MAE 320 – Thermodynamics
HW 2 Assignment

This assignment is due Monday, September 12th, 2016. Each problem is worth the points indicated. Copying of the solution from another is not acceptable.

(1) (16 points) Multiple choice questions (there maybe more than one correct answer)

(1a) (2p) Circle the extensive property
(A) Total Mass
(B) Temperature
(C) Pressure
(D) Density
(E) Total kinetic energy

(1b) (2p) 10 kWh is equal to
(A) \(3.6 \times 10^7\) J
(B) \(3.6 \times 10^7\) W
(C) 10,000 W
(D) \(10^{-8}\) TWh (terawatt-hours)
(E) None of above

(1c) (2p) Circle the one which is NOT a state property of a thermodynamic system?
(A) Specific volume
(B) Boundary work
(C) Heat transfer
(D) Thermal energy
(E) Specific internal energy

(1d) (2p) The unit of specific kinetic energy is (are)
(A) J/kg
(B) J^2/kg^2
(C) W
(D) W/kg
(E) m^2/s^2

(1e) (2p) For closed systems, energy is transferred across the system boundary by means of
(A) Heat Transfer
(B) Work
(C) Mass transfer
(D) Phase transition
(E) None of above

(1f) (2p) The thermal energy of a system includes
(A) Nuclear energy
(B) Chemical energy
(C) Latent energy
(D) Sensible energy
(E) Kinetic energy

(1g) (2p) The least number of independent intensive properties needed to specify a state of a simple compressible system is
(A) 0
(B) 1
(C) 3
(D) 6
(E) None of above

(1h) (2p) circle the one which is conserved during a process:

(A) Energy
(B) Heat
(C) Work
(D) Volume
(E) None of above

(2) (24 points) Simple calculation questions
(2a) (6p) The normal temperature of a healthy human body is 36.6°C. A patient measures his temperature by means of three thermometers, with three different temperature scales. Specifically, the readings are: 103.5°F on Monday, 311.6 K on Tuesday, and 558.3 R on Wednesday. Please check if the patient is recovering and elucidate your answer by converting the values above into °C.

(2b) (6p) The absolute pressure on the bottom of a river is three times higher than that ambient pressure. Please determine the depth of the river if the density of water is 1000 kg/m³ and the atmospheric pressure is 1 bar.

(2c) (6p) Oil with a density of 800 kg/m³ is flowing at a velocity of 20 m/s at the atmospheric pressure in a horizontal tube elevated at 20 m above the sea level. Please determine the diameter of the tube if the rate of mechanical energy (KE, PE and flow work) for oil is $6\times10^4$ J/s.

(2d) (6p) Instructor’s house is maintained at a comfortable temperature by means of an electrical resistor heater during winter. The heater is operated at a constant current $I$ under an applied voltage of 110 V. Please find $I$ if the instructor pays $8.00/day for heating, with the electricity cost of $0.10/kWh. Also, please calculate the heat produced by such a heater hourly. For simplicity, assume that the heater operates uniformly all the time, with 95% of conversion efficiency from the electrical energy to the internal energy of air in the house.

(3) (20 points) An electric fan is used to accelerate the initially quiescent air up to a velocity of 20 m/s with a mass flow rate of 9.6 kg/s. The density of the air is 1.2 kg/m³. The electricity consumption rate is 2.25 kW. The efficiency of the fan in transferring the mechanical work into the kinetic energy of the gas is 87%. Ignoring the change in the potential energy of the gas,

(A) (3p) Draw a schematic diagram of this system showing the conversion of the electrical work to the kinetic energy of the gas.

(B) (3p) Determine the volumetric flow rate of the gas.
(C) (3p) Determine the specific kinetic energy (J/kg) of the gas entering and exiting the fan.
(D) (3p) Determine the rate of kinetic energy (J/s) of the gas exiting the fan.
(E) (4p) Determine the power output of the fan.
(F) (4p) Determine the efficiency of the electrical to mechanical work conversion by the fan.

(4) (20 points) A power generator consists of an internal combustion (IC) engine connected to an electricity producer. Specifically, the engine converts the chemical energy of a combustible fuel into the mechanical work which, in turn, is converted to electricity by the producer. Obviously, the engine efficiency is defined as the ratio of the mechanical power to the consumption rate chemical energy; while the producer efficiency is defined as the ratio of the output of electrical power to mechanical power. Please determine
(A) (4p) The power output of the generator if the output current is 30 A at a voltage of 110 V.
(B) (4p) The power output of the IC engine given the efficiency of the generator of 85%.
(C) (3p) The total mechanical work produced by this engine if it operates continuously for 1 year.
(D) (6p) The total rate of chemical energy consumed (J/s) and the efficiency of the engine when it operates with gasoline and consumes the fuel at a rate of 10 g/min. The chemical energy of fuel is \(4.3 \times 10^7 \text{J/kg}\).
(E) (3p) The total efficiency of the power generator.

(5) (20 points) A rigid tank, filled partly with water, is heated by a burner as illustrated in the figure (right). During this process, the system is being stirred by a paddle wheel for mixing of water. The initial internal energy of water was 1000 kJ. The mechanical work transferred into water by the paddle during the heating process is 200 kJ, the heat loss to the surrounding is 500 kJ, and the heat transfer from the burner to water is 1500 kJ. Please
(A) (4p) List the forms of energy transfer involved in the process.
(B) (4p) Is this a closed system or a control volume system? Explain why or why not.
(C) (5p) Write the First Law of Thermodynamics for this system and have it expressed by an equation with the meaning of each term explained.
(D) (5p) Calculate the total internal energy of water at final state.

(6). (20 Points) The issue of global warming is receiving considerable attention these days. Write an essay (no less than 1 page, single-line space, times new roman font, 11 point) with at least three references on the subject of global warming. Explain what is meant by the term global warming and discuss objectively the scientific evidence that is cited as the basis for the argument that global warming is occurring. Determine the respective contributions to the electric power provided to customers by the electric utility serving your locale attributable to coal, natural gas, oil, biomass, nuclear power, wind power and solar power, and summarize your findings in a pie chart. For each type of contribution to the electric power, evaluate its effect on global warming.

Optional Question: # 24, 26, 57, 63, 72 in text book.