grades 6-8 with much of the material easily adaptable to higher grades.

*Hands-on Optics: Making an Impact with Light* is available through joining the Hands-On Optics program via OSA, SPIE, MESA or NOAO. Contact:

MESA Statewide Office  
300 Lakeside Drive, 7th Floor  
Oakland, CA 94612-3550  
Phone: (510)987-9337  
Email: mesa@ucop.edu

or

Education Outreach  
Optical Society of America  
2010 Massachusetts Ave., N.W.  
Washington, D.C. 20036.1023  
Phone: (202)416-1430 or (800)766-4672  
Email: member@osa.org

or

SPIE  
PO Box 10  
Bellingham WA 98227-0010 USA  
Phone: (360)676-3290  
Email: education@spie.org

or

Education Outreach  
NOAO  
950 N. Cherry Ave.  
Tucson, AZ 85719  
Phone: (520)318-8230  
Email: outreach@noao.edu

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