ECE 2210
Electrical Engineering for Nonmajors
Spring 2019 Class Syllabus

Instructor: Arn Stolp
Office: MEB 2262
Phone: U of U: 581-4205
Only if it’s important: Cell: (801) 657-7766
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. I’m usually around until at least 2:00 p.m. M, W, & F. If I’m not in my office, check the lab. To increase your chances, talk to me in class to say when you’d like to see me. I teach another class right after this one M, W, F.

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

Required books and lab supplies:
Practical Electronics for Inventors, 3rd or 4th Ed, by Paul Scherz
6 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 2220

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 2210 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 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 (in place of class handouts):
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/). 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:  100 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 a 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 location, simply remove your file and slip it under my office door.

**Midterms:**

You will take three 50-minute midterms throughout the semester. They 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:** Thursday, 4/25/19, 8:00 -10am

The final will be comprehensive with greater emphasis on the most recent material. There will be a review Wednesday, 4/24, 1:00pm probably in WEB L103, listen in class for details.

**Labs:** MEB 2265

Lab will be held every week, beginning the second week and including the last week of class. 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.

Two labs will be replaced by a special lecture during lab time.

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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<th>Pts</th>
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<td>Homework</td>
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<td>Labs</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: Friday, January 18, January 11 for session I). Late adds will be allowed January 19-28, 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 Friday, January 18, 2019.

Withdrawal from Full Term Length Classes
Students may WITHDRAW from classes without professor’s permission until Friday, March 8, 2019. Between January 19 and March 8, a “W” will appear on the transcript AND tuition will be charged. Refer to Class Schedule, Tuition and Fees for tuition information.
Withdrawals after March 8 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 (April 23, 2019).

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,
# ECE 2210 Spring 2019 Course Schedule

**Tentative COURSE SCHEDULE**

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<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Lect</th>
<th>Topics</th>
<th>Textbook (3rd ed.)</th>
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<td>Introduction, Basic electrical units &amp; symbols, Kirchhoff's laws</td>
<td>Ch1, 2.1-3, 2.17</td>
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<td>01/11</td>
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<td>Resistance, Ohm's law, Power, Resistors in parallel &amp; series</td>
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<td>01/16</td>
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<td>Voltage and current dividers, Sources, Nodes, Grounds, Branches, Meters</td>
<td>2.10, 2.12-16, 2.18, 3.2</td>
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<td>Superposition, Practical voltage and current sources</td>
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<td>01/21</td>
<td>5</td>
<td>Martin Luther King Day</td>
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<td>W 01/23</td>
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<td>01/30</td>
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<td>Networks, Nodal analysis</td>
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<td>Introduction to AC &amp; Signals</td>
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<td>02/06</td>
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<td>Capacitors, RC first order transients</td>
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<td>Inductors, Resonance, RL first order transients</td>
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<td>Diodes basics, Diodes in DC circuits</td>
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<td>Diodes in AC circuits, Rectification</td>
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<td>Diodes, Transistors</td>
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<td>Transistors &amp; Switching circuits</td>
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<td>Operational Amplifiers</td>
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<td>04/17</td>
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<td>RMS and AC Power</td>
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<td>ME Design Day in Union ballroom, Attendance is required for HW DD</td>
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<td>AC Power, Transformers</td>
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<td>04/22</td>
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<td>Problem Session at normal class time</td>
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<td>Problem Session at normal class time / Review, 1:00pm in___________</td>
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<td>Final Exam, 8:00am</td>
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<td>9 Mar</td>
<td>4</td>
<td>5 Lab lectures 10:45 &amp; 2:00</td>
<td>6 Exam 2 Lab lecture 12:00</td>
<td>7 Lab lecture 8:30 Lab lecture 3:05</td>
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<td>Exam Review 4:00</td>
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<td>9 Lab lectures 10:45 &amp; 2:00 Exam Review 4:00</td>
<td>10 2210 Exam 3 Lab lecture 12:00</td>
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<td>29 ME 2650 8:00</td>
<td>30 ME 2650 8:00</td>
<td>1 ME 2550, 3610-2 8:00 ME 2010, 3300 10:30</td>
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Note: Check these final dates and times for yourself.
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ECE 2210 Spring Semester, 2019  Homeworks & Labs
ECE 2200/10 Lecture 1 Introduction to Electrical Engineering for non-majors

A. Stolp
12/30/11
8/24/15

2200 = 1/2 semester (Civil, Mining)
ECE 2200 Without the Physics is hard, Plan on it!
Decide today when you will take the FINAL:
   Bad 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 ______ (see map for location of lockers)
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>Letter used</th>
<th>Units</th>
<th>Fluid Analogy</th>
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</thead>
<tbody>
<tr>
<td>Q</td>
<td>Coulomb (C)</td>
<td>(\text{m}^3)</td>
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<tr>
<td>I (= \frac{Q}{\text{sec}})</td>
<td>Amp (A, mA, (\mu\text{A},...))</td>
<td>(\text{m}^3) (\text{sec}^{-1})</td>
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<tr>
<td>V or E</td>
<td>volt (V, mV, kV,...)</td>
<td>(\text{Pa} = 1 \cdot \frac{N}{\text{m}^2})</td>
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<td>R (= \frac{V}{I})</td>
<td>Ohm ((\Omega, \text{k}\Omega, \text{M}\Omega,...))</td>
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<tr>
<td>G (= \frac{1}{R})</td>
<td>Siemens (S, also mho, old unit)</td>
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</tr>
<tr>
<td>P = V \cdot I</td>
<td>Watt (W, mW, kW, MW,...)</td>
<td>W</td>
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</tbody>
</table>

Symbols (ideal)

- Node = All points connected by wire
- not connected

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

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

\[ \begin{align*}
I_1 &= I_3 \\
I_1 + I_2 &= I_3 + I_4
\end{align*} \]

Conductors

- 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

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

\[ V_{\text{gains}} = V_{\text{drops}} \] around any loop
Ohm's law (resistors)

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

\[ V = I \cdot R \]

Power

flow \( \frac{m^3}{\text{sec}} \) pressure \( \frac{N}{m^3} \) flow x pressure: \( \frac{m^3}{\text{sec}} \cdot \frac{N}{m^3} = \frac{m}{\text{sec}} \cdot \frac{N}{1} = \frac{N \cdot m}{\text{sec}} = \text{Joule} = W = \text{power} \)

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

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

Parallel Resistors

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:

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

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

\[ R = \frac{1}{\text{slope}} = \frac{\Delta V}{\Delta I} \]

Sources

Battery

\[ \frac{+}{-} \quad \text{or} \quad \frac{+}{-} \quad V_S \]

Voltage sources

Battery Cell

Current source

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

R → infinity
Voltmeter

R → 0
Ammeter

Ohmmeter

ideally:

Voltmeter

Ammeter

Open

Short

Analog meters

Multimeter

Voltmeter

Ammeter

Ohmmeter

Digital meter

Probes

Input & Range Selection

Sample and Hold

Analog to Digital Converter

Display

ECE 2210 Lectures 2 & 3 notes p4
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.

\[
I_1 = 0.01 \text{ m}^3\text{s}^{-1}, \quad I_2 = 0.007 \text{ m}^3\text{s}^{-1}
\]

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

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.

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

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

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.

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

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

4. \[
I_3 = 0.004 \text{ m}^3\text{s}^{-1}, \quad I_5 = 0.001 \text{ m}^3\text{s}^{-1}, \quad I_4 = \]

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

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

6. Again, a similar electrical circuit with the electrical current arrows in the more common position, next to the wires.

\[ I_6 = 0.03 \text{ A} \quad I_7 = 0.08 \text{ A} \quad I_8 = \ldots \]
\[ I_1 = \ldots \quad I_2 = \ldots \quad I_3 = \ldots \]
\[ I_4 = \ldots \quad I_5 = \ldots \]

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

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

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

\[ I_1 = \ldots \quad I_2 = \ldots \]
\[ I_3 = \ldots \quad I_7 = \ldots \]

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

\[ I_2 = 0.005\text{m}^3\text{s}^{-1} \quad I_6 = 0.03\text{m}^3\text{s}^{-1} \quad I_7 = 0.015\text{m}^3\text{s}^{-1} \]

\[ I_1 = \ldots \quad I_3 = \ldots \]
\[ I_4 = \ldots \quad I_5 = \ldots \]

12. What does a negative fluid flow physically mean?

13. \[ I_1 = 0.01\text{A} \quad I_5 = -20\text{mA} \quad I_6 = 35\text{mA} \]

\[ I_2 = \ldots \quad I_3 = \ldots \]
\[ I_4 = \ldots \quad I_7 = \ldots \]

14. What does a negative electrical current physically mean?

15. \[ I_4 = 0.05\text{m}^3\text{s}^{-1} \quad I_5 = 0.03\text{m}^3\text{s}^{-1} \quad I_7 = 0.045\text{m}^3\text{s}^{-1} \]

\[ I_9 = 0.06\text{m}^3\text{s}^{-1} \quad I_1 = \ldots \]
\[ I_2 = \ldots \quad I_3 = \ldots \]
\[ I_6 = \ldots \quad I_8 = \ldots \]
\[ I_{10} = \ldots \quad I_{11} = \ldots \]
16.  
\[
\begin{align*}
I_1 &:= 100 \text{-mA} \\
I_2 &:= 50 \text{-mA} \\
I_3 &:= 30 \text{-mA} \\
I_4 &:= \_\_\_\_\_\_ \\
I_5 &:= \_\_\_\_\_\_ \\
I_6 &:= 66 \text{-mA} \\
I_7 &:= \_\_\_\_\_\_ \\
I_8 &:= \_\_\_\_\_\_ \\
I_9 &:= \_\_\_\_\_\_ \\
I_{10} &:= \_\_\_\_\_\_ \\
I_{11} &:= \_\_\_\_\_\_ \\
\end{align*}
\]

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. $\Delta P_S$ is the pressure difference supplied by the pump (S for Source). $\Delta P_2$ is the pressure difference driving the left turbine and $\Delta P_4$ 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.

\[
\begin{align*}
\Delta P_S &:= 12 \frac{N}{m^2} = 12 \text{ Pa} \\
\Delta P_2 &= \_\_\_\_\_\_ \\
\Delta P_4 &= \_\_\_\_\_\_ \\
\end{align*}
\]

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. $V_S$ is the voltage supplied by the battery. $V_2$ is the voltage across the left resistor and $V_4$ is the voltage across the right resistor. You may assume no voltage drops across any of the wires or connections in practically all electrical schematics; i.e. all connected wires are at exactly the same voltage (electrical potential).

\[
\begin{align*}
V_S &:= 12 \text{ V} \quad (V = \text{volts}) \\
V_2 &= \_\_\_\_\_\_ \\
V_4 &= \_\_\_\_\_\_ \\
\end{align*}
\]

19.  
\[
\begin{align*}
\Delta P_S &:= 400 \text{-kPa} \\
\Delta P_1 &:= 180 \text{-kPa} \\
\Delta P_3 &:= 100 \text{-kPa} \\
\Delta P_5 &= \_\_\_\_\_\_ \\
\Delta P_7 &= \_\_\_\_\_\_ \\
\end{align*}
\]

20.  
\[
\begin{align*}
V_1 &:= 10 \text{-V} \\
V_5 &:= 3 \text{-V} \\
V_7 &:= 2 \text{-V} \\
V_S &= \_\_\_\_\_\_ \\
V_3 &= \_\_\_\_\_\_ \\
\end{align*}
\]
21. 
\[ \Delta P_{S1} := 200 \text{kPa} \quad \Delta P_{S2} := 150 \text{kPa} \]
\[ \Delta P_2 := 50 \text{kPa} \quad \Delta P_6 := 60 \text{kPa} \]
\[ \Delta P_4 = \text{_________} \quad \Delta P_7 = \text{_________} \]

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

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

24. What does a negative pressure difference physically mean?

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

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

27. 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_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\frac{m^3}{s}, I_6 := 0.01\frac{m^3}{s}
2. I_3 = I_4 = I_5 := 0.003\cdot A, I_6 := 0.01\cdot A

3. I_6 = I_1 := 34-mA, I_3 = I_4 := 14-mA
4. I_4 = I_6 := 0.001\frac{m^3}{s}, I_1 = I_2 = I_7 = I_8 := 0.005\frac{m^3}{s}

5. I_4 := 1.2\cdot mA, I_1 = I_2 = I_7 = I_8 := 5.7\cdot mA
6. I_1 = I_2 = I_8 := 80\cdot mA, I_3 = 50\cdot mA, I_4 = I_5 := 30\cdot mA

7. I_1 = 10 = I_4 = I_5 := 0.04\frac{m^3}{s}, I_2 = I_3 = I_7 = I_8 := 0.04\frac{m^3}{s}
8. I_1 = I_10 = I_4 = I_5 := 0.0-A, I_2 = I_3 = I_7 = I_8 := 0.06-A

9. I_1 := 0.080\frac{m^3}{s}, I_2 := 0.016\frac{m^3}{s}, I_3 := 0.064\frac{m^3}{s}
10. I_1 := 0.07 := 42\cdot mA, I_2 := 12\cdot mA, I_3 := 30\cdot mA

11. I_1 := 0.015\frac{m^3}{s}, I_3 := 0.010\frac{m^3}{s}, I_4 := 0.045\frac{m^3}{s}, I_5 := 0.035\frac{m^3}{s}
12. Actual flow is in direction opposite to the arrow direction.

13. I_2 := -15\cdot mA, I_3 := 25\cdot mA, I_4 := 45\cdot mA, I_7 := 10\cdot mA
14. "

15. I_1 := 0.155\frac{m^3}{s}, I_2 := 0.015\frac{m^3}{s}, I_3 := 0.080\frac{m^3}{s}, I_6 := 0.045\frac{m^3}{s}, I_8 := 0.095\frac{m^3}{s}, I_10 := 0.0\frac{m^3}{s}, I_11 := 0.060\frac{m^3}{s}
16. I_4 := 14\cdot mA, I_5 := 16\cdot mA, I_7 := 66\cdot mA, I_8 := 80\cdot mA, I_9 := 20\cdot mA, I_10 := 0\cdot mA, I_11 := 20\cdot mA

17. \Delta P_2 = \Delta P_4 := 12\cdot Pa
18. V_2 = V_4 := 12\cdot V

19. \Delta P_5 := 100\cdot kPa, \Delta P_7 := 120\cdot kPa
20. V_S := 15\cdot V, V_3 := 3\cdot V

21. \Delta P_4 := 0\cdot kPa, \Delta P_7 := 40\cdot kPa
22. V_S := 7.6\cdot V, V_4 := 0\cdot V

23. \Delta P_3 := 200\cdot kPa, \Delta P_2 := 90\cdot kPa, \Delta P_5 := 30\cdot kPa
24. The actual + & - should be reversed from those on drawing

25. V_S := 6\cdot V, V_2 := 2.8\cdot V, V_4 := 3.7\cdot V
26. \Delta P_{S_1} := 280\cdot kPa, \Delta P_{S_2} := 350\cdot kPa, \Delta P_5 := 90\cdot kPa

27. V_4 := 10\cdot V, V_5 := 2\cdot V, V_6 := -5\cdot V battery is charging
28. \Delta P_{S_1} := 2000\cdot kPa, \Delta P_4 := 1200\cdot kPa, \Delta P_5 := 500\cdot kPa, \Delta P_6 := 700\cdot kPa, \Delta P_{10} := 0\cdot kPa

29. V_1 := 4\cdot V, V_2 := 8\cdot V, V_6 := 6\cdot V, V_9 := 14\cdot V, V_{10} := 0\cdot V
1. Ohm's law
Consider the figure at right
For each of the cases below, find the missing value.

\[ V_S = 4 \text{ V} \quad V_R = 4 \text{ V} \quad R = ? \]

\[ I = 0.01 \text{ A} \quad V_R = 4 \text{ V} \quad R = ? \]

\[ V_R = 12 \text{ V} \quad R = 1.5 \text{ k}\Omega \quad I = ? \]

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

\[ I = 5 \text{ mA} \quad R = 2 \text{ k}\Omega \quad V_R = \quad P_R = \]

\[ V_R = 25 \text{ V} \quad R = 100 \text{ \Omega} \quad I = \quad P_R = \]

\[ V_R = 20 \text{ V} \quad I = 0.01 \text{ A} \quad R = \quad P_R = \]

Ignore the fact that the following items run on AC

\[ P_R = 900 \text{ W} \quad V_R = 120 \text{ V} \quad I = \quad R = \]

\[ P_R = 1500 \text{ W} \quad R = 9.6 \text{ \Omega} \quad I = \quad V_S = \]

\[ P_R = 2500 \text{ W} \quad I = 10.5 \text{ A} \quad R = \quad V_S = \]

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

\[ R_1 = 1.8 \text{ k}\Omega \quad R_2 = 1.0 \text{ k}\Omega \quad R_3 = 2.5 \text{ k}\Omega \quad R_4 = 5.6 \text{ k}\Omega \]
Don't forget: Write your folder number in the upper-left corner of your homework.

Answers

1. a) $R = 400 \, \Omega$
   b) $V_R = 28 \, V$
   c) $I = 8 \, mA$

2. a) $V_R = 10 \, V$ $P_R = 50 \, mW$
   b) $I = 0.25 \, A$ $P_R = 6.25 \, W$
   c) $R = 2.0 \, k\Omega$ $P_R = 200 \, mW$
   d) $I = 7.5 \, A$ $R = 16 \, \Omega$
   e) $I = 12.5 \, A$ $V_S = 120 \, V$
   f) $R = 22.7 \, \Omega$ $V_S = 238 \, V$

3. a) $R_{eq} = 10.9 \, k\Omega$
   b) $R_{eq} = 390 \, \Omega$
   c) $R_{eq} = 160 \, \Omega$
   d) $R_{eq} = 81 \, k\Omega$
   e) $R_{eq} = 51.3 \, \Omega$