

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

B.TECH. DEGREE IV SEMESTER EXAMINATION IN MARINE ENGINEERING JUNE 2020

MRE 1402 THERMODYNAMICS AND HEAT TRANSFER (2013 Scheme)

Time: 2hrs 30 Minutes [30 Minutes for Answering and Scanning/Uploading the page of the Answer Sheet] per module

Max. Marks: 70 (14 per module)

INSTRUCTIONS

1. You have to be available in Google Meet on demand by the faculty.
2. You have to share your '**live location**' to the faculty before uploading the answer sheet.
3. You have to answer only one question per module .
4. Answer may not exceed one page of an A4 size paper in a standard handwriting, as far as possible.
5. If at all an answer goes beyond one page, (due to your handwriting) another page can also be used. In such a situation, the page number should be given as 1/2, 2/2.
6. You have to put dated signature along with Register Number, Subject Code, Module/Group Number (as given in the Question Paper) in each page.
7. You have to put the Question Number correctly.
8. After answering the question, you have to scan and upload the answer page.

MODULE - I

(Answer **ANY ONE** question)

- I(1). A heat pump is used to maintain a house at 22°C by extracting heat from the outside air on a day when the outside air temperature is 2°C. The house is estimated to lose heat at a rate of 110000 kJ/h, and the heat pump consumes 5 kW of electric power when running. Is this heat pump powerful enough to do the job? Show mathematically. (14)

OR

- I(2). The chemical analysis of Bituminous coal gave the following ultimate analysis C = 81.5%, H = 4.5%, S = 0.8%, O = 2.6%. The remainder consists of incombustible solid. Determine (i) stoichiometric air to fuel ratio (ii) The actual mass of air supplied per kilogram of fuel when 20% excess air is required for complete combustion (iii) The mass of the products of combustion per kilogram of fuel. Assume that air contains 23% oxygen and 77% nitrogen by mass. (14)

MODULE - II

(Answer *ANY ONE* question)

- II(1). Consider a steam power plant that operates on a simple ideal Rankine cycle and has a net power output of 45 MW. Steam enters the turbine at 7 MPa and 500°C and is cooled in the condenser at a pressure of 10 kPa by running cooling water from a lake through the tubes of the condenser at a rate of 2000 kg/s. Show the cycle on a T-s diagram with respect to saturation lines, and determine (i) the thermal efficiency of the cycle (ii) the mass flow rate of the steam (iii) the temperature rise of the cooling water.
- (14)

OR

- II(2). The following particulars refer to a stage of a parson's reaction turbine consisting of one ring of fixed blades and one ring of moving blades. Mean diameter of the blade ring is 1 meter and its speed is 2800 rpm. The inlet absolute velocity to the blade is 270 metre per second; the blade outlet angle is 20°. The rate of steam flow is 7.25 kg per second. Estimate the following (i) Blade inlet angle (ii) Tangential force on the blades (iii) Power developed in the stage.
- (14)

MODULE - III

(Answer *ANY ONE* question)

- III(1). A single stage single acting air compressor running at 800 r.p.m delivers air at 20 bar. For this purpose the induction and free air condition can be taken as 1.013 bar and 20°C, and air delivery as 0.2 cubic meter per minute. The clearance volume is 5% of the swept volume and the stroke to bore ratio is 1.5:1. Calculate (i) Bore and stroke (ii) volumetric efficiency (iii) Indicated power (iv) isothermal efficiency. The index of compression and expansion is 1.35.
- (14)

OR

- III(2). A single acting air compressor is required to deliver air at 60 bar from an induction pressure of 1 bar at the rate of 1.75 cubic meter per minute measured at free air condition 1.013 bar and 20°C. The compression is carried out in two stages with an ideal intermediate pressure and complete inter cooling. The clearance volume is 2.5% of swept volume in each cylinder and the speed of compressor is 820 r.p.m. The index of compression and re-expansion is 1.3 for both cylinders and the temperatures at the end of the induction stroke in each cylinder are 37°C. The compressor mechanical efficiency is 80%. Calculate the following (i) Indicated power (ii) Swept volume in each cylinder (iii) required power output of the drive motor.

(14)

MODULE - IV(Answer *ANY ONE* question)

- IV(1). Consider a jacket made of five layers of 0.1-mm-thick synthetic fabric ($k = 0.13 \text{ W/m}^\circ\text{C}$) with 1.5-mm-thick air space ($k = 0.026 \text{ W/m}^\circ\text{C}$) between the layers. Assuming the inner surface temperature of the jacket to be 28°C and the surface area to be 1.1 m^2 , determine the rate of heat loss through the jacket when the temperature of the outdoors is -5°C and the heat transfer coefficient at the outer surface is $25 \text{ W/m}^\circ\text{C}$. What would your response be if the jacket is made of a single layer of 0.5 mm thick synthetic fabric? **(14)**

OR

- IV(2). Steam at 320°C flows in a stainless steel pipe ($k = 15 \text{ W/m}^\circ\text{C}$) whose inner and outer diameters are 5 cm and 5.5 cm, respectively. The pipe is covered with 3 cm thick glass wool insulation ($k = 0.038 \text{ W/m}^\circ\text{C}$). Heat is lost to the surroundings at 5°C by natural convection and radiation, with a combined natural convection and radiation heat transfer coefficient of $15 \text{ W/m}^\circ\text{C}$. Taking the heat transfer coefficient inside the pipe to be $80 \text{ W/m}^\circ\text{C}$, determine the rate of heat loss from the steam pipe per unit length of the pipe. Also determine the temperature drops across the pipe shell and the insulation. **(14)**

MODULE - V(Answer *ANY ONE* question)

- V(1). Steam in the condenser of a steam power plant is to be condensed at a temperature of 50°C ($h_{fg} = 2305 \text{ kJ/kg}$) with cooling water ($c_p = 4180 \text{ J/kg}^\circ\text{C}$) from a nearby lake, which enters the tubes of the condenser at 18°C and leaves at 27°C . The surface area of the tubes is 58 m^2 , and the overall heat transfer coefficient is $2400 \text{ W/m}^\circ\text{C}$. Determine the mass flow rate of the cooling water needed and the rate of condensation of the steam in the condenser. **(14)**

OR

- V(2). A double-pipe parallel-flow heat exchanger is to heat water ($c_p = 4180 \text{ J/kg}^\circ\text{C}$) from 25°C to 60°C at a rate of 0.2 kg/s . The heating is to be accomplished by geothermal water ($c_p = 4310 \text{ J/kg}^\circ\text{C}$) available at 140°C at a mass flow rate of 0.3 kg/s . The inner tube is thin-walled and has a diameter of 0.8 cm . If the overall heat transfer coefficient of the heat exchanger is $550 \text{ W/m}^\circ\text{C}$, determine the length of the heat exchanger required to achieve the desired heating. **(14)**
