B Sc. Eng. (ME)/ (2nd Semester) 22 August, 2019(Afternoon)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination — Summer Semester, A.Y. 2018-2019
Course Code: Math 4211 — Time : 1½ hours
Course Title: Differential Equations and Special Functions — Full Marks : 100

There are **4 (Four)** Questions. Answer any **3 (Three)** of them. All Questions carry equal Marks. Programmable calculators are not allowed. Do not write on this question paper. The Symbols have their usual meaning.

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1. a) A pond initially contains 1,000,000 gal of water and an unknown amount of an undesirable chemical. Water containing 0.01 grams of this chemical per gallon flows into the pond at a rate of 300 gal/h. The mixture flows out at the same rate, so the amount of water in the pond remains constant. Assume that the chemical is uniformly distributed throughout the pond.

   (i) Write a differential equation for the amount of chemical in the pond at any time.

   (ii) How much of the chemical will be in the pond after a very long time? Does this limiting amount depend on the amount that was present initially?

   (iii) Write a differential equation for the concentration of the chemical in the pond at time t.

   b) Classify the following equations. Are they ODE or PDE? Is it an equation or a system? What is the order? Is it linear or nonlinear, and if it is linear, is it homogeneous, constant coefficient? If it is an ODE, is it autonomous?

$$(i)\ \frac{\partial^2 v}{\partial x^2} + 3\frac{\partial^2 v}{\partial y^2} = \sin(x)$$

$$(ii)\ \frac{dx}{dt} + \cos(t)x = t^2 + t + 1$$

$$(iii)\ \frac{d^7 F}{dx^7} = 3F(x)$$

$$(iv)\ y'' + 8y' = 1$$

$$(v)\ x'' + tyx' = 0,\ y'' + txy = 0$$

$$(vi)\ \frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial s^2} + u^2$$

2. a) Consider a population of field mice that inhabit at IUT campus. Growth rate of the field mouse population is 0.5/month. Consider that several owls also live in IUT campus and they kill 15 field mice per day.

   (i) Set up a differential equation that describes the rate of change of field mouse at IUT campus considering that the mouse population at time t is $p(t)$.

   (ii) Find the time at which the population becomes extinct if $p(0) = 850$.

   (iii) Find the time of extinction if $p(0) = p_0$, where $0 < p_0 < 900$.

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(iv) Find the initial population p_0 if the population is to become extinct in 1 year.

b) A differential equation is given: $ty' + 2y = \sin t,\ t > 0$

(i) Draw a direction field for the given differential equation.

(ii) Based on an inspection of the direction field, describe how solutions behave for large t.

(iii) Find the general solution of the given differential equation and use it to determine how solutions behave as $t \to \infty$.

3. a) (i) Find the solution of the following initial value problem in explicit form.

(ii) Plot the graph of the solution.

(iii) Determine (at least approximately) the interval in which the solution is defined.

$$\begin{cases} \dfrac{dy}{dx} = \dfrac{3x^2 + 4x + 2}{2(y-1)} \\ y(0) = -1 \end{cases}$$

b) Find the value of b for which the following equation is exact, and then solve it using that value of b. $\left(xy^2 + bx^2 y\right)dx + (x+y)x^2 dy = 0$

4. a) Find an integrating factor and solve the equation:

$$\left[4\left(x^3 / y^2\right) + (3/y)\right]dx + \left[3\left(x / y^2\right) + 4y\right]dy = 0$$

b) Consider the initial value problem

$$4y'' - 8y' + 3y = 0,\ y(0) = 2,\ y'(0) = \frac{1}{2}$$

(i) Find the solution of the following initial value problem.

(ii) Sketch the graph of the solution

(iii) And describe its behavior as t increases.

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B. Sc. Engg.(M)/2nd Sem. 29 August, 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid-Semester Examination — Summer Semester 2018-2019
Course No. Phy 4213 — Time: 1.5 HRS.
Course Title: Waves & Oscillations, Geometrical Optics and Wave Mechanics — Full Marks: 75

There are **FOUR** Questions. Answer any **THREE** Questions
Marks in the Margin indicate full marks
Programmable calculators are not allowed. Do not write on this question paper.

1. (a) What are phase and epoch angle? Obtain the expression for the average kinetic energy of a particle executing simple harmonic motion (SHM). 18
   (b) The displacement of a particle vibrating simple harmonically is given by $y = 15 \sin (15t - \pi/12)$. Determine i) time period, ii) frequency, iii) epoch and iv) maximum acceleration. 7

2. (a) Define superposition of simple harmonic waves. Obtain the expressions for the displacement and phase of the resultant vibration upon superposition of two SHMs in a straight line. 18
   (b) A ball moves in a circular path of 0.14 m diameter with a constant angular speed of 20 rev/s. Its shadow performs simple harmonic motion on the wall behind it. Find the acceleration of the shadow at a turning point of the motion. 7

3. (a) What is free vibration? Establish the differential equation of motion of a particle executing damped vibration and hence solve it to obtain an expression for the displacement of the particle. 18
   (b) A particle of mass 3.0 g is subjected to an elastic force of 48 dyne-cm^{-1} and a damping force of 12 dyne-cm^{-1} .s. If the motion is oscillatory, find its frequency. 7

4. (a) What are longitudinal and transverse waves? 18
   Deduce the equations analytically for the standing waves formed in an open end organ pipe and hence find the positions of the nodes and antinodes with respect to position.
   (b) The displacement of a particle executing SHM at any instant of time is given by $x=0.1 \sin 2\pi (340t - 0.15)$. Calculate wavelength, frequency and time period. 7

B.Sc. Eng. (MCE) 2nd Semester — 30 August 2019 (Afternoon)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination — Summer Semester, A.Y. 2018-2019
Course Code: Chem 4215 — Time : 1.5 hours
Course Title: Chemistry of Engineering Materials — Full Marks : 50

There are **4 (four)** Questions. Answer any **3 (three)** of them.
Marks in the Margin indicate the full marks. The symbols have their usual meaning.

1 a) What is hardness of water? Classify water hardness. 4

b) What is scale and sludge? What are the disadvantages of scale formation in the boiler? Describe how the formation of scale and sludge in the boiler is prevented. $8\frac{2}{3}$

c) 50.0 mL of sample water requires 5.5 mL $AgNO_3$ solution to react completely with chloride ion. Calculate the amount of Cl^- present in the sample water. (25 mL N/20 NaCl solution is required to standardize 26.5 mL $AgNO_3$ solution). 4

2 a) Discuss the principle of prevention of corrosion by sacrificial anode and impressed current cathodic protection method. $5\frac{2}{3}$

b) What are the different factors that affect the rate of underwater corrosion? Discuss elaborately any two of them. 5

c) Write short notes on the following terms: 6
(i) Cavitation-errosion (ii) Corrosion fatigue (iii) Metal spraying.

3 a) Distinguish between organic polymer and inorganic polymer. 4

b) Discuss the reaction mechanism of free radical addition polymerization and ionic addition polymerization? $6\frac{2}{3}$

c) Discuss the synthetic route of only **raw material** of the following polymers: 6
(i) PVC (ii) Melamine (iii) Nylon 6 6 (iv) Teflon.

4 a) Define paint. What are the different component of paints? Discuss their function. 5

b) Briefly discuss (i) Corrosion of boiler, and (ii) Caustic embrittlement. 5

c) Define the following properties of refractories mentioning their important application. $6\frac{2}{3}$
(i) Softening temperature (ii) Porosity (iii) Spalling.

B.Sc Engg.(M)/2nd Sem. August 23, 2019 (Afternoon)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination
Course No.: MCE 4241
Course Title: Computer Programming Applications

Summer Semester, A. Y. 2018-2019
Time: 1 Hours 30 Min(s)
Full Marks: 50

There are 4 (Four) questions. Answer any 3 (Three) questions.

Marks in the margin indicate full marks. Programmable calculators are not allowed.
Do not write on this question paper.

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1. a) Demonstrate the crucial difference between the algebraic expression and C expression with examples. Write and explain the rules for constructing real constants, integer constants and the representation of exponential form in C. (4)

   b) The marks obtained by a student in 3 different subjects are input through the keyboard. The student gets a division as per the following rules. (4)
   Percentage above or equal to 60 – First division.
   Percentage between 50 and 59 – Second division.
   Percentage between 40 and 49 – Third division.
   Percentage less than 40 – Fail.
   Write a program to calculate the division obtained by the student.

   c) Write a program which should add numbers until zero or negative number is provided using while and do while loop. (4)

   d) The basic salary of an employee is input through the keyboard. His dearness allowance is **35%** of basic salary, and house rent allowance is **20%** of basic salary. Write a program to calculate his gross salary. (4.67)

2. a) Demonstrate the syntax and flow chart of loop control structures. (4)

   b) Build up a table which should depict conversion of temperature from Fahrenheit to Celsius using, (4)
      i) While loop.
      ii) Do-While loop.

   c) Write a program to add first eight terms of the following series using a **for** loop: (4.67)

$$\frac{1}{1!}+\frac{2}{2!}+\frac{3}{3!}+\ldots\ldots\ldots$$

   d) According to a study, the approximate level of intelligence of a person can be calculated using the following formula: (4)

$$i=2+(y+0.5x)$$

   Write a program, which will produce a table of values of **i**, **y** and **x**, where **y** varies from 1 to 6 with the increment of one, and, for each value of **y**, **x** varies from 5.5 to 12.5 in steps of 0.5.

3. a) Write a program which to find the grace marks for a student using **switch**. The user (6)

should enter the class obtained by the student and the number of subjects he has failed in.

i) If the student gets first class and the number of subjects he failed in is greater than 3, then he does not get any grace. If the number of subjects he failed in is less than or equal to 3 then the grace is of 5 marks per subject.

ii) If the student gets third class and the number of subjects he failed in is greater than 1, then he does not get any grace. If the number of subjects he failed in is equal to 1 then the grace is of 5 marks per subject.

b) Write the output of the following program; (6)

```
# include <stdio.h>
int main ()
{
  int i;
  double number, sum = 0.0;
  for (i=1; i <= 10; ++i)
  {
    printf ("Enter a n%d: ",i);
    scanf ("%lf", &number);
    if (number < 0.0)
    {
      continue;
    }
    sum += number;
  }
  printf ("Sum = %f",sum);
    return 0;
}
```

c) Use linear interpolation to compute a new freezing temperature for water with a specified salinity. (4.67)

Salinity(ppt)	Freezing Temperature (^{0}F)
20	30.1
24.3	?
35	28.6

4. a) Assume that we have measured the wave period and wave height (distance between crest and trough) for two waves: (11)

	Period(s)	Height(ft)
Wave1	4	0.5
Wave2	10	1.0

Write a C-program to determine the wavelength of two waves and maximum possible height from the combination of two waves.

b) Write a program to calculate overtime pay of 40 employees. Overtime is paid at the rate of 10.00$ per hour for every hour worked above 40 hours. Assume that employees do not work for fractional part of an hour. (5.67)

B.Sc.Engg. (M)/ HDME/4th Sem./
B.Sc.TE(2 Yr-Prog.)/1st Sem.

August 22, 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

MID SEMESTER EXAMINATION
COURSE NO: MCE 4403
COURSE TITLE: MECHANICS OF MATERIALS

SUMMER SEMESTER: 2018-2019
TIME : $1\frac{1}{2}$ HRS
FULL MARKS : 100

There are **Four** Questions. Answer any **Three** Questions.
Marks in the Margin indicate full marks. Assume data if missing or necessary.
Programmable calculators are not allowed. Do not write on this question paper.

1. (a) A uniform rigid block weighting 160 kN is to be supported on three bars as shown in Fig.1a. The outside bars are made of aluminium with each cross-sectional area 400 mm^2 and inside bar is made of steel with cross-sectional area 625 mm^2.Initially there is a 4 mm gap between the block and the top of the steel bar. Determine the stresses developed in the bars. Take E_S= 200 GPa and E_A= 80 GPa. (16)

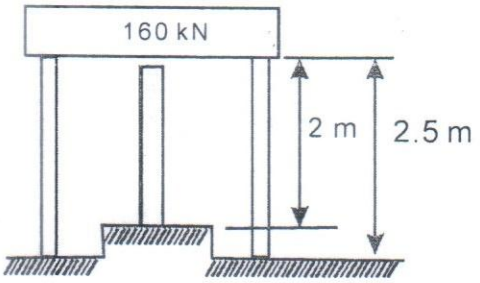
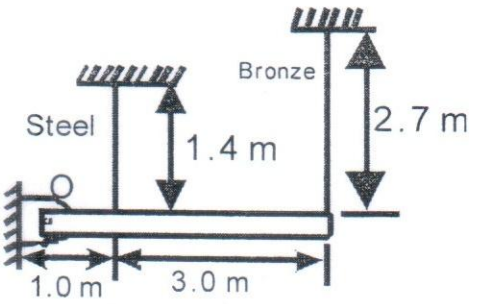


Fig. 1a

(b) A rigid bar of negligible weight is suspended from two vertical rods as shown in Fig.1b The rigid bar is pinned at *O* and remains horizontal initially. Determine the temperature change if the stress developed in the steel rod is 12.7 MPa. Cross-sectional areas of steel and bronze rods are respectively 300 mm^2 and 1200 mm^2. Consider E_{st}=200 GPa, α_{st}=11.7 $\mu m/m^0C$, E_{br}=80 GPa and α_{br}=18.9 $\mu m/m^0C$. (17.33)



2. A simply supported beam, 5 meters long, caries a load of 10 kN on a bracket welded to the beam and uniformly distributed load between *B* and *D*. Draw the shear force and bending moment diagrams for the beam. Find also the point of contraflexure, if any. (33.33)

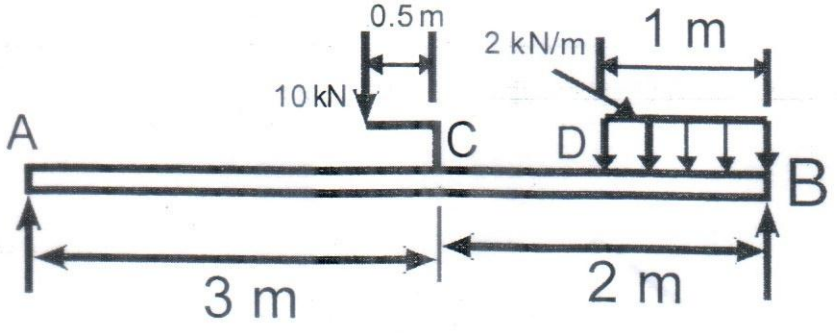


Fig. 2

3. (a) Define bulk modulus K and derive a formula to find the extra fluid which must be pumped into a thin cylinder to raise its pressure by an amount p. (13.33)

(b) Determine how much fluid is required to raise the pressure in a thin cylinder of length 3 m, internal diameter 0.7 m, and wall thickness 12 mm by increasing the pressure to 70 KN/m^2. Take E=210 GPa and ν=0.3 for the material of the cylinder and K =2.1 GPa for the fluid. (20)

4. (a) Derive the expression $\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$ for the elastic bending of a beam. Symbols represent the usual meaning. (13.33)

(b) A cast-iron bracket subjected to bending, has a cross-section of I-shaped with unequal flanges as shown in Fig.4b. If the compressive stress in top flange is not to exceed 17.5 MPa, what is the bending moment, the section can take? If the section is subjected to a shear force of 100 kN, draw the shear stress distribution over the depth of the section. (20)

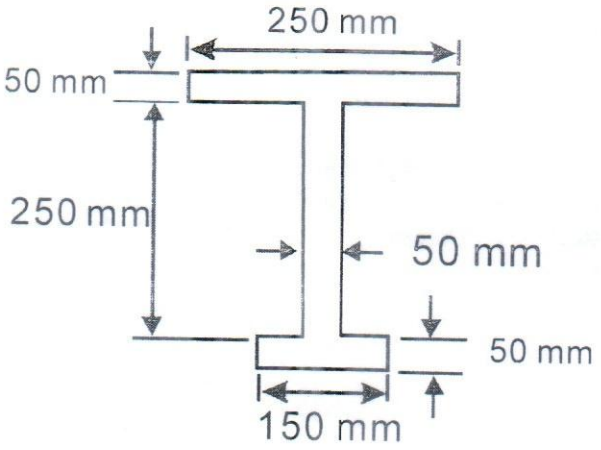


Fig. 4b

B.Sc. Engg. (M)/HDME, 4th Sem. August 29, 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination
Course No.: MCE 4407
Course Title: Instrumentation and Measurements

Summer Semester, A. Y. 2018-2019
Time: 1 Hours 30 Min(s)
Full Marks: 75

There are 4 (Four) questions. Answer any 3 (Three) questions.

All questions carry equal marks/Marks in the margin indicate full marks. Programmable calculators are not allowed. Do not write on this question paper.

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1. a) What is the main difference between a sensor and transducer? Briefly explain a typical temperature and weight measurement system. 13

   b) What is traceability in calibration process? What are the key points to manage and execute a calibration process in a professional manner? 12

2. a) A load cell is calibrated in an environment at a temperature of 20°C and has the following deflection/load characteristic: 13

Load (kg)	0	50	100	150	200	250
Deflection (mm)	0.0	0.9	1.9	3.2	4.2	4.9

When used in an environment at 35°C, its characteristic changes to the following:

Load (kg)	0	50	100	150	200	250
Deflection (mm)	0.3	1.3	2.4	3.7	4.8	5.7

i) Determine the sensitivity at 20°C and 35°C.
ii) Calculate the total zero drift and sensitivity drift at 35°C.
iii) Hence determine the zero drift and sensitivity drift coefficients (in units of μm/°C and (μm per kg)/ (°C).

   b) What is Indicating Instrument and Instrument with a Signal Output? Explain with necessary examples. 12

3. a) What is a capacitive sensor? What are the different parameters that can change the capacitance value? In order to monitor the water level, how can this sensor be used? 13

   b) What is an optocoupler? Explain its working principle with an application. 12

4. a) Explain the working principle of bimetallic strip thermometer with necessary diagram. Write down the characteristics of bimetallic strip thermometer. 13

   b) In a PID controller, how the time-proportional control works? How does the output of a system vary with the change of a P band? 12

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B Sc. Eng./(4th Semester)/B Sc TE(2 Yr/2nd Semester) 30 August, 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination — Summer Semester, A.Y. 2018-2019
Course Code: Math-4411/Math-4699 — Time : 1½ hours
Course Title: Linear Algebra — Full Marks : 75

There are **4 (Four)** Questions. Answer any **3 (Three)** of them. Marks in the margin indicate full marks. Programmable calculators are not allowed. Do not write on this question paper. The Symbols have their usual meanings.

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1. a) Solve the following linear system by Gauss-Jordan elimination method: 13

$$x_1 + 3x_2 - 2x_3 + 2x_5 = 0$$
$$2x_1 + 6x_2 - 5x_3 - 2x_4 + 4x_5 - 3x_6 = -1$$
$$5x_3 + 10x_4 + 15x_6 = 5$$
$$2x_1 + 6x_2 + 8x_4 + 4x_5 + 18x_6 = 6$$

b) A system represents by linear equations is given below. Find the value of a for the cases: 12
(i) infinite (ii) no solution (iii) unique solution.

$$x + y + 7z = -7$$
$$2x + 3y + 17z = -16$$
$$x + 2y + (a^2 + 1)z = 3a$$

2. a) 13

Let, $a_1 = \begin{bmatrix} 1 \\ -2 \\ -5 \end{bmatrix}$, $a_2 = \begin{bmatrix} 2 \\ 5 \\ 6 \end{bmatrix}$, *and* $b = \begin{bmatrix} 7 \\ 4 \\ -3 \end{bmatrix}$

(i) Determine whether b can be generated as a linear combination of a_1 and a_2.
(ii) And whether weights x_1 and x_2 exist such that $x_1a_1 + x_2a_2 = b$

b) 12

Let, $A = \begin{bmatrix} 1 & 3 & 4 \\ -4 & 2 & -6 \\ -3 & -2 & -7 \end{bmatrix}$, *and* $b = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}$, Is the equation $Ax = b$ consistent for all possible values of b_1, b_2, b_3?

3. a) Boron sulfide reacts violently with water to form boric acid and hydrogen sulfide gas (the smell of rotten eggs). The unbalanced equation is 12

$$B_2S_3 + H_2O \rightarrow H_3BO_3 + H_2S$$

Balance the above chemical equation using the linear system of equation approach.

b) Suppose the network in Figure Q3b shows a proposed plan for the traffic flow at Dhaka airport bus stand. 13

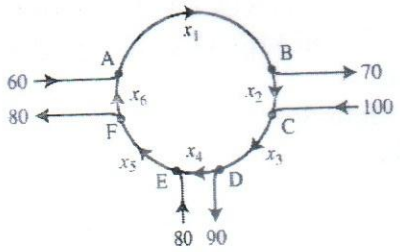

Fig.: Q3b

(i) Find the general solution of the network flow.
(ii) Determine the smallest possible value for x_6.

4. a) 13

Let, $A=\begin{bmatrix} 1 & -3 \\ 3 & 5 \\ -1 & 7 \end{bmatrix}$, $u=\begin{bmatrix} 2 \\ -1 \end{bmatrix}$, $b=\begin{bmatrix} 3 \\ 2 \\ -5 \end{bmatrix}$, *and* $c=\begin{bmatrix} 3 \\ 2 \\ 5 \end{bmatrix}$

define a transformation $T(x):R^2 \to R^3$ by $T(x)=Ax$, so that

$$T(x)=Ax=\begin{bmatrix} 1 & -3 \\ 3 & 5 \\ -1 & 7 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

(i) Find $T(u)$, the image of u under the transformation T.
(ii) Find an x in R^2 whose image under T is b.
(iii) Is there more than one x whose image under T is b?
(iv) Determine if c is in the range of the transformation T.

b) Use the inversion algorithm to find the inverse of the following matrix (if the inverse exists). 12

$$\begin{bmatrix} 2 & -4 & 0 & 0 \\ 1 & 2 & 12 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & -1 & -4 & -5 \end{bmatrix}$$

BSc. Engg (M), 4th Sem

Monday, 26 August, 2019, Morning

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination
Course Code: **MCE 4413**
Course Title: **Heat Transfer: Conduction & Radiation**

Summer Semester : **A.Y. 2018-2019**
Time : **1½ hours**
Full Marks : **75**

There are **4 (Four)** Questions. Answer any **3 (Three)** of them. Assume any missing data if necessary. Do not write on the question paper. Marks in the Margin indicate the full marks.

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1. a) Define Newton's Law of Cooling. Explain different types of thermal resistance. **(05)**
   b) Define thermal conductivity. Derive the "diffusion equation" for general heat conduction in rectangular coordinates. **(10)**
   c) A furnace wall is made of composite wall of total thickness 550 mm. The inside layer is made of refractory material (k=2.3 W/mK) and outside layer is made of an insulating material (k=0.2 W/mK). The mean temperature of the glass inside the furnace is 900°C and interface temperature is 520°C. The heat transfer coefficient between the gases and inner surface can be taken as 230 $W/m^{2}°C$ and between the outside surface and atmosphere as 46 $W/m^{2}°C$. Taking air temperature =30°C, Calculate: (i) Required thickness of each layer, (ii). The rate of heat loss per m^2 area, and (iii) The temperatures of surface exposed to gases and of surface exposed to atmosphere. **(10)**

2. a) Discuss different types of boundary conditions used in heat transfer. **(05)**
   b) Define Thermal Resistance Network. Derive the equation of heat flow through a spherical layer that is exposed to convection on both sides. **(10)**
   c) A 150 mm long steam pipe has inner diameter of 120 mm and outside diameter of 160 mm. It is insulated at the outside with asbestos. The steam temperature is 150°C and the air temperature is 20°C. The convective heat transfer coefficients are: h (steam side) =100 $W/m^{2}°C$, h (air side) = 30 $W/m^{2}°C$, k (asbestos) = 0.8 W/m°C and k (steel) = 42 W/m°C. How thick the asbestos should be provided in order to limit the heat loses to 2.1 kW/m^2? **(10)**

3. a) Differentiate fin efficiency and fin effectiveness. **(05)**
   b) List the purpose of finned surface. Derive an expression for the differential fin equation in a finned surface heat transfer. **(10)**
   c) A current of 300 A passes through a stainless steel wire of 2.5 mm diameter and thermal conductivity k= 20 W/m°C. The resistivity of the wire is $70x10^{-8}$ Ωm and the length of the wire is 2 m. If the wire is submerged in a fluid maintained at 50 °C and convective heat transfer coefficient at the wire surface is 4000 $W/m^{2}°C$, calculate the steady state temperature at the centre and at the surface of the wire. **(10)**

4. a) Explain Lumped system analysis and its criteria. **(05)**
   b) Define critical radius of insulation. Show that the value of critical radius of insulation for sphere is twice of the value of cylinder. **(10)**
   c) Two long rods of the same diameter, one made of brass (k= 85 W/m°C) and other made of copper (k=375 W/m°C) have one of their ends inserted into the furnace. Both of the rods are exposed to the same environment. At a distance 105 mm away from the end, the temperature of the brass rod is 120 °C. At what distance from the furnace end the same temperature would be reached in the copper rod? **(10)**

13

B.Sc.Engg. (M)/4th Sem.
HDME/4th Sem.

Date: 27 August, 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

MID SEMESTER EXAMINATION
COURSE NO. MCE 4425
COURSE TITLE: Metallurgy

SUMMER SEMESTER: 2018-2019
TIME: 1 ½ HRS
FULL MARKS: 50

There are **Four** Questions. Answer any **Three** Questions.
Marks in the Margin indicate full marks.
Graph paper to be supplied.

1. (a) Explain **any three** of the following terms:
(i) Ore mineral (ii) Flux (iii) Roasting (iv) Smelting (v) Sintering (9)

(b) Distinguish between **any two** of the following:
(i) Hardness and Toughness (ii) Ductility and Malleability (iii) Substitutional solid solution and Interstitial solid solution ($7^2/_3$)

2. (a) Draw a neat sketch of the iron blast furnace showing its salient parts. (8)

(b) Give the chemistry of the iron blast furnace involved in the production of pig iron. ($8^2/_3$)

3. (a) What is steel? What are the modern methods of steel making? (3)

(b) Draw a neat sketch of the basic open hearth furnace with regenerative system and describe briefly how steel is produced by the basic open hearth process of steel making. (10)

(c) Why and how are deoxidation and recarburization carried out at the end of the steel making process? ($3^2/_3$)

4. (a) Define eutectic reaction and eutectoid reaction. (4)

(b) Metal A and Metal B are completely soluble in both the liquid and solid states. The melting point of Metal A is 3225^0F and of Metal B is 1945^0F. An alloy containing 40 percent Metal B starts to solidify at 2910^0F by separating crystals of 15 percent Metal B. An alloy containing 70 percent Metal B starts to solidify at 2550^0F by separating crystals of 37 percent Metal B. ($12^2/_3$)

(i) Draw the equilibrium diagram to scale on a piece of graph paper and label all points, lines, and areas.

(ii) For an alloy containing 70 percent Metal B
(1) give the temperature of initial solidification;
(2) give the temperature of final solidification;
(3) give the chemical composition and relative amounts of the phases present at 2440^0F;
(4) draw the cooling curve.

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BSc. Eng. (M)/ HDME/ 6th Sem.
BScTE(2-Yr) 2nd Sem

27 August 2019(Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination — Winter Semester A.Y. 2018-2019
Course Code: MCE 4609/MCE 4693 — Time : 1.5 hours
Course Title: **Machine Design-I**
(Close Book) — Full Marks : 50

There are **4 (Four)** Questions. Answer any **3(Three)** of them.
Assume reasonable value for missing data.
Programmable calculators are not allowed. Don't write on this question paper.

---

1. The cantilevered bar in the Figure 1 is made from a ductile material and is statically loaded with F_x =300 lbf, F_y = 250 lbf, and F_z =0. $(16\frac{2}{3})$

   a) Draw separate free-body diagrams of the arm OC and the arm CD, and compute the values of all forces, moments, and torques that act.
   b) Determine the precise location of the critical stress element at the cross section at *A*.
   c) For the critical stress element, determine the principal stresses and the maximum shear stress.

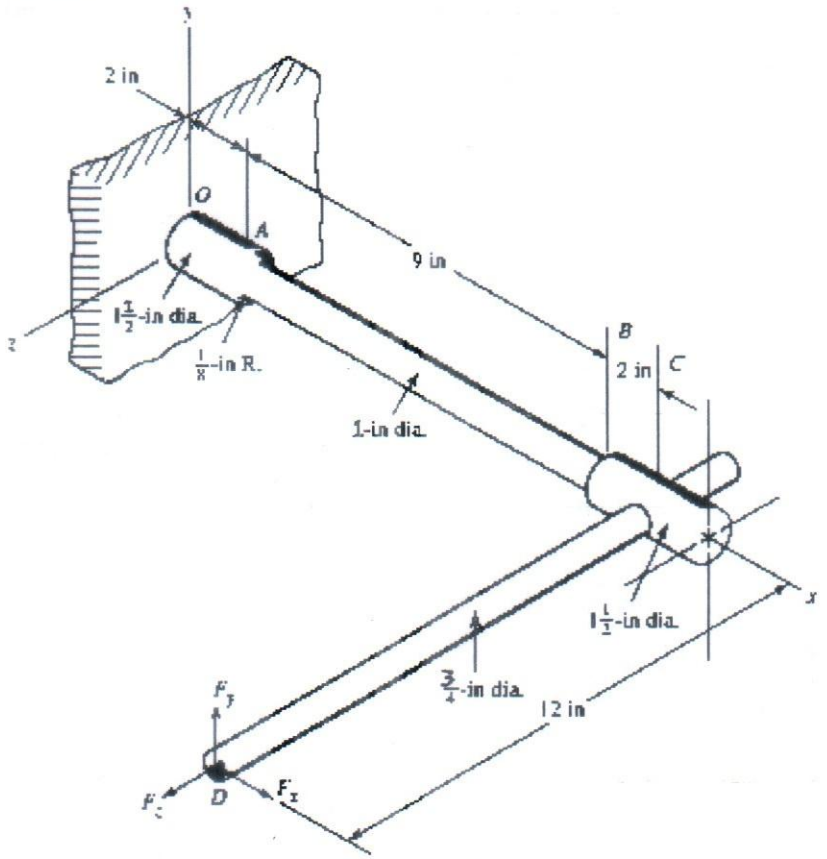


Figure. 1

15

2. The cast-iron bell-crank lever depicted in the Figure. 2 is acted upon by forces F_1 of 2.4 kN and F_2 of 3.2 kN. The section A–A at the central pivot has a curved inner surface with a radius of r_i = 25 mm. Estimate the stresses at the inner and outer surfaces of the curved portion of the lever. $(16\frac{2}{3})$

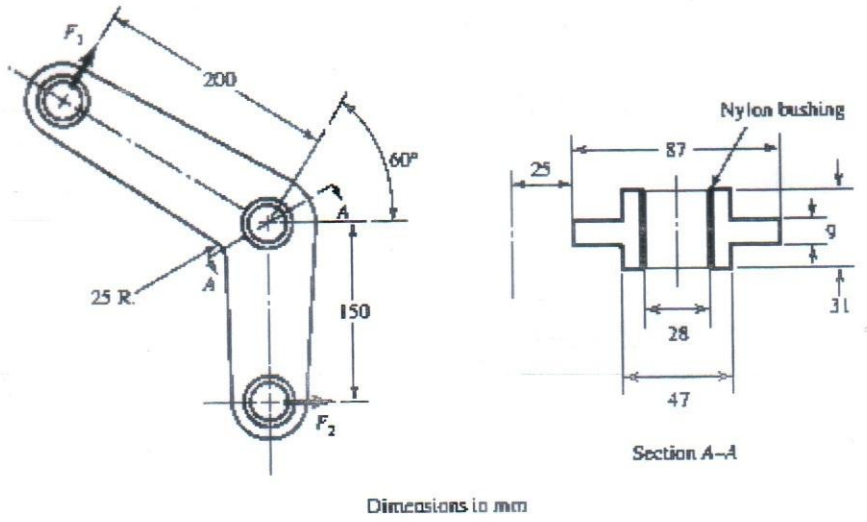


Figure. 2

3. A gear reduction unit uses the countershaft shown in the Figure 3. Gear A receives power from another gear with the transmitted force F_A applied at the 20° pressure angle as shown. The power is transmitted through the shaft and delivered through gear B through a transmitted force F_B= 750 lbf at the pressure angle shown. $(16\frac{2}{3})$

For the steel countershaft specified in the Figure 3, find the deflection and slope of the shaft at point A. Use *superposition* with the deflection equations in Table A–9 or *Singularity functions*. Assume the bearings constitute simple supports.

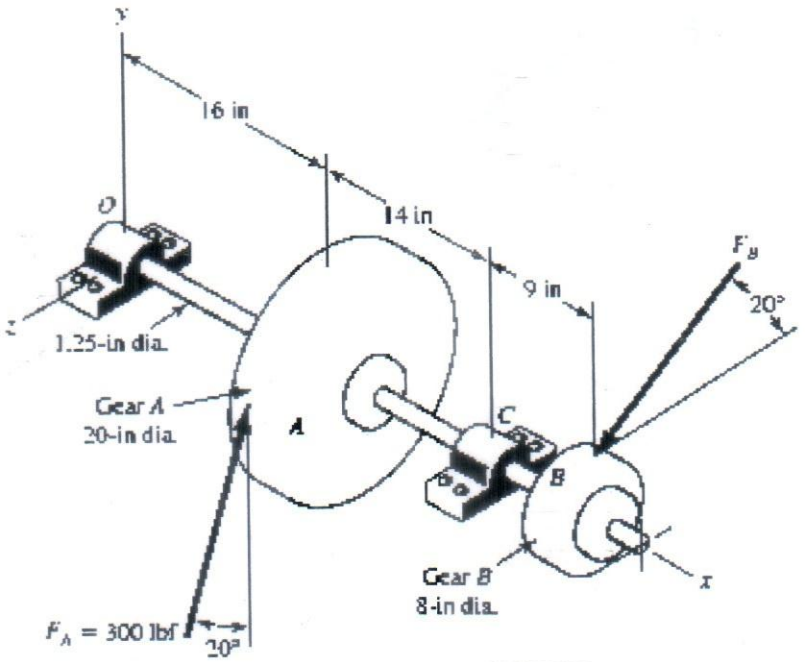


Figure. 3

4. a) Specify the diameter of a round column 1.5 m long that is to carry a maximum load estimated to be 22 kN. Use a design factor n_d=4 and consider the ends as pinned (rounded). The column material is forged AISI 1020 steel without further heat treatment. Preferred size of diameter may be found from Table A-17. (8)

b) Following table gives data regarding the shrink fit of two cylinders and dimensional specification in inches. Elastic constants for different materials may be found in Table A–5. Identify the radial interference δ, then find the interference pressure p, and the tangential normal stress on both sides of the fit surface. If dimensional tolerances are given at fit surfaces, repeat the problem for the highest and lowest stress levels. ($8\frac{2}{3}$)

Inner Cylinder			Outer Cylinder		
Material	**d_i**	**d_o**	**Material**	**D_i**	**D_o**
Steel	0	2.002	Cast iron	2.000	3.00

Equations, Figures, Tables

$$r_n = \frac{A}{\int \frac{dA}{r}}$$

$$\sigma_i = \frac{Mc_i}{Aer_i} \qquad \sigma_o = -\frac{Mc_o}{Aer_o}$$

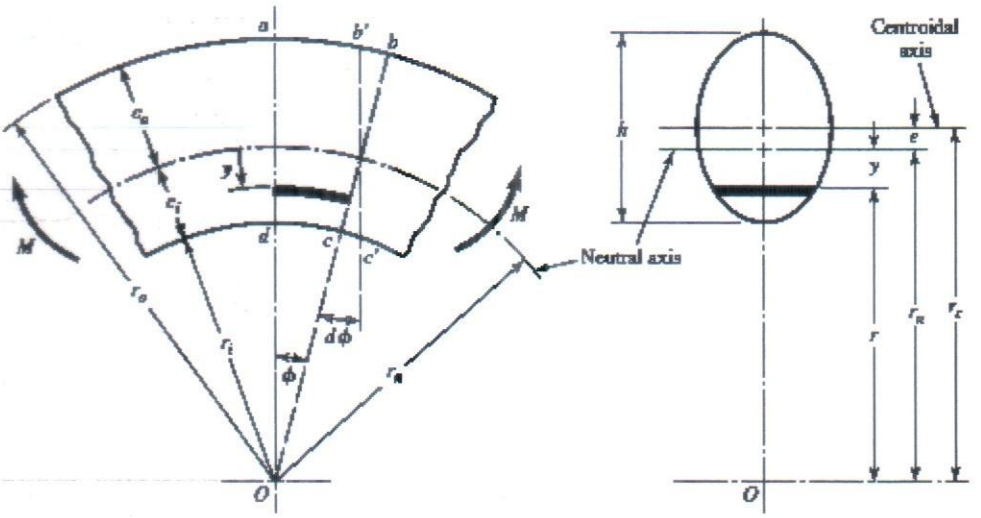


Table 4–2
End-Condition Constants for Euler Columns [to Be Used with Eq. (4–43)]

Column End Conditions	End-Condition Constant C		
	Theoretical Value	Conservative Value	Recommended Value*
Fixed-free	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$
Rounded-rounded	1	1	1
Fixed-rounded	2	1	1.2
Fixed-fixed	4	1	1.2

*To be used only with liberal factors of safety when the column load is accurately known.

$$\frac{P_{cr}}{A} = \frac{C\pi^2 E}{(l/k)^2}$$

$$\left(\frac{l}{k}\right)_1 = \left(\frac{2\pi^2 CE}{S_y}\right)^{1/2}$$

$$\frac{P_{cr}}{A} = a - b\left(\frac{l}{k}\right)^2$$

$a = S_y$

$$b = \left(\frac{S_y}{2\pi}\right)^2 \frac{1}{CE}$$

$$\frac{P_{cr}}{A} = S_y - \left(\frac{S_y}{2\pi}\frac{l}{k}\right)^2 \frac{1}{CE} \qquad \frac{l}{k} \leq \left(\frac{l}{k}\right)_1$$

$$p = \frac{\delta}{R\left[\frac{1}{E_o}\left(\frac{r_o^2 + R^2}{r_o^2 - R^2} + \nu_o\right) + \frac{1}{E_i}\left(\frac{R^2 + r_i^2}{R^2 - r_i^2} - \nu_i\right)\right]}$$

$$p = \frac{E\delta}{2R^3}\left[\frac{(r_o^2 - R^2)(R^2 - r_i^2)}{r_o^2 - r_i^2}\right]$$

$$(\sigma_t)_i\Big|_{r=R} = -p\frac{R^2 + r_i^2}{R^2 - r_i^2}$$

$$(\sigma_t)_o\Big|_{r=R} = p\frac{r_o^2 + R^2}{r_o^2 - R^2}$$

$$\sigma_t = \frac{p_i r_i^2 - p_o r_o^2 - r_i^2 r_o^2 (p_o - p_i)/r^2}{r_o^2 - r_i^2}$$

$$\sigma_r = \frac{p_i r_i^2 - p_o r_o^2 + r_i^2 r_o^2 (p_o - p_i)/r^2}{r_o^2 - r_i^2}$$

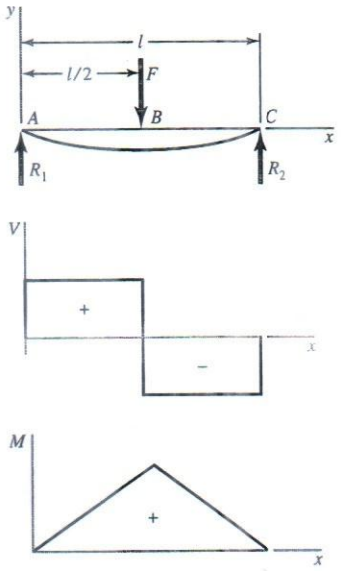
$$\sigma_t = \rho\omega^2\left(\frac{3+\nu}{8}\right)\left(r_i^2 + r_o^2 + \frac{r_i^2 r_o^2}{r^2} - \frac{1+3\nu}{3+\nu}r^2\right)$$

$$\sigma_r = \rho\omega^2\left(\frac{3+\nu}{8}\right)\left(r_i^2 + r_o^2 - \frac{r_i^2 r_o^2}{r^2} - r^2\right)$$

Table A–9

Shear, Moment, and Deflection of Beams (*Note:* Force and moment reactions are positive in the directions shown; equations for shear force V and bending moment M follow the sign conventions given in Sec. 3–2.) (*Continued*)

5 Simple supports—center load



$$R_1 = R_2 = \frac{F}{2}$$

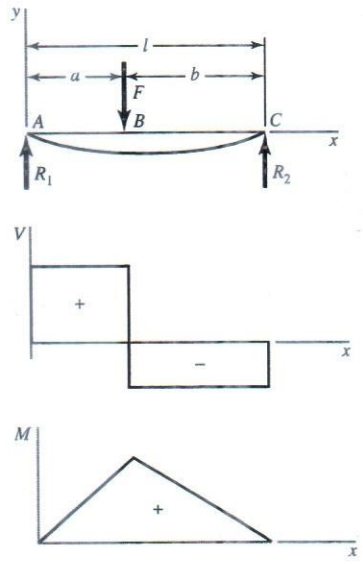
$$V_{AB} = R_1 \qquad V_{BC} = -R_2$$

$$M_{AB} = \frac{Fx}{2} \qquad M_{BC} = \frac{F}{2}(l - x)$$

$$y_{AB} = \frac{Fx}{48EI}(4x^2 - 3l^2)$$

$$y_{\max} = -\frac{Fl^3}{48EI}$$

6 Simple supports—intermediate load



$$R_1 = \frac{Fb}{l} \qquad R_2 = \frac{Fa}{l}$$

$$V_{AB} = R_1 \qquad V_{BC} = -R_2$$

$$M_{AB} = \frac{Fbx}{l} \qquad M_{BC} = \frac{Fa}{l}(l - x)$$

$$y_{AB} = \frac{Fbx}{6EIl}(x^2 + b^2 - l^2)$$

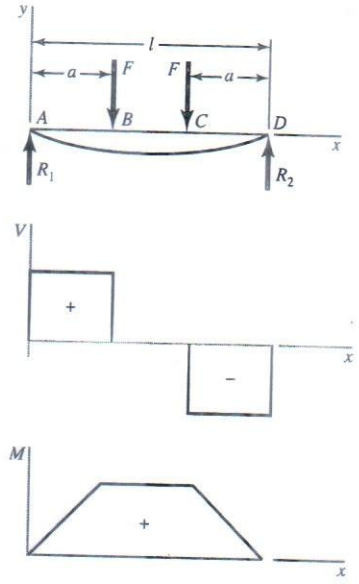
$$y_{BC} = \frac{Fa(l - x)}{6EIl}(x^2 + a^2 - 2lx)$$

(*Continued*)

Table A–9

Shear, Moment, and Deflection of Beams (*Note:* Force and moment reactions are positive in the directions shown; equations for shear force V and bending moment M follow the sign conventions given in Sec. 3–2.) (*Continued*)

9 Simple supports—twin loads



$$R_1 = R_2 = F \qquad V_{AB} = F \qquad V_{BC} = 0$$

$$V_{CD} = -F$$

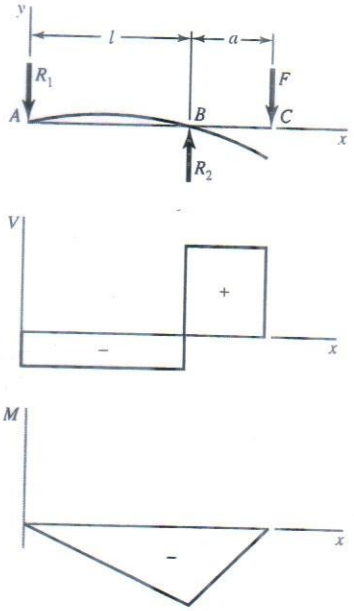
$$M_{AB} = Fx \qquad M_{BC} = Fa \qquad M_{CD} = F(l - x)$$

$$y_{AB} = \frac{Fx}{6EI}(x^2 + 3a^2 - 3la)$$

$$y_{BC} = \frac{Fa}{6EI}(3x^2 + a^2 - 3lx)$$

$$y_{\max} = \frac{Fa}{24EI}(4a^2 - 3l^2)$$

10 Simple supports—overhanging load



$$R_1 = \frac{Fa}{l} \qquad R_2 = \frac{F}{l}(l + a)$$

$$V_{AB} = -\frac{Fa}{l} \qquad V_{BC} = F$$

$$M_{AB} = -\frac{Fax}{l} \qquad M_{BC} = F(x - l - a)$$

$$y_{AB} = \frac{Fax}{6EIl}(l^2 - x^2)$$

$$y_{BC} = \frac{F(x - l)}{6EI}[(x - l)^2 - a(3x - l)]$$

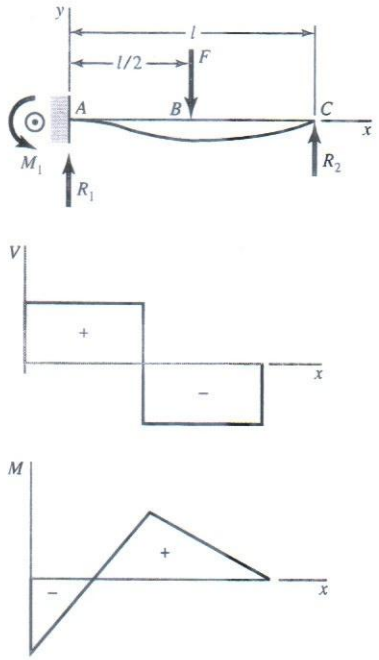
$$y_c = -\frac{Fa^2}{3EI}(l + a)$$

(*Continued*)

Table A–9

Shear, Moment, and Deflection of Beams (*Note:* Force and moment reactions are positive in the directions shown; equations for shear force V and bending moment M follow the sign conventions given in Sec. 3–2.) (*Continued*)

11 One fixed and one simple support—center load



$$R_1 = \frac{11F}{16} \qquad R_2 = \frac{5F}{16} \qquad M_1 = \frac{3Fl}{16}$$

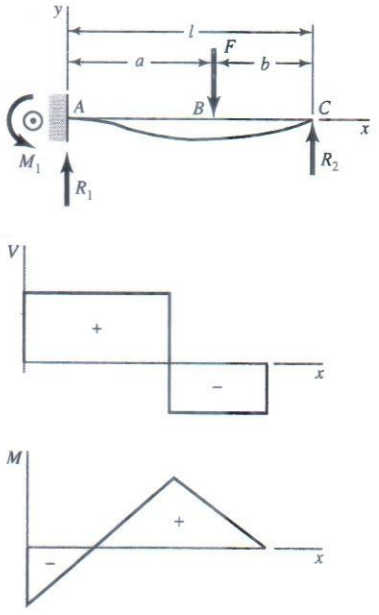
$$V_{AB} = R_1 \qquad V_{BC} = -R_2$$

$$M_{AB} = \frac{F}{16}(11x - 3l) \qquad M_{BC} = \frac{5F}{16}(l - x)$$

$$y_{AB} = \frac{Fx^2}{96EI}(11x - 9l)$$

$$y_{BC} = \frac{F(l - x)}{96EI}(5x^2 + 2l^2 - 10lx)$$

12 One fixed and one simple support—intermediate load



$$R_1 = \frac{Fb}{2l^3}(3l^2 - b^2) \qquad R_2 = \frac{Fa^2}{2l^3}(3l - a)$$

$$M_1 = \frac{Fb}{2l^2}(l^2 - b^2)$$

$$V_{AB} = R_1 \qquad V_{BC} = -R_2$$

$$M_{AB} = \frac{Fb}{2l^3}[b^2l - l^3 + x(3l^2 - b^2)]$$

$$M_{BC} = \frac{Fa^2}{2l^3}(3l^2 - 3lx - al + ax)$$

$$y_{AB} = \frac{Fbx^2}{12EIl^3}[3l(b^2 - l^2) + x(3l^2 - b^2)]$$

$$y_{BC} = y_{AB} - \frac{F(x - a)^3}{6EI}$$

Table A–17

Preferred Sizes and Renard (R-Series) Numbers
(When a choice can be made, use one of these sizes; however, not all parts or items are available in all the sizes shown in the table.)

Fraction of Inches

$\frac{1}{64}$, $\frac{1}{32}$, $\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$, $\frac{9}{16}$, $\frac{5}{8}$, $\frac{11}{16}$, $\frac{3}{4}$, $\frac{7}{8}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, 2, $2\frac{1}{4}$, $2\frac{1}{2}$, $2\frac{3}{4}$, 3, $3\frac{1}{4}$, $3\frac{1}{2}$, $3\frac{3}{4}$, 4, $4\frac{1}{4}$, $4\frac{1}{2}$, $4\frac{3}{4}$, 5, $5\frac{1}{4}$, $5\frac{1}{2}$, $5\frac{3}{4}$, 6, $6\frac{1}{2}$, 7, $7\frac{1}{2}$, 8, $8\frac{1}{2}$, 9, $9\frac{1}{2}$, 10, $10\frac{1}{2}$, 11, $11\frac{1}{2}$, 12, $12\frac{1}{2}$, 13, $13\frac{1}{2}$, 14, $14\frac{1}{2}$, 15, $15\frac{1}{2}$, 16, $16\frac{1}{2}$, 17, $17\frac{1}{2}$, 18, $18\frac{1}{2}$, 19, $19\frac{1}{2}$, 20

Decimal Inches

0.010, 0.012, 0.016, 0.020, 0.025, 0.032, 0.040, 0.05, 0.06, 0.08, 0.10, 0.12, 0.16, 0.20, 0.24, 0.30, 0.40, 0.50, 0.60, 0.80, 1.00, 1.20, 1.40, 1.60, 1.80, 2.0, 2.4, 2.6, 2.8, 3.0, 3.2, 3.4, 3.6, 3.8, 4.0, 4.2, 4.4, 4.6, 4.8, 5.0, 5.2, 5.4, 5.6, 5.8, 6.0, 7.0, 7.5, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5, 16.0, 16.5, 17.0, 17.5, 18.0, 18.5, 19.0, 19.5, 20

Millimeters

0.05, 0.06, 0.08, 0.10, 0.12, 0.16, 0.20, 0.25, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 1.0, 1.1, 1.2, 1.4, 1.5, 1.6, 1.8, 2.0, 2.2, 2.5, 2.8, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 8.0, 9.0, 10, 11, 12, 14, 16, 18, 20, 22, 25, 28, 30, 32, 35, 40, 45, 50, 60, 80, 100, 120, 140, 160, 180, 200, 250, 300

Renard Numbers*

1st choice, R5: 1, 1.6, 2.5, 4, 6.3, 10

2d choice, R10: 1.25, 2, 3.15, 5, 8

3d choice, R20: 1.12, 1.4, 1.8, 2.24, 2.8, 3.55, 4.5, 5.6, 7.1, 9

4th choice, R40: 1.06, 1.18, 1.32, 1.5, 1.7, 1.9, 2.12, 2.36, 2.65, 3, 3.35, 3.75, 4.25, 4.75, 5.3, 6, 6.7, 7.5, 8.5, 9.5

*May be multiplied or divided by powers of 10.

Table A–3

Optional SI Units for Bending Stress $\sigma = Mc/I$, Torsion Stress $\tau = Tr/J$, Axial Stress $\sigma = F/A$, and Direct Shear Stress $\tau = F/A$

Bending and Torsion				Axial and Direct Shear		
M, T	I, J	c, r	σ, τ	F	A	σ, τ
N · m*	m^4	m	Pa	N*	m^2	Pa
N · m	cm^4	cm	MPa (N/mm^2)	N†	mm^2	MPa (N/mm^2)
N · m†	mm^4	mm	GPa	kN	m^2	kPa
kN · m	cm^4	cm	GPa	kN†	mm^2	GPa
N · mm†	mm^4	mm	MPa (N/mm^2)			

*Basic relation.

†Often preferred.

Table A–4

Optional SI Units for Bending Deflection $y = f(Fl^3/EI)$ or $y = f(wl^4/EI)$ and Torsional Deflection $\theta = Tl/GJ$

Bending Deflection					Torsional Deflection				
F, w	l	I	E	y	T	l	J	G	θ
N*	m	m^4	Pa	m	N · m*	m	m^4	Pa	rad
kN†	mm	mm^4	GPa	mm	N · m†	mm	mm^4	GPa	rad
kN	m	m^4	GPa	μm	N · mm	mm	mm^4	MPa (N/mm^2)	rad
N	mm	mm^4	kPa	m	N · m	cm	cm^4	MPa (N/mm^2)	rad

*Basic relation.

†Often preferred.

Table A–5

Physical Constants of Materials

Material	Modulus of Elasticity E		Modulus of Rigidity G		Poisson's Ratio ν	Unit Weight w		
	Mpsi	GPa	Mpsi	GPa		lbf/in^3	lbf/ft^3	kN/m^3
Aluminum (all alloys)	10.4	71.7	3.9	26.9	0.333	0.098	169	26.6
Beryllium copper	18.0	124.0	7.0	48.3	0.285	0.297	513	80.6
Brass	15.4	106.0	5.82	40.1	0.324	0.309	534	83.8
Carbon steel	30.0	207.0	11.5	79.3	0.292	0.282	487	76.5
Cast iron (gray)	14.5	100.0	6.0	41.4	0.211	0.260	450	70.6
Copper	17.2	119.0	6.49	44.7	0.326	0.322	556	87.3
Douglas fir	1.6	11.0	0.6	4.1	0.33	0.016	28	4.3
Glass	6.7	46.2	2.7	18.6	0.245	0.094	162	25.4
Inconel	31.0	214.0	11.0	75.8	0.290	0.307	530	83.3
Lead	5.3	36.5	1.9	13.1	0.425	0.411	710	111.5
Magnesium	6.5	44.8	2.4	16.5	0.350	0.065	112	17.6
Molybdenum	48.0	331.0	17.0	117.0	0.307	0.368	636	100.0
Monel metal	26.0	179.0	9.5	65.5	0.320	0.319	551	86.6
Nickel silver	18.5	127.0	7.0	48.3	0.322	0.316	546	85.8
Nickel steel	30.0	207.0	11.5	79.3	0.291	0.280	484	76.0
Phosphor bronze	16.1	111.0	6.0	41.4	0.349	0.295	510	80.1
Stainless steel (18-8)	27.6	190.0	10.6	73.1	0.305	0.280	484	76.0
Titanium alloys	16.5	114.0	6.2	42.4	0.340	0.160	276	43.4

Table A–20

Deterministic ASTM Minimum Tensile and Yield Strengths for Some Hot-Rolled (HR) and Cold-Drawn (CD) Steels [The strengths listed are estimated ASTM minimum values in the size range 18 to 32 mm ($\frac{3}{4}$ to $1\frac{1}{4}$ in). These strengths are suitable for use with the design factor defined in Sec. 1–10, provided the materials conform to ASTM A6 or A568 requirements or are required in the purchase specifications. Remember that a numbering system is not a specification.] *Source:* 1986 SAE Handbook, p. 2.15.

1 UNS No.	2 SAE and/or AISI No.	3 Process-ing	4 Tensile Strength, MPa (kpsi)	5 Yield Strength, MPa (kpsi)	6 Elongation in 2 in, %	7 Reduction in Area, %	8 Brinell Hardness
G10060	1006	HR	300 (43)	170 (24)	30	55	86
		CD	330 (48)	280 (41)	20	45	95
G10100	1010	HR	320 (47)	180 (26)	28	50	95
		CD	370 (53)	300 (44)	20	40	105
G10150	1015	HR	340 (50)	190 (27.5)	28	50	101
		CD	390 (56)	320 (47)	18	40	111
G10180	1018	HR	400 (58)	220 (32)	25	50	116
		CD	440 (64)	370 (54)	15	40	126
G10200	1020	HR	380 (55)	210 (30)	25	50	111
		CD	470 (68)	390 (57)	15	40	131
G10300	1030	HR	470 (68)	260 (37.5)	20	42	137
		CD	520 (76)	440 (64)	12	35	149
G10350	1035	HR	500 (72)	270 (39.5)	18	40	143
		CD	550 (80)	460 (67)	12	35	163
G10400	1040	HR	520 (76)	290 (42)	18	40	149
		CD	590 (85)	490 (71)	12	35	170
G10450	1045	HR	570 (82)	310 (45)	16	40	163
		CD	630 (91)	530 (77)	12	35	179
G10500	1050	HR	620 (90)	340 (49.5)	15	35	179
		CD	690 (100)	580 (84)	10	30	197
G10600	1060	HR	680 (98)	370 (54)	12	30	201
G10800	1080	HR	770 (112)	420 (61.5)	10	25	229
G10950	1095	HR	830 (120)	460 (66)	10	25	248

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B.Sc. Engg 6th Sem 26 August 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination — Summer Semester: A.Y. 2018-2019
Course Code: Math 4611 — Time : $1\frac{1}{2}$ Hours
Course Title : Numerical Analysis — Full Marks : 75

There are 4 (four) questions. Answering of question 1 is compulsory.
Answer any 2 (two) questions from remaining 3 (three) questions.
Assume any missing data.

1. a) The downward deflection y (m) of a cantilever beam with a uniform load w (kg/m) can be expressed as a function of x in the following equation. [13]

$$\frac{dy}{dx} = \frac{w}{24\,EI}(4x^3 - 12Lx^2 + 12L^2x)$$

Where, x = distance (m), E = the modulus of elasticity = $2\text{x}10^{11}$ Pa, I = moment of inertia = $3.25\text{x}10^{-4}$ m^4, w = 10,000 N/m, and L = length = 4 m.
If y =0 at x = 0, use this equation with Euler's method (Δx = 0.4 m) to compute the deflection from x = 0 to L. Show the results in a table.

b) Suppose that a spherical droplet of liquid evaporates at a rate that is proportional to its surface area. [12]

$$\frac{dV}{dt} = -kA$$

Where, V = volume (mm^3), t = time (min), k = the evaporation rate (mm/min), and A = surface area (mm^2). Use Euler's method to compute the volume of the droplet from t = 0 to 5 min using a step size of 0.5 min. Assume that k = 0.08mm/min and that the droplet initially has a radius of 2.5 mm. Show the results in a table.

2. a) You are designing a spherical tank (Figure 01) to hold water for a small village in a developing country. The volume of liquid it can hold can be computed as [10]

$$V = \pi h^2 \frac{[3R - h]}{3}$$

where V = volume (m^3), h = depth of water in tank (m), and
R = the tank radius (m)
If R = 3 m, what depth must the tank be filled to so that it holds 30 m^3? Use Newton-Raphson method with a starting guess of 10 m and use the stopping criterion of 4% approximate relative error.

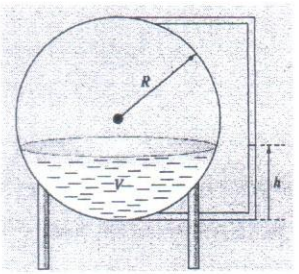


Figure 01

b) The velocity v of a falling parachutist is given by [15]

$$v = \frac{gm}{c}(1 - e^{-\frac{c}{m}t})$$

Where, v = velocity (m/s), g = 9.81 m/s^2, m = mass (kg) and c = drag coefficient (kg/s) and t = time (s).

Use bisection method to determine the drag coefficient needed so that an 82-kg parachutist has a velocity of 36 m/s after 4 s of free fall. Use initial guesses of *lower limit = 3* and *upper limit = 5* and calculate upto 5 iterations.

3. a) The deflection of a uniform beam subject to a linearly increasing distributed load can be computed as [12]

$$y = \frac{w_0}{120\,EIL}(-x^5 + 2L^2x^3 - L^4x)$$

Given that L = 600 cm, E = 50,000 kN/cm^2, I = 30,000 cm^4, and w_0 = 2.5 kN/cm, determine the point of maximum deflection using the golden-section search with initial guesses of *lower limit = 0* and *upper limit = L*. Show calculations for 5 iterations.

b) The two-dimensional distribution of pollutant concentration in a channel can be described by [13]

$c(x, y) = 7.9 + 0.13x + 0.21y - 0.05x^2 - 0.016y^2 - 0.007xy$

Determine the exact location of the peak concentration given the function. Use gradient search with an initial guess of (x,y)=(0.5,5) and with h=0.2 (h is the distance along h axis). Show the calculation for 5 iterations.

4. a) The following data define the sea-level concentration of dissolved oxygen for fresh water as a function of temperature: [13]

T, ^{0}C	0	8	16	24	32	40
O, mg/L	14.621	11.843	9.870	8.418	7.305	6.413

Use Lagrange interpolating polynomials of order 2 through 4 to estimate the concentration of dissolved oxygen at temperature of 19 ^{0}C.

b) Explain why the true error of the first derivative of the function y=f(x) gets quartered by halving the Δx in central divided difference scheme. Δx bears usual meaning. [12]

2.6

B.Sc Engg.(M)/6th Sem
HDME/6th Sem

22
19 August, 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

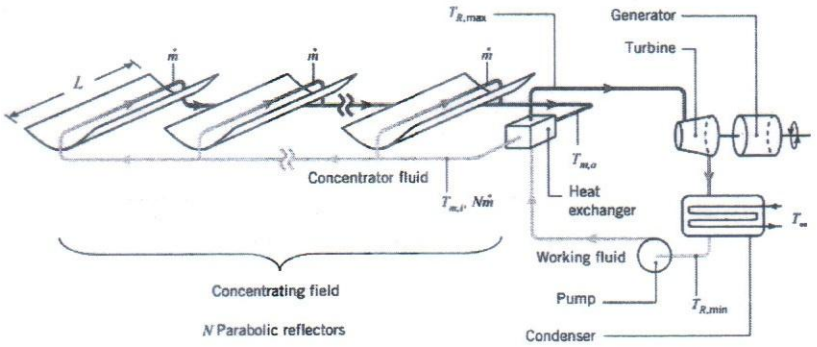
Mid Semester Examination | Summer Semester: A.Y. 2018-2019

Course No. MCE 4613 | TIME: $1\frac{1}{2}$ Hours

Course Title: Convective Heat Transfer, Phase Change and Mass Transfer | Full Marks: 75

There are 4 (Four) Questions. Answer any 3 (Three) Questions.
Marks in the Margin indicate full marks. Don't write on this question paper. Symbols carry their usual meanings. Relevant correlations are provided on a separate page with the question. Assume reasonable values for any missing data. Programmable calculators are not allowed.

1. A method to generate electric power from solar irradiation involves concentrating sunlight onto absorber tubes that are placed at the focal points of parabolic reflectors. The absorber tubes carry a liquid concentrator fluid that is heated as it flows through the tubes. After it leaves the concentrating field, the fluid enters a heat exchanger, where it transfers thermal energy to the working fluid of a Rankine cycle. The cooled concentrator fluid is returned to the concentrator field after it exits the heat exchanger. A power plant consists of many concentrators. [25]



The net effect of a single concentrator-tube arrangement may be approximated as one of creating a constant heating condition at the surface of the tube. Consider conditions for which a concentrated heat flux of $Q'' = 20{,}000$ W/m^2. , assumed to be uniform over the tube surface, heats a concentrator fluid of density, thermal conductivity, specific heat, and viscosity of $\rho = 700$ kg/m^3, $k = 0.078$ W/m.K, $c_p = 2590$ J/kg.K, and $\mu = 0.15 \times 10^{-3}$ N.s/m^2, respectively. The tube diameter is $D = 70$ mm, and the mass flow rate of the fluid in a single concentrator tube is $\dot{m} = 2.5$ kg/s.

i) If the concentrator fluid enters each tube at $T_{m,i} = 400\ ^0$C and exits at $T_{m,o} = 450\ ^0$C, what is the required concentrator length, L? How much heat q is transferred to the concentrator fluid in a single concentrator-tube arrangement?

ii) What is the surface temperature of the tube at the exit of a concentrator, $T_s(L)$?

iii) The maximum and minimum temperatures of the entire power plant are the exit temperature of the concentrator fluid $T_{m,o}$ and the ambient temperature T_∞, respectively. If a temperature difference of $\Delta T=T_{m,o} - T_{R,max}=20\ ^0C$ occurs across the heat exchanger and a second temperature difference of $\Delta T=T_{R,min}-T_\infty=20\ ^0C$ across the condenser, where $T_\infty=20\ ^0C$, determine the minimum number of concentrators N, each of length L, needed to generate P =20 MW of electric power.

2. a) Your client is interested to know the heat transfer from an arbitrary body immersed in a hot fluid and hired you as their consultant. Discuss briefly the steps you will follow to obtain the required results. Unfortunately, you don't have access to any experimental setup which would help you to measure the heat transfer. However, you have access to a wind tunnel facility. Mention any limitation you may have in your experiment. [08]

b) Explain the physical significance of the dimensionless parameters pertaining the boundary layers. [08]

c) It is observed that a 230-mm-diameter pan of water at 23°C has a mass loss rate of $1.5x10^{-5}$ kg/s when the ambient air is dry and at 23°C. [09]

i) Determine the convection mass transfer coefficient for this situation.
ii) Estimate the evaporation mass loss rate when the ambient air has a relative humidity of 50%.
iii) Estimate the evaporation mass loss rate when the water and ambient air temperatures are 47°C, assuming that the convection mass transfer coefficient remains unchanged and the ambient air is dry.

For *Saturated water vapor (T_s = 296K): v_g = 49.4 m^3/kg, (T_s = 320 K): v_g = 13.98 m^3/kg.*

3. a) Elaborate on cross-flow over a cylinder in terms of the fluid flow and heat transfer. Delineate the boundary layer formation and separation and the effect of turbulence with relevant figures. [10]

b) Mercury at 25^0C flows over a 3-m-long and 2-m-wide flat plate maintained at 75^0C with a velocity of 0.8 m/s. Determine the rate of heat transfer from the entire plate. [08]
The properties of mercury at 50°C are k = 8.83632 W/m/^{0}C, $\nu = 1.056 \times 10^{-7}$ m^2/s, Pr = 0.0223.

c) As an engineering intern, you are helping to design a pipe line network in a production facility of a pharmaceutical company. The pipe line will be used for transporting a temperature sensitive fluid, an essential ingredient for many of the pharmaceutical products the company produces. Your supervisor would like to know if there will be any temperature drop/rise for such long pipe containing this fluid as he is concerned about the quality of the products they are going to produce with aforementioned fluid. [07]
Discuss how you would calculate the temperature drop/rise, if any, in this case. Derive the mathematical formulation and draw the property diagram to show the thermodynamic process involved, if relevant.

4. a) You are designing a heat exchanger (with fixed diameter circular tubes) with the aim of obtaining a certain temperature at the outlet. How would you decide if the surface area you have considered for the heat exchanger is satisfactory to fulfill your objective and increasing the surface area further won't necessarily increase the heat transfer at a desired rate? [04]

   b) With neat figures, show the Axial temperature variations for heat transfer in a tube for (*i*) Constant surface heat flux. (*ii*) Constant surface temperature. [04]

   c) Experiments have shown that, for airflow at $T_\infty = 35°C$ and $V_1 = 100$ m/s, the rate of heat transfer from a turbine blade of characteristic length $L_1 = 0.15$ m and surface temperature $T_{s,1} = 300°C$ is $q_1 = 1500$ W. What would be the heat transfer rate from a second turbine blade of characteristic length $L_2 = 0.3$ m operating at $T_{s,2} = 400°C$ in airflow of $T_\infty = 35°C$ and $V_2 = 50$ m/s? The surface area of the blade may be assumed to be directly proportional to its characteristic length. [06]

   d) Discuss how you may obtain convection heat transfer correlation experimentally for a certain geometry. Elaborate the procedure briefly. Could you use the same correlation for convection mass transfer coefficient as well? [08]

   e) What are the advantages of non-dimensionalizing the convection equations? [03]

TABLE 7.7 Summary of convection heat transfer correlations for external flow[a,b]

Correlation		Geometry	Conditions[c]
$\delta = 5x\,Re_x^{-1/2}$	(7.19)	Flat plate	Laminar, T_f
$C_{f,x} = 0.664\,Re_x^{-1/2}$	(7.20)	Flat plate	Laminar, local, T_f
$Nu_x = 0.332\,Re_x^{1/2}\,Pr^{1/3}$	(7.23)	Flat plate	Laminar, local, T_f, $Pr \gtrsim 0.6$
$\delta_t = \delta\,Pr^{-1/3}$	(7.24)	Flat plate	Laminar, T_f
$\overline{C}_{f,x} = 1.328\,Re_x^{-1/2}$	(7.29)	Flat plate	Laminar, average, T_f
$\overline{Nu}_x = 0.664\,Re_x^{1/2}\,Pr^{1/3}$	(7.30)	Flat plate	Laminar, average, T_f, $Pr \gtrsim 0.6$
$Nu_x = 0.564\,Pe_x^{1/2}$	(7.32)	Flat plate	Laminar, local, T_f, $Pr \lesssim 0.05$, $Pe_x \gtrsim 100$
$C_{f,x} = 0.0592\,Re_x^{-1/5}$	(7.34)	Flat plate	Turbulent, local, T_f, $Re_x \lesssim 10^8$
$\delta = 0.37x\,Re_x^{-1/5}$	(7.35)	Flat plate	Turbulent, T_f, $Re_x \lesssim 10^8$

TABLE 8.4 Summary of convection correlations for flow in a circular tube[a,b,e]

$\overline{Nu}_D = 3.66 + \dfrac{0.0668\,Gz_D}{1 + 0.04\,Gz_D^{2/3}}$	(8.57)	Laminar, thermal entry (or combined entry with $Pr \gtrsim 5$), uniform T_s, $Gz_D = (D/x)\,Re_D\,Pr$
$\overline{Nu}_D = \dfrac{\dfrac{3.66}{\tanh[2.264\,Gz_D^{-1/3} + 1.7\,Gz_D^{-2/3}]} + 0.0499\,Gz_D\tanh(Gz_D^{-1})}{\tanh(2.432\,Pr^{1/6}\,Gz_D^{-1/6})}$	(8.58)	Laminar, combined entry, $Pr \gtrsim 0.1$, uniform T_s, $Gz_D = (D/x)\,Re_D\,Pr$
$\dfrac{1}{\sqrt{f}} = -2.0\log\left[\dfrac{e/D}{3.7} + \dfrac{2.51}{Re_D\sqrt{f}}\right]$	(8.20)[c]	Turbulent, fully developed
$f = (0.790\ln Re_D - 1.64)^{-2}$	(8.21)[c]	Turbulent, fully developed, smooth walls, $3000 \lesssim Re_D \lesssim 5 \times 10^6$
$Nu_D = 0.023\,Re_D^{4/5}\,Pr^n$	(8.60)[d]	Turbulent, fully developed, $0.6 \lesssim Pr \lesssim 160$, $Re_D \gtrsim 10{,}000$, $(L/D) \gtrsim 10$, $n = 0.4$ for $T_s > T_m$ and $n = 0.3$ for $T_s < T_m$
$Nu_D = 0.027\,Re_D^{4/5}\,Pr^{1/3}\left(\dfrac{\mu}{\mu_s}\right)^{0.14}$	(8.61)[d]	Turbulent, fully developed, $0.7 \lesssim Pr \lesssim 16{,}700$, $Re_D \gtrsim 10{,}000$, $L/D \gtrsim 10$
$Nu_D = \dfrac{(f/8)(Re_D - 1000)\,Pr}{1 + 12.7(f/8)^{1/2}(Pr^{2/3} - 1)}$	(8.62)[d]	Turbulent, fully developed, $0.5 \lesssim Pr \lesssim 2000$, $3000 \lesssim Re_D \lesssim 5 \times 10^6$, $(L/D) \gtrsim 10$
$Nu_D = 4.82 + 0.0185(Re_D\,Pr)^{0.827}$	(8.64)	Liquid metals, turbulent, fully developed, uniform q_s'', $3.6 \times 10^3 \lesssim Re_D \lesssim 9.05 \times 10^5$, $3 \times 10^{-3} \lesssim Pr \lesssim 5 \times 10^{-2}$, $10^2 \lesssim Re_D\,Pr \lesssim 10^4$
$Nu_D = 5.0 + 0.025(Re_D\,Pr)^{0.8}$	(8.65)	Liquid metals, turbulent, fully developed, uniform T_s, $Re_D\,Pr \gtrsim 100$

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HDME 6th Semester 26 August 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid-Semester Examination Summer Semester, A.Y. 2018-2019
Course No. Hum 4617 Time : $1^1/_2$ Hours
Course Title: Engineering Management Full Marks : 75

There are **4** (FOUR) Questions. Answer any **3** (THREE) of them.
Marks in the Margin indicate the full marks.

1	a)	Briefly explain *Efficiency* and *Effectiveness* from management perspective.	5
	b)	Define the role of a Manager. Discuss three important reasons why the managers are important at different level.	8
	c)	According to *Katz* elaborate on the critical skills a manager requires in managing. Apart from his proposition, what do you think the other important managerial skills are?	12
2	a)	Using the example of pig iron experiment, discuss the management theory proposed by Frederick W Taylor and its influence on today's managers.	10
	b)	Describe some early management examples.	7
	c)	Elaborate how did Max Weber's *Bureaucracy theory* became the structural design for many of today's large organizations.	8
3	a)	Contrast the actions of managers according to the omnipotent and symbolic views	12
	b)	Discuss the characteristics and importance of organizational culture	13
4	a)	Discuss the experiment that had a game-changing impact on management beliefs about the role of people in organizations.	8
	b)	Think yourself as a founder of a start-up technological company; discuss how your employees are going to learn the organizational culture.	10
	c)	Describe the factors that are reshaping and redefining a manager's job.	7

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B.Sc. Engg. (ME)/HDME/ 6th Sem.
BSc TE 2 year 2nd Sem

23 August 2019, Friday (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination
Course No MCE 4621 / 4691
Course Title: Machine Tools

Summer Semester, A. Y. 2018-19
Time: 1½ Hours
Full Marks: 75

There are **4 (Four)** questions. Answer any **3 (Three)** of them.

Marks in the margin indicate full marks. Do not write on this question paper.

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1. a) What do you understand by machine tools? Briefly describe classification of machine tools according to any two criteria. [12]
   b) Describe the major components of a lathe machine with appropriate sketches. [13]

2. a) Describe the major components of a milling machine with appropriate sketches. [13]
   b) Write short notes on any three of the following with appropriate figures: i) Turning ii) Back rake angle iii) Boring iv) Reaming v) Honing [12]

3. a) Write down four key requirements of clamping Describe with necessary diagram any one type of clamp with features. [12]
   b) Write down three main differences between jigs and fixtures. Describe box type jig and angle- plate fixture with figures and features. [13]

4. a) Write down the main differences between piercing and blanking. Describe the major components of a die with appropriate sketches. [12]
   b) Explain any two locating factors. Describe vee locator and drill bush locators with figures and features. [13]

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B.Sc. Engg. (ME)/HDME (6th Semester) August 29, 2019. (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination
Course No.: MCE 4627
Course Title: Tool Engineering

Summer Semester, A. Y. 2018-2019
Time: 1 Hour 30 Min(s)
Full Marks: 75

There are 4 (Four) questions. Answer any 3(Three) questions.

Marks in the margin indicate full marks. Programmable calculators are not allowed. Do not write on this question paper.

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1. a) Write down the differences in between French's model and cross's basic model used for the design process development from the designer's perspective. 10
   b) How the quality function deployment method is used to set the targets to be achieved for the engineering characteristics of a product that satisfy the customer requirements? 15

2. a) What are the different forces in metal cutting and hence explain the merchant's force circle diagram and find out the optimum shear angle value with explanation? 13
   b) Explain briefly the chip formation model and hence find out the shear strain value? 12

3. a) Explain with necessary diagram the single point tool geometry used in machining of turning operation. 10
   b) Explain the constructional details of a plain milling cutter with necessary diagram. 10
   c) How the cutting temperature in the tool-chip interface can be measured? 5

4. a) How the external and internal surface can be located for any work-piece? What should be the locating guideline and processes used in Jigs and Fixtures? 13
   b) What do you mean by Jig and Fixture? What should be the fundamentals principle for the design of a drill jigs and fixtures? 12

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ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

MID SEMESTER EXAMINATION
Course No: MCE-4653
Course Name: Air Conditioning

SUMMER SEMESTER: 2018-2019
TIME : 1HR 30 MIN
FULL MARKS: 75

There are **Four** Questions. Answer any **Three** Questions.
Assume reasonable value for missing data. Figure in the margin indicate full marks.

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1. a) Make a list of different psychrometric processes. Explain the psychrometric process of mixing air stream without condensation. Write the mass and energy balance equation for this process. (10)

   b) A cooling tower is a device that cools a spray air of water by passing it through a stream of air. If 15 m^3/s of air at 35^0C DBT and 24^0C WBT and an atmospheric pressure of 101 kPa enters the tower and the air leaves saturated at 31^0C, (i) to what temperature can this air stream cool a spray of water entering at 38^0C with a flow rate 20 kg/s and (ii) how many kilograms per second of makeup water must be added to compensate for the water that is evaporated? (15)

2. a) Write a short note on By-pass factor of cooling coil. (10)

   b) The atmospheric air at 30^0C DBT and 75% RH enters a cooling coil at the rate of 200 m^3/min. The coil dew point temperature is 14^0C with a BPF of 0.1. Determine- (i) temperature of air leaving the cooling coil; (ii) the capacity of the cooling coil in tones of refrigeration; (iii) the amount water vapor removed per minute and (iv) the sensible heat factor for the process. (15)

3. a) With the help Psychrometric chart, explain cooling and dehumidification process. Also make a mass and energy balance for this process. (10)

   b) The saturated air leaving the cooling section of an air conditioning system at 14^0C at the rate of 50 m^3/min is mixed adiabatically with the outside air at 32^0C and 60% RH at a rate of 20 m^3/min. Assuming mixing at atmospheric pressure, determine (i) the Specific Humidity, (ii) relative humidity, (iii) dry bulb temperature and (iv) volume flow rate of the mixture. (15)

4. a) Derive relationship between relative humidity and degree of saturation. (12)

   b) Find an expression for BPF of cooling and heating coil with all necessary diagrams. (13)

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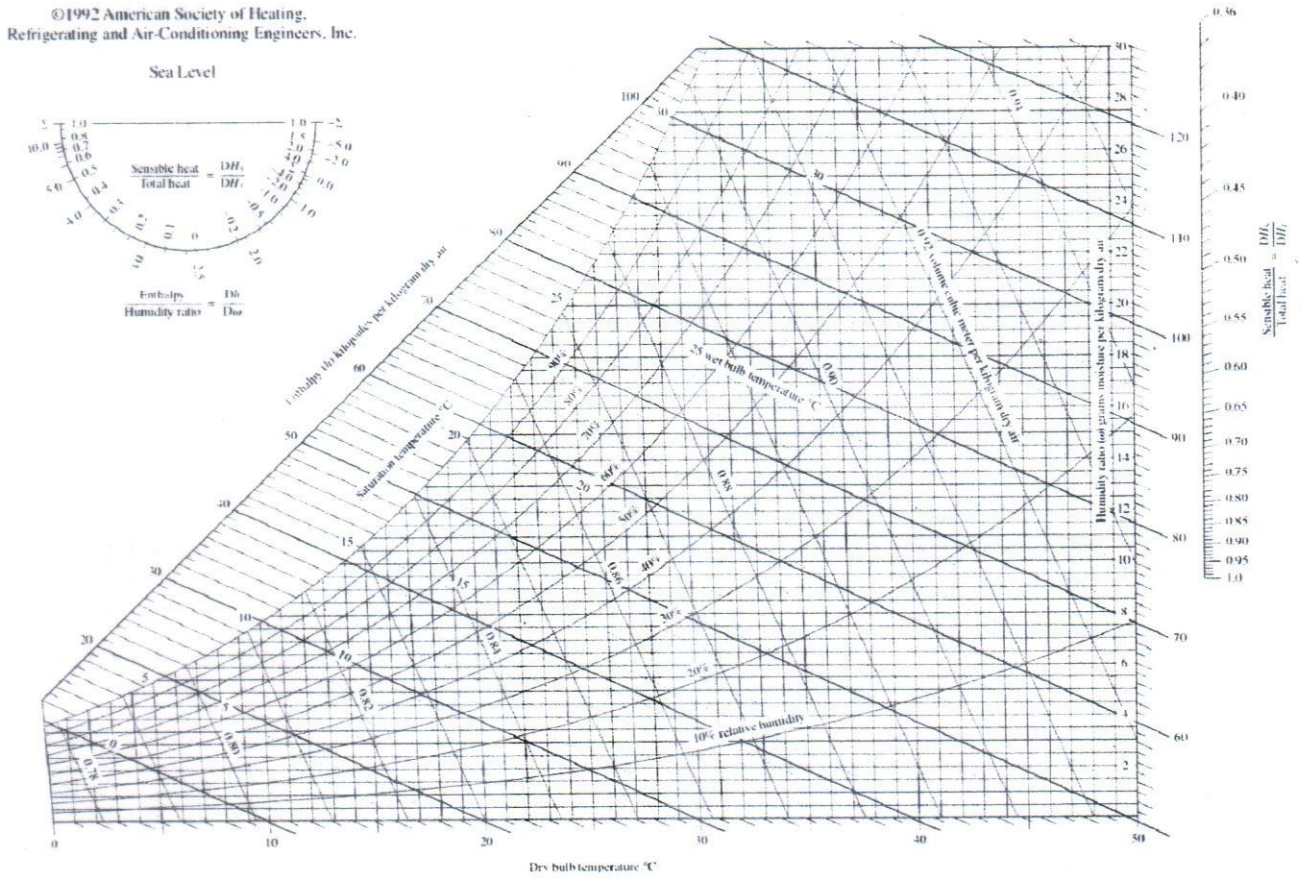
BSc. Engg. (M) 6th Semester/DTE(2nd Sem) **29 August 2019(morning)**



Saturated water—Temperature table

Temp., T °C	Sat. press., P_{sat} kPa	Specific volume, m³/kg: Sat. liquid, v_f	Specific volume, m³/kg: Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Internal energy, kJ/kg: Evap., u_{fg}	Internal energy, kJ/kg: Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Enthalpy, kJ/kg: Evap., h_{fg}	Enthalpy, kJ/kg: Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Entropy, kJ/kg·K: Evap., s_{fg}	Entropy, kJ/kg·K: Sat. vapor, s_g
0.01	0.6117	0.001000	206.00	0.000	2374.9	2374.9	0.001	2500.9	2500.9	0.0000	9.1556	9.1556
5	0.8725	0.001000	147.03	21.019	2360.8	2381.8	21.020	2489.1	2510.1	0.0763	8.9487	9.0249
10	1.2281	0.001000	106.32	42.020	2346.6	2388.7	42.022	2477.2	2519.2	0.1511	8.7488	8.8999
15	1.7057	0.001001	77.885	62.980	2332.5	2395.5	62.982	2465.4	2528.3	0.2245	8.5559	8.7803
20	2.3392	0.001002	57.762	83.913	2318.4	2402.3	83.915	2453.5	2537.4	0.2965	8.3696	8.6661
25	3.1698	0.001003	43.340	104.83	2304.3	2409.1	104.83	2441.7	2546.5	0.3672	8.1895	8.5567
30	4.2469	0.001004	32.879	125.73	2290.2	2415.9	125.74	2429.8	2555.6	0.4368	8.0152	8.4520
35	5.6291	0.001006	25.205	146.63	2276.0	2422.7	146.64	2417.9	2564.6	0.5051	7.8466	8.3517
40	7.3851	0.001008	19.515	167.53	2261.9	2429.4	167.53	2406.0	2573.5	0.5724	7.6832	8.2556
45	9.5953	0.001010	15.251	188.43	2247.7	2436.1	188.44	2394.0	2582.4	0.6386	7.5247	8.1633
50	12.352	0.001012	12.026	209.33	2233.4	2442.7	209.34	2382.0	2591.3	0.7038	7.3710	8.0748
55	15.763	0.001015	9.5639	230.24	2219.1	2449.3	230.26	2369.8	2600.1	0.7680	7.2218	7.9898
60	19.947	0.001017	7.6670	251.16	2204.7	2455.9	251.18	2357.7	2608.8	0.8313	7.0769	7.9082
65	25.043	0.001020	6.1935	272.09	2190.3	2462.4	272.12	2345.4	2617.5	0.8937	6.9360	7.8296
70	31.202	0.001023	5.0396	293.04	2175.8	2468.9	293.07	2333.0	2626.1	0.9551	6.7989	7.7540
75	38.597	0.001026	4.1291	313.99	2161.3	2475.3	314.03	2320.6	2634.6	1.0158	6.6655	7.6812
80	47.416	0.001029	3.4053	334.97	2146.6	2481.6	335.02	2308.0	2643.0	1.0756	6.5355	7.6111
85	57.868	0.001032	2.8261	355.96	2131.9	2487.8	356.02	2295.3	2651.4	1.1346	6.4089	7.5435
90	70.183	0.001036	2.3593	376.97	2117.0	2494.0	377.04	2282.5	2659.6	1.1929	6.2853	7.4782
95	84.609	0.001040	1.9808	398.00	2102.0	2500.1	398.09	2269.6	2667.6	1.2504	6.1647	7.4151
100	101.42	0.001043	1.6720	419.06	2087.0	2506.0	419.17	2256.4	2675.6	1.3072	6.0470	7.3542

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination
Course No. MCE 4663
Course Title: Automatic Control Engineering

Summer Semester, A.Y. 2018-2019
TIME : 1.5 Hours
Full Marks : 75

There are 4 (Four) Questions. Answer any 3 (Three) Questions.
Marks in the margin indicate full marks.

1. Describe the modeling of dynamic response of a Continuous Stared Thermal Reactor(CSTR) control system and express the model in block diagram form. Why and how time lag is considered in this case? 25

2. a) The block diagram of a feed back control system is shown in Fig. 1. 13
-Simplify the block diagram;
-Find the characteristics equation of the transfer function
- Determine the values of K (K>0) that result in a stable close loop system.

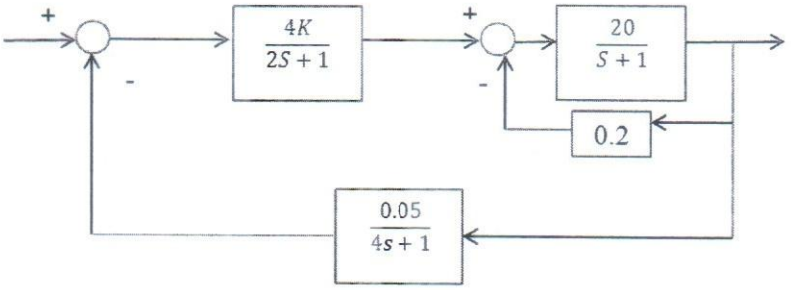


Fig. 1

b) Use the Routh stability criterion to determine the number of roots in the left half plane, right half plane and on the imaginery axis for the given characteristics equation. 12

$$s^5 + 4s^4 + 8s^3 + 8s^2 + 7s + 4 = 0$$

3. A unity-feedback system is characterized by the open-loop transfer function 25

$$G(s) = \frac{1}{s(0.5s+1)(0.2s+1)}$$

(a) Determine the steady –state errors to unit-step, unit-ramp, and unit-parabolic inputs.
(b) Determine rise time, peak time, peak overshoot, and settling time of the unit-step response of the system.

4. For a unity-feedback control system having an open loop transfer function 25

$$G(s) = \frac{k}{s(s^2+8s+32)}; \; k \geq 0$$

Make a rough sketch of the root locus plot of the system, explicitly identifying the centroid, the asymptotes, and the departure angles from complex poles of G(s) and the $\pm j\omega$ cross over points.

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BSc.Engg. ME/HDME (6th Semester) 30 August, 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination	Summer Semester : **A.Y. 2018-2019**
Course Code: **MCE 4671**	Time : **1.5 Hours**
Course Title: **Fossil Fuel Engineering**	Full Marks : **75**

There are 04 (four) Questions. Answer any 03 (three) of them.

Do not write on the Question Paper. Figures in the Margin indicate the Full Marks.

1	a)	Define Fossil Fuel. Briefly discuss its classification based on use in power generation.	07
	b)	Explain how fossil fuels are formed in nature. What are the major factors associated with the process?	10
	c)	Define heating value of a fuel. What is gross calorific value and net calorific value? How heating value of coal can be calculted?	08
2	a)	Define coal. Explain the coal formation theories in detail.	10
	b)	What are the methods of analysing coal? What information can be obtained from proximate analysis of coal? Discuss the importance of such information when considering coal as a fuel in boiler.	15
3	a)	What is coal rank? Discuss the classification of coal with its characteristics.	15
	b)	What is pulverized coal? Discuss advantages and disadvantages of using pulverized coal.	10
4	a)	What is coal mining? Briefly discuss the two major mining methods.	08
	b)	Discuss the adverse environmental impacts of surface mining.	09
	c)	Define petroleum. Discuss the characteristics of a good petroleum reservoir.	08

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ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination
Course Code: **MCE 4805/ MCE 4893**
Course Title: **Power Plant Engineering**

Summer Semester : A.Y. 2018-2019
Time : **1.5 Hours**
Full Marks : **75**

There are 04 (four) Questions. Answer any 03 (three) of them.
Do not write on the Question Paper. Figures in the Margin indicate the Full Marks.
Assume reasonable data if necessary.

---

1 a) What are the basic methods of energy conversion for power production? 03

b) Discuss irreversibility of Rankine cycle with a diagram. 04

c) In a real superheat-reheat Rankine cycle turbine, 250 kg/s steam at pressure and temperature of 15 MPa and 750 K expands to a pressure of 4.0 MPa with an isentropic efficiency of 0.92. Steam is then reheated to a temperature of 783 K, and thereafter expands further with an isentropic efficiency of 0.87 to condenser pressure of 12.15 kPa. The saturated water is then compressed to pressure 15 MPa with an isentropic compression efficiency of 0.81. Calculate the power output and the heat rate of the Rankine cycle turbine. 18

2 a) With the help of Boiling Curve, discuss the safe operating range for steam generators. 09

b) Showing the complete flow path of working fluid, briefly discuss the water and steam circuit of a boiler. 08

c) Briefly discuss about the heat recovery system of a boiler. 08

3 a) What information can be obtained by proximate analysis of coal? Discuss the effects of these information on the performance of coal power plants. 10

b) Briefly discuss different important factors for complete combustion. 08

c) Discuss about Wobbe index and Weaver flame speed factor for gaseous fuels. 07

4 a) Distinguish between pressure-atomized fuel oil burner and air- or steam-atomized fuel oil burner. 06

b) How load duration curve is constructed? Discuss base load, intermediate load and peak load power plants. 07

c) A power station has a maximum demand of 80 MW. The daily load distribution is given below. 12

Time (Hours)	0-6	6-8	8-12	12-14	14-18	18-22	22-24
Load (MW)	40	50	60	50	70	80	40

i) Draw the load curve and determine the load factor for the power station.
ii) What is the load factor of the standby equipment rated at 25 MW that take up all loads in excess of 60 MW?
iii) Find the use factor of standby equipment.

TABLE A–5

Saturated water—Pressure table

Press., P kPa	Sat. temp., T_{sat} °C	Specific volume, m³/kg: Sat. liquid, v_f	Specific volume, m³/kg: Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Internal energy, kJ/kg: Evap., u_{fg}	Internal energy, kJ/kg: Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Enthalpy, kJ/kg: Evap., h_{fg}	Enthalpy, kJ/kg: Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Entropy, kJ/kg·K: Evap., s_{fg}	Entropy, kJ/kg·K: Sat. vapor, s_g
1.0	6.97	0.001000	129.19	29.302	2355.2	2384.5	29.303	2484.4	2513.7	0.1059	8.8690	8.9749
1.5	13.02	0.001001	87.964	54.686	2338.1	2392.8	54.688	2470.1	2524.7	0.1956	8.6314	8.8270
2.0	17.50	0.001001	66.990	73.431	2325.5	2398.9	73.433	2459.5	2532.9	0.2606	8.4621	8.7227
2.5	21.08	0.001002	54.242	88.422	2315.4	2403.8	88.424	2451.0	2539.4	0.3118	8.3302	8.6421
3.0	24.08	0.001003	45.654	100.98	2306.9	2407.9	100.98	2443.9	2544.8	0.3543	8.2222	8.5765
4.0	28.96	0.001004	34.791	121.39	2293.1	2414.5	121.39	2432.3	2553.7	0.4224	8.0510	8.4734
5.0	32.87	0.001005	28.185	137.75	2282.1	2419.8	137.75	2423.0	2560.7	0.4762	7.9176	8.3938
7.5	40.29	0.001008	19.233	168.74	2261.1	2429.8	168.75	2405.3	2574.0	0.5763	7.6738	8.2501
10	45.81	0.001010	14.670	191.79	2245.4	2437.2	191.81	2392.1	2583.9	0.6492	7.4996	8.1488
15	53.97	0.001014	10.020	225.93	2222.1	2448.0	225.94	2372.3	2598.3	0.7549	7.2522	8.0071
20	60.06	0.001017	7.6481	251.40	2204.6	2456.0	251.42	2357.5	2608.9	0.8320	7.0752	7.9073
25	64.96	0.001020	6.2034	271.93	2190.4	2462.4	271.96	2345.5	2617.5	0.8932	6.9370	7.8302
30	69.09	0.001022	5.2287	289.24	2178.5	2467.7	289.27	2335.3	2624.6	0.9441	6.8234	7.7675
40	75.86	0.001026	3.9933	317.58	2158.8	2476.3	317.62	2318.4	2636.1	1.0261	6.6430	7.6691
50	81.32	0.001030	3.2403	340.49	2142.7	2483.2	340.54	2304.7	2645.2	1.0912	6.5019	7.5931

TABLE A–6

Superheated water (*Continued*)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 4.0 MPa (250.35°C)				P = 4.5 MPa (257.44°C)				P = 5.0 MPa (263.94°C)			
Sat.	0.04978	2601.7	2800.8	6.0696	0.04406	2599.7	2798.0	6.0198	0.03945	2597.0	2794.2	5.9737
275	0.05461	2668.9	2887.3	6.2312	0.04733	2651.4	2864.4	6.1429	0.04144	2632.3	2839.5	6.0571
300	0.05887	2726.2	2961.7	6.3639	0.05138	2713.0	2944.2	6.2854	0.04535	2699.0	2925.7	6.2111
350	0.06647	2827.4	3093.3	6.5843	0.05842	2818.6	3081.5	6.5153	0.05197	2809.5	3069.3	6.4516
400	0.07343	2920.8	3214.5	6.7714	0.06477	2914.2	3205.7	6.7071	0.05784	2907.5	3196.7	6.6483
450	0.08004	3011.0	3331.2	6.9386	0.07076	3005.8	3324.2	6.8770	0.06332	3000.6	3317.2	6.8210
500	0.08644	3100.3	3446.0	7.0922	0.07652	3096.0	3440.4	7.0323	0.06858	3091.8	3434.7	6.9781
600	0.09886	3279.4	3674.9	7.3706	0.08766	3276.4	3670.9	7.3127	0.07870	3273.3	3666.9	7.2605
700	0.11098	3462.4	3906.3	7.6214	0.09850	3460.0	3903.3	7.5647	0.08852	3457.7	3900.3	7.5136
800	0.12292	3650.6	4142.3	7.8523	0.10916	3648.8	4140.0	7.7962	0.09816	3646.9	4137.7	7.7458
900	0.13476	3844.8	4383.9	8.0675	0.11972	3843.3	4382.1	8.0118	0.10769	3841.8	4380.2	7.9619
1000	0.14653	4045.1	4631.2	8.2698	0.13020	4043.9	4629.8	8.2144	0.11715	4042.6	4628.3	8.1648
1100	0.15824	4251.4	4884.4	8.4612	0.14064	4250.4	4883.2	8.4060	0.12655	4249.3	4882.1	8.3566
1200	0.16992	4463.5	5143.2	8.6430	0.15103	4462.6	5142.2	8.5880	0.13592	4461.6	5141.3	8.5388
1300	0.18157	4680.9	5407.2	8.8164	0.16140	4680.1	5406.5	8.7616	0.14527	4679.3	5405.7	8.7124

TABLE A–6

Superheated water (*Concluded*)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 15.0 MPa (342.16°C)				P = 17.5 MPa (354.67°C)				P = 20.0 MPa (365.75°C)			
Sat.	0.010341	2455.7	2610.8	5.3108	0.007932	2390.7	2529.5	5.1435	0.005862	2294.8	2412.1	4.9310
350	0.011481	2520.9	2693.1	5.4438								
400	0.015671	2740.6	2975.7	5.8819	0.012463	2684.3	2902.4	5.7211	0.009950	2617.9	2816.9	5.5526
450	0.018477	2880.8	3157.9	6.1434	0.015204	2845.4	3111.4	6.0212	0.012721	2807.3	3061.7	5.9043
500	0.020828	2998.4	3310.8	6.3480	0.017385	2972.4	3276.7	6.2424	0.014793	2945.3	3241.2	6.1446
550	0.022945	3106.2	3450.4	6.5230	0.019305	3085.8	3423.6	6.4266	0.016571	3064.7	3396.2	6.3390
600	0.024921	3209.3	3583.1	6.6796	0.021073	3192.5	3561.3	6.5890	0.018185	3175.3	3539.0	6.5075
650	0.026804	3310.1	3712.1	6.8233	0.022742	3295.8	3693.8	6.7366	0.019695	3281.4	3675.3	6.6593
700	0.028621	3409.8	3839.1	6.9573	0.024342	3397.5	3823.5	6.8735	0.021134	3385.1	3807.8	6.7991
800	0.032121	3609.3	4091.1	7.2037	0.027405	3599.7	4079.3	7.1237	0.023870	3590.1	4067.5	7.0531
900	0.035503	3811.2	4343.7	7.4288	0.030348	3803.5	4334.6	7.3511	0.026484	3795.7	4325.4	7.2829
1000	0.038808	4017.1	4599.2	7.6378	0.033215	4010.7	4592.0	7.5616	0.029020	4004.3	4584.7	7.4950
1100	0.042062	4227.7	4858.6	7.8339	0.036029	4222.3	4852.8	7.7588	0.031504	4216.9	4847.0	7.6933
1200	0.045279	4443.1	5122.3	8.0192	0.038806	4438.5	5117.6	7.9449	0.033952	4433.8	5112.9	7.8802
1300	0.048469	4663.3	5390.3	8.1952	0.041556	4659.2	5386.5	8.1215	0.036371	4655.2	5382.7	8.0574

B.Sc. Engg. (ME) 8th semester/B.ScTE (I& II-YR) 22 August 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination
Course Code: MCE 4807/MCE 4895
Course Title: Mechatronics

Summer Semester, A.Y. 2018-2019
Time : 1 Hour 30 Min
Full Marks : 75

There are 4 (Four) Questions. Answer any 3 (Three) of them.
Marks in the Margin indicate the full marks.

1 a) What is Mechatronics? Explain the different elements of a Mechatronics system? 10

b) Write down the working principles of a strange gauge and hence design a load cell for the measurement of a force during turning operation of mild steel. 9

c) Explain the different features that need to be considered for the selection of measuring devices in an automated system? 6

2 a) Explain with necessary diagram the different phases for the conversion of analog data to digital data. How the number of quantization level, quantization error and quantization level spacing can be calculated? 13

b) Explain the working principle of a digital optical encoder and write down the differences with example the binary encoder and grey code encoder. 12

3 a) Write down and explain the different basic components of a programmable logic controller? Explain the different sequence followed by PLC with example when carrying out a program? 10

b) Explain with block diagram the sequential function chart method used in programming of PLC. 7

4 a) Explain the different categories for automatic identifications method and hence explain the bar code technology used for automated data capture in an automated system. 10

b) A push button emergency switch system needs to be designed for a certain automatic production machine to stop and start the motor controlled machine. A single "start" button is used to turn on the power to the motor of the machine at the beginning of the day. In addition, there are only two "stop" buttons located at different locations around the machine, any one of which can be pressed to immediately turn off power to the machine. (i) Write the truth table for this system. (ii) Write the Boolean logic expression for the system. (iii) Construct the logic network diagram for the system. 15

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BSc. Engg. (M) 8th Sem **29 August 2019 (Morning)**

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

MID SEMESTER EXAMINATION — SUMMER SEMESTER: 2018-2019

Course No: MCE 4811 — TIME : 1HR 30 MIN

Course Name: Fluid Mechanics II — FULL MARKS: 75

There are **Four** Questions. Answer any **Three** Questions.
Assume reasonable value for missing data. Figures in the margin indicate full marks.

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1. a) Consider subsonic flow in a converging nozzle with specified conditions at the nozzle inlet and critical pressure at the nozzle exit. What is the effect of dropping the back pressure well below the critical pressure on (a) the exit velocity, (b) the exit pressure, and (c) the mass flow rate through the nozzle? (12)

   b) Air enters a nozzle at 0.5 MPa, 420 K, and a velocity of 110 m/s. Approximating the flow as isentropic, determine the pressure and temperature of air at a location where the air velocity equals the speed of sound. What is the ratio of the area at this location to the entrance area? (13)

2. a) Is the sonic velocity in a specified medium a fixed quantity, or does it change as the properties of the medium change? Establish your logic through mathematical derivation. (12)

   b) The Airbus A-340 passenger plane has a maximum takeoff weight of about 260,000 kg, a length of 64 m, a wing span of 60 m, a maximum cruising speed of 945 km/h, a seating capacity of 271 passengers, a maximum cruising altitude of 14,000 m, and a maximum range of 12,000 km. The air temperature at the cruising altitude is about -60°C. Determine the Mach number of this plane for the stated limiting conditions. (13)

3. a) Derive the equation for fluid velocity variation with flow area. Explain how this equation governs the shape of a nozzle or a diffuser in subsonic, sonic or supersonic isentropic flow condition. (12)

   b) Air flowing steadily in a nozzle experiences a normal shock at a Mach number of Ma=2.6. If the pressure and temperature of air are 58 kPa and 270 K, respectively, upstream of the shock, calculate the pressure, temperature, velocity, Mach number, and stagnation pressure downstream of the shock. (13)
   Compare these results to those for helium undergoing a normal shock under the same conditions.

4. a) Explain characteristics aspects of Fanno flow using T-s chart and equations. Write the assumptions of this flow. (12)

   b) Compressed air from the compressor of a gas turbine enters the combustion chamber at T_1 =700 K, P_1= 600 kPa, and Ma_1=0.2 at a rate of 0.3 kg/s. Due to combustion, heat is transferred to the air at a rate of 150 kJ/s as it flows through the duct with negligible friction. Determine the Mach number at the duct exit, and the drop in stagnation pressure $P_{01} = P_{02}$. (13)

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The properties of air are k= 1.4 and R = 0.287 kJ/kg·K, and the properties of helium are k= 1.667 and R = 2.0769 kJ/kg·K.

Formulae:

$$\frac{T_0}{T} = 1 + \left(\frac{k-1}{2}\right)\mathrm{Ma}^2 ; \frac{P_0}{P} = \left[1 + \left(\frac{k-1}{2}\right)\mathrm{Ma}^2\right]^{k/(k-1)} ; \frac{\rho_0}{\rho} = \left[1 + \left(\frac{k-1}{2}\right)\mathrm{Ma}^2\right]^{1/(k-1)} ;$$

$$\mathrm{Ma}_2 = \sqrt{\frac{(k-1)\mathrm{Ma}_1^2 + 2}{2k\mathrm{Ma}_1^2 - k + 1}} ; \frac{T_2}{T_1} = \frac{2 + \mathrm{Ma}_1^2(k-1)}{2 + \mathrm{Ma}_2^2(k-1)} ; \frac{P_2}{P_1} = \frac{1 + k\mathrm{Ma}_1^2}{1 + k\mathrm{Ma}_2^2} ; \quad s_2 - s_1 = c_p \ln\frac{T_2}{T_1} - R\ln\frac{P_2}{P_1}$$

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

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid-Semester Examination — Summer Semester, A.Y. 2018-2019
Course No. Hum 4817 — Time : $1^1/_2$ Hours
Course Title: Industrial Management — Full Marks : 75

There are **4** (FOUR) Questions. Answer any **3** (THREE) of them.
Marks in the Margin indicate the full marks.

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1 a) Explain the main aspects of *universal values*. Briefly state the key issues of moderation as laid down in the Qur'an. 6

b) Write the key points on *team work* being demonstrated as core values at University of Malaya. 5

c) Engineering process begins with identification of problems. How to define engineering problems clearly and set objectives? Use the relevant diagram and give some befitting examples. 9

d) What dimensions are covered in industrial management? Explain briefly. 5

2 a) What is strategic planning? Point out its importance for IUT. 5

b) Draw the strategic planning model in a diagram. Briefly state the environmental scanning methodologies applied in strategic planning. 10

c) Suppose you are going to introduce a new production plant. What skills and competencies should you possess with in operating it efficiently and effectively? 10

3 a) Explain social responsibilities of a manufacturing company. 7

b) What are lean philosophy and lean manufacturing system? Why is lean system considered as a *total* system? Give convincing answer in point form. 8

c) How do you now understand the deeper meaning of waste? Explain why waste is considered against humanity. Write adequately. 10

4 a) What is decision analysis in a production plant? What is the importance of preparing a payoff table in a decision analysis? State with an example. 5

b) ABCTextile Company is going to make one of the three decisions depicted in below table. The possible market conditions along with the respective payoffs and probabilities are also mentioned. Determine the best decision using the relevant formula. 6

Decision alternative	Conditions	
	Good foreign competition	Poor foreign competition
Expand the plant	$800,000	500,000
Maintain status quo	1,300,000	(150,000)
Sell now	320,000	320,000
Probability	0.7	0.3

c) The ABC Textile Company is now considering two alternatives: to expand its existing production operation to manufacture a new line of lightweight material; or to purchase land to construct a new facility on in the future. Each of those decision has outcomes based on product market growth in the future that result in another set of decisions (during a ten-year planning horizon), as shown in the following figure of a sequential decision tree (see overleaf). In this figure the square nodes represent decisions and the circle nodes reflect different states of nature and their probabilities. Make the final decision for the company. 14

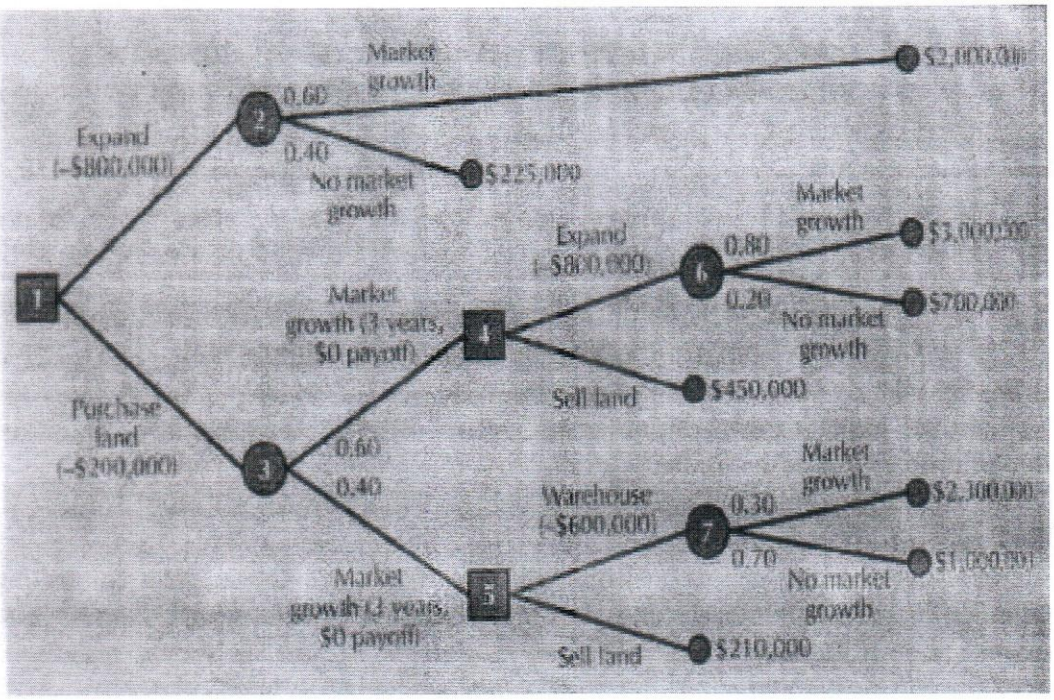

Figure Q4c)

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ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid-Semester Examination — Summer Semester, A.Y. 2018-2019
Course No. MCE 4821 — Time : $1^1/_2$ Hours
Course Title: Material Handling — Full Marks : 75

There are 4 (FOUR) Questions. Answer any 3 (THREE) of them.
Marks in the Margin indicate the full marks.

---

1 a) Distinguish between *resources management* and *material handling* in any manufacturing or service organization. 6

b) Point out the *importance* and *relevance* of material handling in today's manufacturing. Give a brief explanation on each of them. 8

c) What *activities* are covered under material handling in an organization? 6

d) What are *3Ss* in material handling? Explain briefly. 5

2 a) State the *steps* used in material handling design. 5

b) Explain the *principles* of material handling. 10

c) *Who* are responsible for material handling in a manufacturing organization and what are the *major responsibilities* of a material handling group? Write adequately. 10

3 a) The transportation model is thought of as a technique for logistic management. Describe how it might be used in material handling. 7

b) A class of transportation problems are *transshipment* problems. Explain how they differ from normal transportation problems. 5

c) A firm owns facilities at five geographically remote locations. It has manufacturing plants A and B with daily production capacities of 60 and 40 units, respectively. At point C, D and E it has warehouses with daily demands of 20, 30, and 50 units, respectively. Transportation costs per kilometer between these points are the same. Distances are shown in table below. Given that the firm wishes to minimize its total transportation costs, find an optimal solution. Show all steps in your solution. 13

From	To	km	From	To	km
A	B	200	B	D	60
A	C	68	B	E	60
A	D	90	C	D	80
A	E	50	C	E	100
B	C	40	D	E	20

4 a) Describe the traveling salesman formulation and give two examples where it is applicable. 5

b) Consider a problem of supplying some products from Tongi to Shariatpur, Kustia, Jessor, Rajshahi, Comilla, and Noakhali. Further assume that one truck can supply all warehouses before returning to Tongi while travelling a minimum distance. Say the truck driver has supplied approximate distances that are in table below: 20

From	To						
	Tongi	Shariatpur	Kustia	Jessor	Rajshahi	Comilla	Noakhali
Tongi	-	240	210	200	300	80	140
Shariatpur	240	-	100	75	105	115	145
Kustia	210	100	-	65	95	220	255
Jessor	200	75	65	-	85	185	205
Rajshahi	300	105	95	85	-	310	355
Comilla	80	115	220	185	310	-	55
Noakhali	140	145	255	205	355	55	-

Using a heuristic procedure, choose the best route to travel all these towns by the truck. Show all steps and the solution in a probable map (free hand sketch).

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B.Sc. Engg. (ME)/8th Sem. 30 August 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination — Summer Semester, A. Y. 2018-19
Course No MCE 4887 — Time: 1½ Hours
Course Title: Fundamentals of Road Vehicle Dynamics — Full Marks: 75

There are **4 (Four)** questions. Answer any **3 (Three)** of them.

Figures in the margin indicate full marks. Programmable calculators are not allowed. Do not write on this question paper. Symbols have their usual meanings. Some Formulas are provided at the end of the question.

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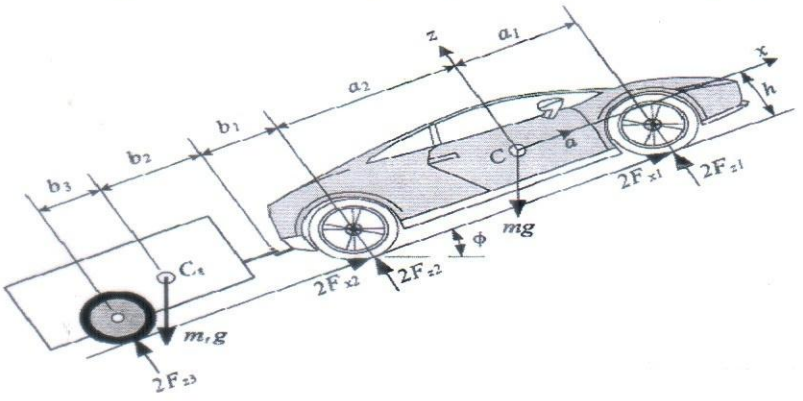
1. a) Describe basic components of a tire with appropriate figures. Write down three main differences between radial and non-radial tires. [13]
   b) Derive the equations for stopping distance and time to stop under constant deceleration condition. If a light truck weighing 3000 lb performing full stop from 60 mph on a level surface with a brake application that develops a steady brake force of 1800 lb, determine the deceleration, stopping distance and time to stop. [12]

2. a) Derive dynamic axle loads mathematical expressions for a car with a trailer attached while is moving up making an angle with acceleration. [13]
   b) A four wheel drive car is acceleration on a level road with $2m/s^2$ acceleration. Find the force at the hinge when the following information is provided. [12]
   For the car, m = 2260 kg , wheelbase, l= 2800 mm, $a_1=a_2$
   For the trailer, m_t = 500 kg, b_1= 850 mm, b_2= 1300 mm, b_3=150 mm, hinge is located at the same height of the centre of gravity of the trailer thus $h_1=h_2$



3. a) What do you understand by road loads? Briefly describe rolling resistance phenomena by mentioning hysteresis effect. A car weighing 72000 lb rolls along at a speed of 67 mph. The air temperature is 55^0F and barometric pressure is 26 inches of Mercury. It is 8 feet wide by 13.5 feet high, and has an aerodynamic drag coefficient of 0.65. The car uses radial-ply tires and assume road surface coefficient is 1 . Calculate the aerodynamic drag, the rolling resistance and the road load horsepower at these conditions. [5+8]
   b) A car is moving on a plane surface with acceleration. Its mass is 1500 kg, wheelbase is 2600 mm, distance from the road surface to the centre of gravity is 700 mm, and coefficient of friction with the road surface is 0.8. Assume distance from the centre of gravity to the front axle and rear axle is equal. Now determine the maximum acceleration if the car is four-wheel drive after equation derivation for it. [12]

4. a) Derive dynamic axle loads mathematical expressions for a car moving up on a crest in an inclined road.. [13]

   b) Write short notes on the following topics: [12]
   i) Side slip angle ii) Camber angle iii) Ackerman Angle iv) Oversteer

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Formulas:

$$\rho = 0.00236 \left(\frac{P_r}{29.92}\right) \left(\frac{519}{460 + T_r}\right)$$

$f_r = (0.0041 + 0.000041\ V)\ C_h$ **Radial tires**

$f_r = (0.0066 + 0.000046\ V)\ C_h$ **Bias-ply tires**

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

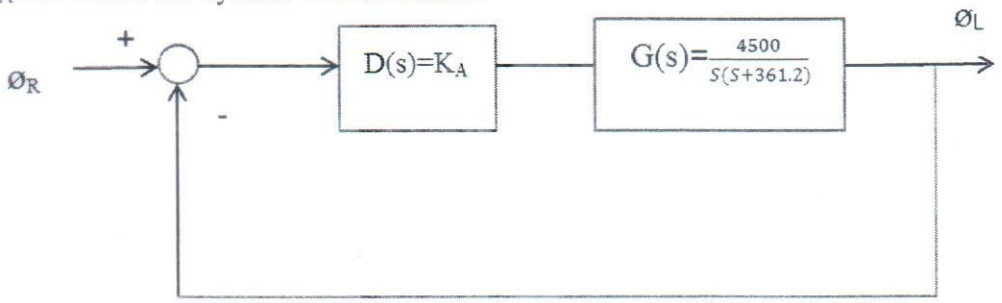
Mid Semester Examination
Course No. MCE 6161
Course Title: Advanced Control Engineering

Summer Semester, A.Y. 2018-2019
TIME : 1.5 Hours
Full Marks : 75

There are 4 (Four) Questions. Answer any 3 (Three) Questions.
Marks in the margin indicate full marks.

1. What are the sequences of math modeling? Write the preconditions for using Impulse Response Method. Describe how a simple spring-mass-damper system can be modeled using (i) State variable Method and (ii) Impulse Response Method. 25

2. a) Block diagram of a control system is given in Fig.. Calculate the amplifier gain K_A for which the system will be stable. 13



b) Explain ROUTH criterion of stability (Necessary and Sufficient). Using Routh Array analise the stability of the control system characteristics equation of which are given below. 12

$$(i)\quad s^6 + 2s^5 + 8s^4 + 2s^3 + 20s^2 + 16s + 16 = 0$$

3. a) What are the transient performance specifications, Using the example of rotating a mass with flexible shaft define the characteristics of a second order system. 15

b) What do you mean by Steady state position error constant K_p, Velocity error constant K_v and Acceleration error constant K_a? Deduce the formulas for calculation of constants K_p, K_v, and K_a. 10

4. A unity-feedback control system has an open loop transfer function 25

$$G(s) = \frac{\boldsymbol{k}}{\boldsymbol{s(s^2+8s+32)}};\ k \geq 0$$

Make a rough sketch of the root locus plot of the system, explicitly identifying the centroid, the asymptotes, and the departure angles from complex poles of G(s) and the $\pm j\omega$ cross over points.

By a trail-and-error application of the angle criterion, locate a point on the locus that gives dominant closed-loop poles with ζ=0.707. Determine the value of k at this point. Corresponding to this value of k, roughly locate the third closed-loop pole and comment upon the dominance condition.

M Sc. Eng./PhD(M) 30 August, 2019(Afternoon)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination — Summer Semester, A.Y. 2019
Course Code: Math 6103 — Time : 1½ hours
Course Title: Advanced Mathematics — Full Marks: 75

There are **4 (Four)** Questions. Answer any **3 (Three)** of them. All Questions carry equal Marks. Programmable calculators are not allowed. Do not write on this question paper. The Symbols have their usual meaning.

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1. a) Sketch andescribe the graphs of the following functions in an *xyz*-coordinate system:

(i) $f(x,y)=1-x-\frac{1}{2}y$

(*ii*) $f(x,y)=\sqrt{1-x^2-y^2}$

(*iii*) $f(x,y)=-\sqrt{x^2+y^2}$

b) (i) Identify the surface and sketch the contour plot of $f(x,y)=4x^2+y^2$ using level curves of height $k = 0, 1, 2, 3, 4, 5$.

(ii) Sketch the graph of the function $f(x,y)=x^2-y^2$ in *xyz*-space and the contour plot using level curves of with different level values.

2. a) Evaluate $\iint_R (2x-y^2)dA$; over the region R enclosed between the lines y = − x +1, y = x +1, and y =3 , using (i) type I and (ii) type II region.

b) Use double integration to find the volume of the tetrahedron bounded by the coordinate planes and the plane 3x + 2y + 4z = 12.

3. Discuss the basic idea of eigenvalues and eigenvectors. Find the eigenvalues and corresponding eigenvectors of the matrix $A=\begin{bmatrix} 5 & 4 & -1 \\ 4 & 5 & -1 \\ -4 & -4 & 2 \end{bmatrix}$; Is the matrix diagonalizable? If so, find a nonsingular matrix P that diagonalizes A, and write down the diagonal matrix D so that $P^{-1}AP = D$.

4. a) Find the directional derivative of $f(x, y, z) = x^2y - yz^3 + xy^2 z$ at the point (1,−2, 4) in the direction of the vector $\mathbf{a} = 2\mathbf{i} + \mathbf{j} - 2\mathbf{k}$. What is the magnitude and direction of maximum rate of change of $f(x, y, z)$ at this point?

b) Find parametric equations of the tangent line to the circular helix $x = \cos t$, $y = \sin t$, $z = t$ at the point where $t = \pi$.

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M.ScTE/2nd Sem 22 August, 2019 (Afternoon)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Mid Semester Examination | Summer Semester: A.Y. 2018-2019
Course No. MCE 6291 | TIME: $1\frac{1}{2}$ Hours
Course Title: Thermal Environmental Engineering | Full Marks: 75

There are 4 (Four) Questions. Answer any 3 (Three) Questions.
Marks in the Margin indicate full marks. Don't write on this question paper. Symbols carry their usual meanings. Thermodynamic property tables will be provided. Assume reasonable values for any missing data. Programmable calculators are not allowed.

1. a) With the help of a schematic diagram and property diagram, elaborate on cascade refrigeration systems. [12]

   b) Refrigerant-134a enters the compressor of a refrigerator as superheated vapor at 0.20 MPa and -5°C at a rate of 0.07 kg/s, and it leaves at 1.2 MPa and 70°C. The refrigerant is cooled in the condenser to 44°C and 1.15 MPa, and it is throttled to 0.21 MPa. Disregarding any heat transfer and pressure drops in the connecting lines between the components, show the cycle on a T-s diagram with respect to saturation lines, and determine (i) the rate of heat removal from the refrigerated space and the power input to the compressor, (ii) the isentropic efficiency of the compressor, and (iii) the COP of the refrigerator. [13]

2. a) With neat diagram, explain the working principle of vapor absorption refrigeration cycle. [13]

   b) An actual refrigerator operates on the vapor compression refrigeration cycle with refrigerant-22 as the working fluid. The refrigerant evaporates at -15°C and condenses at 40°C. The isentropic efficiency of the compressor is 83 percent. The refrigerant is superheated by 5°C at the compressor inlet and subcooled by 5°C at the exit of the condenser. Determine (i) the heat removed from the cooled space and the work input, in kJ/kg and the COP of the cycle. Determine (ii) the same parameters if the cycle operated on the ideal vapor-compression refrigeration cycle between the same evaporating and condensing temperatures. [12]

   The properties of R-22 in the case of actual operation are: $h_1 = 402.49$ kJ/kg, $h_2 = 454.00$ kJ/kg, $h_3 = 243.19$ kJ/kg.

   The properties of R-22 in the case of ideal operation are: $h_1 = 399.04$ kJ/kg, $h_2 = 440.71$ kJ/kg, $h_3 = 249.80$ kJ/kg

   Note: state 1: compressor inlet, state 2: compressor exit, state 3: condenser exit, state 4: evaporator inlet.

3. a) Draw the T-s diagram of multistage compression refrigeration systems and refrigerator-freezer unit with one compressor. [10]

   b) With the help of a schematic diagram and process drawn on psychrometric chart, discuss the following processes: i) Simple heating, ii) Heating with humidification, iii) Cooling with dehumidification [15]

4. a) If you are in a desert, what type of cooling would you recommend to avoid the high cost of cooling? Discuss briefly. [07]

   b) Show that *when two airstreams at two different states (states 1 and 2) are mixed adiabatically, the state of the mixture (state 3) lies on the straight line connecting states 1 and 2 on the psychrometric chart, and the ratio of the distances 2-3 and 3-1 is equal to the ratio of mass flow rates at 1 and 2.* [07]

   c) Saturated air leaving the cooling section of an air-conditioning system at 14^0C at a rate of 50 m^3/min is mixed adiabatically with the outside air at 32^0C and 60 percent relative humidity at a rate of 20 m^3/min. Assuming that the mixing process occurs at a pressure of 1 atm, determine the specific humidity, the relative humidity, the dry-bulb temperature, and the volume flow rate of the mixture. [11]

TABLE A–11

Saturated refrigerant-134a—Temperature table

Temp., T °C	Sat. press., P_{sat} kPa	Specific volume, m³/kg: Sat. liquid, v_f	Specific volume, m³/kg: Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Internal energy, kJ/kg: Evap., u_{fg}	Internal energy, kJ/kg: Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Enthalpy, kJ/kg: Evap., h_{fg}	Enthalpy, kJ/kg: Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Entropy, kJ/kg·K: Evap., s_{fg}	Entropy, kJ/kg·K: Sat. vapor, s_g
−40	51.25	0.0007053	0.36064	−0.036	207.42	207.38	0.00	225.86	225.86	0.00000	0.96869	0.96869
−38	56.86	0.0007082	0.32718	2.472	206.06	208.53	2.512	224.62	227.13	0.01071	0.95516	0.96588
−36	62.95	0.0007111	0.29740	4.987	204.69	209.68	5.032	223.37	228.40	0.02137	0.94182	0.96319
−34	69.56	0.0007141	0.27082	7.509	203.32	210.83	7.559	222.10	229.66	0.03196	0.92867	0.96063
−32	76.71	0.0007171	0.24706	10.04	201.94	211.97	10.09	220.83	230.93	0.04249	0.91569	0.95819
−30	84.43	0.0007201	0.22577	12.58	200.55	213.12	12.64	219.55	232.19	0.05297	0.90289	0.95586
−28	92.76	0.0007232	0.20666	15.12	199.15	214.27	15.19	218.25	233.44	0.06339	0.89024	0.95364
−26	101.73	0.0007264	0.18947	17.67	197.75	215.42	17.75	216.95	234.70	0.07376	0.87776	0.95152
−24	111.37	0.0007296	0.17398	20.23	196.34	216.57	20.31	215.63	235.94	0.08408	0.86542	0.94950
−22	121.72	0.0007328	0.15999	22.80	194.92	217.71	22.89	214.30	237.19	0.09435	0.85323	0.94758
−20	132.82	0.0007361	0.14735	25.37	193.49	218.86	25.47	212.96	238.43	0.10456	0.84119	0.94575
−18	144.69	0.0007394	0.13589	27.96	192.05	220.00	28.07	211.60	239.67	0.11473	0.82927	0.94401
−16	157.38	0.0007428	0.12550	30.55	190.60	221.15	30.67	210.23	240.90	0.12486	0.81749	0.94234
−14	170.93	0.0007463	0.11605	33.15	189.14	222.29	33.28	208.84	242.12	0.13493	0.80583	0.94076
−12	185.37	0.0007498	0.10744	35.76	187.66	223.42	35.90	207.44	243.34	0.14497	0.79429	0.93925
−10	200.74	0.0007533	0.099600	38.38	186.18	224.56	38.53	206.02	244.55	0.15496	0.78286	0.93782
−8	217.08	0.0007570	0.092438	41.01	184.69	225.69	41.17	204.59	245.76	0.16491	0.77154	0.93645
−6	234.44	0.0007607	0.085888	43.64	183.18	226.82	43.82	203.14	246.95	0.17482	0.76033	0.93514
−4	252.85	0.0007644	0.079889	46.29	181.66	227.94	46.48	201.66	248.14	0.18469	0.74921	0.93390
−2	272.36	0.0007683	0.074388	48.94	180.12	229.07	49.15	200.17	249.33	0.19452	0.73819	0.93271
0	293.01	0.0007722	0.069335	51.61	178.58	230.18	51.83	198.67	250.50	0.20432	0.72726	0.93158
2	314.84	0.0007761	0.064690	54.28	177.01	231.30	54.53	197.14	251.66	0.21408	0.71641	0.93050
4	337.90	0.0007802	0.060412	56.97	175.44	232.40	57.23	195.58	252.82	0.22381	0.70565	0.92946
6	362.23	0.0007843	0.056469	59.66	173.84	233.51	59.95	194.01	253.96	0.23351	0.69496	0.92847
8	387.88	0.0007886	0.052829	62.37	172.23	234.60	62.68	192.42	255.09	0.24318	0.68435	0.92752
10	414.89	0.0007929	0.049466	65.09	170.61	235.69	65.42	190.80	256.22	0.25282	0.67380	0.92661
12	443.31	0.0007973	0.046354	67.82	168.96	236.78	68.17	189.16	257.33	0.26243	0.66331	0.92574
14	473.19	0.0008018	0.043471	70.56	167.30	237.86	70.94	187.49	258.43	0.27201	0.65289	0.92490
16	504.58	0.0008064	0.040798	73.31	165.62	238.93	73.72	185.80	259.51	0.28157	0.64252	0.92409
18	537.52	0.0008112	0.038317	76.07	163.92	239.99	76.51	184.08	260.59	0.29111	0.63219	0.92330
20	572.07	0.0008160	0.036012	78.85	162.19	241.04	79.32	182.33	261.64	0.30062	0.62192	0.92254
22	608.27	0.0008209	0.033867	81.64	160.45	242.09	82.14	180.55	262.69	0.31012	0.61168	0.92180
24	646.18	0.0008260	0.031869	84.44	158.68	243.13	84.98	178.74	263.72	0.31959	0.60148	0.92107
26	685.84	0.0008312	0.030008	87.26	156.89	244.15	87.83	176.90	264.73	0.32905	0.59131	0.92036
28	727.31	0.0008366	0.028271	90.09	155.08	245.17	90.70	175.03	265.73	0.33849	0.58117	0.91967
30	770.64	0.0008421	0.026648	92.93	153.24	246.17	93.58	173.13	266.71	0.34792	0.57105	0.91897
32	815.89	0.0008477	0.025131	95.79	151.37	247.17	96.49	171.19	267.67	0.35734	0.56095	0.91829
34	863.11	0.0008535	0.023712	98.67	149.48	248.15	99.41	169.21	268.61	0.36675	0.55086	0.91760
36	912.35	0.0008595	0.022383	101.56	147.55	249.11	102.34	167.19	269.53	0.37615	0.54077	0.91692
38	963.68	0.0008657	0.021137	104.47	145.60	250.07	105.30	165.13	270.44	0.38554	0.53068	0.91622
40	1017.1	0.0008720	0.019968	107.39	143.61	251.00	108.28	163.03	271.31	0.39493	0.52059	0.91552
42	1072.8	0.0008786	0.018870	110.34	141.59	251.92	111.28	160.89	272.17	0.40432	0.51048	0.91480
44	1130.7	0.0008854	0.017837	113.30	139.53	252.83	114.30	158.70	273.00	0.41371	0.50036	0.91407

TABLE A–11

Saturated refrigerant-134a—Temperature table (*Concluded*)

Temp., T °C	Sat. press., P_{sat} kPa	Specific volume, m³/kg: Sat. liquid, v_f	Specific volume, m³/kg: Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Internal energy, kJ/kg: Evap., u_{fg}	Internal energy, kJ/kg: Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Enthalpy, kJ/kg: Evap., h_{fg}	Enthalpy, kJ/kg: Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Entropy, kJ/kg·K: Evap., s_{fg}	Entropy, kJ/kg·K: Sat. vapor, s_g
46	1191.0	0.0008924	0.016866	116.28	137.43	253.71	117.34	156.46	273.80	0.42311	0.49020	0.91331
48	1253.6	0.0008997	0.015951	119.28	135.30	254.58	120.41	154.17	274.57	0.43251	0.48001	0.91252
52	1386.2	0.0009151	0.014276	125.35	130.89	256.24	126.62	149.41	276.03	0.45136	0.45948	0.91084
56	1529.1	0.0009317	0.012782	131.52	126.29	257.81	132.94	144.41	277.35	0.47028	0.43870	0.90898
60	1682.8	0.0009498	0.011434	137.79	121.45	259.23	139.38	139.09	278.47	0.48930	0.41746	0.90676
65	1891.0	0.0009751	0.009959	145.80	115.06	260.86	147.64	132.05	279.69	0.51330	0.39048	0.90379
70	2118.2	0.0010037	0.008650	154.03	108.17	262.20	156.15	124.37	280.52	0.53763	0.36239	0.90002
75	2365.8	0.0010373	0.007486	162.55	100.62	263.17	165.01	115.87	280.88	0.56252	0.33279	0.89531
80	2635.3	0.0010774	0.006439	171.43	92.22	263.66	174.27	106.35	280.63	0.58812	0.30113	0.88925
85	2928.2	0.0011273	0.005484	180.81	82.64	263.45	184.11	95.39	279.51	0.61487	0.26632	0.88120
90	3246.9	0.0011938	0.004591	190.94	71.19	262.13	194.82	82.22	277.04	0.64354	0.22638	0.86991
95	3594.1	0.0012945	0.003713	202.49	56.25	258.73	207.14	64.94	272.08	0.67605	0.17638	0.85243
100	3975.1	0.0015269	0.002657	218.73	29.72	248.46	224.80	34.22	259.02	0.72224	0.09169	0.81393

Source of Data: Tables A–11 through A–13 are generated using the Engineering Equation Solver (EES) software developed by S. A. Klein and F. L. Alvarado. The routine used in calculations is the R134a, which is based on the fundamental equation of state developed by R. Tillner–Roth and H.D. Baehr, "An International Standard Formulation for the Thermodynamic Properties of 1,1,1,2-Tetrafluoroethane (HFC-134a) for temperatures from 170 K to 455 K and pressures up to 70 MPa," *J. Phys. Chem, Ref. Data*, Vol. 23, No. 5, 1994. The enthalpy and entropy values of saturated liquid are set to zero at −40°C (and −40°F).

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(1)

TABLE A–13

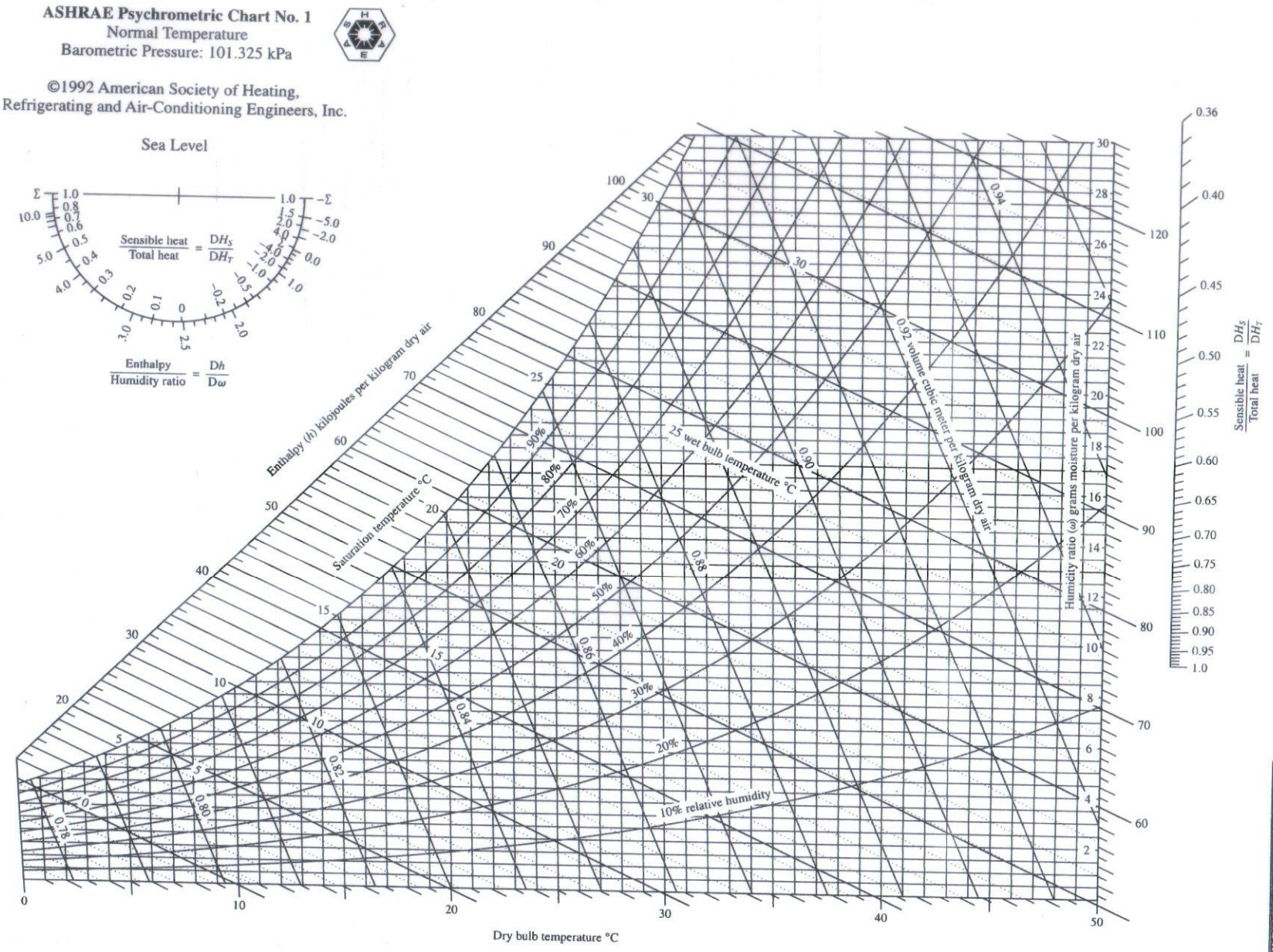
Superheated refrigerant-134a

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 0.06 MPa (T_{sat} = −36.95°C)				P = 0.10 MPa (T_{sat} = −26.37°C)				P = 0.14 MPa (T_{sat} = −18.77°C)							
Sat.	0.31108	209.13	227.80	0.9645	0.19255	215.21	234.46	0.9519	0.14020	219.56	239.19	0.9447				
−20	0.33608	220.62	240.78	1.0175	0.19841	219.68	239.52	0.9721								
−10	0.35048	227.57	248.60	1.0478	0.20743	226.77	247.51	1.0031	0.14605	225.93	246.37	0.9724				
0	0.36476	234.67	256.56	1.0775	0.21630	233.97	255.60	1.0333	0.15263	233.25	254.61	1.0032				
10	0.37893	241.94	264.68	1.1067	0.22506	241.32	263.82	1.0628	0.15908	240.68	262.95	1.0381				
20	0.39302	249.37	272.95	1.1354	0.23373	248.81	272.18	1.0919	0.16544	248.24	271.40	1.0625				
30	0.40705	256.97	281.39	1.1637	0.24233	256.46	280.69	1.1204	0.17172	255.95	279.99	1.0913				
40	0.42102	264.73	289.99	1.1916	0.25088	264.27	289.36	1.1485	0.17794	263.80	288.72	1.1196				
50	0.43495	272.66	298.75	1.2192	0.25937	272.24	298.17	1.1762	0.18412	271.81	297.59	1.1475				
60	0.44883	280.75	307.68	1.2464	0.26783	280.36	307.15	1.2036	0.19025	279.97	306.61	1.1750				
70	0.46269	289.01	316.77	1.2732	0.27626	288.65	316.28	1.2306	0.19635	288.29	315.78	1.2021				
80	0.47651	297.43	326.02	1.2998	0.28465	297.10	325.57	1.2573	0.20242	296.77	325.11	1.2289				
90	0.49032	306.02	335.43	1.3261	0.29303	305.71	335.01	1.2836	0.20847	305.40	334.59	1.2554				
100	0.50410	314.76	345.01	1.3521	0.30138	314.48	344.61	1.3097	0.21449	314.19	344.22	1.2815				
	P = 0.18 MPa (T_{sat} = −12.73°C)				P = 0.20 MPa (T_{sat} = −10.09°C)				P = 0.24 MPa (T_{sat} = −5.38°C)							
Sat.	0.11049	223.01	242.90	0.9398	0.09995	224.51	244.50	0.9379	0.08398	227.17	247.32	0.9348				
−10	0.11189	225.04	245.18	0.9485	0.09991	224.57	244.56	0.9381								
0	0.11722	232.49	253.59	0.9799	0.10481	232.11	253.07	0.9699	0.08617	231.30	251.98	0.9520				
10	0.12240	240.02	262.05	1.0103	0.10955	239.69	261.60	1.0005	0.09026	239.00	260.66	0.9832				
20	0.12748	247.66	270.60	1.0400	0.11418	247.36	270.20	1.0304	0.09423	246.76	269.38	1.0134				
30	0.13248	255.43	279.27	1.0691	0.11874	255.16	278.91	1.0596	0.09812	254.63	278.17	1.0429				
40	0.13741	263.33	288.07	1.0976	0.12322	263.09	287.74	1.0882	0.10193	262.61	287.07	1.0718				
50	0.14230	271.38	297.00	1.1257	0.12766	271.16	296.70	1.1164	0.10570	270.73	296.09	1.1002				
60	0.14715	279.58	306.07	1.1533	0.13206	279.38	305.79	1.1441	0.10942	278.98	305.24	1.1281				
70	0.15196	287.93	315.28	1.1806	0.13641	287.75	315.03	1.1714	0.11310	287.38	314.53	1.1555				
80	0.15673	296.43	324.65	1.2075	0.14074	296.27	324.41	1.1984	0.11675	295.93	323.95	1.1826				
90	0.16149	305.09	334.16	1.2340	0.14504	304.93	333.94	1.2250	0.12038	304.62	333.51	1.2093				
100	0.16622	313.90	343.82	1.2603	0.14933	313.75	343.62	1.2513	0.12398	313.46	343.22	1.2356				
	P = 0.28 MPa (T_{sat} = −1.25°C)				P = 0.32 MPa (T_{sat} = 2.46°C)				P = 0.40 MPa (T_{sat} = 8.91°C)							
Sat.	0.07243	229.49	249.77	0.9323	0.06368	231.55	251.93	0.9303	0.051266	235.10	255.61	0.9271				
0	0.07282	230.46	250.85	0.9362												
10	0.07646	238.29	259.70	0.9681	0.06609	237.56	258.70	0.9545	0.051506	235.99	256.59	0.9306				
20	0.07997	246.15	268.54	0.9987	0.06925	245.51	267.67	0.9856	0.054213	244.19	265.88	0.9628				
30	0.08338	254.08	277.42	1.0285	0.07231	253.52	276.66	1.0158	0.056796	252.37	275.09	0.9937				
40	0.08672	262.12	286.40	1.0577	0.07530	261.62	285.72	1.0452	0.059292	260.60	284.32	1.0237				
50	0.09000	270.28	295.48	1.0862	0.07823	269.83	294.87	1.0739	0.061724	268.92	293.61	1.0529				
60	0.09324	278.58	304.69	1.1143	0.08111	278.17	304.12	1.1022	0.064104	277.34	302.98	1.0814				
70	0.09644	287.01	314.01	1.1419	0.08395	286.64	313.50	1.1299	0.066443	285.88	312.45	1.1095				
80	0.09961	295.59	323.48	1.1690	0.08675	295.24	323.00	1.1572	0.068747	294.54	322.04	1.1370				
90	0.10275	304.30	333.07	1.1958	0.08953	303.99	332.64	1.1841	0.071023	303.34	331.75	1.1641				
100	0.10587	313.17	342.81	1.2223	0.09229	312.87	342.41	1.2106	0.073274	312.28	341.59	1.1908				
110	0.10897	322.18	352.69	1.2484	0.09503	321.91	352.31	1.2368	0.075504	321.35	351.55	1.2172				
120	0.11205	331.34	362.72	1.2742	0.09775	331.08	362.36	1.2627	0.077717	330.56	361.65	1.2432				
130	0.11512	340.65	372.88	1.2998	0.10045	340.41	372.55	1.2883	0.079913	339.92	371.89	1.2689				
140	0.11818	350.11	383.20	1.3251	0.10314	349.88	382.89	1.3136	0.082096	349.42	382.26	1.2943				

TABLE A–13

Superheated refrigerant-134a (*Concluded*)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 0.50 MPa (T_{sat} = 15.71°C)				P = 0.60 MPa (T_{sat} = 21.55°C)				P = 0.70 MPa (T_{sat} = 26.69°C)			
Sat.	0.041168	238.77	259.36	0.9242	0.034335	241.86	262.46	0.9220	0.029392	244.51	265.08	0.9201
20	0.042115	242.42	263.48	0.9384								
30	0.044338	250.86	273.03	0.9704	0.035984	249.24	270.83	0.9500	0.029966	247.49	268.47	0.9314
40	0.046456	259.27	282.50	1.0011	0.037865	257.88	280.60	0.9817	0.031696	256.41	278.59	0.9642
50	0.048499	267.73	291.98	1.0309	0.039659	266.50	290.30	1.0122	0.033322	265.22	288.54	0.9955
60	0.050485	276.27	301.51	1.0600	0.041389	275.17	300.00	1.0417	0.034875	274.03	298.44	1.0257
70	0.052427	284.91	311.12	1.0884	0.043069	283.91	309.75	1.0706	0.036373	282.88	308.34	1.0550
80	0.054331	293.65	320.82	1.1163	0.044710	292.74	319.57	1.0988	0.037829	291.81	318.29	1.0835
90	0.056205	302.52	330.63	1.1436	0.046318	301.69	329.48	1.1265	0.039250	300.84	328.31	1.1115
100	0.058053	311.52	340.55	1.1706	0.047900	310.75	339.49	1.1536	0.040642	309.96	338.41	1.1389
110	0.059880	320.65	350.59	1.1971	0.049458	319.93	349.61	1.1804	0.042010	319.21	348.61	1.1659
120	0.061687	329.91	360.75	1.2233	0.050997	329.24	359.84	1.2068	0.043358	328.57	358.92	1.1925
130	0.063479	339.31	371.05	1.2492	0.052519	338.69	370.20	1.2328	0.044688	338.06	369.34	1.2186
140	0.065256	348.85	381.47	1.2747	0.054027	348.26	380.68	1.2585	0.046004	347.67	379.88	1.2445
150	0.067021	358.52	392.04	1.3000	0.055522	357.98	391.29	1.2838	0.047306	357.42	390.54	1.2700
160	0.068775	368.34	402.73	1.3250	0.057006	367.83	402.03	1.3089	0.048597	367.31	401.32	1.2952
	P = 0.80 MPa (T_{sat} = 31.31°C)				P = 0.90 MPa (T_{sat} = 35.51°C)				P = 1.00 MPa (T_{sat} = 39.37°C)			
Sat.	0.025645	246.82	267.34	0.9185	0.022686	248.82	269.25	0.9169	0.020319	250.71	271.04	0.9157
40	0.027035	254.84	276.46	0.9481	0.023375	253.15	274.19	0.9328	0.020406	251.32	271.73	0.9180
50	0.028547	263.87	286.71	0.9803	0.024809	262.46	284.79	0.9661	0.021796	260.96	282.76	0.9526
60	0.029973	272.85	296.82	1.0111	0.026146	271.62	295.15	0.9977	0.023068	270.33	293.40	0.9851
70	0.031340	281.83	306.90	1.0409	0.027413	280.74	305.41	1.0280	0.024261	279.61	303.87	1.0160
80	0.032659	290.86	316.99	1.0699	0.028630	289.88	315.65	1.0574	0.025398	288.87	314.27	1.0459
90	0.033941	299.97	327.12	1.0982	0.029806	299.08	325.90	1.0861	0.026492	298.17	324.66	1.0749
100	0.035193	309.17	337.32	1.1259	0.030951	308.35	336.21	1.1141	0.027552	307.52	335.08	1.1032
110	0.036420	318.47	347.61	1.1531	0.032068	317.72	346.58	1.1415	0.028584	316.96	345.54	1.1309
120	0.037625	327.89	357.99	1.1798	0.033164	327.19	357.04	1.1684	0.029592	326.49	356.08	1.1580
130	0.038813	337.42	368.47	1.2062	0.034241	336.78	367.59	1.1949	0.030581	336.12	366.70	1.1847
140	0.039985	347.08	379.07	1.2321	0.035302	346.48	378.25	1.2211	0.031554	345.87	377.42	1.2110
150	0.041143	356.86	389.78	1.2577	0.036349	356.30	389.01	1.2468	0.032512	355.73	388.24	1.2369
160	0.042290	366.78	400.61	1.2830	0.037384	366.25	399.89	1.2722	0.033457	365.71	399.17	1.2624
170	0.043427	376.83	411.57	1.3081	0.038408	376.33	410.89	1.2973	0.034392	375.82	410.22	1.2876
180	0.044554	387.01	422.65	1.3328	0.039423	386.54	422.02	1.3221	0.035317	386.06	421.38	1.3125
	P = 1.20 MPa (T_{sat} = 46.29°C)				P = 1.40 MPa (T_{sat} = 52.40°C)				P = 1.60 MPa (T_{sat} = 57.88°C)			
Sat.	0.016728	253.84	273.92	0.9132	0.014119	256.40	276.17	0.9107	0.012134	258.50	277.92	0.9080
50	0.017201	257.64	278.28	0.9268								
60	0.018404	267.57	289.66	0.9615	0.015005	264.46	285.47	0.9389	0.012372	260.91	280.71	0.9164
70	0.019502	277.23	300.63	0.9939	0.016060	274.62	297.10	0.9733	0.013430	271.78	293.27	0.9536
80	0.020529	286.77	311.40	1.0249	0.017023	284.51	308.34	1.0056	0.014362	282.11	305.09	0.9875
90	0.021506	296.28	322.09	1.0547	0.017923	294.28	319.37	1.0364	0.015215	292.19	316.53	1.0195
100	0.022442	305.81	332.74	1.0836	0.018778	304.01	330.30	1.0661	0.016014	302.16	327.78	1.0501
110	0.023348	315.40	343.41	1.1119	0.019597	313.76	341.19	1.0949	0.016773	312.09	338.93	1.0795
120	0.024228	325.05	354.12	1.1395	0.020388	323.55	352.09	1.1230	0.017500	322.03	350.03	1.1081
130	0.025086	334.79	364.90	1.1665	0.021155	333.41	363.02	1.1504	0.018201	332.02	361.14	1.1360
140	0.025927	344.63	375.74	1.1931	0.021904	343.34	374.01	1.1773	0.018882	342.06	372.27	1.1633
150	0.026753	354.57	386.68	1.2192	0.022636	353.37	385.07	1.2038	0.019545	352.19	383.46	1.1901
160	0.027566	364.63	397.71	1.2450	0.023355	363.51	396.20	1.2298	0.020194	362.40	394.71	1.2164
170	0.028367	374.80	408.84	1.2704	0.024061	373.75	407.43	1.2554	0.020830	372.71	406.04	1.2422
180	0.029158	385.10	420.09	1.2955	0.024757	384.12	418.78	1.2808	0.021456	383.13	417.46	1.2677



Prepared by Center for Applied Thermodynamic Studies, University of Idaho.

FIGURE A–31
Psychrometric chart at 1 atm total pressure.

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