

SOLAR HEATING ACADEMY

Train the Trainer



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SOLAR HEATING

TRAIN THE TRAINER TO OFFER A 48 HOUR SOLAR HEATING COURSE AS PREPARATION FOR THE NABCEP ENTRY LEVEL SOLAR HEATING INSTALLER EXAMINATION

PURPOSE

The purpose of the Solar Heating Train the Trainer experience is to review the sequence and content of the developed 48 hour solar heating module series along with related resources, activities, training/delivery methodologies, and equipment and facility details. The 48 hour class modules/activities are designed to prepare students to take the NABCEP Entry Level Solar Heating Installer Examination.

AUDIENCE

The Train the Trainer experience is designed for adult-level trainers/facilitators with varied backgrounds in alternative energy/solar energy, HVAC, plumbing, construction, roofing, electricity, as well as those who are new to solar but excited to learn. Classroom/laboratory organization details will be discussed; however participants are expected to have some familiarity with laboratory-based (hands-on) adult training programs.

OBJECTIVES

1. Introduce participants to NABCEP Certified Solar Heating Installer Examination.
2. Introduce participants to the developed solar heating module (PowerPoint) series.
3. Introduce participants to solar heating activities and trainers.
4. Develop participants' capacity to plan, organize, and conduct training.
5. Engage participants in a review of principles and concepts of adult learning.
6. Assist participants in initial solar heating program planning.

METHODOLOGY

The Train the Trainer experience will include:

1. A presentation and discussion of module audience, delivery, sequence and content.
2. A review of module related print and Internet resources.
3. An introduction to module related hands-on classroom activities
4. A review of laboratory tools, equipment, and supplies.
5. A discussion on safety related issues in a 48 hour class.
6. A review of laboratory solar heating trainers and related activities.
7. A discussion regarding the care and handling of an intensive tool, material, component, and equipment dependent curriculum.
8. An opportunity to consider a solar heating startup at your facility.

STRUCTURE: Two days.

1. Day one classroom: module, delivery system, and resource review. Participants will engage in selected individual and small group activities.
2. Day two laboratory: environment, tools, materials, components, and equipment. Participants will be engaged in discussions regarding tools, equipment, laboratory organization and safety, management/inventory concerns, and hands-on solar heating activities. Participants will complete the day with a review of the two day training and the initial development of individual plans-of-action for solar heating program start-ups at their institutions. Session will culminate with a report-out of developmental plans.

MATERIALS AND TOOLS: Each of the two days will include an introduction, review of learning objectives, and activities. Participants will be provided copies of the NACBEP Solar Heating Installer Resource Guide, and a thumb drive containing solar heating resources. Both the Guide and drive contents will be reviewed.

TIME: Two days, 8:00-12:00, 1:00-5:00, 10 hours classroom, 6 hours lab.

CLOTHING: Casual. Hands-on activities can get wet and dirty. Bring personal work gloves, hard hat, and safety glasses as available. No open-toed shoes/sandals. Hard hats and glasses are available on site.

TIMETABLE

TIME	DAY ONE	DAY TWO
8:00 - 8:30	Welcome, sign-in	Welcome, sign-in
8:30 - 10:15	Introductions, objectives NABCEP exam Module, resource overview Module #1	Objective review Tour of facility: tools, equipment, trainers, lab organization and maintenance, safety
10:15 - 10:30	Break	Break
10:35 - 12:00	Module #2 Teaching/learning review	Activities: Sweating pipe, knot tying, multimeter tests, component identification, controllers
12:00 - 1:00	Lunch	Lunch
1:00 – 2:30	Modules #3 & #4	Hampton trainers, Heliodyne trainer
2:30 – 2:35	Break	Break
2:35 – 3:55	Modules #5 & #6	Program development
3:55 – 4:00	Break	Break
4:00 – 5:00	Tailgate Meeting Day One review, Plans for Day Two	Tailgate meeting Report outs, next steps, training review

Solar Heating Information Sheets

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Solar Heating Program Development Plan

Institution: _____

Date: _____

Developer(s): _____

The objective of this plan is to promote the offering of a forty-six hour solar heating installer course at my/our institution that will prepare students to take the North American Board of Certified Energy Practitioners (NABCEP) entry level solar heating examination.

PROGRAM ELEMENTS

CURRICULUM

- ✓ Solar heating modules keyed to NABCEP examination elements.
- ✓ Print and Internet resources, indexed to the solar heating modules that provide illustrations, examples, graphs, and topic expansion.
- ✓ Hands-on solar heating activities that help to reinforce module concepts.
- ✓ Downloadable *NABCEP Solar Heating Installer Resource Guide* as text.

☐ _____

☐ _____

MISSING ELEMENTS

☐ _____

☐ _____

CLASSROOM FACILITY

- ✓ White board (chalkboard), easel/paper, instructor computer with DVD and Internet connection.
- ✓ Tables suitable for display, demonstration, and small group activity.

☐ _____

☐ _____

MISSING ELEMENTS

☐ _____

☐ _____

INDOOR LABORATORY FACILITY (Draw floor plan on separate sheet)

- ✓ Indoor laboratory suitable for solar heating demonstration and trainer experiences.
- ✓ Floor space _____
- ✓ Work benches _____
- ✓ Displays _____
- ✓ Storage cabinets _____
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____
- ✓ Indoor or outdoor covered workbench area for pipe cutting, assembly, sweating, testing, component assembly/testing.

OUTDOOR LABORATORY FACILITY (Draw layout on separate sheet)

- ✓ Outdoor laboratory suitable for solar heating demonstrations and student crew system testing/commissioning activities.
- ✓ Secured (fenced) area
- ✓ Open (unsecured) area
- ✓ Classroom roof (under 6 ft, over 6 ft, area supports #? students)
- ✓ Outdoor storage (hoses, mounts)

- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

TOOLS (Refer to solar heating hand tool list)

- ✓ Tools to order:

- _____
- _____
- _____

✓ **Tool source(s):**

EQUIPMENT (Refer to training notes and solar heating equipment list and activity sheets)

✓ **Equipment to order:**

✓ **Equipment source(s):**

CONSUMABLES (Refer to training notes, solar heating list and activity sheets)

✓ **Consumables to order:**

✓ **Consumables source(s):**

TRAINERS (Refer to training notes, solar heating list and activity sheets)

✓ Trainers to order:

✓ Trainers source(s):

SYSTEMS (Refer to training notes, NABCEP text, solar heating list and activity sheets)

✓ Systems to order:

✓ Systems source(s):

COMPONENTS (Refer to training notes, NABCEP text, solar heating list and activity sheets)

✓ Component to order:

✓ **Component source(s):**

This basic introduction is a useful activity in conjunction with broader safety instruction.

Personal Safety

1. Wear proper eye protection.
2. Review personal clothing for work appropriateness. Secure loose clothing. Cover or tie back long hair around rotating equipment.
3. Remove jewelry.
4. Wear gloves when handling sharp/rough materials. Aluminum collector frames and copper pipe get very hot in the sun. Avoid wearing gloves when operating rotating tools and moving machinery.
5. Do not use flammable materials for cleaning.
6. Use full face shield in operations producing quantities of chips/dust.
7. Ear protection may be required when working in enclosed areas.
8. Wear heavy gloves (heavy cotton, canvas, leather) when doing hot work.
9. Wear hiking style boots to support ankles, reduce ladder fatigue, reduce roof treatment damage, and provide traction on roof installs.
10. Coveralls should be considered for roof installs.
11. Use soap and water frequently to prevent disease and infection.

Write Four Additional Personal Safety Guidelines

12. _____
13. _____
14. _____
15. _____

This basic introduction is a useful activity in conjunction with broader safety instruction.

General Safety

1. Know where fire extinguishers are located.
2. Report injuries to the instructor.
3. Notify the instructor of any hand or power tool that does not appear to work properly.
4. Work carefully with tools while wearing appropriate safety eyewear.
5. Maintain an organized and clean work area.
6. Get assistance when carrying long objects and items weighing over 50 pounds.
7. Wear hard hat for protection from falling objects.
8. Observe appropriate fall protection procedures.
9. If you feel ill do not work with tools and equipment.
10. Know where the first aid kit and eye wash station are located.
11. Use proper lifting techniques when lifting heavy objects.
12. Be considerate of the safety of others.
13. Do not use compressed air to clean your clothes or body.
14. Use oil and grease free hand tools. Clean tools and place them in their proper place at the end of each session.
15. Move carefully in work areas

Write Five Different General Safety Guidelines

16. _____
17. _____
18. _____
19. _____

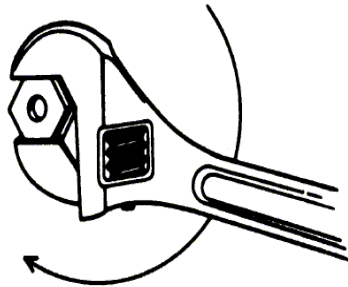
This basic hand tool test is potentially a pre-test and a useful activity in conjunction with broader safety instruction.

Hand Tool Safety Test

Solar Heating

Student Name: _____ Score: _____

1. ☐True ☐False When tightening a nut with an adjustable wrench, always pull the wrench toward you; never push the wrench away from you.



2. ☐True ☐False Screwdrivers may be used for purposes other than driving or removing screws, such as prying open can lids.
3. ☐True ☐False Snips are permissible for cutting wire.
4. ☐True ☐False Safety goggles should always be worn whenever you work with hand tools.
5. ☐True ☐False Every tool was designed to do a certain job. Use it for its intended purpose.
6. ☐True ☐False Tools subject to impact (chisels, star drill, punches, etc.) tend to "mushroom". Keep them dressed (sharpened) to avoid flying spalls.

7. ☐True ☐False Secure your work in a vise whenever possible. Never hold small work in your hand when using a screwdriver.
8. ☐True ☐False Wrenches, if adjustable, must work freely and adjust properly. Gripping teeth or smooth jaws should not be worn. Always use the proper size for the job.
9. ☐True ☐False Always wear the PPE required for the job. Protect your eyes, hands, ears and other body parts. Keep clothing out of your work.

10. Which is more dangerous, a sharp knife or a dull knife?

11. What should you do with a damaged power tool that belongs to you?

12. What does OSHA stand for?

13. Write in one probable cause for each hand tool injury listed.

a. Loss of eye/vision:

b. Puncture wounds:

c. Severed fingers, tendons and arteries:

d. Broken bones:

e. Contusions:

Student Signature:

Date:

ANSWERS: 1-T (control), 2-F, 3-F (damage to cutting edges), 4-T, 5-T, 6-T, 7-T (possible impalement), 8-T, 9-T (PPE - personal protection equipment), 10 - dull knife is more dangerous as the user will apply greater force – greater chance to slip and slice, 11 – damaged tools of all types should be taken out of service until repaired or replaced, 12 – Occupational Safety & Health Administration, 13 (a) – not wearing safety glasses/goggles, foreign object/tool entering eye, 13 (b) - holding work in one hand using screwdriver/awl/punch in the other, 13 (c) - finger in shear zone (equipment), lifting too heavy a weight, tool/puncture wound, 13 (d) – falling, slipping, ladder spill, 13 (e) – hard impact from heavy tool/equipment.

Skill Sets and Crew Management Sheets

The next two pages offer two related classroom/laboratory management charts.

“Skill Sets” is a form distributed early, either the first or second class meeting, to each student. Students are requested to self-assess their backgrounds/experiences/and skill levels in a variety of categories (see chart). The exercise is simplified in to two check-off categories, “strong” and “some”. The instructor collects completed sheets promptly from students – give the exercise about 10 or 15 minutes maximum.

A very quick scan of the form tells you as instructor two important details - who your lead people will be and who your people with few to no hand tool skills are.

“Crew Management” is a form that the instructor uses to establish solar heating installation “crews”. Using the quickly scanned Skill Sets forms the instructor assigns individual students to crew assignments/responsibilities.

The over-riding principle in using the two forms is to ensure that people with solar heating related tool skills and experience are in lead positions AND with crew assignments the instructor informs EVERYONE that if a lead/knowledgeable is holding a tool, turning a wrench, or adjusting a system setting – that individual is in jeopardy of being tossed out of the classroom. (Clearly this is a point made in class with a smile and a bit of humor). The key is that the lead people have the job to guide others on their crew. It is not unusual that you will have people in a solar heating class who have never held a torch and/or never worked with a drill motor – etc. The people in the class that know how to solder, for example, are there to help those that do not know.

The Crew Management chart was developed for solar heating system installations in a laboratory where two systems were being installed simultaneously on and under a roof. Roof and ground/basement crews alternated with installs so that everyone had an opportunity to work on collector installations (roof) and tank/pump/controller installations (ground/basement).

Adjust the charts to best serve the local instructional setting.

NAME: _____

DATE: _____

SKILL SETS

	1	2
	STRONG	SOME
Personal Safety		
Hand Tool Safety		
Site Assessment		
Collector Installation		
Water Heater Installation		
Pipe/Tank Insulation		
Connect System Piping		
Install Piping Run		
Install Mechanical Systems		
Piping System Design		
Roof/Height Work		
Installing Electrical Controls		
Performing System Checkout		
Installing Pumps		
Running A Job		
Reading Wiring Diagrams		
Parts Inventory		
Sales/Marketing		
Ladder Safety		
Estimating/Financing		
Blueprint Reading		
Construction/Carpentry		
Natural/Other Gas Work		
Hand Tools Use		
Internet/Ethernet/WiFi		
Contractor (1=Prof. 2=Amateur)		
Mechanic (1=Prof. 2=Amateur)		
Electrician (1=Prof. 2=Amateur)		
Plumber (1=Prof. 2=Amateur)		
Orienteering (1=Prof. 2=Amateur)		
Artillerist (1=Prof. 2=Amateur)		
Surveyor (1=Prof. 2=Amateur)		
Navigator (1=Prof. 2=Amateur)		
Cartographer (1=Prof. 2=Amateur)		
Astronomer (1=Prof. 2=Amateur)		
Civil Engineer (1=Prof. 2=Amateur)		
Roofer (1=Prof. 2=Amateur)		

DATE
INSTALL TYPE

NAME

NAME

EAST FOREMAN

WEST FOREMAN

EAST ROOF CREW

WEST ROOF CREW

Crew Lead
Crew Tool Bag
Safety Lead
Safety Posts
Safety Rails
Ladder Boss
Bucket/Rope Hoist
Collector Rails Lead
Oateys
Collector Parts Boss
Sweeper
Harness Boss

Crew Lead
Crew Tool Bag
Safety Lead
Safety Posts
Safety Rails
Ladder Boss
Bucket/Rope Hoist
Collector Rails Lead
Oateys
Collector Parts Boss
Sweeper
Harness Boss

EAST GROUND CREW

WEST GROUND CREW

Crew Lead
Tool Bag Boss
Safety Lead
Collector Crew Lead
Appliance Boss
Tool Truck Boss
Parts Truck Boss
Helmut Truck Boss
Safety Posts Truck Boss
Safety Rails Truck Boss
Hose, Cord, & Sweeper

Crew Lead
Tool Bag Boss
Safety Lead
Collector Crew Lead
Appliance Boss
Tool Truck Boss
Parts Truck Boss
Helmut Truck Boss
Safety Posts Truck Boss
Safety Rails Truck Boss
Hose, Cord, & Sweeper

Optional pre-test used early in course offering. Students exchange tests for grading. Instructor discusses each item. Students retain tests for study.

SOLAR HEATING SYSTEMS PRE-TEST

NAME: _____ DATE: _____

REVIEWER: _____ SCORE: _____

Circle the letter of the correct response(s).

1. When is insulation placed on the solar heating system?
 - a. Prior to installation
 - b. While under construction and accessible
 - c. After pressure test
 - d. After commissioning

2. What is the minimum slope on drain-back system pipe outside of conditioned space?
 - a. 20%
 - b. ½ inch per foot
 - c. ¼ inch per foot
 - d. 3 inches

- 3-5. What are three things you care about for protection of your Solar Thermal System?
 - a. Protecting your system against low temperatures
 - b. Protecting your system against harmful UV radiation
 - c. Protecting your system against high temperatures
 - d. Protecting your system against bird/rodent damage
 - e. Protecting your system against wind/hail damage
 - f. Protect your system against scaling (water quality)

6. Where do you get the diagram for a hydraulic OG-300 system?
 - a. SRCC <http://www.solar-rating.org/>
 - b. California Plumbing Code
 - c. Underwriters Laboratory
 - d. California Building Code

Circle the letter of the one correct response.

7. What is the approximate maximum desirable temperature for the bottom of a glass lined steel Solar Hot Water storage tank?
 - a. 220 degrees Fahrenheit
 - b. 300 degrees Fahrenheit
 - c. 180 degrees Fahrenheit
 - d. 120 degrees Fahrenheit
8. Polysun is computer simulation software that does what mainly?
 - a. Gives system pricing information for Domestic SHW systems
 - b. Calculates and estimates the solar fraction of Domestic SHW systems in a given geographical location
 - c. Compares various forms of renewable energy to one another and suggests the best option to the installer
 - d. Presents Solar Hot Water to the consumer in a fun interactive video game format
9. Sunlight falling on the United States for what length of time transfers enough energy to power the nation for one year?
 - a. one half day
 - b. one week
 - c. one day
 - d. one month
10. The water in a solar storage tank can get very hot so it's important to regulate the hot water output temperature to prevent scalding. This valve can be set at different hot water output temperatures and automatically mixes the hot solar water with the cold water inlet. Typical set temperature is between 120-140 degrees. What is the name of this valve?
 - a. Tempering Valve
 - b. Temperature Valve
 - c. Mixing Valve
 - d. Isolation Valve
11. The Solar Fraction is the ratio of energy supplied by the sun to the amount of energy needed to supply the total hot water demand. As an example a Solar Fraction of 20% is where only 1/5th of the energy needed to heat hot water is supplied by the sun. What is the most desirable solar fraction to achieve when designing a new Solar Hot Water system?
 - a. at least 80% during winter months
 - b. 100%
 - c. 80% or greater
 - d. 60% to 80%

12. The longest day of the year is:
 - a. December 13
 - b. December 21
 - c. June 21
 - d. July 13
13. When calculating the optimal size Solar Hot Water systems what is the normal daily hot water consumption for one person in the United States?
 - a. 50 gallons
 - b. 40 gallons
 - c. 30 gallons
 - d. 20 gallons
14. Carrying the collector by the header is allowed when:
 - a. You're actually on the roof and getting a grip on the collector is difficult
 - b. Removing a collector from a stack of other collectors
 - c. It's okay in all the mentioned scenarios
 - d. You need to attach straps to the collector to pull it onto the roof
 - e. It's never okay to carry the collector by the headers
15. This system uses a glycol and water mixture circulating through the collectors to prevent freezing, corrosion, scaling and boiling.
 - a. Closed Loop
 - b. Open Loop
 - c. Thermosyphon
 - d. Prototype
16. The collector rail splice kit's main purpose is to:
 - a. Connect collector rails at different angles to allow for unique roofs
 - b. Connect collector rails to accommodate an array of more than 2 collectors
 - c. Add seasoning to dishes for people who like their food spicy!
 - d. Add strength to a single collector mounting
17. What is a "Risse" sleeve?
 - a. Pipe insulation for long pipe runs to and from the collector array
 - b. Special insulation used to protect the collectors when not in use
 - c. A type of insulation designed specifically to insulate DOS connections
 - d. A convenient way to carry your peanut butter cup candies
18. A Shrader valve is located on the underside of the expansion tank. This is the same type of valve used to fill an automobile tire. When no pressure exists in the piping connecting the roof to the Heliodyne Helio-Pak how much pressure should exist in the expansion tank? (This is called a pre-charge pressure).
 - a. 100 psi
 - b. . No pressure
 - c. 50 psi
 - d. 25 psi

19. Solar Hot Water storage tanks are normally tall and thin in order to keep the cold water entering the tank somewhat separated from the existing hot water in the tank. This feature causes allows hotter water to be drawn from the tank before it becomes cold. What is the name of the property this tank design feature promotes?
- a. isolation
 - b. saturation
 - c. layering
 - d. stratification
20. What amount of water storage is recommended for every square foot of collector area? (Tricky question: How much hot water per square foot plus how much storage per gallon of production.)
- a. 2.5 to 3 gallons
 - b. 1.5 to 3 gallons
 - c. 0.5 to 1.5 gallons
 - d. 1.5 to 2 gallons
21. The expansion tank absorbs excess water pressure which could otherwise damage the plumbing structure. Some tanks use a bladder, some use a diaphragm. Why is a bladder style tank beneficial to an installer?
- a. Mounts in any orientation
 - b. Must be mounted in a vertical position
 - c. Larger simpler to install size
 - d. Less sensitive to glycol
22. What was the name of the first commercial solar hot water heater designed by Clarence Kemp, sold in the United States in 1891?
- a. Solar Snapper
 - b. Hot Box
 - c. Solar Still
 - d. Solar Climax
23. What type of absorber surface produces the highest solar energy capture?
- a. Black Chrome
 - b. Black Paint
 - c. Acid Etched
 - d. Blue Sputtered
24. Insulating the pipe runs on a system is primarily necessary because
- a. none of these reasons
 - b. it reduces the amount of heat loss
 - c. it looks nicer than copper pipes
 - d. it keeps the moisture contained during condensation

25. Air valves are operated either manually or automatically. They are installed at the highest point in the solar loop. How should float type air vents be positioned?
- a. horizontally
 - b. air valves are not sensitive to orientation
 - c. 45 degrees from vertical
 - d. vertically

True or False

26. Solar Hot Water is suitable for all regions of the United States.
- a. True
 - b. False

Matching

27-42. Select correct component name from the list below and write that name on the line provided.





























FEMALE PIPE UNION

COPPER BEND

BALL VALVE

FEMALE PIPE TEE

COPPER TEE

BOILER DRAIN

CHECK VALVE

SCREW CLAMPS

EXPANSION TANK

VACUUM RELIEF VALVE

FEMALE PIPE BEND

DIVERTA FLO

PROGRESS 90 ELBOW

DIELECTRIC UNION

GATE VALVE

PEX MANIFOLD

BRASS PIPE NIPPLE

43. Select correct knot, bend or hitch name from the list below and write that name on the line provided.



GRANNY KNOT

CLOVE HITCH TWO HALF HITCHES

SHEET BEND

BOWLINE

Pre-Test Answers

- | | |
|------------------------|--------------------------|
| 1 – c | 37 – Screw Clamps |
| 2 – c | 38 – Boiler Drain |
| 3,4,5 – a,c,f | 39 – Vacuum Relief Valve |
| 6 – a | 40 – Copper Bend |
| 7 – c | 41 – Propress 90 Elbow |
| 8 – b | 42 – Clove Hitch |
| 9 – a | |
| 10 – a | |
| 11 – d | |
| 12 – c | |
| 13 – d | |
| 14 – e | |
| 15 – a | |
| 16 – b | |
| 17 – c | |
| 18 – d | |
| 19 – d | |
| 20 – b | |
| 21 – a | |
| 22 – d | |
| 23 – d | |
| 24 – b | |
| 25 – d | |
| 26 – True | |
| 27 – DivertaFlo | |
| 28 – Check Valve | |
| 29 – Brass Pipe Nipple | |
| 30 – PEX Manifold | |
| 31 – Dielectric Union | |
| 32 – Female Pipe Bend | |
| 33 – Ball Valve | |
| 34 – Female Pipe Tee | |
| 35 – Gate Valve | |
| 36 – Female Pipe Union | |

Another optional examination – or mix and match. This test has been used in semester-long, three credit hour, (105 clock hour) classes. Possible use: test question bank.

SOLAR HEATING FINAL

NAME: _____

DATE: _____

REVIEWER NAME: _____

ITEMS # 1-40: WRITE IN the term, which best fits, each definition.

NOTE: LIST OF POSSIBLE CHOICES PROVIDED ON PAGE FOUR.

1. _____ A valve that allows fluid to flow in only one direction.
2. _____ The temperature of the surrounding air.
3. _____ The angle at which the sun's electromagnetic energy falls on an object.
4. _____ The glass covering on collectors.
5. _____ The surface area or opening, of a Flat Plate Collector, through which sunlight travels to reach the absorber. (Typically slightly less than the advertised collector length and width.)
6. _____ The extra heat provided by a conventional heating system for periods of cloudiness or intense cold when a solar heating system cannot provide enough.
7. _____ The angular distance between true south and the point on the horizon directly below the sun.
8. _____ A non-vented system wherein the solar loop fluid does not mix with domestic water through the use of a Heat Exchanger.
9. _____ A device that collects solar radiation and converts it to heat.
10. _____ The flow of heat due through a fluid or gas.

11. _____ A device that measures the difference in temperature (aka Delta T, or ΔT) between two or more locations and switches a pump(s) on or off in relation to user settings.
12. _____ The angular distance from the horizon to the sun.
13. _____ The relative ability of a surface to emit energy by radiation - to release absorbed heat. (A scale factor, between 0 and 1. The duller and blacker a material is, the closer its "e" is to 1. The more reflective a material is, the lower its "e").
14. _____ The darkened surface in a collector that absorbs the solar radiation and converts it to heat energy.
15. _____ A Heat exchanger wherein the two fluids pass each other in opposite directions.
16. _____ Difference in temperature between two locations.
17. _____ A device designed to compensate for fluid expansion and contraction in a closed-loop system.
18. _____ A device used to measure the volume of fluid flowing through a system.
19. _____ A vented system wherein the solar loop contains potable water.
20. _____ A condition caused as a result of a conducting liquid making contact with two different metals that are not properly isolated physically and/or electrically.
21. _____ The flow of heat due through a solid.
22. _____ A fluid (water, water-glycol mix, etc.) used to move heat from one location to another.
23. _____ A term used in reference to radiant heating systems.
24. _____ The flow of energy through open space via electromagnetic waves, such as visible light.
25. _____ Abbreviation for the American Society of Heating and Air-Conditioning Engineers.
26. _____ The apparent path that the Sun traces out in the sky during the year. (Approximate: 42.9° spring & autumn, 66.4° summer, 19.4° winter).

27. _____ Sensing device which changes its electrical resistance according to temperature.
28. _____ A pipe with multiple outlets.
29. _____ Un-pressurized Solar Hot Water (SHW) system wherein solar fluid drains back from the collectors via gravity into a storage tank until pumped back to the collectors to harvest heat.
30. _____ A measure of solar radiation energy received on a given surface area in a given time. It is commonly expressed as average irradiance in watts per square meter (W/m^2).
31. _____ A circular projection of the sky that can be used to determine solar positions and to calculate shading.
32. _____ The process that makes water circulate automatically between a warm collector and a cooler storage tank above it.
33. _____ Drinkable water.
34. _____ A relatively non-toxic antifreeze used in solar systems.
35. _____ The flow channels or pipes inside of a collector through which the heat transfer liquid moves across the face of an absorber.
36. _____ A surface that absorbs solar energy efficiently but does not radiate solar energy well. Used on absorber plates.
37. _____ Electromagnetic energy emitted by the sun.
38. _____ A condition caused by non-circulating solar fluid in a closed-loop system.
39. _____ A device that promotes the transfer of heat from collector fluid to domestic water.
40. _____ Term defining the planetary “plane” of our solar system.

ANSWER “CHOICES” FOR QUESTIONS #1-40 ABOVE.

NOTE: THERE ARE MORE CHOICES GIVEN THAN QUESTIONS ASKED.

Flow Meter,	Manifold,	Absorber,
Open Loop System,	Solar Radiation,	Passive Systems,
Absorptance,	Radiation,	Potable Water,
Sun Path Diagram,	Active System,	Conductance,
Selective Surface,	Insulation,	Diffuse Radiation,
Aesthetics,	Hydronic,	Watt
Longitude,	Air System,	Galvanic Corrosion
Direct Radiation,	Collector,	Altitude,
Aperture,	Insolation,	Thermistor,
Counter-flow Heat Exchanger,		British Thermal Unit (BTU),
Therm,	DHW,	Radiation,
Heat Pump,	Glazing,	Ambient Temperature,
Check Valve,	Ecliptic,	Emissivity,
Closed-loop Solar System,		Thermosiphoning,
Collector Efficiency,	Conduction,	Header,
Degree Day,	Convection,	ASHRAE,
Heat Exchanger,	Emittance,	Azimuth,
Propylene Glycol,	Expansion Tank,	Angle of Incidence,
Latitude,	Batch Heater,	Delta T or ΔT ,
Heat Transfer Fluid,	Auxiliary Heat,	Risers,
Concentrating Collector,		Tilt Angle,
Flat Plate Collector	Indirect System,	Ball Valve,
Eutectic Salts,	Direct System, Stagnation,	
Differential Temperature Controller,		Drainback System.

ITEMS # 41: Circle the MULTIPLE CHOICE letter, which best fits, each question.

41. The most effective space heating system that uses the lowest temperatures is:
- A. Forced air systems
 - B. Radiant floor heating systems
 - C. Baseboard converters
 - D. Wall-mounted fan converters
42. The worst heat transfer medium is:
- A. Air
 - B. Water
 - C. Hydrocarbon oils
 - D. Water/glycol mix
43. The best system for solar space heating is:
- A. Water collection, water storage, water distribution
 - B. Air collection, water storage, air distribution
 - C. Air collection, water storage, water distribution
 - D. Water collection, water storage, air distribution
44. Which of these microclimate factors reduce the quantity of solar energy received on the earth's surface:
- A. Early afternoon thunderstorms
 - B. Local haze or fog
 - C. Smoke and pollution from factories and cities
 - D. All of the above
45. Flat plate collectors on drainback systems can be mounted in all of the following ways except:
- A. Horizontal, flush mounted on a south facing roof
 - B. Horizontal, strut mounted on an east facing roof
 - C. Vertical, flush mounted on a south facing roof
 - D. Vertical, strut mounted on an east facing roof
46. The sun is at its lowest point in the sky in the northern hemisphere on:
- A. March 21
 - B. June 22
 - C. September 21
 - D. December 21
47. A noisy system could be caused by all of the following except:
- A. An air locked pump
 - B. Entrapped air in the piping
 - C. A water hammer shock arrestor
 - D. A vacuum breaker installed too high on a well system

48. Which of the following should be considered in a site analysis for location of the collectors:
- A. Location to prevent shading
 - B. Aesthetics
 - C. Low system pressure
 - D. All of the above
49. A possible cause for no hot water in the morning is:
- A. Nighttime thermosiphoning
 - B. Improperly plumbed check valves
 - C. Low system pressure
 - D. All of the above
50. You are concerned about shading from multiple rows of collectors facing south. Which time and date would you use to calculate the distance between the rows?
- A. December 21st, 3PM
 - B. December 21st, 12PM
 - C. June 21st, Noon
 - D. June 21st, 10AM
51. The only system/s that can be counted on to handle long hard freezes are:
- A. Pressurized Glycol Indirect
 - B. Drindown
 - C. Drainback Indirect
 - D. Open Loop Active
 - E. Thermosyphon Direct
 - F. ICS Direct
 - G. E and F
 - H. B and D
 - I. A and C
 - J. B and E
52. Frost and snow present a unique problem in defrosting and eliminating snow with the following type of solar thermal collector:
- A. Flat Plate
 - B. Unglazed Pool
 - C. Evacuated Tube
 - D. ICS
53. The most efficient heat exchange design is:
- A. Mix-flow
 - B. Counter-flow
 - C. Parallel flow
 - D. Immersed coil-in-tank

54. The following metals for piping is preferred for solar hot water (SHW) systems incorporating flat plate or vacuum tube collectors:
- A. Galvanized steel
 - B. CPVC
 - C. Black iron
 - D. Copper
55. The solar hot water system (SHW) with the fewest components is:
- A. Direct active open loop
 - B. Indirect drainback
 - C. Indirect pressurized glycol
 - D. ICS
56. Adding a second pump in parallel to the first pump:
- A. Increases flow
 - B. Increases head
 - C. Increases head and flow
 - D. Decreases head, increases flow
57. All of the following are characteristics of a good heat transfer fluid except:
- A. Non-corrosive
 - B. Highly dissolved solids
 - C. Chemically inert
 - D. Low viscosity
58. The most common heat transfer solution used in indirect SHW systems:
- A. Ethylene glycol
 - B. Hydrocarbon oils
 - C. Propylene glycol
 - D. Silicone oils
59. The “brains” of a SHW system:
- A. AC or DC pump
 - B. Hot water heater timer
 - C. Collector and tank sensors
 - D. Differential controller
60. The main components that make a drainback system unique:
- A. Differential controller and expansion tank
 - B. High head pump and reservoir tank
 - C. Exterior heat exchanger and DC pump
 - D. Air elimination valve and check valve
61. The following components can be found in a drainback system except:
- A. Pressure relief valves
 - B. Cast iron pumps
 - C. 33% glycol, 67% water solar loop fluid
 - D. Expansion tanks

62. Which of the following might be used in a drainback AND pressurized glycol system?
- A. Expansion tank
 - B. Air vent
 - C. Flow meter
 - D. Both A and C
63. A drainback system vented to the atmosphere cannot use a pump with a ____??____ impeller.
- A. Stainless steel
 - B. Hi-temp plastic
 - C. Brass
 - D. Cast iron
64. Most heat loss from a swimming pool is due to:
- A. Radiation
 - B. Convection
 - C. Evaporation
 - D. Conduction
65. You have been asked by a client what may be done to further extend her swimming pool season. She already has a functioning, non-shaded, south facing, and 100% ratio collector area to swimming pool surface area system. Your first suggestion would be:
- A. A pool blanket and reel
 - B. More solar collectors
 - C. Wind-break fencing around the pool
 - D. Paint the pool black.
66. If the ambient air temperature in a windy area is consistently 30° F below the pool temperature, the best collector choice is:
- A. Unglazed copper
 - B. Tube and web unglazed polypropylene
 - C. Glazed flat plate
 - D. Loose tube unglazed polypropylene
67. The following types of brackets are useful for non-penetrating attachments on standing-seam metal roofs:
- A. J4
 - B. S-5!
 - C. L brackets
 - D. M-4 connectors
68. The downside to using a copper tube collector on a direct pool system is:
- A. Solar lag
 - B. Bigger pressure drop than with polypropylene
 - C. Acidic pool water will turn pool blue or black
 - D. Promotes bacteria growth

69. Most residential pool heating systems with 2" or smaller pipe use:
- A. Schedule 80 PVC
 - B. Schedule 40 PVC
 - C. Schedule 120 CPVC
 - D. Schedule 20 ABS
70. The best way to safely control the temperature of hot water from the solar tank to the home user is:
- A. Vacation bypass valve
 - B. Check valve
 - C. Anti-scald valve
 - D. Ball valve
71. A required safety device attached to solar hot water tanks is:
- A. Check valve
 - B. Ball valve
 - C. T&P valve
 - D. Expansion tank
72. Insulation should cover all of the following except:
- A. Tees
 - B. Bends
 - C. Pressure relief valves
 - D. Check valves
73. The main differences between anti-scald and mixing or tempering valves are:
- A. Mixing valves cannot be used on SHW systems with natural gas heaters
 - B. Anti-scald valves and mixing valves can be used identically for anti-scald purposes but not tempering valves
 - C. Anti-scald valves respond quickly and rapidly to changes in water pressure unlike mixing or tempering valves
 - D. Anti-scald valves and mixing or tempering valves differ in name only and can be used for the same purpose
74. All of the following are recommended as a protective coating for exterior pipe insulation except:
- A. Aluminum pipe jacket
 - B. Aluminum flashing material
 - C. Duct tape
 - D. Wakaflex
75. The spectrum of sunlight that does the most damage to pipe insulation is:
- A. Visible
 - B. Infrared
 - C. Ultraviolet
 - D. X-ray

76. The lowest temperature a person could be scalded is:
- A. 120° F
 - B. 130° F
 - C. 140° F
 - D. 150° F
77. The type of collector that commonly uses a heat pipe as part of the collector's header is:
- A. Flat plate
 - B. Evacuated tube
 - C. Unglazed
 - D. ICS
78. Which of the following agencies provide certification of solar collectors or systems?
- A. California Energy Office
 - B. National Renewable Energy Lab
 - C. Sandia Lab
 - D. Solar Rating & Certification Corp
79. The following is/are acceptable roof attachment/s when installing SHW collectors:
- A. J or hook bolts
 - B. Lag bolts
 - C. Sheathing bolts
 - D. A & B
80. The requirement unique to open loop Thermosyphon systems is:
- A. Heat exchanger is below the collector
 - B. Tank must be installed in-line with the collector
 - C. Tank must be installed vertically above the collector
 - D. A PV module and DC pump are required
81. Problem: Not enough hot water. Possible cause/s related to the collector:
- A. Partially shaded collector
 - B. Dirty glazing
 - C. Improper collector orientation
 - D. All of the above
82. Problem: Not enough hot water. Possible cause/s related to the pump:
- A. Runs continuously
 - B. Loose wiring
 - C. Air entrapment
 - D. All of the above
83. Problem: Noisy system. Possible solution/s:
- A. Loosen vent screw, bleed air
 - B. Lower vacuum breaker
 - C. Neither A or B
 - D. Both A & B

84. Problem: High electric use. Possible cause/s:
- A. Nighttime thermosiphoning
 - B. Dripping pressure relief valve
 - C. Cold water supply dip tube missing/too short
 - D. Plumbing leak
 - E. All of the above
 - F. A & D only
85. Problem: Indirect drainback does not drain when pump is off. Possible solution/s:
- A. Correct collector loop fluid pH
 - B. Solder leaking roof collector plumbing connection
 - C. Clean or replace vacuum breaker
 - D. All of the above
86. Problem: No hot water in the morning. Possible cause/s:
- A. Malfunctioning check valve
 - B. Sensor wires reversed
 - C. Nighttime thermosiphoning
 - D. All of the above
 - E. None of the above
87. Problem: Controller does not run system “automatically” but will operate in the “manual” mode. Possible cause/s:
- A. Defective or incorrect sensor
 - B. Resistance problem
 - C. Wiring short or open
 - D. All of the above
 - E. None of the above

SHORT ANSWER - LIST. List the three things you care about for protecting a SHW system:

88. _____

89. _____

90. _____

Final Answers

1 – Check	51 - I
2 – Ambient	52 - C
3 – Angle of Incidence	53 - B
4 – Glazing	54 - D
5 – Aperture	55 - D
6 – Auxiliary	56 - A
7 – Azimuth	57 - B
8 – Indirect (or open)	58 - C
9 – Collector (or absorber)	59 - D
10 – Convection	60 - B
11 – Differential Controller	61 - D
12 – Altitude	62 - C
13 – Emissivity	63 - D
14 – Selective Surface (or absorber)	64 - C
15 – Counter Flow	65 - A
16 – Delta T (or ΔT)	66 - C
17 – Expansion Tank	67 - B
18 – Flow Meter	68 - C
19 – Open Loop (or drainback or direct)	69 - A
20 – Galvanic Corrosion	70 - C
21 – Conduction	71 - C
22 – Propylene Glycol (or heat transfer fluid)	72 - C
23 – Hydronic	73 - C
24 – Radiation	74 - C
25 – ASHRAE	75 - C
26 – Sun Path Diagram	76 - A
27 – Thermistor	77 - B
28 – Manifold (or header)	78 - D
29 – Drainback	79 - D
30 – Insolation	80 - C
31 – Sun Path Diagram	81 - D
32 – Thermosiphoning (or convection)	82 - D
33 – Potable	83 - D
34 – Propylene Glycol (or heat transfer fluid)	84 - E
35 – Risers	85 - C
36 – Selective Surface (or absorber)	86 - D
37 – Radiation	87 - D
38 – Stagnation	88 – High Heat
39 – Heat Exchanger	89 – Freezing
40 – Ecliptic	90 – Scaling
41 – B	
42 – A	
43 – A	
44 – D	
45 – A	
46 – D	
47 – C	
48 – D	
49 – D	
50 - A	

Example of one course syllabus used in a full semester, four credit hour (105 clock hour) solar heating class.

COURSE SYLLABUS SOLAR HEATING SYSTEMS

FAVORITE COLLEGE
DD/MM/YYYY

LOCATION: ET-105 LECTURE, ET-123 SOLAR LAB,

CALENDAR: TUESDAY - THURSDAY

MEET TIME: 9:00AM – 12:30PM, Room ET 105
1:00PM – 3:30, Room ET 123

UNITS - 4

FIELD TRIPS: TWO, POSSIBLY THREE

- FIRST: MAJOR FLAT PLATE MANUFACTURER
- SECOND: SOLAR SEMINAR
- THIRD: TBA

INSTRUCTOR: Solar Guru

OFFICE HOURS: TUE: 3:30-4:30PM BY APPOINTMENT, ET-124C
(access from ET-123)

WELCOME

“Solar Heating Systems” focuses on the process, systems, components, and installation of residential solar domestic hot water and swimming pool heating. Learning strategies will include lecture, demonstration, guest speaker, field trip, bench-top, roof-top, and simulation activities. Students will engage in technical print and on-line readings, hands-on/heads-on activities, and related individual and team assignments. Students must expect to and have the ability to climb ladders, work at a height of ten feet off of the ground, operate soldering torches, work in a hot-water environment, work productively both individually and cooperatively in teams, and lift fifty pounds in weight.

REQUIRED TEXTS/DOCUMENTS: (Note: List is 2 years old. Use newer NABCEP, etc).

1. Solar Water Heating--Revised & Expanded Edition: A Comprehensive Guide to Solar Water and Space Heating Systems (Mother Earth News Wiser Living Series) (Paperback), Revised and Expanded, 2010.

2. Solar Water and Pool Heating Manual: Design and Installation & Repair and Maintenance, FSEC-IN-24. Free download at: [PDF] Solar Water and Pool Heating Manual File Format: PDF/Adobe Acrobat - Quick View Pool Heating Manual. Design and Installation. &. Repair and Maintenance. Florida Solar Energy Center. Cocoa, Florida. [HTTP://WWW.FSEC.UCF.EDU](http://www.fsec.ucf.edu). FSEC-IN-24 ... www.fsec.ucf.edu/.../solar.../manual/.../Section_1_Intro_SolarConcepts.pdf - Similar

3. NABCEP Study Guide for Solar Water and Pool Heating System Installers and Sample Questions with Answer Key. North American Board of Certified Energy Practitioners, NABCEP. Free download at: [PDF] <http://www.nabcep.org/wp-content/uploads/2008/11/nabcepstudyguidev4-2april2009.pdf>
Version 4.2 – April 2009. Copies of Version 1.1 – June 2006 distributed in class.

4. Idronics: Solar Thermal Combisystems: A Technical Journal from Caleffi Hydronic Solutions. Free download at: [PDF]: http://www.caleffi.us/caleffi/en_US/Site/Technical_library/Idraulica_magazine/index.sdo
Download item #6, 2009 Solar Thermal Combisystems, Rev 1. Caleffi North America, Inc., 3883 W. Milwaukee Rd., Milwaukee, Wisconsin, 53208.

5. Installation Training Video '09. Free DVD distributed to each student in class. Heliodyne Solar Hot Water, Richmond, California, 2009.

6. Solar Construction Safety. Oregon Solar Energy Industries Association. Developed under grant from Oregon Occupational Safety and Health Division, Department of Consumer and Business Services. 2006. Individual copies available free, on-loan in class. Downloadable copies at www.safety@oseia.org

7. About the California Solar Initiative. (Linked under General Market CSI program). California Public Utilities Commission. <http://www.cpuc.ca.gov/PUC/energy/Solar/>

8. California Solar Initiative Program Handbook. June 2010, posted 6/17/2010. GoSolar California. (Acrobat PDF file, 203 pages, 1.8 MB). <http://www.gosolarcalifornia.ca.gov/> or <http://www.gosolarcalifornia.ca.gov/documents/csi.php>

SUPPLIES/EQUIPMENT

Students are strongly encouraged to individually procure and use:

- Safety glasses/goggles (goggles are often best over prescription glasses)
- “\$10-type” electronic calculator
- Work gloves (aluminum solar collector frames get hot!)
- Three-ring binder, note paper, graph paper, pencils
- Hiking, trekking, boots (think hot roof and ladder climbing)
- Personal water
- Work clothing. Long-sleeved, light-colored work shirt, sun glasses, sun screen
- Access to Internet and email.

Class-use safety glasses, safety harnesses and hard hats are available. Internet access is available for course segments.

DAY-TO-DAY OPERATIONS

- Observe safety procedures at all times.
- Classes begin on-time.
- Attendance and participation are key to student success.
- Breaks and lunch period TBD in class.
- Electronic and paper assignments and quizzes are due as scheduled. Late work is accepted only if prior arrangements have been made to do so.
- Cell radios and other electronic devices must be muted in class.
- All students participate in all class assignments, including set-ups, wrap-ups, and clean-ups.
- Class activities can be altered, often at the last moment, due to weather conditions, guest speaker schedules, and field-trip opportunities.
- All students will be expected to conduct themselves in a business-like manner. This course operates in a tool and materials environment with significant safety concerns. Inappropriate behavior/horseplay will not be tolerated.

PARTICIPATION

This is a very active, classroom and laboratory, individual and group assignment, cannot-miss-a-day learning opportunity requiring students to actively demonstrate individual and team work (small and large group) skills, as well as personal initiative appropriate to a solar thermal curriculum.

QUIZZES

Quizzes must be taken as assigned, and announced in class, at the completion of a course segment. Quizzes are largely written with multiple choice, true/false, and/or write-in items.

SKILL CHECK-OFFS

Students are required to demonstrate proficiency in skill-sets appropriate to solar thermal systems (example: sweating pipe).

MIDTERM EXAMINATION

The midterm must be taken as assigned, and announced in class. The midterm is a written examination consisting largely of multiple choice, true/false, and/or write-in items.

FINAL PROJECT

Each student will design a SRCC OG-300 solar thermal system suited to her/his home (or parent's home, or friends home). Project requirements include: detailed site evaluation, load analysis, system design, component list, and price/cost breakdown.

FINAL EXAMINATION

The final must be taken as assigned, and announced in class. The final is a written examination consisting largely of multiple choice, true/false, and/or write-in items. Many final items will be taken from previous quizzes/midterm.

STUDENT LEARNING OUTCOMES

Solar Heating Systems

This course will cover the theory and application of solar thermal systems. This includes solar water heating for domestic use, radiant floor heating, swimming pools and spas. Additional topics include solar air heating and applications of power concentration.

SLO #1. Identify the different types of solar thermal systems.

SLO #2. Use the different building codes and standards to design solar thermal systems.

SLO #3. Build solar thermal systems.

GRADES

Grades are determined on a competitive basis. Points from all activities are compiled at the end of the course for each student. To receive an "A" the student must accumulate at least 90% of available points; a "B" – 78%; a "C" – 66%; a "D" 55% of the points of the top score.

Participation	30%
Quizzes	10%
Skill Check-offs	15%
Midterm	10%
Final Project	25%
Final Examination	10%

WITHDRAWING FROM THIS COURSE

Students who wish to drop this course must return computer components issued and complete a course withdrawal form at the DVC Admissions Office. Non-attendance will result in a grade of "F". It is the student's responsibility to drop from the course, not the instructor's. Consult the DVC Web Advisor/college bulletin for appropriate withdrawal calendar dates.

Solar Heating Resources

(Note: This list, like all resource lists, should be continually updated and it is provided as a potential resource, not an endorsement. Update this list with your local/regional contacts. Make it yours.)

BOOKS/PERIODICALS

Solar Water Heating: A Comprehensive Guide to Solar Water and Space Heating Systems

By Bob Ramlow and Benjamin Nusz. New Society Publishers (2006), ISBN: 0865715610 (Second edition avail July 2010)

Solar Hot Water Systems: Lessons Learned 1977 to Today

By Tom Lane. Energy Conservation Services (2004)
www.ecs-solar.com
www.newsociety.com

EDUCATION, RESEARCH, AGENCIES, ASSOCIATIONS

American Solar Energy Society, Inc. (ASES)

2400 Central Ave., G-1
Boulder, CO 80301
(303) 443-3130
www.ases.org

New Mexico Solar Energy Association

1009 Bradbury Dr., SE #35
Albuquerque, NM 87106
(505) 246-0400
(888) 886-6765
info@nmsea.org

Database of State Incentives for Renewable Energy

<http://www.dsireusa.org/>

Florida Solar Energy Center

1679 Clearlake Rd.
Cocoa, FL 32922
(407) 638-1000
www.fsec.ucf.edu

Home Power Magazine

<http://www.homepower.com/>

Interstate Renewable Energy Council (IREC)

P.O. Box 1156
Latham, New York 12110-1156
(518) 458-6059

www.irecusa.org

National Renewable Energy Laboratory

1617 Cole Blvd.
Golden, CO 80401
(303) 275-3000
www.nrel.gov

Renew-Ability

Moodle
<http://renew-ability.org/moodle/>

Solar Energy Industries Association (directory of
SRCC ratings)

122 C St. NW, 4th floor
Washington, DC 20001
(202) 383-2600
www.seia.org/cs/home

Solar Energy International

P.O. Box 715
Carbondale, CO 81623
(970) 963-8855
www.solarenergy.org

Solar Living Institute

13771 S. Hwy. 101
P.O. Box 836
Hopland, CA 95449
(707) 744-2017
www.solarliving.org

Solar Rating and Certification Corporation

1679 Clearlake Road
Cocoa, FL 32922-5703
(321) 638-1537
www.solar-rating.org

The American Solar Center

<http://www.azsolarcenter.com/>

**U.S. Department of Energy: Efficiency and
Renewable Energy Clearinghouse**

PO Box 3048
Merrifield, VA 22116
(800) 363-3732
www.eere.energy.gov/RE/solar_hotwater.html

CONTRACTORS/FINANCING

Clean Power Finance

<http://www.cleanpowerfinance.com/>

Find Solar

Solar contractors and cost estimator

www.findsolar.com

EQUIPMENT SUPPLIERS

Caleffi Hydronic Solutions

Radiant Heating

http://www.caleffi.us/caleffi/en_US/index.sdo

Fast Jack™ and Tile Trac™ Racking Systems

<http://www.prosolar.com/>

Heliodyne, Inc.

4910 Seaport Ave

Richmond, CA 94804

510 237-9614

www.heliodyne.com

Pex Supply

Radiant Heating Supplies

Hydronics

<http://www.pexsupply.com/>

Professional Equipment

<http://www.professionalequipment.com/register.asp>

Radiant Panel Association

<http://www.radiantpanelassociation.org/i4a/pages/index.cfm?pageid=471>

Real Goods Solar Inc.

833 W. South Boulder Rd.

Louisville, CO 80027

(800) 919-2400

www.realgoods.com

Watts

Water Safety and Flow Control Supplies

https://www.watts.com/pages/_products_sub.asp?catId=64&parCat=2238

SOLAR HEATING PROGRAM

PUBLICATIONS, EQUIPMENT, TOOLS, AND SUPPLIES REQUIRED*

The following equipment and tool lists are provided in the spirit of supporting solar heating programs to grow. This list would be a great starting place for program designers building a full semester course with 25 students enrolled. Designers developing a shorter duration, focused course, such as a 48 hour NABCEP entry-level preparation course with 10 to 15 students, may be able to offer an honest program with fewer resources (example: fewer complete SH systems).

Equipment, tools and supplies should be justified by course objectives:

1. Working Safely with Solar Thermal Systems 5%
2. Identifying Systems and Their Components 8%
3. Adapting a System Design 10%
4. Conducting a Site Assessment 5%
5. Installing Solar Collectors 10%
6. Installing Water Heater and Storage Tanks 10%
7. Installing Piping, Pipe Insulation and Connecting System Piping 10%
8. Installing Mechanical/Plumbing Equipment and Other Components 10%
9. Installing Electrical Control Systems 10%
10. Installing Operation and Identification Tags and Labels 2%
11. Performing a System Checkout 10%
12. Maintaining and Troubleshooting a Solar Thermal System 10%

*Organizational tool used to identify equipment, tools, and supplies required in solar thermal program. (NABCEP Study Guide for Solar Water and Pool Heating System Installers).

SOLAR HEATING LIBRARY

SOLAR THERMAL REFERENCES AND RESOURCES

Instruction and training materials, regulations, and codes and standards associated with the design and installation of solar thermal systems references

1. Solar Water and Pool Heating Manual, Design and Installation & Repair and Maintenance, January, 2006. Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL 32922-5703. www.fsec.usc.edu
2. 2005 Code of Federal Regulations, Chapter 29 Part 1926 Safety and Health Regulations for Construction. U.S. Department of Labor/OSHA, OSHA Publications, P.O. Box 37535, Washington, D.C. 20013-7535. <http://www.osha.gov>
3. SRCC Document OG 300, Operating Guidelines and Minimum Standards for Certifying Solar Water Heating Systems, May 2002, Solar Rating and Certification Corporation. <http://www.solar-rating.org/>
4. The Copper Tube Handbook, Copper Development Association, 260 Madison Avenue, New York, NY 10016. www.copper.org
5. Residential Solar Water Heater with Heat Exchanger. Provided by solar water heater manufacturers upon purchase of the unit. The manual may be downloaded from the NABCEP website at www.nabcep.org
6. Uniform Plumbing Code, 2006. International Association of Plumbing & Mechanical Officials, 5001 East Philadelphia Street, Ontario, CA 91761-2816. <http://www.iapmo.org>
7. Planning and Installing Solar Thermal Systems: A guide for installers, architects and engineers. James & James (Science Publishers) Ltd. www.earthscan.co.uk .
8. Solar Thermal Systems, Successful Planning and Construction. Felix A. Peuser, Karl-Heinz Remmers, Martin Schnauss. Solarpraxis, published by James & James (Science Publishers) Ltd. www.earthscan.co.uk .
9. Solar Water Heating: A Comprehensive Guide to Solar Water and Space Heating Systems, by Bob Ramlow with Benjamin Nusz. Published by New Society Publishers. www.newsociety.com .
10. Solar Hot Water Systems Lessons Learned 1977 to Today, 2004. Tom Lane Energy Conservation Services, 6120 SW 13th Street, Gainesville, FL 32608 http://www.ecs-solar.com/lessons_learned.htm
11. Roofing Construction and Estimating, Daniel Atcheson, Craftsman Book Co., 6058 Corte Del Cedro, P.O. Box 6500, Carlsbad, CA 92018 <http://craftsman->

book.com/products/index.php?main_page=cbc_product_book_info&products_id=147Energy Conservation Services, Note: The National Roofing Contractors Association's Roofing and Waterproofing Manual, 5th Edition is a good resource for those replacing a current roof surface.

12. OSHA Regulations

Chapter 29 of the U.S. Code of Federal Regulations, Part 1926, Safety and Health Regulations for Construction. Part 1926 consists of 26 subparts, labeled from A to Z. OSHA rules most relevant to solar installations include

Subpart D - Occupational Health and Environmental Controls

Subpart E – Personal Protective and Life Saving Equipment

Subpart P – Tools, Hand, and Portable Power Tools

Subpart Q – Welding, Cutting, Brazing

SOLAR HEATING OUTDOOR ROOF SIMULATION LABORATORY

Example: An outdoor solar thermal roof laboratory offers a true-to-life experience. The structure is sixty feet long, sixteen feet deep, stands seven feet above ground on the low side, with a slope of 5/12. The entire roof slopes to the South (180° magnetic), and is roofed with a variety of roofing materials.

- | | |
|--------------------------|---|
| 1. OSHA Fall Protection | 2 Warning line systems (Flag Line)
20 Guard Rail Post
2 End Rail
20 Rail Receiver
40 Toe Board Clip
Toe boards
25 Safety harnesses Kits |
| 2. Portable Scaffolding: | 2- 1000 LB Capacity: 6' X 6' |
| 3. Head protection: | 30 Hard hats |
| 4. Ladders | 2 – 14' Straight
2 - 8' Step
2 – Standoffs
1 - Lift |
| 5. Line | 5 - 25'-3/8" Life Line (6500lb) |
| 6. Extension cords | 3 - (100'-12/3 outdoor) |

SOLAR HEATING TOOLS/EQUIPMENT SUPPLIED BY PROGRAM

EQUIPMENT/TOOLS/SUPPLIES REQUIRED BY INDIVIDUAL STUDENTS/STUDENT TEAMS TO MEET PROGRAM OBJECTIVES

How many of each tool do we need? Consider that your students will be grouped during installation activities in “crews”. Each crew needs a tool bag with a hammer, a pipe cutter, etc. It’s a good idea to have at least one each of infrequently used tools in solar heating, such as an ammeter, per class. Consult with the solar heating instructor and class activity/objective sheet.

HAND TOOLS

- 3-foot level
- PVC pipe cutter
- Copper pipe cutter
- Framing square
- Roofing bar (Fubar)
- Handy bar
- Slap hammer
- Aviation Snips (S-L-R set)
- Wire stripper/crimper
- Hand saw
- Hack saw
- Crescent wrench set
- Flare nut wrenches
- Combo end wrench set
- Allen wrench set
- Socket set

TEST EQUIPMENT

- Pocket thermometer
- Multimeter
- Clamp Ammeter
- Pressure and flow rate gauge
- Vacuum gauge
- Pitch level

ASSEMBLY/CONSTRUCTION EQUIPMENT

- Drill motor
- Drill index
- Propane (or MAP) torch (self/piezo lighting)
- Wire brush
- Acetylene torch
- Brazing goggles

Soldering station (non flammable table/surface)

HEALTH/SAFETY EQUIPMENT

Face masks
Respirators (attic safety, demo only)
Lens cleaning station
Eye wash station
First aid station
Fire extinguishers

SUPPLIES AND CONSUMABLES

Flexible tubing assortment, clamps
PVC pipe and fittings assortment
 PVC cleaner
 PVC solvent
 PVC adhesive
Copper pipe and fittings assortment
 Flux
 Solder
Roof penetration sealant
Duck tape

SUN PATH FINDER

Pathfinder
Software

INSTRUCTOR (CLASS) DEMONSTRATIONS

EQUIPMENT/TOOLS/SUPPLIES REQUIRED TO PROVIDE CLASS DEMONSTRATIONS OF PROGRAM SYSTEMS AND PROCESSES

LABORATORY DEMONSTRATION EQUIPMENT

Control systems

- Differential
- Photovoltaic
- Timers

Pumps

- AC
- DC
- PV panel to run DC pump

Pipe

- PVC pipe
- PVC fitting assortment
- Copper pipe
- Copper fitting assortment
- Copper flexible tubing
- Flex connectors
- Pipe hangers (asst)

Valves/Gauges/Breakers

- Common P/T valves
- Common P/T gauges
- Safety valves
- Vacuum breaker
- Check valves
- Air vents
- Freeze protection mechanisms
- Integrated check valves
- Pressure relief valves
- Temperature relief valves
- Isolation, cut-off and drain valves
- Non contact thermometer

Meters

- Pressure and flow rate gauge
- Ph test kit
- Glycol test kit
- DC power supply

Collectors/Systems/Heat Exchangers

- Swimming pool system
- Closed loop system
- Open loop system
- Thermosyphon system
- Drainback system
- Radiant heating system

Insulation

- Insulation examples
- Tank insulating blanket

Tanks

- Storage tank
- Drainback tank
- Expansion tank
- Expansion tank, bladder type
- Thermosiphon tank
- Conventional electric water heater
- Conventional natural gas water heater
- Storage vault (construction materials)

Mounting/Installation/System Charging

- Various manufacturer mounting design and mounting hardware
- Flashing and sealing components and materials
- Collector mounting brackets, hardware
- Roof standoffs, vents, flashings
- Strain relief hardware
- Wire chaffing material
- Heat transfer fluids
- Tags/labels (for certified systems)

SOLAR THERMAL TOOLS/EQUIPMENT SUPPLIED BY STUDENT

(Potential for industry sponsored tool kit scholarships?)

- Eye protection (goggles)
- Gloves
- 25' measuring tape
- Pencils, marking pens, chalk
- Utility pouch
- 16oz claw hammer
- Screwdriver set
- Flat pry bar
- Knee pads
- Square
- Mini (torpedo) level
- Pliers set