CHAPTER 2. ENERGY; ENERGY TRANSFER; GENERAL ENERGY ANALYSES

1) What forms of energy involved during the heating of water on an electric range? What are the energy transformations that take place?

2) What is mechanical energy and mechanical efficiency? How does the mechanical energy differ from thermal energy? What are the forms of mechanical energy of a fluid stream?

3) Determine either the followings are heat or work interaction:
   a) A gas in a piston–cylinder device is compressed, and as a result its temperature rises.
   b) A room is heated by an iron that is left plugged in (Take the entire room, including the iron, as the system)
   c) An insulated room is heated by burning candles. Is this a heat or work interaction? Take the entire room, including the candles, as the system.

4) For a cycle, is the net work necessarily zero? For what kind of systems will this be the case?

5) On a hot summer day, a student turns his fan on when he leaves his room in the morning. When he returns in the evening, will the room be warmer or cooler than the neighboring rooms? Why? Assume all the doors and windows are kept closed.

6) Consider a river flowing toward a lake at an average velocity of 3 m/s at a rate of 500 m$^3$/s at a location 90 m above the lake surface. Determine the total mechanical energy of the river water per unit mass and the power generation potential of the entire river at that location.

7) The engine of a 1500-kg automobile has a power rating of 75 kW. Determine the time required to accelerate this car from rest to a speed of 100 km/h at full power on a level road. Is your answer realistic?

8) A vertical piston–cylinder device contains water and is being heated on top of a range. During the process, 65 Btu of heat is transferred to the water, and heat losses from the side walls amount to 8 Btu. The piston rises as a result of evaporation, and 5 Btu of work is done by the vapor. Determine the change in the energy of the water for this process. 
   (Answer: 52 Btu)

9) A university campus has 200 classrooms and 400 faculty offices. The classrooms are equipped with 12 fluorescent tubes, each consuming 110 W, including the electricity used by the ballasts. The faculty offices, on average, have half as many tubes. The campus is open 240 days a year. The classrooms and faculty offices are not occupied an average of 4 h a day, but the lights are kept on. If the unit cost of electricity is $0.082/kWh, determine how much the campus will save a year if the lights in the classrooms and faculty offices are turned off during unoccupied periods.
10) A fan is to accelerate quiescent air to a velocity of 10 m/s at a rate of 4 m$^3$/s. Determine the minimum power that must be supplied to the fan. Take the density of air to be 1.18 kg/m$^3$.

\[(Answer: 236 \text{ W})\]

11) The driving force for fluid flow is the pressure difference, and a pump operates by raising the pressure of a fluid (by converting the mechanical shaft work to flow energy). A gasoline pump is measured to consume 5.2 kW of electric power when operating. If the pressure differential between the outlet and inlet of the pump is measured to be 5 kPa and the changes in velocity and elevation are negligible, determine the maximum possible volume flow rate of gasoline.

\[\Delta P = 5 \text{ kPa}\]

12) Water is pumped from a lower reservoir to a higher reservoir by a pump that provides 20 kW of shaft power. The free surface of the upper reservoir is 45 m higher than that of the lower reservoir. If the flow rate of water is measured to be 0.03 m$^3$/s, determine mechanical power that is converted to thermal energy during this process due to frictional effects.

13) A 75-hp (shaft output) motor that has an efficiency of 91.0 percent is worn out and is to be replaced by a high-efficiency motor that has an efficiency of 95.4 percent. The motor operates 4368 hours a year at a load factor of 0.75. Taking the cost of electricity to be $0.08/kWh, determine the amount of energy and money saved as a result of installing the high-efficiency motor instead of the standard motor. Also, determine the simple payback period if the purchase prices of the standard and high-efficiency motors are $5449 and $5520, respectively.

14) A glycerin pump is powered by a 5 kW electric motor. The pressure differential between the outlet and the inlet of the pump at full load is measured to be 211 kPa. What is the overall efficiency of the pump if the flow rate through the pump is 18 L/s and the changes in elevation and the flow velocity across the pump are negligible?
15) Water is pumped from a lake to a storage tank 20 m above at a rate of 70 L/s while consuming 20.4 kW of electric power. Disregarding any frictional losses in the pipes and any changes in kinetic energy, determine (a) the overall efficiency of the pump–motor unit and (b) the pressure difference between the inlet and the exit of the pump.

![Diagram of water pumping system]

16) An oil pump is drawing 35 kW of electric power while pumping oil (ρ=860 kg/m³) with at a rate of 0.1 m³/s. The inlet and outlet diameters of the pipe are 8 cm and 12 cm, respectively. If the pressure rise of oil in the pump is measured to be 400 kPa and the motor efficiency is 90 percent, determine the mechanical efficiency of the pump.

![Diagram of oil pumping system]

17) Electric power is to be generated by installing a hydraulic turbine–generator at a site 70 m below the free surface of a large water reservoir that can supply water at a rate of 1500 kg/s steadily. If the mechanical power output of the turbine is 800 kW and the electric power generation is 750 kW;

a) Determine the turbine efficiency and the combined turbine–generator efficiency of this plant. Neglect losses in the pipes.

b) Disregarding frictional losses in piping, estimate the electric power output of this plant

18) Large wind turbines with blade span diameters of over 100 m are available for electric power generation. Consider a wind turbine with a blade span diameter of 100 m installed at a site subjected to steady winds at 8 m/s. Taking the overall efficiency of the wind turbine to be 32 percent and the air density to be 1.25 kg/m³, determine the electric power generated by this wind turbine. Also, assuming steady winds of 8 m/s during a 24-hour period, determine the amount of electric energy and the revenue generated per day for a unit price of $0.06/kWh for electricity.