Where: WEB 1460  
When: Tues/Thurs 12:25 - 13:45

Office Hours: Wednesdays 1:30-2:30pm in MEB 2256

Textbook: Class notes, reading material & online resources will be provided.

http://lons.utah.edu/
Optics (Science & engineering of light) applied to efficient Generation & Utilization of energy

Learning Objectives

* Learn the fundamentals of optical design & engineering

* Apply our knowledge to innovate (create new ideas that are practical, high impact & commercializable)

* Be aware of emerging technologies over the horizon
Topics of interest

Optical Design (non-imaging optics)

Thermodynamics of solar-thermal & photovoltaic devices

Novel approaches to light management in photovoltaic devices

Emerging areas of relevant technology
Grading

30% Mid-term exam on October 3 in class

Team-based projects

40% Four team presentations in class [First one on September 24]

30% Team submission to CU Cleantech new business challenge [Due December 13]

Tentative Schedule

[Details not visible]
Tentative Schedule

http://lons.utah.edu/
Projects

Teams assigned by me

Project topics

Project Deliverables

Team presentations

National Clean Energy Business Plan Competition
Project Topics

- solar cooker
- solar water pasteurization
- solar water desalination
- solar refrigeration
- Daylighting
- solar water-heating
- Photovoltaics

Cost
Durability
Storage (space requirements)
Cultural factors
Ease of use
Climate conditions

Others (you propose).
4 Project Presentations (10% each)

Literature Review; Discuss pros, cons, comparisons, overview of existing technologies. September 24

Your idea. Be bold, Be creative. Take risks. October 24

Technical details of your idea. Build-out (demo). Simulations. November 21

Business Plan, Commercialization strategy. December 12
National Clean Energy Business Plan Competition

* US Dept. of Energy sponsored. Finalists present in D.C. Significant prizes & resources to launch startups.

* Regional Competition: CU Cleantech New Venture Challenge (http://nvc.cucleantech.org)
  - Submission deadline March 4, 2014. But our class **deadline is Dec. 13, 2013.**
  - Submission materials:
    - Executive Summary (2 pages): Opportunity, go-to-market strategy, market & industry analysis, **technical product description**, risks, economics & team.
    - 5-minute Video pitch: Be creative. Can be product demo, elevator pitch, slide presentation, etc.
    - IP declaration: Note any intellectual property that you think can be patented.

* First-round winners present in Boulder, CO. Monetary prizes & support from National Renewable Energy Laboratory.
Why technologies for the developing world?

- Abundant solar resources with little access to infra-structure (electric grid, roads, etc.).
- Biomass resources are fast depleting & also contribute to CO2 emissions.
- Huge impact possible: ~ 1 out of every 4 people have no access to electricity.
- Market Opportunity to build sustainable technological solutions.
Solar Cooking

Types of cookers

Heat Principles

Materials Requirements

Other design considerations

Challenges for adoption
Solar Box Cooker

- Inner box enclosed in clear glass/plastic
- Simple construction
- Reflector
- Insulation
- Slow, even cooking
- Safe & easy to use
Panel Cooker

Parabolic Cooker

- Higher temperatures possible
- Cooks quickly
- Needs sun-tracking
- More complex & expensive
- Risk of fires & eye injury

Brainstorm: how would you improve these cookers?
Fresnel Lens Cooker

Higher temperatures possible
Cooks quickly
Needs sun-tracking
More complex & expensive
Risk of fires & eye injury
Heat Principles

Heat Gain: Glass orientation

- Which box will receive more sunlight?
- Which box has more losses?
Heat Gain: Greenhouse effect

Visible light passes through glass.
Absorbed by dark pot, which re-radiates at longer wavelengths, which are trapped inside.

The absorbed energy must be conducted to the food efficiently.

Figure 2. The greenhouse effect
Heat Gain: Glass orientation

Which box will receive more sunlight?
Which box has more losses?

Figure 3. Glass orientation
Heat Gain: Reflectors

Reflectors can increase effective light capture area (aperture).

Figure 4. Reflectors for additional solar gain

Brainstorm: How would you increase this gain?
Heat Loss: Conduction, Radiation & Convection

- Absorber plate insulated from bottom of cooker.
- Radiant heat (longer wavelength) trapped by container (glass, foil, etc.).
- Heated air may leak through gaps, doors (convection).

Figure 6. Heat radiates from warm cookware.
Heat Storage

- Thermal mass is the ability to retain heat.
- Higher thermal mass takes longer to heat up.

Figure 8. Thermal mass inside of the solar box.
Materials Requirements

- **Structural materials**: wood, cardboard, metals, bamboo, bricks, stone, plastic, rattan, etc.
- **Insulation**: Al foil, down feathers, cellulose, rice hulls, wool, etc.
- **Transparent material**: glass, high-temp plastics (oven roasting bags), etc.
- **Moisture resistance**: lower walls must protect the rest of the cooler from moisture.

Figure 9: Materials: structural, insulation, transparent, and moisture resistant.
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Structural materials
- wood, cardboard, metals, bamboo, bricks, stone, plastic, rattan, etc.

Insulation
- Al foil, down feathers, cellulose, rice hulls, wool, etc.

Transparent material
- glass, high-temp plastics (oven roasting bags), etc.

Moisture resistance
- Inner walls must protect the rest of the cooker from moisture.
Other design considerations

<table>
<thead>
<tr>
<th>Size</th>
<th>Sunlight collection area</th>
<th>Solar cooker proportion</th>
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<tbody>
<tr>
<td>- Appropriate for amount of food.</td>
<td>- Larger collection area → higher temperature</td>
<td>- Is a square box better than a rectangular box?</td>
</tr>
<tr>
<td>- Portability needs.</td>
<td>- As long as heat loss is not increased</td>
<td>- Which direction should the rectangular box be oriented?</td>
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<tr>
<td>- Cookware accommodation.</td>
<td></td>
<td>- Is tracking required?</td>
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Challenges for adoption

Opportunities for technologists!
New market opportunities as fuel prices rise
Can we combine these technologies with micro-credit?
Can we incorporate solar cooking into home designs.

• Taste of food
• Temperature control
• What about cloudy days?
• Cost
• Disruption traditional gender roles.