<table>
<tr><td colspan="3">Practical Training Thermodynamics

Submissions

Date of submission: Sunday, 30/01/2022</td><td>HOCHSCHULE RHEIN-WAAL
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<tr><td>Module</td><td>Thermodynamics, B. Sc.</td><td>2708</td><td>Version WS 21/22-1.0
4 pages</td></tr>
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I confirm that the submitted work is my own and was prepared without the use of any unauthorised aid or materials.

First and Last Name (To be printed legibly)	**Register No.**	**Signature**
Abdelrahman Mostafa	ID: 29528	
Evaluation	**Maximum points**	**Achieved points**
PT 1	**4**	
PT 2	**4**	
PT 3	**4**	
	Total points: 12	

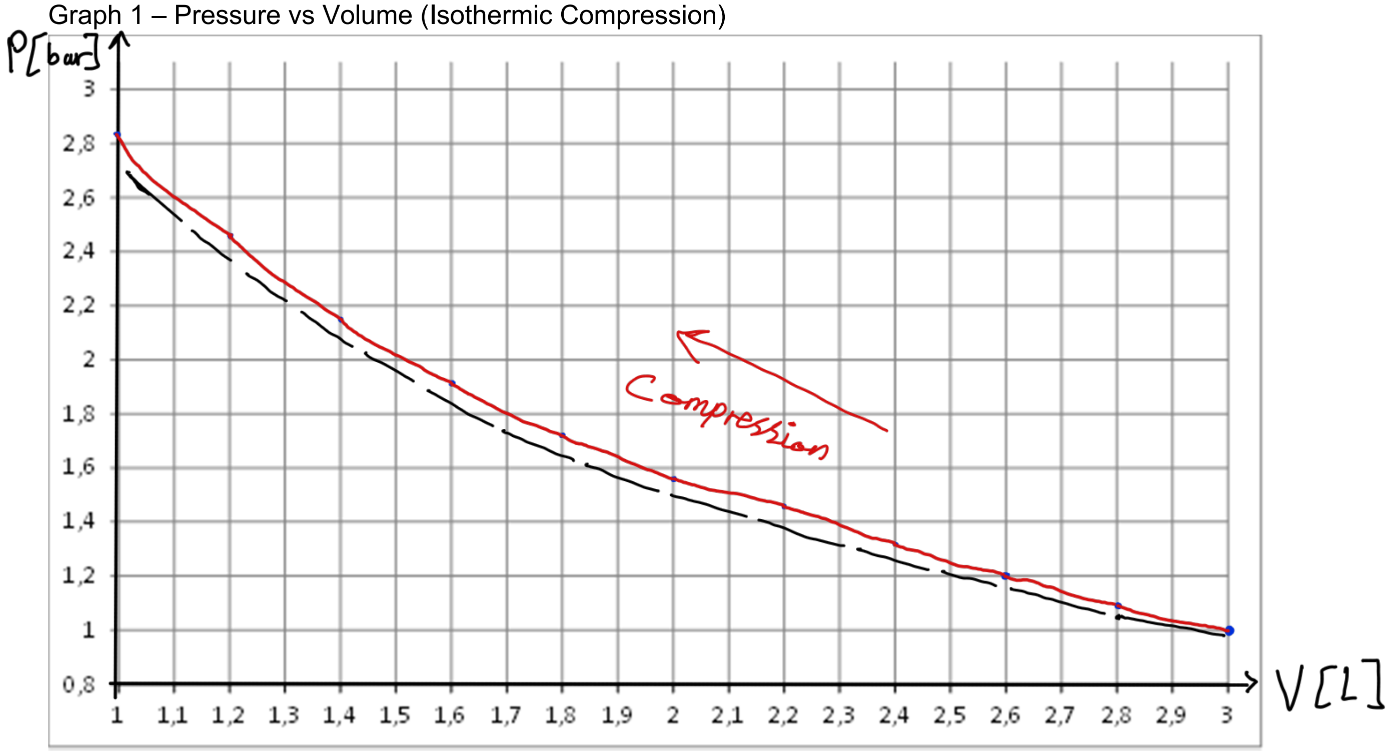
Practical Training PT 1
Ideal Gas Law

1. Plot the ***isothermal compression*** data from the video by using a solid line.

2. Keeping the starting temperature constant (State 1 acc. to video), plot an ideal curve by a dashed line from
   State 1: Volume = 3 litres; pressure = 1 bar
   State 2: Volume compressed to 1 litre.

3. Clearly label both axes. Indicate by an arrow in which direction compression occurs.

Graph 1 – Pressure vs Volume (Isothermic Compression)



P[bar]	V[L]
1	3.0
1.12	2.8
1.2	2.6
1.33	2.4
1.45	2.2
1.56	2.0
1.73	1.8
1.93	1.6
2.15	1.4
2.45	1.2
2.85	1.0

Compression

Practical Training PT 2
Air Compressor – Determination of work

During the experiment at time 1:40 min, manometer reading is 5 bar and power consumption at ammeter is 3.3 A. Calculate the work done at that particular time and outlet temperature.

Ambient condition: 1 bar and 20 °C

Equation for the work done, i.e. output work:

$$W_{12} = \frac{n}{n-1} R T_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1 \right]$$

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$$

<u>Given:</u>

Polytropic coefficient: $n = 1.3$

Ideal gas constant: $R = 287 \frac{J}{kg\,K}$

Density of air at 20°C: $\rho = 1.2041 \frac{kg}{m^3}$

Volume flow rate: $V = 115 \frac{L}{min}$

Motor Voltage: 230 V at 50 Hz

What is the inlet temperature in K and the inlet pressure in bar?

$P_1 = 1\ bar$, $T_1 = 20\,C^\circ \Rightarrow T_1 = 293\,K$

What is the outlet temperature at time 1:40 min?

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = 293K \left(\frac{5\ \cancel{bar}}{1\ \cancel{bar}}\right)^{\frac{1.3-1}{1.3}} = 424.8\,K$$

At time 1:40 min, how much work $(\frac{kJ}{kg})$ is done by the piston?

$$W_{12} = \frac{n}{n-1} R \cdot T_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1 \right] = \frac{1.3}{1.3-1} \left(287 \frac{J}{Kg \cdot \cancel{K}}\right) (293 \cancel{K}) \left[\left(\frac{5\ \cancel{bar}}{1\ \cancel{bar}}\right)^{\frac{1.3-1}{1.3}} - 1 \right] = 163895.66 \frac{J}{Kg}$$

$$\Rightarrow W_{12} = 163.895 \frac{KJ}{Kg}$$

What is the input power at time 1.40 min?

$$P = I \cdot U = (3.3A)(230V) = 759\,W$$

Practical Training PT 3
Steam Engine – Determination of thermal efficiency

Please fill in the following table.

Calculate the missing figures in the grey shaded cells.

The aim is to determine the thermal efficiency.

$$\dot{m}_{Fuel} = \rho_{Fuel} \cdot \dot{V}_{Fuel}$$

Density of Propane	1,919	kg/m³
Calculated mass flow	2.132×10^{-5}	kg/s

$$\eta_{th} = \frac{P_T}{\dot{Q}_{in}}$$

Thermal efficiency	26.81%

$$\dot{Q}_{in} = \dot{m}_{Steam} (h_3'' - h_2)$$

$$\dot{m}_{Steam} = \rho_C \cdot \dot{V}_C$$

Density of water	1.000	kg/m³
Calculated condensate flow	1.883×10^{-4}	kg/s
Enthalpy at T3	2717.183	kJ/kg
Enthalpy at T2 ($h = c_p\, T$)	1230.6	kJ/kg
Heat input from boiler	493.63	W

$$\dot{Q}_{out} = \dot{m}_{CW} \cdot c_{P,CW} \cdot (T_{out} - T_{in})$$

Density of water	1.000	kg/m³
Specific heat capacity	4,2	kJ/kgK
Heat rejected by cooling	361.29	W

$$P_T = \dot{Q}_{in} - \dot{Q}_{out}$$

Power produced by turbine	132.34	W

From Lap3 pdf, page 18: $\dot{V}_{fuel} = 40\,L/h = 40 \frac{\cancel{L}}{\cancel{h}} \cdot \frac{\cancel{h}}{3600\,s} \cdot \frac{10^{-3} m^3}{\cancel{L}} = 1.11 \times 10^{-5}\, m^3/s \Rightarrow \dot{m}_{fuel} = \rho_{fuel} \cdot (\dot{V}_{fuel})$

$\Rightarrow \dot{m}_{fuel} = 1.919\, Kg/m^3 (1.11 \times 10^{-5} m^3/s) = 2.132 \times 10^{-5}\, Kg/s$

$\dot{V}_c = 11.3\, cm^3/min = 11.3 \frac{\cancel{cm^3}}{\cancel{min}} \cdot \frac{\cancel{1 min}}{60\,s} \cdot \frac{10^{-6} m^3}{\cancel{cm^3}} \Rightarrow \dot{V}_c = 1.883 \times 10^{-7}\, m^3/s$

$\Rightarrow \dot{m}_{steam} = \rho_c \cdot \dot{V}_c = 10^3 Kg/\cancel{m^3} (1.883 \cdot 10^{-7} \cancel{m^3}/s) = 1.883 \times 10^{-4}\, Kg/s$

Enthalpy at T_3: from table A 3 & by interpolation to get h_g at T_3 (saturated steam).

$\Rightarrow h_3 = 2717.183\, KJ/Kg$

Enthalpy at $T_2 \Rightarrow h_2 = C_p \cdot T_2 = (4.2\, KJ/Kg \cdot \cancel{K})(293\,\cancel{K}) = 1230.6\, KJ/Kg$

$\dot{Q}_{in} = \eta_B \cdot \dot{m}_{feul} \cdot H_{feul} = 0.5 \cdot 2.132 \times 10^{-5}\, Kg/s\, (46350\, KJ/Kg) = 493.63\, W$

$\dot{Q}_{out} = \dot{m}_{cw} \cdot C_{p,cw} (T_{out} - T_{in}) = 361.29\, W$

$P_T = \dot{Q}_{in} - \dot{Q}_{out} = 132.34\, W$

$\eta_{th} = \frac{P_T}{\dot{Q}_{in}} = 0.2681 = 26.81\%$