ECE 2200
Electrical Engineering for Civil Engineers
Spring 2019 Class Syllabus

Instructor: Arn Stolp
Office: MEB 2262
Phone: U of U: 581-4205
E-mail: arnstolp@ece.utah.edu (I rarely check my e-mail, so let me know by some other method if you send me email that I need to read.)
Office hours: My “office hours” are the problem sessions. Otherwise, it’s catch me if you can. To increase your chances, talk to me in class, or leave a phone message to say when you’d like to see me. I’m usually around until at least 2:00 p.m. M, W, & F. If I’m not in my office, check the lab.

Web Site: http://www.ece.utah.edu/~ece2210/index2200.html

Required books and lab supplies:
Practical Electronics for Inventors, 3rd or 4th Ed, by Paul Scherz
3 required class material packs (available on website) & Ring binder
Lab notebook (bound or spiral)
Breadboard & Lab parts available for purchase at lab (~$16 on your U-card)

Prerequisites:
MATH 2250 and PHYCS 2210, PHYCS 2220 is strongly recommended

Introduction:
In case you haven’t noticed, you’re surrounded by electrical and electronic devices. Electrical motion, measurement and control are powerful and cheap, so they’re used everywhere and are part of every technical career, including yours. Maybe you can find a job where other people make all the decisions concerning wiring, power distribution, electric motors, communications systems, instrumentation, and control; but do you really want that? Do you really want to be the clueless one?

ECE 2200 will introduce you to some of the basics of electrical engineering. This may not seem important now, but I think you will find these concepts very useful in your future classes and jobs. Besides, they’ll help you pass the FE exam, and that should be of immediate concern.

I teach concepts and the use of those concepts to solve problems, not formulas and memorization. The hands-down easiest way get a good grade in this class is to learn those concepts.

This class consists of:
Lectures: W & F 9:40 -10:30 am in WEB L103
Lectures set the direction and tone of the class and cover more than the written material. You will be held accountable for everything discussed in the lectures, so your attendance is important.
Problem Sessions: M 9:40am in WEB WEB L103 & W __________ in __________

We cover a lot of material in this class and there is rarely enough lecture time to work examples or to answer your questions in detail. I will not cover new material in the problem session, so you can get by without coming, but I think you’ll find it worth your while.

Textbook:
The text contains a great deal of practical, useful information beyond the theoretical material we cover in this class. It should prove to be a good reference. The reading page numbers are for the 3rd edition (4th edition page may be a little different).

Supplementary Packets:
I’ve supplemented the textbook with packs of class material which you will download from the class web site (http://www.ece.utah.edu/~ece2210/index2200.html). You should have received a class email with links. The packets are separated into class notes, homework assignments, and lab instructions. The packets available now will cover the first half of the class, additional packets will be available in March. Much of this material is also available individually on the web site. You will probably want to print much of this material. You can sign on to computers in the lab with the same user name and password you use (or can get) in the Engman computer lab (the one in WEB, floor L2). Then you can use the printers in the lab. The packets are designed to be printed on both sides of the pages. Please conserve paper and weight in your backpack.

Homework, homework, and more homework: 50 pts.
Expect a homework assignment for each lecture, to be turned in twice-a-week, usually on Mondays and Thursdays, all from the Homeworks packet. Homework will be your main study tool. As such, I’ll give you all the answers so that you can check your work immediately. In fact, you’ll have to self-correct your homework. If you can’t get the answer, check the web site for corrections, study some more, come to the problem session, ask for help, or see the posted solutions. Sometimes I even post solutions before the homework is due. So, you might ask, “Why is it handed in and ‘graded’?”. Well, to answer a question with a question, “Would you even do it otherwise?”

Your homework should be neat and clear and show all your work. For most problems the grader will simply check to see that you’ve done it and that your paper shows the enough work to get the answer. Only a few problems will be checked in greater detail. You may collaborate with others to learn how to do the homework, but will need to hand in your own work. Copying or allowing another student to copy your work is considered cheating.

You will probably learn more from doing the homework than any other part of this class. If you thoroughly understand the homework, you will know what the class is about, and the exams should give you no trouble.

On the 2nd floor of MEB, in center hallway, you’ll find some lockers with slots in the doors. Drop your homework in the ECE 2210 HOMEWORK locker by 5:00 p.m. of the due date. I will accept some late homework for some credit. Bring it directly to me, and don’t do it habitually. Solutions will be posted in my office window. Graded homework, lab notebooks and exams will be returned to a file cabinet in MEB 2101 according to a folder number you will receive later. Once you get your number, you should write it on the
upper left-hand corner of everything you hand in. Your material will be an unlocked drawer and will not be secure. If you want your material returned to a locked drawer simply remove your file and slip it under my office door.

**Midterm:**

Midterm: 100 pts.

One 50-minute midterm will cover material up to the time of the test. My exams are designed to see if you learned concepts and problem solving strategies and whether you can work with them, sometimes in new and different ways. Don't try to memorize formulas or specific problems. Exams also cover what you learn in the labs. All exams are closed book, closed notes, no phones, tablets or computers allowed. The class may be split into two or more rooms on exam days, listen in class for details.

**Final:** In your last lab (ask 1st class day), or Wed., 9:40am 3/6/19 (Recommended) 100 pts.

The 50 minute final will be comprehensive with greater emphasis on the most recent material. I highly recommend that you take the exam at the later date so that you will have enough time to study. If you want to take the your final in your last lab, you will need to tell me at the first class so that you can start labs the first week. If you say nothing the first day then you will have to take the later exam (which is the best choice by far).

**Labs:** MEB 2265 60 pts.

Lab will be held every week, including the last week of class. Lab may start the first week of class-- listen in class the first day for details. Many of the subjects covered in lab aren’t covered anywhere else in class, so make sure you pay attention and read the lab instructions. You will have to keep a laboratory notebook as a requirement of the lab. Your lab TA will collect and grade these notebooks.

Labs are not optional. For each lab that you miss or fail (< 60% score), your final grade will suffer a half letter drop (5% of possible points). Be sure to make-up any labs you miss or fail.

**Grades:**

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<td>Labs:</td>
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<td>90-93</td>
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If you want any deviations from the normal requirements (say credit for labs, you’ve done before) you will need to see me before the work would normally be due and get an agreement in writing. You’ll need to turn in your copy of the agreement with your final, so I’ll remember to grade you properly.
Americans with Disabilities Act (ADA)
The University of Utah seeks to provide equal access to its programs, services, and activities for people with disabilities. If you need accommodations in a class, reasonable prior notice needs to be given to the instructor and to the Center for Disability Services, 162 Olpin Union, 581-5020 (V/TDD) to make arrangements for accommodations. All written information in a course can be made available in alternative format with prior notification to the Center for Disability Services.

Adding Classes
Please read carefully: All classes must be added within two weeks of the beginning of the semester (deadline: January 11 for session I). Late adds will be allowed (January 12-? for session I), requiring only the instructor’s signature. Any request to add a class after January 28, will require signatures from the instructor, department, and Dean, and need to be accompanied by a petition letter to the Dean’s office.

A $50 FEE WILL BE ASSESSED BY THE REGISTRAR’S OFFICE FOR ADDING CLASSES AFTER January 28.

Withdrawal Procedures
See the web page for details: http://registrar.utah.edu/academic-calendars/
See the Class Schedule or web for more details. Please note the difference between the terms “drop” and “withdraw”. Drop implies that the student will not be held financially responsible and a “W” will not be listed on the transcript. Withdraw means that a “W” will appear on the student’s transcript and tuition will be charged.

Drop Period – No Penalty
Students may DROP any class without penalty or permission until (January 11 for session I).

Withdrawal from Full Term Length Classes
Students may WITHDRAW from classes without professor’s permission until Friday, February 1 for session I. Between (January 11 to February 1 for session I), a “W” will appear on the transcript AND tuition will be charged. Refer to Class Schedule, Tuition and Fees for tuition information.
Withdrawals after (February 1 for session I) will only be granted due to compelling, nonacademic emergencies. A petition and supporting documentation must be submitted to the Dean’s Office, 1602 Warnock Engineering Building. Petitions must be received before the last day of classes (February 26 for session I).

Withdrawal from Session I & Session II
See the web page for details: http://registrar.utah.edu/academic-calendars/spring2019.php

Repeating Courses
When a College of Engineering class is taken more than once, only the grade for the second attempt is counted. Grades of W, I, or V on the student’s record count as having taken the class. Some departments enforce these guidelines for other courses as well (e.g., math, physics, biology, chemistry). Attempts of courses taken at transfer institutions count as one attempt. This means a student may take the course only one time at the University of Utah. Courses taken at the University of Utah may not be taken a second time at another institution. If a second attempt is needed, it must be at the University of Utah. Please work with your department advisor to determine the value of repeating courses. Students should note that anyone who takes a required class twice and does not have a satisfactory grade the second time may not be able to graduate. It is the responsibility of the student to work with the department of their major to determine how this policy applies in extenuating circumstances.

Appeals Procedures
See the Code of Student Rights and Responsibilities, located in the Class Schedule or on the UofU Web site for more details

Appeals of Grades and other Academic Actions
If a student believes that an academic action is arbitrary or capricious he/she should discuss the action with the involved faculty member and attempt to resolve. If unable to resolve, the student may appeal the action in accordance with the following procedure:
1. Appeal to Department Chair (in writing) within 40 business days; chair must notify student of a decision within 15 days. If faculty member or student disagrees with decision, then,
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<tr>
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<td>W 01/16</td>
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<td>Voltage and current dividers, Sources, Nodes, Grounds, Branches, Meters</td>
<td>2.10, 2.12-16</td>
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<td>Superposition, Practical voltage and current sources</td>
<td>2.18, 3.2</td>
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<td>2.23, 3.6</td>
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<td>Steady-state Sinusoids, Phasors, &amp; Complex numbers</td>
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<td>13</td>
<td>Phasors, Impedance, &amp; AC circuits</td>
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**ECE 2210 continues below. You may attend, but no more work will be required or accepted.**

| 8    | W 02/27 | 14      | AC circuit examples                                                    | 2.29-30            |
|      | F 03/01 | 15      | Filters & Bode plots                                                   | 2.31-33, notes     |
| 9    |         |         | Second order transients, Laplace Impedance, Transfer functions          | 2.34, notes        |
|      | W 03/06 |         | Exam 2                                                                |                    |
|      | F 03/08 | 17      | Second order transients, Time-domain solutions                         | notes              |
| 10   | M 03/11 |         | Spring Break                                                           |                    |
|      | F 03/15 |         |                                                                        |                    |
| 11   | W 03/13 | 18      | Second order transients, Initial and final conditions                   | notes              |
|      | F 03/15 | 19      | Second order transient examples, Systems                               | notes              |
| 12   | W 03/27 | 20      | Diodes basics, Diodes in DC circuits                                   | 4.2                |
|      | F 03/29 | 21      | Diodes in AC circuits, Rectification                                   | 4.2, notes         |
| 13   | W 04/03 | 22      | Diodes, Transistors                                                    | 4.3                |
|      | F 04/05 | 23      | Transistors & Switching circuits                                       | 4.3, notes         |
| 14   |         |         | Operational Amplifiers                                                | Ch 8               |
|      | W 04/10 |         | Exam 3                                                                |                    |
|      | F 04/12 | 25      | Operational Amplifiers                                                | Ch 8               |
| 15   | W 04/17 | 26      | RMS and AC Power                                                       | 2.21-22            |
|      | F 04/19 | 27      | AC Power, Transformers                                                | 2.28, 3.8          |
| 16   | M 04/22 |         | Problem Session at normal class time                                  |                    |
|      | W 04/24 |         | Problem Session at normal class time / Review, 1:00pm in               |                    |
|      | F 04/26 |         | Final Exam, 8:00am                                                    |                    |

ECE 2200  Spring 2019  Course Schedule
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<td>Jan</td>
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<td>24 Reading Day ECE 2210 prob ses Final Review 1:00</td>
<td>25 Finals begin ECE 2210 8:00am</td>
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<td>2 Freedom</td>
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</table>
ECE 2200/10 Lecture 1  Introduction to Electrical Engineering for non-majors

2200 = 1/2 semester (Civil, Mining)
ECE 2200 Without the Physics is hard, Plan on it!
Decide today when you will take the **FINAL**:

1st option: Final in your last lab session, Start labs this Thurs.

If you don't take the later final you will have to start labs **Thursday, THIS WEEK**

2210 = Full semester (Mechanical, Chemical, Mat. Sci, etc.)
Labs start **next week**
2210 Final Thursday, April 25, 8:00am.

**BOTH**
Bring a lab notebook and a U-card loaded with $15 to 1st lab.

Homeworks are due by 5:00 pm in locker ________

WARNING: HWs are often due on non-class days.

**Problem sessions** M, 9:40 in regular classroom  W, ________________

Copy packets are on class website, check your email and/or syllabus for links

**How to survive**
1. Easiest way to get through school is to actually learn and retain what you are asked to learn.
   Even if you're too busy, don't lose your good study practices.
   What you "just get by" on today will cost you later.
   Don't fall for the "I'll never need to know this" trap. Sure, much of what you learn you may not use, but you will need some of it, some day, either in the current class, future classes, or maybe sometime in your career. Don't waste time second-guessing the curriculum, It'll still be easier to just do your best to learn and retain what is covered.

2. Don't fall for the "traps".
   Homework answers, Problem session solutions, Posted solutions, Lecture notes.

3. KEEP UP! Use calendar.

4. Make "permanent notes" after you've finished a subject or section and feel that you know it.

**Lecture**

### Basic electrical quantities

<table>
<thead>
<tr>
<th>Basic electrical quantities</th>
<th>Letter used</th>
<th>Units</th>
<th>Fluid Analogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge, actually moves</td>
<td>Q</td>
<td>Coulomb (C)</td>
<td>( \text{m}^3 )</td>
</tr>
<tr>
<td>Current, like fluid flow</td>
<td>I = ( \frac{Q}{\text{sec}} )</td>
<td>Amp (A, mA, ( \mu \text{A}, \ldots ))</td>
<td>( \text{m}^3 ) sec</td>
</tr>
<tr>
<td>Voltage, like pressure</td>
<td>V or E</td>
<td>volt (V, mV, kV,\ldots)</td>
<td>( \text{Pa} = 1 \cdot \frac{N}{\text{m}^2} )</td>
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<tr>
<td>Resistance</td>
<td>R = ( \frac{V}{I} )</td>
<td>Ohm (( \Omega ), k( \Omega ), M( \Omega ),\ldots)</td>
<td></td>
</tr>
<tr>
<td>Conductance</td>
<td>G = ( \frac{1}{R} )</td>
<td>Siemens (S, also mho, old unit)</td>
<td></td>
</tr>
<tr>
<td>Power = energy/time</td>
<td>P = V \cdot I</td>
<td>Watt (W, mW, kW, MW,\ldots)</td>
<td>W</td>
</tr>
</tbody>
</table>

**Symbols (ideal)**

- **Node** = All points connected by wire
- **Not connected**
- **Battery**
- **Variable Resistor**
- **Potentiometer**

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ECE 2210 Lecture 1 notes p1
KCL, Kirchhoff's Current Law

\[ I_{in} = I_{out} \text{ of any point, part, or section} \]

\[ \begin{align*}
2m^3/s & \quad \text{in} \\
2C/s & \quad \text{metal wire (conductor)} \\
= 2A & \quad \text{out}
\end{align*} \]

\[ \begin{align*}
in & \quad \text{in} \\
2m^3/s & \quad \text{pipe}
\end{align*} \]

Battery also obeys KCL
No accumulation of charge anywhere, so it must circulate around.
Leads to the concept of a "Circuit"

Voltage is like pressure
KVL, Kirchhoff's Voltage Law

\[ V_{gains} = V_{drops} \text{ around any loop} \]

Conductors
Nonconductors
Massless fluid in our analogy
No gravity effects
No Bernoulli effects
Reasonable because:
Electron mass is \( 9.11 \times 10^{-31} \text{ kg} \).
Electron charge is \( 1.6 \times 10^{-19} \text{ C} \).
Negative charge flows in negative direction.
**Ohm's law** (resistors)

\[ V = I \cdot R \]

\[ R = \frac{V}{I} \]

Definition of resistance and the unit "Ω".

**Power**

\[ \text{flow } \frac{m^3}{\text{sec}} \quad \text{pressure } \frac{N}{m^3} \quad \text{flow } \times \text{pressure: } \frac{m^3}{\text{sec}} \cdot \frac{N}{m^3} = \frac{m}{\text{sec}} \cdot \frac{N}{m^2} = \frac{Joule}{\text{sec}} = W = \text{power} \]

Same for electricity. Power: \[ P = I \cdot V \]

Power dissipated by resistors: \[ P = V \cdot I = \frac{V^2}{R} = I^2 \cdot R \]

**Series Resistors**

![Series Resistors](image)

Resistors are in series if and only if exactly the **same current** flows through each resistor.

**Parallel Resistors**

![Parallel Resistors](image)

Resistors are in parallel if and only if the **same voltage** is across each resistor.
All resistor-only networks can be reduced to a single equivalent, but not always by means of series and parallel concepts.

**Voltage Divider**

**Series:**

\[ R_{eq} = R_1 + R_2 + R_3 + \ldots \]

Exactly the same current through each resistor

**Voltage divider:**

\[ V_{Rn} = V_{total} \frac{R_n}{R_1 + R_2 + R_3 + \ldots} \]

**Current Divider**

**Parallel:**

\[ R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots} \]

Exactly the same voltage across each resistor

**Current divider:**

\[ I_{Rn} = I_{total} \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots} \]

May have to combine some resistors first to get series and parallel resistors to use with divider expressions.
Resistors

\[ V = I \times R \]

Sources

- **Battery**
  \[ V = I \times R \]

- **Cell**

  Less intuitive, less like sources we are used to seeing.

Ground

- Ground is considered zero volts and is a reference for other voltages.
Nodes & Branches

**Node** = all points connected by wire, all at same voltage (potential)

**Branch** = all parts with the same current

---

Meters

- **Voltmeter**
- **Ammeter**
- **Ohmmeter**

Ideally:
- Voltmeter: open
- Ammeter: short

---

**Analog meters**

- Multimeter

- Voltmeter

- Ammeter

- Ohmmeter

---

**Digital meter**

- Probes

- Input & Range Selection

- Sample and Hold

- Analog to Digital Converter

- Display
There are a number of lockers on the 2nd floor of the MEB, in the center hallway. These lockers have slots cut in their doors so that homework and lab notebooks can be dropped through the slots. Turn in your homework in the locker marked "ECE 2210/00 Homework". (Sometimes lockers are separated as "ECE 2200 Homework" and "ECE 2210 Homework", look carefully the first time.) Homework is due by 5:00 p.m. on the due date.

The following problems are not meant to be hard. You should be able to do most of them in your head with no special formulas or calculations. In fact you should find them rather dumb and trivial. That's the point, I want to drill these concepts into your head so that you'll find them easy.

1. The figure at right shows a hydraulic system with a pump that converts rotational energy to fluid energy and two turbines which convert that energy back to rotational energy. Do NOT assume that the turbines are equal in size. This is a closed system containing an incompressible fluid with no places for that fluid to collect; i.e. flow in = flow out of any point or object. Kirchhoff's current law applies. The volumetric fluid flows are indicated by the arrows.

\[ I_1 = 0.01 \, \text{m}^3/\text{s} \quad I_2 = 0.007 \, \text{m}^3/\text{s} \]

\[ I_3 = \quad \quad I_4 = \quad \quad I_5 = \quad \quad I_6 = \quad \quad \]

2. The figure at right shows an electrical circuit with a battery that converts chemical energy to electrical energy and two resistors which convert that electrical energy to heat energy. Do NOT assume that the resistors are equal in size. All electrical circuits are closed systems containing incompressible charges with no places for those charges to collect; i.e. flow in = flow out of any point or object. Kirchhoff's current law applies. The electrical currents are indicated by the arrows.

\[ I_1 = 0.01 \, \text{A} \quad I_2 = 0.007 \, \text{A} \]

\[ I_3 = \quad \quad I_4 = \quad \quad I_5 = \quad \quad I_6 = \quad \quad \]

3. The figure at right shows a similar electrical circuit only now the electrical currents are indicated by the arrows next to the wires. This is a more common way to show the current flow because a little arrow in the wire is too easily confused with the electrical symbol for a diode. You'll learn about diodes later.

\[ I_2 = 20 \, \text{mA} \quad I_5 = 14 \, \text{mA} \]

\[ I_6 = \quad \quad I_1 = \quad \quad I_3 = \quad \quad I_4 = \quad \quad \]

4. 

\[ I_3 = 0.004 \, \text{m}^3/\text{s} \quad I_5 = 0.001 \, \text{m}^3/\text{s} \]

\[ I_4 = \quad \quad I_2 = \quad \quad I_1 = \quad \quad I_6 = \quad \quad \]

\[ I_7 = \quad \quad I_8 = \quad \quad \]
5. \[ I_3 = 4.5 \text{ mA} \quad I_5 = 1.2 \text{ mA} \quad I_4 = \_\_\_\_\_ \]
   \[ I_2 = \_\_\_\_\_ \quad I_1 = \_\_\_\_\_ \quad I_6 = \_\_\_\_\_ \]
   \[ I_7 = \_\_\_\_\_ \quad I_8 = \_\_\_\_\_ \]

6. Again, a similar electrical circuit with the electrical current arrows in the more common position, next to the wires.
   \[ I_6 = 0.03 \text{ A} \quad I_7 = 0.08 \text{ A} \quad I_8 = \_\_\_\_\_ \]
   \[ I_1 = \_\_\_\_\_ \quad I_2 = \_\_\_\_\_ \quad I_3 = \_\_\_\_\_ \]
   \[ I_4 = \_\_\_\_\_ \quad I_5 = \_\_\_\_\_ \]

7. \[ I_9 = 0.04 \text{ m}^3/s \]
   \[ I_1 = \_\_\_\_\_ \quad I_2 = \_\_\_\_\_ \]
   \[ I_3 = \_\_\_\_\_ \quad I_4 = \_\_\_\_\_ \quad I_5 = \_\_\_\_\_ \]
   \[ I_6 = \_\_\_\_\_ \quad I_7 = \_\_\_\_\_ \quad I_8 = \_\_\_\_\_ \quad I_7 = \_\_\_\_\_ \quad I_{10} = \_\_\_\_\_ \]

8. \[ I_9 = 0.06 \text{ A} \]
   \[ I_1 = \_\_\_\_\_ \quad I_2 = \_\_\_\_\_ \]
   \[ I_3 = \_\_\_\_\_ \quad I_4 = \_\_\_\_\_ \quad I_5 = \_\_\_\_\_ \]
   \[ I_6 = \_\_\_\_\_ \quad I_7 = \_\_\_\_\_ \quad I_8 = \_\_\_\_\_ \quad I_7 = \_\_\_\_\_ \quad I_{10} = \_\_\_\_\_ \]

9. \[ I_4 = 0.05 \text{ m}^3/s \quad I_5 = 0.014 \text{ m}^3/s \quad I_6 = 0.03 \text{ m}^3/s \]
   \[ I_1 = \_\_\_\_\_ \quad I_2 = \_\_\_\_\_ \]
   \[ I_3 = \_\_\_\_\_ \quad I_7 = \_\_\_\_\_ \]
10. I_4 = 20 mA  I_5 = 10 mA  I_6 = 22 mA

I_1 = ________  I_2 = ________
I_3 = ________  I_7 = ________

11. Careful here, there are now two pumps. Also, given the flow arrows shown, one or more of the flows must come out negative.

I_2 = 0.005 m^3/s  I_6 = 0.03 m^3/s  I_7 = 0.015 m^3/s

I_1 = ________  I_3 = ________
I_4 = ________  I_5 = ________

12. What does a negative fluid flow physically mean?

13. I_1 = 0.01 A  I_5 = -20 mA  I_6 = 35 mA

I_2 = ________  I_3 = ________
I_4 = ________  I_7 = ________

14. What does a negative electrical current physically mean?

15. I_4 = 0.05 m^3/s  I_5 = 0.03 m^3/s  I_7 = 0.045 m^3/s

I_9 = 0.06 m^3/s

I_1 = ________
I_2 = ________  I_3 = ________
I_6 = ________  I_8 = ________
I_{10} = ________  I_{11} = ________
16. I\textsubscript{1} := 100-mA \quad I\textsubscript{2} := 50-mA \quad I\textsubscript{3} := 30-mA
\begin{align*}
I\textsubscript{6} := 66-mA & \quad I\textsubscript{4} = \underline{\hspace{2cm}} \\
I\textsubscript{5} = \underline{\hspace{2cm}} & \quad I\textsubscript{7} = \underline{\hspace{2cm}} \\
I\textsubscript{8} = \underline{\hspace{2cm}} & \quad I\textsubscript{9} = \underline{\hspace{2cm}} \\
I\textsubscript{10} = \underline{\hspace{2cm}} & \quad I\textsubscript{11} = \underline{\hspace{2cm}}
\end{align*}

17. The figure at right shows the pressure differentials across elements in a hydraulic system. The side indicated by the + sign is the higher pressure side. Conversely, - indicates the lower pressure. \(\Delta P\textsubscript{S}\) is the pressure difference supplied by the pump (S for Source). \(\Delta P\textsubscript{2}\) is the pressure difference driving the left turbine and \(\Delta P\textsubscript{4}\) is the pressure difference driving the right turbine. Assume no pressure losses or discontinuities in the pipes, joints, or corners; i.e. all connected pipes are at exactly the same pressure. Finally, the fluid has no mass, so gravity and Bernoulli can go take a hike.

\begin{align*}
\Delta P\textsubscript{S} := 12-N/m^2 & = 12-Pa & \Delta P\textsubscript{2} = \underline{\hspace{2cm}} & \Delta P\textsubscript{4} = \underline{\hspace{2cm}}
\end{align*}

Yes, I know that these are ridiculously low pressures for a hydraulic system.

18. The figure at right shows the voltage differentials across elements in an electrical circuit. The side indicated by the + sign is the higher voltage side. Conversely, - indicates the lower voltage. \(V\textsubscript{S}\) is the voltage supplied by the battery. \(V\textsubscript{2}\) is the voltage across the left resistor and \(V\textsubscript{4}\) is the voltage across the right resistor. You may assume no voltage drops across any of the wires or connections in practically \textit{all} electrical schematics; i.e. all connected wires are at exactly the same voltage (electrical potential).

\begin{align*}
V\textsubscript{S} := 12-V & \quad (V = \text{volts}) & V\textsubscript{2} = \underline{\hspace{2cm}} & V\textsubscript{4} = \underline{\hspace{2cm}}
\end{align*}

19. \(\Delta P\textsubscript{S} := 400-kPa\) \quad \(\Delta P\textsubscript{1} := 180-kPa\) \quad \(\Delta P\textsubscript{3} := 100-kPa\)
\begin{align*}
\Delta P\textsubscript{5} = \underline{\hspace{2cm}} & \quad \Delta P\textsubscript{7} = \underline{\hspace{2cm}}
\end{align*}

20. \(V\textsubscript{1} := 10-V\) \quad \(V\textsubscript{5} := 3-V\) \quad \(V\textsubscript{7} := 2-V\)
\begin{align*}
V\textsubscript{S} = \underline{\hspace{2cm}} & \quad V\textsubscript{3} = \underline{\hspace{2cm}}
\end{align*}
21. \[ \Delta P_{S1} := 200 \text{ kPa} \]
   \[ \Delta P_2 := 50 \text{ kPa} \]
   \[ \Delta P_4 = \quad \] \[ \Delta P_7 = \quad \]

22. \[ V_{S1} := 6 \text{ V} \]
   \[ V_2 := 2 \text{ V} \]
   \[ V_6 := 2.4 \text{ V} \]
   \[ V_7 := 3.2 \text{ V} \]
   \[ V_{S2} = \quad \] \[ V_4 = \quad \]

23. \[ \Delta P_3 := 120 \text{ kPa} \]
   \[ \Delta P_4 := 80 \text{ kPa} \]
   \[ \Delta P_6 := 110 \text{ kPa} \]
   \[ \Delta P_S = \quad \] \[ \Delta P_2 = \quad \]
   \[ \Delta P_5 = \quad \]

24. What does a negative pressure difference physically mean?

25. \[ V_3 := 2.3 \text{ V} \]
   \[ V_5 := 0.5 \text{ V} \]
   \[ V_6 := 3.2 \text{ V} \]
   \[ V_S = \quad \] \[ V_2 = \quad \]
   \[ V_4 = \quad \]

26. Watch your + and - signs very carefully now.

27. \[ V_{S1} := 14 \text{ V} \]
   \[ V_{S2} := 3 \text{ V} \]
   \[ V_2 := 6 \text{ V} \]
   \[ V_3 := 4 \text{ V} \]
   \[ V_4 = \quad \] \[ V_5 = \quad \]
   \[ V_6 = \quad \]
   Think about the current through the 2nd battery. What is happening to that battery?
ΔP_1 := 200-kPa
ΔP_2 := 1100-kPa
ΔP_3 := 600-kPa
ΔP_9 := 1800-kPa

ΔP_S = 
ΔP_4 = 

ΔP_5 = 
ΔP_6 = 

ΔP_10 = 

V_S := 18-V 
V_3 := 6-V 
V_4 := 8-V 
V_5 := 2-V

V_1 = 
V_2 = 

V_6 = 
V_9 = 

V_10 = 

Answers
1. I_3 = I_4 = I_5 := 0.003-m^3/s, I_6 := 0.01-m^3/s
2. I_3 = I_4 = I_5 := 0.003-A, I_6 := 0.01-A
3. I_6 = I_1 := 34-mA, I_3 = I_4 := 14-mA
4. I_4 = I_6 := 0.001-m^3/s , I_1 = I_2 = I_7 = I_8 := 0.005-m^3/s
5. I_4 = I_6 := 1.2-mA, I_1 = I_2 = I_7 = I_8 := 5.7-mA
6. I_1 = I_2 = I_8 := 80-mA, I_3 = 50-mA, I_4 = I_5 := 30-mA
7. I_1 = I_2 = I_4 = I_5 := 0-m^3/s, I_2 = I_3 = I_7 = I_8 := 0.04-m^3/s
8. I_1 = I_10 = I_4 = I_5 := 0-A, I_2 = I_3 = I_7 = I_8 := 0.06-A
9. I_1 = I_7 := 0.080-m^3/s, I_2 := 0.016-m^3/s, I_3 := 0.064-m^3/s
10. I_1 = I_7 := 42-mA, I_2 := 12-mA, I_3 := 30-mA
11. I_1 := 0.015-m^3/s, I_3 := 0.010-m^3/s, I_4 := 0.045-m^3/s, I_5 := 0.035-m^3/s
12. Actual flow is in direction opposite to the arrow direction.
13. "
14. "
15. I_1 := 0.155-m^3/s, I_2 := 0.15-m^3/s, I_3 := 0.080-m^3/s, I_6 := 0.045-m^3/s, I_8 := 0.095-m^3/s, I_10 := 0.035-m^3/s, I_11 := 0.060-m^3/s
17. ΔP_2 := ΔP_4 := 12-Pa
18. V_2 := V_4 := 12-V
19. ΔP_5 := 100-kPa, ΔP_7 := 120-kPa
20. V_S := 15-V, V_3 := 3-V
21. ΔP_4 := 0-kPa, ΔP_7 := 40-kPa
22. V_S := 7.6-V, V_4 := 0-V
23. ΔP_5 := 200-kPa, ΔP_2 := 90-kPa, ΔP_5 := 30-kPa
24. The actual + & - should be reversed from those on drawing
25. V_S := 6-V, V_2 := 2.8-V, V_4 := 3.7-V
26. ΔP_S1 := 280-kPa, ΔP_S2 := 350-kPa, ΔP_5 := 90-kPa
27. V_4 := 10-V, V_5 := 2-V, V_6 := -5-V battery is charging
28. ΔP_S := 2000-kPa, ΔP_4 := 1200-kPa, ΔP_5 := 500-kPa
29. V_1 := 4-V, V_2 := 8-V, V_6 := 6-V, V_9 := 14-V, V_10 := 0-V
1. Ohm's law
   Consider the figure at right.
   For each of the cases below, find the missing value.

   ![Ohm's Law Diagram]

   a) $I = 0.01\,\text{A}$  $V_R = 4\,\text{V}$  $R = ?$

   b) $I = 50\,\text{mA}$  $R = 560\,\Omega$  $V_R = ?$

   c) $V_R = 12\,\text{V}$  $R = 1.5\,\text{k}\Omega$  $I = ?$

2. Power and Ohm's law. Same circuit as above. For each of the cases below, find the missing values.

   a) $I = 5\,\text{mA}$  $R = 2\,\text{k}\Omega$  $V_R = \quad \quad \quad P_R =$

   b) $V_R = 25\,\text{V}$  $R = 100\,\Omega$  $I = \quad \quad \quad P_R =$

   c) $V_R = 20\,\text{V}$  $I = 0.01\,\text{A}$  $R = \quad \quad \quad P_R =$

   Ignore the fact that the following items run on AC

   d) $P_R = 900\,\text{W}$  $V_R = 120\,\text{V}$  $I = \quad \quad \quad R =$

   e) $P_R = 1500\,\text{W}$  $R = 9.6\,\Omega$  $I = \quad \quad \quad V_S =$

   f) $P_R = 2500\,\text{W}$  $I = 10.5\,\text{A}$  $R = \quad \quad \quad V_S =$

3. Find the equivalent resistance of each of these networks, i.e. what would an ohmmeter read if hooked to the terminals.

   ![Resistor Network Diagram]

   a) $R_1 = 1.8\,\text{k}\Omega$  $R_2 = 1.0\,\text{k}\Omega$  $R_3 = 2.5\,\text{k}\Omega$  $R_4 = 5.6\,\text{k}\Omega$
b) \[ R_2 = 2.2 \text{k}\Omega \]
\[ R_1 = 1.5 \text{k}\Omega \]
\[ R_3 = 900 \Omega \]
\[ R_4 = 3 \text{k}\Omega \]

c) \[ R_1 = 120 \Omega \]
\[ R_2 = 80 \Omega \]
\[ R_3 = 80 \Omega \]

d) \[ R_1 = 110 \text{k}\Omega \]
\[ R_2 = 68 \text{k}\Omega \]
\[ R_3 = 82 \text{k}\Omega \]

e) \[ R_1 = 150 \Omega \]
\[ R_2 = 56 \Omega \]
\[ R_3 = 22 \Omega \]

Don't forget: Write your folder number in the upper-left corner of your homework.

Answers
1. a) \[ R = 400 \Omega \]
   b) \[ V_R = 28 \text{V} \]
   c) \[ I = 8 \text{mA} \]
2. a) \[ V_R = 10 \text{V} \]
   b) \[ I = 0.25 \text{A} \]
   c) \[ R = 2.0 \text{k}\Omega \]
   d) \[ I = 7.5 \text{A} \]
   e) \[ I = 12.5 \text{A} \]
   f) \[ R = 22.7 \text{k}\Omega \]
3. a) \[ R_{eq} = 10.9 \text{k}\Omega \]
   b) \[ R_{eq} = 390 \Omega \]
   c) \[ R_{eq} = 160 \Omega \]
   d) \[ R_{eq} = 81 \text{k}\Omega \]
   e) \[ R_{eq} = 51.3 \Omega \]
   f) \[ V_S = 238 \text{V} \]