

Hybrid Vehicles

Event Structure:

The participants will work in teams of two. The event will take 50 minutes and will be paper-based. Calculators are permitted. A few pages of notes are permitted.

Description:

Hybrid cars have become more common due to our increasing concern about climate change and rising oil prices. As a mechanical engineer, you may be responsible for designing components for new hybrid cars. This event will test your basic knowledge of the lithium-ion battery (commonly used in cell phones, laptops, Boeing 787, and some hybrid/electric cars) and internal combustion engines.

Preparation:

To perform well in the event, the student must be able to do the following things:

- Explain how the lithium-ion battery operates
- Be familiar with the materials used for the battery anode, separator, cathode, and electrolyte
- Understand how the battery can degrade and fail
- Understand the benefits and limitations of using batteries on a hybrid car
- Be familiar with the main methods of heat transfer: conduction, convection, and radiation
- Know the difference between a premixed and non-premixed flame
- Understand the differences between gasoline and diesel engines
- Apply basic calculus (differentiation and integration) to physical problems

Sample Problems:

1. A discharged lithium-ion battery is constructed using a thin slice of graphite as anode, a piece of porous polypropylene sheet as separator, and a thin piece of lithium cobalt oxide as cathode. The dimensions of the anode, separator, and cathode are 1 cm x 2 cm x 50 microns, 1 cm x 2 cm x 25 microns, and 1 cm x 2 cm x 50 microns, respectively. When charging the battery, lithium ions deintercalate from the cathode and intercalate into the anode. Once the battery is fully charged, the anode has expanded by 10% in volume, and the cathode has expanded by 20% in volume. Assuming the overall volume of the battery is held constant, calculate the percentage in volume change for the separator. Since the separator is porous, what does this mean to the pores and the ability for lithium ions to pass through these pores?

2. Due to space constraints, one of the battery packs is placed next to the internal combustion engine and separated by 2 cm of foam insulation. During maximum power, the outside surface temperature of the engine can reach 220°C. If the highest temperature that the battery can experience is 120°C before going unstable, are the current placements of the battery pack and the engine safe? The heat transfer rate through the insulation is 720 W/m², and the thermal conductivity of the insulation is 0.12 W/m °C.

Contact:

This event is designed by Collen Leng (email contact: zleng@princeton.edu).

All email inquiries about the event should have the subject line: "PEO Event Inquiry – Hybrid Vehicles."