Student Journal Template

Solar Power Cell Project

Course Materials Located at:
http://www.pe.tamu.edu/blasingame/data/Ei_08B/
Student Journal Template:

● **Objectives of This Template:**
  1. Provide the student with a "work area" to perform their tasks relative to the Solar Power Project.
  2. Provide a record of student work such that a team presentation can be constructed using the journals of the team members.
  3. Assist the instructor(s) with the evaluation of individual student work and the team presentation.

● **This Template Provides:**
  1. Orientation to the engineering process.
  2. Project tasks and reporting structure.
Solar Cell Power Project — Summer 2008
Texas A&M University — College of Engineering
Engineering Insights Program

Engineering Process
Engineering Process:

● **Approach:**
  ■ Define the need or task.
  ■ Define how the need or task can be met (in concept/approach).
  ■ Assess the viability of the concept/approach via modeling.
  ■ Verify the concept/approach through testing.
  ■ Communicate the findings:
    — Report writing and/or presentation.
    — Your poster presentation needs to reflect this process.

● **Example:**
  ■ **Need/Task:** *Evaluate the concept of a solar car using a model(s)*
    — Physical model: Lego solar car kit
    — Hypothesis: Solar car can operate in variety of light
    — Process: Construct/test Lego solar car
    — Testing: Power in (sun); Power out (car)
    — Evaluation: Test solar cell with/without loads
Project Tasks and Reporting Structure
Task List:

**Day 1:** (Monday p.m. — 13:30-17:30 — 315 CVLB)
- (45 min) Class Introductions (leads: Conkey/Blasingame)
- (45 min) Energy Lecture (lead: Blasingame)
- (30 min) **Break**
- (60 min) Light Intensity (lead: Blasingame)
- (60 min) Solar Cell Power Test (lead: Blasingame)
- [night] Buggy Load Test (lead: Conkey)
- [night] Web Search on Solar Cells

**Day 2:** (Tuesday p.m. — 13:30-17:30 — 315 CVLB)
- (60 min) Run Test Solar Car (lead: Blasingame)
- (60 min) Power Test Solar Car (lead: Conkey)
- (30 min) **Break**
- (60 min) Load Test Solar Car (lead: Conkey)
- (30 min) Prepare Results/Work on Team Poster
- [night] Continue work on poster.

**Day 3:** (Wednesday p.m. — 13:30-17:00 — Zachry Lobby)
- (90 min) Poster Presentations (all)
- (60 min) Awards Ceremony (all)
**Task: Introductions (Day 1)**

- **Tell us about YOU:**
  - What do you like to do? (e.g., sports, school, work?)
  - What do you NOT like to do? (e.g., cut the grass, work, bathe?)
  - Why are you interested in Engineering? (Are you just crazy?)
  - Jobs? Hobbies? Interests? Desires? (Tell us about YOU!)
  - Expectations of this program? (Happiness = Low Expectations!)
**Task: Introductions (Conkey/Blasingame)**

**CONKEY, Andy**
*(aka: "The Ninja")*

"A teacher must never impose this student to fit his favorite pattern; a good teacher functions as a pointer, exposing his student’s vulnerability (and) causing him to explore..."  
Bruce Lee

**BLASINGAME, Tom**
*(aka: "El Guerrero")*

"The quality of a person's life is in direct proportion to their commitment to excellence, regardless of their field of endeavor."

From a fortune cookie (2008.07.13)
Task: Energy Lecture (Day 1)

- Energy Lecture: Blasingame

  - Energy Supply and Consumption:
    - ACCESS to energy $\rightarrow$ wealth and prosperity.
    - Supply is tight due to demand from emerging economies.
    - The future will be a mix of energy sources...

  - Fossil Fuels:
    - Oil, gas, and coal provide $\approx$ 90 percent of U.S. energy supply.
    - Oil, gas, and coal will be part of the energy mix — period.

  - Nuclear:
    - No new nuclear power plants in U.S. since late 1970's.
    - Nuclear energy $\approx$ 18 % of electricity in U.S. — France $\approx$ 80 %!

  - Alternatives/Renewables:
    - Geothermal: Almost limitless geothermal potential (U.S.).
    - Solar: (Some) Very good solar resources (U.S.).
    - Wind: Wind is good (not great), but incentives (TX)?
    - Biomass: Competition with food?
**Task: Light Intensity Correlation (Day 1)**

- **Light Intensity Correlation:**
  - **Description:** In this experiment, the goal is to assess the light intensity (measured using a light intensity meter) as a function of distance from the source.
  - **Materials:** Incandescent lamp, tape measure, light meter.
  - **Procedure:**
    1. Find/acquire an incandescent light fixture.
    2. Define zero distance is as close as possible to the bulb.
    3. Turn on the light intensity meter and begin taking readings at specific distances to the incandescent bulb — starting at a distance far from the bulb.
    4. Record light intensity readings until you are about half a foot (or 0.15 meters) from the bulb.
    5. Transcribe distances and readings into MS Excel — plot light intensity (w/m²) (y-axis) versus distance from the bulb (m) (x-axis) on Cartesian, semi-log, and log-log coordinates.
    6. Develop an appropriate model for this behavior.

- **Specifications/requirements sheet is attached.**
**Task:** Light Intensity Correlation (Day 1)

- **Work in MS Excel: Data**

<table>
<thead>
<tr>
<th>Distance (ft)</th>
<th>Distance (m)</th>
<th>Light Intensity (w/m²) (Data)</th>
<th>Light Intensity (w/m²) (Model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50</td>
<td>0.15</td>
<td>550</td>
<td>517</td>
</tr>
<tr>
<td>0.75</td>
<td>0.23</td>
<td>233</td>
<td>230</td>
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<td>5.00</td>
<td>1.52</td>
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<tr>
<td>6.00</td>
<td>1.83</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

**Observations:**

The log-log plot shows a "slope" or -2 (i.e., 2 blocks down, 1 block to the right). This implies that:

\[ w = a (d^{-b}) \]

*a* is the intercept of the trend at d=1 (*a* = 12 w/m²). *b*=2 (from observation -- see log-log plot).

**Model**

\[ w = a (d^{-2}) \]

\[ a = 12 \ w/m^2 \]

\[ b = 2 \text{ dimensionless} \]
**Task:** Light Intensity Correlation (Day 1)

- **Work in MS Excel:** Work Plots

**Light Intensity Data -- Cartesian Format**

**Light Intensity Data -- Semilog (x-axis) Format**

**Light Intensity Data -- Semilog (y-axis) Format**

**Light Intensity Data -- Log-Log (x and y-axes) Format**

**Slope = -1/2**

**Slope = -1**

**Slope = -2**

**Intercept ? 12 w/m^2**
**Task:** Light Intensity Correlation (Day 1)

- **Work in MS Excel:** Final (Correlation) Plot

![Light Intensity Correlation Plot](image)

- **Light Intensity Data**
  - Log-log (x and y-axes) Format

- **LI_data**
- **LI_model**
**Task: Solar Cell Power Test (Day 1)**

- **Solar Cell Power Test:**
  - **Description:** Test the solar cells for voltage and current.
  - **Materials:** Lego solar cells, multi-meter, strong sunshine.
  - **Procedure:**
    1. Connect a solar cell to the volt portion of the multi-meter.
    2. Standing in the sun, check voltage (v).
    3. Connect a motor to the solar cell, check the current (amp).
    4. Using a piece of paper to shade the solar cell, check output of voltage and current at 25, 50, and 75% of the cell covered.
    5. Transcribe these readings into MS Excel — plot voltage (v) and current (amp) on the y-axis versus % reduction of solar cell surface area on Cartesian, semi-log, and log-log coordinates.
    6. Are the voltage and current changing linearly with the reduction of surface area of the solar cell to capture light? Develop an appropriate model for this behavior.

- **Specifications/requirements sheet is attached.**
**Task: Buggy Load Test (Day 1)**

- **Buggy Load Test:**
  - **Description:** Load test the car using 9-volt battery pack.
  - **Materials:** Stopwatch, tape measure, mass/weight set (4 sets at 250 grams per set), Lego vehicle with 9-volt battery pack, flat ground.
  - **Procedure:**
    1. Construct Lego car without solar panels (or at least, disconnect solar panels).
    2. Mark off a distance that is at least 10 feet long (leave room for "start-up" and "run-off"). Mark off the path on a hard surface.
    3. Place the vehicle one foot (or more) behind the "start" mark. Make a couple of trial runs timing the vehicle between the two lines. Then, make timed runs that will be recorded in the table below. Make 4 four time trials for each load case. Be sure to use the same load values as used for the runs down the incline.
    4. Create an MS Excel spreadsheet — enter and plot your data as instructed. Save to your USB driver.
  - **Specifications/requirements sheet is attached.**
Task: Web Search on Solar Cells (Day 1)

Web Search on Solar Cells:

- Each TEAM MEMBER is to search the web for the following:
  - Keywords: Words/definitions related to solar cells
  - Applications: Application(s) of solar cells
  - Issues: 4 or 5 factors related to use of solar cells
  - Description: Explain (in simple terms) how solar cells work

- Each TEAM is to prepare a "bullet list" of their findings.
Task: Run Test Solar Car (Day 2)

• Run Test Solar Car:
  ■ Materials: Your team will be given a Lego kit containing "solar cell" projects. This kit has to last for at least this summer (several groups) — please do not lose or break any components (sorry to have to mention this, we are just not sure if we can get replacement parts).
  ■ Each team will construct and run test a "solar cell" car.
  ■ Procedure:
    1. Construction of the project car (with engines/solar cells).
    2. Testing of the project car on different surfaces (estimated speed, current, effect of shading (using paper), etc.)
    4. Discussion (bullet points) of observations, challenges, etc.
    5. Develop an appropriate model for this behavior.
  ■ Specifications/requirements sheet is attached.
**Task:** Load Test Solar Car (Day 2)

**Load Test Team Solar Car:**
- You team is to "load test" your team solar car.
- **Procedure:**
  1. Test your car with specified loads (i.e., weights).
  2. Construction of performance tables and graphs.
  3. Discussion (bullet points) of observations, challenges, etc.
  4. Develop an appropriate model for this behavior.
- **Specifications/requirements sheet is attached.**
**Task:** Prepare Team Poster (Day 2)

**Prepare Team Poster:**

- CAREFULLY review the "Poster/Presentation Requirements/Judging Criteria" materials given in this document. Requirement = you must do this.
- CAREFULLY review the "Poster Guidelines/Suggestions" materials given in this document. These are probably more helpful than the "requirements."
- Keep good records (inside this journal document, for example).
- Balance the workload — everyone should have a primary task, as well as a couple of secondary tasks.
- **DO NOT WAIT UNTIL TUESDAY NIGHT TO GET STARTED** (we won't let you do this, but I wanted to remind everyone to get started as soon as possible).
**Task:** Poster Presentations (Day 3)

- **Poster Presentations:** (location Zachry lobby)
  - Make certain that your slides are well organized.
  - Make certain that EVERYONE is familiar with the material.
  - Each student should respond/engage with judge.
  - Don't be nervous (preparation = confidence).
Task: Awards Ceremony (Day 3)

- **Awards Ceremony**: (location Zachry 102)
  - Be on your best behavior (turn of phones, etc.).
  - If you win, be modest and appreciative.
  - If you don't win, be supportive — this is an exercise in teaming.
Feedback: Once You are Home…

- Feel free to write or call us with your comment/suggestions.
- Seriously, keep in touch — we would love to hear from you.
Solar Cell Power Project-Take/Week 3

Tasks outline:

**Task 1:** Introduction (Day time activity for day 1)
- Lecture on power usage.
- Web search on solar cells? (do at night time when buggy is being built too?)

**Task 2:** Relation of power meter readings (Day time activities for day 1)
- Take readings of an incandescent lamp at different distances. Enter data into Excel and observe the $1/r^2$ relation of intensity
- Take readings outdoors in direct sun, shaded area, and off of surface. If there is a reading on meter, indicates that photons are bouncing around everywhere.

**Task 3:** Measure power into solar cell and output voltage as area of solar cell is covered by different transparency films (clear and colored).
- Attach motor to solar cells. Connect wire harness so that voltage and current readings can be made.
- Compare power into solar cell to electrical power to motor speed.

**Task 4:** Build a buggy and determine performance. (Night time activities for day 1)
- Build a buggy that will be driven by a motor(s).
  - Buggy needs to be capable of carrying up to 500 grams of weights.
  - Dimension restrictions? Weight restrictions?
  - Attach motors to buggy and operate using 9-volt power supply. Measure voltage into motor and time how long it takes it travel a set distance in the hallway for various loads.
    - Weight of buggy with solar cells attached is required. The power pack will be drive the buggy through an umbilical chord.
    - Timed test over a set distance with various loads (100, 200, 300, 400, 500 g) will be made. Average velocity will be taken.

**Task 5:** Estimate power required to drive buggy (Day time activities day 2)
- Estimate power available from solar panels and estimate performance of buggy once solar cells are attached. Will need to reweigh the vehicles and use graphs to estimate time it might take to travel some distance.
  - Weight of buggy with solar cells attached is required.
  - Timed test over a set distance with various loads (no load, 200, 400, ??? g) will be made changing the transparency on the solar cell. Average velocity will be taken.

**Task 6:** Finalize graphs and Power point presentations (Night activities Day 2)
Solar Power Cell Project
Engineering Insights Program — Summer 2008

Task: Light Intensity

Task: Each team is to study the power reading of the light meter relative to distance from source.

1. Each team is to study the power reading of the light meter relative to distance from source.
2. Each team is to study the power reading of the light meter when it is pointed in different directions.
3. Each team is to study the power reading of the light meter when it is covered with various transparencies.

Objective: The relation of the observed power read by a light power meter to distance from the source will be observed. The recorded data will then be entered into an Excel spreadsheet and you will plot and attempt to fit with an (appropriate) equation (model). Another qualitative exercise is to use the light intensity meter outdoors to establish the effect of orientation on light intensity from the sun.

Equipment: Light meter, incandescent lamp, tape measure, colored transparencies.

Procedure:

1. Set up an incandescent bulb with a wattage from 75 to 100 watts. The primary direction of the lamp can be horizontal or vertical.
2. Set up a tape measure so that readings can be made every 6 inches up to 10 feet away.
3. Take readings with the light meter from the position of maximum reading (i.e. do get too close to the lamp and burn out the meter), and take readings every six inches. Record data in the table.
4. Take the light meter outside and take readings with the light meter directed toward the sun, angled away from the sun, in the shade, and pointed toward a building. Record these readings.
5. Take the light meter outside and take readings with different types of transparencies covering the light meter. Make sure the light meter is oriented in the same direction relative to the sun each time a layer is applied.
6. Create an MS Excel spreadsheet — enter and plot your data as instructed. Save to your USB drive!

Light Meter Readings: (circle the appropriate units in distance, then convert to meters (m))

Task 1: Indoor Readings

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Distance (ft, in, cm?)</th>
<th>Distance (m)</th>
<th>Light Intensity Meter Reading (W/m²)</th>
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</table>

Comments/Observations:
### Task 2: Outdoor Readings

**Sunny/Cloudy:** 

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Direction (e.g., towards or away from the sun, angle, etc.)</th>
<th>Meter Reading (W/m²)</th>
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</thead>
<tbody>
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</table>

**Comments/Observations:**

### Task 3: Outdoor Readings with Transparent/Translucent Coatings

**Sunny/Cloudy:**

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Translucent Sheet (none, clear, color)</th>
<th>Direction (e.g., towards or away from the sun, angle, etc.)</th>
<th>Meter Reading (W/m²)</th>
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</thead>
<tbody>
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<td>12</td>
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</tbody>
</table>

**Comments/Observations:**
Task: Each team is to study the power input and output relations for a solar cell that is subjected to various transparent or translucent coverings.

Method: A solar cell will be connected to a motor. The incident solar power will be recorded and then the voltage out and the current out of the solar cell will be measured as the solar cell is covered up. This data will be used to determine the output power of the solar cell.

Equipment: Two multi-meters, solar cell, Lego motor, 4 alligator clip leads, ruler (metric), transparent/translucent coverings.

Procedure:
1. Connect the circuit as shown in lecture, but do not attach the clips to the solar cell.
2. Have your circuit checked before connecting the solar cell leads and turning on the meters.
3. Record the initial value of the voltage and current readings. Also note how fast the motor turns. Time how long it takes to make 10 revolutions.
4. Cover the solar cell with one layer of transparency. Record the voltage and current for each covering.
5. Create an MS Excel spreadsheet — enter and plot your data as instructed. Save to your USB drive!

Solar Cell Power Study: (be sure to circle the correct units of current, voltage, and power)

Dimension of the solar cell: width = _________ cm  depth: _________ cm

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Light Intensity Meter Reading (W/m²)</th>
<th>Covering (none, clear, color)</th>
<th>Motor Speed (rpm)</th>
<th>Current (A or mA)</th>
<th>Voltage (V or mV)</th>
<th>Power (W or mW)</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

Comments/Observations:
Task: Buggy Load Test

To determine the relationship for the power to drive your buggy with respect to the load that it is carrying.

Method: The power required to drive the buggy through a specified distance can be estimated by knowing the velocity and drag force of the vehicle.

Equipment: Stopwatch, tape measure, mass/weight set (4 sets at 150 grams per set), Lego vehicle with 9-volt battery pack, flat ground.

Procedure:
1. Mark off a distance that is at least 10 feet long (leave room for "start-up" and "run-off"). Mark off the path on a hard surface.
2. Place the vehicle one foot (or more) behind the "start" mark. Make a couple of trial runs timing the vehicle between the two lines. Then, make timed runs that will be recorded in the table below. Make 4 four time trials for each load case. Be sure to use the same load values as used for the runs down the incline.
3. Create an MS Excel spreadsheet — enter and plot your data as instructed. Save to your USB drive!

Drag Test: (be sure to circle the correct units of current, voltage, and power)

Weight of empty vehicle: ______________________ ozs grams (circle the appropriate units)
Distance between markers: _________________________ units (inches feet _______)

Include units on table.

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Load ( )</th>
<th>Voltage (V)</th>
<th>( t_1 ) ( )</th>
<th>( t_2 ) ( )</th>
<th>( t_3 ) ( )</th>
<th>( t_{avg} ) ( )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 (No load)</td>
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Note: Make comments on observations on back of this sheet. Include a sketch of the test setup.