University of Leicester

National HE STEM Programme
Physics

CROSSWINDS ARE CRITICAL

AN INTRODUCTION TO ELECTRICITY AND MAGNETISM

The Centre for Interdisciplinary Science

CETL Physics Innovations

PREAMBLE

The original version of ‘Crosswinds are Critical’ is run as a Laboratory Group Research Project, undertaken by students in small groups. There are four laboratory sessions of 3 hours each as well as two facilitated workshops. For each of the workshops there is set question for class discussion, that are marked at the workshops. These workshop questions are designed to support the practical work by providing ideas and relevant theory. Most of the required theory can be found in any undergraduate physics text book.

This version of the problem has been adapted as a purely theoretical exercise as an introduction to electricity and mangetism.

INTENDED LEARNING OUTCOMES

By the end of the module students should be able to solve problems involving

- Resistances, current and voltages of series and parallel components
- Ohm's Law
- Kirchhoff's Laws
- Potential Dividers
- Capacitor voltage and resistance whilst charging and discharging
- RC circuits and their time constants
- Capacitor smoothing
- Dynamos
- Faradays law and induced current

READING LIST

The reading list is that provided for the original module. Other equivalent textbooks are available.

READY TO STUDY

- Breithhaupt, J., ***Physics***. Palgrave Foundations.

ESSENTIAL

- Tipler, P.A., ***Physics for Scientists and Engineers***. Freeman.

PROBLEM STATEMENT

From a local Newspaper:

CROSSWINDS ARE CRITICAL

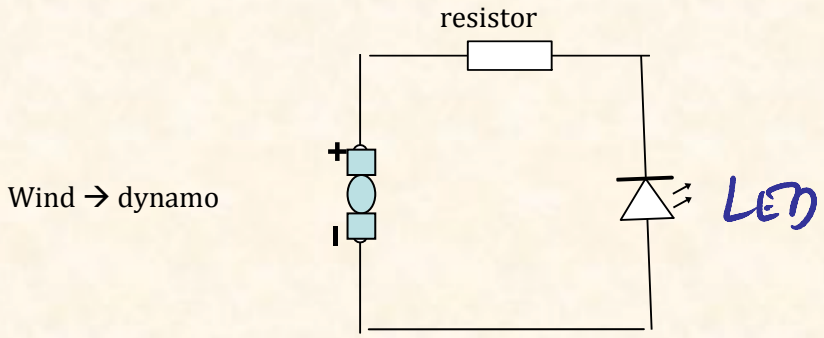
Another incident this week serves as a reminder for pilots to consider crosswinds on approach to land. Bob C's Puffin Aerosport suffered minor damage after a gust of wind affected the aircraft on landing. Bob was approaching runway 27 (due west), with air traffic control reporting wind from the north west at 21 knots. The Puffin is rated for crosswind components up to 15 knots, so Bob went ahead with his landing, only to be caught by a gust on touchdown. The plane veered onto the grass at the side of the runway and bent an undercarriage leg. The airport emergency team arrived at the scene quickly, but Bob was unharmed and able to exit the aircraft unassisted. He intends to have the Puffin flying again within three weeks.

This is the second incident this year involving crosswinds. Pilots are advised to read the operating manuals for their aircraft to determine crosswind limitations and operating procedures. When on approach, monitor the wind information given by air traffic control and keep an eye on the windsock to assess gusting.

Asked if anything was being done about this state of affairs a spokesperson for Otherton Airport management said that they would be pleased to receive ideas for a safety beacon, but that this would have to get CAA approval.

From the Directorate of Research:

With regard to the safety beacon, I've got some data for you below on the laboratory equipment. Here's a suggested circuit. Do you think it will work?



We can add a capacitor to smooth the output if the wind is gusting.

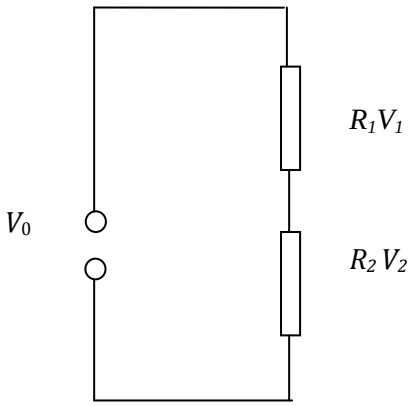
Once you've given me the relevant data I can scale this up. We'll want to patent this so I need technical details in your report.

SUGGESTED DELIVERABLE

Individual Report

QUESTIONS FOR CLASS DISCUSSION

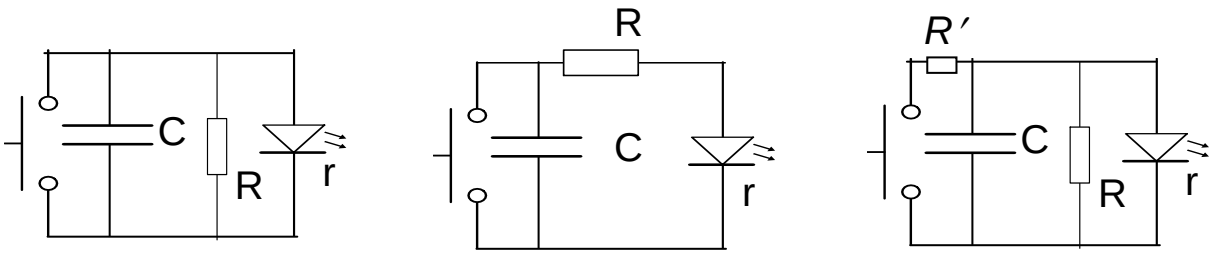
1. A DC power source provides a voltage V_0. A voltage V is required to drive a device ($V < V_0$). This is to be achieved by choosing two resistors R_1 and R_2. What ratio R_1/ R_2 is required? How might you decide on the absolute values?



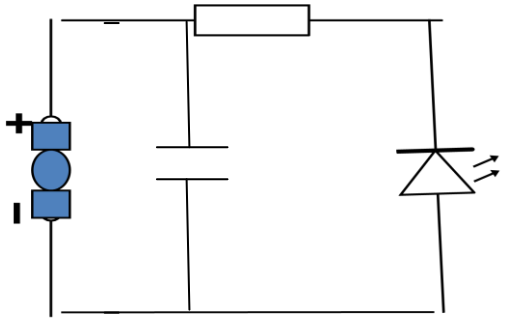
2. An uncharged capacitor has an effective resistance of zero whereas a fully charged capacitor has an infinite resistance. Can you explain this statement?

3. A fully charged capacitor, capacitance C is discharged through a resistor R. What is the time constant of circuit?

What are the time constants of the circuits shown?



4. In the circuit below, how does the capacitor discharge when the dynamo stops?



How should the circuit be modified?

5. A circular coil of radius *a* rotates at an angular speed ω in a uniform magnetic field B. What is the output voltage? Estimate the magnetic field in the dynamo you have been using.

6. A dynamo is powered by a wind of speed *v* and provides an output voltage V. By estimating the work done dynamically by the wind and electrically by the dynamo derive a relation of the form $V \propto v^{\alpha}$