# ENGG1300
# Introduction to Electrical Systems
# Week 1

Lecturers:

Dr Philip Terrill, p.terrill@uq.edu.au

# Lecturer

- Dr Philip Terrill – Course Coordinator & Lecturer
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  - Consultation by appointment

# ENGG1300 – Why?

- Foundation course for those continuing in Electrical Engineering and Mechatronics.
- Compulsory course for mechanical and software engineers – gives you basic knowledge of circuits.
- Elective for other engineers/scientists – gives you an appreciation of electric circuits & systems.

- Designed to be both a “first” and a “last” course in electrical engineering

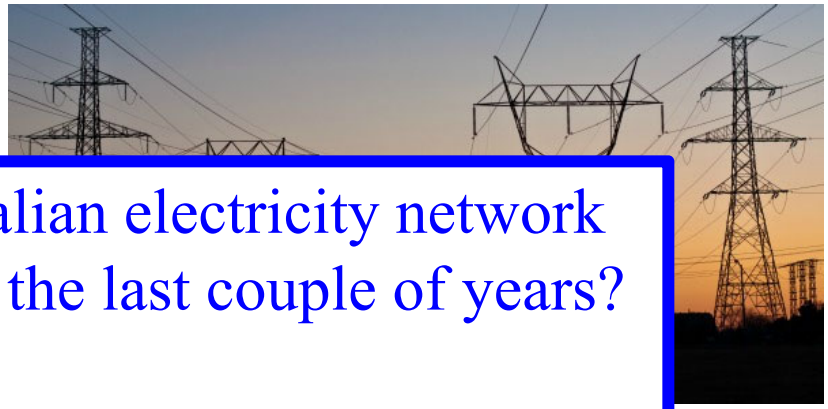
- **Who do we have in the class?**

# ENGG1300 – What is it about?

- Circuit Theory – calculating the operating conditions (voltage, current) of an electric circuit, including:
  - DC Circuits, where currents and voltages are constant
  - AC Circuits, where currents and voltages vary with time. These include:
    - AC power supply circuits,
    - Multimedia signals such as audio and video represented by time-varying voltages.
  - Models of circuit behaviour
    - And, how well these models predict the behaviour of our circuits in the "real world"
    - Lab work to compare models to actual behaviour first hand

# ENGG1300 – What is it about?

**Power & Energy Systems**: which are responsible for delivering domestic and commercial energy, including newer renewable energy sources.



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Why have parts of the Australian electricity network suffering power outages over the last couple of years?

Are renewables the problem or the solution?

How do we fix it?

http://econews.com.au/news-to-sustain-our-world/qld-algae-experiment-may-lower-carbon-emissions/

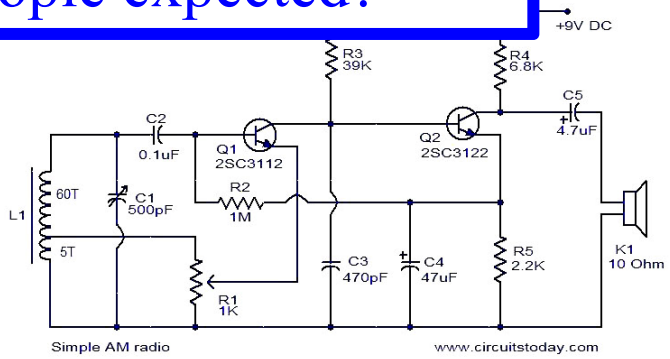
# ENGG1300 – What is it about?

**Communication Systems**: How information, such as audio, video, telephony, is represented, stored and transmitted electrically


What is the speed limiting part of the national broadband network?

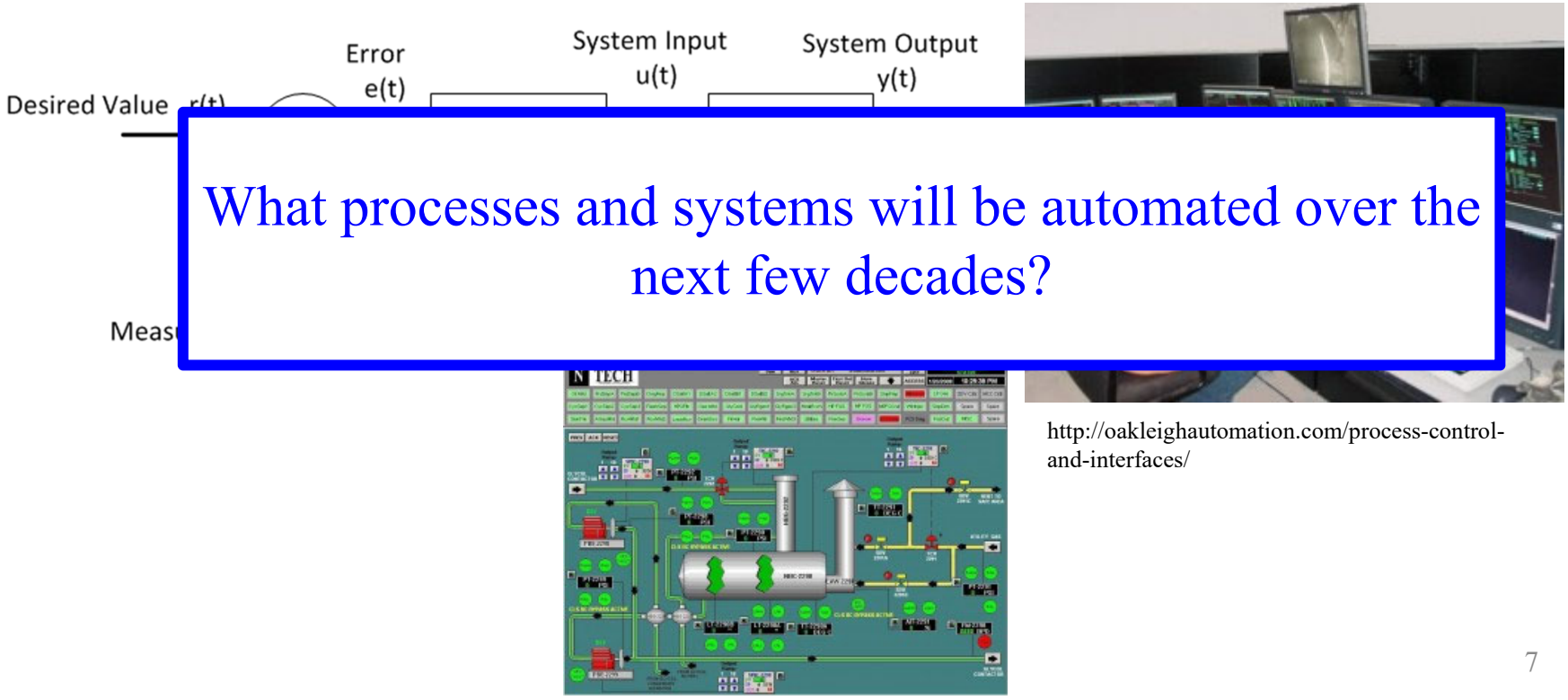
Why is it slower than some people expected?

http://www.news.com.a
e6frfro0-12261310094



# ENGG1300 – What is it about?

**Control systems**: how electric circuits are used to allow automatic control of machines (e.g. cruise control, autopilot, robots, motors, traffic lights, …)




What processes and systems will be automated over the next few decades?

http://oakleighautomation.com/process-control-and-interfaces/

# My Challenge to You:

## To critically think about:

- The functionality and design of electrical systems
- How electrical systems interact with the physical world and other engineering systems
- The role of electrical systems in society
- The technical and scientific details behind many of Australia's (and the world's) big debates:
  - What communication infrastructure does Australia need for the future, and what's an affordable way of implementing it?
  - What are the future sources of electrical energy in Australia? What are the challenges of integrating renewable sources?
  - How does increasing electrical automation affect our lives?
    - How do we steer towards *The Jetsons*….
    - Rather than *Terminator*?

# Course Structure: “Active Learning”

- Lectures are kept to a minimum (1 hours per week):
  - Will provide context and direction to the week’s study
  - Concepts will not be fully explained in lectures. Some concepts might not be mentioned at all.
- Primary learning session will be the Two×2-hour active learning sessions each week (P1, P2, P3, P4, P5, P6), guided by a team of Tutors:
  - You will be expected to complete preparation materials beforehand (videos, readings, examples, short unassessed quiz’s): **You should allocate 1 hour before each lab to do this.**
  - These combine mini-lectures, tutorials, laboratories (simulation or practical) and discussion exercises all into a single active learning session.
  - You need to attend every session… You will need to work hard!
  - We will have allocated seating to get started.

# Textbook

- Hambley, Allan R. Electrical Engineering: Principles & Applications. Pearson. Upper Saddle River [New Jersey]. Seventh edition. ISBN-13:978-1-292-22312-4.
  - Not compulsory
  - Several copies in the library
  - Earlier editions would also be fine
  - Plenty of other alternative texts that cover the same material: go to the library and find one you like!

- This is also the text for the follow-on 2nd year electrical engineering course ELEC2003; and is useful for part of the next course ELEC2004; and is a generally handy reference.

# Assessment

- Four different assessment activities:-
  - A weekly on-line quiz, due every Monday at 4pm (except week 1 and 12). Best 10 of 11 quizzes count 2% each, and **20% total**.
  - An online mid-semester test 8am-10am Monday 29th March (week 6 lecture slot). **15%**
  - A short design report documenting your solution to an audio filtering problem, Due 2pm, 13th May. **10%**
  - A *closed-book* Final Exam. (Final exam period). **55%**
  - Casio fx-82 or UQ approved and labelled calculator allowed in exams (make sure you have one, and get it labelled if necessary)
  - You must achieve greater than 45% in the final exam in order to pass the course (grade capped at a 3 otherwise).

# Weekly Quiz.

- Accessible via Blackboard
- Due each Monday, 4pm except week 1 and 12.
  - There is a practice quiz (you can take as many times as you wish), plus the real quiz, which you can take 3 times (best attempt counts, 60 minute limit on each attempt).
  - You will have typically completed the required theory by the first practical class each week.
  - Practice + quiz would normally take about 1 hour if you have completed the relevant learning activities beforehand.
- First quiz due 4pm Monday 1st March (Week 2)

# Typical Week

1. Attend Monday lecture via zoom (typically 90 minutes).
2. Do preparation for Prac A, including preparation quiz (about 1 hour in your own time) [can be done before or after lecture]
3. Attend Prac A (2 hours Scheduled)
4. Do preparation for Prac B, including preparation quiz (about 1 hour in your own time)
5. Attend Prac B (2 hours Scheduled)
6. Solutions/Answers to most theory questions from lab released
7. Work through weekly practice quiz until you are confident
8. Complete the assessable weekly quiz (best of up to 3 attempts)

Please make the most of these resources! Students who get the most out of the course (and who subsequently get the best grades) diligently complete these activities each week.

# Course Profile

- Every course at UQ has a course profile, which enrolled students can access via Blackboard.
- This is the "contract" with students about how the course will run, what the assessment will be, relevant policies, etc.
- It is essential that you read the course profile for every course that you undertake:

- Any questions? Anything not make sense? Ask as early as possible.

# Got a Question?

To help us get the right information to you as quickly as possible, please follow the following order for getting the information you need:

1. Got a question?
   - Is it **administrative**? ⇒ Check the course profile
   - Is it **technical**? ⇒ Check pre-reading notes/videos; lecture notes; on-line resources, text-book
2. Ask a tutor in one of your scheduled prac sessions (particularly for technical questions)
3. Post a question on online discussion forum (that way everyone can benefit from your query)
4. Email Course Coordinator

# Timetables, Changing & Dropping Courses

- Class Allocation is via Allocate+ system via your my.UQ Dashboard: http://portal.my.uq.edu.au/
  1. Go to **'mySI-net' to** Enrol in chosen course
  2. Go to **'My Timetable'** to use the allocate+ system to preference class times (till 29/1/21).
  3. Classes then allocated automatically with personal timetable released 8/2/2021
  4. Class Adjustment (8/2/21-5/3/21): Didn't get the time you wanted, or now need to change times? Use **'My Timetable'** to:
     - Swap to other classes if there is space.
     - Add name to waitlist to swap to preferred class
     - Contact eait.mytimetable@uq.edu.au if you still have unavoidable clashes

- Need to **change** courses? Go to step (1) then (4) above. Adding courses is available till **Friday 5/3/2021**.

- Need to **drop** a Courses?
  - International students MUST discuss with EAIT faculty office before reducing below #8.
  - Census date (last day to drop a course without financial liability): **31st March 2021**
  - Last day to withdraw from a course without academic penalty: **30th April 2021**

# Email Etiquette

- Emails to University staff (and students you do not know) should be professional, and well written:
  - Avoid Slang and "txt" language
  - Use only REAL words and use punctuation, and capitals
- You normally have the persons name and title:
  - 'Good morning Professor Jones'
  - I'm happy for you to write to me with "Hi Phil" or similar
- NOT:
  - Dear Sir/Madam....
  - "Hey Guys", Hey Fellas, Hey Dude, G'day Mate
- Check your UQ email account regularly
- If you must use gmail/yahoo etc accounts, make sure they have a professional address:
  - i.e: pterrill@mail.com
  - NOT sexysurfer@mail.com; hardcorefragger@mail.com
- Keep in mind if applying for jobs, professional networking etc too.
- Think before you send!

# Some expectations

# Objectives for Week 1

- Week 1 is about modelling, analysing, constructing and measuring simple circuits composed of DC voltage sources and resistors
- Why should we care?
  - These circuit elements are basic building blocks that allow us to **model** important "real world" devices we commonly use in electrical systems:
    - Batteries; DC plug-pack power supplies (i.e. laptop charger)
    - Physical resistive elements that are essential for constructing electrical circuits and are important in their own right, but we can also use them to model: incandescent light globes; heater elements; some types of motors.
  - We will assume high school physics, and that you have a conceptual understanding of current as a flow of electrons; and voltage as a difference in charge
    - A folder of preparatory videos have been provided on blackboard to refresh this material (learning resources -> week 1 -> pre-reading materials.

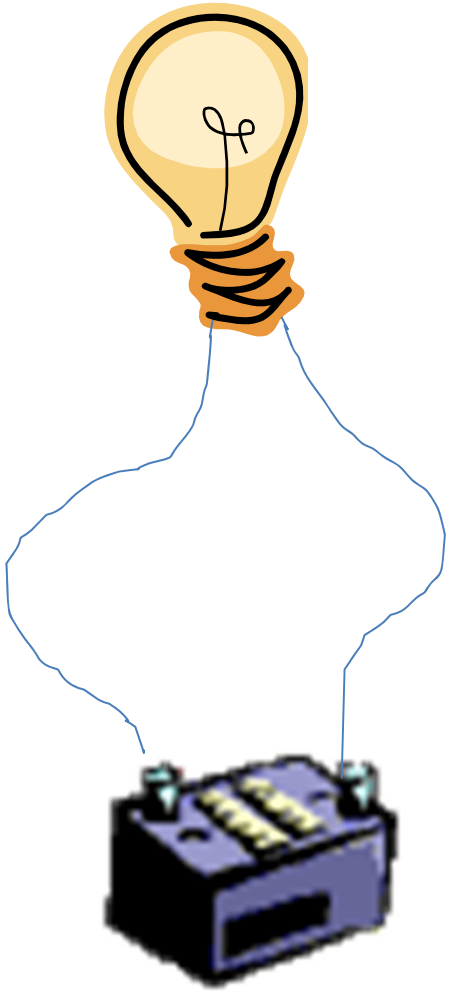
# Class Activity 1

Introduce yourself to the people seated around you. In groups of 3 or 4 people, spend around 3 minutes to:

You've heard of re-inventing the wheel? Today you are working for "Kettle Sons, Daughters & Associates". You are going to re-invent the kettle….

Propose three different systems (not necessarily electronic) to automatically switch off an electric kettle once it has boiled

# Rationale for week 1:

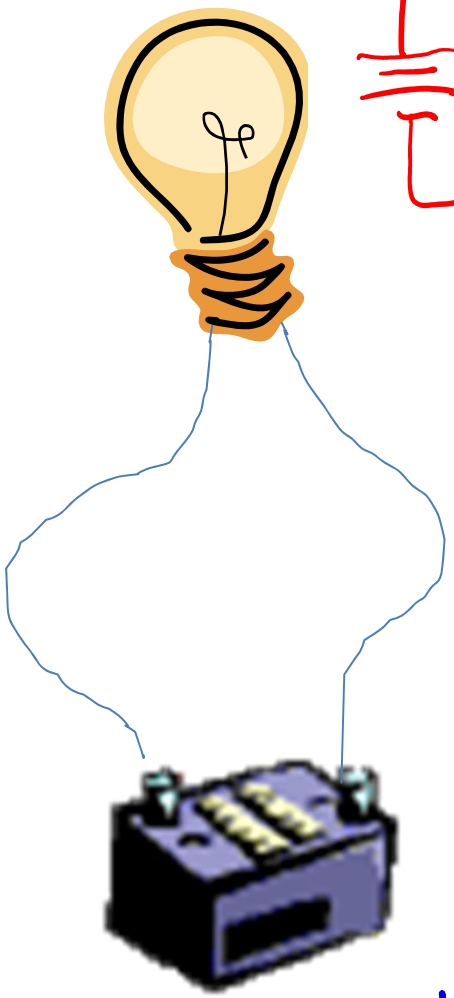


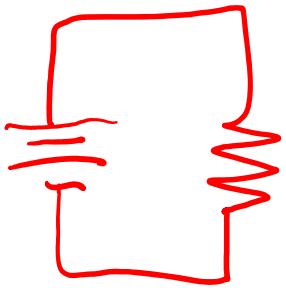
As an engineer, what might we want to make **predictions** about this design:

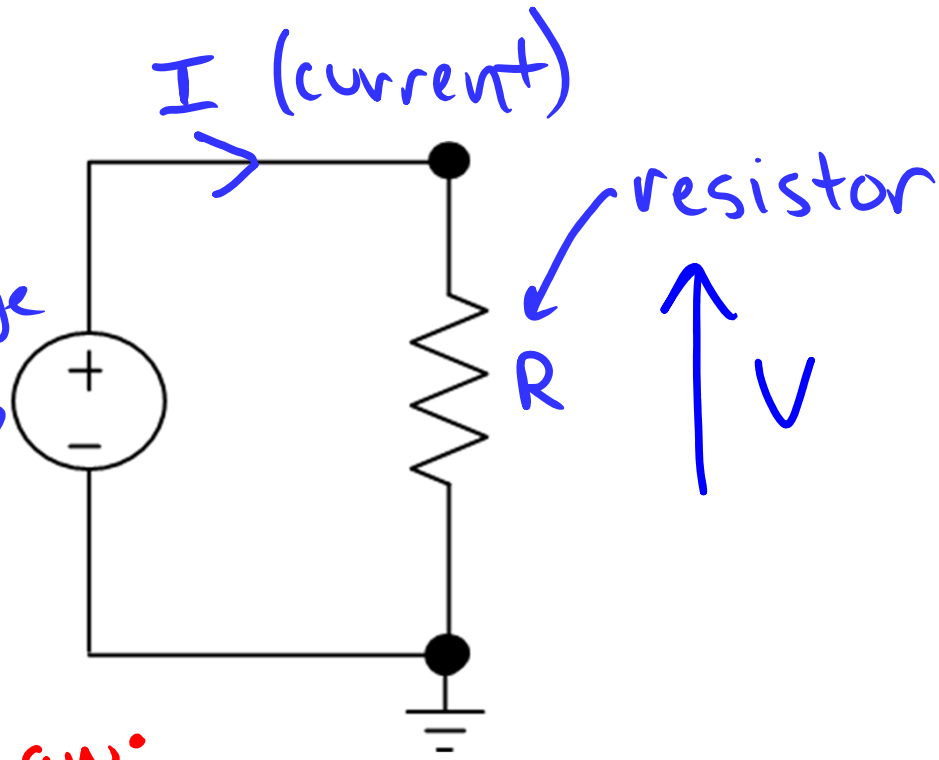
- What current should the cable should we use be rated to?
- How bright will the light be (i.e. Power dissipated)?
- How long will the battery last (i.e. Energy supplied/consumed)?

As such we want to be able to **model** the behaviour of this circuit

# Convert to a Circuit








Ohm's Law:

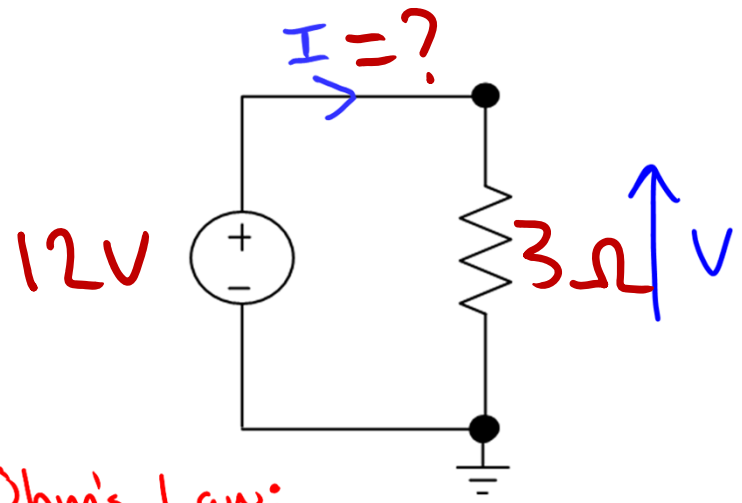
$$V = I \times R$$

← resistance (Ohm's, Ω)

↙ Voltage (Volts, V)

↖ current (Amperes, A)

# Solving a simple circuit




$V = I \times R$

$12 = I \times 3$

$\therefore I = \frac{12}{3} = 4A$

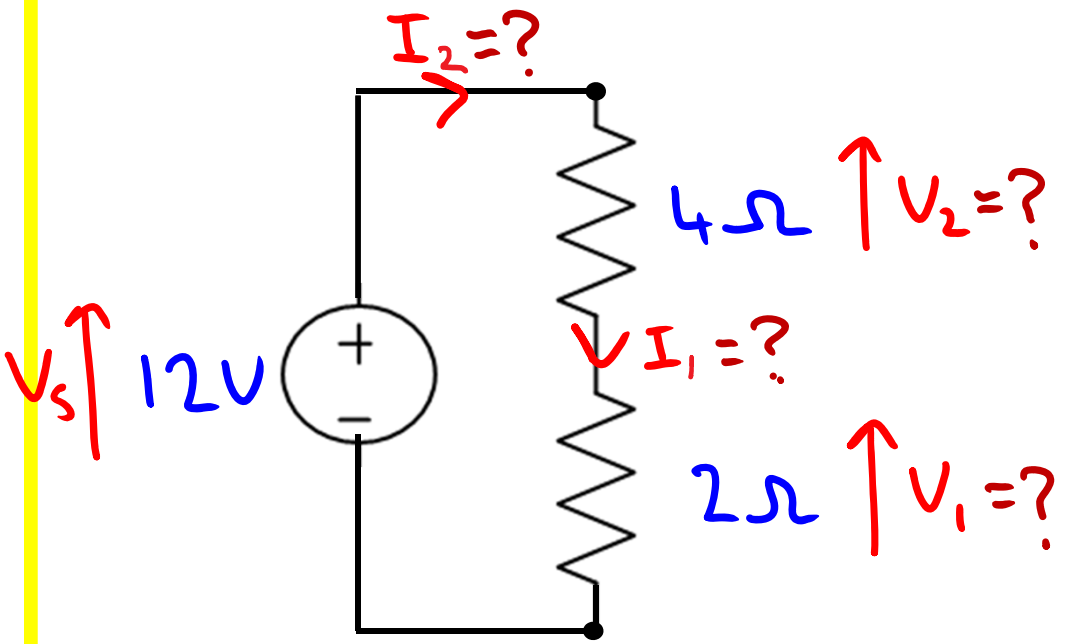
Ohm's Law:

$V = I \times R$ ← resistance (Ohm's, Ω)

↙ Voltage (Volts, V)

↖ current (Amperes, A)

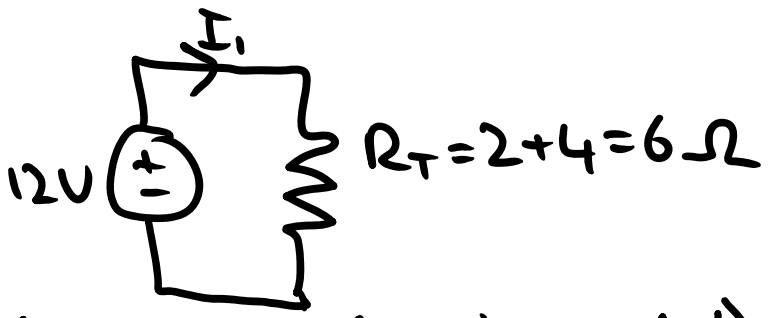
# Circuits with Series Elements




These resistors are in "Series" (The current through each is the same: $I_1 = I_2$)

We can simplify by calculating total resistance: $R_T = R_1 + R_2$

Redraw as:




(one port network model)

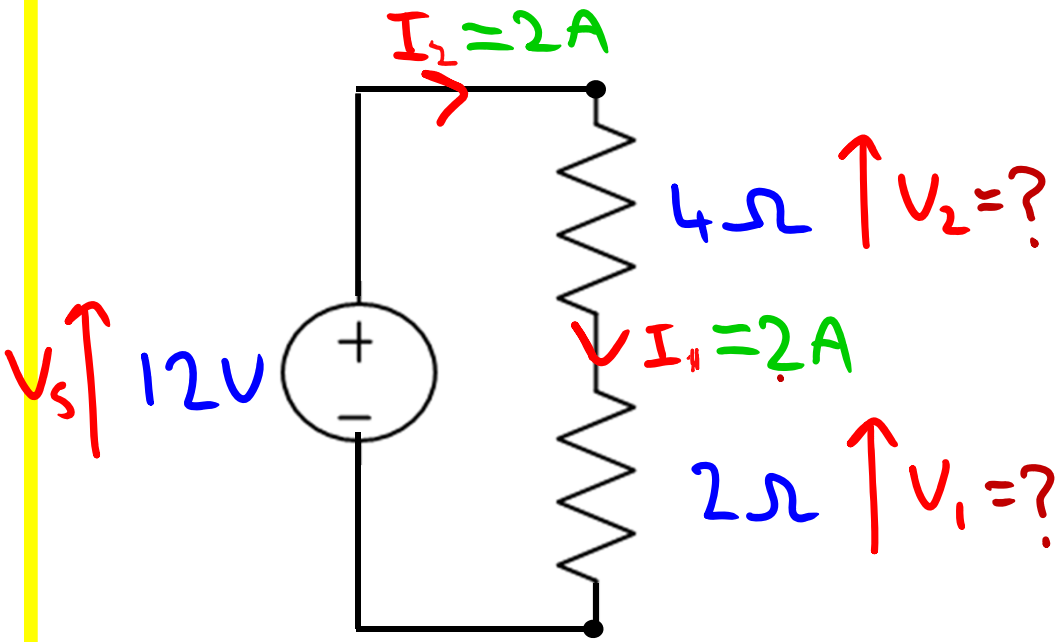
And now we have:

$V = I \times R$

$12 = I_1 \times 6 \Rightarrow I_1 = \frac{12}{6} = 2A$

We can return to original figure for $V_1$ and $V_2$

# Circuits with Series Elements




We can now apply Ohm's law to each resistor:

$V_1 = I \times R = 2 \times 2 = 4V$

$V_2 = I \times R = 2 \times 4 = 8V$

Now we can observe that:

$V_1 + V_2 = 4 + 8 = 12V = V_s$

This makes intuitive sense but is formally stated in Kirchoff's Voltage Law (KVL):

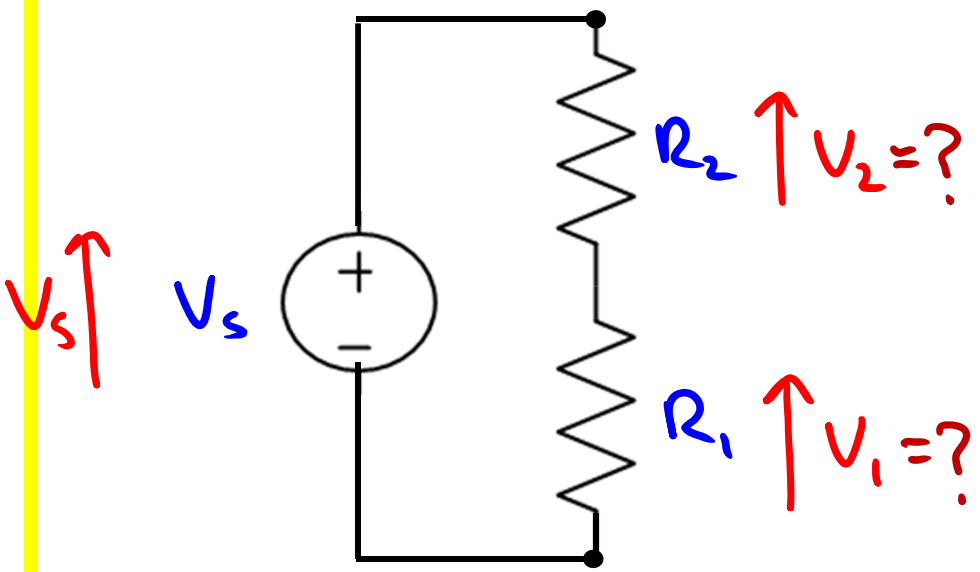
"The sum of voltages around a loop equals zero"

i.e: $V_s + (-V_1) + (-V_2) = 0$

[watch signs!!]

$V_s = V_1 + V_2$

# Circuits with Series Elements




In some cases we may not need to calculate the current, and it may be convenient to calculate $V_1$ and $V_2$ directly.

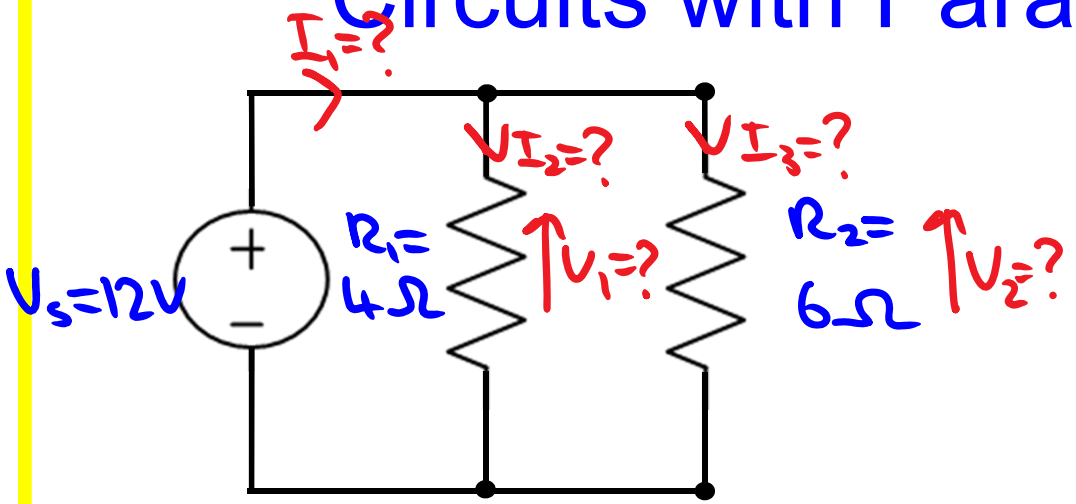
We can derive the voltage divider rule:

$$I = \frac{V_s}{R_T} = \frac{V_s}{R_1 + R_2}$$

$$V_1 = I \times R_1 = V_s\left(\frac{R_1}{R_1 + R_2}\right)$$

$$V_2 = I \times R_2 = V_s\left(\frac{R_2}{R_1 + R_2}\right)$$

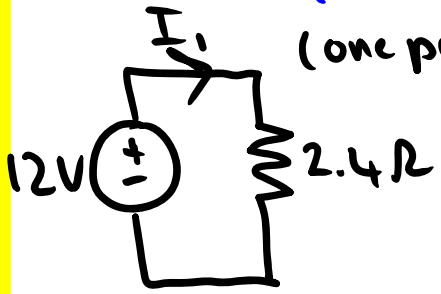
# Circuits with Parallel Elements




These resistors are in "parallel":

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow R_T = \frac{R_1 R_2}{R_1 + R_2}$$

$$R_T = \frac{4 \times 6}{4+6} = \frac{24}{10} = 2.4\,\Omega$$




(one port network model)

$$I_1 = \frac{V}{R} = \frac{12}{2.4} = 5A.$$

We can also see that the voltage across parallel resistors is equal:

i.e: $V_1 = V_2 = V_s = 12V$

Apply Ohm's law to each resistor:

$$I_2 = \frac{V_1}{R_1} = \frac{12}{4} = 3A$$

$$I_3 = \frac{V_2}{R_2} = \frac{12}{6} = 2A$$

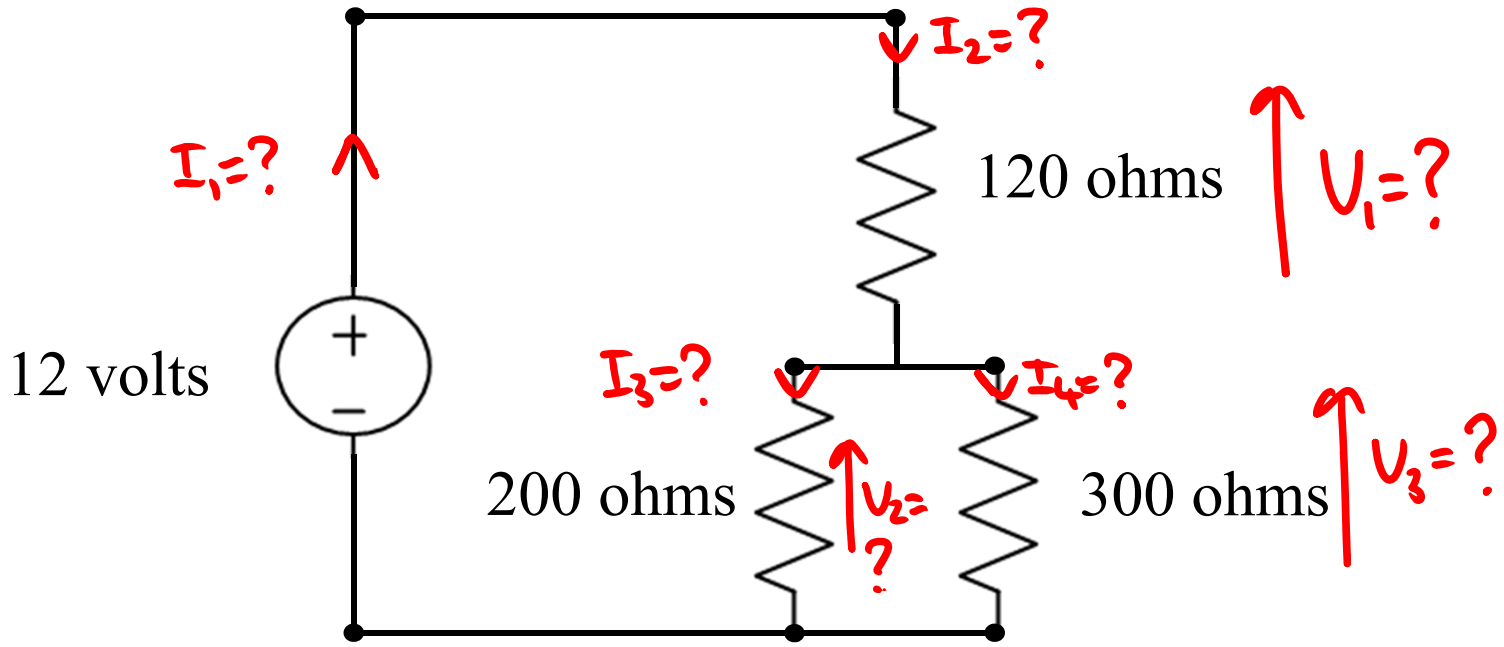
And we can see that:

$I_2 + I_3 = 5A = I_1$

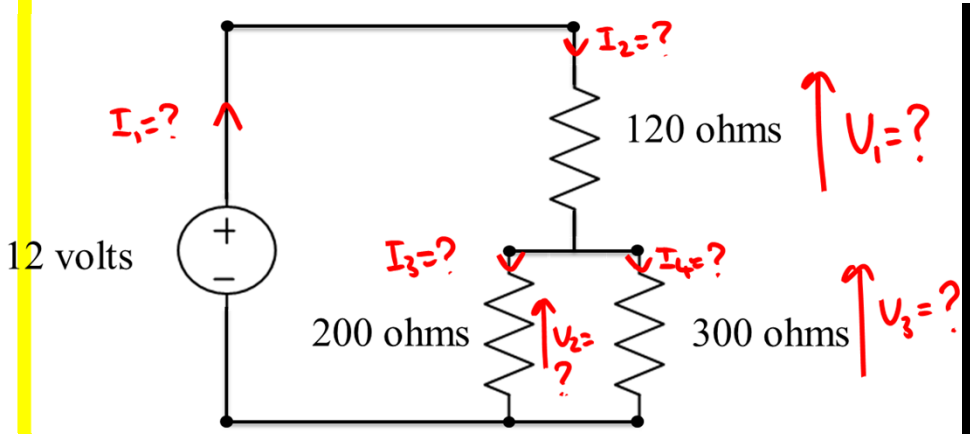
"Kirchoff's Current Law"

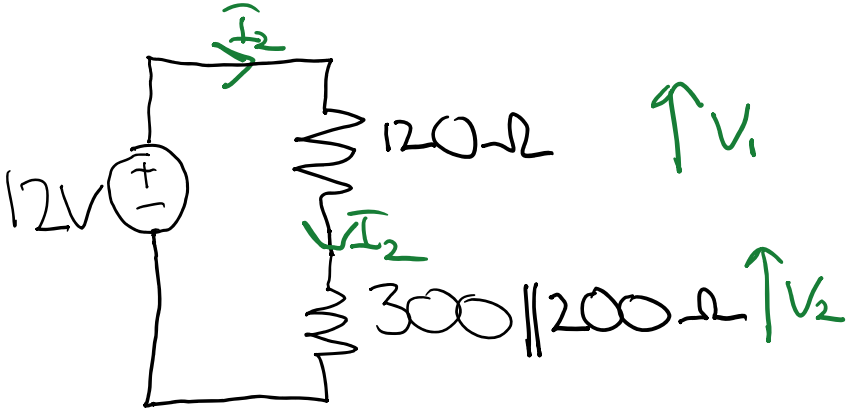
"The sum of currents into a node equals zero"

# Solving a slightly more complicated circuit…..



# Solving a slightly more complicated circuit…..




Parallel Components

$$300||200 = \frac{R_1 R_2}{R_1 + R_2} = \frac{300 \times 200}{300 + 200}$$

Voltage Divider:

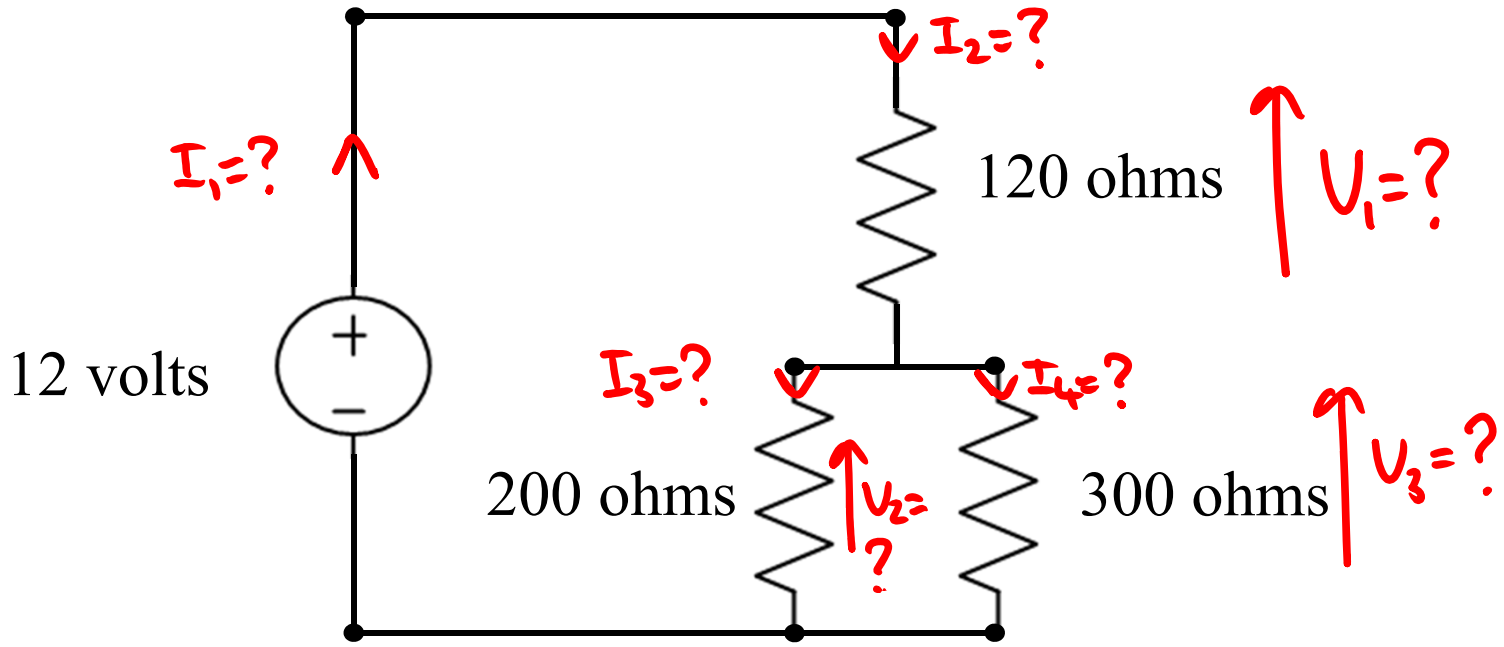
$$V_1 = \frac{V_s \times R_1}{R_1 + R_T} = \frac{12 \times 120}{120 + 200||300} = ?$$

$$V_3 = \frac{V_s \times R_T}{R_1 + R_T} = \frac{200||300}{120 + 200||300} = ?$$

Ohm's Law

$$I_1 = I_2 = \frac{V_1}{120} = ? \quad I_3 = \frac{V_3}{200} = ? \quad I_4 = \frac{V_3}{300} = ?$$

# Solving a slightly more complicated circuit…..




Calculate the voltage at each node; the current through each branch; and the power supplied or consumed by each component in the circuit

Think about this, and then attempt in lab (II) this week.

# Week 1 Summary

- Circuits, Nodes, Branches
- One-port Resistor Networks and Series and Parallel Resistors
- Voltage Dividers (for series resistors)
- Current Dividers (for parallel resistors)
- Voltage, Current, Power (volts, amperes, watts)
- Circuit Laws:
  - Kirchhoff's Current Law (KCL)
  - Kirchhoff's Voltage Law (KVL)
- Component Laws (Ohm's Law, Ideal Voltage and Current Sources)
- Power supplied or delivered
- Solving simple circuits
- Introduction to the electronics lab
- Constructing and testing circuits, and comparing to theoretical models.

# Key Points This Week

1. Make sure you are signed up for one of Active Learning Lab streams (i.e. one of P01-P06)
2. Monday/Tuesday/Wednesday – Pre-reading for Lab 1A
3. Monday/Tuesday/Wednesday– Lab 1A
4. Wednesday/Thursday/Friday – Pre-reading for Lab 1B (intro to lab equipment)
5. Wednesday/Thursday/Friday – Lab 1B
6. By 4pm Monday 1st March – try practice quiz 1, and complete on-line quiz 1.