9.32 Air enters the compressor of an ideal cold air-standard Brayton cycle at 100 kPa, 300 K, with a mass flow rate of 6 kg/s. The compressor pressure ratio is 10, and the turbine inlet temperature is 1400 K. For $k = 1.4$, calculate
   a. the thermal efficiency of the cycle.
      Answer: 48.2%
   b. the back work ratio.
   c. the net power developed, in kW.
      Answer: 2386

9.34 The rate of heat addition to an ideal air-standard Brayton cycle is $5.2 \times 10^6$ Btu/h. The pressure ratio for the cycle is 12 and the minimum and maximum temperatures are 520°F and 2800°F, respectively. Determine
   a. the thermal efficiency of the cycle.
   b. the mass flow rate of air, in lb/h.
   c. the net power developed by the cycle, in hp.

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Consider a gas turbine power plant operating on an ideal air-standard Brayton cycle. Dry air enters the compressor with a volumetric flow rate of 5 m³/s at 100 kPa and 300 K (State 1) and exits the compressor at 600 kPa (State 2). Air enters the turbine at 1600 K (State 3) and exits the turbine at 100 kPa (State 4).

(a) Determine the net power output (kW) of the cycle.
(b) Calculate thermal efficiency (%) of the cycle.
(c) Find the back work ratio of the cycle.
(d) Perform an exergy accounting of the net exergy increase in the combustor.
(e) Determine the exergetic (2nd law) efficiency (%) of the cycle.
(f) Show the cycle on T-s diagram. Label states, show temperature values, and indicate appropriate lines of constant pressure.
(g) Plot the variation of net power output, cycle thermal efficiency, and back work ratio for compressor pressure ratios ranging from 6 to 16.

Answer: (b) 37.2%
Consider a gas turbine power plant operating on a regenerative Brayton cycle. Dry air enters the compressor with a volumetric flow rate of 5 m³/s at 100 kPa and 300 K (State 1) and exits the compressor at 1200 kPa (State 2). The compressor has an isentropic efficiency of 85%. Air exiting the compressor enters a regenerative heat exchanger of 80% effectiveness and is heated to State X before entering the combustor. Air enters the turbine at 1600 K (State 3) and exits the turbine at 100 kPa (State 4). The turbine has an isentropic efficiency of 90%. Air leaving the turbine enters the regenerative heat exchanger and exits at State Y.

(a) Determine the net power output (kW) of the cycle.
(b) Calculate thermal efficiency (%) of the cycle.
(c) Find the back work ratio of the cycle.
(d) What is the rate of entropy generation (kW/K) for the regenerative heat exchanger?
(e) Determine the rate of flow exergy (kW) for the air leaving the regenerative heat exchanger and entering to the combustor if the environment is at 100 kPa and 300 K.
(f) Does regeneration always increase thermal efficiency of the cycle for a given compressor ratio and turbine inlet temperature? Justify your answer.

Answer: (c) 0.473
Consider a gas turbine power plant operating on an ideal air-standard Brayton cycle with intercooling and reheating. Dry air enters the low-pressure compressor with a volumetric flow rate of 5 m³/s at 100 kPa and 300 K (State 1) and exits the compressor at 346.4 kPa (State 2). Air leaving the low-pressure compressor is cooled to 300 K (State 3) and is then compressed to 1200 kPa (State 4) in the high-pressure compressor. Air enters the high-pressure turbine at 1200 kPa and 1600 K (State 5) and exits at 346.4 kPa (State 6). Air leaving the high-pressure turbine is reheated to 1600 K (State 7) and is then expanded to 100 kPa (State 8) in the low-pressure turbine.

(a) Determine the net power output (kW) of the cycle.
(b) Calculate thermal efficiency (%) of the cycle.
(c) Find the back work ratio of the cycle.
(d) Does intercooling always increase thermal efficiency of the cycle for a given compressor ratio and turbine inlet temperature? Justify your answer.
(e) Does intercooling always increase net power output of the cycle for a given compressor ratio and turbine inlet temperature? Justify your answer.

Answer: (a) 4247.82 kW
Air at 26 kPa, 230 K, and 220 m/s enters a turbojet engine in flight. The air mass flow rate is 25 kg/s. The compressor pressure ratio is 11, the turbine inlet temperature is 1400 K, and air exits the nozzle at 26 kPa. The diffuser and nozzle processes are isentropic, the compressor and turbine have isentropic efficiencies of 85% and 90%, respectively, and there is no pressure drop for flow through the combustor. Kinetic energy is negligible everywhere except at the diffuser inlet and the nozzle exit. On the basis of air-standard analysis, determine

a. the pressures, in kPa, and temperatures, in K, at each principal state.

b. the rate of heat addition to the air passing through the combustor, in kJ/s.

c. the velocity at the nozzle exit, in m/s.

Air enters the diffuser of a ramjet engine (Fig. 9.27c) at 6 lbf/in.$^2$, 420°R, with a velocity of 1600 ft/s, and decelerates essentially to zero velocity. After combustion, the gases reach a temperature of 2200°R before being discharged through the nozzle at 6 lbf/in.$^2$. On the basis of an air-standard analysis, determine

a. the pressure at the diffuser exit, in lbf/in.$^2$.

b. the velocity at the nozzle exit, in ft/s.

Neglect kinetic energy except at the diffuser inlet and the nozzle exit. Assume combustion occurs at constant pressure and flow through the diffuser and nozzle is isentropic.

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(a), (b), (c) Textbook Problem 9.58 (See above)
(d) Plot the variation of rate of heat addition, turbine exit pressure, and nozzle exit velocity for compressor pressure ratio ranging from 6 to 14.

Answer: (c) 985.7 m/s

Note:
Please include your EES code(s), parametric tables, and plots for (d). Assumptions, basic equation(s), system sketch can be either submitted separately or included within the EES code(s). EES code(s) should contain variable definitions, comments, etc.