1.1 Principles of Cryogenics Engineering

- This is an introductory (graduate level) course in the principles and practices of cryogenic engineering.
- Topics to be covered include:
  - properties of materials and fluids commonly used in cryogenic systems
  - large-scale and cryocooler systems for refrigeration and liquefaction
  - heat transfer and fluid dynamics in cryogenics
  - cryogenic instrumentation & measurement techniques
  - elements of cryogenic system design
  - safe storage and transfer of cryogenics fluids.
- The practical element of the course will consist of application of the principles and theory to the design of cryogenic systems. Specific examples to be discussed will include:
  - design of low heat leak structural supports
  - thermal mass considerations
  - thermal insulation systems
  - storage of cryogens
  - cryogenic heat exchangers
  - instrumentation for cryogenics, temperature measurement uncertainties.

Instructors

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Course Outline/Lectures

Day 1: Properties of cryogenic fluids and materials (Van Sciver)

- Thermal state properties of solids (codes: Cryocomp)
- Transport properties of materials
- Mechanical properties of materials
- Properties of cryogenic fluids (REFPROP)
- Unique properties of hydrogen
- Properties of helium including superfluidity (HEPAK)

Day 2: Refrigeration and liquefaction systems (Pfotenhauer)

- Large scale refrigerators / liquefiers
- Refrigeration Cycles
- Refrigeration hardware
- Cryocoolers
- Regenerator design (REGEN)

Day 3: Cryogenic heat transfer and fluid dynamics (Van Sciver)

- Fluid mechanics of cryogens
- Heat transfer mechanisms
- Boiling heat transfer
- Two phase flow and natural circulation
- Superfluid helium (He II)

Course Outline/Lectures

Day 4: Instrumentation & measurement techniques (Pfotenhauer)

- Temperature measurement
- Pressure measurement
- Flow metering
- Level measurement

Day 5: Elements of cryostat design (Van Sciver, Pfotenhauer)

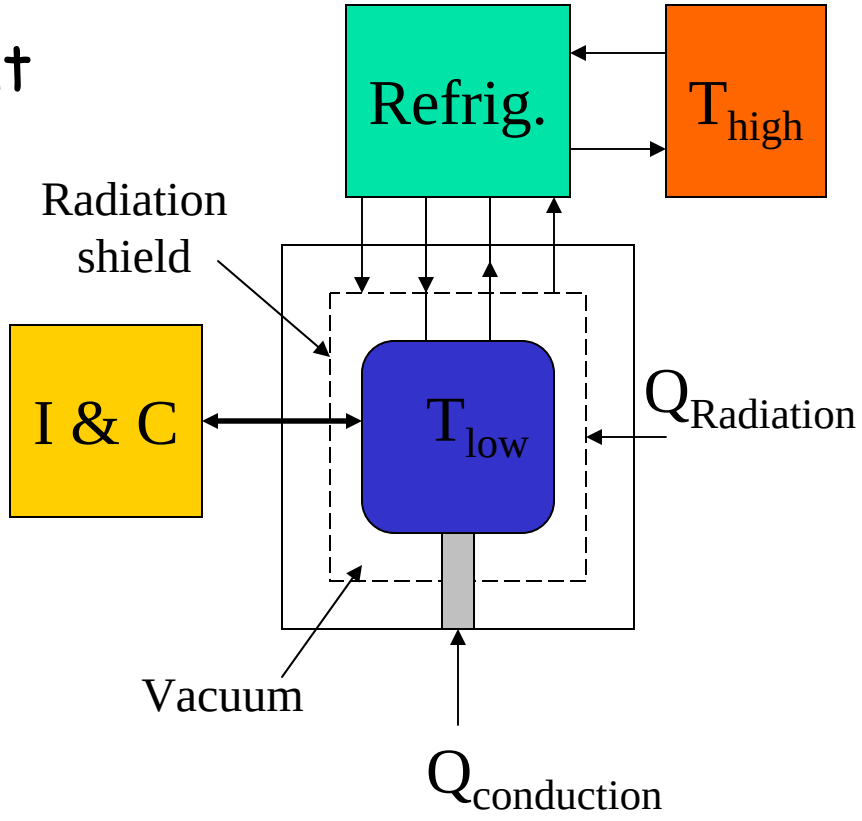
- Thermal insulation systems
- Design of low heat leak structural supports
- Instrumentation and current leads
- Thermal mass considerations
- Safe storage and transfer of cryogenics fluids

Evaluation:

- Homework (daily)
- Final Exam (Day 5)

Major components of a cryogenic system

- Low temperature environment
- Source of refrigeration
- Heat exchange medium
- Thermal insulation
- Structural support
- Instrumentation and control



All these components need to operate in concert, reliably and safely