



**Class: 2<sup>nd</sup>**

**Subject: Thermodynamics**

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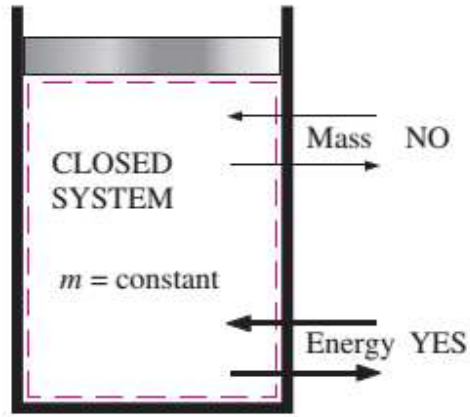
## Thermodynamics Tutorial problems

### A- First Law of Thermodynamics N.F.E.E Applications

4- Steam enters a cylinder fitted with a **piston** at a pressure of **20 MN/m<sup>2</sup>** and a temperature of **500 deg C**. The steam expands to a pressure of **200 kN/m<sup>2</sup>** and a temperature of **200 deg C**. During the expansion there is a net **heat loss** from the steam through the walls of the cylinder and piston of **120 kJ/kg**.

Determine the displacement **work done** by **one kg** of steam during this expansion.

[Ans:168.6kJ/kg]



Close system نظام مغلق

piston



فقدان حرارة (-)

heat loss

المطلوب

work done

Given :

Steam  
البخار

الحالة الاولى

Compression  
انضغاط

$$P1 = 20MPa ,$$
$$T1 = 500 \text{ }^\circ\text{C}$$

الحالة الثانية

Expands  
توسع

$$P2 = 200KPa ,$$
$$\text{Or } P2 = 0.2MPa$$
$$T2 = 200 \text{ }^\circ\text{C}$$

$$Q = -120 \text{ kJ/kg} , \quad m = 1 \text{ kg}$$

Solution :

ملاحظة/ بما ان النظام مغلق فيجب ايجاد الطاقة الداخلية  $u$   
وذلك باستخدام جداول البخار steam table



**TABLE A-6**

Superheated water (Concluded)

$T$ °C	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/kg · K	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/kg · K	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/kg · K
$P = 15.0 \text{ MPa (342.16}^\circ\text{C)}$					$P = 17.5 \text{ MPa (354.67}^\circ\text{C)}$				$P = 20.0 \text{ MPa (365.75}^\circ\text{C)}$			
Sat.	0.010341	2455.7	2610.8	5.3108	0.007932	2390.7	2529.5	5.1435	0.005862	2344.8	2412.1	4.9310
350	0.011481	2520.9	2693.1	5.4438								
400	0.015671	2740.6	2975.7	5.8819	0.012463	2684.3	2902.4	5.7211	0.009950	2617.9	2816.9	5.5526
450	0.018477	2880.8	3157.9	6.1434	0.015204	2845.4	3111.4	6.0212	0.012721	2977.3	3001.7	5.9043
500										2945.3	3011.7	6.1446
550	0.022945	3106.2	3450.4	6.5230	0.019305	3085.8	3423.6	6.4266	0.016571	3064.7	3330.2	6.3390
600	0.024921	3209.3	3583.1	6.6796	0.021073	3192.5	3561.3	6.5890	0.018185	3175.3	3539.0	6.5075
650	0.026804	3310.1	3712.1	6.8233	0.022742	3295.8	3693.8	6.7366	0.019695	3281.4	3675.3	6.6593
700	0.028621	3409.8	3839.1	6.9573	0.024342	3397.5	3823.5	6.8735	0.021134	3385.1	3807.8	6.7991
800	0.032121	3609.3	4091.1	7.2037	0.027405	3599.7	4079.3	7.1237	0.023870	3590.1	4067.5	7.0531
900	0.035503	3811.2	4343.7	7.4288	0.030348	3803.5	4334.6	7.3511	0.026484	3795.7	4325.4	7.2829
1000	0.038808	4017.1	4599.2	7.6378	0.033215	4010.7	4592.0	7.5616	0.029020	4004.3	4584.7	7.4950
1100	0.042062	4227.7	4858.6	7.8339	0.036029	4222.3	4852.8	7.7588	0.031504	4216.9	4847.0	7.6933
1200	0.045279	4443.1	5122.3	8.0192	0.038806	4438.5	5117.6	7.9449	0.033952	4433.8	5112.9	7.8802
1300	0.048469	4663.3	5390.3	8.1952	0.041556	4659.2	5386.5	8.1215	0.036371	4655.2	5382.7	8.0574
$P = 25.0 \text{ MPa}$					$P = 30.0 \text{ MPa}$				$P = 35.0 \text{ MPa}$			
375	0.001978	1799.9	1849.4	4.0345	0.001792	1738.1	1791.9	3.9313	0.001701	1702.8	1762.4	3.8724



$u_1$

	$P = 0.20 \text{ MPa (120.21}^\circ\text{C)}$				$P = 0.30 \text{ MPa (133.52}^\circ\text{C)}$				$P = 0.40 \text{ MPa (143.61}^\circ\text{C)}$			
Sat.	0.88578	2577.1	2706.3	7.1270	0.60582	2543.2	2724.9	6.9917	0.46242	2553.1	2738.1	6.8955
150	0.95986	2577.1	2769.1	7.2810	0.63402	2571.0	2761.2	7.0792	0.47088	2564.4	2752.8	6.9306
200	1.00000	2654.6	2812.2	7.5081	0.71643	2651.0	2865.9	7.3132	0.53434	2647.2	2860.9	7.1723
250	1.19890	2731.4	2971.2	7.7100	0.79645	2728.9	2967.9	7.5180	0.59520	2726.4	2964.5	7.3804
300	1.31623	2808.8	3072.1	7.8941	0.87535	2807.0	3069.6	7.7037	0.65489	2805.1	3067.1	7.5677
400	1.54934	2967.2	3277.0	8.2236	1.03155	2966.0	3275.5	8.0347	0.77265	2964.9	3273.9	7.9003
500	1.78142	3131.4	3487.7	8.5153	1.18672	3130.6	3486.6	8.3271	0.88936	3129.8	3485.5	8.1933
600	2.01302	3302.2	3704.8	8.7793	1.34139	3301.6	3704.0	8.5915	1.00558	3301.0	3703.3	8.4580
700	2.24434	3479.9	3928.8	9.0221	1.49580	3479.5	3928.2	8.8345	1.12152	3479.0	3927.6	8.7012
800	2.47550	3664.7	4159.8	9.2479	1.65004	3664.3	4159.3	9.0605	1.23730	3663.9	4158.9	8.9274
900	2.70656	3856.3	4397.7	9.4598	1.80417	3856.0	4397.3	9.2725	1.35298	3855.7	4396.9	9.1394
1000	2.93755	4054.8	4642.3	9.6599	1.95824	4054.5	4642.0	9.4726	1.46859	4054.3	4641.7	9.3396
1100	3.16848	4259.6	4893.3	9.8497	2.11226	4259.4	4893.1	9.6624	1.58414	4259.2	4892.9	9.5295
1200	3.39938	4470.5	5150.4	10.0304	2.26624	4470.3	5150.2	9.8431	1.69966	4470.2	5150.0	9.7102
1300	3.63026	4687.1	5413.1	10.2029	2.42019	4686.9	5413.0	10.0157	1.81516	4686.7	5412.8	9.8828

$u_2$

$$Q - W = \Delta U + \Delta KE + \Delta PE$$

$$\Delta KE \text{ \& } \Delta PE = 0$$

$$Q - W = \Delta U$$

Per kg -----  $q - w = \Delta u$

$$W = m * [q - (u_2 - u_1)]$$

$$W = q - (u_2 - u_1) \longrightarrow m = 1 \text{ kg}$$

$$W = -120 - (2654.6 - 2945.3)$$

$$\underline{\underline{W = 179.5 \text{ KJ/Kg}}}$$