

Dr. Dean Livelybrooks  
Dept. of Physics; Univ. of  
Oregon  
Winter 2018

**Physics 162 – Physics of Solar and Renewable Energies**  
**SYLLABUS**

<b>INSTRUCTOR</b>	<b>Dr. Dean Livelybrooks</b> Office: 225 Willamette Hall, Email: <a href="mailto:dlivelyb@uoregon.edu">dlivelyb@uoregon.edu</a>
<b>CLASS TIMES</b>	MWF 11:00–11:50, Willamette 100 <i>Attendance is not required, but is <b>very</b> strongly recommended.</i>
<b>TEACHING ASSISTANTS</b>	Graduate student teaching fellow (GTF): <ul style="list-style-type: none"><li>• Blake Parris: <a href="mailto:parris@uoregon.edu">parris@uoregon.edu</a></li></ul> Science Literacy Program (SLP) Fellows: <ul style="list-style-type: none"><li>• Graduate: Jordan Palamos: <a href="mailto:jpalamos@uoregon.edu">jpalamos@uoregon.edu</a></li><li>• Undergraduate:</li></ul>
<b>OFFICE HOURS</b>	<b>Make use of office hours!</b> Even if you don't have specific questions about homework, feel free to drop by and chat about course topics. <ul style="list-style-type: none"><li>• Dr. Livelybrooks ('Dr. D. '), Thurs. 09:30, Fri. 13:30, Willamette 225.</li><li>• Blake Parris, GTF, Weds. 16:00 (4pm), Willamette 40. Thurs. 14:00 (Price Science Library and Commons Physics Drop-In Center)</li><li>• Jordan Palamos: Weds. 09:00, Willamette 315.</li></ul> Note: <i>office hour times may change</i> , both by request (if particular times are bad for many students) and due to scheduling conflicts of the instructors (e.g. travel). <i>You're strongly encouraged to come to office hours, either with specific course-related questions, or just to chat about physics, science, and other general topics.</i>
<b>EMAIL</b>	<b>Email:</b> You can certainly ask questions of me and the teaching assistants by email. I usually respond within 48 hours. Although I encourage emails between

	students, the instructor, SLP Fellows and the TA to encourage learning, I (personally) rarely respond to emails that begin “Hey...” or are otherwise poorly constructed.
<b>TEXTBOOK</b>	<ul style="list-style-type: none"> <li>• There is no required textbook for the course. The lectures plus supplemental readings supplied via Canvas will be sufficient.</li> <li>• <i>Energy, Environment, and Climate</i> by Richard Wolfson is recommended - it’s a very good, recent book on these topics. I’ve placed a copy on reserve at the Science Library.</li> </ul> <p>We’ll also use parts of <i>Sustainable Energy - Without the Hot Air</i> by David MacKay, a remarkable book that quantifies a lot of energy-related issues. The book is available <b>free</b> online, at <a href="http://www.withouthotair.com/">http://www.withouthotair.com/</a> .</p>

### TOPICS AND AIMS

Modern civilization uses vast amounts of energy from sources that are unsustainable and with environmentally-damaging byproducts. What are our alternatives? Can they meet our needs?

We’ll summarize, briefly, conventional energy sources and their environmental impacts. We will look at alternative forms of energy—solar, wind, wave, geothermal, biomass, etc.—and their challenges, including their general intermittency and the problem of energy storage. We will do this *quantitatively*, investigating the physical science underlying various energy sources, the electrical distribution grid, storage schemes, and conservation efforts. Why? It’s easy to have good intentions about energy and the environment, but without quantitative analysis, good intentions alone are insufficient for guiding important decisions and can often do real harm.

*Who are you?* By enrolling in this course, we assume it’s likely that you care about energy issues. We assume that, as university students, you’ll be the decision-makers of the future - businesspeople, policy makers, or at least voters - who will be faced with complex choices having to do with energy and society.

We’ll examine a variety of topics:

1. Present energy usage and sources
2. Energy: what is it?, what is power?, how do we compare different forms?
3. Fossil Fuels and their environmental impacts, including climate change (Brief\*)
4. Wind, wave, and geothermal energy sources
5. Solar energy
6. Energy storage
7. Energy conservation

8. Biomass

9. (if time allows) Geoengineering and other tactics for dealing with climate change

\* Fossil fuels and Climate Change are discussed at length in **Physics 161** (Physics of Energy and the Environment). Physics 161 **is not** a prerequisite for 162.

*Other goals:* We will develop our abilities to think critically and quantitatively about scientific issues. Science, contrary to what you may have experienced in the past, is not about “learning facts” but rather about learning how to investigate and draw logical conclusions. We’ll practice this!

<b>LEARNING OUTCOMES</b>	Students completing the course will have enhanced their abilities to: <ul style="list-style-type: none"><li>• conceptualize how physical principles influence energy use;</li><li>• assess and interpret graphs and quantitative data, and;</li><li>• understand the process by which science generates knowledge.</li></ul>
<b>CANVAS</b>	We will be using Canvas in this course to distribute course materials, and also for online assignments. URL: <a href="https://canvas.uoregon.edu/">https://canvas.uoregon.edu/</a>
<b>HOMEWORK</b>	There will be six (6) homework assignments, about one every other week. Feel free to discuss the questions with others, but of course, <u>the work you submit should be your own</u> . Assignments will mainly be submitted online, via Canvas. Solutions to all the problem sets will be posted - <b>study</b> these. <u>No late homework will be accepted</u> . Some assignments will involve finding and analyzing data. You should be able to navigate the internet and make simple graphs (e.g. with Excel). <i>Homework grading:</i> (1) Each student’s lowest score will be dropped from the overall total. (2) We will not comment in detail on your homework when grading it. It is especially important to study the problem set solutions. (3) <u>Feel free to discuss homeworks during office hours</u> (with instructor, SLP Fellows, TA).
<b>QUIZZES</b>	There will be five (5) short quizzes. (They won’t be surprises; you’ll get advance notice of at least one class.) <u>These will be done on-line within Canvas</u> . We’ll use these to assess understanding of key points as we progress without the heavy weight of a “real” exam. Each student’s lowest quiz score will be dropped from the overall total. There won’t be any make-up quizzes; if you miss one, this will be the quiz dropped from your overall grade calculation.

<p><b>POP. SCIENCE ARTICLES</b></p>	<p>We will assign five (5) “popular” science articles and ask you to analyze and comment on them. These will interleave weekly with Quizzes, above. These assignments will be described further as the term progresses.</p>
<p><b>CLICKERS</b></p>	<p>We’ll use “iclickers,” personal response systems that allow real-time polling and assessment in class. There is a participation grade associated with the clickers, described further in the grading section. Each student needs one clicker, which looks like this:</p>  <p>Clickers can be purchased at the bookstore. Borrowing a clicker from someone <i>not</i> enrolled in this course <u>will</u> work fine as long as you always use this clicker in class, and no one else is using it in class.</p> <p><b>Clicker registration:</b> We’ll do this through Canvas - details TBA; <b>don’t</b> use iclicker.com!</p> <p><b>Overall score.</b> Clicker points cannot be made up. However, I realize that absences are unavoidable, and so I will rescale the clicker scores so that 90% counts as 100%; i.e. you can miss 10% of the clicker</p>
<p><b>GRADING</b></p>	<p>The various grade components and their weights for the final grade are:</p> <ul style="list-style-type: none"> <li>• <i>Homework Assignments: 15%</i></li> <li>• <i>Quizzes: 20%</i></li> <li>• <i>Popular Science Article Assignments: 15%</i></li> <li>• <i>Clicker (participation): 10%</i></li> <li>• <i>Midterm Exam (Friday, February 9): 20%</i></li> <li>• <i>Final Exam (Friday, March 23, 10:15): 20%</i></li> </ul> <p><b>Overall Grade:</b>  A=88–100%; B=76–87.9%; C=64–75.9%; D=52–63.9%; F&lt;52%.</p> <p><b>Absences.</b> Students with a serious and well-documented reason for missing an exam should contact Dr. Livelybrooks to discuss accommodations.</p>
<p><b>LAPTOPS IN CLASS</b></p> <p><u>The use of laptop computers in class is not allowed.</u> Why? Several studies, plus past experience, show that students using laptops in class spend a great deal of time on non-</p>	

class-related activities (surfing the web, playing games, ...) and that these distractions negatively impact both learning and grades. This alone isn't a reason to ban laptops - you're responsible for your own performance in class. *In addition*, however, studies have shown that non-class-related laptop use distracts and impacts the learning of *other students nearby*. (E.g. Fried, C. B. *Computers & Education* **50**, 906-914 (2008).) Plus, *students* have complained to me about the environment created by their classmates' laptop use.

Taking notes by hand, by the way, is more effective in cementing concepts in your mind. (Note, by the way, that lecture slides are posted online, so you don't have to frantically transcribe everything anyway.)

**In summary, laptops are not allowed in class.** The only exceptions will be for people with documented medical needs; please see me if this is the case.

<p><b>HOW TO DO WELL IN THE COURSE</b></p>	<ul style="list-style-type: none"> <li>• Attend class.</li> <li>• Do the homework, and study the solutions.</li> <li>• Work on understanding all the concepts and example questions discussed in the lectures and the homework. "Understanding" does <i>not</i> mean "it sounds like it makes sense to me," but more deeply, "I could explain this concept to one of my classmates."</li> <li>• Come to my or the SLP Fellows/GTFs' office hours with questions!</li> <li>• <i>Another suggestion: <b>Sleep!</b> Numerous studies show that sleeping helps both memory and understanding.</i></li> </ul>
<p><b>STUDENTS WITH DISABILITIES</b></p>	<p>If aspects of the instruction or design of this course result in barriers to your inclusion, please notify me as soon as possible. You are also welcome to contact Disability Services in 164 Oregon Hall, 346-1155.</p>

Dr. Dean Livelybrooks, University of Oregon

**Calendar: Physics 162, Winter 2018**

DATE	AGENDA ( <i>DRAFT!</i> )
<p>Week 1: January 8, 10, 12</p>	
<p>Mo 8<sup>th</sup></p>	<p><i>Class 1:</i> Very short intro to present energy usage and making sense of graphs. Course Syllabus.  <i>Reading:</i> none</p>

	<p><i>Assignments: (new)</i> Popular Science Reading Assignment 1, due Friday, Jan. 12. )  <b>(new)</b> Homework #1, due Weds. Jan. 17, by 9pm. <b>(new)</b> Math Diagnostic first attempt due Friday 12th.</p>
Weds 10 <sup>th</sup>	<p><i>Class 2:</i> Estimation; Power (usage and definition), and Energy.  <i>Reading:</i> Chapter 1 of “Make it stick” (preface &amp; Chpt. 1; pdf found in Canvas under Files).  <i>Assignments:</i> (reminder) Popular Science Reading Assignment 1, due Friday, Jan. 12. (reminder) Homework #1, due Weds. Jan. 17, by 9pm. Math Diagnostic first attempt due Friday 12th.</p>
Fri 12 <sup>th</sup>	<p><i>Class 3:</i> Fossil fuels usage and impacts.  <i>Reading (suggested):</i> Wolfson, Chapter 5 (5.1–5.3,5.5)  <b>Assignment Due:</b> First try to pass Math Diagnostic Quiz (on-line, by 9pm). Popular Science Reading Assignment 1 due today by 9pm (in Canvas).  <i>Assignments:</i> (reminder) Homework #1, due Weds, 17–January. <b>(new)</b> Quiz 1 due Friday, 19–Jan.</p>
<b>Week 2: January 15, 17, 19</b>	
Mo 15 <sup>th</sup>	<p><i>Martin Luther King Birthday—UO Holiday</i>  <i>Assignments:</i> (reminder) Homework #1, due Weds, 17–January. (reminder) Quiz #1 due Friday, 19–Jan. Pass Math Diagnostic Quiz by Friday, 19–Jan. by 9pm. <b>(new)</b> Popular Science Article #2 due Friday, 26<sup>th</sup>.</p>
Weds 17 <sup>th</sup>	<p><i>Class 4:</i> a few thoughts/calculations; hydroelectric power I  <i>Reading (suggested):</i> Wolfson, Chapter 10.1  <b>Assignment Due:</b> Homework #1 due today by 9pm.  <i>Assignments:</i> (reminder) Quiz #1 due Friday, 19–Jan. Pass Math Diagnostic Quiz by Friday, 19–Jan. by 9pm. <b>(new)</b> Homework #2, due next Weds. 24<sup>th</sup> (reminder) Popular Science Article #2 due Friday, 26<sup>th</sup>.</p>
Fri 19 <sup>th</sup>	<p><i>Class 5:</i> hydroelectric power II; types/forms of energy.  <i>Reading (suggested):</i> Wolfson, Chapter 3  <b>Assignment Due:</b> Quiz #1, due today, start of class! Math Diagnostic Quiz passed today by 9pm.  <i>Assignments:</i> (reminder) Homework #2, due next Weds. 24<sup>th</sup>; (reminder) Popular Science Article Assignment #2, due next Friday, Jan. 26<sup>th</sup>.</p>
<b>Week 3: January 22, 24, 26</b>	
Mo 22 <sup>th</sup>	<p><i>Class 6:</i> an example of unit conversions; converting between energy forms; conservation of energy</p>

	<p><i>Reading (suggested):</i> Wolfson, Chapter 3</p> <p><i>Assignments:</i> (reminder) Homework #2, due this Weds. 24<sup>th</sup>; (reminder) Popular Science Article Assignment #2, due this Friday, Jan. 26<sup>th</sup>.</p>
Weds 24 <sup>th</sup>	<p><i>Class 7:</i> a few electricity basics; the U.S. electrical grid.</p> <p><i>Reading (suggested):</i> Wolfson, Chapter 11.1</p> <p><b>Assignment Due: Homework #2 due today by 9pm.</b></p> <p><i>Assignments:</i> (reminder) Popular Science Article Assignment #2, due this Friday, 26<sup>th</sup> by 9pm. <b>(new)</b> Homework #3 due in two weeks Weds (7-Feb.) by 9pm.</p>
Fri 26 <sup>th</sup>	<p><i>Class 8; A mystifying demonstration; Introduction to wind power.</i></p> <p><i>Reading (suggested):</i> Wolfson, Chapter 10.2</p> <p><b>Assignment Due: Popular Science Article Assignment #2 due today by 9pm.</b></p> <p><i>Assignments:</i> (reminder) Homework #3 due next Weds., 7-Feb. <b>(new)</b> Quiz #2 due Friday, 2-Feb. by start of class. <b>(new)</b> Popular Science Article #3 due Friday, 9-Feb.</p>
<b>Week 4: January 29, 31, February 2</b>	
Mo 29 <sup>th</sup>	<p><i>Class 9:</i> Wind power II: efficiency, siting, environmental impacts, review</p> <p><i>Assignments:</i> (reminder) Homework #3 due Weds. 7-Feb. (reminder) Quiz #2 due this Friday, 2-Feb. by start of class. (reminder) Popular Science Article #3 due Friday, 9-Feb.</p>
Weds 31 <sup>st</sup>	<p><i>Class 10:</i> Solar Energy—availability, distribution, electricity &amp; solar panels</p> <p><i>Reading (suggested):</i> Wolfson, Chapter 9.1</p> <p><i>Assignments:</i> (reminder) Quiz #2 due this Friday, 2-Feb. by start of class. (reminder) Homework #3 due next Weds, 7-Feb. (reminder) Popular Science Article #3 due Friday, 9-Feb.</p>
Fri 2 <sup>nd</sup>	<p><i>Class 11:</i> How do solar panels (aka ‘photovoltaics’) work? (start with the basics: voltage, current, power, etc.)</p> <p><i>Reading (suggested):</i> Wolfson, Chapter 9.2</p> <p><b>Assignment Due: Quiz #2 due today, start of class.</b></p> <p><i>Assignments:</i> (reminder) Homework #3 due next Weds, 7-Feb. (reminder) Popular Science Article #3 due Friday, 9-Feb.</p>
<b>Week 5: February 5, 7, 9</b>	
Mo 5 <sup>th</sup>	<p><i>Class 12:</i> Crystals, band gaps, semiconductors (the ‘guts’ of photovoltaics)</p> <p><i>Assignments:</i> (reminder) Homework #3 due next Weds, 7-Feb. (reminder) Popular Science Article #3 due Friday, 9-Feb.</p>
Weds 7 <sup>th</sup>	<p><i>Class 13:</i> p-n junctions, photons make free electron/hole pairs</p>

	<p><b>Assignment Due: Homework #3 due today by 9pm.</b></p> <p><i>Assignments:</i> (reminder) Popular Science Article #3 due this Friday, 9-Feb. <b>(new)</b> Homework #4 due Weds, 21-Feb. by 9pm.</p>
Fri 9 <sup>th</sup>	<p><b>Class 14: Midterm Exam</b></p> <p><b>Assignment Due: Popular Science Article Assignment #3 due today by 9pm.</b></p> <p><i>Assignments:</i> (reminder) Homework #4 due Weds (21-Feb). <b>(new)</b> Quiz #3 due by next Friday, 16-Feb. <b>(new)</b> Popular Assignment #4 due in two weeks (Fri, 23-Feb).</p>
<b>Week 6: February 12, 14, 16</b>	
Mo 12 <sup>th</sup>	<p><b>Class 15:</b> band gap and photon energies, electromagnetic waves &amp; the solar spectrum</p> <p><i>Assignments:</i> (reminder) Homework #4 due Weds, 21-Feb. (reminder) Quiz #3 due by this Friday, 16-Feb. (reminder) Popular Assignment #4 due Fri, 23-Feb.</p>
Weds 14 <sup>th</sup>	<p><b>Class 16:</b> Land use for solar electricity?; Solar for direct heating and ‘solar thermal’ for electricity</p> <p><i>Reading (suggested):</i> Wolfson, Chapter 9.3, 9.4</p> <p><i>Assignments:</i> (reminder) Quiz #3 due by this Friday, 16-Feb. (reminder) Homework #4 due next Weds. 21-Feb, by 9pm. (reminder) Popular Assignment #4 due Fri, 23-Feb</p>
Fri 16 <sup>th</sup>	<p><b>Class 17:</b> Intro to energy storage: starting with batteries in transportation</p> <p><i>Reading (suggested):</i> Wolfson, Chapter 11</p> <p><b>Assignment Due: Quiz #3 due today, start of class.</b></p> <p><i>Assignments:</i> (reminder) Homework #4 due next Weds. 21-Feb. (reminder) Popular Assignment #4 due Fri, 23-Feb</p>
<b>Week 7: February 19, 21, 23</b>	
Mo 19 <sup>th</sup>	<p><b>Class 18:</b> More on electrical energy storage—fixed systems</p> <p><i>Reading (suggested):</i> Wolfson, Chapter 11. (later in section)</p> <p><i>Assignments:</i> (reminder) Homework #4 due this Weds. 21-Feb. (reminder) Popular Assignment #4 due this Friday, 23-Feb</p>
Weds 21 <sup>st</sup>	<p><b>Class 19:</b> Finish fixed electrical energy storage systems</p> <p><b>Assignment Due: Homework #4 due today by 9pm.</b></p> <p><i>Assignments:</i> (reminder) Popular Assignment #4 due this Friday, 23-Feb. <b>(new)</b> Homework #5 due Weds. 7-March, by 9pm.</p>
Fri 23 <sup>rd</sup>	<p><b>Class 20;</b> Converting heat energy into ‘higher forms:’ what thermodynamics tells us.</p> <p><i>Reading (suggested):</i> Wolfson, Chapter 4.7, 4.8</p> <p><b>Assignments Due: Popular Science Article Assignment #4 due today by 9pm.</b></p>

	<p><i>Assignments:</i> (reminder) Homework #5 due next Weds. 7–March.; <b>(new)</b> Quiz #4 due next Friday, 2–March by start of class; <b>(new)</b> {last} Popular Science Article Assignment #5 due in two weeks, Friday 9–March, by 9pm.</p>
<b>Week 8: February 26, 28, March 2</b>	
Mo 26 <sup>th</sup>	<p><i>Class 21:</i> Practical aspects of thermodynamics.</p> <p><i>Assignments:</i> (reminder) Homework #5 due next Weds. 7–March.; (reminder) Quiz #4 due this Friday, 2–March by start of class; (reminder) Popular Science Article Assignment #5 due Friday 9–March.</p>
Weds 28 <sup>th</sup>	<p><i>Class 22:</i> Geothermal Energy</p> <p><i>Reading (suggested):</i> Wolfson, Chapter 8.1, 8.2</p> <p><i>Assignments:</i> (reminder) Quiz #4 due this Friday, 2–March by start of class; (reminder) Homework #5 due next Weds, 7–March; (reminder) Popular Science Article Assignment #5 due Friday 9–March</p>
Fri 2 <sup>nd</sup>	<p><i>Class 23:</i> Efficiencies in energy type conversions; intro to biofuels</p> <p><i>Reading (suggested):</i> Wolfson, Chapter 10.3</p> <p><b>Assignment Due: Quiz #4 due today, start of class.</b></p> <p><i>Assignment:</i> (reminder) {last} Homework #5 due next Weds, 7–March; (reminder) Popular Science Article Assignment #5 due next Friday 9–March.</p>
<b>Week 9: March 5, 7, 9</b>	
Mo 5 <sup>th</sup>	<p><i>Class 24:</i> Biofuels</p> <p><i>Assignment:</i> (reminder) {last} Homework #5 due this Weds, 7–March; (reminder) Popular Science Article Assignment #5 due this Friday 9–March</p>
Weds 7 <sup>th</sup>	<p><i>Lecture 25:</i> Biofuels—last bits; nuclear energy</p> <p><i>Reading (suggested):</i> Wolfson, Chapter 7</p> <p><b>Assignment Due: Homework #5 due today by 9pm.</b></p> <p><i>Assignment:</i> (reminder) Popular Science Article Assignment #5 due this Friday 9–March. <b>(new)</b> {last} Homework #6 due next Weds, 14–March, by 9pm.</p>
Fri 9 <sup>th</sup>	<p><i>Lecture 26: nuclear energy II; hydrogen as a fuel</i></p> <p><i>Reading (suggested):</i> Wolfson, Chapter 11.2</p> <p><b>Assignments Due: Popular Science Article Assignment #5 due today by 9pm</b></p> <p><i>Assignments:</i> (reminder) Homework #6 due next Weds., 14–March. <b>(new)</b> {last} Quiz #5 due next Friday, 16–March, by start of class.</p>
<b>Week 10: March 12, 14, 16</b>	
Mo 12 <sup>th</sup>	<p><i>Lecture 27:</i> Smart grids; scaling in transportation, symmetries, comparisons</p>

	<p><i>Assignments:</i> (reminder) Homework #6 due Weds., 14-March. (reminder) {last} Quiz #5 due this Friday, 16-March, by start of class.</p>
Weds 14 <sup>th</sup>	<p><i>Lecture 28: Summing up and Review I</i></p> <p><b><i>Assignment Due:</i> Homework #6 due today by 9pm.</b></p> <p><i>Assignments:</i> (reminder) {last} Quiz #5 due this Friday, 16-March, by start of class.</p>
Fri 16 <sup>th</sup>	<p><i>Lecture 29: Review II &amp; question time</i></p> <p><b><i>Assignment Due:</i> Quiz 5 due today, start of class.</b></p>
<p><b>Final Exam Week, Friday March 23, 10:15-12:15</b></p>	
Fri 23 <sup>rd</sup>	<p>FINAL EXAM</p>