

Problem 1

Steam flows into a turbine at a rate of 10kg/s, and 10kW of heat are lost from the turbine, Ignoring elevation and kinetic energy effects, what is most nearly the power (kW) output from the turbine?

	Inlet Conditions	Exit Conditions
Pressure	1.0 MPa	0.1 MPa
Temperature	350 °C	-
Quality	-	100%

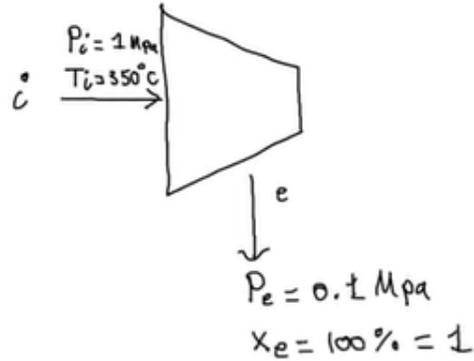
- (A) 1250
- (B) 4778
- (C) 4812
- (D) 3500

Problem 1

$$x = \frac{m_{\text{vap}}}{m_{\text{tot}}}$$

$$x = 1 \rightarrow \text{sat vapor}$$

$$x = 0 \rightarrow \text{sat liquid}$$



Page 158 from the FE handbook

	$p = 0.80 \text{ MPa (170.43}^\circ\text{C)}$				$p = 1.00 \text{ MPa (179.91}^\circ\text{C)}$			
Sat.	0.2404	2576.8	2769.1	6.6628	0.19444	2583.6	2778.1	6.5865
200	0.2608	2630.6	2839.3	6.8158	0.2060	2621.9	2827.9	6.6940
250	0.2931	2715.5	2950.0	7.0384	0.2327	2709.9	2942.6	6.9247
300	0.3241	2797.2	3056.5	7.2328	0.2579	2793.2	3051.2	7.1229
350	0.3544	2878.2	3161.7	7.4089	0.2825	2875.2	3157.7	7.3011
400	0.3843	2959.7	3267.1	7.5716	0.3066	2957.3	3263.9	7.4651
500	0.4433	3126.0	3480.6	7.8673	0.3541	3124.4	3478.5	7.7622
600	0.5018	3297.9	3699.4	8.1333	0.4011	3296.8	3697.9	8.0290
700	0.5601	3476.2	3924.2	8.3770	0.4478	3475.3	3923.1	8.2731
800	0.6181	3661.1	4155.6	8.6033	0.4943	3660.4	4154.7	8.4996
900	0.6761	3852.8	4393.7	8.8153	0.5407	3852.2	4392.9	8.7118
1000	0.7340	4051.0	4638.2	9.0153	0.5871	4050.5	4637.6	8.9119
1100	0.7919	4255.6	4889.1	9.2050	0.6335	4255.1	4888.6	9.1017
1200	0.8497	4466.1	5145.9	9.3855	0.6798	4465.6	5145.4	9.2822
1300	0.9076	4681.8	5407.9	9.5575	0.7261	4681.3	5407.4	9.4543

	$p = 0.10 \text{ MPa (99.63}^\circ\text{C)}$			
Sat.	1.6940	2506.1	2675.5	7.3594
100	1.6958	2506.7	2676.2	7.3614
150	1.9364	2582.8	2776.4	7.6134
200	2.172	2658.1	2875.3	7.8343
250	2.406	2733.7	2974.3	8.0333

Steam flows into a turbine at a rate of 10 kg/s, and 10 kW of heat are lost from the turbine. Ignoring elevation and kinetic energy effects, what is most nearly the power (kW) output from the turbine?

For Steady-Flow Systems on page 148 of the FE Handbook:

First Law of Thermodynamics

$$\dot{Q} - \dot{W} = \dot{m} \left[h_e - h_i + \frac{V_e^2 - V_i^2}{2} + g(z_e - z_i) \right]$$

KE

PE

For the inlet,

$$h_i = 3157.7 \text{ kJ/kg}$$

For the exit,

$$x = 1 = 100\% \therefore \text{sat vapor}$$

$$h_e = 2675.5 \text{ kJ/kg}$$

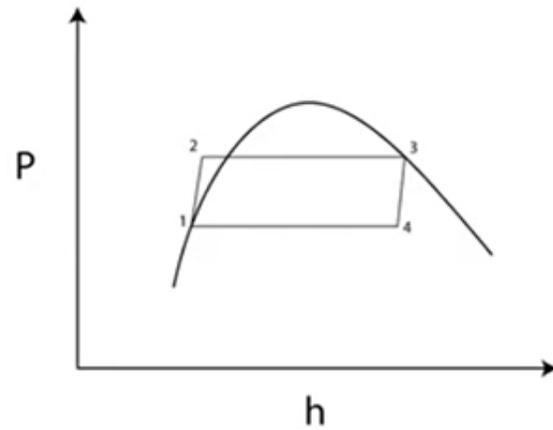
$$\dot{W} = \dot{m} (h_i - h_e) - \dot{Q}$$

$$\dot{W} = 10 \frac{\text{kg}}{\text{s}} \left(3157.7 \frac{\text{kJ}}{\text{kg}} - 2675.5 \frac{\text{kJ}}{\text{kg}} \right) - 10 \text{ kW}$$

$$\dot{W} = \boxed{4812 \text{ kW}}$$

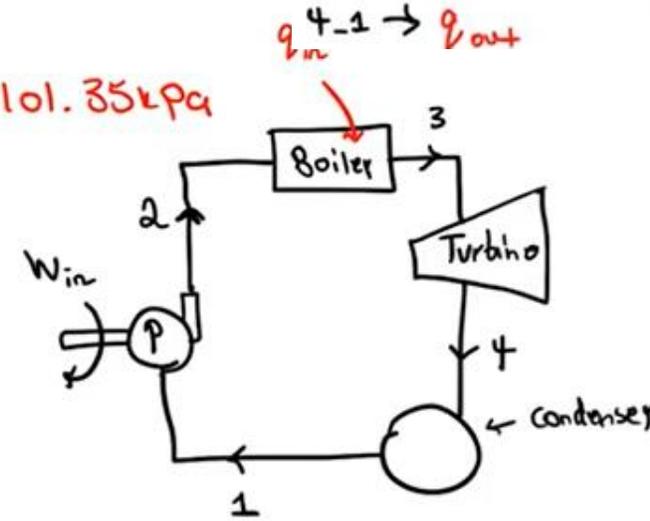
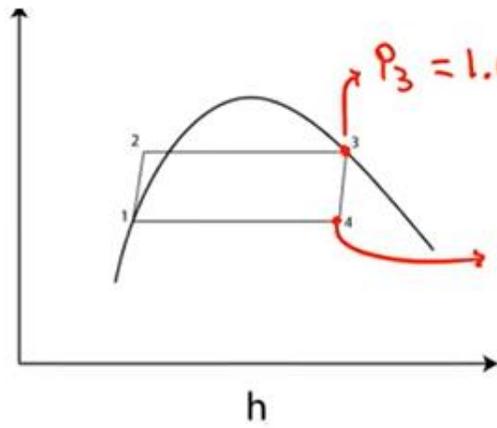
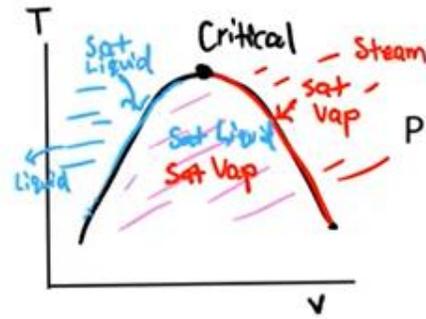
Problem 2

The graph below shows the Rankine cycle using a pressure vs enthalpy diagram. The pressure at state 3 is 1.0021 MPa and the pressure at state four is 101.35 kPa. The enthalpy (kJ/kg) at state 4 is most nearly:



- (A) 2500.5
- (B) 2389.4
- (C) 2676.0

Problem 2

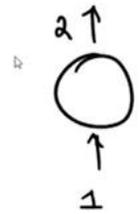


1-2 → Reversible Adiabatic (Isentropic)-Comp
 2-3 → q_{in}
 3-4 → Reversible Adiabatic (Isentropic)-Exp
 4-1 → q_{out}

Find: h_4

Need to calculate quality, x , from page 144 of the FE Handbook

→ pump
 $W_{pump} = h_2 - h_1 = (\Delta P)V$



→ Boiler
 $W = 0$
 $q_{in} = h_3 - h_2$

→ Turbine
 $q = 0$
 $W_{out} = h_3 - h_4$

→ Condenser
 $W = 0$
 $q_{out} = h_4 - h_1$

$$h_4 = h_f + x h_{fg}$$

$$h_4 = 419.04 \frac{kJ}{kg} + (0.873)(2257.0 \frac{kJ}{kg})$$

$$h_4 = \boxed{2389.4 \frac{kJ}{kg}}$$

3 → 4

$$s_3 = s_4$$

$$s_3 = s_4 = 6.5857 \frac{kJ}{kg \cdot K}$$

$$s_4 = s_f + x s_{fg}$$

$$x = \frac{s_4 - s_f}{s_{fg}} = \frac{6.5857 \frac{kJ}{kg \cdot K} - 1.3069 \frac{kJ}{kg \cdot K}}{6.0480 \frac{kJ}{kg \cdot K}}$$

$$x = 0.873$$

Problem 3

5000 cfm of outdoor air is brought into an HVAC system air handling unit (AHU) with an outdoor air intake size of 2 ft x 3 ft. The air is at 95 °F and 40% relative humidity and is cooled down to 55 °F and 80% relative humidity. The mass flowrate (lb./min) of the air being conditioned is most nearly:

- (A) 349.89
- (B) 14.29
- (C) 5000
- (D) 456.23

Problem 3

$T = 95^\circ\text{F}$
 $\phi = 40\%$
 \dot{m}_a

HVAC

$T = 55^\circ\text{F}$
 $\omega = 80\%$

$$\dot{m}_a = \frac{\text{Volume flow rate}}{\text{Specific Volume}} = \frac{5,000 \text{ ft}^3/\text{min}}{14.3 \text{ ft}^3/\text{lb}}$$
$$\dot{m}_a = 349.65 \frac{\text{lb}}{\text{min}}$$

Problem 4

5000 cfm of outdoor air is brought into an HVAC system air handling unit (AHU) with an outdoor air intake size of 2 ft x 3 ft. The air is at 95 °F and 40% relative humidity and is cooled down to 55 °F and 80% relative humidity. The total cooling provided to this air flow in “kW of cooling” is most nearly:

- (A) 25
 - (B) 20.9
 - (C) 6.15
 - (D) 8.56
-

Problem 4

$$Q_L = \dot{m}_a (h_1 - h_2)$$
$$= 349.65 \frac{\text{lb}}{\text{min}} (38.8 \frac{\text{BTU}}{\text{lb}} - 21.3 \frac{\text{BTU}}{\text{lb}})$$

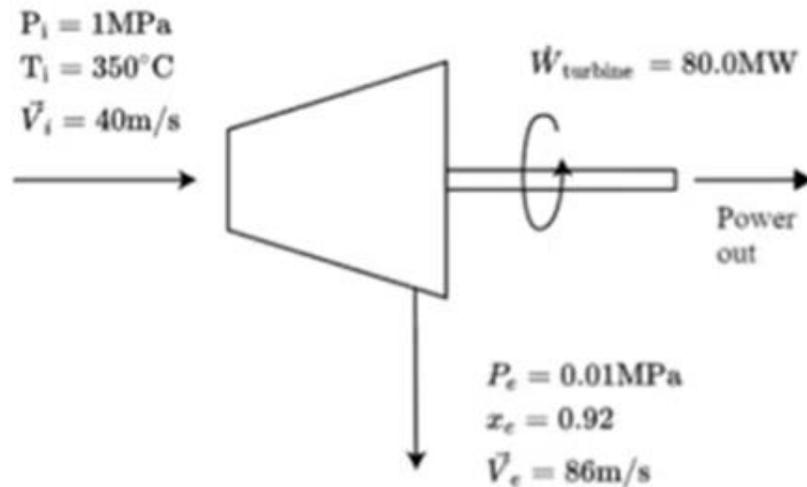
$$Q_L = 6118.88 \frac{\text{BTU}}{\text{min}} \times \frac{60 \text{ min}}{1 \text{ hr}}$$

$$Q_L = \frac{367132.5 \text{ BTU/hr}}{3.413}$$

$$Q_h = 107.57 \text{ kW}$$

Problem 5

Consider steady state, steady flow of steam through a turbine used for electricity generation. You may assume that the process is adiabatic. The steam inlet and exit conditions are shown in the figure below. The enthalpies at inlet and exit is most nearly what:



- (A) $h_i = 3777.7, h_e = 2448.9$
- (B) $h_i = 3157.7, h_e = 2388.9$
- (C) $h_i = 3557.7, h_e = 2504.5$
- (D) $h_i = 1547.7, h_e = 6584.5$

Problem 5

$h_i \rightarrow$ Superheated Tables

$$h_i = 3157.7 \text{ kJ/kg}$$
$$h_e = h_g + x_e h_{fg} \rightarrow (h_g - h_g)$$

	($^{\circ}$)x	y(h _g)	
x_1	45	188.45	y_1
x	45.8	y	
x_2	50	209.33	y_2

$$\frac{x - x_1}{x_2 - x_1} = \frac{y - y_1}{y_2 - y_1}$$
$$y = y_1 + (x - x_1) \left(\frac{y_2 - y_1}{x_2 - x_1} \right)$$
$$y = h_g = 192 \text{ kJ/kg}$$

Aster interpolation,
 $h_g @ 45.8^{\circ}\text{C} \rightarrow h_g = 2580 \text{ kJ/kg}$

$$h_e = 192 \frac{\text{kJ}}{\text{kg}} + 0.92 \left(2580 \frac{\text{kJ}}{\text{kg}} - 192 \frac{\text{kJ}}{\text{kg}} \right)$$
$$h_e = 2390 \text{ kJ/kg}$$

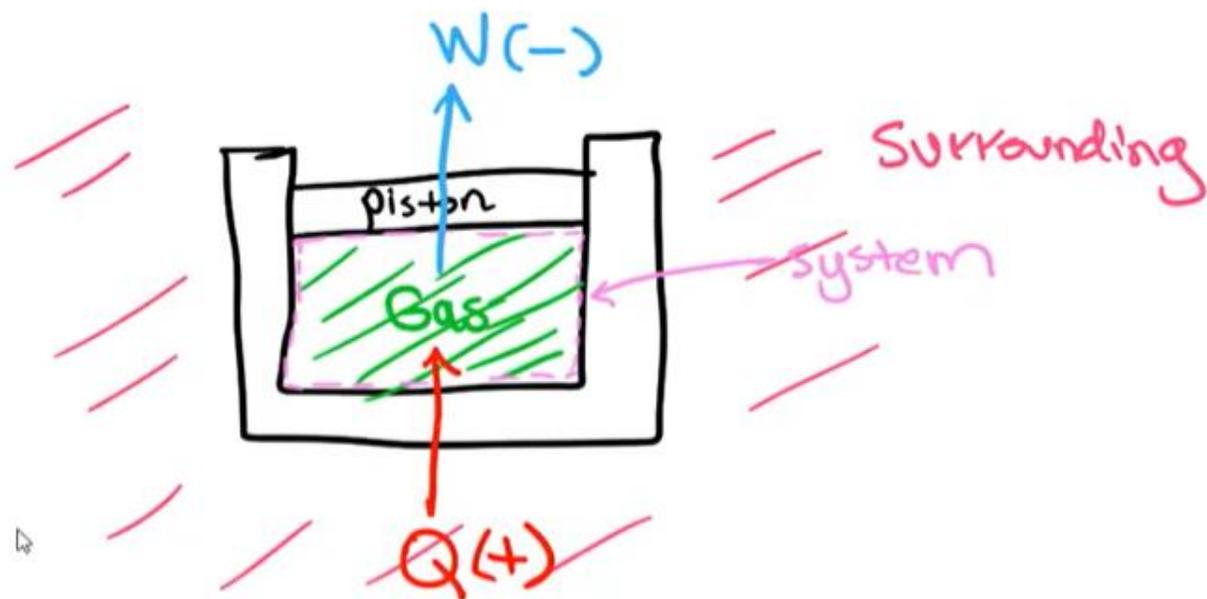
Problem 6

A gas is contained within a piston-cylinder assembly. The gas does 250 joules of work on the surroundings as 350 joules of heat are added through the base. Ignoring kinetic and potential energy effects, the change in energy of the system is most nearly:

- (A) 100 J
- (B) 250 J
- (C) 350 J
- (D) 600 J

most nearly:

- (A) 100 J
- (B) 250 J
- (C) 350 J
- (D) 600 J

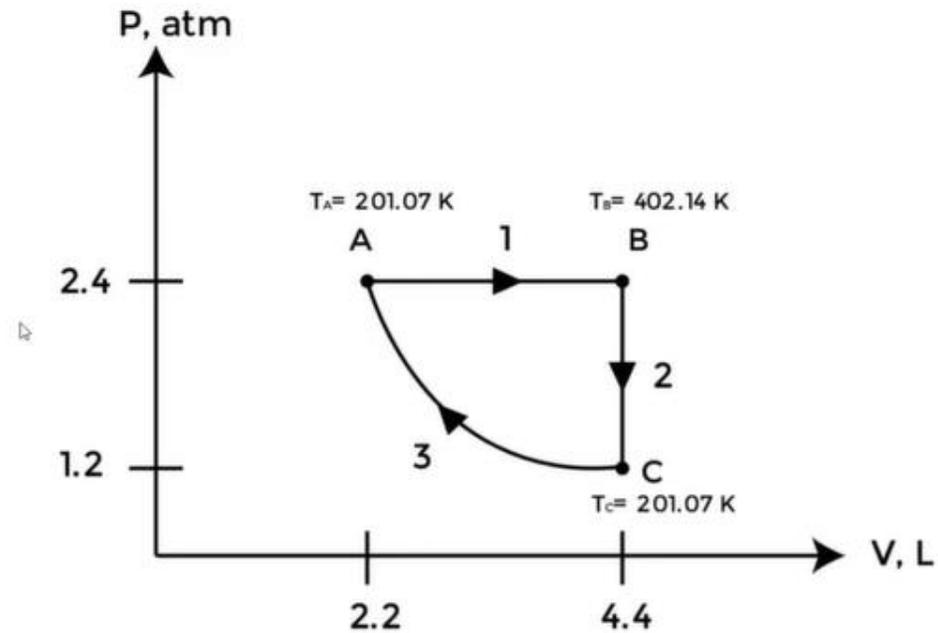


$$Q - W = \Delta U + \cancel{\Delta KE} + \cancel{\Delta PE}$$

$$\Delta U = 350 \text{ J} - 250 \text{ J} = \boxed{100 \text{ J}}$$

Problem 7

A 0.32 mol ideal monoatomic gas in a piston-cylinder undergoes the following thermodynamic cycle consisting of three processes.



The work for process A-B is most nearly:

Problem 7

The work for process A-B is most nearly:

- (A) 530 J
- (B) 535 J
- (C) 520 J
- (D) 528 J

A-B \Rightarrow Constant pressure Expansion

$$1 \text{ L} \cdot \text{atm} = 101.3 \text{ J}$$

$$W_b = P\Delta V$$

$$W_{A-B} = 2.4 \text{ atm} (4.4 \text{ L} - 2.2 \text{ L})$$

$$W_{A-B} = 5.28 \text{ atm} \cdot \text{L} = \boxed{535 \text{ J}} \rightarrow *$$

The work for process B-C is most nearly:

- (A) 145 J
- (B) -320 J
- (C) 25 J
- (D) 0 J

The work for process C-A is most nearly:

- (A) -366 J
- (B) -371 J
- (C) -25 J
- (D) 0 J

$$W_{C-A} = nRT \ln \left(\frac{V_2}{V_1} \right)$$

$$W_{C-A} = 0.32 \text{ mol} (201.07 \text{ K}) \left(0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \right) \ln \left(\frac{2.2 \text{ L}}{4.4 \text{ L}} \right)$$

$$W_{C-A} = -3.66 \text{ L} \cdot \text{atm}$$

$$W_{C-A} = \boxed{-371 \text{ J}} \rightarrow *$$



YouTube

fe exam thermodynamics



SIGN IN

How much heat energy is required to increase the temperature of 7 moles of each of the following gases by 50K? (a) Helium at a constant volume of 5.4L (b) Argon at a constant pressure of 9.2 atm (c) N₂ at a constant volume of 0.50 m³ (d) CO₂ at a constant pressure of 1.4 × 10⁵ Pa.

He

Subscribe

How much heat energy is required to increase the temperature of 7 moles of each of the following gases by 50K? (a) Helium at a constant volume of 5.4L (b) Argon at a constant pressure of 9.2 atm (c) N₂ at a constant volume of 0.50 m³ (d) CO₂ at a constant pressure of 1.4 × 10⁵ Pa.

$$\text{He } C_v = 12.47 \text{ J/mol K}$$

$$C_v = \frac{3}{2} R \quad Q = +$$

$$Q = n C_v \Delta T \quad \Delta T = \textcircled{+}$$

$$= 7(12.47)(50)$$
$$= + 4,364.5 \text{ J}$$



YouTube

fe exam thermodynamics



SIGN IN

A car engine takes in air at 25°C and 1 atm and compresses it adiabatically to 0.1 times the original volume. The air has a gamma ratio of 1.4. What is the final temperature and pressure?

$$P_1 V_1^\gamma = P_2 V_2^\gamma \quad T_1 = 298 \text{ K} \quad T_2 =$$
$$1(1)^{1.4} = P_2(0.1)^{1.4} \quad P_1 = 1 \text{ atm} \quad P_2 =$$
$$V_1 = 1 \text{ L} \quad V_2 = 0.1 \text{ L}$$
$$P_2 = 25.1 \text{ atm}$$
$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$
$$298(1)^{0.4} = T_2(0.1)^{0.4}$$
$$T_2 = 748.5$$

Subscribe

Problem 9

—

Problem 10

Problem 10

Problem 1

Problem 1

Problem 2

Problem 2

Problem 3

Problem 3

Problem 4

—

Problem 4

—

Problem 5

Problem 5

Problem 6

Problem 6

Problem 7

Problem 7

Problem 8

Problem 8

Problem 9

—

Problem 9

—

Problem 10

—

Problem 10

—