Better Buildings Require A Better Workforce

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Building Technologies Office

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Pacific Northwest National Laboratory
Why Building Science Education

Starting a New Future...

Building America Building Science Education Summit

Building America Building Science Education Roadmap
April 2013

DOE Challenge Home Student Competition
April 2013
DOE Building Science Ed. Program

Framework for Consistent Building Science Competency for all Workforce Classifications

DOE Guidelines for Building Science Education

Building Science Fully Integrated in Professional Degree Programs

DOE ‘Race to Zero’ Student Design Competition

Building Science Fully Understood and Valued in the Market

Building America Building Science Translator
GBSE Implementation Strategy

1. ACKNOWLEDGE KNOWLEDGE GAP
2. BUILD KNOWLEDGE FRAMEWORK
3. ENGAGE COLLECTIVE IMPACT
Access to well-trained trades and professionals is a barrier to wide-scale market transformation for high performance buildings.
Builder Challenges*:

- Limited access to skilled trade partners
- Lack of code official’s familiarity with new techniques and products
- Inconsistent quality control for building ratings
- Lack of value recognition with appraisals

* Source: DOE Zero Energy Ready Home Production Builders Roundtable, November 2014
A consistent framework embraced by all stakeholders is needed to deliver consistent building science competency.
Developed with dozens of industry professionals and professors over multiple expert meetings
## Workforce Classifications

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<td>Insurers</td>
<td>Civil/Struc.</td>
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## Building Science Skills

<table>
<thead>
<tr>
<th>1 Integration of Whole-Bldg. Sys.</th>
<th>2 Building Science Principles</th>
<th>3 Operations &amp; Maintenance</th>
<th>4 Building Testing</th>
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</thead>
<tbody>
<tr>
<td>1.1 Performance</td>
<td>2.1 Heat Transfer</td>
<td>3.1 User Interface/Cont.</td>
<td>4.1 Commissioning</td>
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<td>1.2 Life-Cycle Cost Eff.</td>
<td>2.2 Material Selection</td>
<td>3.2 Preventative Maint.</td>
<td>4.2 Diag. &amp; Forensics</td>
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<td>1.3 Disaster Resistance</td>
<td>2.3 Moisture Transport</td>
<td>3.3 Replacement/Renov.</td>
<td>4.3 Perf. Mon./Assess.</td>
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<td>1.4 Int. Design &amp; Const.</td>
<td>2.4 Control Layers</td>
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<td>4.4 Ntl. Codes &amp; Stds</td>
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<td>1.5 Quality Management</td>
<td>2.5 Convective Transprt.</td>
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<td>4.5 Cert. Programs</td>
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<td>1.6 Bldg/Energy Model’g</td>
<td>2.6 Hygrothermal Anal.</td>
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<td>1.7 Cost Trade-Off Anal.</td>
<td>2.7 HVAC Systems</td>
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<td>2.8 HVAC Inter. w/Struc.</td>
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<td>2.9 Fenestration</td>
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<td>2.10 Plumbing Systems</td>
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<td>2.11 Electrical Systems</td>
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<td>2.12 Lgting &amp; Appliances</td>
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<td>2.13 Indoor Air Quality</td>
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<td>2.14 Control/Automation</td>
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Consistent Framework – Proficiency Levels

Building Science Proficiency Based on Blooms Taxonomy

<table>
<thead>
<tr>
<th>Level</th>
<th>Proficiency</th>
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<tbody>
<tr>
<td>1</td>
<td>Remember (Knowledge)</td>
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<tr>
<td>2</td>
<td>Understand (Comprehension)</td>
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<td>3</td>
<td>Apply (Application)</td>
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<td>4</td>
<td>Analyze (Analysis)</td>
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<td>5</td>
<td>Evaluate (Synthesis)</td>
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<tr>
<td>6</td>
<td>Create (Design)</td>
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</table>
## Consistent Framework - Building Science Education Matrix

### JOB CLASSIFICATIONS

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<tbody>
<tr>
<td>c. Disaster resistance/resilience</td>
<td>c. Convective mass (air) transport (pressure/flow)</td>
<td>c. Replacement &amp; renovation</td>
<td>c. Performance monitoring/assessment</td>
</tr>
<tr>
<td>d. Systems integration and optimization</td>
<td>d. Material selection (E ticking, thermal/mass, moisture)</td>
<td>d. Indoor environmental quality (thermal comfort, health)</td>
<td>d. National codes and standards</td>
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<tr>
<td>e. Integrated design and construction</td>
<td>e. Control layers (water, air, vapor, thermal, solar)</td>
<td>e. Control/Automation systems</td>
<td>e. Certification programs</td>
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</tbody>
</table>

### Building Science Principles

<table>
<thead>
<tr>
<th>a. Heating, cooling, ventilation, dehumidification</th>
<th>b. HVAC systems (heating, cooling, ventilation, dehumidification)</th>
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</thead>
<tbody>
<tr>
<td>c. HVAC interactions with enclosure</td>
<td>d. Fan performance</td>
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</tbody>
</table>

### Operations and Maintenance

<table>
<thead>
<tr>
<th>a. User interface and controls</th>
<th>b. Preventative maintenance</th>
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<tbody>
<tr>
<td>c. Replacement &amp; renovation</td>
<td>d. Indoor environmental quality (thermal comfort, health)</td>
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</table>

### Building Testing

<table>
<thead>
<tr>
<th>a. Commissioning</th>
<th>b. Diagnostics &amp; Forensics</th>
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<tr>
<td>e. Certification programs</td>
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</table>
### Consistent Framework - Building Science Education Matrix

#### BSE Guideline

A matrix of proficiency levels for each job classification.

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<tbody>
<tr>
<td></td>
<td>a. Simultaneous consideration of energy, durability, comfort</td>
<td>b. Life cycle cost-effectiveness analysis</td>
<td>c. Disaster resistance/resiliency</td>
<td>a. Commissioning</td>
</tr>
<tr>
<td></td>
<td>b. Life cycle cost-effectiveness analysis</td>
<td>c. Disaster resistance/resiliency</td>
<td>e. Integrated design and construction</td>
<td>b. Diagnostics &amp; forensics</td>
</tr>
<tr>
<td></td>
<td>d. Integrated design and construction</td>
<td>e. Quality management</td>
<td>g. Building and energy modeling</td>
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<td></td>
<td>e. Quality management</td>
<td>f. Building and energy modeling</td>
<td>g. Cost trade-off analysis</td>
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<tr>
<td></td>
<td>f. Building and energy modeling</td>
<td>g. Cost trade-off analysis</td>
<td>h. Cost trade-off analysis</td>
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</tr>
<tr>
<td>1. Integration of the Whole-Building System</td>
<td>1</td>
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<tr>
<td>2. Building Science Principles</td>
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<tr>
<td>3. Operations and Maintenance</td>
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<tr>
<td>4. Building Testing</td>
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</tbody>
</table>
Building Science Education Guidelines for Performance Assessor

A summary of the proficiency levels for the core competencies are displayed in the graphic below. For each core competency level described in this checklist, it is assumed that the organization or student is proficient in the level described, as well as all the cognitive levels below that level.

### Average Performance Assessor Proficiency Levels

<table>
<thead>
<tr>
<th>Integration of the Whole-Building System</th>
<th>Building Science Principles</th>
<th>Operations and Maintenance</th>
<th>Building Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
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</tbody>
</table>

As the entity responsible for managing home energy certifiers, a performance assessor who writes energy assessments/recommendation reports, and conducts energy modeling should be proficient in the following categories:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Proficiency Level</th>
<th>Checkbox</th>
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</thead>
<tbody>
<tr>
<td>Building science principles related to the enclosure</td>
<td>Average = 5</td>
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<tr>
<td>Heat transfer (convection, conduction and radiation)</td>
<td>5</td>
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<tr>
<td>Moisture transport of liquid</td>
<td>5</td>
<td></td>
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<tr>
<td>Convective air transport due to pressure differences</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Material selection (IAQ, thermal mass, moisture)</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Controls layers (heat, vapor, water, air and solar gain)</td>
<td>5</td>
<td></td>
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<tr>
<td>Hygrothermal analysis</td>
<td>5</td>
<td></td>
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<tr>
<td>HVAC interactions with the enclosure</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>HVAC systems (heating, cooling and ventilation)</td>
<td>4</td>
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<tr>
<td>Penetration considerations</td>
<td>5</td>
<td></td>
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<tr>
<td>Plumbing systems (heating, distribution, conservation)</td>
<td>4</td>
<td></td>
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<tr>
<td>Electrical systems</td>
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<tr>
<td>Lighting appliances and miscellaneous loads</td>
<td>4</td>
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<tr>
<td>Indoor environmental quality (uniform temp. &amp; indoor pollutants)</td>
<td>4</td>
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<tr>
<td>Control automation systems</td>
<td>4</td>
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<tr>
<td>Operations and maintenance</td>
<td>Average = 4</td>
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<tr>
<td>User controls (e.g. thermostat)</td>
<td>4</td>
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<tr>
<td>Preventative maintenance (e.g. cleaning air filters)</td>
<td>4</td>
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<tr>
<td>Determination of appropriate replacement choices</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Building testing and certification</td>
<td>Average = 4</td>
<td></td>
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<tr>
<td>Commissioning</td>
<td>5</td>
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<tr>
<td>Diagnostics and forensics</td>
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<tr>
<td>Monitoring</td>
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<tr>
<td>National codes and standards</td>
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<tr>
<td>Certification programs</td>
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</table>

The ____________________________ performance assessment certification body has incorporated all of the relevant information in the above checklist into their training materials.

Signature _____________________
Audience:
• Trainers
• Professors

Consistent Content:
• Learning Objectives
• Lecture Notes/Handouts
• Demonstrations
• Exam Q+A

Application:
• Required Curriculum
• Textbooks
• Classes/Presentations
## Database of Education Resources – BSE Solution Center Concept

### Skills

<table>
<thead>
<tr>
<th>Proficiency</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
</table>

1. **Integration of Whole-Building System**
   - 1.1: Performance: Energy, Durability, Comfort, IAQ
   - 1.2: Life-Cycle Cost-Effectiveness Analysis
   - 1.3: Disaster Resistance/Resiliency
   - 1.4: Integrated Design and Construction
   - 1.5: Quality Management
   - 1.6: Building and Energy Modeling
   - 1.7: Cost Trade-Off Analysis

2. **Building Science Principles**
   - 2.1: Heat Transfer (Conduction, Radiation, Convection)
   - 2.2: Moisture Transport (Liquid, Vapor, Psychrometrics)
   - 2.3: Convective Mass (air) Transport (Pressure/Flow)
   - 2.4: Material Selection (IAQ, Thermal Mass, Moisture)
   - 2.5: Control Layers (Thermal, Vapor, Water, Air, Solar Gain)
   - 2.6: Hygrothermal Analysis
   - 2.7: HVAC Systems (Heating, Cooling, and Ventilation)
   - 2.8: HVAC Interactions with Enclosure
   - 2.9: Fenestration
   - 2.10: Plumbing Systems (Heating, Distribution, Conservation)
   - 2.11: Electrical Systems
   - 2.12: Lighting/Appliances and Miscellaneous Loads
   - 2.13: Indoor Envir. Quality (Thermal Comfort, Health, Safety)
   - 2.14: Control/Automation Systems

3. **Operation & Maint.**
   - 3.1: User Interface and Controls
   - 3.2: Preventive Maintenance
   - 3.3: Replacement and Renovation

4. **Building Testing**
   - 4.1: Commissioning
   - 4.2: Diagnostics and Forensics
   - 4.3: Performance Monitoring/Assessment

---

**Level 1:** Identify and state the units for: heat flux, heat rate, thermal conductivity, temperature gradient, emissivity, heat transfer coefficient

**Level 2:** Define key terms including conduction, convection, radiation, energy, steady state.

**Level 3:** Calculate heat transport, conductivity, area or temperature difference through a solid using Fourier’s law.

**Level 4:** Draw a heat transfer diagram that shows each mode of heat transfer in context with the geometry.

**Level 5:** Determine the mode of heat transfer most important or likely to occur in a system if given information about the substances/processes involved.

**Level 6:** Design an integrated hybrid thermal envelope.

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**2. Building Science Principles - 2.1 Heat Transfer**
### Skills

<table>
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<th>Proficiency</th>
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<th>3</th>
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<td>1.4: Integrated Design and Construction</td>
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<td>1.5: Quality Management</td>
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<td>1.6: Building and Energy Modeling</td>
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<td>1.7: Cost Trade-Off Analysis</td>
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<td>2.3: Convective Mass (air) Transport (Pressure/Flow)</td>
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<td>2.4: Material Selection (IAQ, Thermal Mass, Moisture)</td>
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<td>2.5: Control Layers (Thermal, Vapor, Water, Air, Solar Gain)</td>
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<td>2.6: Hygrothermal Analysis</td>
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<td>2.7: HVAC Systems (Heating, Cooling, and Ventilation)</td>
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<td>2.8: HVAC Interactions with Enclosure</td>
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<td>2.9: Fenestration</td>
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<td>2.13: Indoor Envir. Quality (Thermal Comfort, Health, Safety)</td>
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<td><strong>Operation &amp; Maint.</strong></td>
<td>3.1: User Interface and Controls</td>
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<td>3.2: Preventive Maintenance</td>
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<td>3.3: Replacement and Renovation</td>
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<td><strong>Building Testing</strong></td>
<td>4.1: Commissioning</td>
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<td>4.2: Diagnostics and Forensics</td>
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<td>4.3: Performance Monitoring/Assessment</td>
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</table>
Job Classification
Click on the image above to find content organized by job classification. Examples include mechanical engineer, appraiser, home performance contractor, code official and many more!

READ MORE

The Building Science Education Solution Center provides complete, accurate training material and curriculum for a full range of building-related professions. New to the BSE Solution Center? Visit our webinar for detailed information and a tour of the BSE Solution Center.

As a community-driven tool, we welcome your comments on how to continuously improve the Solution Center. Educators and professors should register to unlock assessment questions and practice problems.
BUILDING SCIENCE EDUCATION SOLUTION CENTER

Job Classifications

Click on the component for a list of corresponding component subcategories. Select on subcategory to display a list of related Guides.

- DESIGN & CONSTRUCTION PROFESSIONALS
  - Architect
  - Mechanical Engineer
  - Civil Engineer
  - Landscape Architect
  - Material Science Engineer

- TRANSACTION PROFESSIONALS
- CODE OFFICIALS
- PROGRAM MANAGERS
- HOMEOWNERS

K-12 SCHOOLS
BUILDING SCIENCE EDUCATION SOLUTION CENTER

Mechanical Engineer Checklist

- Design - Create unique plans, alternatives related to:
  - Heat transfer
  - HVAC interactions with the enclosure
  - User controls
  - Determination of appropriate replacement choices
  - Commissioning
  - Monitoring

- Evaluation - Identify solutions to problems using past evidence to support actions related to:
  - Simultaneous consideration of energy, durability, comfort and IAQ

- Analysis - Identify causes of problems using past evidence to support actions related to:

- Application - Apply knowledge in familiar situations to solve problems related to:
Heat Transfer - Synthesis

Heat transfer is defined as the transfer of thermal energy due to a spatial temperature difference. Heat transfer may occur due to three different modes (conduction, convection, and radiation) depending on the physical system.

Most systems in buildings actually experience a combination of all three forms of heat transfer, and other energy flows. To analyze a system with multi-mode heat transfer we use conservation of energy. In a general form, conservation of energy is simply accounting for energy into a control volume and energy out of a control volume.

For a system we represent each type of heat transfer \( q \) as energy \( E \) in or out the system and include any energy generated \( (E_g) \) by the system. Any energy stored by the system \( (\Delta E_{st}) \) is also accounted for, but is often negligible in a steady state system. The result is a simplified form of conservation of energy that is useful for solving heat transfer problems.

\[
E_{in} - E_{out} + E_g = \Delta E_{st}
\]

### Learning Objectives

1. Identify and state the units for: heat flux, heat rate, thermal conductivity, temperature gradient, emissivity, heat transfer coefficient.
2. Define key terms including conduction, convection, radiation, energy, steady state.
3. Write Fourier’s law, Newton’s law of cooling, and the Stefan Boltzmann law with appropriate assumptions and temperatures for a given problem.
4. Write and simplify conservation of energy to model heat transfer processes.
5. Calculate heat transport, conductivity, area or temperature difference through a solid using Fourier’s law.
6. Calculate heat transport, area, or heat transfer coefficient using Newton’s law of cooling.
7. Calculate heat transport, emissivity, or temperatures due to radiation using the Stephan Boltzmann law.
8. Draw a heat transfer diagram that shows each mode of heat transfer in context with the geometry.
Heat Transfer - Synthesis

Heat transfer is defined as the transfer of thermal energy due to a spatial temperature difference. Heat transfer may occur due to three different modes (conduction, convection, and radiation) depending on the physical system.

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For a system we represent each type of heat transfer ($q$) as energy ($E$) in or out the system and include any energy generated ($E_g$) by the system. Any energy stored by the system ($\Delta E_{st}$) is also accounted for, but is often negligible in a steady state system. The result is a simplified form of conservation of energy that is useful for solving heat transfer problems.

$$E_{in} - E_{out} + E_g = \Delta E_{st}$$

Learning Objectives | Teaching Materials | Problem Sets | Exams/Assessments
--- | --- | --- | ---
Lecture Notes
Handout 1 - Thermal Metric Hot Box Apparatus (BSC)
Handout 2 - Problem Set (Synthesis)
Handout 3 - Exam Set (Synthesis)
Video 1 - Misconceptions About Temperature
Video 2 - Chocolate Bunny Destroyed with Conduction, Convection, then Radiation

Additional References:
Heat Transfer - Synthesis

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$$E_{in} - E_{out} + E_g = \Delta E_{st}$$

### Learning Objectives
1) Objectives: Determine the mode of heat transfer most important or most likely to occur in a system if given information about the substances/processes involved. Draw a heat transfer diagram that shows each mode of heat transfer in context with the geometry.

   The thermos shown below is used to store hot coffee at 100°C. The thermos is constructed of two thin aluminum shells.
   a) Draw and label the heat transfer flows for the system using the arrow system discussed. Make sure each arrow show the correct direction of heat transfer (hot to cold).
   b) What do you believe will be the most important heat transfer mechanisms? Why?
   c) How would you improve the design of the thermos?

2) Objectives: Calculate heat transport, conductivity, area or temperature difference through a solid using Fourier’s law.

   The inner and outer surfaces of a 5 m x 6 m brick wall of thickness 30 cm and thermal conductivity 0.69 W/m-K are maintained at temperatures of 20°C and 50°C respectively.
   a) Sketch the system and include arrows for each mode of heat transfer.
   b) Determine the rate of heat transfer through the wall, in W.
Heat Transfer - Synthesis

Heat transfer is defined as the transfer of thermal energy due to a spatial temperature difference. Heat transfer may occur due to three different modes (conduction, convection, and radiation) depending on the physical system.

Most systems in buildings actually experience a combination of all three forms of heat transfer, and other energy flows. To analyze a system with multi-mode heat transfer we use conservation of energy. In a general form, conservation of energy is simply accounting for energy into a control volume and energy out of a control volume.

For a system we represent each type of heat transfer (q) as energy (E) in or out the system and include any energy generated (Eg) by the system. Any energy stored by the system (∆E_st) is also accounted for, but is often negligible in a steady state system. The result is a simplified form of conservation of energy that is useful for solving heat transfer problems.

\[ E_{\text{in}} - E_{\text{out}} + E_g = ∆E_{\text{st}} \]

<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Teaching Materials</th>
<th>Problem Sets</th>
<th>Exams/Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Calculate heat transport, conductivity, area or temperature difference through a solid using Fourier’s law. Consider steady-state conditions for one-dimensional conduction in a plane wall having a thermal conductivity ( k = 20 \text{W/mK} ) and a thickness ( L = 0.25 \text{m} ), with no internal heat generation. Determine the unknown quantity for each variation in this problem.</td>
<td></td>
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</tr>
<tr>
<td>a) ( T_1 = 0 \text{C}, T_2 = 25 \text{C} )</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>b) ( T_1 = 25 \text{C}, \frac{dT}{dx} = -80 \text{K/m} )</td>
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<tr>
<td>2) Consider a flat metal plate with dimensions and conductivity shown. The bottom of the plate is insulated, but a very thin strip heater below the plate with power ( 1670 \text{W/m}^2 ) is used to warm the plate so ( T_1 = 98.75 \text{C} ). Air in the room with ( T_1 = 20 \text{C} ) cools the top of the plate. The temperature of the surroundings are also assumed to be ( 20 \text{ C} ).</td>
<td></td>
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</tr>
<tr>
<td>a) Sketch a heat transfer diagram for the system</td>
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<tr>
<td>b) Draw the control volume needed to solve for the heat transfer coefficient in the air, and write the conservation of energy for the system.</td>
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<tr>
<td>c) Solve for the heat transfer coefficient in the air. Show as much detail as possible.</td>
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<tr>
<td>d) Is radiation or convection more important in the cooling of the plate?</td>
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</tr>
</tbody>
</table>
The commitment of a group of important actors from different sectors to a common agenda for solving a specific social problem.

“Collective Impact” by John Kania and Mark Kramer
Partnering Mechanism – Align with Complementary Programs

Trade Associations
- Licensing Exams
- Continuing Education

Universities
- Existing curriculum infusion
- New classes
- Structured minor
- State Licensing Exams

General Public
- High School Textbooks
Silver Level Partnerships
• MOUs
• Guideline Integrated with One Class

Gold Level
• MOUs
• Guideline Integrated with > 3 Classes

Platinum Level
• MOUs
• Guidelines Fully Integrated
• Self-Certified Program
• New Minor or Focus Program Area

What Does Success Look Like?
MOU’s Signed
- The Appraisal Foundation
- University of Portland
- University of Minnesota
- EEBA

MOU’s in Progress
- Virginia Tech
- RESNET
- AIA
How do the Guidelines for Building Science Education Compare to the Workforce Guidelines?
Goals:

- Better Building Performance
- Better Workforce Credentials
- Better Workforce Knowledge

Collective Impact Process:

- Industry Involvement
- Extensive Stakeholder Input
- Partnering with Education Programs
- Aligning with other Private and Federal Efforts
- Adoption of Guidelines by Education Programs
Differences

Workforce Guidelines

Framework
- 4 Specific Residential Workforce Classifications

Means
- Specific Tasks

End Goal
- Specific Knowledge, Skills & Abilities Related to Those Tasks

Guidelines for Building Science Education

Framework
- Full Spectrum of Residential & Commercial Workforce Classifications

Means
- Broad Building Science Knowledge & Skills

End Goal
- Workforce Prepared to Integrate Building Science
DOE Building Science Ed. Program

Framework for Consistent Building Science Competency for all Workforce Classifications

DOE Guidelines for Building Science Education

Building Science Fully Integrated in Professional Degree Programs

DOE ‘Race to Zero’ Student Design Competition

Building Science Fully Understood and Valued in the Market

Building America Building Science Translator
Engage college students across the U.S. to integrate building science in design projects so they are better prepared for the future... zero energy buildings.
Annual competition

Teams sponsored by a collegiate institution

At least three students and a faculty advisor

Multidisciplinary team with industry advisor(s)

Options:
- Single-Family Urban
- Single-Family Suburban
- Low-Rise Multi-Family
- Affordable Housing

Design target is DOE Zero Energy Ready Home
• Two-Day Building Science Course
• Demonstrate integration of building science principles (Analyses, Sections, Details)
• Constructions solutions practical from a mainstream builder’s perspective
• Cost-effective from the buyer’s perspective (P-I-T-I-U-M)
DOE Race to Zero Student Design Competition

2016 Schedule

• **September 3, 2015:** Registration Opens

• **November 2, 2015:** Registration Deadline

• **November 19, 2015:** DOE Invites up to 40 Teams

• **March 24, 2016:** Submittals Due

• **April 16-17, 2016:** Judging, Awards and Career Connections @ NREL
DOE Race to Zero Student Design Competition

2014 Teams

- 300+ Students
- 26 Universities
- 28 Teams
DOE Race to Zero Student Design Competition
2015 Teams

- 300+ Students
- 27 Universities
- 33 Teams
DOE Challenge Home Student Design Competition

The Setting
DOE Challenge Home Student Design Competition
The Anticipation
DOE Challenge Home Student Design Competition
The Shark Tank
DOE Challenge Home Student Design Competition
The Networking
DOE Challenge Home Student Design Competition

The Learning
DOE Challenge Home Student Design Competition
The Giving it Back to Jurors
DOE Challenge Home Student Design Competition
The Inspiration
DOE Challenge Home Student Design Competition
The Winner – University of MN
Detailed attention to maintain critical **control layers** for all enclosure components

- Continuous **air and water** management system
  - Orange: W.R. Grace Perm-a-Barrier
  - Red: Huber ZIP sheathing system
  - Blue: Foundation waterproofing
  - Purple: Cross-laminated polyethylene membrane

- Optimal **thermal** insulation with minimal thermal bridging

- Deliberate **vapor** control strategy to limit wetting and enhance drying
Maximum southern exposure allows for optimal energy generation

**Total Area = 735 SF**

**Inclination angle = 28.4°**

**Azimuth angle = 180°**
DOE Challenge Home Student Design Competition
Areas for Improvement

Area for Improvement:
• Judging Process
• Alignment with Schedules
• Fit Within Weekend

Planned Improvement:
• More Defined Template
• Simpler Scoring
• Earlier Registration
• Compressed Schedule
High Impact:
• Change Skills
• Change Curriculum
• Change Program Isolation
• Change Lives

Low Cost:
~$450K/competition
Thank you!

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