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

Office Hours: by email appointment

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 9 in class

Team-based projects

40% Four team presentations in class [First one on September 25]

30% Team submission to CU Cleantech new business challenge [Due December 12]
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 25**

Your idea. Be bold, Be creative. Take risks. **October 30**

Technical details of your idea. Build-out (demo). Simulations. **November 25**

Business Plan, Commercialization plan. **December 11**
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 Sprin 2015. But our class deadline is Dec. 11, 2014.
  • 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

- Sunlight collection area
  - Larger collection area = higher temperatures
  - As long as food is not exposed

- Solar cooker proportion
  - Do a square box before a rectangular box?
  - Which direction should the rectangular box be oriented?
  - Is tracking required?

Challenges for adoption

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

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.
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**
inner walls must protect the rest of the cooker from moisture.
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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</table>
| • Appropriate for amount of food.  
• Portability needs.  
• Cookware accommodation. | • Larger collection area -> higher temperature  
• As long as heat loss is not increased | • Is a square box better than a rectangular box?  
• Which direction should the rectangular box be oriented?  
• Is tracking required? |
Challenges for adoption

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

Opportunities for technologists!
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