قسم الهندسة الميكانيكية
ديناميكا حرارية 2
أ. مصطفى أبوردويس
ربيع 2023/2022
نهائي

Misurata University

Faculty of Engineering

Mechanical Engineering

Thermodynamics II

Final Examination

Date: 15.07.2023

Time allowed 3 Hours

MUSTAFA IDRIES ABURWAIS

الســـــــؤال الأول (10 درجات)

أ. دورة كارنو ليست نموذجا واقعيًا لتشتغل عليه المحطة البخارية، وإنما حد أعلى نظري تقارن به باقي دورات الديناميكا الحرارية"، وضح ذلك من خلال ذكر الأسباب التي تمنع استخدام دورة كارنوت كدورة يبنى عليها تصميم المحطة البخارية. وماهي الطرق المتاحة لتحسين كفاءة دورة رانكن؟

ب. دورة ديزل ودورة أوتو هما نوعان من دورات محركات الاحتراق الداخلي، حيث تختلف الدورتان في العديد من الفروقات وضح هذه فروقات؟ ثم علل سبب استخدام الإنتالبي بدل الطاقة الداخلية في العلاقة المستخدمة لحساب الحرارة المضافة في دورة ديزل مع استنتاج هذه العلاقة؟ وحتى تكون كلا الدورتين قابلة للفهم النظري بشكل بسيط، تم تطبيق فرضيات الهواء القياسي عليها، تكلم عن هذه الفرضيات بإيجاز ؟

Question2 (10Marks): Select the correct answer from the list.

1. Consider a simple ideal Rankine cycle with fixed turbine inlet conditions. What is the effect of lowering the condenser pressure on:

Pump work input	a	increases	b	decreases	c	remains the same
Turbine work	a	increases	b	decreases	c	remains the same
Heat rejected	a	increases	b	decreases	c	remains the same
Heat supplied	a	increases	b	decreases	c	remains the same
Cycle efficiency	a	increases	b	decreases	c	remains the same

2. Consider a simple ideal Rankine cycle with fixed boiler and condenser pressures. What is the effect of superheating the steam to a higher temperature on:

Pump work input	a	increases	b	decreases	c	remains the same
Turbine work	a	increases	b	decreases	c	remains the same
Heat rejected	a	increases	b	decreases	c	remains the same
Heat supplied	a	increases	b	decreases	c	remains the same
Cycle efficiency	a	increases	b	decreases	c	remains the same

3. How do the following quantities change when the simple ideal Rankine cycle is modified with regeneration? Assume the mass flow rate through the boiler is the same:

Pump work input	a	increases	b	decreases	c	remains the same
Turbine work	a	increases	b	decreases	c	remains the same
Heat rejected	a	increases	b	decreases	c	remains the same
Heat supplied	a	increases	b	decreases	c	remains the same

4. How do the following quantities change when a simple ideal Rankine cycle is modified with reheating? Assume the mass flow rate is maintained the:

Pump work input	a	increases	b	decreases	c	remains the same
Turbine work	a	increases	b	decreases	c	remains the same
Heat rejected	a	increases	b	decreases	c	remains the same
Heat supplied	a	increases	b	decreases	c	remains the same

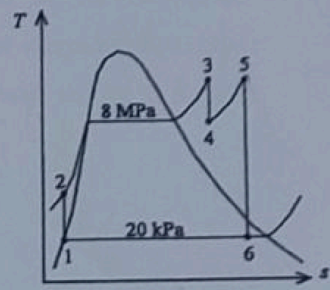
Question3 (15Marks)

a) Water vapor at 6 $MPa, 600C^o$ enters a turbine operating at steady state and expands adiabatically to 10 kPa. The mass flow rate is 2 kg/s and the isentropic turbine efficiency is 94.7%. Kinetic and potential energy effects are negligible. Determine

1. the power developed by the turbine, in kW.
2. the rate at which exergy is destroyed within the turbine, in kW.
3. the energetic turbine efficiency.

Let $T_o = 298K$, $P_o = 1\ bar$

b) A steam power plant operates on the ideal reheat Rankine cycle. Steam enters the high pressure turbine at 8 MPa and 500°C and leaves at 3 MPa. Steam is then reheated at constant pressure to 500°C before it expands to 20 kPa in the low pressure turbine. Determine the turbine work output, in kJ/kg, and the thermal efficiency of the cycle.



	1	2	3	4	5	6
$h(\frac{kJ}{kg})$	251.42		3399.5	3105.1	3457.2	
$s(\frac{kJ}{kg.k})$	-	-	6.7266		7.2359	7.2359

Question4 (8Marks):

a) Air enters the compressor of an ideal air-standard Brayton cycle at 100 kPa, 300 K, with a volumetric flow rate of 5 m3/s. The compressor pressure ratio is 10. The turbine inlet temperature is 1400 K. the turbine and compressor each have an isentropic efficiency of 80%. Determine

1. the thermal efficiency of the cycle.
2. the back work ratio.
3. the net power developed, in kW.

Question5 (7Marks): Answer one of the following questions.

a) An air-standard Diesel cycle has a compression ratio of 18.2 . Air is at $27°C$ *and* $100\ kPa$ at the beginning of the compression process and at $1700\ K$ at the end of the heat addition process. Accounting for the variation of specific heats with temperature, determine

1. the cutoff ratio.
2. the heat rejection per unit mass.
3. the thermal efficiency.

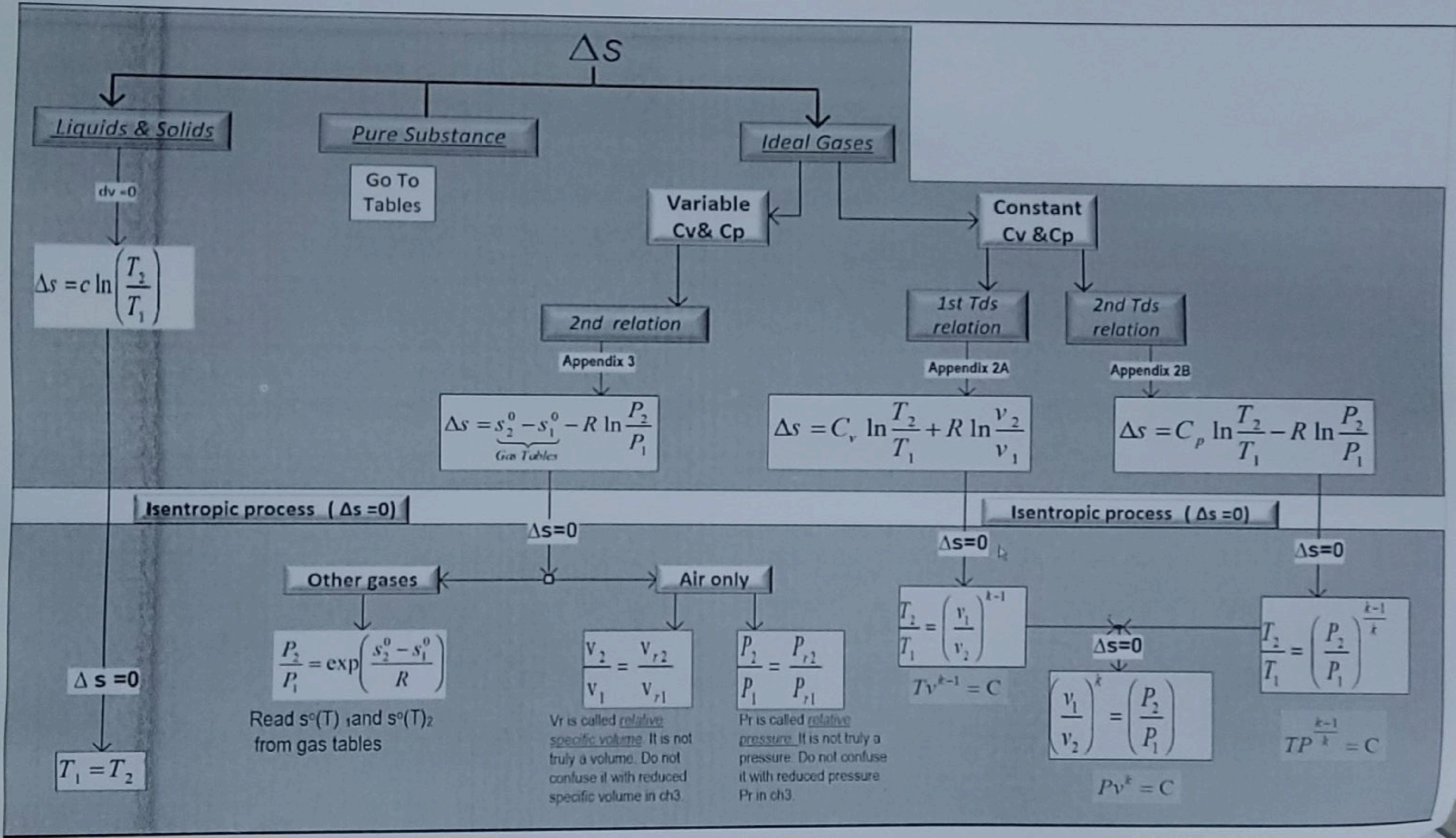
b) The compression ratio of an air-standard Otto cycle is 9.5. Prior to the isentropic compression process, the air is at $100\ kPa, 35°C$, and $600\ cm^3$. The temperature at the end of the isentropic expansion process is $800\ K$. Using specific heat values at room temperature, determine:

1. the highest temperature and pressure in the cycle.
2. the amount of heat transferred in, in kJ.
3. the thermal efficiency.
4. the mean effective pressure.

Question6 (5Marks):

a) Consider the complete combustion of methane (CH_4) with 150% theoretical air (50 % excess air).

1. Balance the combustion equation.
2. Find the AF ratio on mass basis.
3. Find the equivalence ratio.



Δs
Liquids & Solids
Pure Substance
Ideal Gases
dv = 0
Go To Tables
Variable Cv& Cp
Constant Cv &Cp
$\Delta s = c \ln\left(\frac{T_2}{T_1}\right)$
2nd relation
1st Tds relation
2nd Tds relation
Appendix 3
Appendix 2A
Appendix 2B
$\Delta s = \underbrace{s_2^0 - s_1^0}_{\text{Gas Tables}} - R \ln \frac{P_2}{P_1}$
$\Delta s = C_v \ln \frac{T_2}{T_1} + R \ln \frac{v_2}{v_1}$
$\Delta s = C_p \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1}$
Isentropic process (Δs =0)
Isentropic process (Δs =0)
Δs=0
Other gases
Air only
Δs=0
Δs=0
Δ s =0
$\frac{P_2}{P_1} = \exp\left(\frac{s_2^0 - s_1^0}{R}\right)$
$\frac{v_2}{v_1} = \frac{v_{r2}}{v_{r1}}$
$\frac{P_2}{P_1} = \frac{P_{r2}}{P_{r1}}$
$\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{k-1}$
Δs=0
$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$
$T_1 = T_2$
Read s°(T)₁and s°(T)₂ from gas tables
Vr is called relative specific volume. It is not truly a volume. Do not confuse it with reduced specific volume in ch3.
Pr is called relative pressure. It is not truly a pressure. Do not confuse it with reduced pressure Pr in ch3.
$Tv^{k-1} = C$
$\left(\frac{v_1}{v_2}\right)^k = \left(\frac{P_2}{P_1}\right)$
$TP^{\frac{k-1}{k}} = C$
$Pv^k = C$