College of Health & Science
School of Engineering

UNIVERSITY OF LINCOLN
UNITED KINGDOM

Time Constrained Assessment

Module Title	**Energy Systems and Conversion**
Module Code	**EGR3030**
Module Coordinator	**Dr Ali Aliyu**
Duration of Assessment	**4 hours**
Date	**13/01/2025**
Release Time	**09:00**
Submission Time	**13:00 (14:20 PASS)**

General Instructions to Candidates.

1. You **must** submit your answers to TurnItIn on Blackboard **before** the submission time: failure to do so will be classified as misconduct in examinations. It is strongly recommended you submit at least 15 minutes prior to the deadline.
2. You **must** also send a copy of your work to: sepssubmissions@lincoln.ac.uk at the same time. You must place the Module Code and your Student ID in the Subject Field of the Mail.
3. For students who choose to word process their answers, hand-written notes or diagrams **must** be photographed (preferably using Microsoft Lens which is available as part of your Office 365 package) and inserted into the Word Document as an image.
4. This assessment is an open resource format: you may use online resources, lecture and seminar notes, textbooks and journals. All sources must be correctly attributed or referenced.
5. All work will be subject to plagiarism and academic integrity checks. In submitting your assessment, you are certifying that this is entirely your own work, without input from either commercial or non-commercial writers or editors or advanced technologies such as artificial intelligence services unless explicitly allowed and referenced. If standard checks suggest otherwise, Academic Misconduct Regulations will be applied.
6. The duration of the Time Constrained Assessment will vary for those students with Personalised Academic Study Support (PASS) plan. Extensions do not apply, but Extenuating Circumstances can be applied for in the normal way.

Module Specific Instructions to Candidates

1. Answer any 4 questions.
2. All questions carry equal marks.
3. No further marks will be awarded for answers to a fifth question
4. Useful equations are given in the Appendix
5. Thermodynamic tables uploaded in the Blackboard content for this module may be used

Question 1

a. What are the main sources of losses that prevent a wind turbine from operating at or near the Betz limit? [5 marks]

b. An engineer boasting about the virtues of their new wind turbine claimed it has an efficiency of 65.3%. Starting from $P = \frac{1}{2}m(v_1^2 - v_2^2)$, with P being the power output resulting from a change in wind velocity from v_1 to v_2 across turbine's blades, show that the engineer's claim cannot be true and calculate the number of percentage points his estimation is off by. [5 marks]

c. A wind turbine rated at 5 MW with a rotor radius of 48 m operates in a location where the air density is 1.2 kg/m3. The number of hours, H, of operation of the wind turbine at a given wind speed is given by a Rayleigh PDF distribution:

$$H(u) = \frac{\pi}{2}\left(\frac{u}{\bar{u}^2}\right)\exp\left[-\frac{\pi}{4}\left(\frac{u}{\bar{u}}\right)^2\right]$$

The rated wind speed is 13 m/s, and its cut-out wind speed is 25 m/s. Calculate the annual income from this turbine if the electricity it produces is sold at 10p/kWh. [You are required to use Excel or MATLAB for this problem. Tabulate your results accordingly]

[15 marks]

[Total: 25 marks]

[End of Question 1]

Question 2

a. Which is worse – putting petrol in a diesel engine or vice versa? Rationalise each scenario. [5 marks]

b. In an air-standard Brayton cycle (Figure 1), air enters the compressor at 100 kPa and 15 C. The exit pressure at the compressor is 1000 kPa. The maximum temperature in the cycle is 1,100 C. Determine:
   i. the temperature and pressure at each point in the cycle, [10 marks]
   ii. the compressor work, turbine work, and the cycle's efficiency. [10 marks]

Assume that air behaves as an ideal gas with a constant specific heat at 300 K. Also assume that each process within the cycle is steady and no kinetic or potential energy changes occur. [Note that thermodynamic tables are required in this task]

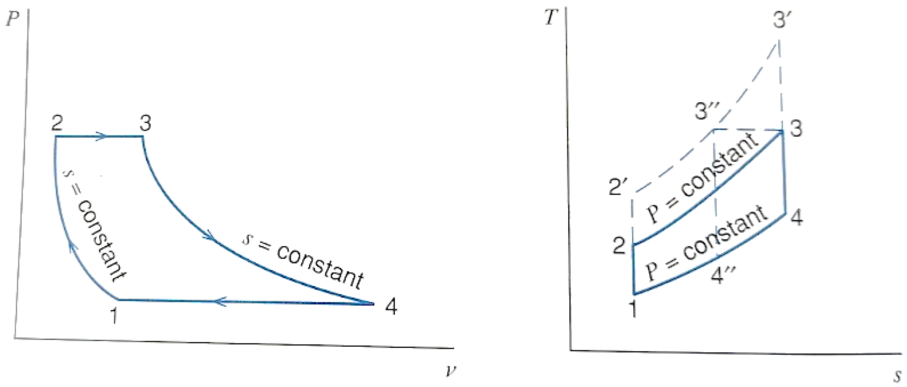

Figure 1: Brayton cycle schematic for Q2b.

[Total: 25 marks]

[End of question 2]

Question 3

a. Explain what is meant by stoichiometric air? [2 marks]

b. What do you understand by lean and rich fuel mixtures? State an advantage and a disadvantage of an engine running on either. [8 marks]

c. Producer gas which is obtained from coal with the volumetric based composition given in the table below is combusted with 20% excess air. Calculate the air-to-fuel ratio:

Methane	3
Carbon dioxide	4.5
Oxygen	0.6
Carbon monoxide	27
Hydrogen	14
Nitrogen	50.9

i. On a volumetric basis and [10 marks]
ii. On a mass basis [5 marks]

Note: you may assume that the air and fuel are the same temperature and pressure.

[Total: 25 marks]

[End of question 3]

Question 4

Superheated steam goes into a steam turbine at 1 million Pascals of pressure. The inlet temperature is 300 °C and the entrance velocity is 50 m/s. at the outlet, the steam has a pressure of 150 kPa and a velocity of 200 m/s. With reference to Figure 2:

a. What are the main assumptions and conservation laws you would use to analyse this system? Accompany your answer with equations [5 marks]
b. calculate the work done per kg of steam flowing through the turbine. [10 marks]
c. With the aid of (two) schematics, explain why a cogeneration system will be more suited for district heating than a combined cycle system. [10 marks]

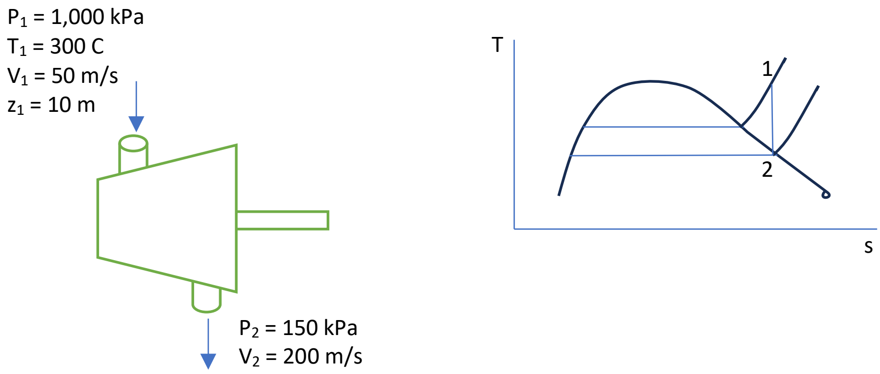

Figure 2: Steam turbine schematic for Question 4a & b

[Total: 25 marks]

[End of question 4]

Question 5

a. Exergy and energy are very important quantities in the analysis and design of new power generation systems. As an engineer in a reputable company, a student on placement came to you with a question as they would like to know the difference between the two. Give them 3 differences, using equations where necessary.

[6 marks]

b. Engineers at Boxhall's engineers have designed a new 5-passenger compact SUV with fuel economy in mind and have named it Boxhall Compact. The Boxhall Compact has a frontal area of 2.55 m^2, a drag coefficient of 0.31, rolling resistance coefficient of 0.01, a weight of 1205 kg, maximum tractive force at low speeds of 2998 N, and tractive power at maximum speed of 30.5 kW. It has rear end space for storage. Assuming air density of 1.1 kg/m^3, calculate:
   i. the tractive or cruising power requirement at 97 km/h [5 marks]
   ii. the maximum speed (you may use a spreadsheet solver tool e.g., Goal Seek or a programmable calculator) [5 marks]
   iii. the maximum gradeability and explain what it means [5 marks]
   iv. Time to reach 96 km/h accelerating from rest. (Assume acceleration in a vacuum with zero friction, and the maximum low speed traction force is maintained over the whole range of speeds) [4 marks]

[Total: 25 marks]

[End of Question 5]

[End of Time Constrained Assessment]