



INTERNAL ASSESSMENT APPROVAL FORM (INCLUDING COLLABORATIVE PROVISION)

This form is used to ensure that assessment specifications have been through an internal review process prior to external examination/approval and release to students. It should be completed for each assessment for a particular module. The assessment tasks, criteria and marking scheme should accompany this form.

PARTNER (and taught location if relevant):	Coleg Sirgar				
EXTERNAL EXAMINER NAME:	TO BE ADVISED				
ASSESSMENT AUTHOR:	CHRIS DAVIES				
MODULE TITLE:	Thermofwids 2				
MODULE CODE:	860H5012		MODULE LEVEL:	5	
COMPONENT NO. (e.g. 1 of 2):	2		COMPONENT WEIGHTING (e.g. 50% of the module):	50%	
ASSESSMENT PERIOD	☒ Semester 1	☐ Semester 1 Re-sit	☒ Semester 2	☐ Semester 2 Re-sit	Other, please state
TYPE OF ASSESSMENT:	☐ Coursework		☒ Examination (MAINT RE-SIT)		☐ Practical
LANGUAGE OF ASSESSMENT:	ENGLISH		TRANSLATION REQUIRED (Y/N):	N	
FOR EXAMINATIONS ONLY. SPECIFY BELOW ANY ADDITIONAL MATERIAL(S) TO BE USED IN THE EXAMINATION					
This box will expand as you type					

INTERNAL MODERATOR PLEASE TICK TO INDICATE THAT THE ASSESSMENT INCLUDES:		Please ✓		Comments
		YES	NO	
1	Tasks that are specified clearly, accurately and comprehensibly, with appropriate use of language and neat presentation	✓		
2	Tasks which enable the module learning outcomes to be demonstrated (as per the module syllabus)	✓		
3	Tasks which conform to the assessment described in the module syllabus	✓		
4	Tasks which are written at the appropriate level of the Framework for Higher Education Qualifications (see http://www.qaa.ac.uk/docs/qaa/quality-code/qualifications-frameworks.pdf?sfvrsn=170af781_14).	✓		
5	Clear criteria for assessment and guidance about how marking/grading will be applied	✓		
6	Guidance about expected evidence for submission, e.g. essay or report, word count, bibliography and references	n/a		Forwards Extern moderator
7	Reference to good academic conduct, for example referencing, plagiarism and Turnitin	n/a		
8	Actions to complete	n/a		
This box will expand as you type				
SIGNATURE OF APPROVAL:		SIGNATURE		DATE
INTERNAL MODERATOR: I confirm that this version of the assessment specification is ready		Adam Twelch		07/10/19

to be sent to the Partnership Team Leader		
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ONLY TO BE COMPLETED IF THE ASSESSMENT IS LINKED TO A COLLABORATIVE PARTNER

PARTNERSHIP TEAM LEADER PLEASE TICK TO INDICATE THAT THE ASSESSMENT INCLUDES:		Please ✓		Comments
		YES	NO	
1	Tasks that are specified clearly, accurately and comprehensibly, with appropriate use of language and neat presentation			
2	Tasks which enable the module learning outcomes to be demonstrated (as per the module syllabus)			
3	Tasks which conform to the assessment described in the module syllabus			
4	Tasks which are written at the appropriate level of the Framework for Higher Education Qualifications (see http://www.qaa.ac.uk/docs/qaa/quality-code/qualifications-frameworks.pdf?sfvrsn=170af781_14).			
5	Clear criteria for assessment and guidance about how marking/grading will be applied			
6	Guidance about expected evidence for submission, e.g. essay or report, word count, bibliography and references			
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8	Actions to complete <i>This box will expand as you type</i>			
SIGNATURE OF APPROVAL:		SIGNATURE		DATE
PTL: I confirm that this version of the assessment specification is ready to be sent to the External Examiner				

UWTSD PROVISION: please submit the completed document to the appropriate Programme Director.

COLLABORATIVE PROVISION: please submit the completed document (or make available electronically) to the Partnership Team Leader. This must be in accord with specific arrangements for sharing electronic documents (e.g. via SharePoint or similar).

The assessment tasks, criteria and marking scheme should accompany this form

THIS DOCUMENT IS ALSO AVAILABLE IN WELSH

LOCATION: COLEG SIR GAR (GRAIG)

LLEOLIAD: COLEG SIR GAR (GRAIG)

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
JAN 2020

CYFNOD ARHOLIADAU
ION 2020

MODULE CODE: SGDM5012
THERMOFLUIDS 2

TIME: 2 HOURS

ANSWER FOUR QUESTIONS OUT OF FIVE

Equipment or materials required

Calculators are permitted.

Steam and refrigeration tables will be provided.

Moody diagram is provided.

Enthalpy v Entropy diagram is provided.

Adnoddau neu ddefnyddiau sydd eu hangen

Calculators are permitted

Steam and refrigeration tables will be provided.

Moody diagram is provided.

Enthalpy v Entropy diagram is provided.

QUESTION 1

a) Explain what is meant by isentropic efficiency and explain the effect it has on a practical steam cycle when compared with an ideal cycle.

[10 marks]

b) Steam at a pressure of 60 bar and a temperature of 400°C expands in a turbine to a final state of 1 bar and a dryness of 0.94 at a rate of 10 kg/s. Sketch the process on an enthalpy/entropy chart for steam and using the chart provided calculate:

- i) the power developed by the turbine
- ii) the pressure and temperature during the expansion when condensation will start to occur.
- iii) The isentropic efficiency of the turbine

The expansion can be assumed to be adiabatic and changes in kinetic and potential energy can be ignored. All assumptions made should be clearly stated and explained.

[15 marks]

Total marks for Question 1 = 25 Marks

QUESTION 2.

a) An oil pipeline is laid on an incline and rises 12metres over its length. When 100litres/s of oil is flowing, the pressure at the inlet of the pipe is 400kN/m^2 . If the pipe diameter is 120mm at inlet and 100mm at outlet, calculate the pressure at the outlet of the pipe, if the pressure loss due to friction is equivalent to 1.2 metres of water.

(Take the density of oil = 900kg/m^3)

[12 marks]

b) Explain the significance of the upper and lower critical Reynolds Numbers for flow. Using the work of Osborne Reynolds explain how these parameters were established.

[13 marks]

Total marks for Question 2 = 25 Marks

QUESTION 3

a) Make a sketch of a Temperature-Enthalpy diagram for steam and explain how this diagram has been formed, highlighting clearly the different phases on the diagram.

[10 marks]

b) Steam at a pressure of 30 bar and a temperature of 350°C occupies a volume of 0.16m³. It is expanded in a non-flow process according to the law $PV^{1.3} = C$ to a final pressure of 6 bar.

Calculate:

- (i) the mass of steam present.
- (ii) the final dryness fraction of the steam.
- (iii) the specific work done by the steam in the expansion.

[15 marks]

Total marks for Question 3 = 25 Marks

QUESTION 4

A four cylinder, four stroke petrol engine develops a torque of 220Nm at 2500 rpm. The engine has a bore and a stroke of 110mm and 100mm respectively, and is run at an air/fuel ratio of 14/1 with a specific fuel consumption of 0.364kg/kWh. The atmospheric conditions at the time of the test were 1.01bar and 15°C. If the calorific value of the fuel is 44,200kJ/kg calculate:

- i) the brake thermal efficiency

[10 marks]

- ii) the volumetric efficiency

[15 marks]

The characteristic gas constant for air $R=0.287$ kJ/kgK

Total marks for Question 4 = 25 marks

QUESTION 5

A centrifugal pump is to be used to deliver water to a storage tank on top of a building. The static lift for the pump is 12 metres, and the desired flow rate to the tank is 10 l/s.

The pipework system comprises two gate valves (used as isolating valves), a gate valve for flow control, four 90° bends, 30 metres of pipe, and an abrupt entry and exit to and from the system.

The pipe is galvanised steel with a diameter of 100mm throughout.

The pump has the following head characteristic:

Total Head (metres of water)	25	24	19.5	12.5	7.5
Volume Flow (m ³ /s)	0	0.004	0.008	0.012	0.014

Calculate:

- i) the actual flow rate that will be achieved using the above pump on the system as specified.

(20 marks)

- ii) the theoretical power to drive the pump under the above conditions.

(5 marks)

Take the density of water = 1000 kg/m³

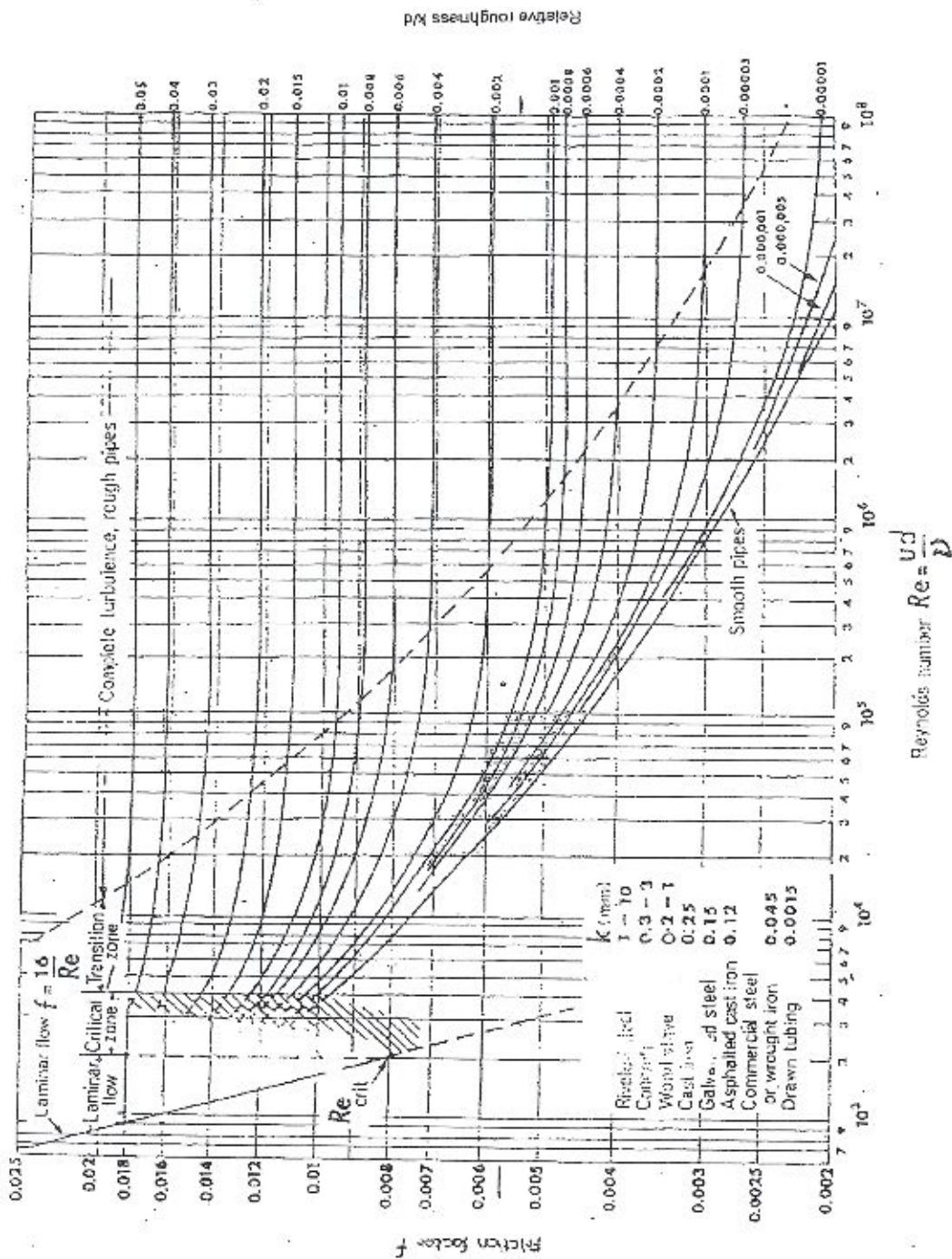
and the viscosity of water = 0.001136 kg/ms

Loss factors for fittings:

Gate valve (fully open) 0.2

90° bend 0.9

Total marks for Question 5 = 25 marks



Variation of Friction Factor with Re (Moody Diagram)

Formula and Data Sheet

Note: In the following formulae all symbols have their usual meaning

Steady State Heat Transfer

U values:

$$q = U A \Delta T$$

Conduction in a plane wall with a linear temperature distribution:

$$q = kA \frac{(T_1 - T_2)}{L}$$

Convection:

$$q = h A (T_s - T_\infty)$$

Conduction through composite wall, made of three flat slabs with conductivities k_A , k_B , and k_C , in contact with fluids on both sides:

$$q = \frac{T_{\infty,1} - T_{\infty,4}}{\left(\frac{1}{h_1 A} + \frac{L_A}{k_A A} + \frac{L_B}{k_B A} + \frac{L_C}{k_C A} + \frac{1}{h_4 A} \right)}$$

Internal Combustion Engines

$$\text{Indicated Power} = P_i L A N n \quad (2 \text{ Stroke})$$

$$= P_i L A \frac{N}{2} n \quad (4 \text{ Stroke})$$

$$\text{Brake Power} = P_b L A N n \quad (2 \text{ Stroke})$$

$$= P_b L A \frac{N}{2} n \quad (4 \text{ Stroke})$$

$$= 2\pi N T$$

$$\text{Fuel Energy (Energy Supplied)} = \text{Mass Flow of Fuel} \times \text{Calorific Value} = m_f \times CV$$

$$\text{Mechanical Efficiency} = \frac{\text{Brake Power}}{\text{Indicated Power}} \times 100\%$$

$$\text{Brake Thermal Efficiency} = \frac{\text{Brake Power}}{\text{Energy Supplied}} \times 100\%$$

$$\text{Specific Fuel Consumption} = \frac{\text{Mass Flow of Fuel}}{\text{Brake Power}}$$

$$\text{Volumetric Efficiency} = \frac{\text{Induced Volume}}{\text{Swept Volume}} \times 100\%$$

Gas and Steam Turbines

Perfect Gas Relationships:

$$\frac{T_1}{T_2} = \left(\frac{P_1}{P_2} \right)^{\frac{\gamma-1}{\gamma}} \qquad \frac{T_1}{T_2} = \left(\frac{V_2}{V_1} \right)^{\gamma-1}$$

$$\text{Change of Enthalpy of a Perfect Gas } (H_2 - H_1) = m \times c_p \times (T_2 - T_1)$$

Properties of Vapours:

$$\text{Specific Enthalpy of Wet Steam} = h_f + x h_{fg}$$

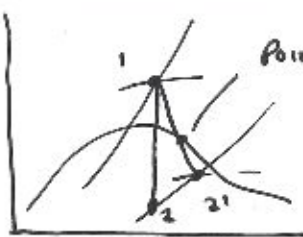
$$\text{Specific Volume of Wet Steam} = xv_g$$

$$\text{Thermal Efficiency of a Turbine} = \frac{\text{Net Work Output}}{\text{Heat Supplied}}$$

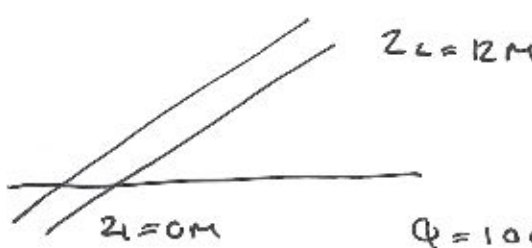
EXAMINATION SOLUTIONS

(to accompany the examination paper sent to the external examiner
but NOT to be seen by students)

Programme:	Bsc (Hons) MECHANICAL ENG	Level:	5
Module:	Thermofluids 2		
Author:	CHRIS DAVIES	Page:	1/5

Q1	Question	Marks
(a)	 POINT OF CONDENSATION ISOTHERMAL EFFICIENCY IS NOW CLOSE THE PROCESS IS TO ISOTHERMAL $\eta = \frac{h_1 - h_2'}{h_1 - h_2}$ DISAGREE / DEFINITION OF ISOTHERMAL PROCESS AS A REVERSIBLE ADIABATIC. $P_1 = 60 \text{ bar}$ $P_2 = 10 \text{ bar}$ $\dot{m} = 10 \text{ kg/s}$ $T = 400^\circ\text{C}$ $x_{2'} = 0.94$ $h_1 = 3180 \text{ kJ/kg}$ (from chart) = 3177 kJ/kg (from table) $h_{2'} = 2540 \text{ kJ/kg}$ $h_2 = 2370 \text{ kJ/kg}$ Power developed = $(h_1 - h_{2'}) \times \dot{m}$ $= 10(3180 - 2540)$ $= \underline{6.4 \text{ MW}}$ from chart pressure + temperature at point of condensation $\approx 4.5 \text{ bar}, 150^\circ\text{C}$ $\eta = \frac{3180 - 2540}{3180 - 2370} = 0.79 \text{ (79\%)}$	(10) (5) (5) (5)



Q 2	Question	Marks
	 $Q = 100 \text{ L/s}$ $h_f = 1.2 \text{ M}$ $P_1 = 400 \text{ kN/m}^2$ $d_1 = 120 \text{ mm} \therefore A_1 = \frac{\pi \times 0.12^2}{4} = 0.0113 \text{ m}^2$ $d_2 = 100 \text{ mm} \therefore A_2 = \frac{\pi \times 0.1^2}{4} = 7.85 \times 10^{-3} \text{ m}^2$ $C_1 = \frac{0.1}{0.0113} = 8.85 \text{ m/s}$ $C_2 = \frac{0.1}{7.85 \times 10^{-3}} = 12.7 \text{ m/s}$ (4) $\frac{P_1}{\rho g} + \frac{C_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{C_2^2}{2g} + Z_2 + h_c$ (2) $\frac{400,000}{900 \times 9.81} + \frac{8.85^2}{2 \times 9.81} + 0 = \frac{P_2}{900 \times 9.81} + \frac{12.73^2}{2 \times 9.81} + 10 + 1.2$ $4.53 + 3.3 + 0 = \frac{P_2}{8829} + 2.77 + 10 + 1.2$ $34.63 \times 8829 = P_2$ $P_2 = 305748 \text{ N/m}^2$ (6)	
(b)	UPPER AND LOWER CRITICAL REYNOLDS NUMBERS DEFINED TO ANALYSE EACH ZONE (LAMINAR, TURBULENT + TRANSITION. DESCRIPTION OF THE REYNOLDS EXPERIMENT WITH A PLOT OF RESULTS TO SHOW EACH ZONE / REGION	(6) (7)

25

3



Q4	Question	Marks
(a)	$T = 220 \text{ mm}$ $N = 2500 \text{ rpm}$ $P_a = 1.01 \text{ bar}$ $T_a = 15^\circ \text{C}$ $D = 110 \text{ mm}$ $L = 100 \text{ mm}$ $\lambda = 4$ $C_v = 44200 \text{ kJ/kg}$ $A/f = 14/1$ $SFC = 0.364 \text{ kg/kWh}$ $\eta_{bth} = \frac{bp}{m \times C_v}$ $bp = 2\pi NT$ $bp = 2\pi \times \frac{2500}{60} \times 220$ $bp = 57595.8 \text{ W}$ $SFC = \frac{\dot{m}}{bp} \Rightarrow \dot{m} = SFC \times bp$ $= \frac{0.364 \times 57.59}{3600} = \frac{0.0058 \text{ kg/s}}{0.0058}$ $\eta_{bth} = \frac{57.595}{0.0058 \times 44200} = 0.224 \text{ (22.4\%)}$	(5)
(b)	MASS OF AIR INDUCED = $14 \times 0.0058 = 0.0812 \text{ kg/s}$ MASS OF CHARGE INDUCED = $0.0812 + 0.0058$ $= 0.087 \text{ kg/s}$ MASS OF CHARGE / CYL / S = $0.087 / 4 = 0.02175 \text{ kg/s}$ VOLUME INDUCED / CYL / SEC FROM PV=MT $V = \frac{mRT}{P} \Rightarrow \frac{0.02175 \times 287 \times 288}{1.01 \times 10^5}$ $V = 0.0178 \text{ m}^3/\text{s}$ SCRAP VOL = $L \times A \times N/2 = 0.1 \times (\frac{\pi}{4} \times 0.11^2) \times \frac{2500}{60 \times 2}$ $= 0.0197 \text{ m}^3/\text{s}$ $\eta_v = \frac{0.0178}{0.0197} = 90.3\%$	(5)

Q 5	Question	Marks
	$Q = 0.01 \text{ m}^3/\text{s}$ $a = \frac{\pi \times 0.1^2}{4} = 0.00785 \text{ m}^2$ $V = 1.273 \text{ m/s}$	(2)
	$Re = \frac{\rho v d}{\mu} = \frac{1000 \times 1.273 \times 0.1}{0.001136} = 112059.9 (1.1 \times 10^5)$	(2)
	$\frac{v}{d} = \frac{0.15}{100} = 0.0015 \therefore f = 0.0059$	(2)
	$\text{Primary Loss} = \frac{4 \times 0.0059 \times 30 \times 1.273^2}{2 \times 9.81 \times 0.1} = \underline{0.58 \text{ m}}$	(3)
	$\Sigma K = (3 \times 0.2) + (4 \times 0.9) + 1.5 = 5.7$ $\text{Secondary Loss} = \frac{5.7 \times 1.273^2}{2 \times 9.81} = \underline{0.47 \text{ m}}$	(3)
	$\text{Total Loss} = 0.58 + 0.47 + \text{static lift (12)} = \underline{13.05 \text{ m}}$	
	$\frac{h_2}{h_1} = \frac{Q_2^2}{Q_1^2}$ TAKE $Q_2 = 0.012 \text{ m}^3/\text{s}$ $h_2 = 1.055 \times \frac{0.012^2}{0.01^2} = 1.055 \times \frac{0.000144}{0.0001}$ $h_2 = \underline{13.519 \text{ m}}$	
	$\frac{h_3}{h_1} = \frac{Q_3^2}{Q_1^2}$ TAKE $Q_3 = 0.008 \text{ m}^3/\text{s}$ $h_3 = 1.055 \times \frac{0.008^2}{0.01^2} = 0.675 \text{ m} (12.67 \text{ m})$	(3)
	$\text{PLOTS GRAPH TO DETERMINE } Q = 0.0114 \text{ m}^3/\text{s}$	(5)
	$P_{\text{pump}} = P \times Q$ $= (1000 \times 9.81 \times 13.5) \times 0.0114$ $= \underline{1.51 \text{ kW}}$	(5)



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

LOCATION: COLEG SIR GAR (GRAIG)

LLEOLIAD: COLEG SIR GAR (GRAIG)

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
2020

CYFNOD ARHOLIADAU
2020

(RESIT)
MODULE CODE: SGDM5012
THERMOFLUIDS 2

TIME: 2 HOURS

ANSWER FOUR QUESTIONS OUT OF FIVE

Equipment or materials required

Calculators are permitted.

Steam and refrigeration tables will be provided.

Moody diagram is provided.

Enthalpy v Entropy diagram is provided.

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Caniateir cyfrifiannellau

Bydd tablau Stêm a Rheweiddiad yn cael eu darparu

Darperir diagram Moody

Darperir diagram Enthalpi v Entropi

QUESTION 1

- a) Explain what is meant by 'primary' and 'secondary' losses in pipework systems.

[7 marks]

- b) Water flows through a 50mm diameter circular pipe at the rate of $0.009 \text{ m}^3/\text{s}$. The pipe has a constant diameter and includes four 90° bends, two gate valves (open), has a sharp, abrupt exit, and has a total length of 30metres

Determine the total pressure loss due to friction along the pipe, if the pipe roughness is 0.15mm.

Secondary losses should be calculated from:

$$H = \frac{kc^2}{2g}$$

where typical values of k are:

90° bend $k = 0.9$

Gate valve (open) $k = 0.2$

Take the density and viscosity of water as $1000\text{kg}/\text{m}^3$ and 0.00106 kg/ms respectively.

[10 Marks]

- c) If the volume flow rate can vary from zero to $0.012\text{m}^3/\text{s}$, plot the system pressure loss characteristic.

[8 Marks]

Total marks for Question 1 = 25 Marks

QUESTION 2

- a) Sketch the 'Air Standard' Cycle for a 4 stroke spark ignition internal combustion engine, and describe the processes involved.

How does this compare to an actual, practical, cycle? Highlight the key areas of difference.

[10 marks]

- b) The performance of an engine can be affected by many factors. List three such factors and explain the effect they can have on performance.

[10 marks]

- c) Explain what is meant by a 'consumption loop' with regard to engine performance. What parameters would need to be measured during an engine test in order to produce a 'consumption loop'

[5 marks]

Total marks for Question 2 = 25 Marks

QUESTION 3

- a) Explain what is meant by the 'Isentropic efficiency' of a process.

[8 marks]

- b) Steam expands through a horizontal adiabatic nozzle from a pressure of 50 bar and a temperature of 400°C to a final pressure of 1 bar and a dryness fraction of 0.94.

If the mass flow of steam is 1.5 kg/s using the steam charts and tables provided, calculate:

- i) the exit velocity of the steam from the nozzle

[7 marks]

- ii) the nozzle exit area

[5 marks]

- iii) the isentropic efficiency of this process

[5 marks]

All assumptions made should be clearly explained.

Total marks for Question 3 = 25 Marks

QUESTION 4

- a) A four cylinder, four stroke petrol engine is testing at full load at a speed of 3000 rev/min. The brake mean effective pressure at this speed was 6.2 bar. The engine has a bore and stroke of 90mm and 100mm respectively, and is run at an air/fuel ratio of 12/1 with a specific fuel consumption of 0.364 kg/kWh. The atmospheric conditions at the time of the test were 1.01 bar and 15°C. If the calorific value of the fuel is 44,200 kJ/kg calculate:

- i) the brake power [8 marks]
- ii) the brake thermal efficiency [8 marks]
- iii) the volumetric efficiency [9 marks]

(The characteristic gas constant for air $R = 0.287 \text{ kJ/kgK}$)

Total Marks for Question 4 = 25

QUESTION 5

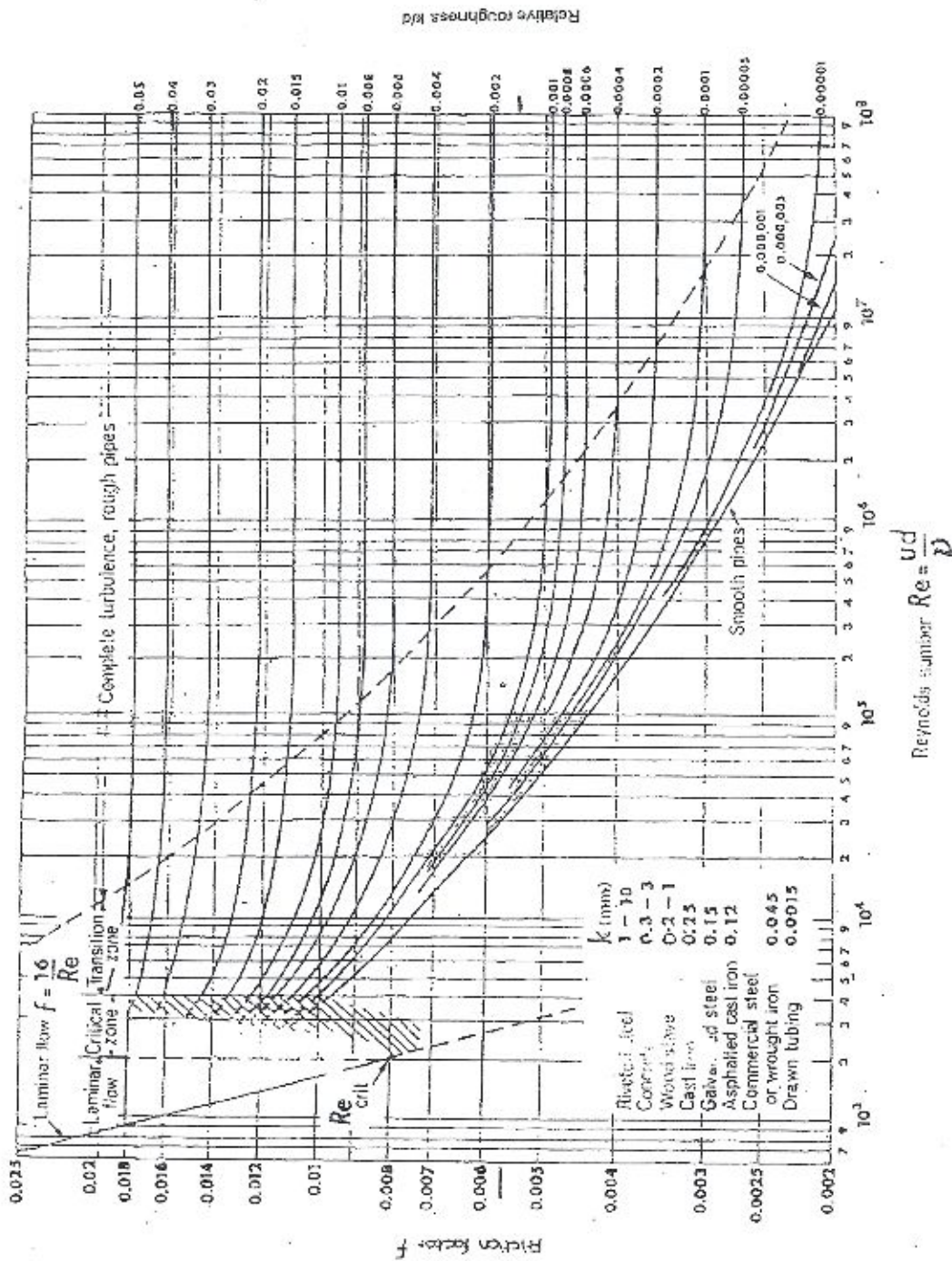
- a) Explain what is meant by the term 'dryness fraction' as applied to wet steam. Make reference to a temperature/ enthalpy diagram for steam in your answer. [9 marks]
- b) A quantity of steam at a pressure of 9 bar and a dryness fraction of 0.8 occupies a volume of 0.15 m^3 . It expands in a non-flow polytropic process according to the law $pv^{1.1} = C$, until the pressure is reduced to 3 bar.

Calculate:

- i) the final dryness fraction
- ii) the final temperature
- iii) the mass of steam present
- iv) the work done during the expansion

[4 marks each]

Total Marks for Question 5 = 25 Marks



Variation of Friction Factor with Re (Moody Diagram)

Formula and Data Sheet

Note: In the following formulae all symbols have their usual meaning

Steady State Heat Transfer

U values:

$$q = U A \Delta T$$

Conduction in a plane wall with a linear temperature distribution:

$$q = kA \frac{(T_1 - T_2)}{L}$$

Convection:

$$q = h A (T_s - T_\infty)$$

Conduction through composite wall, made of three flat slabs with conductivities k_A , k_B , and k_C , in contact with fluids on both sides:

$$q = \frac{T_{\infty,1} - T_{\infty,4}}{\left(\frac{1}{h_1 A} + \frac{L_A}{k_A A} + \frac{L_B}{k_B A} + \frac{L_C}{k_C A} + \frac{1}{h_4 A} \right)}$$

Internal Combustion Engines

$$\text{Indicated Power} = P_i L A N n \quad (2 \text{ Stroke})$$

$$= P_i L A \frac{N}{2} n \quad (4 \text{ Stroke})$$

$$\text{Brake Power} = P_b L A N n \quad (2 \text{ Stroke})$$

$$= P_b L A \frac{N}{2} n \quad (4 \text{ Stroke})$$

$$= 2\pi N T$$

$$\text{Fuel Energy (Energy Supplied)} = \text{Mass Flow of Fuel} \times \text{Calorific Value} = m_f \times CV$$

$$\text{Mechanical Efficiency} = \frac{\text{Brake Power}}{\text{Indicated Power}} \times 100\%$$

$$\text{Brake Thermal Efficiency} = \frac{\text{Brake Power}}{\text{Energy Supplied}} \times 100\%$$

$$\text{Specific Fuel Consumption} = \frac{\text{Mass Flow of Fuel}}{\text{Brake Power}}$$

$$\text{Volumetric Efficiency} = \frac{\text{Induced Volume}}{\text{Swept Volume}} \times 100\%$$

Gas and Steam Turbines

Perfect Gas Relationships:

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

$$\frac{T_1}{T_2} = \left(\frac{V_2}{V_1} \right)^{\gamma-1}$$

$$\text{Change of Enthalpy of a Perfect Gas } (H_2 - H_1) = m \times c_p \times (T_2 - T_1)$$

Properties of Vapours:

$$\text{Specific Enthalpy of Wet Steam} = h_f + x h_{fg}$$

$$\text{Specific Volume of Wet Steam} = x v_g$$

$$\text{Thermal Efficiency of a Turbine} = \frac{\text{Net Work Output}}{\text{Heat Supplied}}$$



EXAMINATION SOLUTIONS

(to accompany the examination paper sent to the external examiner
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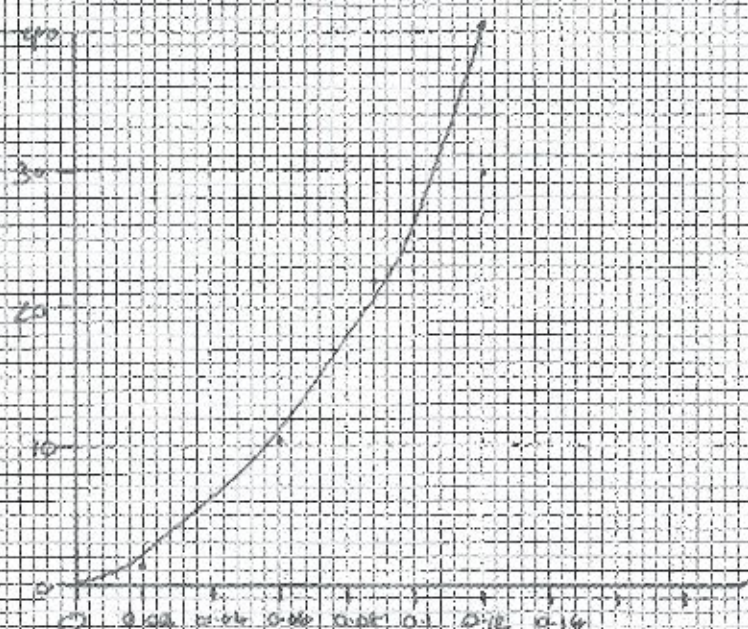
Programme:	BSc (Hons) MECHANICAL ENG	Level:	5
Module:	PEDM5012 THERMOFLUIDS 2		
Author:	CHRIS DAVIES	Page:	11

Q1	Question	Marks
(a)	PRIMARY LOSSES - FUNCTION OF PIPE (CONDITION & LENGTH) SECONDARY LOSSES - LOSSES IN FITTINGS & FETTERINGS DISCUSSING OF TYPICAL FEATURES & EFFECT ON LOSSES	(7)
(b)	$Q = 0.009 \text{ m}^3/\text{s}$ $A = \frac{\pi \times 0.05^2}{4} = 0.001964 \text{ m}^2$ $V = Q/A = \frac{0.009}{0.001964} = 4.58 \text{ m/s}$ $Re = \frac{\rho V d}{\mu} = \frac{1000 \times 4.58 \times 0.05}{0.00106} = 216038$ $k/d = 0.15/50 = 0.03$ FROM MOODY DIAGRAM $f = 0.0068$ $h = \frac{4 f L V^2}{2 g} = \frac{4 \times 0.0068 \times 30 \times 4.58^2}{2 \times 9.81 \times 0.05} = 17.45 \text{ m}$ $\Sigma K = (4 \times 0.2) + (2 \times 0.2) + (1.0) = 5$ $h = \frac{5 \times 4.58^2}{2 \times 9.81} = 5.345 \text{ m}$ TOTAL LOSS = $17.45 + 5.345 = 22.79 \text{ m}$ $\therefore P = 1000 \times 9.81 \times 22.79 = 22.36 \text{ kN/m}^2$	(10)

when $Q = 0.06 \text{ m}^3/\text{s}$ $H = 12.79 \times \frac{(0.06)^2}{(0.09)} = 10.73 \text{ m}$

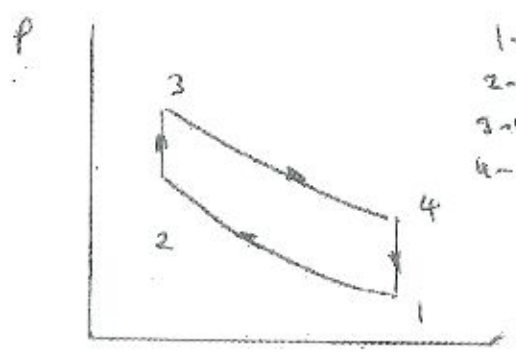
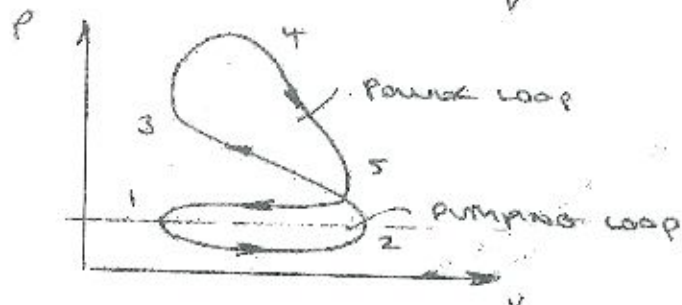
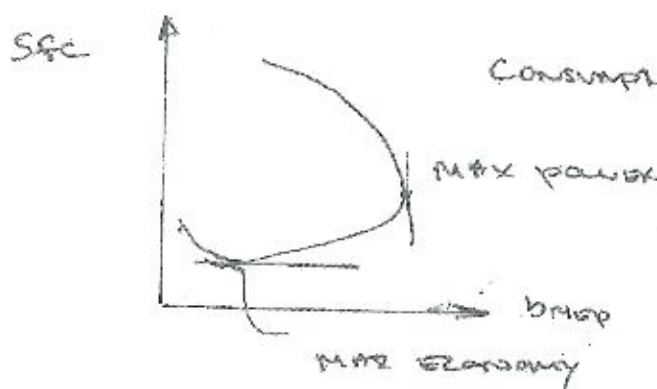
when $Q = 0.12 \text{ m}^3/\text{s}$ $H = 12.79 \times \frac{(0.12)^2}{(0.09)} = 40.56 \text{ m}$

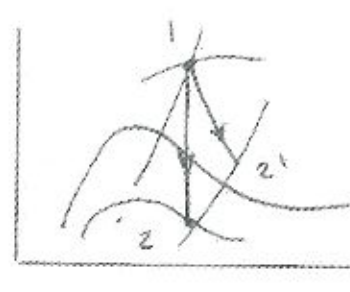
when $Q = 0.03 \text{ m}^3/\text{s}$ $H = 12.79 \times \frac{(0.03)^2}{(0.09)} = 1.28 \text{ m}$



(8)

(a)

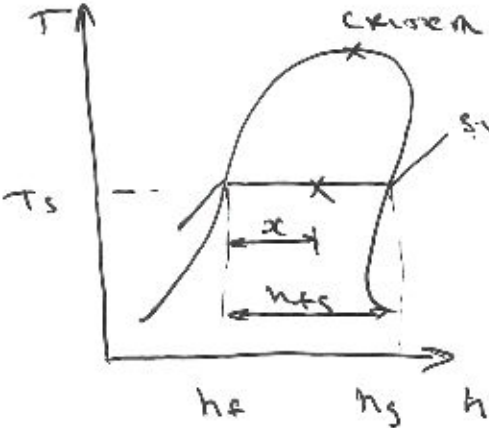
Q1	Q2	Question	Marks
(A)		 1-2 ISOTROPIC COMPRESSION 2-3 CONSTANT VOLUME COMBUSTION 3-4 ISOTROPIC EXPANSION 4-1 CONSTANT VOLUME COOLING 	(10)
(B)		FACTORS AFFECTING PERFORMANCE INCLUDE (i) IGNITION TIMING (ii) VALVE TIMING (iii) COMPRESSION RATIO + DISCUSS (iv) FUEL SPECIFICATION (v) ATMOSPHERIC CONDITIONS	(10)
(C)		 CONSUMPTION LOOP MAX POWER MAX ECONOMY FACTORS TO BE MEASURED (i) TORQUE (ii) SPEED (iii) FUEL FLOW	(3)

Q3	Question	Marks
(a)	THIS IS HOW CLOSE THE PROCESS IS TO BEING CONSTANT ENTROPY IE THE IDEAL PROCESS (REVERSIBLE ADIABATIC).  1-2 isentropic 1-2' actual $\eta = \frac{h_1 - h_{2'}}{h_1 - h_2}$	(8)
(b)	FROM S.F.E.E $h_1 = h_2 + \frac{C_2^2}{2000}$	
(i)	$h_1 = h$ at 50 bar, 400 °C = 3196 kJ/kg $h_2 = h$ at 1 bar $x = 0.94$ $h_2 = h_f + 0.94 h_{fg}$ $h_2 = 417 + (0.94 \times 2258) \quad h_{2'} = 2539.52 \text{ kJ/kg}$ FROM h-s CHART $h_2 = 2410 \text{ kJ/kg}$. $3196 = 2539.52 + \frac{C_2^2}{2000}$ $(3196 - 2539.52) \times 2000 = C_2^2 \quad \therefore C_2 = \underline{\underline{1145 \text{ m/s}}}$	(7)
(ii)	$\dot{Q} = \dot{m} = \rho A C = \frac{A C}{M} \quad 1.5 = \frac{A \times 1145}{(0.94 \times 1.694)}$ $\therefore A = \frac{1.5 \times (0.94 \times 1.694)}{1145} = \underline{\underline{2 \times 10^{-3} \text{ m}^2}}$	(5)
(iii)	$\eta = \frac{3196 - 2539.5}{3196 - 2410} = \underline{\underline{83.42\%}}$	(5)



Q.4	Question	Marks
	$n = 4$ $N = 3000 \text{ rev/min}$ $b_{mep} = 6.2 \text{ bar}$ $d = 0.09 \text{ m}$ $L = 0.1 \text{ m}$ $A/F = 12/1$ $sfc = 0.364 \text{ kg/kWh}$ $p_{atm} = 1.01 \text{ bar}$ $T_{atm} = 288 \text{ K}$ $CV = 44200 \text{ kJ/kg}$	
(a)	$b_p = p_{b,LA} (N/L) \pi$ $= 6.2 \times 10^5 \times 0.1 \times \frac{\pi \times 0.09^2}{4} \times \left(\frac{3000}{60 \times 2} \right) \times 4$ $b_p = 39448 \text{ W}$	(8)
(b)	$sfc = \dot{m}_f / b_p$ $\therefore \dot{m}_f = sfc \times b_p$ $\dot{m}_f = \frac{0.364 \times 39.5}{3600} \text{ kg/s}$ $\dot{m}_f = 0.0399 \text{ kg/s}$ $Z_{br} = \frac{b_p}{\dot{m}_f CV} = \frac{39.5}{0.0399 \times 44200} = 22.34\%$	(6)
(c)	$\text{Mass of Air} = 12 \times 0.004 = 0.048 \text{ kg/s}$ $\text{Mass of charges} = 0.048 + 0.04 = 0.082 \text{ kg/s}$ $\text{Mass of charges / cylinder / sec} = \frac{0.082}{4} = 0.0205 \text{ kg/s/cy}$ $\text{From } pV = mRT$ $V = \frac{mRT}{p}$ (Volume of charges induced / s / cy) $V = \frac{0.0205 \times 287 \times 288}{1.01 \times 10^5} = 0.01064 \text{ m}^3/\text{s}$ $\text{Swept Volume} = L \times A \times N/2 = 0.1 \times \frac{\pi \times 0.09^2}{4} \times \frac{3000}{60 \times 2}$ $= 0.0159 \text{ m}^3/\text{s}$ $\therefore Z_v = \frac{0.01064}{0.0159} = 67\%$	(9)



Q8	Q5 Question	Marks
(a)	 CRITICAL POINT SUPERHEATED STEAM TS x h_g h_f h DC = DRYNESS FRACTION 0 → 1 (DRY SAT VAPOR) SAT LIQUID HIGHLIGHT T-h DIAGRAM + POSITION OF DC IDENTIFY VALUES BETWEEN 0 & 1 AND DISCUSS RELATIVE VALUES	(9)
(b)	(i) $P_1 = 9 \text{ bar}$ $P_2 = 3 \text{ bar}$ $x_1 = 0.8$ $PV^{1.1} = C$ $V_1 = 0.15 \text{ m}^3$ $V_{S1} = 0.2149 \text{ m}^3/\text{kg}$ $M_1 = 0.8 \times 0.2149$ $M_1 = 0.1719 \text{ kg}$ $P_1 M_1^{1.1} = P_2 M_2^{1.1}$ $P_1 M_1^{1.1} = P_2 M_1^{1.1}$ $M_2^{1.1} = \frac{P_1}{P_2} \times M_1^{1.1}$ $= \frac{9}{3} \times 0.1719^{1.1}$ $M_2 = 0.3976 \text{ kg}$	(4)
(ii)	IF ② IS A WET CONDITION $T_2 = T_S = 133.5^\circ\text{C}$	(4)
(iii)	MASS - $\frac{V_1}{M_1} = \frac{0.15}{0.1719} = 0.873 \text{ kg}$	(4)
(iv)	$W = \frac{P_1 M_1 - P_2 M_2}{n-1} = \frac{(9 \times 10^5 \times 0.1719) - (3 \times 10^5 \times 0.3976)}{1.1 - 1}$ $W = 35.43 \text{ kJ/kg}$	(4)