Wind Power

Division B/C

Georgia Tech Event Workshop Series
2024-25

Science Olympiad at Georgia Tech®

01 RULES SHEET

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04 TIPS FROM A VETERAN

05 OTHER FREE RESOURCES

The Rules Sheet

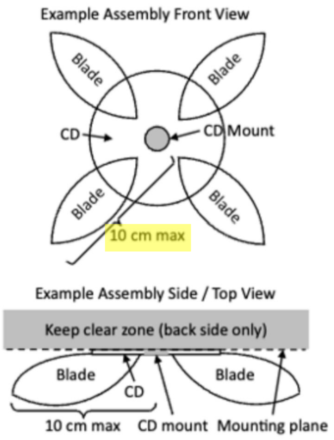
2. **<u>EVENT PARAMETERS</u>:**
   a. Each team may bring one three-ring binder of any size containing information in any form and from any source, attached using the available rings. Sheet protectors, lamination, tabs and labels are permitted. Participants may remove information or pages for their use during any part of the event.
   b. Each team may also bring tools, supplies, writing utensils, and two calculators (Class III) for use during any part of the event.
   c. Each team may bring one pre-constructed blade assembly device.
   d. The Event Supervisor will provide the testing materials listed in the COMPETITION AREA section. **Teams should not bring these materials.**
   e. Competitors must wear eye protection during Part II. Teams without proper eye protection must be immediately informed and given an opportunity to obtain eye protection if time allows.

- While you can bring unlimited notes, they won't be super useful unless they're organized, so make sure to use tabs/labels and include a Table of Contents
- Don't bring your own test stand, although making one will be helpful during the testing phase
- **<u>Class III Calculators:</u>** Non-graphing, programmable calculators (no TI-84s)

The Rules Sheet

- The only difference between Div. C and Div B. rules this year is the maximum radius of the build (**10 cm vs. 14 cm**)
  - Stay within these limits to avoid 10% deduction or disqualification (radius measured from center of CD)
- *Where to buy a CD?*
  - Buy for $10 on Amazon
  - Ask parents for old CDs
- **Blades must not extend behind CD or be heavy enough to cause damage to the testing set-up**
  - The lighter your device, the faster it spins/the more power it generates, so this is against your best interest anyways

Div C:



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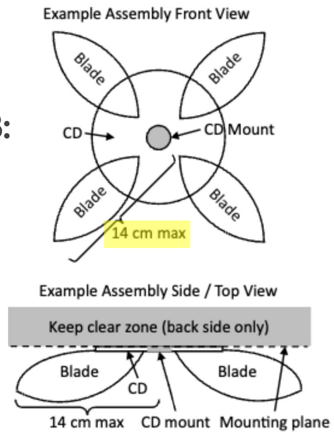
Div B:



The Rules Sheet

Topics Covered in Written Test (Part I: The Competition):

- Rotor and blade design of wind turbines
- Types of generators and their design
- Power storage
- Power transmission and distribution
- Siting (finding a location) and installing wind turbines and power storage/distribution systems <- new this year
- History and societal impacts of wind power

- Use this list as a starting point for research and organizing notes
  - Ex: gather information on one topic per week, split topics between partners
- **These topics are what event supervisors are referencing when writing exams**
  - They are vague so the best strategy is to just collect as much related info on each concept as possible

The Rules Sheet

Part II: Device Testing

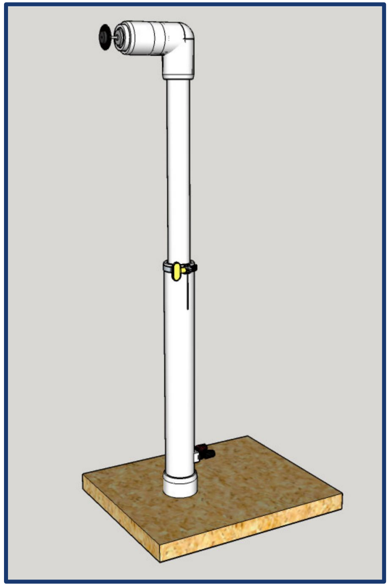
a. The blade assembly must be tested once with the fan at a low wind speed and once at a high wind speed. **It is recommended to conduct the low speed test first to ensure no device components detach before attempting the high speed test.**

d. **Teams have 2 minutes and 15 seconds of set-up time preceding each Measurement Period to attach their blade assembly to the motor/generator mount and position it.** At the request of the students, the Event Supervisor must turn on or off the fan during the set-up to allow the students to better position the blade assembly relative to the fan.

- You have 2 minutes and 15 seconds to optimally position your blade–use it!!!
- Make sure you're testing your build at a high and low fan speed

Making Your Test Stand

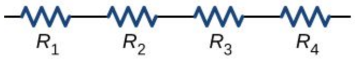
- Having one of these to test your build before competition is incredibly useful!
- You can find detailed instruction for how to build and test stand and the materials involved on the:
  - Official Science Olympiad Website
- Links for Buying Materials:
  - 20" Box Fan
  - DC Motor attached to CD holder
  - PVC Pipes
  - Adjustable Clamps
  - 1k Ohm Resistors



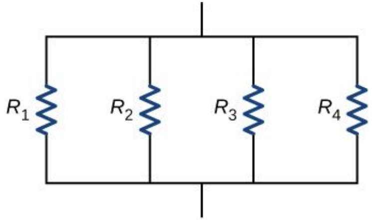
DIFFICULT TOPICS

Topic 1: Circuit Analysis

- Exam writers may ask you to **solve a simple circuit** as part of the power storage or transmission topic
  - Success on questions like these comes with *a lot of practice*
  - Keys to circuit analysis are
    - **Ohm's Law: $V = IR$**
    - **Power Equation: $P = IV$**
    - **Energy Equation: $E = P\Delta t = P(dt)$**
    - **Resistors in Series/Parallel: $R_S = R_1 + ... + R_n$; $R_P = 1 / (1/R_1 + ... + 1/R_n)$**



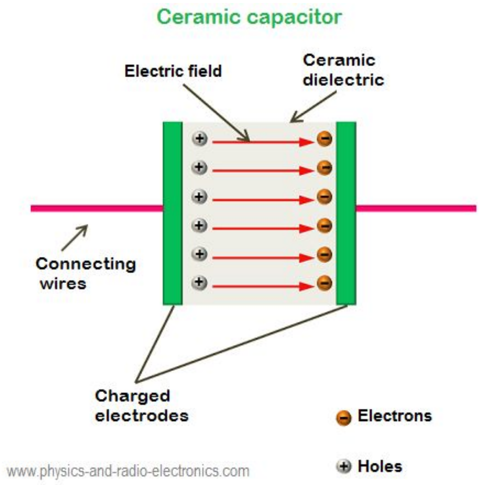
(a) Resistors connected in series



(b) Resistors connected in parallel

Topic 1: Circuit Analysis

- **Capacitors:**
  - A passive, two-terminal device that stores electric charge short-term
- Two metal plates separated by an insulating material (dielectric)
- **Important Equations:**
  - $Q = CV$
    - Q = Charge (Coulombs)
    - C = Capacitance (Farads)
    - V = Voltage (Volts)
  - $C = \epsilon_o A/d$
    - ϵ_o = Electrostatic Constant: $8.85\times10^{-12}\ C^2/(N\cdot m^2)$
    - A = Plate Area (m^2)
    - d = Distance Between Plates (m)



Topic 1: Circuit Analysis

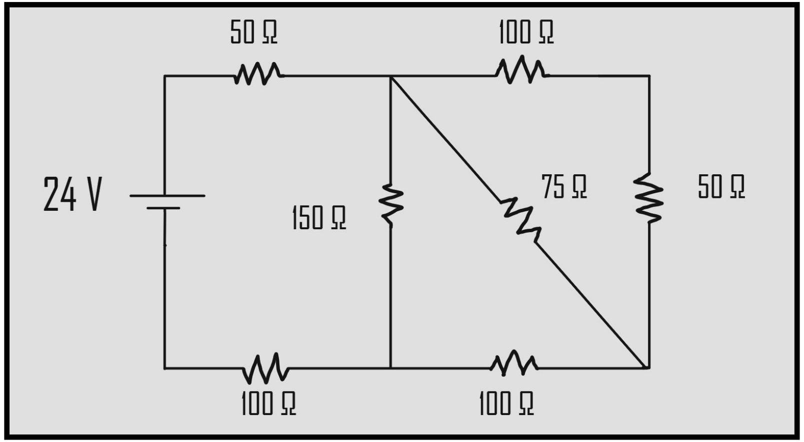
- Capacitors take time to charge and discharge, which can be visualized in this simulation
- I(t) = C (dV/dt)
  - *Current is equal to the capacitance times the change in voltage over time*
  - Once charged, current stops flowing in a circuit
- To find the voltage across a capacitor at a particular point in time after connected to a voltage source, we solve the differential equation to yield:

$$v(t) = V_o\left(1 - e^{\frac{-t}{RC}}\right)$$

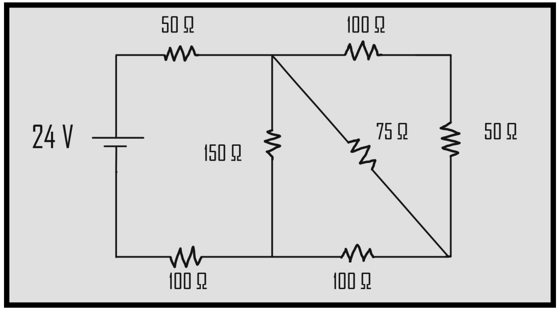
Example Question: Circuits

Imagine the circuit below is a network of power transmission lines.

Calculate the energy dissipated across the 75 ohm resistor after 30 seconds:



Answer



$R(tot) = 50\ \Omega + 1/[1/(1/[1/(100\ \Omega + 50\ \Omega) + 1/75\ \Omega] + 100\ \Omega) + 1/150\ \Omega] + 100\ \Omega = 225\ \Omega$

$I(tot) = 24\ V/225\ \Omega = 0.107\ A$

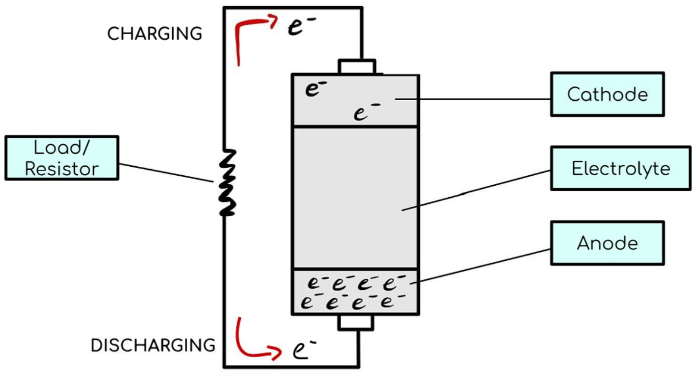
$I(75\ \Omega) = 0.107\ A\ [(100\ \Omega + 50\ \Omega)/(100\ \Omega + 50\ \Omega + 75\ \Omega)] = 0.0711\ A$

$P(75\ \Omega) = (0.0711\ A)2\ (75\ \Omega) = 0.379\ W$

$E = 0.379\ W * 30\ s = 11.4\ J$

Topic 2: Batteries

- Batteries are generally used for long-term energy storage
- Know several types of batteries and their applications
- **Battery Capacity (Ampere x hours or Ah):**
  - Measure of ability to store or supply electrical energy
  - Describes how much current is provided by the battery in a certain interval of time
    - Ex: a battery that supplies 15 Amperes in 10 hrs has a capacity of 150 Ah
- **Current Rate (C-Rate: hrs^-1) =**
  - (Discharge or Charge Current)/Capacity
  - Ex: At 2C, a 10 Ah battery will supply 20 A for 30 minutes

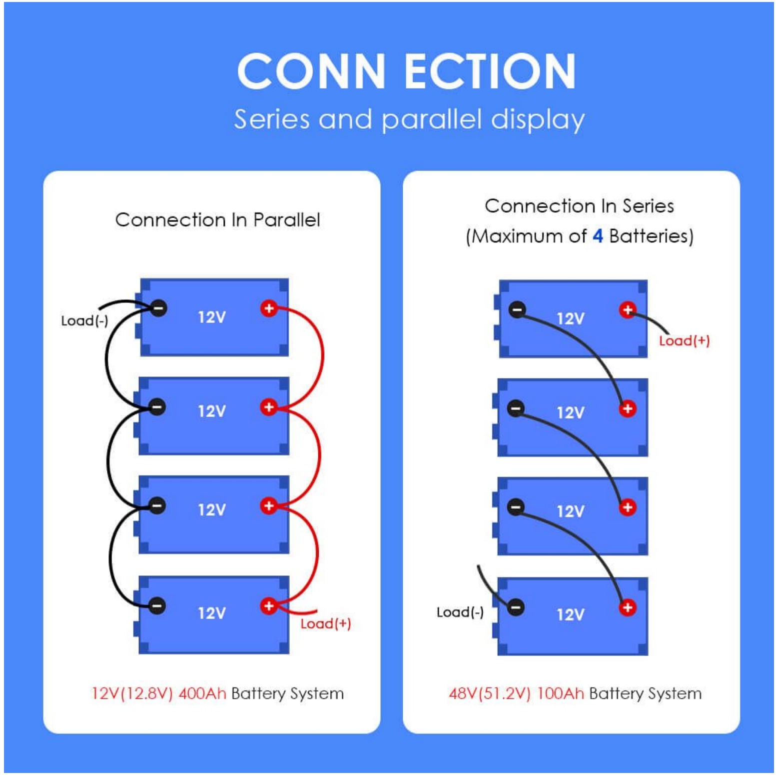


Topic 2: Batteries

- Batteries in parallel will have summed capacities and unchanged voltage
- Batteries in series will have unchanged capacities and summer voltages

Question: If a lithium-ion battery has a C-rate of 4C and a capacity of 234 Ah, what is its discharge current?

Answer: 4 hrs-1 x 234 A-hrs = 936 A



Topic 3: Types of Wind Turbines

Horizontal Axis Wind Turbines (HAWTs)

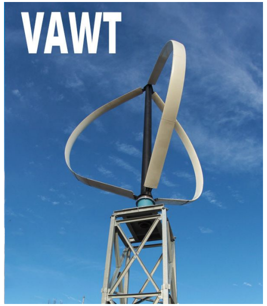
Advantages:

- Can harness stronger winds higher in the atmosphere
- Are self-starting
- Generally, perform reliably

Disadvantages:

- Require a yaw system to move the rotor such that it's facing the wind
- Difficult/expensive installation process

Vertical Axis Wind Turbines (VAWTs)



Advantages:

- Can harness wind power from all directions without a gear system
- Easier maintenance because it is lower to the ground

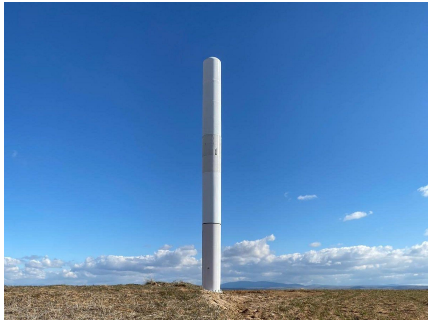
Disadvantages:

- Lower efficiency due to complex aerodynamic design
- Experience vibration due to turbulent and slower air flow near the ground

Example Question: Matching

Savonius

Darrieus



Vortex

Savonius
Darrieus
Vortex
Magnus
Multi-Rotor

Magnus

Multi-Rotor

Potential Build Designs

Tips from a Veteran

- Start going through practice tests about a month before your first competition
  - Will shed light on topics you still need to take notes on/study

- Designate one person to come up and test your build and one person to remain taking the written test (this will optimize your time)

- The simpler your design, the better!
  - 2-3 blades is often most effective, cardstock/construction paper works as a great blade material, you can experiment with different blade shapes

- Make sure you are familiar with the different types of power plants and have their diagrams in your notes

Tips from a Veteran

- There's a very large chance that either a **matching question** or **labeling the diagram question** will show up on your exam
    - To prepare, ensure that you have a definitions list in your notes and several diagrams of things like generators and wind turbines

- **For historical/environmental impact info**, the Wind Power SciOly Wiki Page, the US Energy Information Administration, and Renewable Energy World are all great resources
    - Wikipedia is also your friend, but avoid copying and pasting whole Wikipedia pages onto your notes because you will waste time sifting through info

- Don't take the event too seriously! Prioritize having fun :)

THANKS!