ENG 3165 LECTURE 1

THERMODYNAMICS COMPONENT

Getting started……

Introduction

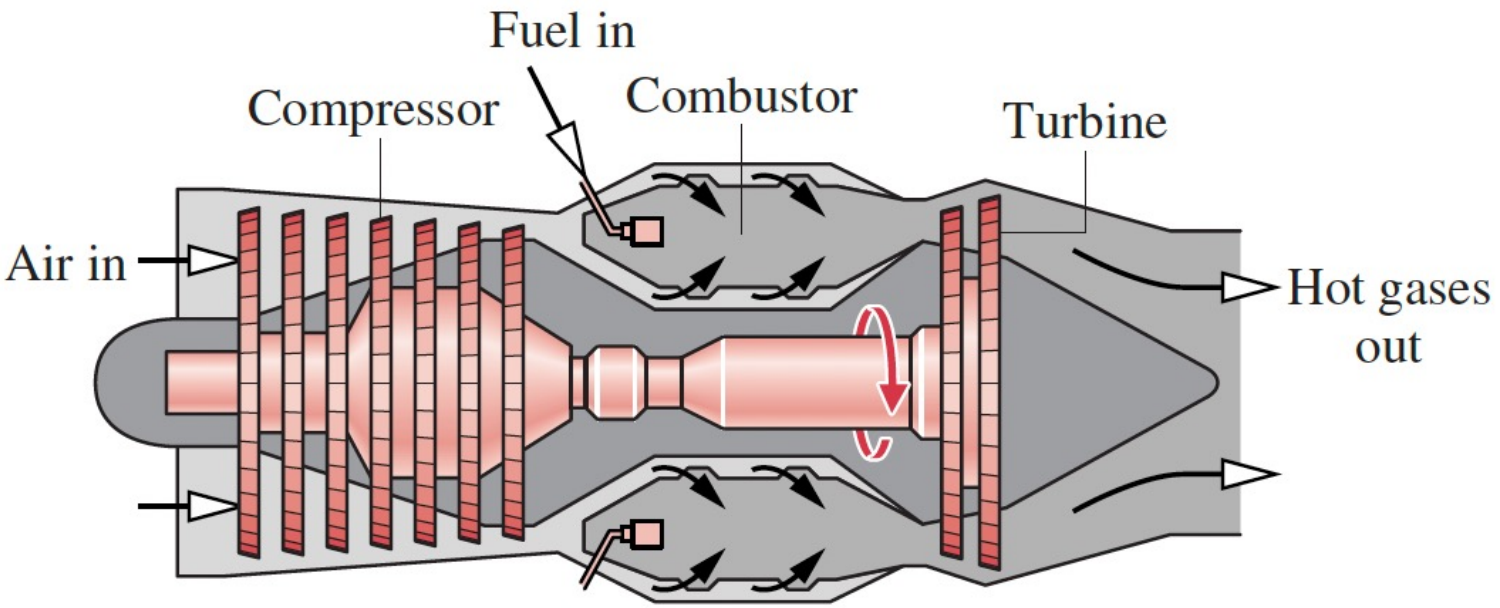
- Thermal systems engineering is concerned with how energy is utilized to accomplish beneficial functions in industry, transportation, and the home, and also the role energy plays in the study of human, animal, and plant life.
- In industry, thermal systems are found in electric power generating plants, chemical processing plants, and in manufacturing facilities. Our transportation needs are met by various types of engines, power converters, and cooling equipment.
- In the home, appliances such as ovens, refrigerators, and furnaces represent thermal systems.
- In living things, the respiratory and circulatory systems are thermal systems, as are equipment for life support and surgical procedures.

Introduction

- Thermal systems involve the storage, transfer, and conversion of energy. Energy can be stored within a system in different forms, such as **kinetic energy** and **gravitational potential energy.** Energy also can be stored within the matter making up the system.
- Energy can be transferred between a **system** and its **surroundings by work, heat transfer**, and the flow of hot or cold streams of matter. Energy also can be converted from one form to another.
- For example, energy stored in the chemical bonds of fuels can be converted to electrical or mechanical power in fuel cells and internal combustion engines.

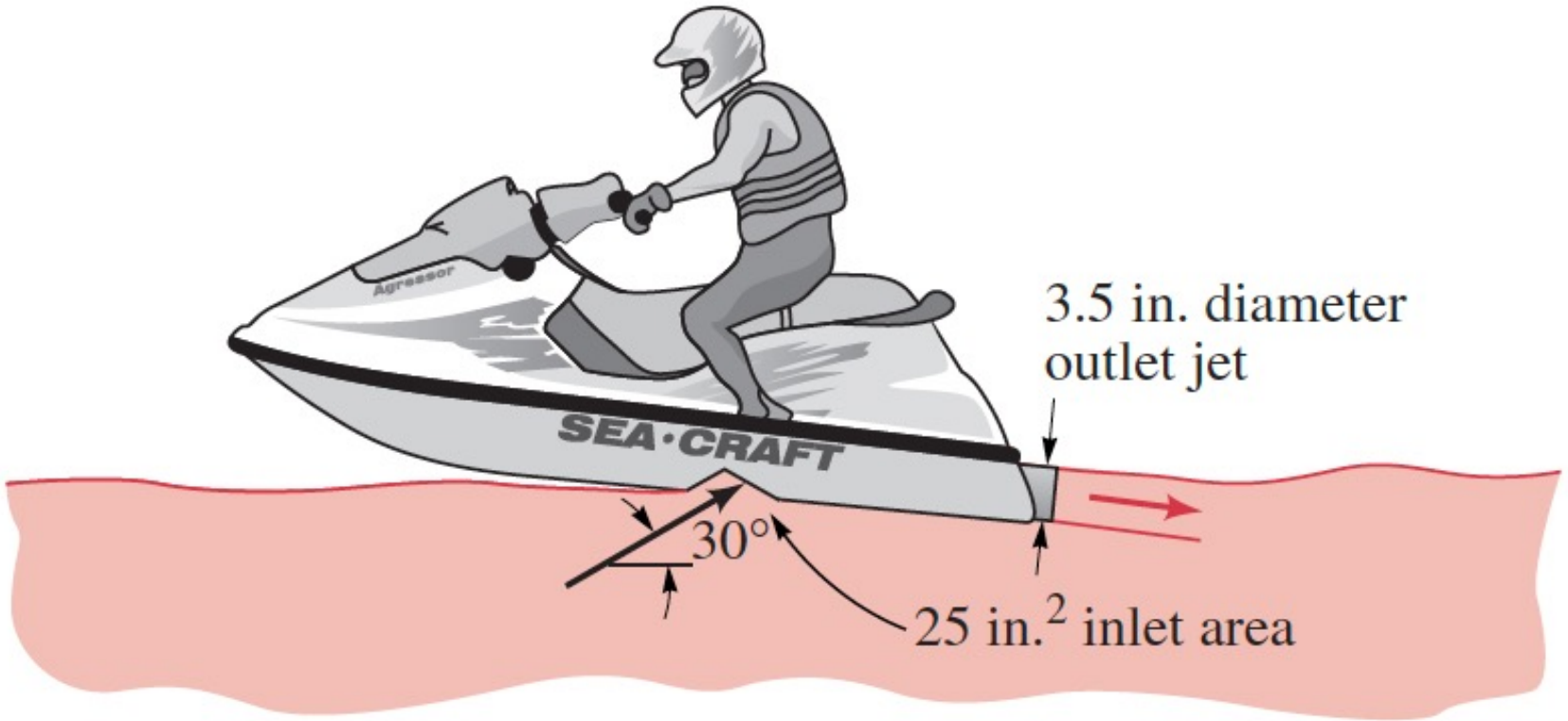
THERMAL SYSTEMS APPLICATIONS

- The **turbojet engine**, **jet ski**, and **electrical power plant** represent thermal systems involving conversion of energy in fossil fuels to achieve a desired outcome.
- Components of these systems also involve work and heat transfer.



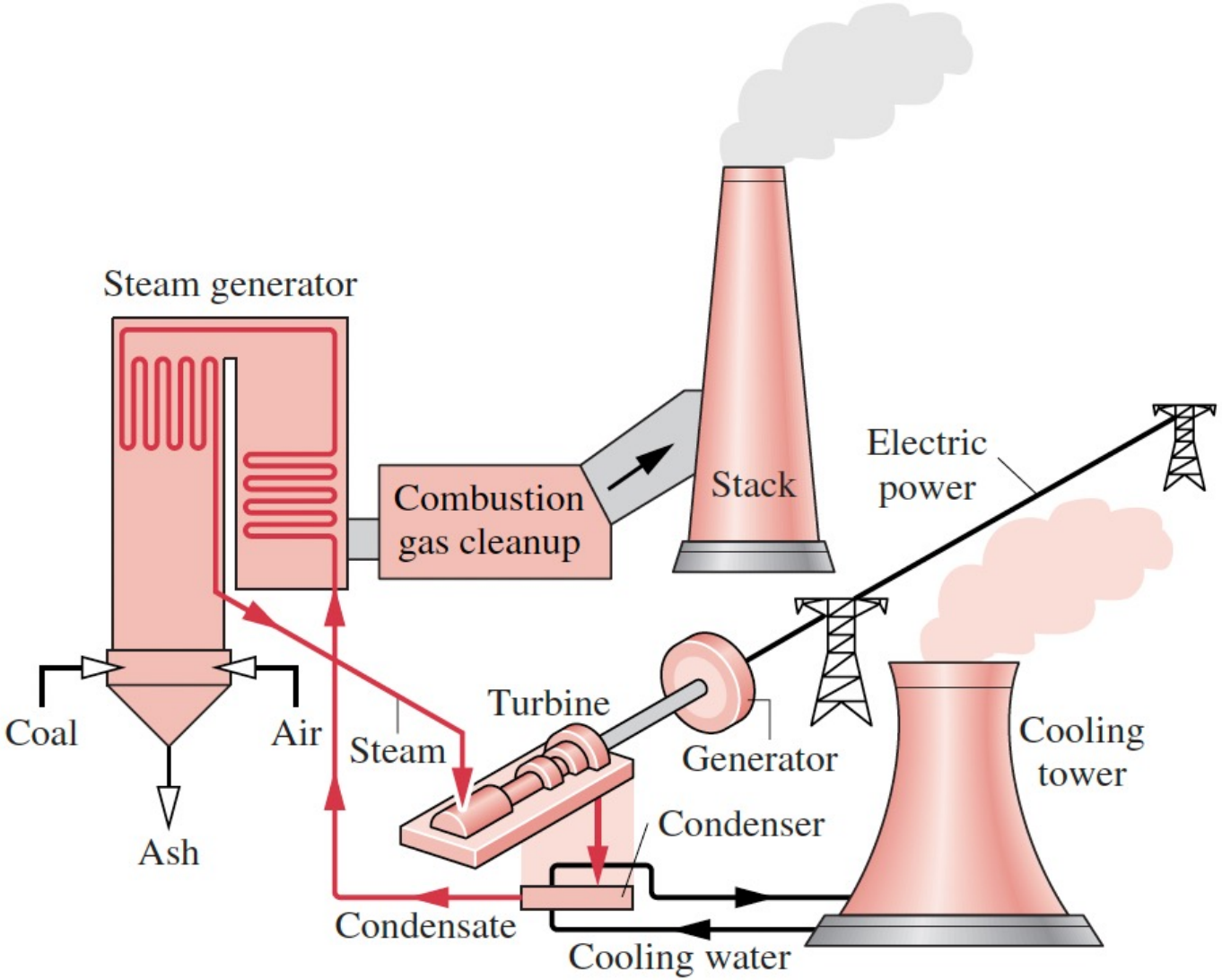
Turbojet engine

THERMAL SYSTEMS APPLICATIONS



Jet ski water =-pump propulsion

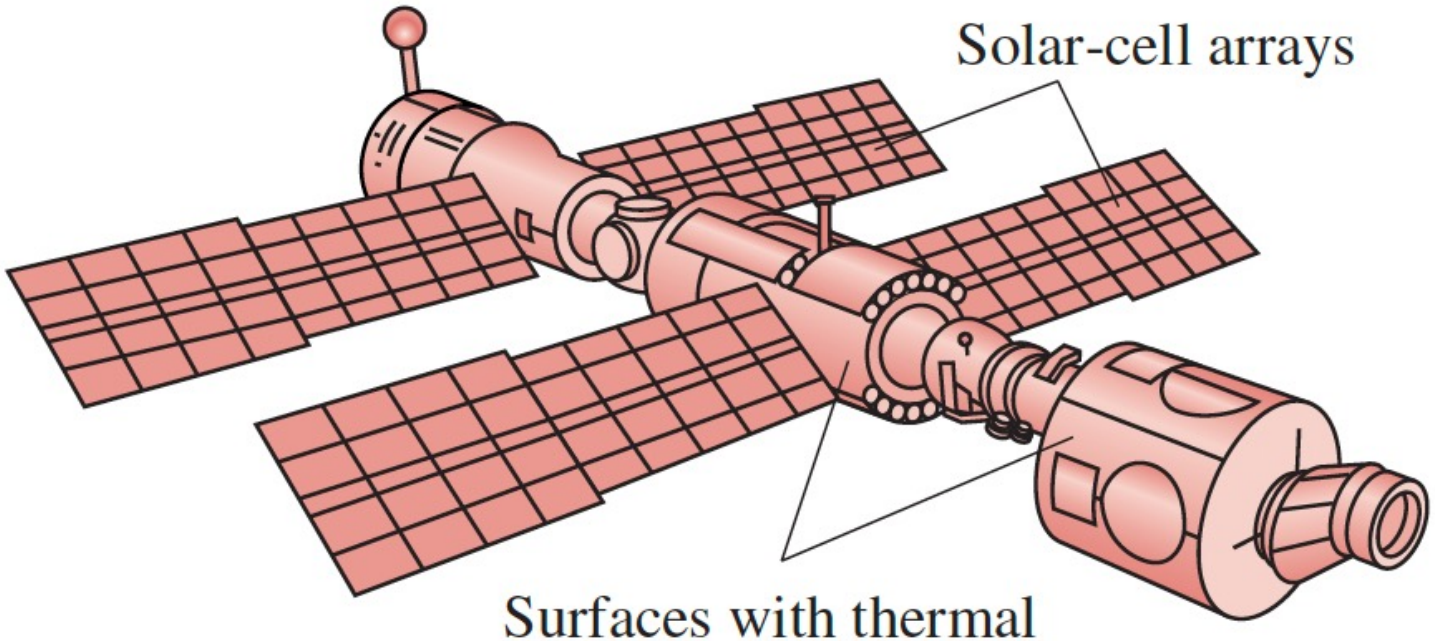
THERMAL SYSTEMS APPLICATIONS



Electrical power plant

THERMAL SYSTEMS APPLICATIONS

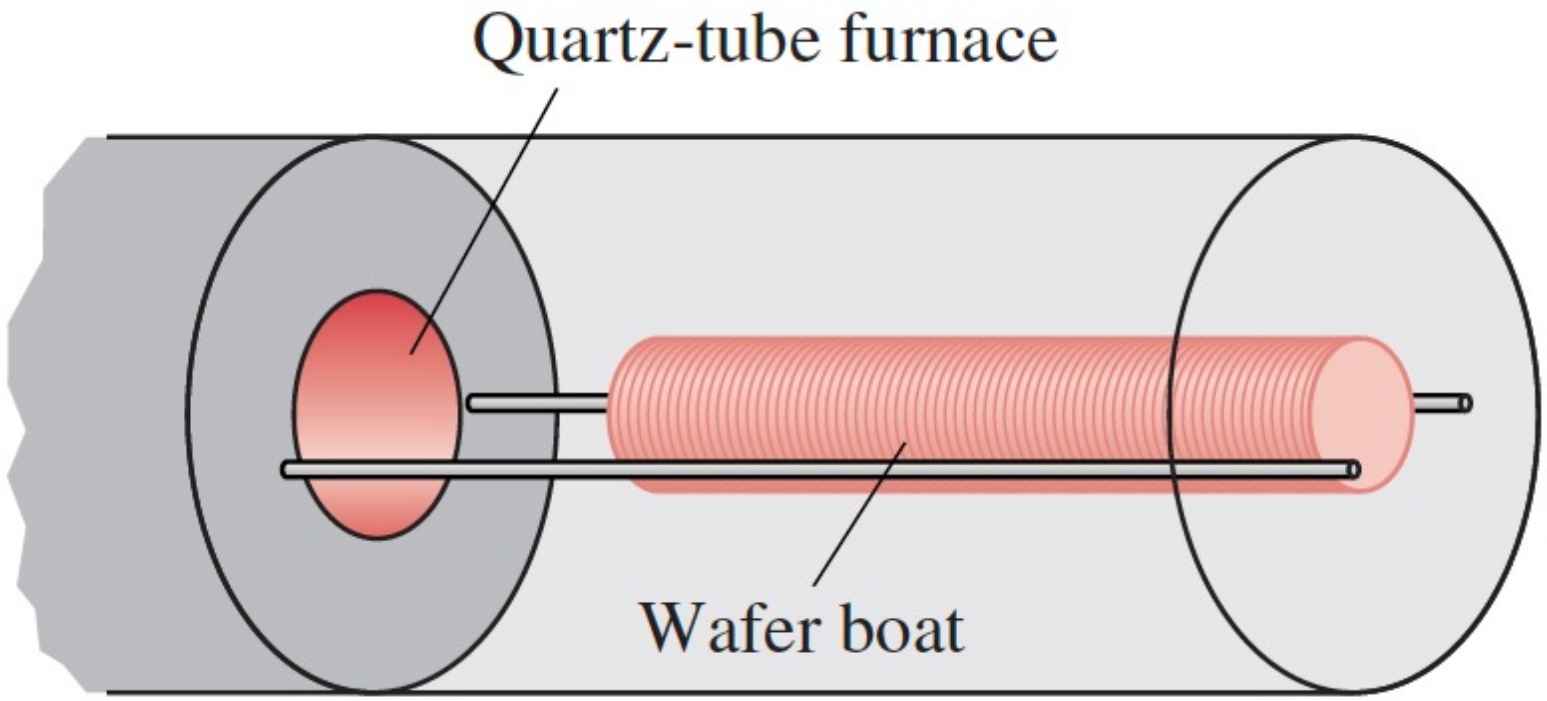
- For life support on the **International Space Station**, solar energy is converted to electrical energy and provides energy for plant growth experimentation and other purposes.



International Space Station

THERMAL SYSTEMS APPLICATIONS

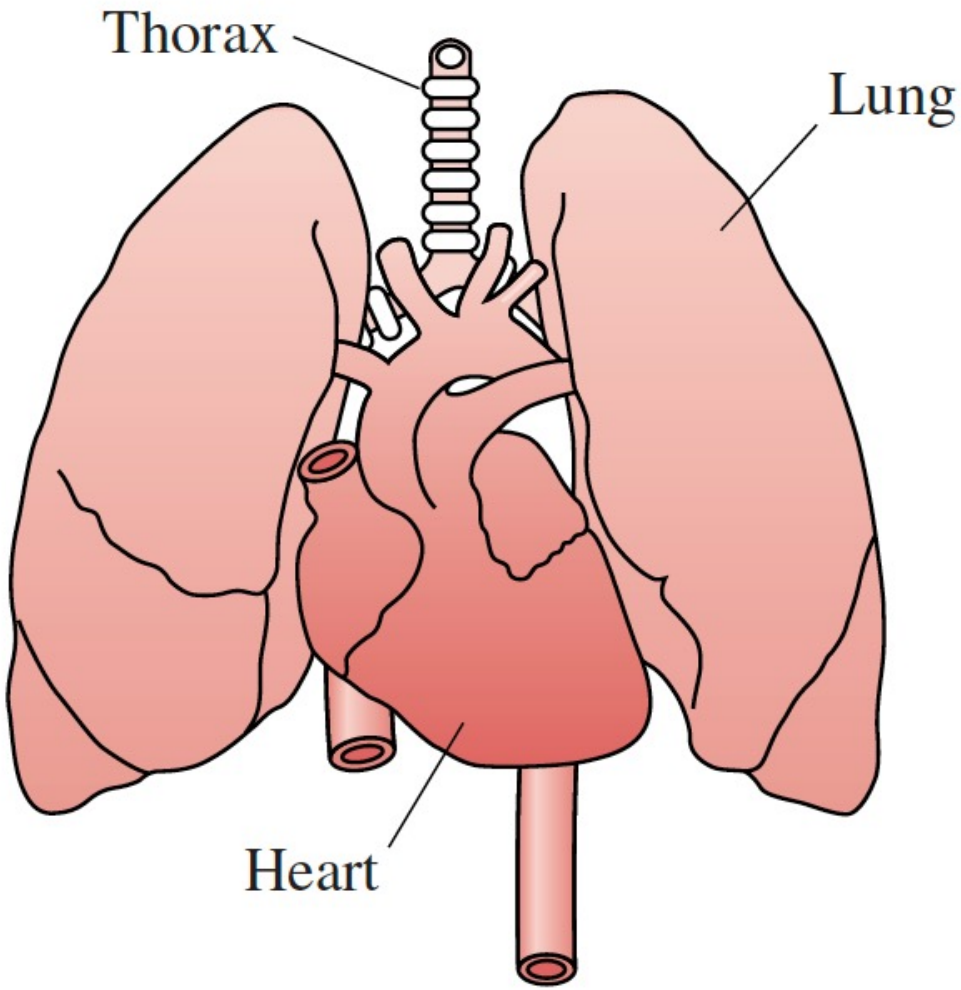
- **Semiconductor** manufacturing processes such as high temperature annealing of silicon wafers involve energy conversion and significant heat transfer effects.



High-temperature annealing of silicon wafers

THERMAL SYSTEMS APPLICATIONS

- The **human cardiovascular system** is a complex combination of fluid flow and heat transfer components that regulates the flow of blood and air to within the relatively narrow range of conditions required to maintain life.



Human cardiovascular system

THERMAL SYSTEM CASE STUDIES

- Thermal systems typically consist of a combination of components that function together as a whole. The components themselves and the overall system can be analyzed using principles drawn from three disciplines: thermodynamics, fluid mechanics, and heat transfer. The nature of an analysis depends on what needs to be understood to evaluate system performance or to design or upgrade a system. Engineers who perform such work need to learn thermal systems principles and how they are applied in different situations.

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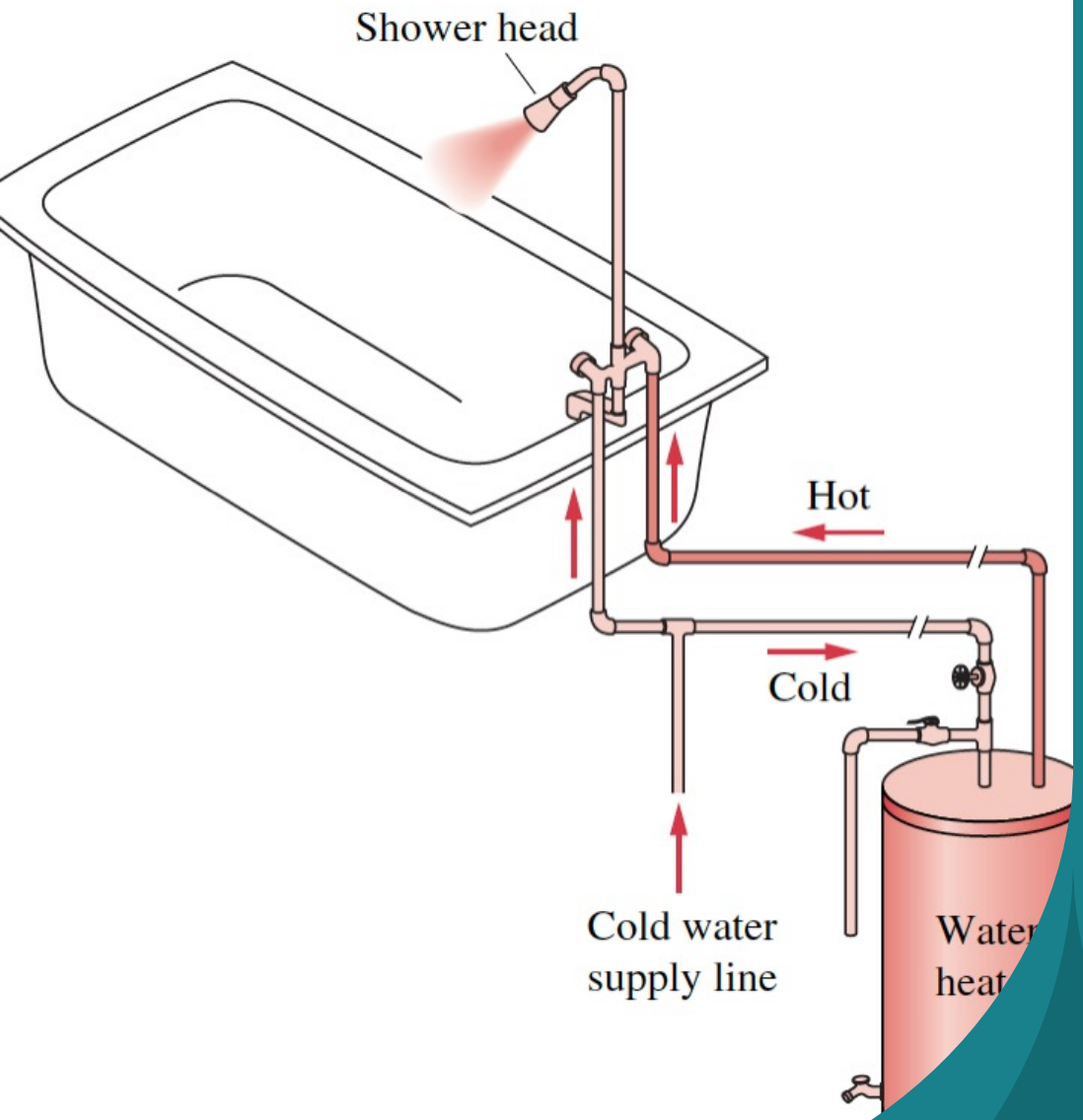


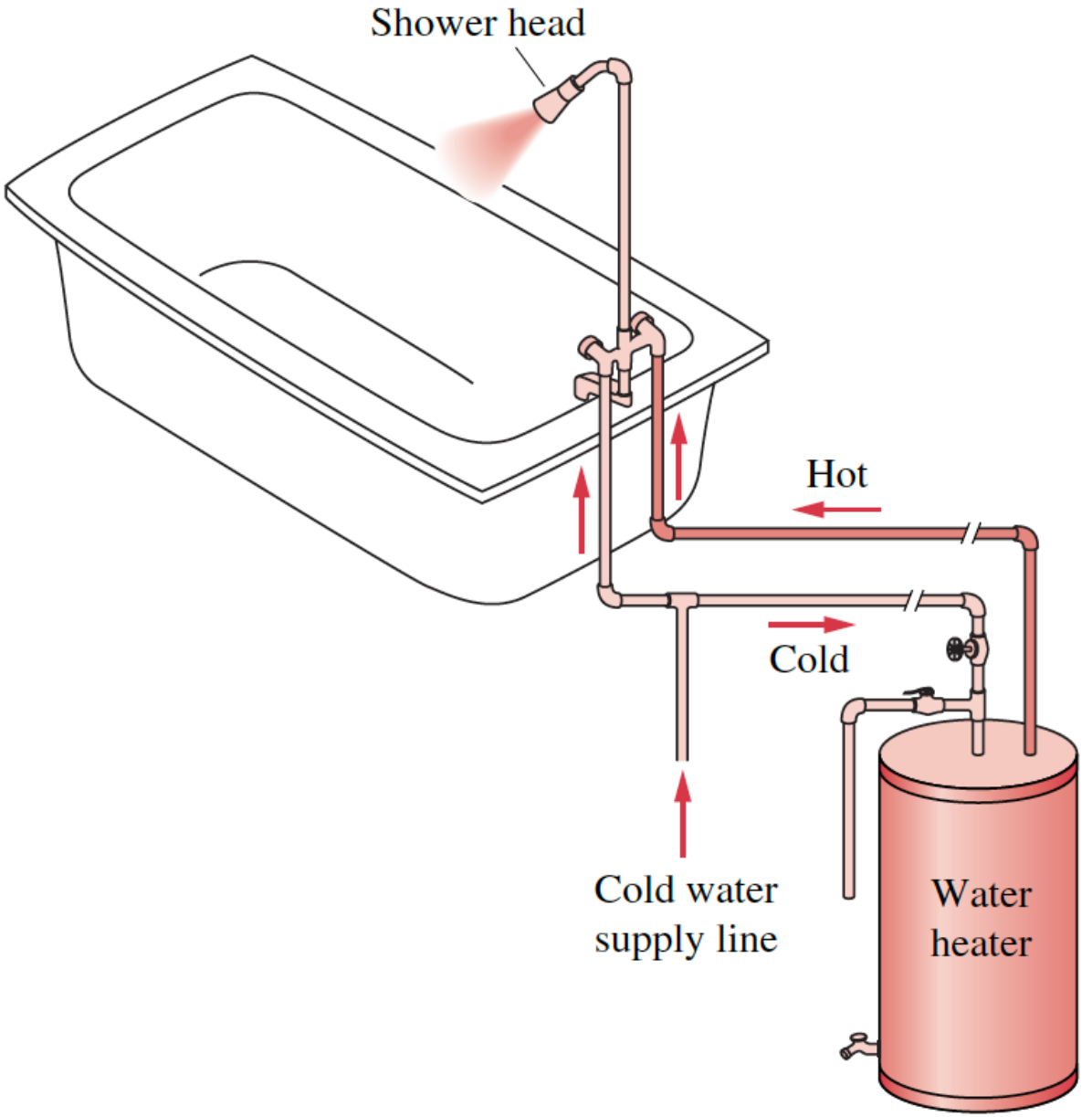
THERMAL SYSTEM CASE STUDIES: DOMESTIC HOT WATER SUPPLY

The installation that provides hot water for your shower is an everyday example of a thermal system. A typical system includes:

- a water supply
- a hot-water heater
- hot-water and cold-water delivery pipes
- a faucet and a shower head

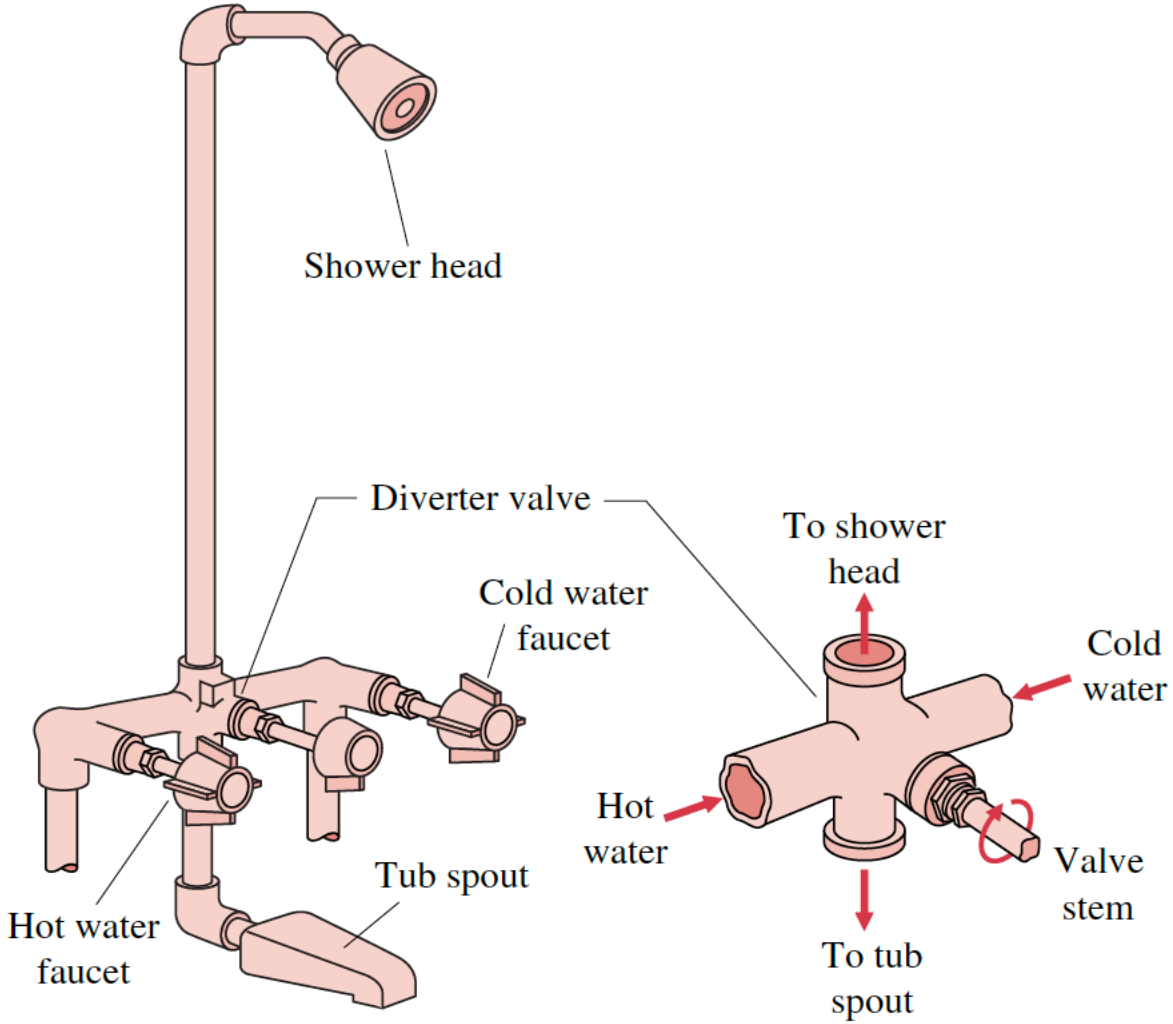
THERMAL SYSTEM CASE STUDIES: DOMESTIC HOT WATER SUPPLY

- The function of the system is to deliver a water stream with the desired flow rate and temperature.
- Cold water enters from the supply pipe with a pressure greater than the atmosphere, at low velocity and an elevation below ground level.
- Water exits the shower head at atmospheric pressure, with higher velocity and elevation, and it is comfortably hot.
- The increase in temperature from inlet to outlet depends on energy added to the water by heating elements in the hot water heater.
- The energy added can be evaluated using principles from **thermodynamics and heat transfer**



THERMAL SYSTEM CASE STUDIES: DOMESTIC HOT WATER SUPPLY

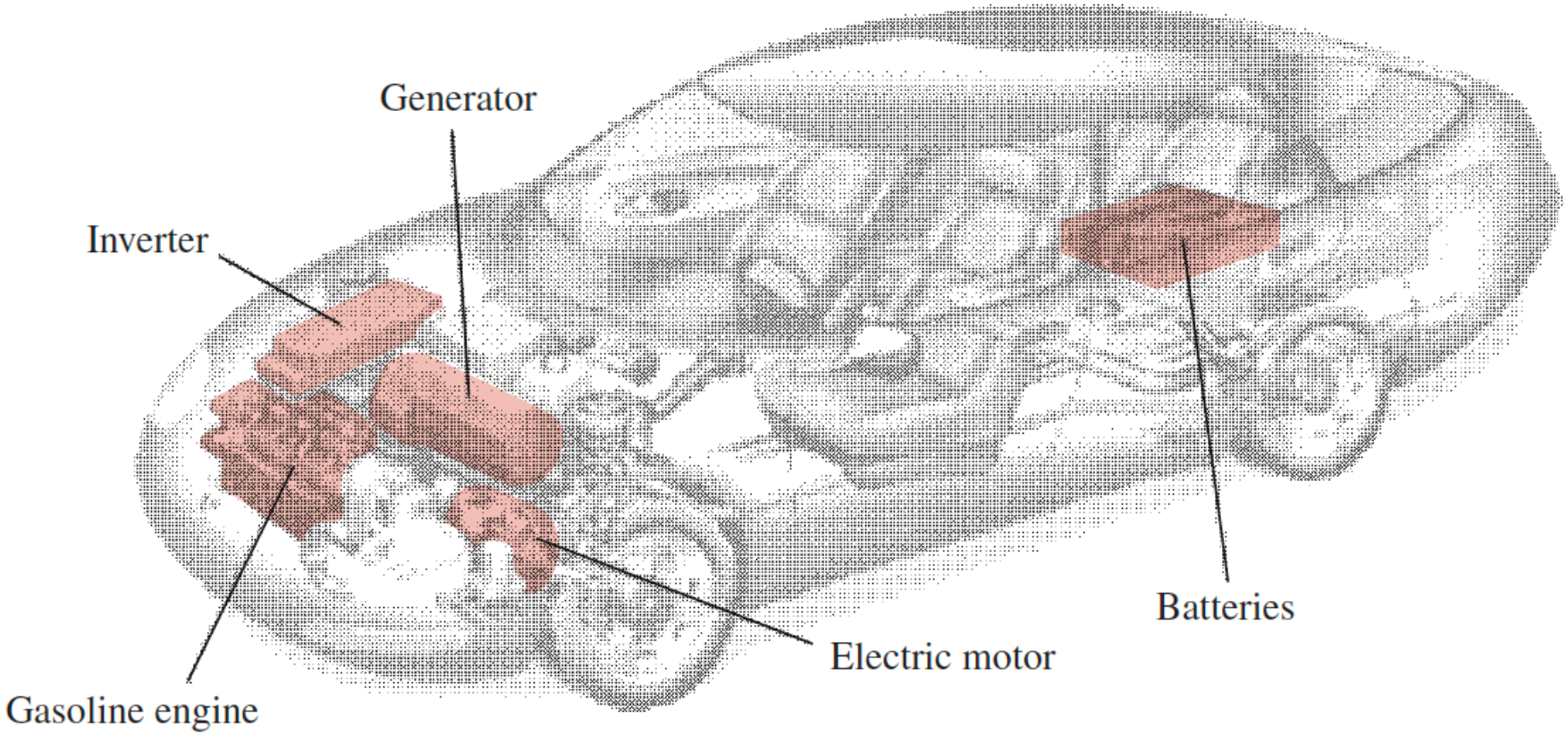
- The relationships among the values of pressure, velocity, and elevation are affected by the pipe sizes, pipe lengths, and the types of fittings used. Such relationships can be evaluated using fluid mechanics principles.
- Water heaters are designed to achieve appropriate heat transfer characteristics so that the energy supplied is transferred to the water in the tank rather than lost to the surrounding air.
- Also required is a thermostat to call for further heating when necessary.
- When there are long lengths of pipe between the hot water heater and the shower head, it also may be advantageous to insulate the pipes.



THERMAL SYSTEM CASE STUDIES: HYBRID ELECTRIC VEHICLES

- Automobile manufacturers are producing hybrid cars that utilize two or more sources of power within a single vehicle to achieve better fuel economy.
- Illustrated in the figure on the following slide is a hybrid electric vehicle (HEV) that combines a gasoline-fueled engine with a set of batteries that power an electric motor.
- The gasoline engine and the electric motor are each connected to the transmission and are capable of running the car by themselves or in combination depending on which is more effective in powering the vehicle.

THERMAL SYSTEM CASE STUDIES: HYBRID ELECTRIC VEHICLES



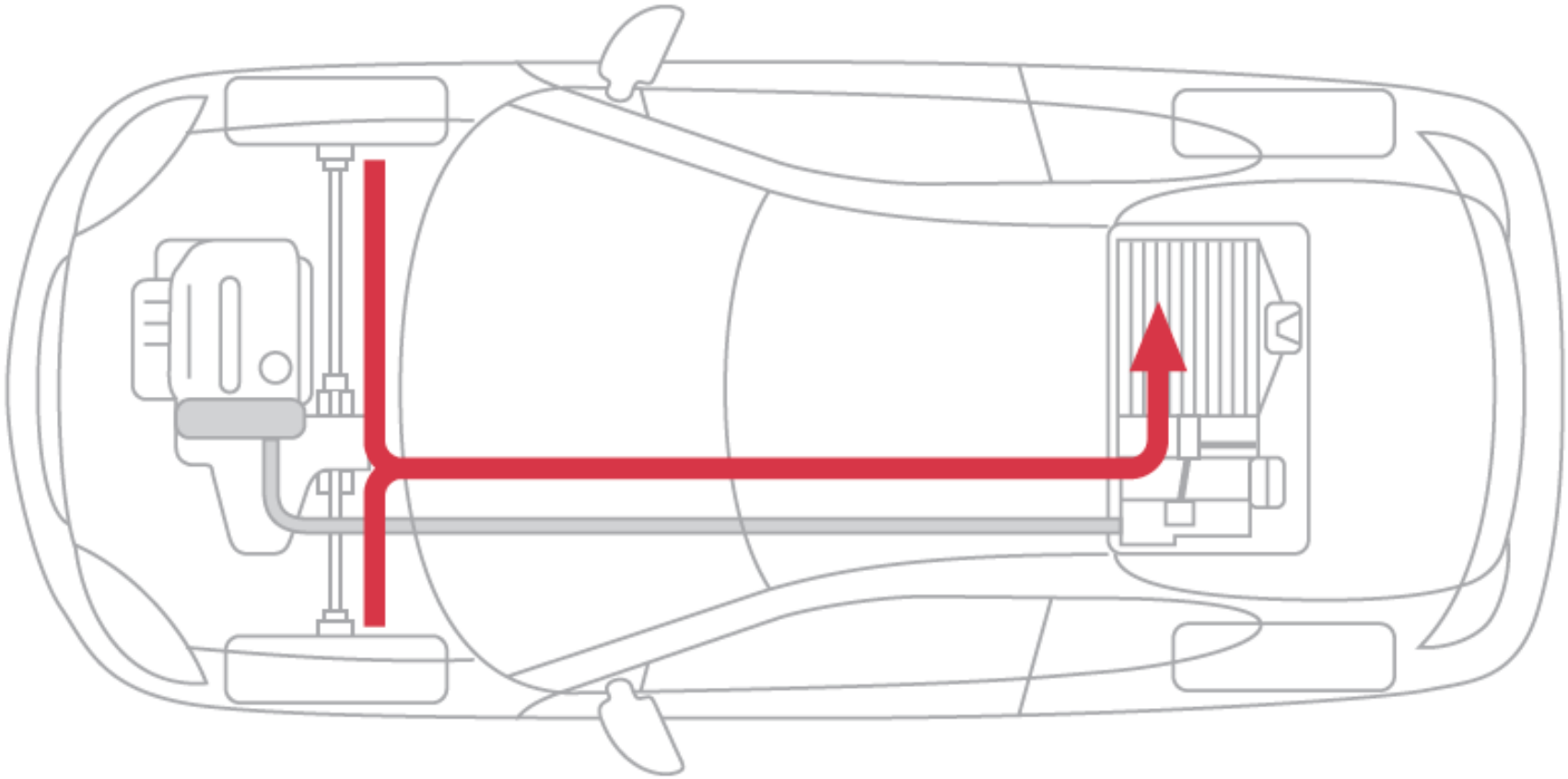
(*a*) Overview of the vehicle showing key thermal systems

THERMAL SYSTEM CASE STUDIES: HYBRID ELECTRIC VEHICLES

What makes this type of hybrid particularly fuel efficient is the inclusion of several features in the design:

- the ability to recover energy during braking and to store it in the electric batteries,
- the ability to shut off the gasoline engine when stopped in traffic and meet power needs by the battery alone,
- special design to reduce aerodynamic drag and the use of tires that have very low rolling resistance (friction), and
- the use of lightweight composite materials such as carbon fiber and the increased use of lightweight metals such as aluminum and magnesium.

THERMAL SYSTEM CASE STUDIES: HYBRID ELECTRIC VEHICLES



(*b*) Regenerative braking mode with energy flow from wheels to battery

ANALYSIS OF THERMAL SYSTEMS

- The first step in analysis is the identification of the system and how it interacts with its surroundings.
- Attention then turns to the pertinent physical laws and relationships that allow system behavior to be described.
- Analysis of thermal systems uses, directly or indirectly, one or more of four basic laws:

1. **Conservation of mass**
2. **Conservation of energy**
3. **Conservation of momentum**
4. **Second law of thermodynamics**

THERMAL SCIENCE DISCIPLINES

- **Thermodynamics** provides the foundation for analysis of thermal systems through the **conservation of mass** and **conservation of energy principles**, the **second law of thermodynamics**, and property relations.
- **Fluid mechanics** and **heat transfer** provide additional concepts, including the empirical laws necessary to specify, for instance, material choices, component sizing, and fluid medium characteristics.
- For example, thermodynamic analysis can tell you the final temperature of a hot workpiece quenched in an oil, but the rate at which it will cool is predicted using a heat transfer analysis.

THERMAL SCIENCE DISCIPLINES

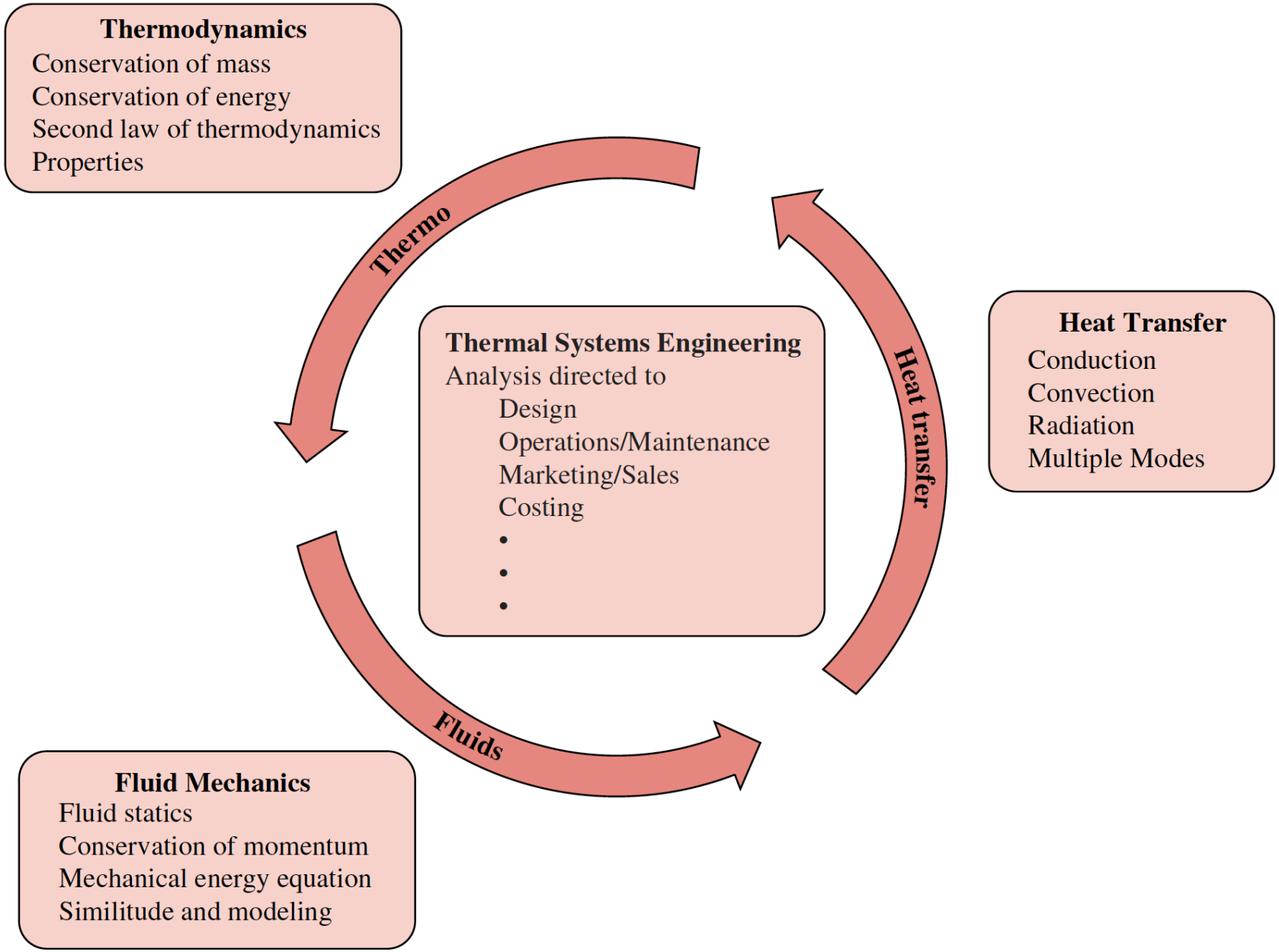
- **Fluid mechanics** is concerned with the behavior of fluids at rest or in motion.
- Two fundamentals that play central roles in our discussion of fluid mechanics are the **conservation of momentum** principle that stems from Newton's second law of motion and the **mechanical energy equation**.
- Principles of fluid mechanics allow the study of fluids flowing inside pipes (internal flows) and over surfaces (external flows) with consideration of frictional effects and lift/drag forces..

THERMAL SCIENCE DISCIPLINES

Heat transfer is concerned with energy transfer as a consequence of a temperature difference. There are three modes of heat transfer.

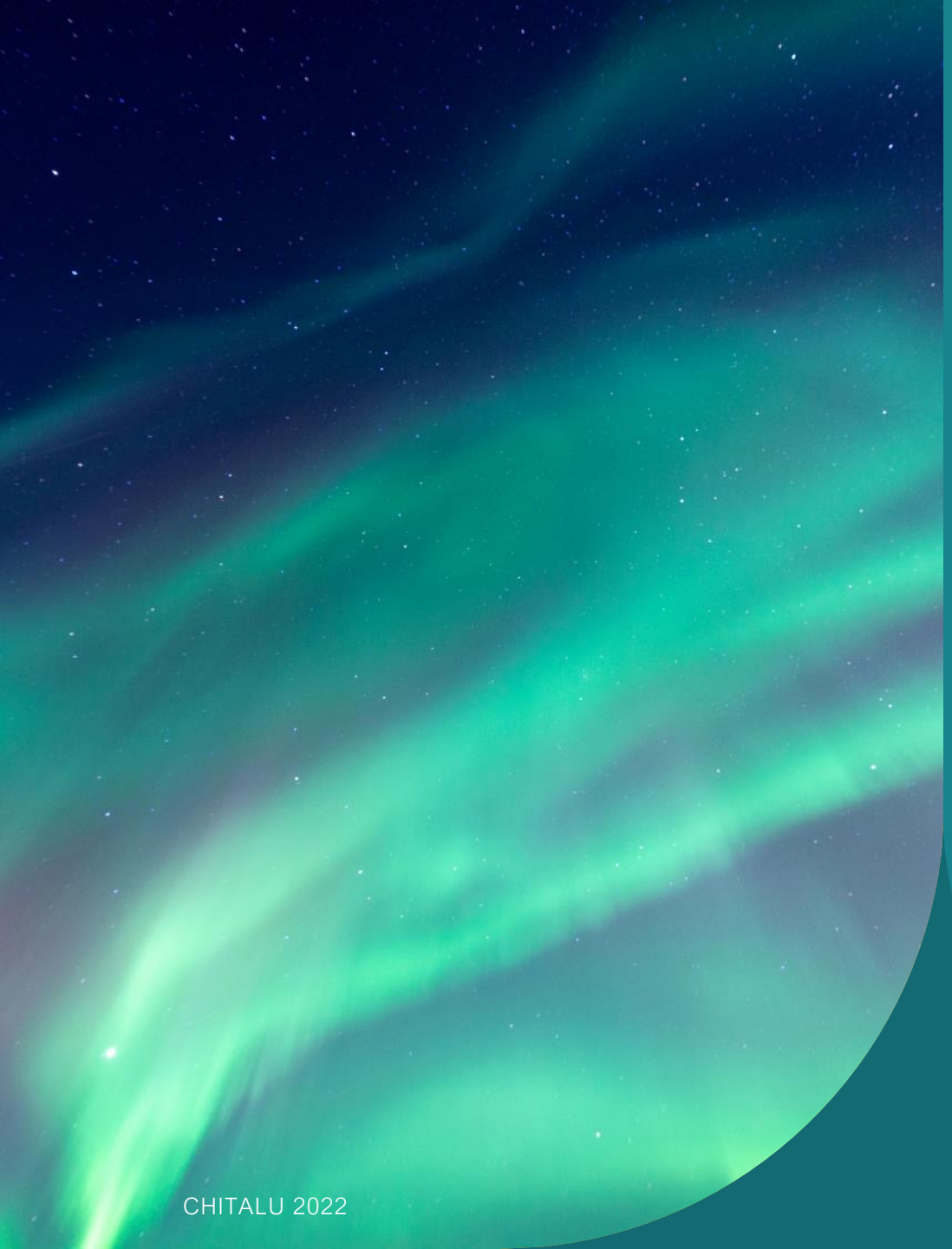
- **Conduction** refers to heat transfer through a medium across which a temperature difference exists.
- **Convection** refers to heat transfer between a surface and a moving or still fluid having a different temperature.
- The third mode of heat transfer is termed **thermal radiation** and represents the net exchange of energy between surfaces at different temperatures by electromagnetic waves independent of any intervening medium.
- For these modes, the heat transfer rates depend on the transport properties of substances, geometrical parameters, and temperatures.

THERMAL SCIENCE DISCIPLINES



““Nothing in life is certain except death, taxes – and the second law of thermodynamics.”

Seth Lloyd



Thank You

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