



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: September 2023

Module Number: MN4303

Module Name: Marine Engineering Computer Aided Drawing

[Four Hours]

[Answer all parts of the question, the question carries 100 marks]

Instructions to Candidates:

- The question paper contains one question and four (04) pages including this page.
- Answer all parts of the question.
- Marks allocated for each part of the question have been indicated.
- The answer should be drawn in accordance with B.S.308:1993 and hidden details should be omitted.
- Use the ISO A2 sheet for drawing all views and other details.
- The selected scale must ensure uniform distribution and coverage of the drawing on the sheet.
- Write your **Index Number, the Module Code and the Title of the paper** in the specified space of the drawing sheet.
- Save the softcopy of your drawing in AutoCAD 2018 or lower version giving your Index Number and the Module Code (Eg. EG_2020_XXXX MN4303)

Q1

- Figure Q1 shows details of a Crane Hook. The description of the hook is given below;
- The two side plates are held together by three 44 dia. studs, one of which is shown.
 - The swivel block fits into two bushes, which are secured to the side plates by three M10 set screws in their flanges.
 - The hook is free to revolve in a 40 dia. bush fitted in the swivel block and a thrust washer is fitted between an M30 nut on the screwed end of the hook, and the top of the bush.

a) Draw the following views of the Crane Hook in First Angle Projection

- i) Sectional elevation through the axis of the swivel block, showing all parts assembled. [30 Marks]

- ii) End elevation [20 Marks]

- iii) Sectional plan view through the axis of swivel block. [20 Marks]

b) Complete the drawing by adding the following,

- i) A part list, with the parts clearly identified on the assembled drawing [05 Marks]

- ii) Title and subtitles [02 Marks]

- iii) The projection symbol [02 Marks]

- iv) All dimensions [02 Marks]

- v) Suitable scale [05 Marks]

[01 Marks]

c) Electronic drawing values

c) Electronic drawing values

i) Select a suitable standard paper for the drawing

[02 Marks]

ii) Use suitable drawing layers

[05 Marks]

iii) Use suitable text styles

[02 Marks]

iv) Use suitable dimension styles

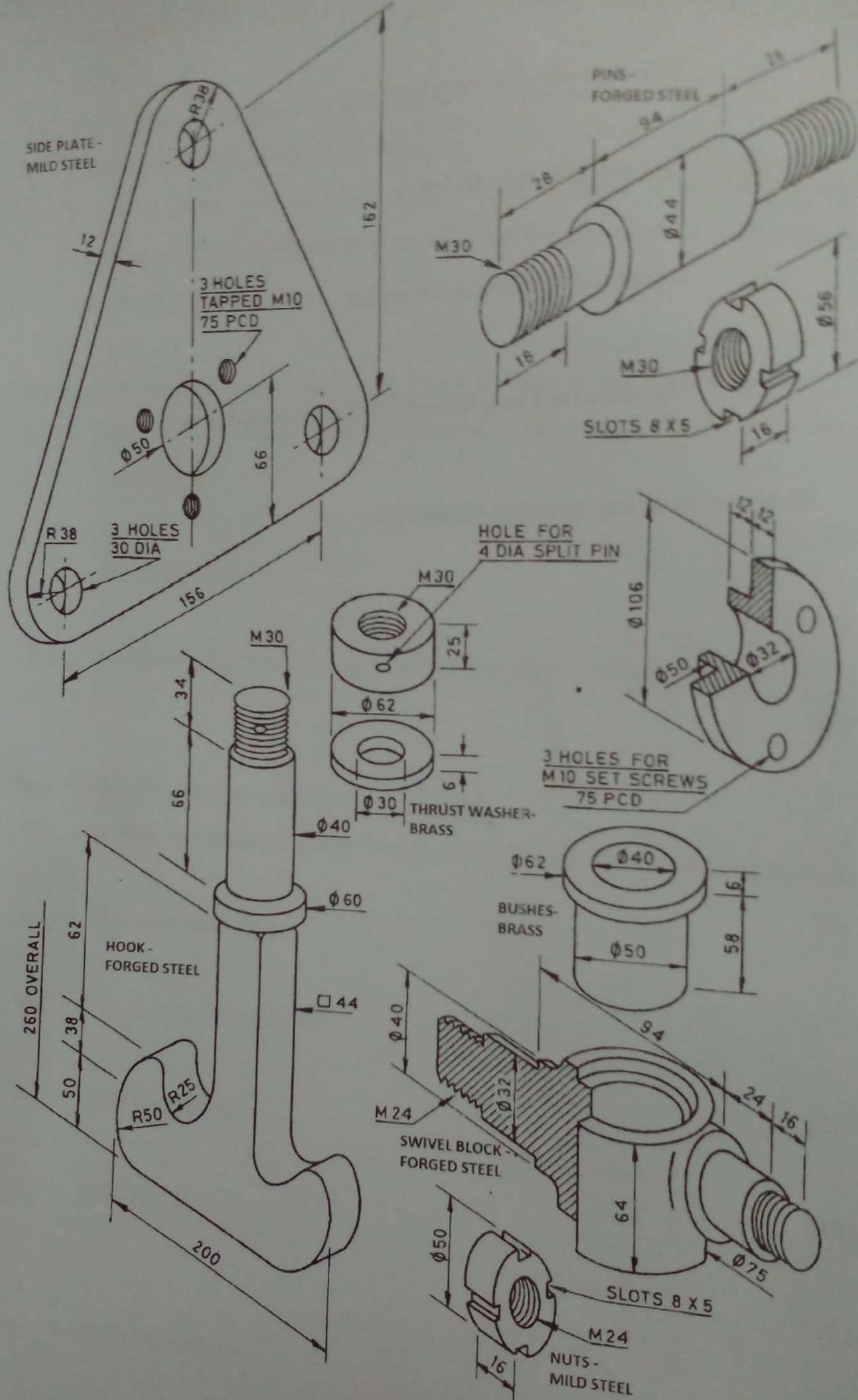
[04 Marks]

v) Use standard heights for dimensions and text

[02 Marks]

Note: Assume any missing dimensions

Figure Q1: Crane Hook





End-Semester 4 Examination in Engineering: September 2023

Module Number: ME4210

Module Name: Analog and Digital Electronics
[Three Hours]

[Answer all questions, each question carries 12 marks]

This paper contains 5 questions on 5 pages.

Clearly state any assumptions that you may make.

In order to get full marks, make sure to use standard notations and SI units, where appropriate.

- Q1.** (a) Analog to Digital Conversion (ADC) plays a major role in the context of analog electronics.

Explain the necessity of ADC in electronic circuits and main steps followed during the process of converting analog signals to digital format.

[2.0 Marks]

- (b) Using neat sketches, briefly describe the non-inverting and inverting op-amp configurations.

[3.0 Marks]

- (c) Suppose you have been asked to design an audio mixer for adding together individual waveforms or sounds from three different source channels (vocal, drum, and guitar) before sending them to an audio recorder.

Sketch the circuit diagram that you are going to propose for the above requirement using a summing amplifier.

[3.0 Marks]

- (d) Briefly describe the importance of including Voltage to Current Converters in control systems when transmitting signals over long distances.

[2.0 Marks]

- (e) Multiplexing is a technique used to combine and send multiple data streams over a single medium. Using a sketch, briefly explain the operation of a 4-to-1 multiplexer.

[2.0 Marks]

Q2. (a) Using neat sketches, briefly describe the four (4) types of analog filters, categorized by the range of frequencies they allow to pass.

[2.0 Marks]

(b) Briefly explain the difference between active and passive filters.

[2.0 Marks]

(c) Assume you are an engineer who has been assigned to design a condition monitoring system for bridge structures. For this application, you will employ vibration sensors equipped with a transmitter installed along the bridge structure to monitor and record its vibration levels over a specified period. The transmitted frequency levels, intended for the analysis of the structural condition of the bridge must remain below 170 Hz.

Design a non-inverting active low-pass filter circuit, as depicted in **Figure Q2(c)**, with the following specifications:

A gain of 10 at low frequencies, a high-frequency cut-off (corner frequency) of 170 Hz, and an input impedance of $10\text{ k}\Omega$.

(i) Calculate all the resistor and capacitor values of the filter circuit.

(ii) Draw the frequency response curve of the filter.

[8.0 Marks]

Q3 (a) Briefly explain why Programmable Logic Controllers (PLCs) are preferred over microcontrollers when it comes to industrial applications.

[2.0 Marks]

(b) List **four (04)** advantages of PLCs compared to conventional relay control systems.

[2.0 Marks]

(c) Suppose you are tasked with controlling a CNC lathe machine using a PLC. The layout of the main components of the CNC lathe machine is shown in **Figure Q3(c)**, and the control system is expected to perform the following functions:

- The 'Main Motor' of the CNC spindle needs to be controlled using a Single Switch (detent type).
- The main motor bearing needs to be continuously lubricated using the 'Lubrication Pump' while in operation.
- After switching off the main motor, it takes approximately 30 seconds for it to slow down and reach to complete stop. During this period, lubrication for the main motor bearings should continue.
- An 'Alarm' will be activated to alert the operator if the lubrication level falls below a predetermined value or if the lubrication flow is

interrupted for any reason. In such cases, the main motor will be automatically stopped until the issue is resolved.

- A 'Liquid Level Sensor' (LLS) is used to sense the lubricant level and a 'Flow Sensor' (FS) is used to detect the status of the lubrication pump.
- During machine operation, a 'Green Indicator' bulb should illuminate, and it should turn off once all the components are completely stopped.
- The fully automated system is to be activated using a Master Switch.

Draw the input/output mapping table and develop a ladder logic program for the above application.

[8.0 Marks]

- Q4 (a) Briefly explain the main difference between Finite Impulse Response filters and Infinite Impulse Response filters.

[1.0 Marks]

- (b) Consider the digital filter given by the following difference equation.

$$y[n] = 3x[n] - 5x[n-3] + y[n-1] - 4y[n-2]$$

- (i) Explain the meaning of the term $[n-1]$.

- (ii) Construct the transfer function (z^{-1} transform) for the given difference equation.

- (iii) Construct the direct form 1 signal flow graph to the given difference equation using z^{-1} blocks for delays.

- (iv) Transform the constructed signal flow graph for the above question, to a direct form 2 signal flow graph using z^{-1} blocks for delays.

[8.0 Marks]

- (c) Consider the digital filter given by the following difference equation.

$$y[n] = 3x[n] - 5x[n-1] + 2x[n-3] - 4x[n-5]$$

Derive the frequency response of the filter.

[3.0 Marks]

- 5 (a) Draw the T-type flip-flop with correctly marked pins and write down its characteristic equation.

[1.0 Marks]

- (b) Briefly explain the operation of a D-type flip-flop.

[2.0 Marks]

- (c) You are asked to design a control system of a remote control robot. Here, the

control system gets the inputs from the sensors and user commands, and moves the robot accordingly. Given below are the inputs and outputs of the controller.

Inputs and status:

1. Forward obstacle sensor
'1' if there is an obstacle at the front and '0' if there are no obstacles at the front
2. Backward obstacle sensor
'1' if there is an obstacle at the back and '0' if there are no obstacles at the back
3. User remote control forward push button
'1' if the user needs the robot to go forward and '0' if the user does not need the robot to go forward
4. User remote control backward push button
'1' if the user needs the robot to go backwards and '0' if the user does not need the robot to go backwards
5. User remote control brake push button
'1' if the user needs the robot to stop and '0' if the user does not need the robot to stop

Outputs:

1. Forward motor
'1' robot goes forward and '0' robot does not go forward
2. Backward motor
'1' robot goes backwards and '0' robot does not go backwards

Notes:

1. When the user presses an input push button, the input value is '1'. When the user let go of the push button, the input value is '0'.
2. To stop the robot, make both outputs to '0'.

Given below is the operation of the control system.

- The control system should memorise the user input even if the user let go of the push button.
- The main control system will move or stop the robot according to the memorised user input.
- If there are obstacles in the moving direction of the robot, the robot will stop till the obstacles move away.
- After the obstacles move away, the controller commands to move the robot according to the memorised user input.
- If the memorised user input is to brake or stop the robot, the controller will stop the robot regardless of the presence of obstacles.
- The user can decide to change the moving direction or to stop the robot at any time.

Assumption

The user will push only one button at a given time.

- (i) Construct the state diagram.

- (ii) Comment whether the state reduction is possible or not.
- (iii) Assign values to states using binary numbers (State assignment).
- (iv) Construct the state table using D-type flip-flops.

[9.0 Marks]

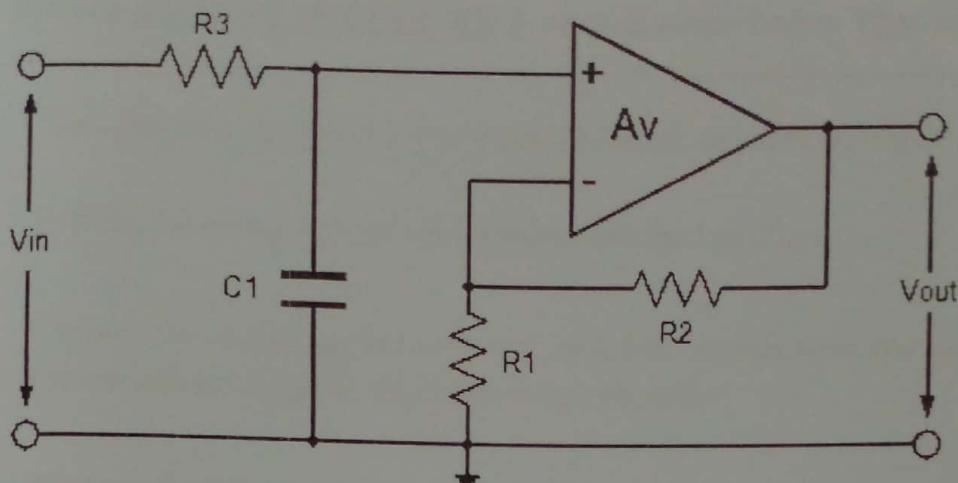


Figure Q2(c) - Circuit diagram of non-inverting active low-pass filter

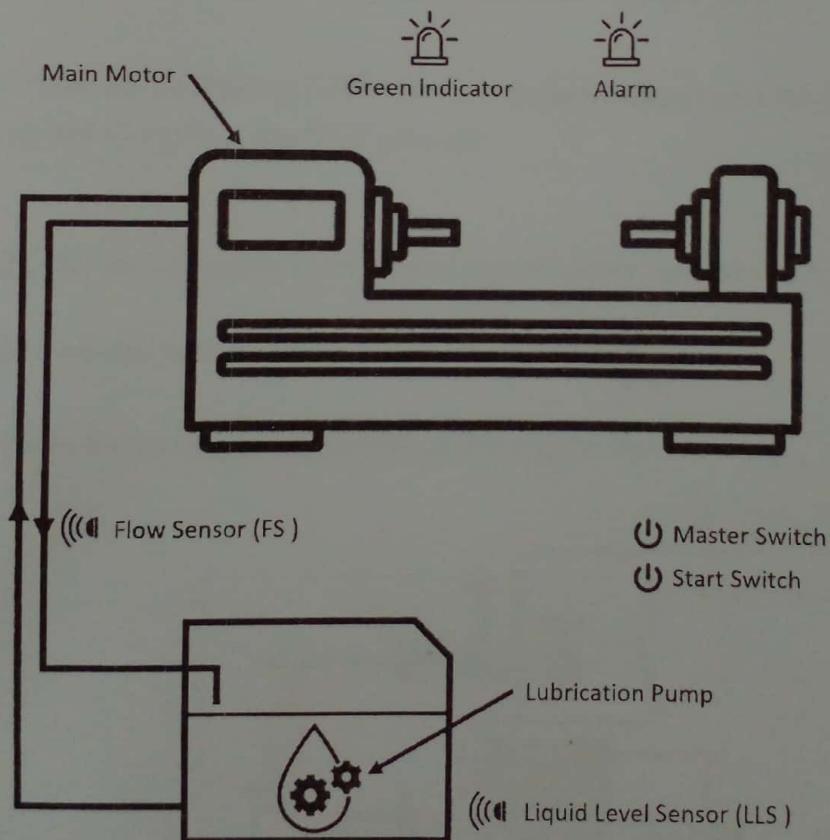


Figure Q3(c) - Main components of the CNC lathe machine

End of the paper.



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: September 2023

Module Number: MN4304

Module Name: Marine Engineering Knowledge

[Three Hours]

[Answer all questions, Maximum marks: 100, Pass mark: 50]

Instructions to Candidates:

1. Answer any FIVE questions.
2. This question paper has SIX questions on four pages.
3. Maximum marks allocated for each section of questions are shown.
4. Drawings and sketches should be clear, neat and in approximate proportion.
5. Use marine colour code for sketches and plans. Red colour is allowed only for sketches.
6. Start your answers to each question on a fresh page.
7. All questions carry equal marks.
8. Clear labelled sketches will be given credits.

Data and Information: Nil

Q1 a) State the factors that may affect the efficiency of air compressors. Explain their influences over the efficiency. [06 marks]

b) Explain the necessity of compressed air used onboard ship. [04 marks]

c) State with reasons the necessity of maintaining bumping clearance of an air compressor. [04 marks]

d) If an air compressor fails to unload on starting, one or all of the following could occur.

State the correct occurrence and give adequate reasons to support your answer.

- (i). Compressor would dangerously over speed
- (ii). Air receiver pressure would be excessively low
- (iii). Circuit breaker would open on starting
- (iv). Compressor would pump lube oil

[06 marks]

Q2 a) Sketch and describe the operation of an electrohydraulic type four ram steering gear system. [08 marks]

b) Distinguish clearly the operation between follow up and non-follow up steering gear systems. [02 marks]

c) State four main assumptions made in designing an electric steering gear system. [04 marks]

d) Sketch and describe a marine tele-motor transmitter, receiver and associated piping [06 marks]

Q3 a) With reference to transmission line of a ship explain,

(i). the Shafting line is angled and the lubricating oil tank is left open to the shaft even at stay. [04 marks]

(ii). Plummer blocks are of different designs according to their location. [02 marks]

- b) Sketch an oil lubricated stern tube and explain its operation. [08 marks]
- c) What general effects might be continued running at service speed followed by resonance in heavy weather have on marine machinery? [02 marks]
- d) State the abnormal stresses which may be imposed on:
- (i) intermediate shafting
 - (ii) tail shafting,
 - (iii) shafting coupling bolts,
 - (iv) thrust shaft
- [04 marks]

- Q4 a) State the methods of spreading and combating a fire respectively. [04 marks]
- b) Sketch and describe a Soda -Acid type portable fire extinguisher giving suitable chemical reactions caused during operation, indicating operating time, area of coverage and recharging after use. [08 marks]
- c) State the general information indicated on a portable fire extinguisher. [04 marks]
- d) Discuss about the preventive measures to be taken on Class C and Class D fires. [04 marks]

- Q5 a) What general effects might be continued running at service speed followed by resonance in heavy weather have on marine machinery? [02 marks]
- b) (i) Define the phenomenon 'cavitation' followed by reasons to cause it. [03 marks]
- (ii) Distinguish the types of cavitation and locations that they may cause on a Propeller. [03 marks]
- c) With reference to marine piping systems state the application of gland packings. [04 marks]

- b) Discuss the operation of a diesel/heavy fuel oil supply system for two stroke marine diesel engines operating at slow speed, by giving a suitable sketch. [08 marks]

Q6 a) With reference to deck machinery system installed on a ship explain the operation and construction of a Capstan used for mooring. [05 marks]

- b) Draw timing diagrams to indicate both the 2 stroke and 4 stroke cycle to include all aspects of marine diesel engine operation. [05 marks]

- c) Explain the procedure employed to check deflection of a crank shaft. [05 marks]

- d) State causes for crank shaft deflection [05 marks]



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: September 2023

Module Number: MN 4307

Module Name: Steam Plants and Gas Turbines

[Three Hours]

[Answer Five Questions selecting at least one question from each section.
Each question carries equal marks. Clear labelled sketches will be given credits.]

SECTION – A – STEAM BOILERS

Q1 a) Sketch and describe the operation and construction of an External Superheater 'D' Type I (ESD I) type water tube boiler.

[07 Marks]

b) As an officer on watch, when the low water level alarm in the boiler frequently activates, assuming the gauge glass is clear and in good working order, what should be the course of action?

[07 Marks]

c) Why is it important to conduct regular water testing in auxiliary boilers? For each test normally carried out, state;

- i. the reasons for maintaining proper water quality in these systems.
- ii. acceptable values for any particular type of auxiliary boiler,
- iii. action required when measured values differ appreciably from desired values.

[06 marks]

Q2 a) With reference to Water tube boilers:

- i. Explain the necessity in controlling the superheat temperature of steam and methods employed for its control.
- ii. State the reasons to install de-super heater and attemperator on a boiler.
- iii. Explain with reasons for using extremely low ppm water with water tube boilers.

[06 marks]

b) Sketch and describe closed feed water system and indicate the direction of flow in all

- c) Sketch and describe a De-aerator installed in a Closed Feed Water System [04 marks]
- d) Sketch and describe a Tubular type water level gauge glass fitted to a boiler. [04 marks]

SECTION - B - STEAM TURBINES

Q3 a) With reference to impulse turbines draw velocity, pressure and enthalpy characteristics of steam for compounding for velocity and compounding for pressure stages. [08 marks]

b) Discuss with diagrams the passage of steam through a reaction turbine, explain clearly what happens to the steam as it passes through a stage in the turbine. [07 Marks]

c) Explain saturated and superheated Rankine cycles. [05 Marks]

Q4 a) State the type of losses caused with steam turbines. [05 Marks]

b) A turbine protection system is provided with all installations to prevent damage resulting from an internal turbine fault or the malfunction of some associated equipment.

i. State the arrangements made to shut the turbine down in an emergency. [03Marks]

ii. Identify the main fault conditions leading to operate this arrangement. [03Marks]

c) Explain the difference between condensing and non-condensing type of turbines Systems, giving suitable circuit diagrams. [03 Marks]

d) Explain the necessity in using extraction and reheating stages in steam turbine configurations operating at multiple pressures. [05 Marks]

SECTION - C - GAS TURBINES

- Q5 a) State three different methods of compressor blade attachment. [3 Marks]
- b) State the two methods of minimizing the gap between the compressor blades and housing. Provide a brief explanation of each. [5 Marks]
- c) Provide a detailed explanation of the different methods of blade cooling in the turbine section of a gas turbine. [6 Marks]
- d) Explain your understanding of the term "work done factor" of the compressor section of a gas turbine clearly highlighting the need to incorporate such a factor when calculating the work done by the compressor. [6 Marks]
- Q6 (a) Name the three different zones of a gas turbine combustion system. Provide a detailed explanation of each zone clearly emphasizing their respective functions. [6 Marks]
- (b) "The diffuser of the combustor is essential for the efficient performance of a Gas Turbine". Do you agree with this statement? Provide a detailed justification for your answer. [6 Marks]
- (c) Provide a comparison between an "annular combustor" and a "tubo-annular combustor" clearly highlighting their differences. [6 Marks]
- (d) Formation of NOx is a major concern related to the combustion process in a gas turbine. Provide a brief explanation on the formation of NOx in a gas turbine. State two methods of reducing emission of NOx from a gas turbine. [2 Marks]

[Answer all questions, each question carries 12 marks]

This paper contains 5 questions on 7 pages.

Clearly state any assumptions that you may make.

In order to get full marks, make sure to use standard notations and SI units, where appropriate. Take $g = 9.81 \text{ m/s}^2$.

- Q1. (a) Briefly describe the following terms relating to spur gear using an appropriate diagram.

- Addendum
- Dedendum
- Clearance
- Pressure angle

[2.0 Marks]

- (b) The compound gear train given in Figure Q1(b) is used to lift an 80 kg load at a constant velocity of 0.5 m/s using a motor attached to the input gear A. The diameter of the output pulley is 10 cm. Assume that there are no losses between the gears and pulleys. Answer the following,

- Find the torque required at the motor to support the weight.
- Determine the rotating direction of the motor to lift the load.
- Calculate the required rotational speed of the motor to lift the load at the given linear speed.

[7.0 Marks]

- (c) Describe three (3) possible power transmission options for an epicyclic gear unit.

[3.0 Marks]

- (a) Assume you were tasked with designing a cam and follower mechanism for a punching machine to achieve a specific punching tool movement. The desired movement of the punching tool (follower) is as follows,

- Lift of the tool is 50 mm during the first 60° of cam rotation

(Question Q2 is continued on page 2)

- Dwell for the next 90°
- During the next 60° of cam rotation, the tool returns to its original position.
- Dwell during the remaining 150° .

Take the radius of the base circle of the cam as 25 mm.

Design the profile of the cam to maintain a constant velocity for the follower during rising and falling.

[7.0 Marks]

- (b) The Torque - Crank Angle diagram for a crank piston engine is given in **Figure Q2(b)**. The work done during each step is indicated in the diagram, and the crankshaft needs to maintain a speed within the range of 420 - 450 rev / min.
- Determine the moment of inertia of a suitable flywheel for the given application in order to maintain the required speed range.
 - Find the mass of the flywheel with a radius of 0.25 m.

[5.0 Marks]

- Q3.** (a) Consider a disc spinning about the X - axis with an angular speed, ω_x as shown in **Figure Q3(a)**. If a torque is applied in Z - direction, show that the disc will rotate about Y - axis and the applied torque (T) should be equal to $I\omega_x\omega_y$ to precess the disc (rotation about the Y - axis) with an angular speed, ω_y .

[3.0 Marks]

- (b) **Figure Q3(b)** shows a ship turning right on a radius 250 m with a velocity of 2.5 m/s. The turbine engine of the ship is mounted in the lengthways of the ship as shown. The effective mass of the engine is 1000 kg with the radius of gyration of 0.5 m. If the engine rotates clockwise at 7200 rpm when viewed from the back,
- Calculate the magnitude of the gyroscopic couple produced when the ship turns.
 - Using suitable sketches, explain clearly the effect of the couple on the ship's motion.

- (c) A nosewheel assembly for a small aircraft designed based on the four-bar mechanism is shown in **Figure Q3(c)**.
- Sketch the kinematic skeleton diagram showing all the links. Label the crank, rocker, and coupler.
 - Determine the mobility of this mechanism through Gruebler's Equation. State the Grashof's Theorem and check whether the above mechanism satisfies it or not. Briefly describe the result.

[5.0 Marks]

- Q4** This question is related to the position, velocity, and acceleration analysis of a mechanism.
- (a) A toggle clamp is used for securing a workpiece during a machining operation. **Figure Q4(a)** shows such a toggle clamp with main dimensions given in mm. Determine the angle at which the handle must be displaced in order to lift the clamp arm by 30° .
 (Hint: You may draw the original and displaced configuration of the toggle clamp)

- (b) A single-cylinder reciprocating engine shown in **Figure Q4(b)** has a crank AB of 40 mm and a connecting rod BC of 100 mm. The crank rotates at 3000 rev/min clockwise. The mass of the piston of the engine is 0.48 kg and the diameter is 80 mm. It is also given that the gas pressure acting on the piston is 1.25 MPa at the moment shown.
- Draw the velocity and acceleration diagram for the configuration shown.
 - Determine the velocity and acceleration of the piston.
 - Calculate the effective turning moment acting on the crank.
 - State all the assumptions.

[4.0 Marks]

- Q5** (a) Briefly explain by giving four reasons why the balancing of reciprocating engines is important.

[2.0 Marks]

- (b) **Figure Q5(b)** shows a long rotor with distributed mass that is mounted in bearings at A and B. Suppose that two equal masses m_1 and m_2 are placed at opposite ends of the rotor and at equal distances r_1 and r_2 from the axis of rotation. Show that why the rotor is statically balanced but dynamically unbalanced when $m_1 = m_2$ and $r_1 = r_2$.

[1.5 Marks]

- (c) The shaft illustrated in **Figure Q5(c)** is to be balanced by placing masses in the correction planes L and R. The weights of the three masses m_1 , m_2 , and m_3 are 1.125 N, 0.85 N, and 1.4 N, respectively. The dimensions are $R_1 = 125$ mm, $R_2 = 100$ mm, $R_3 = 125$ mm, $a = 25$ mm, $b = e = 200$ mm, $c = 250$ mm, and $d = 225$ mm. Calculate the magnitudes of the corrections in Nmm and their angular orientations.

[4.0 Marks]

- (d) **Figure Q5(d)** shows a compressor configuration that consists of three inline pistons of mass 0.4 kg with a crank radius of 50 mm and connecting rod length to crank radius ratio (n) of 3. The cranks are equally spaced in angle and position as shown. When the crank rotates at 20 rad/s, determine,

- the primary and secondary forces.
- the primary and secondary turning moment about the reference plane XX.
- the masses and angles of the cranks for primary balancing if the system is to be balanced by placing mass in planes XX and YY with the same crank radius and ratio n .

[4.5 Marks]

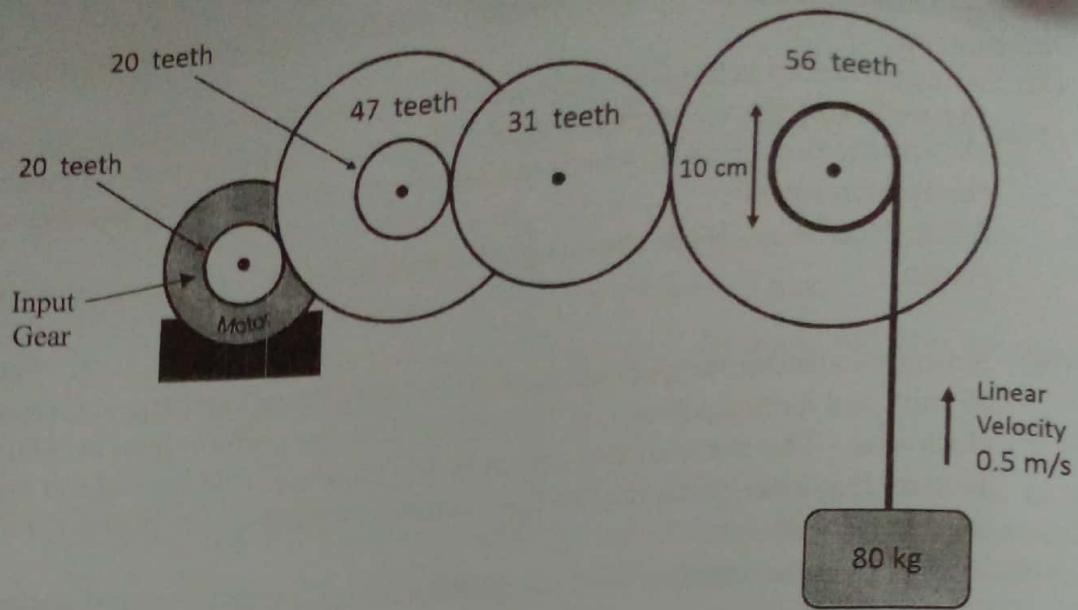


Figure Q1(b): The layout of the compound gear train

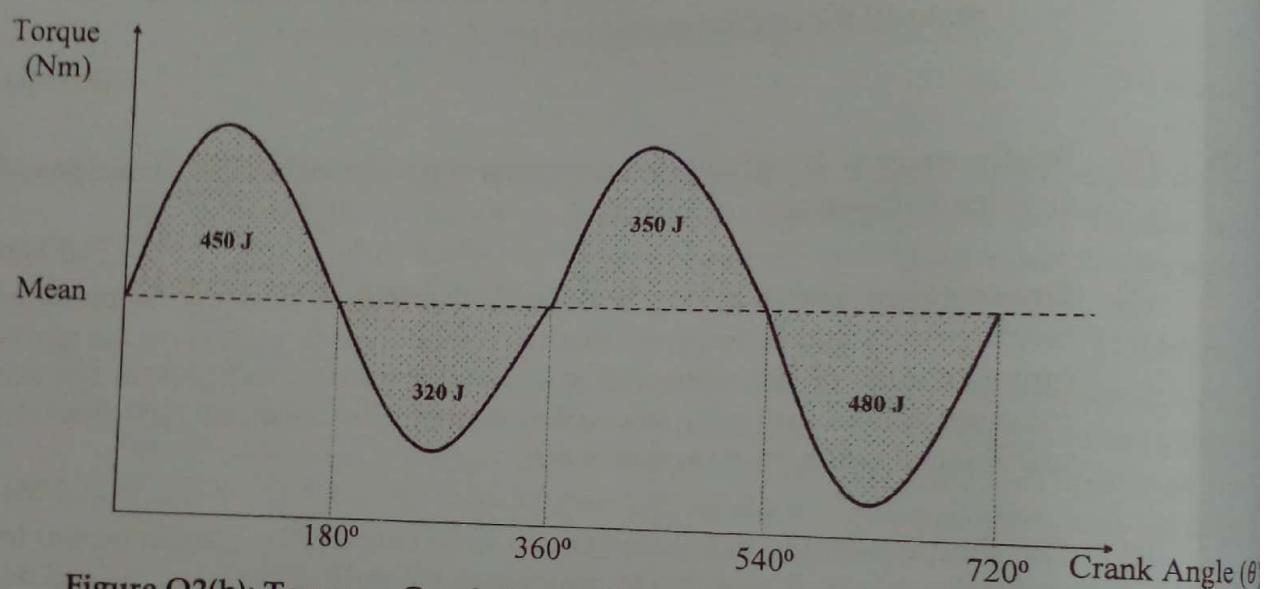


Figure Q2(b): Torque - Crank Angle diagram for a crank piston engine

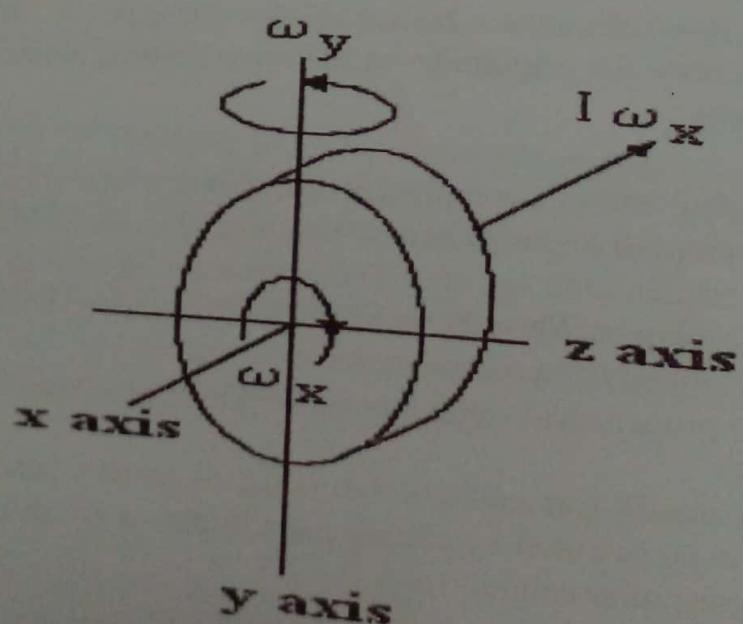


Figure Q3(a) - Spinning disc

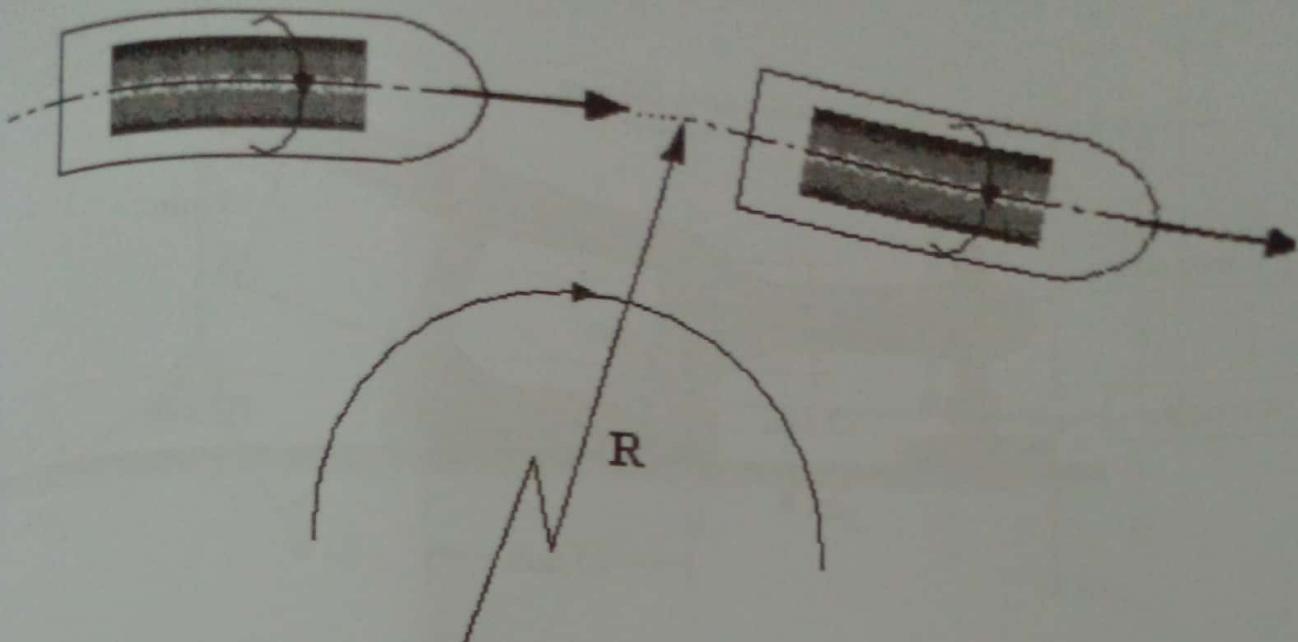


Figure Q3(b): Ship motion

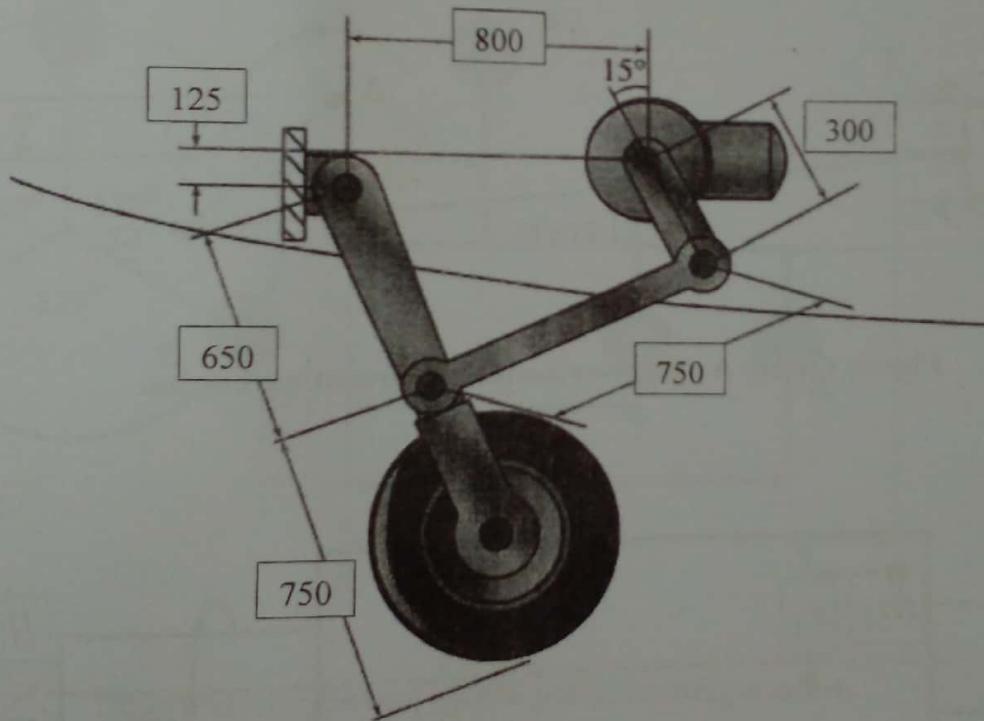


Figure Q3(c): Nosewheel assembly design for a small aircraft (all dimensions are in mm)

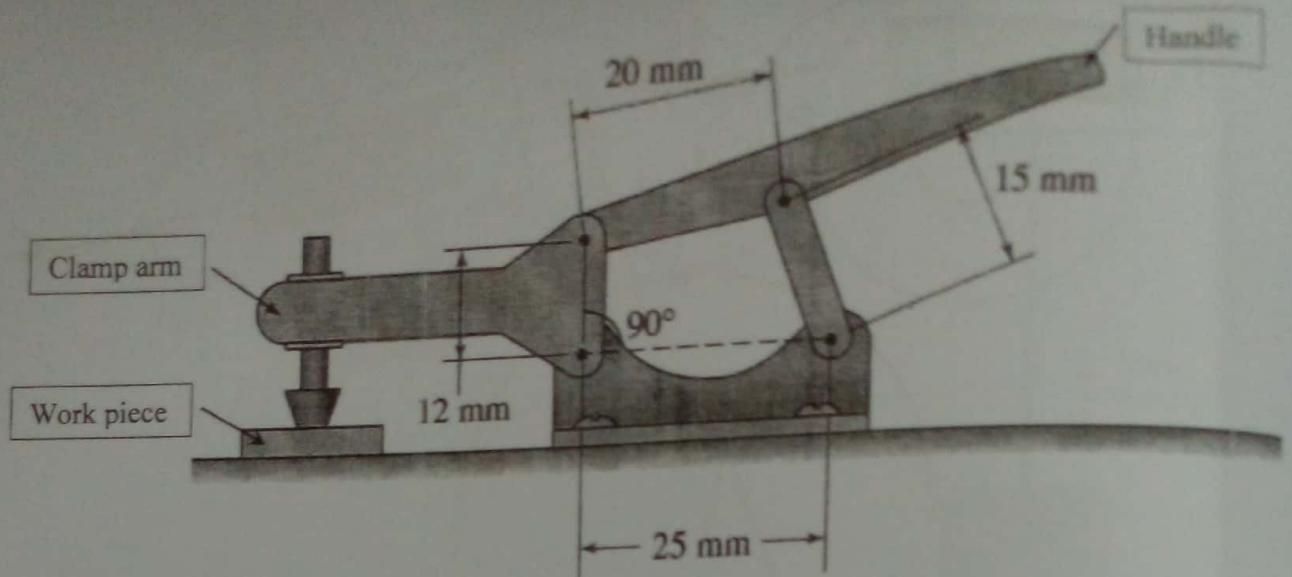


Figure Q4(a): A toggle clamp device

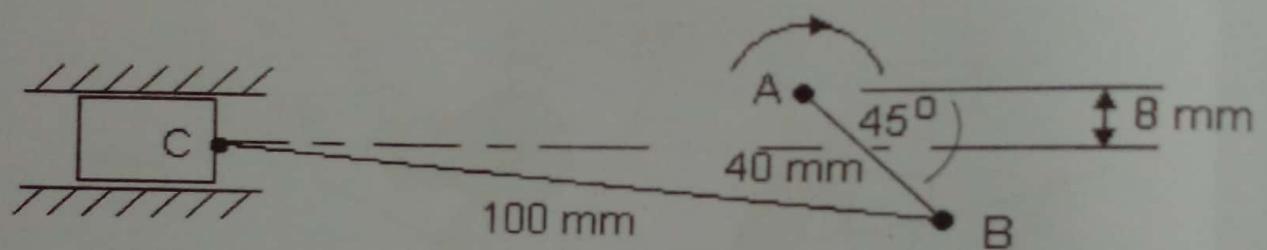


Figure Q4(b): A single-cylinder reciprocating engine

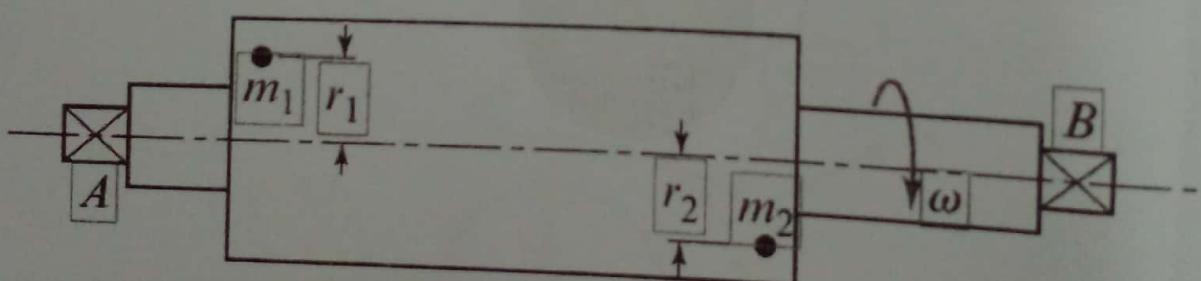


Figure Q5(b): Shaft with two masses

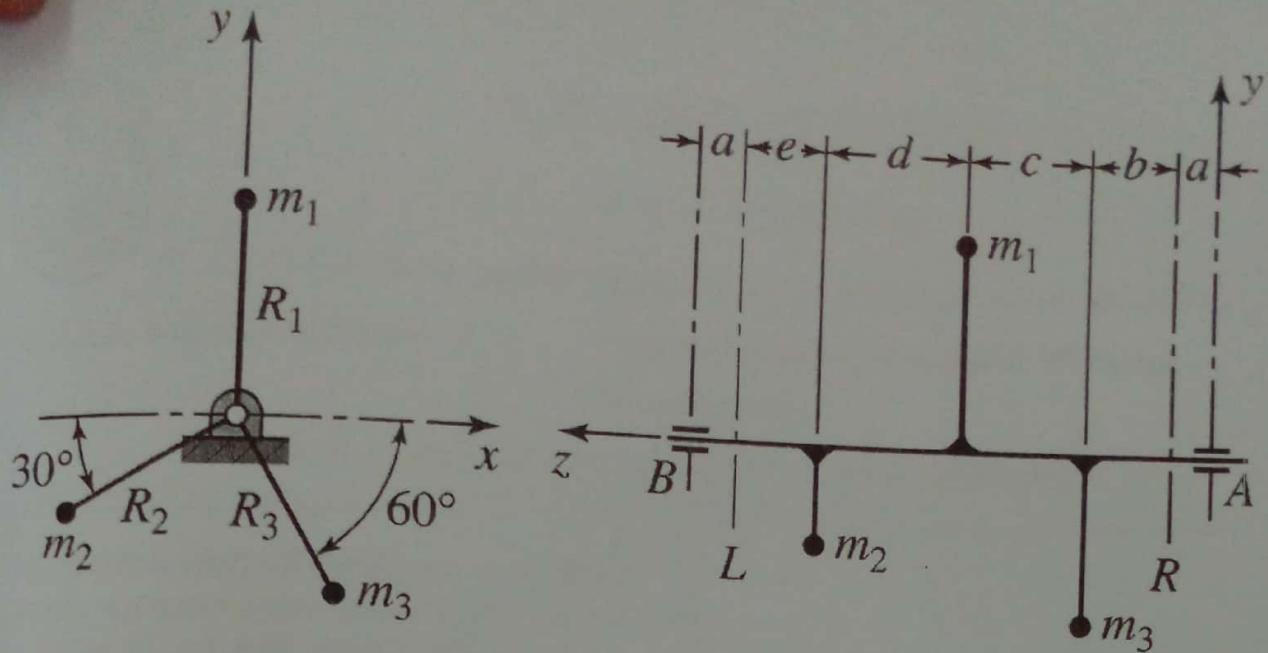


Figure Q5(c): Shaft with three masses

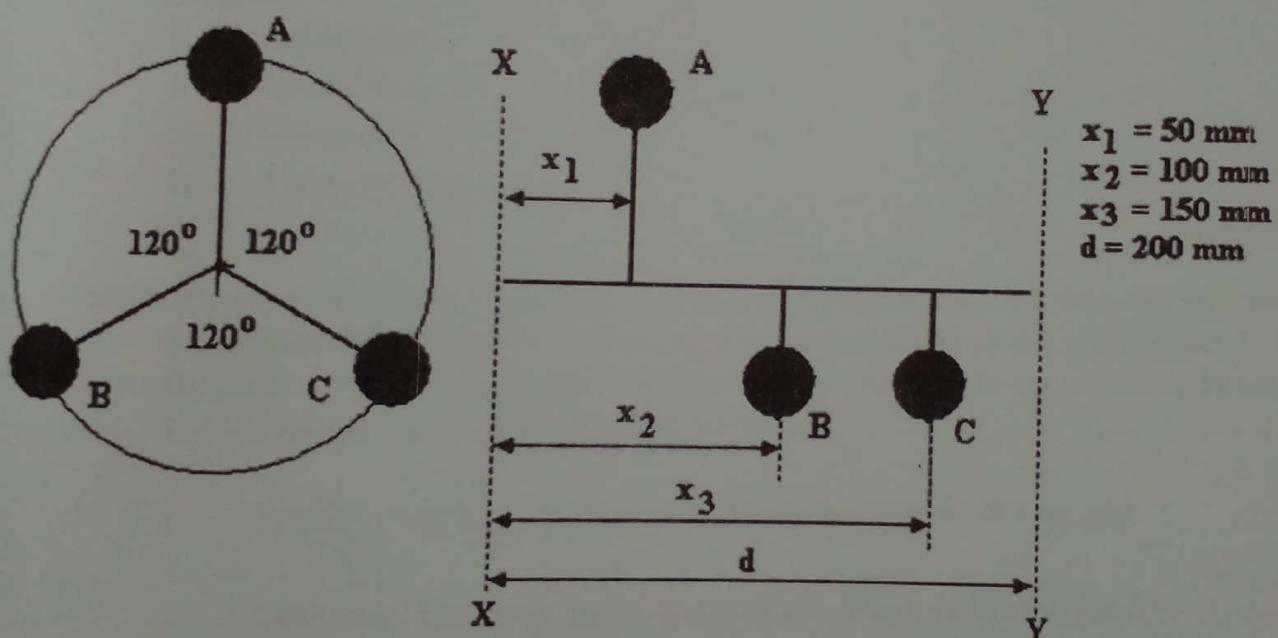
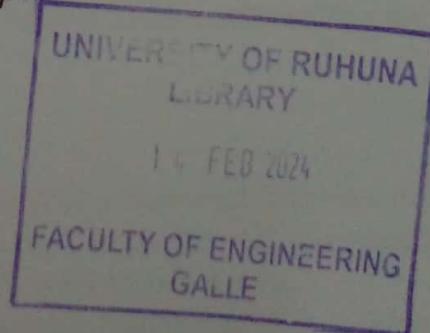


Figure Q5(d): Compression piston configuration

End of the paper





Faculty of Engineering

End-Semester 4 Examination in Engineering: September 2023

Module Number: MN4306

Module Name: Ship Design and Construction
Technology - I

[Three Hours]

[Answer FIVE questions, Maximum marks: 100, Pass mark: 50].

Instructions to Candidates:

1. Answer any FIVE questions.
2. This question paper has SIX questions on four pages.
3. Maximum marks allocated for each section of questions are shown.
4. Drawings and sketches should be clear, neat and in approximate proportion.
5. Use marine colour code for sketches and plans. Red colour is allowed only for sketches.
6. Start your answers to each question on a fresh page.
7. All questions carry equal marks.
8. Clear labelled sketches will be given credits.

Data and Information: Nil

- Q1 a) Describe the circumstances which cause panting and pounding stresses. [04 marks]
- b) With the aid of a sketch, describe a typical arrangement to resist panting at the fore-end of a vessel. [08 marks]
- c) Describe the arrangements to resist pounding. [04 marks]
- d) With the aid of sketches, explain what is meant by the terms "hogging" and "sagging". [04 marks]
- Q2 a) With reference to aft peak tank describe the members which are normally found in aft peak Tank construction. [06 marks]
- b) State type of welding and distinguish the difference between MIG and TIG welding. [04 marks]
- c) With suitable circuit diagrams explain the operation of a hydraulically operated watertight door. [06 marks]
- d) Why water tight bulk heads are required in a ship construction? [04 marks]
- Q3 a) Explain wet type underwater welding system used in ship repairing process with an appropriate circuit diagram. State with reasons the type of polarity of current being used for electrode holder. [08 marks]
- b) Sketch a watertight door and frame showing the manner of attachment to the bulkhead and the additional reinforcement carried by the bulkhead to compensate for the aperture. [06 marks]
- c) Explain the operation of a hydraulic controlled watertight door giving suitable circuit diagrams for remote operation of it. [06 marks]

Q4 a) Sketch and describe the different floors used in the construction of a double bottom showing brackets, stiffeners, scallops, cutouts, floors, lightening holes, struts, bracket floors, solid floors, etc indicating where each type is employed.

[07 marks]

b) Illustrate the difference between watertight and non-watertight cutouts with sketches.

[07 marks]

c) State and draw type of weld symbols illustrating butt, fillet and corner joints used in ship construction process.

[06 marks]

Q5 a) State the type of bulkheads used during construction and respective locations in a vessel.

[04 marks]

b) Explain the stresses that a ship is subject to at the forward end of a large cargo vessel and show with the aid of a sketch the structural members that form the construction of the vessel to withstand these stresses.

[08 marks]

c) State and draw type of weld symbols illustrating butt, fillet and corner joints used in ship construction process.

[04 marks]

d) Defects may occur during welding which affect the quality and hardness of plates. State type of destructive testing carried out in ship building.

[04 marks]

Q6 Location markings are numbers and letters on bulkheads, doors, hatches and Various fittings to indicate their position in the ship.

a) A ship consists of two decks on super structure and Six decks on hull. Hull is sectioned by Four main transverse bulkheads.

Mark followings on above sketch;

(i) Decks and sections

(ii) Longitudinal sub divisions 2AA, 2AZ, 2DA, 2DB, 2DC, 2DY, 2DZ, 3CA, 3CB, 3CZ

- (iii) the compartment 5C more than one deck high Doors 2C/D, 4CZ, 5CA,
- (iv) the compartment 1B extending beyond a main section aft.

[10 marks]

- b) With reference to Deck Plan on second deck mark followings

- (i) transverse subdivisions 2A, 2B1, 2B2, 2C0, 2C1, 2C2, 2C3, 2C4,
- (ii) contained compartments in 2B1, 2B2 and 2D0
- (iii) Doors 2A/B port and 2A/B/ Stbd
- (iv) hatches 2D port, 2D stbd, 2C2, 2B2, 2B1and 2AA

[10 marks]



Instructions to Candidates:

- This paper contains 8 questions in 9 pages.
- Answer to the question Q1 to Q7 on the question paper.
- Use separate answer sheets for Q8 and attach those answer sheets to the question paper.
- Write down your index number on the top of the question paper.

Q1 Fill in the blanks with suitable articles where necessary. If any blank does not need an article, put "X".

- i. My brother is Second Mate on cargo ship and he is at most of time.
- ii. steam was used to provide power for a kind of mechanical toy in ancient times by Greek inventor named Hero of Alexandria.
- iii. moon lit everything and sea was beautiful, so we stayed up enjoying rare summer night.
- iv. After strenuous interrogation seaman confessed his crime and was sent to prison. The captain went to prison to see him but wasn't allowed visitors.
- v. The passengers met at dinning saloon and they had lunch together.
- vi. When on holiday I like to go swimming by day and dancing at night.

[0.5 x 20 =10 Marks]

Q2

Fill in the blanks in the following SMCP using prepositions given in the box. You may use some of them more than once.

With

after

at

up

within

- i. I'm sinking collision.
- ii. I'm drifting 4 knots.
- iii. I have problems cargo.
- iv. I can only proceed slow speed
- v. I'm danger of capsizing.
- vi. Proceed your voyage.
- vii. Person picked is a crew member.
- viii. Assist search in the vicinity of position
- ix. ETA at distress position 4 hours.
- x. There is a risk of grounding low water.

[0.5 x 10 = 5 marks]

Q3

Fill in the blanks with the correct form of the verb or adjective.

- i. If the ship had reduced the speed, the waves (not hit) the hull so violently
- ii. The minister had hardly finished his speech when the earthquake (shake) the building.
- iii. Everybody will be at the office at about 08:30 tomorrow as the meeting (start) at nine o'clock.
- iv. I wasn't surprised to hear that Monoj (have) an accident because he is such a reckless driver.
- v. Urbanization (always / be) a problem causing several environmental issues ever since the rate of

- migration.....
revolution..... (increase) after the industrial
- vi. If I (be) you, I would accept the job
- vii. More parcels people bought goods in e-shops. (deliver) last year because
- viii. By the time the troops have ended. (arrive), the war will
- ix. Less money days by most of the people in our country. (spend) on clothes these
- x. By the year 2050, linguists the Indo-European language family for more than 200 years. (study)
- xi. Increasing fuel prices problem for people for the last two years, therefore, during this time many people have preferred to sell their cars and buy smaller ones. (become) a major
- xii. He (die) of Corona, if the helicopter hadn't rescued him from the sea.
- xiii. I don't feel well. I think I (throw) up.
- xiv. She won't finish it on time, if she (start) right now.
- xv. I (meet) my girl -friend this evening
- xvi. Unless you exercise regularly, you (not be) able to lose some weight.
- xvii. If Amal (be) here, he would kill you
- xviii. Your email (answer) tomorrow.
- xix. Avatar is probably the (bad) film I have ever seen.
- xx. Who is the (powerful) person in your country?

[0.5 x20= 10 Marks]

Forecast	foggy	clear	sunshine	rainfall
frost	chilly	Blizzard	stormy	mild

- i. There was a very bad last night. The wind blew so heavily that our old oak tree fell down
- ii. It was so that the airport was shut down because visibility was too low.
- iii. It can get a bit in the evening, so you should take a jacket with you.
- iv. When I woke up this morning, I saw that the ground was covered with
- v. According to the weather, a warm front with occasional showers will reach us by evening.
- vi. The skies were and there was no wind. It was absolutely perfect for a hike.
- vii. Some alpine regions do not get much because they are situated between mountains.
- viii. We had a rather winter this year. Even January was warmer than normal.
- ix. After the last few rainy days, it was great to get some for a change
- x. A swept through the north-eastern part of the country with extremely low temperatures and huge amounts of snow.

[0.5x10= 5 Marks]

Read the text and answer the given questions. Note that any unnecessary information for the answer will reduce marks.

INDUSTRIAL SHIPS

Industrial ships are designed to carry out industrial processes at sea, like (a) drawing out raw materials and food resources from waters. The activities that take place aboard these ships include (b) extracting oil and mineral salts, or (c) catching and processing fish and crustaceans like crabs, shrimps and lobsters. Thus, if we consider the function the ships perform, we can clearly distinguish between the extractive and (d) processing ships. The first type includes trawlers and seiners. A trawler is the most popular vessel among (e) fishing ships. Its name comes from the name of the activity, 'trawling', which means (f) catching fish by (g) dragging a fishing net along the sea bed. The trawl can be launched either over the ship side or over the stern.

Spain and Norway have been (h) taking the lead with respect to the number, size and the variety of trawlers built. (i) Non-trawling vessels can range from simple crafts which deploy a net, to (j) fishing vessels that first lay out nets, even for a distance of a few kilometers, and then wait for the shoal of fish to swim into it. The typical representatives are seiners, tuna clippers and crab boats. A seiner makes use of a special kind of net called a seine net in the following way: the net hangs vertically in water. Its top edge floats and its bottom is weighted and equipped with a rope. When a shoal of fish swims into the net, the rope tightens and closes around it.

Processing ships receive fish or other sea goods from extractive ships, process them into products, and bring them to ports. They must be fitted with special machines for processing, (k) canning and (l) storing.

Categorize the underlined words (present participles) under the following headings according to the function they do in the passage. Write the correct letter in the relevant column.

Answer the questions given below.

i. Name the two types of Industrial ships and the function of each one.

.....

ii. Name the types of non-trawling vessels mentioned in this passage.

.....

iii. What is the main difference of catching fish by trawlers and non-trawling vessels?

.....

iv. Describe the mechanism of a seiner.

.....

Finds words from the passage with similar meanings to the following phrases

i. Remove or takes out by force-

.....

ii. Perform a series of activities to preserve it-

.....

iii. Animals that live in water and have a hard outer shell and many legs-

.....

iv. Use something effectively-

.....

[0.5 x 8 = 4 Marks]

Read the text on "Cargo space" and fill in blanks with the words given in the box.

Ro-Ro	Lanes	Meters	Car	Length
General	Bulk	Liquids	Ullage	Different

Cargo space on board (a)..... ships is expressed in the length of (b)..... and is measured in (c)..... It can also be expressed as bale capacity and measured in cubic meters or cubic feet. Cargo space on board Con-Ro vessels is expressed both in TEU for the number of containers the vessel can carry and in the number of cars it can take on (d)..... decks so the (e)..... of lanes is also given. Cargo space can be filled with (f)..... types of cargo. It can usually be divided into space for (g)..... cargo which is packed and (h)..... cargo, both liquid and dry, which is loose. Different (i)..... and chemicals can evaporate from their receptacles and tanks and in such cases the unfilled space is called (j).....

[0.5 x10= 5 Marks]

Read the following passage on WEATHER and answer the questions. Note that any unnecessary information for the answer will reduce marks.

WEATHER

A. The weather is the state of the atmosphere with reference to wind, temperature, state of the sea, cloudiness, precipitation, atmospheric pressure, humidity, mist, fog and ice conditions. It is important for seamen to understand all the phenomena connected with the weather and to be able to read weather maps and listen to the weather forecast and report weather conditions at sea such as the visibility and the direction of wind and its force according to the Beaufort Wind Scale. Winds are mainly caused by a difference of temperature which in turn is sometimes responsible for the differences of barometric pressure. The strength and speed of wind at any given time depend on the gradient of atmospheric pressure that is the rate at which pressure changes with distance.

B. Waves are primarily caused by the wind and its action on the surface of the water. Their height depends on how long the wind has been blowing and also

on the strength of the wind. Waves formed by the wind blowing locally are termed "sea". Waves formed by the wind blowing at a distance from the place of observation are termed "swell". Some waves result from earthquakes or underwater seaquakes and on approaching shallow water they become abnormally high and begin to break with great violence causing enormous devastation and loss of life. They are termed "tsunami" and we will all remember the tragic waves caused by a seaquake near Sumatra on Dec. 26th, 2004, which claimed the lives of nearly 300,000 people in South - East Asia. Visibility at sea may be affected by various weather conditions in different parts of the world. In the north it may be affected by rain, sleet, snow, hail and blizzards or snowstorms. In the south it may be affected by torrential rains, drizzle or showers as well as by sand storms. Mist, haze and fog may appear in all areas of the world at different times of the year. The passage of very cold air over much warmer water causes arctic sea smoke, frost smoke or steam fog. It is formed when the lowest layers of the cold air heated by contact with the warm sea tend to rise and are chilled to their dew point on meeting colder air than themselves.

C. Clouds consist of minute drops of water or ice crystals formed by the condensation of water vapour and held in suspension in the atmosphere. There are two main types of clouds: stratiform or layer cloud, resembling fog but not resting on the ground, and cumuliform or white cotton-wool cloud with much greater vertical development than horizontal extent. There are also combinations of these types depending on the height of occurrence and then we speak about cirrus clouds and cirro-cumulus, and cirro-stratus, which are high clouds; alto-cumulus, alto-stratus and nimbo-stratus, which are medium height clouds and strato-cumulus, stratus, cumulus and cumulo-nimbus, which are low clouds.

Clouds usually help in forecasting the weather. Generally speaking, soft round clouds mean fine dry weather with some wind but not very strong. Harsh and jagged clouds mean strong winds. Black clouds mean rain squalls. High clouds moving in a different direction from lower ones foretell a change of the wind.

- i. Write the definition of the term "weather".
- ii. What is the main cause for the winds?
- iii. Mention two factors that are responsible for the height of the seas.
- iv. Differentiate the terms "sea" and "swell".
- v. Explain briefly the formation of sea smoke, frost smoke, or steam fog.

- v. How are clouds formed?
- vii. What is the main difference of Stratiform clouds and cumuliform clouds?
- viii. How do you know there will be a change in wind by observing clouds?

Find the words to match the meanings of the following phrases.

- i. A fact or situation that is observed to exist whose cause is in question..... (paragraph A)
- ii. Great destruction..... (paragraph B)
- iii. With rough sharp points (paragraph C)
- iv. Halt temporary..... (paragraph C)

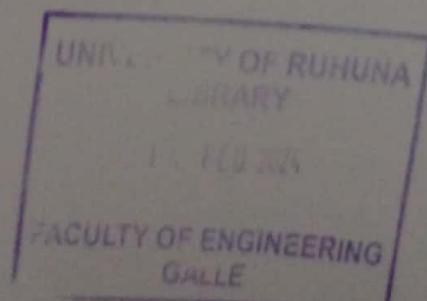
[15 Marks]

Write an essay on one of the topics given below using not more than 250 words.

Your essay will be marked based on organization, content and the structure.

- a) Ocean Pollution and the Fishing Industry
 - causes for ocean pollution
 - how it affects the fishing industry
 - steps that could be taken to minimize it
- b) Deforestation and its consequences
 - causes
 - effects
 - prevention
- c) What are your career plans in the Maritime Industry
 - reasons to choose your career
 - requirements to be fulfilled
 - advantages vs. disadvantages

[10 marks]





UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: September 2023

Module Number: IS4305

Module Name: Probability and Statistics (C 18)

[Three Hours]

[Answer all questions, each question carries twelve marks]

- Q1. a) A particular company wanted to compare and contrast the two different types of glass bottles that it manufactures, for future changes. Therefore, a sample of 20 glass bottles of each type was selected and the internal pressure strength of each bottle was measured, resulting in the following data.

Type 1: 84 88 90 92 94 94 94 96 98 100 100
 100 100 102 104 106 107 107 107 115

Type 2: 97 98 99 98 98 99 99 99 100 100 100
 100 101 101 101 101 102 102 102 108

- i Obtain five number summaries of each sample.
- ii Construct a comparative boxplot (plotting both boxplots against the same scale), and use it to compare and contrast the internal pressure strength of the two types of glass bottles.

[8 Marks]

- b) Consider the following data on the thickness of the floor plate of an aboveground tank that is used to store crude oil.

43, 46, 52, 55, 55, 56, 58, 60, 62, 63, 64, 66, 66, 72, 74, 74, 74, 75, 77, 77, 78, 83, 85, 85, 87, 88, 90, 91, 94

- i Find the sample mean and the sample standard deviation of these data.
- ii Display the data in a Stem-and-Leaf diagram. Do the data appear to be approximately normal?
- iii What percentage of data values are within 2 standard deviations of the mean?

[4 Marks]

- Q2. a) A particular company manufactures transistors and on a given day, the production consists of 10 defective transistors (that immediately fail when put in use), 15 partially defective (that fail after a couple of hours of use), and 75 acceptable transistors. A transistor is chosen at random and put into use. If it does not immediately fail, what is the probability that it is acceptable?

[3 Marks]

b) Define appropriate random variables and list all the values for each of the following experiments.

- i For safety purposes, a factory manager is interested in how many factory floor accidents occur in a given year.
ii A company manufactures metal cylinders that are used in the construction of a particular type of engine. The metal cylinders it manufactures can have a diameter anywhere between 49.5 and 50.5 mm. Suppose that the company manager is interested in finding the probability that a metal cylinder has a diameter between 49.8 and 50.1 mm.

[2 Marks]

- c) A certain gas station has six pumps. If a random variable X denotes the number of pumps that are in use at a particular time of day. If Table Q2.c) gives the probability distribution of X , find the following probabilities.

Table Q2.c)

X	0	1	2	3	4	5	6
$P(x)$	0.05	0.10	0.15	0.25	0.20	0.15	0.10

i $\Pr(X \leq 2)$

ii $\Pr(X \geq 3)$

[2 Marks]

- d) Consider a random variable X has a discrete uniform distribution with the probability mass function $P(x)$, where

$$P(x) = \begin{cases} \frac{1}{n} & ; x = 1, 2, 3, \dots, n \\ 0 & ; \text{otherwise} \end{cases}$$

Compute $E(X)$ and $V(X)$.

(Hint: The sum of the first n positive integers is $\frac{n(n+1)}{2}$, whereas the sum of their squares is $\frac{n(n+1)(2n+1)}{6}$).

[5 Marks]

- Q3. a) A random sample of a particular type of concrete cylinders were selected and measured their strength, resulting in the following data.

7.4, 5.8, 6.5, 8.4, 9.3, 10.0, 5.9, 7.3, 6.3, 8.1, 7.0, 7.6, 6.5, 9.0, 8.2, 8.7, 7.8, 9.7, 11.6, 11.3

- i Calculate a point estimate of the mean value of strength for the conceptual population of all concrete cylinders manufactured in this particular type.
ii Calculate a point estimate of the strength value that separates the weakest 50% of all such concrete cylinders from the strongest 50%, and state which estimator you used.
iii Calculate a point estimate of the population standard deviation σ . Which estimator did you use?

- b) A random sample of size 17 was obtained on the breakdown voltage of electrically stressed circuits and found that its variance was 137324.3. Find the 95% confidence interval for σ . [3 Marks]
- c) Random samples were taken on the tensile strength of liner specimens both when a certain fusion process was used and when the process was not used and the relevant data are summarized in Table Q3.b). [3 Marks]

Table Q3.b)

	n	\bar{x}	s
No fusion	40	290.2	277.3
Fused	35	310.8	205.9

Does the data suggest that the fusion process increased the true average tensile strength by more than 10 units?

[5 Marks]

4. a) A computer manufacturer used four different designs for manufacturing a particular electrical circuit board. And he identified that there are three possible failure modes for the circuit board. He obtained the data on the number of failures in each mode in each design and the data is summarized in Table Q4.a).

Table Q4.a)
Failure Mode

Design		1	2	3
	1	16	40	11
2	8	17	7	
3	10	31	13	
4	9	12	6	

Does the design type appear to have an effect on failure mode?

- b) An experiment was carried out to investigate the water quality in tap water in a particular city. Four tap water samples were obtained from four different locations of the city and their heavy metal content (ppm) was measured. The relevant data are displayed in Table Q4.b).

Table Q4.b)

Heavy Metal Content (ppm)			
Location 1	Location 2	Location 3	Location 4
5	8	6	7
7	7	8	8
8	6	7	8
9	7	9	6

Test for the equality of mean metal content at $\alpha = 0.05$.

(Hint: In the usual notations, $N = \sum_{i=1}^l n_i$; $SSTr = \frac{\sum_{i=1}^s y_{i*}^2}{n_i} - \frac{\bar{y}_{**}^2}{N}$;

$$SST = \sum_{i=1}^s \sum_{j=1}^{n_i} y_{ij}^2 - \frac{\bar{y}_{**}^2}{N} ; SST = SSTR + SSE$$

[6 Marks]

Q5. Table Q5.a) gives the monthly data of a chemical plant in the year 2022 on electric power consumption (y), average ambient temperature (x_1), the number of days in the week (x_2), the average product purity (x_3), and the tons of product produce (x_4).

a) Calculate Karl Pearson Correlation coefficient (r) between the electric power consumption and the average ambient temperature and explain the relationship. [2 Marks]

b) Based on the part a), determine the equation of the estimated regression line. [2 Marks]

c) Based on part b), calculate R^2 and comment. [2 Marks]

d) If Table Q5.b) gives the partial correlations between y and x_i 's, explain each of the relationships. [2 Marks]

e) Use the given information in Table Q5.c) to state the multiple linear regression model using all independent variables. [2 Marks]

f) Predict power consumption for a month in which $x_1 = 75^0F$, $x_2 = 24$ days, $x_3 = 90\%$, and $x_4 = 98$ tons.

$$\text{[Hint: } \hat{\beta}_1 = \frac{n \sum_{i=1}^n x_i y_i - (\sum_{i=1}^n x_i)(\sum_{i=1}^n y_i)}{n \sum_{i=1}^n x_i^2 - (\sum_{i=1}^n x_i)^2}, \quad \hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x}, \text{]}$$

$$r = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{(n-1) \sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (y_i - \bar{y})^2}$$

[2 Marks]

Table Q5.a)

Y	$X_1 ({}^0F)$	X_2 (days)	X_3 (%)	X_4 (tons)
240	25	24	91	100
236	31	21	90	95
290	45	24	88	110
274	60	25	87	88
301	65	25	91	94
316	72	26	94	99
300	80	25	87	97
296	84	25	86	96
267	75	24	88	110
276	60	25	91	105
288	50	25	90	100
261	38	23	89	98

Table Q5.b)

	Y
X_2	0.803
X_3	0.049
X_4	-0.009

Table Q5.c)

Predictor	Coefficient
x_1	0.6054
x_2	8.924
x_3	1.437
x_4	0.0136
Constant	-102.7



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: September 2023

Module Number: MN 4201

Module Name: Applied Thermodynamics

[Three Hours]

[Answer All questions, each question carries 20 marks]

Instructions:

1. Required steam tables are provided.
2. Ideal gas properties of air are provided in Table 1.
3. One dimensional isentropic compressible flow data is provided in Table 2.
4. Start your answers to each question on a fresh page.

Q1 a) What are the four processes of the ideal Diesel cycles? Sketch P-V and T-S Diagrams showing all the processes of the ideal Diesel cycle.

[4.0 Marks]

b) An ideal Otto cycle has a compression ratio of 8. At the beginning of the compression process, air is at 95 kPa and 27°C, and 750 kJ/kg of heat is transferred to air during the constant volume heat addition process. Taking into account the variation of specific heats with temperature, determine

(Note : Gas Constant of air $R=0.287 \text{ kJ/kgK}$)

i) the pressure and temperature at the end of the heat addition process,

[4.0 Marks]

ii) the net work output per unit mass,

[4.0 Marks]

iii) the thermal efficiency and

[4.0 Marks]

iv) the mean effective pressure for the cycle.

[4.0 Marks]

22 a) What are the four processes of the simple ideal Rankine Cycle? Sketch the T-S Diagram of the simple ideal Rankine cycle showing all the processes.

[3.0 Marks]

- b) Consider a steam power plant that operates on the ideal reheat Rankine cycle. The plant maintains the boiler at 17.5 MPa, the reheater at 2 MPa, and the condenser at 50 kPa. The temperature is 550°C at the entrance of the high-pressure turbine, and 300°C at the entrance of the low-pressure turbine. Determine the thermal efficiency of this system. [10.0 Marks]
- c) State three methods of increasing the thermal efficiency of a simple ideal Rankine Cycle. Provide a briefly explanation for each of the stated methods. [5.0 Marks]
- d) What are the drawbacks of having an excess of moisture in steam within a steam turbine? [2.0 Marks]

Q3 a) Explain the term "back work ratio"

[2.0 Marks]

- b) A gas-turbine power plant operates on the simple Brayton cycle with air as the working fluid and delivers 32 MW of power. The minimum and maximum temperatures in the cycle are 310 K and 900 K respectively. The pressure of air at the compressor exit is 8 times the value at the compressor inlet. Assuming an isentropic efficiency of 80% for the compressor and 86% for the turbine, determine the mass flow rate of air through the cycle.

[10.0 Marks]

- c) Explain how the inefficiencies of the turbine and the compressor affect the following

i) Back work ratio.

ii) Thermal efficiency of a gas turbine engine.

[4.0 Marks]

[4.0 Marks]

Q4 a) Can a shock wave develop in the converging section of a converging-diverging nozzle? Explain.

[4.0 Marks]

- b) Explain the term stagnation process in your own words and state three stagnation properties.

[4.0 Marks]

- c) Derive the relationship between stagnant temperature, static temperature and dynamic temperature.

[4.0 Marks]

- d) Air enters a nozzle at 0.5 MPa, 420 K, and a velocity of 110 m/s. Approximating the flow as isentropic, determine the followings.

(Assume $k=1.4$ for air. Refer Table 2 as required)

- i. The pressure and temperature of air at a location where the air velocity equals the speed of sound.

[4.0 Marks]

- ii. The ratio of the area at this location to the entrance area?

[4.0 Marks]

- 5 a) Explain the difference between "air to fuel ratio" and "equivalence ratio".

[4.0 Marks]

- b) "The maximum temperature encountered in a combustion chamber is lower than the theoretical adiabatic flame temperature". Do you agree with this statement? Explain in detail.

[4.0 Marks]

- c) Liquid propane (C_3H_8) enters a combustion chamber at $25^\circ C$ at a rate of 1.2 kg/minute where it is mixed and burned with 150% excess air that enters the combustion chamber at $12^\circ C$. If the combustion is complete and the exit temperature of the combustion gases is 1200 K, determine the followings.

(Refer Table 3 for relevant enthalpy values)

- i. The mass flow rate of air.

[6.0 Marks]

- ii. The rate of heat transfer from the combustion chamber.

[6.0 Marks]

$$Ma^* = Ma \sqrt{\frac{k+1}{2 + (k-1)Ma^2}}$$

$$\frac{A}{A^*} = \frac{1}{Ma} \left(\frac{2}{k+1} \right) \left(1 + \frac{k-1}{2} Ma^2 \right)^{0.5(k+1)/(k-1)}$$

$$\frac{P}{P_0} = \left(1 + \frac{k-1}{2} Ma^2 \right)^{-k/(k-1)}$$

$$\frac{\rho}{\rho_0} = \left(1 + \frac{k-1}{2} Ma^2 \right)^{-1/(k-1)}$$

$$\frac{T}{T_0} = \left(1 + \frac{k-1}{2} Ma^2 \right)^{-1}$$

One-dimensional isentropic compressible-flow functions for an ideal gas with $k = 1.4$

Ma	Ma*	A/A*	P/P ₀	ρ/ρ_0	T/T ₀
0	0	∞	1.0000	1.0000	1.0000
0.1	0.1094	5.8218	0.9930	0.9950	0.9980
0.2	0.2182	2.9635	0.9725	0.9803	0.9921
0.3	0.3257	2.0351	0.9395	0.9564	0.9823
0.4	0.4313	1.5901	0.8956	0.9243	0.9690
0.5	0.5345	1.3398	0.8430	0.8852	0.9524
0.6	0.6348	1.1882	0.7840	0.8405	0.9328
0.7	0.7318	1.0944	0.7209	0.7916	0.9107
0.8	0.8251	1.0382	0.6560	0.7400	0.8865
0.9	0.9146	1.0089	0.5913	0.6870	0.8606
1.0	1.0000	1.0000	0.5283	0.6339	0.8333
1.2	1.1583	1.0304	0.4124	0.5311	0.7764
1.4	1.2999	1.1149	0.3142	0.4374	0.7184
1.6	1.4254	1.2502	0.2353	0.3557	0.6614
1.8	1.5360	1.4390	0.1740	0.2868	0.6068
2.0	1.6330	1.6875	0.1278	0.2300	0.5556
2.2	1.7179	2.0050	0.0935	0.1841	0.5081
2.4	1.7922	2.4031	0.0684	0.1472	0.4647
2.6	1.8571	2.8960	0.0501	0.1179	0.4252
2.8	1.9140	3.5001	0.0368	0.0946	0.3894
3.0	1.9640	4.2346	0.0272	0.0760	0.3571
5.0	2.2361	25.000	0.0019	0.0113	0.1667
∞	2.2495	∞	0	0	0

- dimensional isentropic compressible flow function for an ideal gas with $k = 1.2$ for