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| Course 04: Introduction to Energy Science |
| Task 01: Identify types and sources of energy and their common end-usesTask 02: Identify the causes and consequences of climate changeTask 03: Identify sources of renewable energyTask 04: Identify basic units and measurementTask 05: Review force, mass, velocity, and flowTask 06: Introduce basic physical properties pressure temperature and densityTask 07: Introduce the concept of heat and temperatureTask 08: Introduce the concepts of energy and work, kinetic energy, and potential energyTask 09: Introduce the Law of conservation of energyTask 10: Introduce the Second Law of Thermodynamics |

1. A home gains 4000 BTU over the course of a day. How many kJ was gained?

1 BTU (imperial) = 1.055 kJ

4000 BTU = 4220.22 kJ

1. What units would be used to measure the power consumption of a light bulb?

Watts would be used to measure the power consumption of a light bulb.

1. What units would be used to measure the energy consumption of a light bulb?

Watt-hour or kilowatt-hour would be used to measure the energy consumption of the light bulb. Energy has a time component that needs to be accounted for.

1. An ice cube at 0°C is melting in water. A thermometer reads the water temperature at 0°C as the ice melts. Explain what is happening

As the ice is melting, it is absorbing the energy around to reach thermal equilibrium. The water is of a higher thermal energy compared to the ice, and the ice will continue to absorb the energy from the liquid water until the ice reaches the same temperature as the liquid water.

1. What are the main forms of energy transfer and explain them.

Conduction – heat transfer via contact

Convection – heat transfer via a fluid

Radiation – heat transfer via emission of electromagnetic waves

1. On hot days, when the wind blows, why does it feel good?

When the wind blows on a hot day, it produces heat loss via convection. The wind pulls the heat from the body away from it.

1. If a piece of copper at 200°C is dropped into a pot of room temperature water, what can you expect to happen?

The temperature of the copper would rapidly decrease while the water temperature would rapidly increase. As the temperature becomes closer the rate of heat exchange decreases until each of the substances reaches thermal equilibrium.

1. A bathtub and a mug both read the same temperature at 50°C. Which one has more heat? Which one has a higher temperature?

The bathtub would have more heat, but both would have the same temperature. Heat is the thermal capacity of a substance, while temperature is the measurable kinetic energy of a substance.

1. In order for heat to transfer, what must be present?

A thermal difference between the objects in question

1. A 4-kW resistance heater in a water heater runs for 3 hours to raise the water temperature to the desired level. Determine the amount of electric energy used in both kWh and kJ.

To determine the kWh used for this question, we would take the 4-kW heater and multiple it by the hours it ran.

4 kW\*3 hours = 12 kWh.

1 kWh = 3600 kJ.

12 kWh \* 3600 kJ = 43200 kJ

1. The gas tank of a car is filled with a nozzle that discharges gasoline at a constant flow rate. Based on unit considerations of quantities, obtain a relation for the filling time in terms of the volume (V) of the tank (in L) and the discharge rate of gasoline. Express the answer in both metric and imperial.

This question is designed for students to work on unit conversion and their understanding of how units cancel out.

The discharge from the nozzle is noted as L/s

The volume of the gas tank is fixed in L. Therefore, we have the time it takes to fill the gas tank as $t=\frac{volume of the tank}{discharge rate}$ which works out to be $t=\frac{L}{\frac{L}{s}}$ which leaves just seconds. When doing this question in imperial measurement, the liters would become gallons.

1. Consider two closed systems A and B. System A contains 3000 kJ of thermal energy at 20°C, whereas system B contains 500 BTU of thermal energy at 160°F. Now the systems are brought into contact with each other. Determine the direction of any heat transfer between the two systems.

Heat always moves from a high temperature to a lower temperature. To accurately compare which has higher thermal energy, both systems need to be in the same units.

160°F = ~71°C. Since system B has higher thermal energy, energy would be transferred from system B to system A.

1. What is the temperature of heated air at 170°C in Fahrenheit, Kelvin, and Rankine?

170°C = 338°F = 443.15 kelvin = 797.67 rankine

1. The hydraulic lift in a car repair shop has an output diameter of 30 cm and is to lift cars up to 2000 kg. Determine both the fluid gage pressure and absolute pressure that must be maintained in the reservoir.

Gage pressure is expressed as $P\_{g}=\frac{W}{A}$ , $W=m\*g$, and $A=πr^{2}$

$W=2000 kg\*9.81 m/s^{2} $🡪 $W=19,620 kg\*m/s^{2}$

$A= π\*(\frac{0.3 m}{2})^{2}$ 🡪 $A= 0.0707 m^{2}$

$P\_{g}=\frac{19,620 kg\*m/s^{2}}{0.0707 m^{2}}$ 🡪$P\_{g}=277,510.71 N/m^{2}$ 🡪 $P\_{g}=278 kPa$

$$P\_{abs}= P\_{g}+ P\_{atm}$$

$P\_{abs}=287 kPa+101 kPa $🡪 $P\_{abs}=388 kPa$

1. The temperature of a system rises by 160°C during a heating process. Express the rise the temperature rise in °F?

160°C difference in temperature is 288°F. To find the difference, regardless of where the starting and ending points are, will yield the same results. Assuming the starting temperature is 0°C and the end temperature is 160°C, these values need to be converted to Fahrenheit. From there, the difference between the two values can be used. Some students may get 320°F. This is due to the conversion of 160°C to Fahrenheit.

1. A system at has a temperature drop from 600°C to 400°C. Express the temperature drop in K, R, and °F.

To express the temperature drop correctly, each of the temperatures need to be converted to their respective temperatures

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| --- | --- | --- | --- |
|  | Low Temp | High Temp | Difference |
| Celsius | 400 | 600 | 200 |
| Fahrenheit | 752 | 1112 | 360 |
| Kelvin | 673.15 | 873.15 | 200 |
| Rankine | 1211.67 | 1571.67 | 360 |

1. Hyperthermia of 5°C above body temperature is considered fatal. What is the temperature rise in kelvins and °F?

Assuming normal body temperature to be 37°C, 42°C would be considered fatal.

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| --- | --- | --- | --- |
|  | Start | End | Difference |
| Celsius | 37 | 42 | 5 |
| Fahrenheit | 98.6 | 107.6 | 9 |
| Kelvin | 310.15 | 315.15 | 5 |

1. A house is losing heat at a rate of 1800 kJ/h per °C temperature difference between the indoor and outdoor temperatures. Express the rate of heat loss from this house in kelvins and °F.

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|  | Heat Loss Rate |
| Celsius | 1800 |
| Fahrenheit | 3272 |
| Kelvin | 2073.2 |

1. Portable electric heaters are commonly used to heat small rooms. Explain the energy transformation involved during this heating process.

Portable electric heaters convert electrical energy into thermal energy. This process is completed by high resistance inside the portable heater, which generates large quantities of heat due to high obstruction in the flow of current.

1. Electric power is to be generated by installing a hydraulic turbine-generator at a site 120 m below the free surface of a large water reservoir that can supply water at a rate of 1500 kg/s steadily. Determine the power generation potential.

$E=∆PE$, $∆PE =m\*g\*h$

$∆PE =1,500\frac{kg}{s}\* 9.81\frac{m}{s}\*120 m$ 🡪 $∆PE=1,765,800 J$ 🡪 $∆PE=1.77 MJ$

$$E=1.77 MW of power$$

1. A water jet that leaves a nozzle at 60 m/s at a flow rate of 120 kg/s is to be used to generate power by striking the buckets on the perimeter of the wheel. Determine the power generation potential of this water jet.

$$P=\frac{1}{2}\*m\*V^{2}$$

$$P=\frac{1}{2}\*120\frac{kg}{s}\*\left(60\frac{m}{s}\right)^{2}$$

$P=216,000 watts$ 🡪 $P=216 kW$