BSc. Engg. (M) 1st Sem 18 May 2019

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

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

SEMESTER FFINAL EXAMINATION Winter Semester: 2018-2019
Course No: MCE-4101 TIME : 03 HRS
Course Name: Intro. to Mechanical Engineering FULL MARKS: 100

There are **EIGHT** Questions. Answer any **SIX** Questions.
Assume reasonable value for missing data. Marks in the margin indicate full marks.

1. a) What do you mean by conventional and non-conventional energy resources? Explain the formation process of the fossilized fuel in the nature. ($8^{1}/_{3}$)
   b) Why Natural Gas is known as Clean Energy fuel? Write some benefits and precautions of using natural gas as a fuel. ($8^{1}/_{3}$)

2. a) Explain the wind and hydro cycles that turns into useful form of energy in the nature. ($8^{1}/_{3}$)
   b) Explain with necessary diagrams the mechanisms of converting solar energy into Thermal and Electrical energy. ($8^{1}/_{3}$)

3. a) Using simple diagram explain general principle of power transmission process for a front engine light automotive car. ($8^{1}/_{3}$)
   b) Why engine cooling is necessary for an automotive car and how it is done? Explain with simple diagram. ($8^{1}/_{3}$)

4. a) Briefly discuss the car ignition system? What is the firing order for four stroke engine and why it is important? ($8^{1}/_{3}$)
   b) Define turbo machines for energy transfer to and from the fluid. Classify turbomachines according to different categories. ($8^{1}/_{3}$)

5. a) What are the different hydroelectric turbines used in practice? Briefly explain on what basis the choice of hydro turbine depends. ($8^{1}/_{3}$)
   b) With a neat sketch explain the working principle of Turbo Jet engine which is used in aircraft propulsion system. ($8^{1}/_{3}$)

6. a) Show different major components of a Locomotive Boiler and explain each of their functions. ($8^{1}/_{3}$)
   b) Draw necessary diagram of a four stroke diesel engine and explain processes that takes place in different strokes. Make a comparison between the four stroke diesel and petrol engines. ($8^{1}/_{3}$)

7. a) What is a Refrigeration process? Write some applications of Refrigeration. Define the term "Ton of Refrigeration". ($8^{1}/_{3}$)
   b) Explain briefly the working principle of Vapour Compression Refrigeration system using a simple diagram. Draw the cycle on P-h diagram. ($8^{1}/_{3}$)

8. Write Short Notes on: ($5\times3^{1}/_{3}$)
   i) Pure substance
   ii) Boiler mountings and Accessories
   iii) Solar Energy
   iv) Engine lubrication system
   v) Biomass

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B.Sc. Engg. (M)/1st Sem. 16 May, 2019

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

Semester Final Examination
Course No: MCE 4103
Course Title: Engineering Mechanics

Winter Semester: A.Y. 2018-2019
TIME: 3 Hours
Full Marks: 200

There are **Eight** Questions. Answer any **Six** Questions. All questions carry equal marks.
Assume reasonable value for missing data.

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1 **(a)** An airplane starts from rest, travels ***5000 ft*** down a runway, and after uniform acceleration, takes off with a speed of ***162 mi/h***. It then climbs in a straight line with a uniform acceleration of ***3 ft/s²*** until it reaches a constant speed of ***220 mi/h***. Draw the *s–t*, *v–t*, and *a–t* graphs that describe the motion. *(1 mile =1610 m)*

(b) The projectile (***Figure 1b***) is launched with a velocity V_o. Determine the range *R*, the maximum height ***h*** attained, and the time of flight. Express the results in terms of the angle θ and V_o .The acceleration due to gravity is ***g***.

2 **(a)** At the instant (***Figure 2a***) cars ***A*** and ***B*** are traveling with speed of ***18m/s*** and ***12m/s***, respectively. Also at this instant, ***A*** has a decrease in speed of ***2m/s²***, and ***B*** has an increase in speed of ***3m/s²***. Determine the velocity and acceleration of ***B*** with respect to ***A.***

(b) Using a forked rod ***(Figure 2b)*** a smooth cylinder **C** having a mass of **0.5 kg** is forced to move along the vertical slotted path $r = 0.5\theta$ m where θ is in radians. If the angular position of the arm is $\theta = 0.5\,t^2$ rad, where *t* is in seconds, determine the force of the rod on the cylinder and the normal force of the slot on the cylinder at the instant $t = 2s$.The cylinder is in contact with only one edge of the rod and slot at any instant.

3. **(a)** The ***50-lb*** block rests on the rough surface (***Figure 3a***) for which the coefficient of kinetic friction is $\mu_k = 0.2$. A force, where ***s*** in ft, acts on the block in the direction shown. If the spring is originally upstretched ***(s=0)*** and the block is at rest, determine the power developed by the force the instant the block has moved ***s = 1.5 ft***.

(b) The ***3500 lb*** automobile shown in ***(Figure 3b)*** travels down the 10^0 inclined road at a speed of ***20ft/s***. If the driver jams on the brakes, causing his wheels to lock, determine how far ***s*** the tires skid on the road. The coefficient of kinetic friction between the wheels and the road is $\mu_k = 0.5$.

4 (a) Determine the maximum weight of the bucket ***(Figure 4a)*** that the wire system can support so that no single wire develops a tension exceeding ***100 lb***.

(b) Locate the centroid ***(x, y)*** of the composite area ***(Figure 4b).***

5 (a) Member ***AB*** has the angular motions shown in ***(Figure5a)***. Determine the angular velocity and angular acceleration of members ***CB*** and ***DC***.

(b) The large window depicted in (***Figure 5b)*** is opened using a hydraulic cylinder ***AB***. If the cylinder extends at a constant rate of ***0.5m/s***, determine the angular velocity and angular acceleration of the window at the instant $\theta = 30^0$.

6 (a) The hemisphere ***(Figure 6a)*** is formed by rotating the shaded area around the **y**-axis. Determine the moment of inertia I_y and express the result in terms of total mass **m** of the hemisphere. The material has a constant density **ρ**.

(b) Derive the rotational equation of motion which should state that the sum of the moments of all the external forces about the body's mass center ***G*** is equal to the product of the moment of inertia of the body about an axis passing through ***G*** and the body's angular acceleration (Corresponding arbitrary body is demonstrated in ***Figure 6b***).

7 (a) If the gear ***(Figure 7a)*** is released from rest, determine its angular velocity after its center of gravity ***O*** has descended a distance of ***4ft***. The gear has a weight of ***100lb*** and a radius of gyration about its center of gravity of ***k=0.75ft***.

(b) The ***700-kg*** pipe is equally suspended from the two tines of the fork lift shown in the Figure. It is undergoing a swinging motion such that when $\theta = 30^0$ it is momentarily at rest. Determine the normal and frictional forces acting on each tine which are needed to support the pipe at the instant $\theta = 0^0$. Measurements of the pipe and the suspender are shown in ***Figure7b***. Neglect the mass of the suspender and the thickness of the pipe.

8 (a) If the resultant of the four forces is $F_R = \{-360k\}$, determine the tension developed in each cable ***(Figure 8a)***. Due to symmetry, the tension in the four cables is the same.

(b) Determine the moment of inertia of the area shown in ***Figure 8b*** about the ***x*** **axis**.

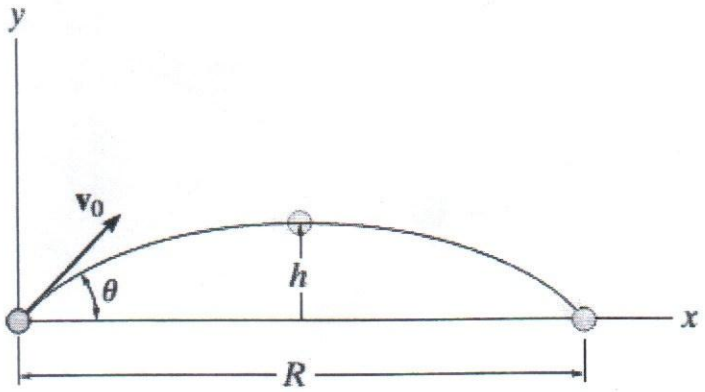

Figure 1b

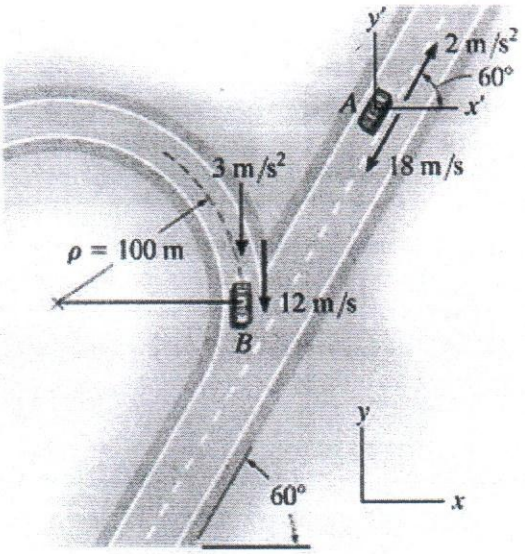

Figure 2a

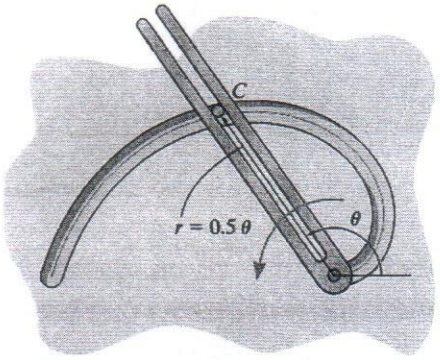

Figure 2b`

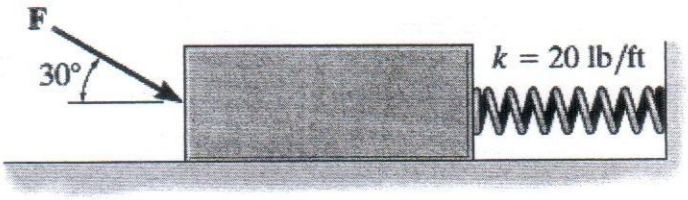

Figure 3a

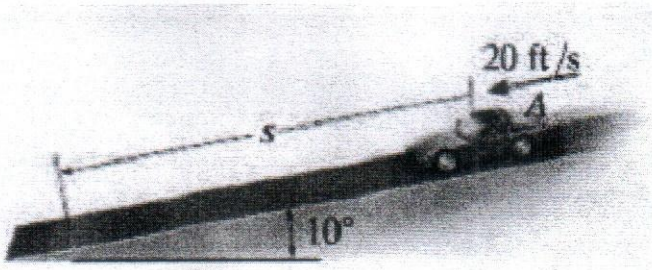

Figure 3b

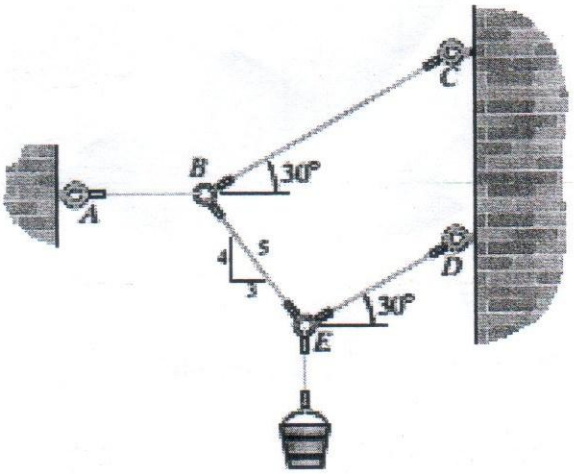

Figure 4a

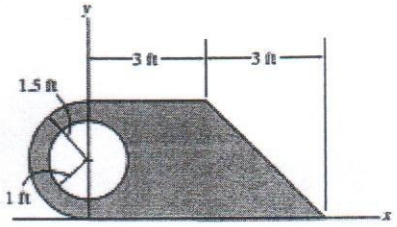

Figure 4b

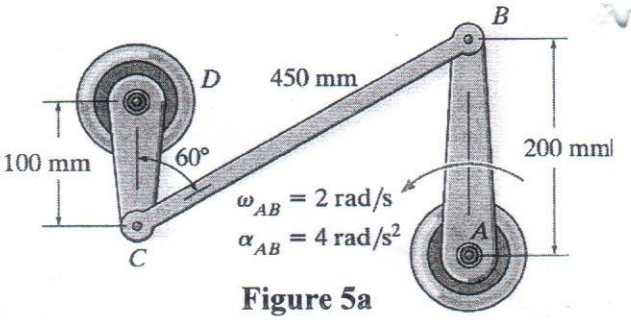

Figure 5a

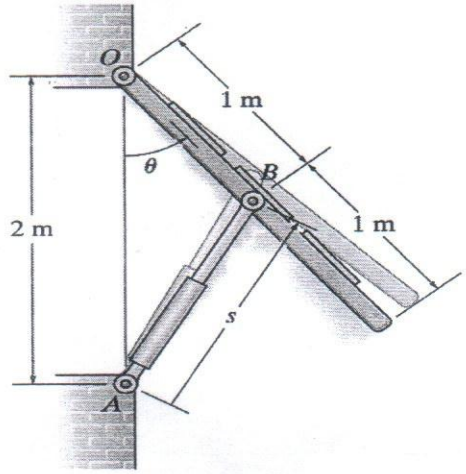

Figure5b

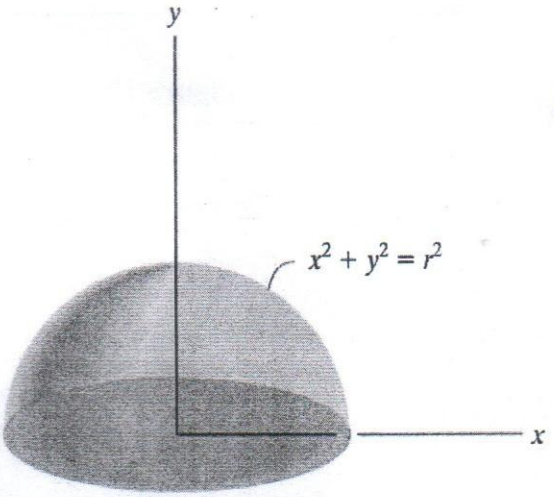

Figure 6a

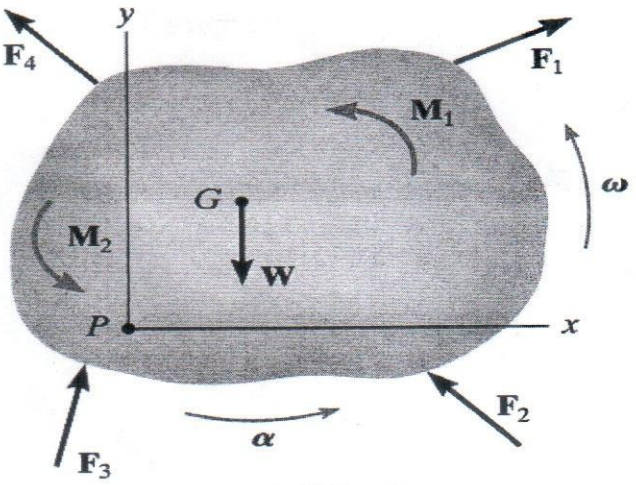

Figure 6b

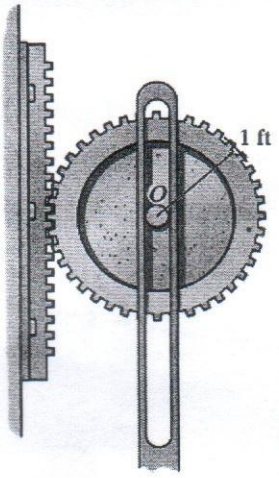

Figure 7a

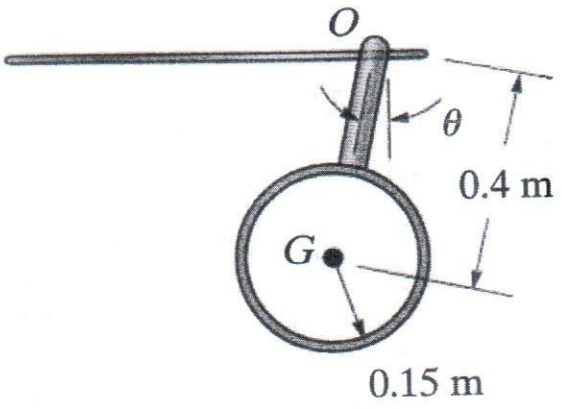

Figure-7b

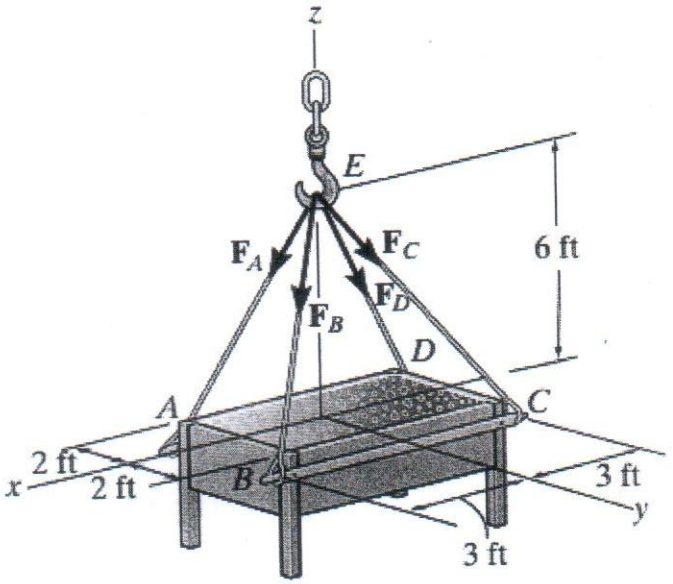

Figure-8a

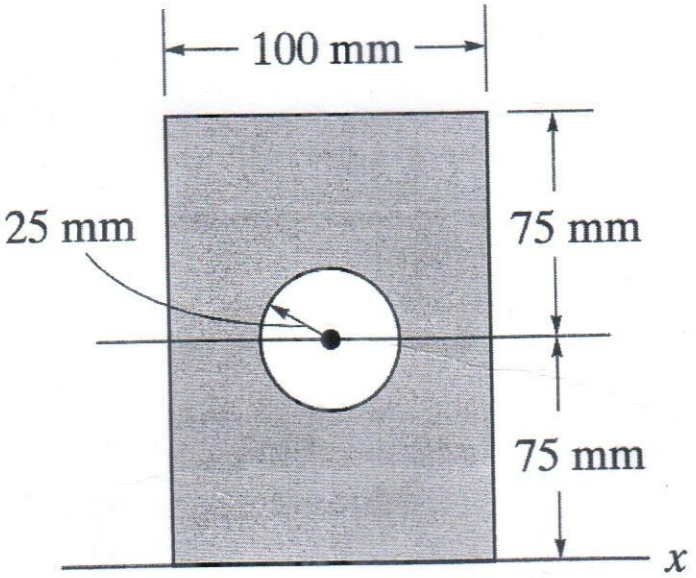

Figure-8b

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B Sc. Eng.(M)(1st Semester) 27 May, 2019

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Final Semester Examination — Winter Semester, A.Y. 2018-2019

Course Code: Math 4111 — Time : 3 hours

Course Title: Solid Geometry, Differential and Integral Calculus — Full Marks: 200

There are **8 (Eight)** Questions. Answer any **6 (Six)** 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) Fig. 01 shows the graph of a function $g(t)$ with domain [-4, 0] and range [-3, 0]. Find the domains and ranges of the following functions, and sketch their graphs.
(i) $g(-t)$ (ii) $-g(t)$ (iii) $g(t)+3$ (iv) $1-g(t)$ (v) $y\,g(-t+2)$ (vi) $g(1-t)$.

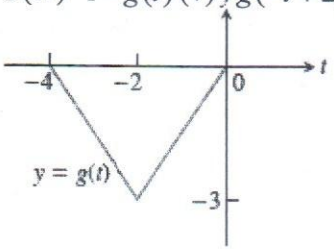

Fig: 01

b) (i) How does the fluid level rapidly drop inside a vertical cylindrical tank with radius 1 m., if you pump the fluid out at the rate of 3000 L./min?

(ii) Find the horizontal asymptotes of the graph of $f(x)=\dfrac{x^3-2}{|x|^3+1}$

2. a) (i) What is the equation of the tangent line approximation to the graph of a function f at the point $(c, f(c))$? How are linearizations used? Give examples.

(ii) Find the linearization of $f(x)=\sqrt{1+x}$ at $x=3$

b) (i) What is the difference between a relative maximum and an absolute maximum on an interval I?

(ii) Find the extrema of $f(x)=2\sin x-\cos 2x$ on the interval $[0, 2\pi]$

3. a) (i) Describe the test for Concavity in your own words.

(ii) Determine the points of inflection and discuss the concavity of the graph of $f(x)=x^4-4x^3$

b) A drainage channel is to be made so that its cross section is a trapezoid with equally sloping sides (Shown in Fig 02). If the sides and bottom all have a length of 5 ft, how should the angle θ $(0 \le \theta \le \pi/2)$ be chosen to yield the greatest cross-sectional area of the channel?

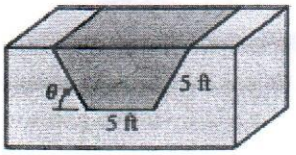

Fig. 02

4. a) (i) Which type of function can have a slant asymptote? How do you determine the equation of a slant asymptote?

(ii) Sketch the graph of $f(x)=\dfrac{x^3}{x^2+1}$

b) (i) What are the hypotheses and conclusion of Rolle's Theorem? Are the hypotheses really necessary? Explain.

(ii) When an object is removed from a furnace and placed in an environment with a constant temperature of 90° F, its core temperature is 1500° F. Five hours later the core temperature is 390° F. Explain why there must exist a time in the interval when the temperature is decreasing at a rate of 222° F per hour.

5. a) (i) Describe l'Hôpital's Rule. How do you know when to use the rule and when to stop? Give an example.

(ii) List six different indeterminate forms.

(iii) Evaluate the following limit, using L'Hôpital's Rule if necessary. $\lim_{x\to\infty}\left(2x\sin\frac{1}{x}\right)$

b) (i) What does it mean for a function F to be an antiderivative of a function f on an interval I?

(ii) Can a function have more than one antiderivative? If so, how are the antiderivatives related? Explain.

(iii) The graph of a function f is given in Fig.03. Make a rough sketch of an antiderivative F, given that $F(0) = 2$.

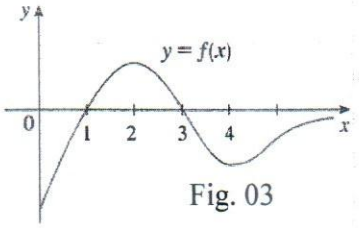

Fig. 03

6. a) (i) How can you sometimes estimate quantities like distance traveled, area, and average value with finite sums? Why might you want to do so?

(ii) Let A be the area of the region that lies under the graph of $f(x)=4-x^2$ between $x=-2$ and $x=2$. Using right endpoints with four rectangles, estimate the area of A.

b) (i) What is a Riemann sum? Why might you want to consider such a sum?

(ii) What is the Fundamental Theorem of Calculus? Why is it so important? Illustrate each part of the theorem with an example.

(iii) Consider again our analysis of a heavy rock blown straight up from the ground by a dynamite blast. The velocity of the rock at any time t during its motion was given as $v(t) = 160 - 32t$ ft/sec. (a) Find the displacement of the rock during the time period $0 \le t \le 8$. (b) Find the total distance traveled during this time period.

7. a) (i) How are the disk and washer methods for calculating volumes derived from the method of slicing? Give examples of volume calculations by these methods.

(ii) Find the volume of the solid obtained by rotating the region R enclosed by the curves $y = x$ and $y = x^2$ about the line $y = 2$.

b) (i) Find the volume of the solid obtained by rotating the region bounded by $y = x - x^2$ and $y = 0$ about the line $x = 2$, using cylindrical shell method.

(ii) A force of 40 N is required to hold a spring that has been stretched from its natural length of 10 cm to a length of 15 cm. Using the definite intregation calculate the work in stretching the spring from 15 cm to 18 cm?

8. a) Find the magnitude and equation of the shortest distance between the lines $\frac{x-3}{1}=\frac{y-5}{-2}=\frac{z-7}{1}$ and $\frac{x+1}{7}=\frac{y+1}{-6}=\frac{z-1}{1}$

Also, find the points where the line of shortest distance intersects the given lines.

b) Find the equation of the sphere having the circle $x^2+y^2+z^2+10y-4z-8=0,\ x+y+z=3$ as a great circle.

B.Sc. Engg.(M)/1nd Sem. 21 May, 2019 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Final Examination — Winter Semester 2018-2019
Course Code: Phy 4113 — Time: 3 HRS.
Course Title : Structure of Matter, Electricity & Magnetism and Modern Physics — Full Marks: 150

There are **EIGHT** Questions. Answer any **SIX** Questions.
Marks in the Margin indicate Full Marks.
Programmable calculators are not allowed. Do not write on this question paper.

1. (a) Define electric potential energy in an electric field. Derive an expression for the potential at a point on the axis of a uniformly charged circular disc whose surface charge density is σ (C/m^2). (18 + 7)
   (b) Calculate the mutual electric potential energy of the four charges $+1.0 \times 10^{-9}$, -3.0×10^{-9}, $+2.0 \times 10^{-9}$ and $+4.0 \times 10^{-9}$ C, assuming that these are situated on the four corners of a square having side length l0.0 cm in cyclic order. ($\varepsilon_o = 8.9 \times 10^{-12}$ C/N-m^2).

2. (a) Define current, current density, resistance and resistivity. What kind of parameters are they? Derive an expression for the drift speed of electrons inside a conductor in terms of electron concentration and current density, when an electric field is applied to it. (18 + 7)
   (b) The current density in a cylindrical wire of diameter 5.0 mm is uniform across the cross-section of the wire and is given by 2.5×10^5 A/m^2. What is the current through the outer portion of the wire between radial distances R/2 and R of the wire, where R is the radius of cross-section of the wire?

3. (a) Define the coefficient of self-induction and mutual induction. Obtain an expression for the self inductance of a long straight solenoid of length l, cross-sectional area A, and wound uniformly with n turns of wire per unit length, which carrying an instantaneous current I. (18 + 7)
   (b) A solenoid of 100 cm long has 10 turns/cm. Its circular cross-sectional area has a diameter of 4.0 cm. Calculate the coefficient of self-induction of the solenoid. ($\mu_o = 4\pi \times 10^{-7}$ wb/A-m and assume in the solenoid is filled with air).

4. (a) What is time dilation in special theory of relativity? Obtain an expression for relativistic time in special theory of relativity. (18 + 7)
   (b) How fast must a spacecraft travel relative to the earth for each day on the spacecraft t_o correspond to 2 days on the earth?

5. (a) Show from the special theory of relativity that massless particle can exist only if they move with the speed of light. (18 + 7)

Obtain the expressions for the velocity from the Lorentz transformation equations.

(b) Spacecraft A is moving at 0.80c with respect to the earth. If spacecraft B is to pass A at a relative speed of 0.60c in the same direction, what speed must B have with respect to the earth?

6. (a) What is radioactivity? Derive the relations for half-life and mean lifetime of a radioactive element and hence establish the relation between these two. (18 + 7)

(b) One gram of radium is reduced by 2.1 mg in 5 years by α-decay. Calculate the half-life of radium.

7. (a) What is a unit cell of a crystalline solid? Find the expressions for atomic radii of bcc and fcc crystal lattices. (10+8+7)

(b) Distinguish between conductors, semiconductors and insulators from band theory of solids.

(c) Discuss different types of semiconductors from band theory of solids.

8. Write short notes on the followings: (25/3x3=25)

(a) Charge is quantized.

(b) Pair production and annihilation.

(c) State and explain Biot-Savart law.

B.Sc.Engg (M)-1st Semester 24 May 2019 (Friday)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

SEMESTER FINAL EXAMINATION
Course No: Chem 4115
Course title: Physical and Inorganic Chemistry

WINTER SEMESTER 2018-2019
Time: 3 hours
Full Marks: 150

Programmable calculators are not allowed. Do not write anything on the question paper
There are **8(eight)** questions. Answer any **6(six)** of them
Figures in the right margin indicate full marks.

Q1. a) State and explain Henry's law. What is the effect of temperature on the solubility of gases in liquids. [10]

b) What is critical solution temperature (CST)? Draw and explain the CST diagram for the water – triethyl amine system. [10]

c) Discuss briefly hydrogen bonds with an example. [5]

Q2. a) What is energy of activation (Ea)? Derive an equation showing the relationship between temperature and rate constant (k). [10]

b) Discuss the isolation and differential methods to find the order of a reaction. [8]

c) The value of the half-life for a first order reaction is 1000 seconds. At what time $1/10^{th}$ of the reactant will remain unreacted? [7]

Q3. a) Define modern periodic table. Classify elements in terms of electronic configuration. [8]

b) Discuss the variation of properties of elements within periods and groups with reference to their (i) Ionic radii (ii) Electro negativity and (iii) Ionization potential [8]

c) What are inert gases? Discuss the uses of helium and argon. How can you prove that, helium is a mono atomic gas? [9]

Q4. a) Define heat of solution and heat of combustion with suitable examples. How can you determine the heat of combustion in a laboratory? [8]

b) Derive mathematical equation showing the effect of temperature on the heat of reaction. Name the equation. [10]

c) The heat of reaction of $N_2 + 3H_2 \rightarrow 2NH_3$ at 27^0C was found to be -21.976 kcal. What will be the heat of reaction at 50°C? The heat capacities Cp at 27°C for N_2, H_2 and NH_3 are 6.8, 6.77 and 8.86 $cal.mol^{-1}.deg^{-1}$ respectively. [7]

Q5. a) Derive a relationship between elevation of boiling point of the solvent and the molecular mass of the dissolved non-volatile solute in the solvent. [10]

b) Explain why the boiling point of a liquid rises when a non volatile solute is dissolved in it and the dissolution of gases in liquid is exothermic. [6]

c) The vapour pressure of ether at 25°C is 445mm of Hg. When 6.5gm solute is dissolved in 50gm ether, the vapour pressure of the solution is 410mm of Hg. What is the MW of the solute when the MW of ether is 74gm/mol ? [9]

Q6. a) What is Equilibrium Constant (K)? Show how the equilibrium constant (K) is related with temperature with the derivation of the mathematical equation. [10]

b) What is Buffer solution? How can it be classified? Show how Buffer solution operates in different medium. [9]

c) For the reaction $2NH_3(g) \leftrightarrow 3H_2(g) + N_2(g)$ at equilibrium, the value of Kp is 1.22×10^{-3} atm at 25°C and 2.16 atm at 225°C. Calculate ΔH for the reaction. [6]

Q7. a) Derive the integrated rate equation for a first order reaction $A \rightarrow P$ and prove that the half life for a first order reaction is independent of initial concentration. [10]

b) A first order reaction is 40% complete at the end of 50mins. What will be value of the rate constant (k)? In how many minutes will the reaction be 80% complete? [8]

c) Discuss two methods for the determination of order of a reaction. [7]

Q8. Write short notes: [5x5=25]

a) Isober and Isotope

b) Quantum Number

c) Relationship between "Kp" and "Kc"

d) Le Chatelier Principle

e) Rutherford's Atom Model

B.Sc. Eng. /1st Semester (EE) 17 May 2019

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

Semester Final Examination — Winter Semester, A.Y. 2018-2019
Course Code: Chem 4121 — Time: 3 hours
Course Title: Engineering Chemistry — Full Marks: 150

There are **8 (Eight)** Questions. Answer any **6 (Six)** of them.
Use the graph paper wherever necessary. Marks in the Margin indicate the full marks.

1 a) Define Cell and Battery. Describe the working principle of alkaline dry cell along with diagram. 8

b) What is corrosion? What are the factors accelerating the rate of corrosion? How corrosion can be controlled? 9

c) A cell is constructed by connecting a chromium and an iron electrode. The standard electrode potentials are given below. 8

$$E^0_{Cr^{3+}(aq)|Cr(s)} = 0.75\ V \quad E^0_{Fe^{2+}(aq)|Fe(s)} = -0.45\ V$$

(i) Calculate the standard cell potential. Write down the half-cell reaction and total cell reaction.

(ii) If concentration of Cr^{3+} and Fe^{2+} are 0.10M and 0.01M, calculate the cell potential at 25^0C temperature.

2 a) Define order of the reaction. Describe differential method for the determination of reaction order. 9

b) Deduce an expression showing the effect of temperature on chemical equilibrium constant. 8

c) The experimental data for the decomposition of NO_2 is given below 8

$$2NO_2(g) \Rightarrow 2NO(g) + O_2(g)$$

Time (min)	Conc. (M)
0	0.0165
10	0.0124
20	0.0093
30	0.0071
40	0.0053
50	0.0039
60	0.0029

(i) Find out the order of the reaction.

(ii) Calculate the rate constant for the decomposition of NO_2.

3 a) What is equivalent conductance? How the equivalent conductance changes with variation of concentration of solution? 8

b) State and explain Kohlrausch's law. Write at least three application of Kohlrausch's law. 10

c) Paracetamol has a pK_a of 3.5. (i) Calculate the ratio of ionized/unionized of the drug in the stomach where pH is 1. (ii) Calculate the ratio of ionized/unionized in the intestine where pH is 6. (iii)Based on these calculations- where is aspirin absorbed within the body? 7

4 a) What do you mean by colligative property? Prove that lowering of vapour pressure of dilute solution containing non-volatile solute is a colligative property. 8

b) Derive an expression relating depression of freezing point of a solution and molar mass of solute with the help of vapour pressure- temperature diagram. 10

c) Glycol ($C_nH_{2n}(OH)_2$) is a derivative of a hydrocarbon. A solution containging 1.821 g glycol per dm^{-3} has osmotic pressure 51.8 cm (Hg) at 10^0C. Calculate the molecular mass, and also determine the molecular formula of the glycol. 7

5 a) Describe the main features of Valence-Shell Electron-Pair Repulsion (VSEPR) model for predicting the shape of molecules (two, three and four electron pairs). Predict the shape of the following molecules according to VSEPR model (i) ICl_3, (ii) SO_2, (iii) XeF_4, and (iv) IF_5.. 12

b) What is hybridization? How the shaped of the molecules can be predicted from different types of hybridization? 8

c) What is ionic bond? Discuss Fajan's rule for explaining covalent character of ionic compound. 5

6 a) What is de-Broglie equation? Show that de-Broglie equation is applicable only for microscopic particle like electron. Electron has a mass = 9.10×10^{-28} g and moves with a velocity 2.188×10^{-8} cm/sec, $h = 6.625 \times 10^{-27}$ J.S. 6

b) Derive an expression applying Bohr atom model for the calculation of energy and wavelength of radiation obtained in the emission of spectrum of hydrogen. 12

c) Calculate the shortest wavelength of the electromagnetic radiation emitted by the hydrogen atom in undergoing a transition from the $n = 6$ level. Calculate the energy of the emitted photon. 7

7 a) State and explain first law of thermodynamics. Prove that at constant pressure $\mathbf{dH = q_p}$. 8

b) What is ionization energy? What are the factors affecting ionization energy? Briefly discuss them. 9

c) Consider the combustion (burning) of methane, CH_4, in oxygen. 8

$$CH_4(g) + 2O_2(g) \Rightarrow CO_2(g) + 2H_2O(l)$$

The heat of reaction at 25^0C and 1.00 atm is -890.2 kJ. What is the change in volume when 1.00 mol CH_4 reacts with 2.00 mol O_2? (You can ignore the volume of liquid water, which is insignificant compared with volumes of gases.) What is w for this change? Calculate. ΔU for the change indicated by the chemical equation.

8 a) Deduce phase rule. 9

b) What is the difference between thermotropic and lyotropic liquid crystals? Write the application of liquid crystals. 8

c) Discuss different types of organic reactions with suitable examples. 8

B.Sc. Engg (M) 3rd Sem 23 May 2019

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DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination — Winter Semester: A.Y. 2018-2019
Course Code: MCE 4305 — Time : 3.0 Hours
Course Title : Basic Thermodynamics — Full Marks : 150

There are 8 (Eight) Questions. Answer any 6 (Six) Questions.
Figures in the right margin indicate full marks. Don't write on this question paper.
(Assume any missing data)

1. a) What are the limitations of *First Law of Thermodynamics*? Show the equivalence between the Kelvin-Plank's and Clausius's statements of the *Second Law of Thermodynamics*. [8]

b) What is meant by Quasi-static process? "Quasi-static processes and reversible processes are used interchangeably but they have a difference"- Explain. [7]

c) Steam enters a nozzle at 400 ^{0}C and 800 kPa with a velocity of 10 m/s, and leaves at 300 ^{0}C and 200 kPa while losing heat at a rate of 25 kW. For an inlet area of 800 cm^2, determine the velocity and the volume flow rate of the steam at the nozzle exit. [10]

2. a) Draw a schematic diagram of a boiler plant. [7]

b) Draw a La-Mont Boiler with proper labelling. [10]

c) Our general understanding says that heat does not flow from lower temperature to higher temperature. Is there any way to transfer heat from lower temperature to higher temperature? Justify your answer using laws of thermodynamics. [8]

3. a) What will happen if petrol is used in diesel engine and vice versa? [5]

b) Why are high compression ratios not used in spark ignition engines? [5]

c) For a specified compression ratio, is a diesel or gasoline engine more efficient? [5]

d) An engine working on the Otto cycle, has a cylinder diameter of 150 mm and a stroke of 225 mm. The clearance volume is 1.25 x 10^{-3} m^3. Find the air standard efficiency of this engine. [10]

4. a) Do Intercooling and reheating effect the thermal efficiency in gas power cycle that is not accompanied by regeneration? Why? [5]

b) How work can be saved in multistage compression with cooling and multistage expansion with heating in Brayton Cycle/Gas Power Cycle? Show it in *P-V* diagram. [8]

c) Air is used as the working fluid in a simple ideal Brayton cycle that has a pressure ratio of 12, a compressor inlet temperature of 300 K, and a turbine inlet temperature of 1000 K. Determine the required mass flow rate of air for a net power output of 70 MW, assuming both the compressor and the turbine have an isentropic efficiency of 85 percent. Assume constant specific heats at room temperature. [12]

5. a) Why is the Carnot cycle not a realistic model for steam power plants? What modifications do we need in the Carnot cycle to use it in the steam power plants? [7]

   b) Consider a 210-MW steam power plant that operates on a simple ideal Rankin cycle. Steam enters the turbine at 10 MPa and 500 ^{0}C and is cooled in the condenser at a pressure of 10 kPa. Show the cycle on a *T-s* diagram, and determine- [12]

   (i) the quality of the steam at the turbine exit,
   (ii) the thermal efficiency of the cycle, and
   (iii) the mass flow rate of the steam.

   c) For the same 210-MW steam power plant and same boiler and condenser pressures used in question 5(b), if the Rankin cycle is replaced by Carnot cycle where water enters the boiler as saturated liquid and steam enters the turbine as saturated vapor, determine- [6]

   (i) the quality of the steam at the turbine exit,
   (ii) the thermal efficiency of the cycle, and
   (iii) the mass flow rate of the steam.

6. a) Why is the reversed Carnot cycle executed within the saturation dome not a realistic model for refrigeration cycles? [5]

   b) Draw the schematic diagram of absorption refrigeration cycle. [8]

   c) A steady-flow Carnot refrigeration cycle uses *refrigerant-134a* as the working fluid. The refrigerant changes from saturated vapor to saturated liquid at 60 ^{0}C in the condenser as it rejects heat. The evaporator pressure is 140 kPa. Show the cycle on a *T-s* diagram, and determine- [12]

   (i) the coefficient of performance,
   (ii) the amount of heat absorbed from the refrigerated space, and
   (iii) the net work input.

7. a) Is it possible to obtain saturated air from unsaturated air without adding any moisture? Explain. [5]

   b) After a long walk in the 12 ^{0}C outdoors, a person wearing glasses enters a room at 25 ^{0}C and 55 percent relative humidity. Determine whether the glasses will become fogged. [8]

   c) A wet cooling tower is to cool 60 kg/s of water from 40 ^{0}C to 33 ^{0}C. Atmospheric air enters the tower at 1 atm with dry and wet-bulb temperatures of 22 ^{0}C and 16 ^{0}C, respectively, and leaves at 30 ^{0}C with a relative humidity of 95 percent. Using the psychrometric chart, determine- [12]

   (i) the volume flow rate of air into the cooling tower, and
   (ii) the mass flow rate of the required makeup water.

8. a) What are the conditions at which steam acts more like an ideal gas? [5]

   b) What is the significance of measuring wet bulb temperature? [7]

   c) An air-conditioning system operates at a total pressure of 1 atm and consists of a heating section and a humidifier that supplies wet steam (saturated water vapor) at 100 ^{0}C. Air enters the heating section at 10 ^{0}C and 70 percent relative humidity at a rate of 35 m^3/min, and it leaves the humidifying section at 20 ^{0}C and 60 percent relative humidity. Determine- [13]

   (i) the temperature and relative humidity of air when it leaves the heating section,
   (ii) the rate of heat transfer in the heating section, and
   (iii) the rate at which water is added to the air in the humidifying section.

Saturated water—Pressure table

Press., P kPa	Sat. temp., T_{sat} °C	Specific volume, m³/kg: Sat. liquid, v_f	Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
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
75	91.76	0.001037	2.2172	384.36	2111.8	2496.1	384.44	2278.0	2662.4	1.2132	6.2426	7.4558
100	99.61	0.001043	1.6941	417.40	2088.2	2505.6	417.51	2257.5	2675.0	1.3028	6.0562	7.3589
700	164.95	0.001108	0.27278	696.23	1875.6	2571.8	697.00	2065.8	2762.8	1.9918	4.7153	6.7071
750	167.75	0.001111	0.25552	708.40	1865.6	2574.0	709.24	2056.4	2765.7	2.0195	4.6642	6.6837
8000	295.01	0.001384	0.023525	1306.0	1264.5	2570.5	1317.1	1441.6	2758.7	3.2077	2.5373	5.7450
9000	303.35	0.001418	0.020489	1350.9	1207.6	2558.5	1363.7	1379.3	2742.9	3.2866	2.3925	5.6791
10,000	311.00	0.001452	0.018028	1393.3	1151.8	2545.2	1407.8	1317.6	2725.5	3.3603	2.2556	5.6159
11,000	318.08	0.001488	0.015988	1433.9	1096.6	2530.4	1450.2	1256.1	2706.3	3.4299	2.1245	5.5544
12,000	324.68	0.001526	0.014264	1473.0	1041.3	2514.3	1491.3	1194.1	2685.4	3.4964	1.9975	5.4939

Superheated water (*Continued*)

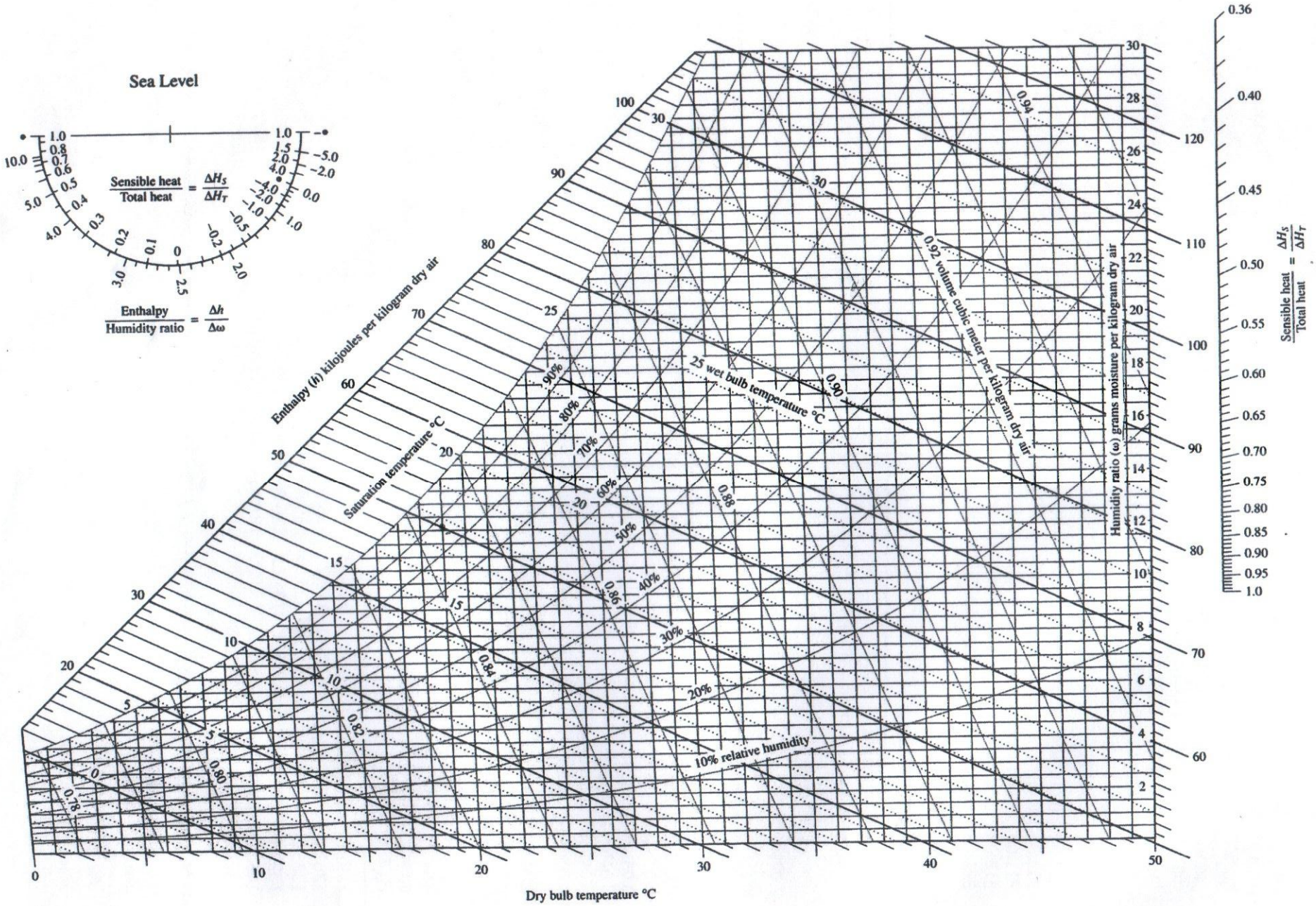
T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 9.0 MPa (303.35°C)				P = 10.0 MPa (311.00°C)				P = 12.5 MPa (327.81°C)			
Sat.	0.020489	2558.5	2742.9	5.6791	0.018028	2545.2	2725.5	5.6159	0.013496	2505.6	2674.3	5.4638
325	0.023284	2647.6	2857.1	5.8738	0.019877	2611.6	2810.3	5.7596				
350	0.025816	2725.0	2957.3	6.0380	0.022440	2699.6	2924.0	5.9460	0.016138	2624.9	2826.6	5.7130
400	0.029960	2849.2	3118.8	6.2876	0.026436	2833.1	3097.5	6.2141	0.020030	2789.6	3040.0	6.0433
450	0.033524	2956.3	3258.0	6.4872	0.029782	2944.5	3242.4	6.4219	0.023019	2913.7	3201.5	6.2749
500	0.036793	3056.3	3387.4	6.6603	0.032811	3047.0	3375.1	6.5995	0.025630	3023.2	3343.6	6.4651
550	0.039885	3153.0	3512.0	6.8164	0.035655	3145.4	3502.0	6.7585	0.028033	3126.1	3476.5	6.6317
600	0.042861	3248.4	3634.1	6.9605	0.038378	3242.0	3625.8	6.9045	0.030306	3225.8	3604.6	6.7828
650	0.045755	3343.4	3755.2	7.0954	0.041018	3338.0	3748.1	7.0408	0.032491	3324.1	3730.2	6.9227
700	0.048589	3438.8	3876.1	7.2229	0.043597	3434.0	3870.0	7.1693	0.034612	3422.0	3854.6	7.0540
800	0.054132	3632.0	4119.2	7.4606	0.048629	3628.2	4114.5	7.4085	0.038724	3618.8	4102.8	7.2967

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

Temp., T °C	Sat. press., P_{sat} kPa	Specific volume, m³/kg: Sat. liquid, v_f	Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Evap., s_{fg}	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

Saturated refrigerant-134a—Pressure table

Press., P kPa	Sat. temp., T_{sat} °C	Specific volume, m³/kg: Sat. liquid, v_f	Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
60	−36.95	0.0007097	0.31108	3.795	205.34	209.13	3.837	223.96	227.80	0.01633	0.94812	0.96445
70	−33.87	0.0007143	0.26921	7.672	203.23	210.90	7.722	222.02	229.74	0.03264	0.92783	0.96047
80	−31.13	0.0007184	0.23749	11.14	201.33	212.48	11.20	220.27	231.47	0.04707	0.91009	0.95716
90	−28.65	0.0007222	0.21261	14.30	199.60	213.90	14.36	218.67	233.04	0.06003	0.89431	0.95434
100	−26.37	0.0007258	0.19255	17.19	198.01	215.21	17.27	217.19	234.46	0.07182	0.88008	0.95191
120	−22.32	0.0007323	0.16216	22.38	195.15	217.53	22.47	214.52	236.99	0.09269	0.85520	0.94789
140	−18.77	0.0007381	0.14020	26.96	192.60	219.56	27.06	212.13	239.19	0.11080	0.83387	0.94467
160	−15.60	0.0007435	0.12355	31.06	190.31	221.37	31.18	209.96	241.14	0.12686	0.81517	0.94202


Sea Level
Sensible heat / Total heat = ΔHS / ΔHT
Enthalpy / Humidity ratio = Δh / Δω
Enthalpy (h) kilojoules per kilogram dry air
Saturation temperature °C
Humidity ratio (ω) grams moisture per kilogram dry air
Sensible heat / Total heat = ΔHS / ΔHT
Dry bulb temperature °C
25 wet bulb temperature °C
0.92 volume cubic meter per kilogram dry air
10% relative humidity
90%
80%
70%
60%
50%
40%
30%
20%
0.94
0.90
0.88
0.86
0.84
0.82
0.80
0.78

B Sc. Eng. (ME) (3rd Semester)/B Sc TE (2 Year, 1st Sem.) 28 May, 2019

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

Semester Final Examination — Winter Semester, A.Y. 2018-2019
Course Code: Math 4311/Math 4599 — Time : 3 hours
Course Title: Vector Analysis — Full Marks: 150

There are **8 (Eight)** questions. Answer any **6 (Six)** out of them. All questions carry equal marks. Programmable calculators are not allowed. Do not write on the question paper. The symbols used have their usual meaning.

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1. a) Three vectors of magnitudes p, 2p, 3p meet in a point and their directions are along the diagonals of the adjacent faces of a cube. Determine their resultant and its direction cosines.

   b) A rigid body is spanning with an angular velocity 10 rad/s about an axis of direction (3,3,4) passing through the point (4,-2, 6). Find the velocity of the particle at the point (-3,-4,-3).

   c) Test whether the vectors $(\boldsymbol{a}-\boldsymbol{b}), (\boldsymbol{b}-\boldsymbol{c}), (\boldsymbol{c}-\boldsymbol{a})$ are linearly dependent or not?

2. a) Obtain a set of vectors reciprocal to the three vectors $\boldsymbol{a_1} = -2\boldsymbol{i}+\boldsymbol{j}+3\boldsymbol{k}$, $\boldsymbol{a_2} = \boldsymbol{i}-2\boldsymbol{j}+\boldsymbol{k}$ and $\boldsymbol{a_3} = \boldsymbol{i}+\boldsymbol{j}-3\boldsymbol{k}$.

   b) If $\hat{\mathbf{a}}$, $\hat{\mathbf{b}}$ are unit vectors and θ is the angle between them then show that $\sin\frac{\theta}{2} = \frac{1}{2}\left|\hat{a}-\hat{b}\right|$.

   c) Show that $r = ae^{m_1 t} + be^{m_2 t}$ is a solution of $\frac{d^2\underline{r}}{dt^2} + p\frac{d\underline{r}}{dt} + q\underline{r} = 0$ (p, q being constants), where m_1 and m_2 are the distinct roots of the equation $m^2 + pm + q = 0$.

3. a) A particle moves so that its position vector is given by $\underline{r} = \cos\omega t\,\underline{i} + \sin\omega t\,\underline{j}$ where ω is a constant. Show that (i) the velocity v of the particle is perpendicular to $\underline{r}$. (ii) $\underline{r}\times\underline{v}$ = a constant vector.

   b) Let C be the curve $y = x^3 - 3x^2 + 4x - 1$ joining points (1, 1) and (2, 3). Find the value of $\int_C \left(8z^2 - 12iz\right)dz$.

   c) If $\boldsymbol{r} = \mathbf{a}\cos(\mathrm{mt}) + \mathbf{b}\sin(\mathrm{mt})$, where **a** and **b** are constant vectors and m, a constant scalar, show that (*i*) $\left(\boldsymbol{r}\times\frac{d\boldsymbol{r}}{dt}\right) = m(\mathbf{a}\times\mathbf{b})$; (*ii*) $\frac{d^2\boldsymbol{r}}{dt^2} + m^2\boldsymbol{r} = 0$.

4. a) Find the equations of the tangent line and the normal plane at the point (1, -2, 5) to the curve $x^2 + y^2 + z^2 = 25$, $x + y + z = 4$.

b) Is the vector field $\mathbf{F}=\left(x^3z-2xyz\right)\mathbf{i}+\left(xy-3x^2yz\right)\mathbf{j}+\left(yz^2-xz\right)\mathbf{k}$ solenoidal? If so, find a vector function $\mathbf{V}$ such that $\mathbf{F}=\nabla\times\mathbf{V}$.

5 a) State and verify *Gauss divergence theorem* for $\mathbf{F}=\left(x^2-z^2\right)\mathbf{i}+2xy\mathbf{j}+\left(y^2+z\right)\mathbf{k}$ taken over the region bounded by cylinder $y^2+z^2=9$ and the planes x = 0 and x = 3.

b) Show that $\nabla\left(\mathbf{F}\cdot\mathbf{G}\right)=\mathbf{F}\times\left(\nabla\times\mathbf{G}\right)+\mathbf{G}\times\left(\nabla\times\mathbf{F}\right)+\left(\mathbf{F}\cdot\nabla\right)\mathbf{G}+\left(\mathbf{G}\cdot\nabla\right)\mathbf{F}$.

6 a) State and verify *Green's theorem in the plane* for $\int_C\left(2x-y^3\right)dx-xydy$ where C is the boundary of the region enclosed by $x^2+y^2=1$ and $x^2+y^2=4$.

b) Find curl of $\mathbf{F}$ where $\mathbf{F}=\left(x^2-y^2+2xz\right)\mathbf{i}+\left(xz-xy+yz\right)\mathbf{j}+\left(z^2+x^2\right)\mathbf{k}$. Also show that the vectors given by curl $\mathbf{F}$ at the points P(1, 2, -3) and Q(2, 3, 12) are orthogonal.

7 a) Find the indicated roots and locate them graphically for $\left(-4+4i\right)^{1/5}$

b) Define *Analytic function* and *Harmonic function*. If $f(z) = u + iv$ is an analytic function, then show that u and v are both Harmonic functions.

c) State *Cauchy Integral Formula* and use it to evaluate $\int_C\frac{dz}{\left(z^2-1\right)}$, where C is the circle $|z|=2$.

8 a) State *Laurent's Theorem* and utilize it to expand $f(z)=\frac{z}{(z-1)(2-z)}$ vaild for $|z-1|>1$.

b) State *Residue Theorem*. Determine the poles of $\frac{4-3z}{z(z-1)(z-2)}$, over $C:|z|=\frac{3}{2}$ and residue at each pole. Hence evaluate $\int_C\frac{4-3z}{z(z-1)(z-2)}dz$, over $C:|z|=\frac{3}{2}$.

B.Sc. Engg. (ME (3rd Sem) 17 May 2017 (Friday)

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

Semester Final Examination — Winter Semester, A.Y. 2018-2019
Course Code: MCE 4321 — Time : 3 hours
Course Title: Manufacturing Process — Full Marks : 200

There are 8 (EIGHT) Questions. Answer any 6 (SIX) of them.

Marks in the Margin indicate the full marks.

1.	a)	What is Manufacturing process? Broadly classify the different engineering manufacturing process and hence explain the fundamentals of metal forming processes.	15
	b)	Write down the differences between cold working, warm working and hot working processes.	11.33
	c)	Write a short note on cluster mill rolling process.	7
2	a)	Explain with neat sketches the different process sequence for the fabrication of cans used in food and beverage industries.	18
	b)	What are the differences between impression die forging process and flash less forging process? Explain with necessary diagram the different stages in flash less forging.	15.33
3.	a)	List the different types of cutting operations that can be performed on a lathe and hence explain with necessary diagram the facing grooving, taper turning and knurling operation.	15
	b)	Write down the differences between radial drill and column drilling machine. How the general purpose drill is classified? Explain with neat sketches the different types of drill point angels available for drill.	18.33
4	a)	Write down the differences between shaping and planning machine. Explain with necessary diagram the hydraulic rapid return speed mechanism.	15.33
	b)	Write down the differences between up cut milling and down cut milling and hence explain with necessary diagram the pocket milling, profile milling and end milling operation that can be performed in a milling machine.	18
5	a)	Explain with necessary diagram in details the Gas Metal Arc Welding process and Gas Tungsten Arc Welding processes.	17.33
	b)	Explain briefly the resistance spot welding process and write down the differences between resistance seam welding and resistance projection welding processes.	16
6	a)	Explain in details the different types of defects associated during welding operations.	10.33
	b)	Propose a suitable process for the fabrication of plastic products like pipes, fittings, curtain rails and explain in details with necessary diagram the manufacturing technique used.	18
	c)	Which type of plastics is called Plastic memory and why?	05
7	a)	What is powder metallurgy? Explain in details with necessary diagram the powder rolling and powder extrusion process used in powder metallurgy for the fabrication of different powder metallurgy parts.	15.33
	b)	Explain briefly with simplified flow chart the different steps that need to be followed as process sequence in powder metallurgy method.	18
8	a)	What is pattern? Write down the different types of pattern and explain briefly the different types of allowances that need to be considered for the design of pattern.	17.33
	b)	Explain with flow diagram the operational sequences for (i) vacuum sealed molding process (ii) Evaporative pattern casting process.	16

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BBA in TM(3rd Semester) 16 May, 2019

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

SEMESTER FINAL.EXAMINATION — WINTER SEMESTER (2018 - 2019)
COURSE NO. MCE 4361 — TIME: 3 hours
COURSE TITLE: Basic Mechanical Engineering 1 — FULL MARKS: 150

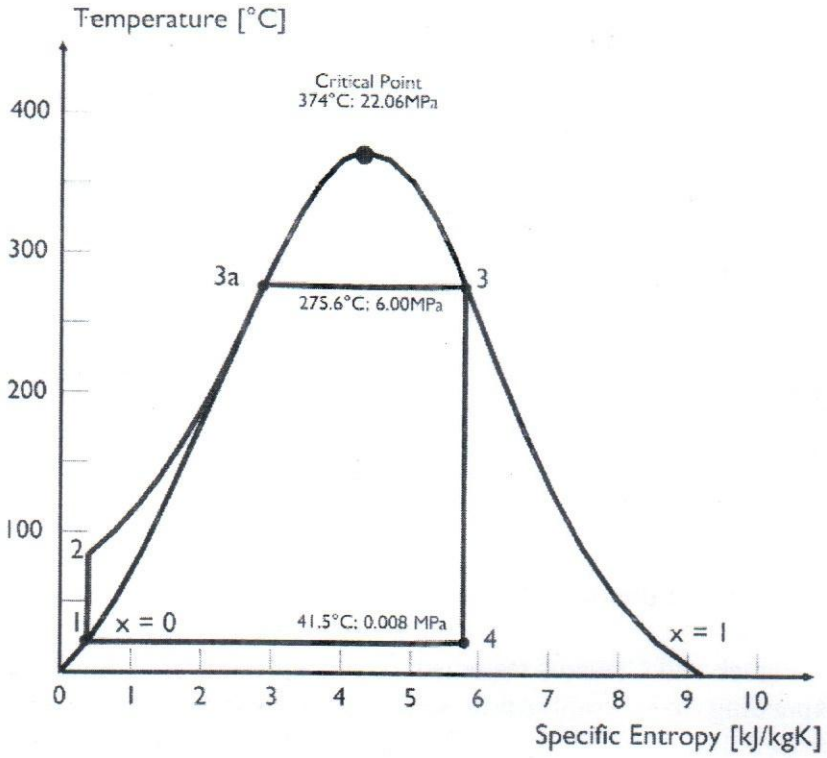
There are **8 (Eight)** Questions. Answer any **6 (Six)** of them. Marks in the Margin indicate full marks. Steam Tables will be supplied by the Department of MCE during Examination. Programmable calculators are not allowed. Do not write on this question paper.

1. a. How do we classify primary, secondary and renewable fuels? Explain them with appropriate examples. 15
   b. Name different types of thermodynamics and discuss about the processes. 10

2. a. State Kelvin-Planck and Clausius statement of second law of Thermodynamics. 08
   b. The gas expanding in a combustion space of a reciprocating engine has an initial pressure, temperature and volume of 50 bar, 1623^0 C and 50,000 mm^3 respectively. The gas expands through a volume ratio of 20 according to the law $PV^{1.25}$= constant. Calculate (i) the work transfer and (ii) heat transfer of the expansion process. 17
   Take $R = 270\ J/Kg\ K$ and $C_p = J/Kg\ K$

3. a. A reciprocating steam engine is supplied with dry saturated steam at a pressure of 1.6 MPa (specific volume = 0.1238 m^3/kg). The stroke of the engine is 0.8 m and bore is 0.3 m. The clearance volume is negligible. The steam enters the cylinder, expands at constant pressure for 1/4 of the stroke and then expands reversibly according to a law PV = constant, till the end of the stroke. Calculate (i) the mass of the steam (ii) the work transfer and heat transfer in the process. The system may be considered as a close system. 17
   b. A Carnot engine works at high temperature 600 Kelvin with the efficiency of 40%. If the efficiency of the engine is 75% and the low temperature kept constant, what is the high temperature? 08

4. In a simple Rankine cycle, steam turbine running with saturated steam (dry steam). In this case the turbine operates at steady state with inlet conditions of 6 MPa, $t = 275.6°C$, $x = 1$ (point 3). Steam leaves this stage of turbine at a pressure of 0.008 MPa, 41.5°C and $x =$ *???* (point 4). 25
   Calculate:
   1. the vapor quality of the outlet steam
   2. the enthalpy difference between these two states (3 → 4), which corresponds to the work done by the steam, W_T.
   3. the enthalpy difference between these two states (1 → 2), which corresponds to the work done by pumps, W_P.
   4. the enthalpy difference between these two states (2 → 3), which corresponds to the net heat added in the steam generator
   5. the thermodynamic efficiency of this cycle and compare this value with the Carnot's efficiency



5. a. Distinguish between two stroke cycle and four stroke cycle engine. 05
   b. An internal combustion engine operates on an ideal Otto cycle with a compression ratio of eight and a displacement volume of 0.3 liters. At the beginning of the compression process, air is at 27^0C and 95 kPa, and 750 kJ/kg of heat is transferred to the air during the constant volume heating process. Determine the 10
   i. net work output ii. thermal efficiency iii. mean effective pressure
   c. An internal combustion engine operates on an ideal Diesel cycle with a compression ratio of 16, a cutoff ratio of 2, and a displacement volume of 0.3 liters. At the beginning of the compression process, air is at 27C and 95 kPa. Determine the 10
   i. net work output ii. thermal efficiency
   iii. mean effective pressure iv. maximum temperature in the engine
   v. Carnot cycle efficiency of the engine

6. a. Define and classify boiler. Discuss the merits of water tube boiler over fire tube boiler. 05
   b. Discuss about any five boiler mountings. 10
   c. Discuss about any five boiler accessories. 10

7. a. Describe equation of continuity. 07
   b. Classify nozzle and describe them. 10
   c. Distinguish between impulse and reaction turbine. 08

8. a. Differentiate between Newtonian and non- Newtonian fluids 06
   b. Define rotodynamic and positive displacement pump. Enlist different components of rotodynamic pump with their sketches. 14
   c. What are the advantages of submersible pump over other pumps? 05

BSc Engg.(EEE)/3rd Sem

18 May, 2019

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

Semester Final Examination
Course No: MCE 4391
Course Title: Basic Mechanical Engineering

Winter Semester: A.Y. 2018-2019
Time: 3 Hours
Full Marks: 150

There are 8 (Eight) Questions. Answer any 6 (Six) Questions.
Marks in the Margin indicate full marks. Don't write on this question paper. Relevant correlations, charts are provided on separate pages with the question. Programmable calculators are not allowed.

Use separate scripts for each section.

Section A

1(a) What is irreversibility? Write down the factors responsible for the system to be irreversible? (05)

(b) What are the basic differences between entropy and enthalpy? (04)

(c) Define the gross and net calorific values of fuel? (04)

(d) In an air standrad diesel cycle, the compression begins at 125 KPa and 40°C. If the compression ratio is 15 and the heat added is 1500 MJ/kg, Find (i) maximum temperature in the cycle, (ii) work done per kg of air (iii) cycle efficiency, (iv) temperature at the end of the isentropic expansion, (v) cut-off ratio and (vi) mean effective pressuere of the cycle. (12)

2(a) What are Ton of Refrigeration and COP? (05)

(b) Write down the working principle of vapor compression refrigeration system with the help of block, P-h and T-s diagrams. (10)

(c) A vapor compression refrigeration cycle using refrigerant R12 operates at condensing temperature of 45°C and evaporative temperature of -15°C. The efficiency of the compressor is 85% and the mass flow rate of the refrigerant is 0.35 kg/s. Determine (i) the compressor power, (ii) refrigerating effect, (iii) heat rejection from the condenser, and (iv) COP. (10)

3(a) What is refrigerant? What are the desirable properties of an ideal refrigerant? (05)

(b) Write short notes on EER, ODP and GWP. (06)

(c) Write down the characteristics and applications of commonly used compressors in the fields of refrigeration and air conditioning. (09)

(d) Why are the solenoid valve, drier and filter used in the refrigeration system? (05)

4(a) Write short notes on chemical dehumidification, evaporative cooling, relative humiditiy, specific humidity and absolute humidity. (10)

(b) What are the basic differences between package air conditioning system and central air conditioning system? (05)

(c) The dry bulb and wet bulb temperatures of the room are measured as 30°C and 20°C, respectively. After the psychometric process, the room condition is changed and the new dry bulb and wet bulb temperatures of the room are now measured as 50°C and 30°C, respectively. Calculate all the psychometric parameters while incorporating the process on psychometric chart. (10)

Section B

5(a) Draw the schematic of Pelton turbine. Label the important components of it. (6)

(b) Define specific speed of the turbine. What is the importance of it? A turbine is designed to deliver 694,600 watts with a head of 60 metres operating at 80 revolutions per minute. Suggest the type of turbine that would be suitable. (10)

(c) A reaction turbine, whose runner radii are $r_1 = 300$ mm and $r_2 = 150$ mm, operates under the following conditions: $Q = 0.057$ m^3/s, $\omega = 25$ rad/s, $\alpha_1 = 30°$, $V_1 = 6$ m/s, $\alpha_2 = 80°$, and $V_2 = 3$ m/s. Assuming ideal conditions, find the torque applied to the runner, the head on the turbine, and the fluid power. Use $\rho = 1000$ kg/m^3. (9)

6(a) Water is pumped between two reservoirs in a pipeline with the following characteristics: $D = 300$ mm, $L = 70$ m, $f = 0.025$, $\sum K = 2.5$, where f is the friction factor and $\sum$K is all the minor losses in the pipe. All other notations have the usual meaning. The radial-flow pump characteristic curve is approximated by the formula, $H_p = 22.9 + 10.7Q - 111Q^2$; where H_P is in meters and Q is in m^3/s. Determine the discharge Q_D and pump head H_D for the following situations: (a) $z_2 - z_1 = 15$ m, one pump placed in operation; and (b) $z_2 - z_1 = 15$ m, with two identical pumps operating in parallel. (13)

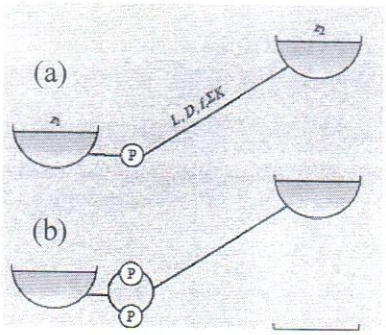


Fig. for the Q. No. 6(a)

(b) Write short notes on any of the following three (out of four): (i) Cavitations in turbomachines, (ii) Performance curve of pump, (iii) Peristaltic pump and (iv) Advantages of centrifugal pump over reciprocating pump. (12)

7(a) What is antalgic gait? What are the components you need to use for gait analysis and what are they used for? (12)

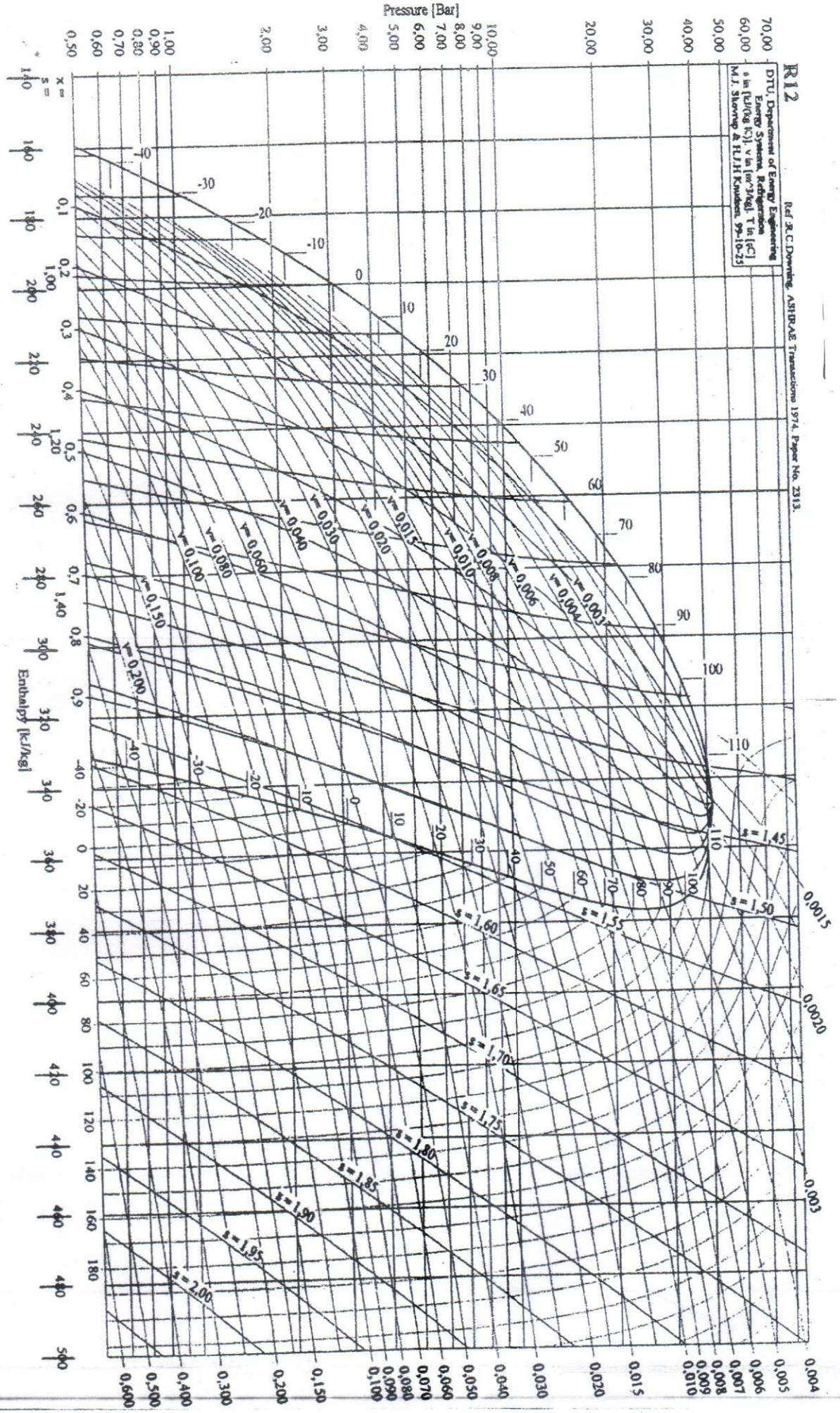
(b) How the knowledge of mechanics can be used for disease detection? (5)

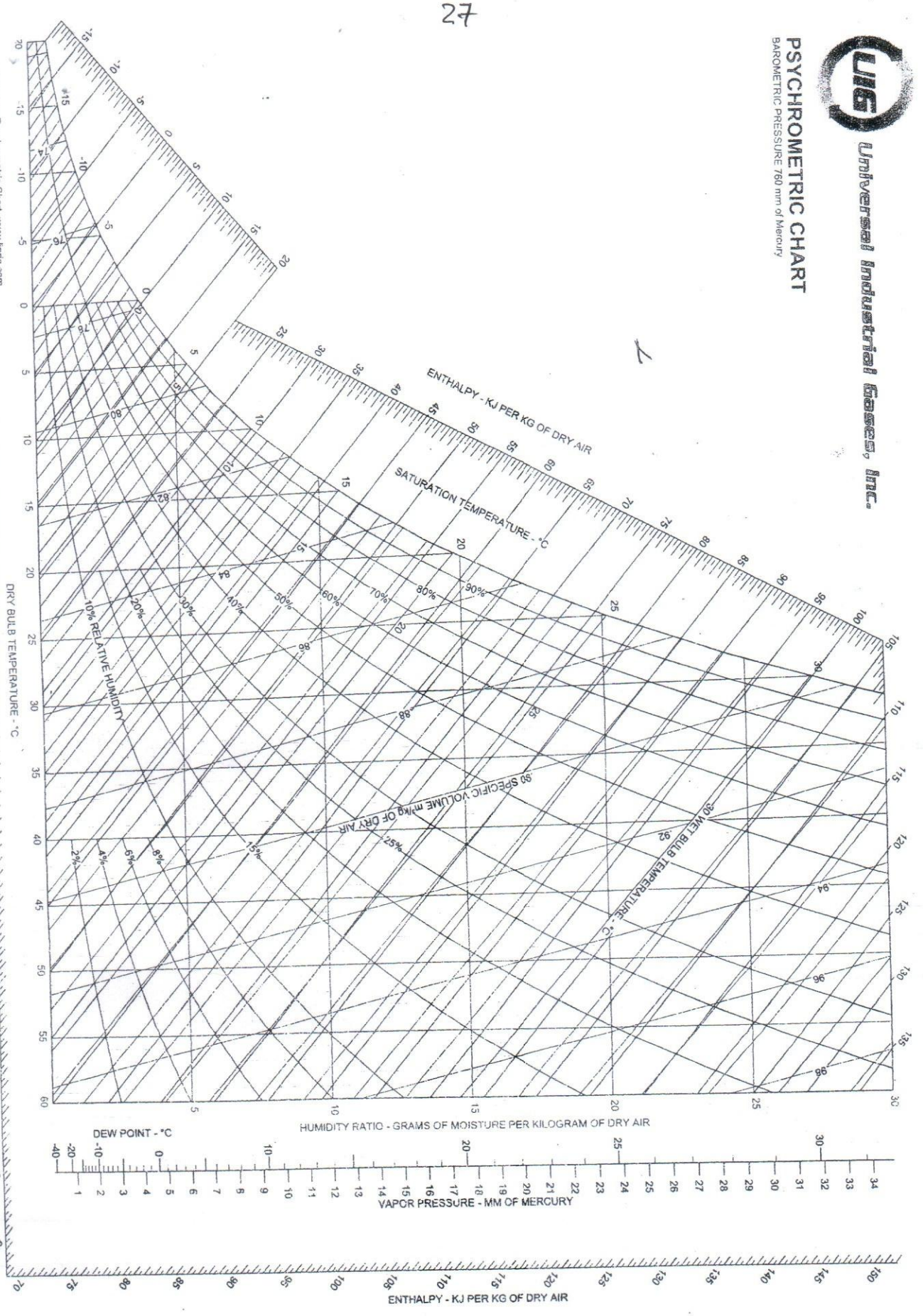
(c) The tibia is the major weight-bearing bone in the lower extremity. If 89% of body mass is proximal to the knee joint, how much compressive force acts on each tibia when a 600 N person stands in anatomical position? How much compressive force acts on each tibia if the person holds two 20 N sack of groceries? (8)

8(a) What are the steps involved in Otto cycle? Explain the steps with schematic and P-V diagram. (13)

(b) Mention the differences between four stroke and two stroke engines? (7)

(c) What is the physical significance of compression ratio in IC engine? (5)


R12
Ref. R.C. Downing, ASHRAE Transactions 1974, Paper No. 2313.
DTU, Department of Energy Engineering
Energy Systems, Refrigeration
s in [kJ/(kg K)], v in [m^3/kg], T in [°C]
M.J. Skovrup & H.J.H. Knudsen, 99-10-25
Pressure [Bar]
Enthalpy [kJ/kg]
x =
s =
v= 0,200
v= 0,150
v= 0,100
v= 0,080
v= 0,060
v= 0,040
v= 0,030
v= 0,020
v= 0,015
v= 0,010
v= 0,008
v= 0,006
v= 0,004
v= 0,003
s = 1,45
s = 1,50
s = 1,55
s = 1,60
s = 1,65
s = 1,70
s = 1,75
s = 1,80
s = 1,85
s = 1,90
s = 1,95
s = 2,00


Universal Industrial Gases, Inc.
PSYCHROMETRIC CHART
BAROMETRIC PRESSURE 760 mm of Mercury
Company Psychrometric Chart. www.linric.com
ENTHALPY - KJ PER KG OF DRY AIR
SATURATION TEMPERATURE - °C
10% RELATIVE HUMIDITY
DRY BULB TEMPERATURE - °C
SPECIFIC VOLUME m³/kg OF DRY AIR
WET BULB TEMPERATURE - °C
HUMIDITY RATIO - GRAMS OF MOISTURE PER KILOGRAM OF DRY AIR
DEW POINT - °C
VAPOR PRESSURE - MM OF MERCURY
ENTHALPY - KJ PER KG OF DRY AIR

BSc. Eng. (M)/ HDME/ 5th Sem.
BScTE(2 Yr.)/ 1st Sem.

23 May 2019

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

Semester Final Examination — Winter Semester A.Y. 2018-2019
Course Code: MCE 4503/MCE 4595 — Time : 3 hours
Course Title: Mechanics of Machines — Full Marks : 150

There are **8(Eight)** Questions. Answer any **6(Six)** of them.
Marks in the margin indicate the full marks. Assume reasonable value for missing data if necessary.
Don't write on this question paper.

1. Part of the gear train in Figure 1 for a machine tool is shown. Compound gears 2 and 3 slide on a splined shaft so that gear 3 can mesh with gear 4 or gear 2 can mesh with gear 6. Also, compound gears 14 and 15 slide on a splined shaft so that gear 14 can mesh with gear 16 or gear 15 can mesh with gear 17. 25
(a) If gear 3 meshes with gear 4, what are the two possible spindle speeds for a motor speed of 1800 rpm?
(b) Now assume that gear 14 meshes with gear 16, and gear 2 meshes with gear 6. Gears 2, 3, 4, and 6 are standard and have the same diametral pitch. What are the tooth numbers on gears 2 and 6 if the spindle speed is 130±3 rpm?

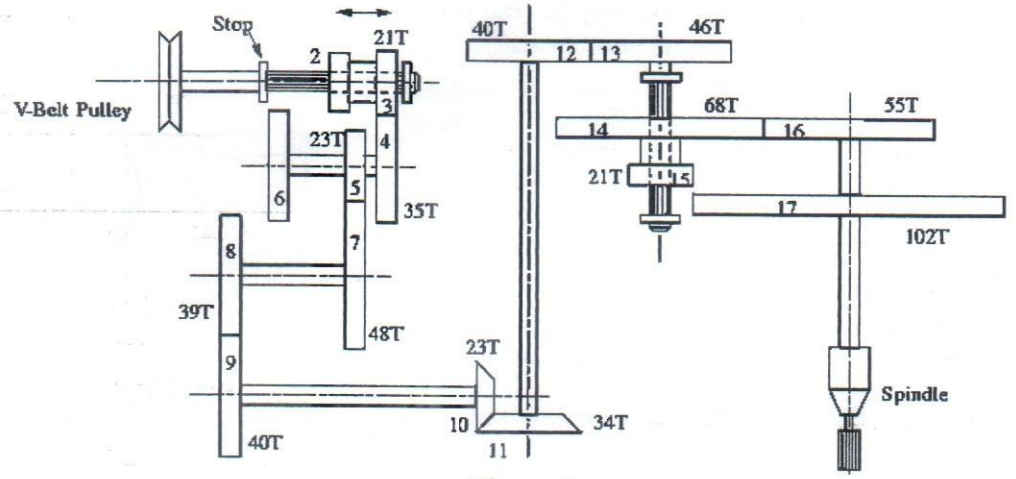


Figure 1

2. In the gear train shown in Figure 2 gears 2 and 4, 6 and 7, and 3 and 9 are fixed together. If the angular velocity of the carrier is given, determine the angular velocity of gear 9. 25

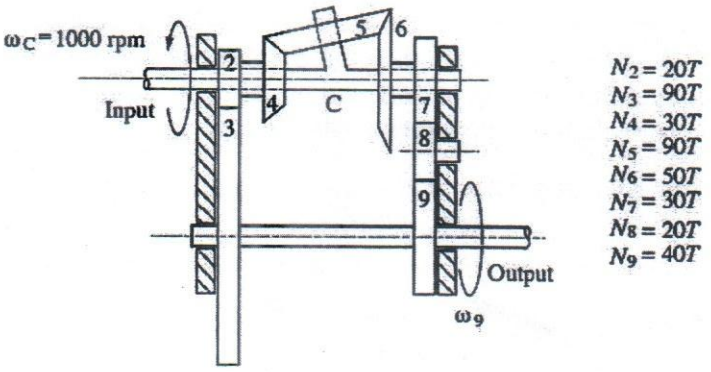


Figure 2

3. Design a fourbar mechanism to move the link shown in Figure 3 (page 3) from position 2 to position 3. Ignore the first position and the fixed pivots O_2 and O_4 shown. Add a driver dyad to limit its motion to the range of positions designed, making it a six bar. Solve the problem on that figure and attach it with your script. 25

4. The crosshead linkage shown in Figure 4 (page 4) has 2 DOF with inputs at crossheads 2 and 5. Find $\mathbf{V}_B$, $\mathbf{V}_{P3}$, and $\mathbf{V}_{P4}$ if the crossheads are each moving toward the origin of The XY coordinate system with a speed of 20 in/sec. Use graphical method. 25

5. For the linkage shown in Figure 5 (page 5) locate all the *instantaneous centers*. You can solve the problem on that figure and attach it with your script. 25

6. In the mechanism shown in Figure 6 (page 6), link 2 is rotating CCW at the rate of 4 rad/s (constant). In the position shown, link 2 is horizontal. Write the appropriate vector equations, solve them using vector polygons, and 25
   a) Determine ${}^{v}C_4$, ω_3, and ω_4.
   b) Determine ${}^{a}C_4$, α_3, and α_4.
   Link lengths: AB = 1.25 in, BC = 2.5 in, CD = 2.5 in
   You can solve the problem on that figure and attach it with your script.

7. a) Drawing simplified diagrams, discuss in detail different cases of *Grashof* and *non-Grashof* conditions for a *fourbar pin-jointed mechanism* for a single degree of freedom. 17
   c) Determine the mobility of the planar linkage shown in Figure 7. Show the equations used to determine your answer. 8

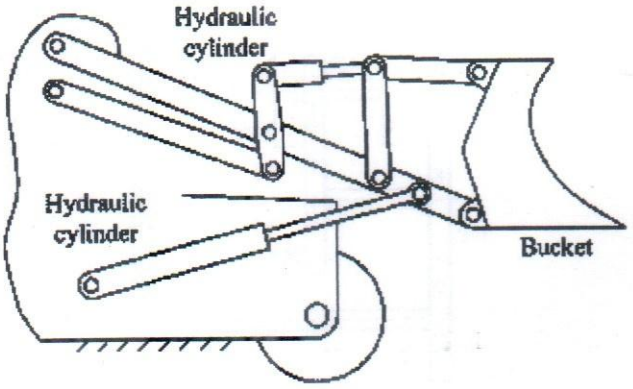


Figure 7

8. a) "When a machinery is balanced dynamically it automatically ensures its static balance". Explain with simplified figure and equation. 5
   b) *A, B, C, D* are four masses carried by a rotating shaft at radii 100, 125, 200 and 150 mm respectively. The planes in which the masses revolve are spaced 600 mm apart and the mass of *B, C* and *D* are 10 kg, 5 kg and 4kg respectively. 20
   Find the required mass *A* and the relative angular settings of the four masses so that the shaft shall be in complete balance.

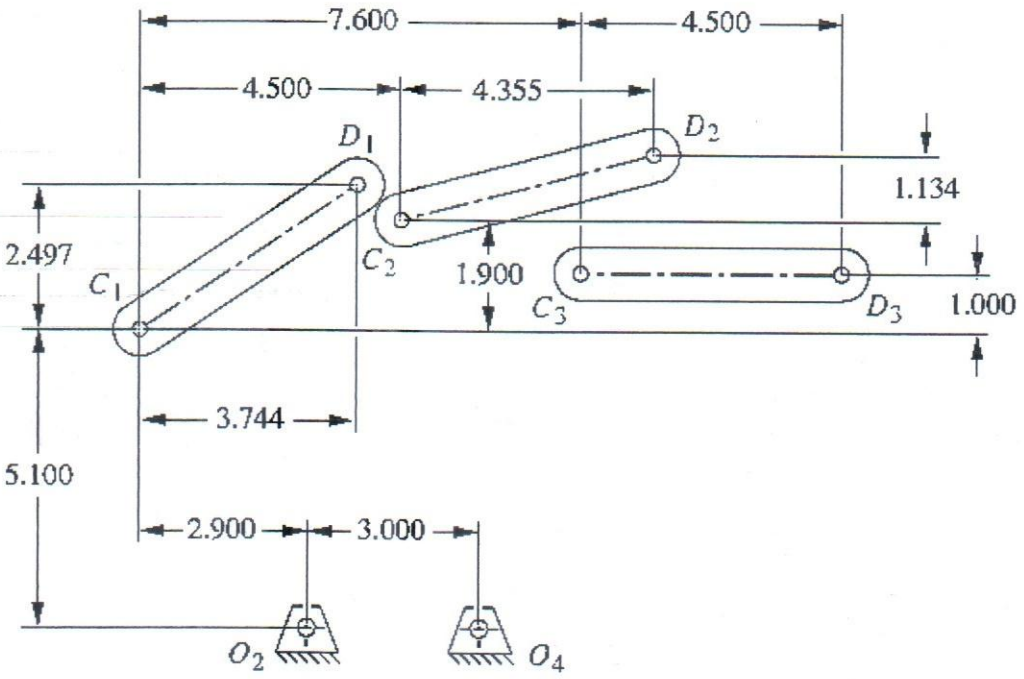

7.600
4.500
4.500
4.355
D_1
D_2
1.134
2.497
C_1
C_2
1.900
C_3
D_3
1.000
3.744
5.100
2.900
3.000
O_2
O_4

Figure 3

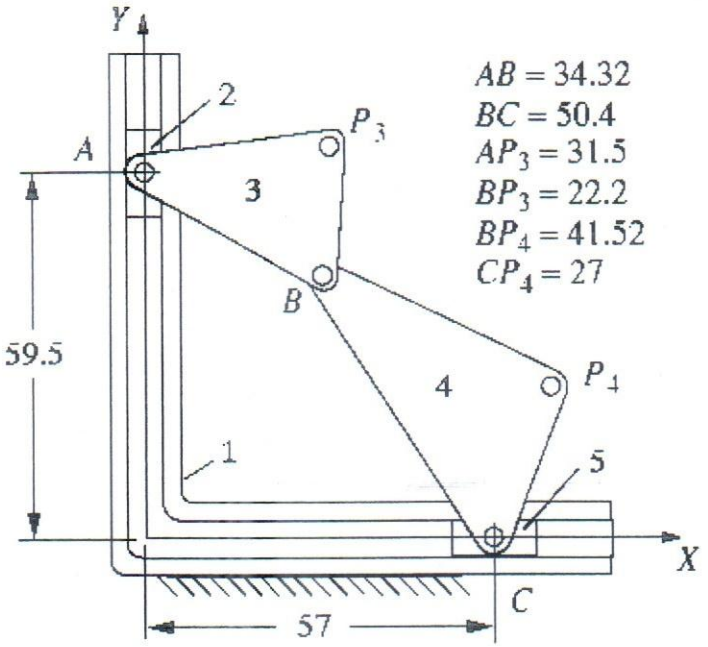

Y
2
A
P_3
3
$AB = 34.32$
$BC = 50.4$
$AP_3 = 31.5$
$BP_3 = 22.2$
$BP_4 = 41.52$
$CP_4 = 27$
B
59.5
4
P_4
1
5
X
C
57

Figure 4

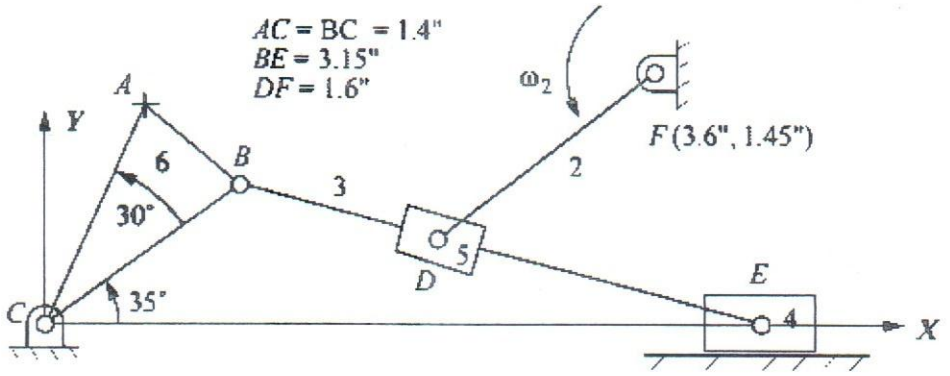


Figure 5

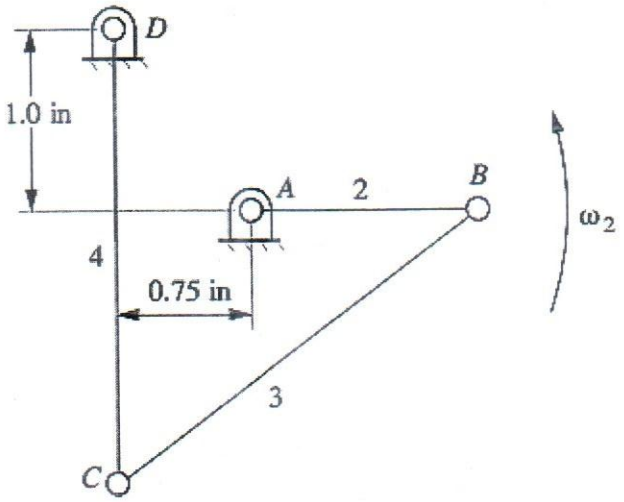


Figure 6

No. of Students - 107 33
B.Sc.Engg. (M)5th Sem./
B.Sc. TE (2 Yr. Prog), 1st Sem. 17 May, 2019 (Friday)

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

Semester Final Examination — Winter Semester, A.Y. 2018-2019
Course No. MCE 4507/MCE 4593 — TIME : 3.0 Hours
Course Title: Control and Automation — Full Marks : 100

There are 8 (Eight) Questions. Answer any 6(Six) Questions.
Marks in the margin indicate full marks.

1.	a)	Sketch the construction of a pneumatically actuated diaphragm type single-seated control valve .What is the advantage of using a equal percentage valve over a linear valve?	8-2/3
	b)	Discuss the construction, advantages and disadvantages of a double-seated control valve	8
2.		Describe with necessary diagram the major types of direction control valves ((i) Pilot – operated Check Valves, (ii) Solenoid operated three-position four-way directional valve and (iii) Relief Valves), their construction, operation and symbol	16-2/3
3.	a)	Describe with sketches of different steps of a Hydraulic Circuit for a Reciprocating Cylinder with Automatic Venting at End of Cycle.	16-2/3
4.	a)	Explain with a sketch the principle of operation of a flapper nozzle amplifier and hence derive the approximate relationship between the output pressure and displacement .	8-2/3
	b)	Sketch and explain the operation of a flapper nozzle amplifier in closed loop.	8
5.		Sketch the schematic arrangement of a pneumatic proportional controller and draw the closed loop block diagram.	16-2/3
6		Apply linearisation technique to develop the transfer function of a pneumatic proportional controller.	16-2/3
7.		With the help of the example of a rotating mass with a flexible shaft explain the characteristics of a second order system. Draw the graph for different ζ.	16-2/3
8.	a)	Draw the block diagrams for Proportional(P), Integral(I), Proportional plus Integral(PI) and Proportional plus integral plus Derivative (PID) controller.	10-2/3
	b)	Sketch the graphs for comparison among the transient responses with P, I and P-I control system.	6

B.Sc. Engg. (ME)/HDME/ 5th Sem 25 May 2019

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

Semester Final Examination — Winter Semester, A. Y. 2018-19
Course No Math 4511 — Time: 3 Hours
Course Title: Statistics and Quality Control — Full Marks: 150

There are **8 (Eight)** questions. Answer any **6 (Six)** of them.

Marks in the margin indicate full marks. Programmable calculators are not allowed. Do not write on this question paper. Assume reasonable values if required. Some Formulas and charts are provided at the end of the question/separately.

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1. a) Raw data on the length of a product in mm collected from a factory is tabled below: [20]

198	176	206	230	215
171	236	267	192	204
213	224	191	210	231
257	193	208	271	244
170	181	226	178	173
218	217	284	158	250
210	260	169	175	205

i. Make the data into appropriate classes and then prepare a frequency table.
ii. Determine the Range, Mean, Standard Deviation and Kurtosis
iii. Draw a stem and leaf diagram.

b) Define control group, placebo and blinding with respect to design of experiments. Differentiate between completely randomized design and blocked design. [5]

2. a) Suppose you are going to implement a new quality control method. Describe any three change management strategies that you would like to apply with the practical step related to the given strategy. [12]

b) The monthly sales of mufflers in a district follow the normal distribution with a mean of 1,200 and a standard deviation of 225. The manufacturer would like to establish inventory levels such that there is only a 5 percent chance of running out of stock. Where should the manufacturer set the inventory levels? [5]

c) In a TV show, a contestant selects one of the three doors, behind one of the doors there is a prize, and behind the other two there are no prizes. After the contestant selects a door but does not open yet, the host opens one of the remaining two doors and reveals that there is no prize behind it. The host then asks the contestant whether he wants to switch his choice to the other unopened door or stick to his initial selection. Using statistical probability analysis, suggest what the contestant should do. [8]

3. a) A manufacturer of window frames knows from long experience that 5 percent of the production will have some type of minor defect that will require an adjustment. What is the probability that in a sample of 20 window frames: [8]
i. None will need adjustment?
ii. At least one will need adjustment?
iii. More than two will need adjustment?

b) According to the Department of Health, the mean number of hours of TV Viewing per week is higher among adult women than men. A recent study showed women spent an average of 34 hours per week watching TV and men 29 hours per week. Assume that the distribution of hours watched follows the normal distribution for both groups, and that the standard deviation among the women is 4.5 hours and it is 5.1 hours for the men. [10]

i. What percent of the women watch TV less than 40 hours per week?
ii. What percent of the men watch TV more than 25 hours per week?
iii. How many hours of TV do the one percent of women who watch the most TV per week watch?

c) What do you understand by Quality Function Deployment? Describe the steps involved in Quality Function Deployment. [7]

4. a) SP Bolts Ltd. Produces bolts of a certain diameter. From a day's production a sample of 5 pipes is selected randomly from the production line and their diameters (in mm) are recorded. The average diameter and range of this sample (of size 5) are computed and recorded. The Quality Control Engineer collected this type of samples in 10 days in the month of April and the findings are shown in table below. From this table, draw the *X-bar* and *R* chart. After finalizing the control charts, in a given day, five(5) bolts are randomly selected with the diameter(mm) of 8.746, 8.789, 10.01, 9.89, and 9.20. Now using the control charts, comment on it. [12]

Day	Average diameter of the sample(mm)	Range, *R*
1	10.769	0.050
2	10.730	0.016
3	10.718	0.040
4	10.728	0.014
5	10.730	0.029
6	10.720	0.020
7	10.711	0.038
8	10.713	0.026
9	10.718	0.008
10	10.789	0.032

b) Suppose samples of 200 cards are taken form a keypunch operation at 2 hour intervals to quality control the keypunch process. The percentage of cards in error for the past 10 samples is found to be 0.9%, 1.7%, 1.6%, 2%,1.5%, 1.8%,1.4%, 1.8%, 1.1% and 1.2%. Draw the *p* chart using the above data. Now if you have taken a sample of 200 cards today and found the percentage of cards in error as 5 percent. So what would you do as a production engineer? [7]

c) What do you understand by ISO? Why an organization would go for an ISO certification? Write down the main difference among ISO 9000,14000 and 45000 series. [6]

5. a) Define AQL, LTPD, Type I error and Type II error. The ITU hardware store has just received the shipment of 4000 wrenches. If the AQL is 200 defective items in the shipment and the LTPD is 7 percent, find a sampling plan(*n* and *c* using the nomograph. Please attach the nomograph with your answer script. [12]

b) A new process has started and Range for 10 subgroups are provided in the table. Here sample size is 4. If the specification is 700 ± 60 , what is the process capability index ? What action would you recommend? [Here d_2=2.059 for the sample size of 4] [8]

Subgroup no	Range, R
1	12
2	9
3	7
4	9
5	8
6	16
7	21
8	32
9	17
10	31

c) State Pareto 80/20 principle with an example. [5]

6. a) A stockbroker at Critical Securities reported that the mean rate of return on a sample of 10 oil stocks was 12.6 percent with a standard deviation of 3.9 percent. The mean rate of return on a sample of 8 utility stocks was 10.9 percent with a standard deviation of 3.5 percent. At the .05 significance level, can we conclude that there is more variation in the oil stocks? [6]

b) NK builder Ltd wishes to compare the two companies they use to appraise the value of residential homes. It selected a sample of 10 residential properties and scheduled both firms for an appraisal. The results, reported in Thousand $, are provided in the table below. At the .05 significance level, can we conclude there is a difference in the mean appraised values of the homes? [12]

Home	Schadek	Bowyer
1	137	129
2	110	105
3	131	119
4	142	140
5	105	98
6	130	123
7	131	127
8	110	116
9	125	122
10	149	146

c) The authority of IUT thinks that mean spending on food by IUT students per month has changed from $70 per month lately. To verity it, a survey was conducted picking 60 students randomly. From the survey, sample average comes up as $65 and sample standard deviation as $20. Here level of significance is set as 0.05. Now using relevant hypothesis testing method, comment on the claim of the IUT authority. [7]

7. a) The Roper Organization conducted identical surveys in 1995 and 2015. One question asked women was "Are most men basically kind, gentle, and thoughtful?" The 1995 survey revealed that, of the 3,000 women surveyed, 2,010 said that they were. In 2015, 1,530 of the 3,000 women surveyed thought that men were kind, gentle, and thoughtful. At the .05 level, can we conclude that women think men are less kind, gentle, and thoughtful in 2015 compared with 1995? [5]

b) The budget director for NK Media Inc would like to compare the daily travel expenses for the sales staff and the audit staff. She collected the following sample information: [14]
Sales ($) 131,135,146,165,136,142
Audit ($) 130,102,129,143,149,120,139
At the .10 significance level, can she conclude that the mean daily expenses are greater for the sales staff than the audit staff?

c) A student in public administration wants to determine the mean amount members of city councils in large cities earn per month as remuneration for being a council member. The error in estimating the mean is to be less than $100 with a 95 percent level of confidence. The student found a report by the Department of Labor that estimated the standard deviation to be $1,000. What is the required sample size? [6]

8. a) The demand for newspapers over the past 4 years and the corresponding population in a small town are shown below. Using regression method, forecast the demand of the newspaper in future (i.e. 2019) if the population becomes 61,000. Also find the coefficient of correlation, coefficient of determination and comment on the significance of the found value of these two coefficients. [10]

year	Newspaper demand (no of copies)	Population (no of people)
2015	3500	24567
2016	5100	29333
2017	5400	32000
2018	5600	33500

b) The union representing the Bottle Blowers of Argentina (BBA) is considering a proposal to merge with the Truck Drivers Union. According to BBA union bylaws, at least three-fourths of the union membership must approve any merger. A random sample of 2,000 current BBA members reveals 1,600 plan to vote for the merger proposal. What is the estimate of the population proportion? Develop a 95 percent confidence interval for the population proportion. Basing your decision on this sample information, can you conclude that the necessary proportion of BBA members favor the merger? Why? [8]

c) Suppose the President wants an estimate of the proportion of the population who support his current policy toward gun control. The President wants the estimate to be within .04 of the true proportion. Assume a 95 percent level of confidence. The President's political advisors estimated the proportion supporting the current policy to be 0.60. [7]

i. How large of a sample is required?

ii. How large of a sample would be necessary if no estimate were available for the proportion that support current policy?

----OOOO----

Control Chart Constants

Sample Size, n	A_2	D_3	D_4
2	1.880	0	3.267
3	1.023	0	2.575
4	0.729	0	2.282
5	0.577	0	2.115
6	0.483	0	2.004

$$UCL = \bar{\bar{x}} + A_2\bar{R}$$
$$LCL = \bar{\bar{x}} - A_2\bar{R}$$
$$UCL = D_4\bar{R}$$
$$LCL = D_3\bar{R}$$

Bayes: $P(A \mid B) = P(B \mid A)\,P(A) / P(B)$

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$b(x; n, P) = {}^{n}C_x * P^x * (1 - P)^{n-x}$$

$$P(x; \mu) = (e^{-\mu}) * (\mu^x) / x!$$

$$h(x; N, n, k) = [\,{}^{k}C_x\,] * [\,{}^{N-k}C_{n-x}\,] / [\,{}^{N}C_n\,]$$

$$Z\ \frac{\bar{x} - \mu}{\sigma/\sqrt{n}}$$

Sturg's rule, `i = R / (1 + 3.322 logn)`

$$a_4 = \frac{\sum_{i=1}^{n} f_i (X_i - \bar{X})^4}{n \times s^4}$$

CORRELATION COEFFICIENT

$$r = \frac{\Sigma(X - \bar{X})(Y - \bar{Y})}{(n-1)\,s_x\,s_y}$$

SLOPE OF THE REGRESSION LINE

$$b = r\frac{s_y}{s_x}$$

Y-INTERCEPT

$$a = \bar{Y} - b\bar{X}$$

Capability Index, C_p = USL – LSL / 6 * σ where $\sigma = \bar{R} / d_2$

$$z = \frac{p - \pi}{\sqrt{\frac{\pi(1-\pi)}{n}}} \qquad z = \frac{\bar{X} - \mu}{s/\sqrt{n}} \qquad z = \frac{\bar{X} - \mu}{\sigma/\sqrt{n}}$$

$$n = \left(\frac{zs}{E}\right)^2 \quad n = p(1-p)\left(\frac{z}{E}\right)^2$$

TWO-SAMPLE TEST OF PROPORTIONS

$$z = \frac{p_1 - p_2}{\sqrt{\frac{p_c(1-p_c)}{n_1} + \frac{p_c(1-p_c)}{n_2}}}$$

POOLED PROPORTION

$$p_c = \frac{X_1 + X_2}{n_1 + n_2}$$

SMALL SAMPLE TEST FOR MEAN

$$t = \frac{\bar{X} - \mu}{s/\sqrt{n}}$$

CONFIDENCE INTERVAL FOR A POPULATION PROPORTION

$$p \pm z\sqrt{\frac{p(1-p)}{n}}$$

CONFIDENCE INTERVAL FOR THE POPULATION MEAN, σ UNKNOWN

$$\bar{X} \pm t\frac{s}{\sqrt{n}}$$

TEST STATISTIC FOR COMPARING TWO VARIANCES

$$F = \frac{s_1^2}{s_2^2}$$

PAIRED *t* TEST

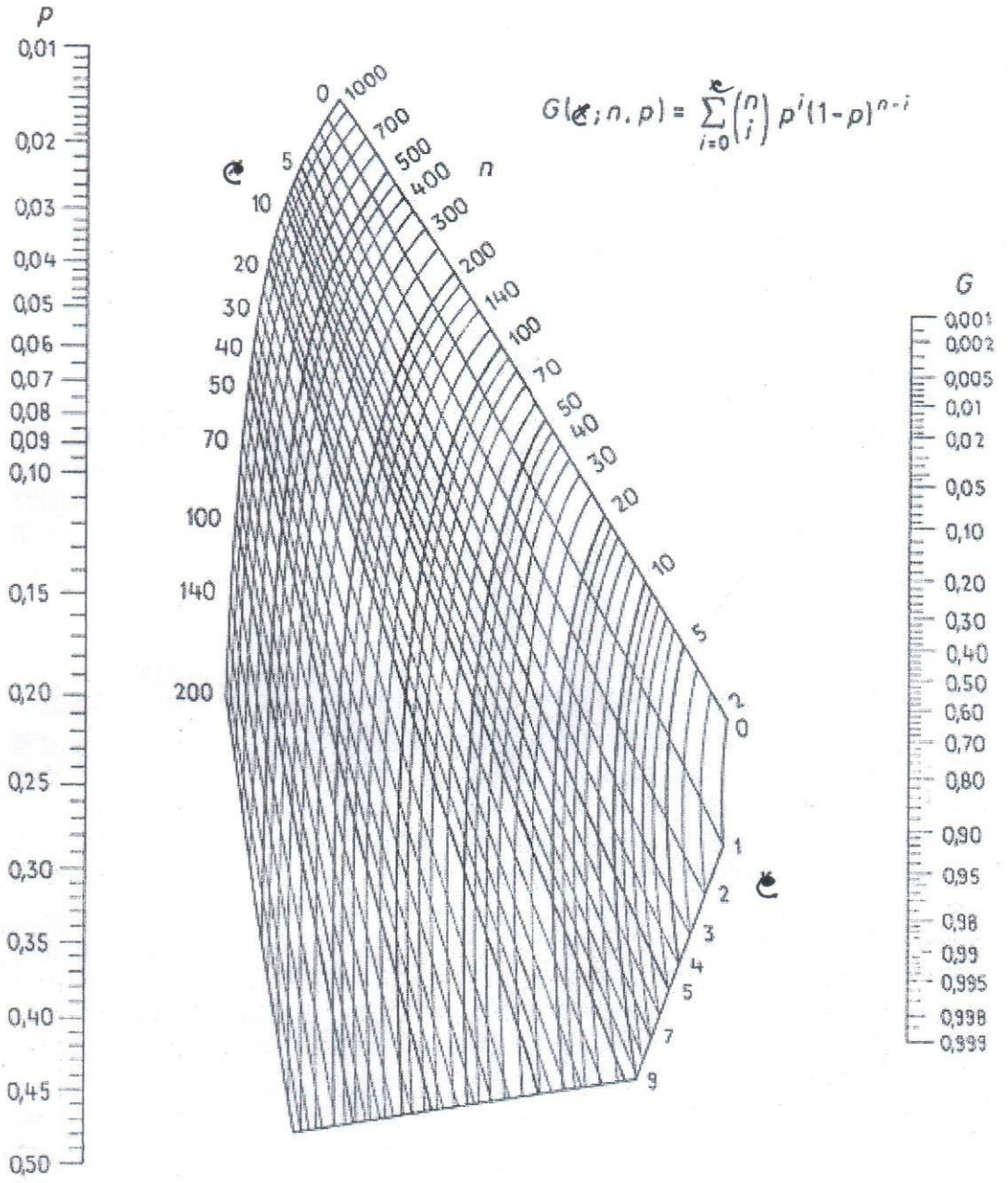
$$t = \frac{\bar{d}}{s_d/\sqrt{n}}$$

$$s_d = \sqrt{\frac{\Sigma(d - \bar{d})^2}{n-1}}$$

(2)

Confidence Intervals						
	80%	90%	95%	98%	99%	99.9%
Level of Significance for One-Tailed Test, α						
df	0.100	0.050	0.025	0.010	0.005	0.0005
Level of Significance for Two-Tailed Test, α						
	0.20	0.10	0.05	0.02	0.01	0.001
1	3.078	6.314	12.706	31.821	63.657	636.619
2	1.886	2.920	4.303	6.965	9.925	31.599
3	1.638	2.353	3.182	4.541	5.841	12.924
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.869
6	1.440	1.943	2.447	3.143	3.707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.408
8	1.397	1.860	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.250	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.140
15	1.341	1.753	2.131	2.602	2.947	4.073
16	1.337	1.746	2.120	2.583	2.921	4.015
17	1.333	1.740	2.110	2.567	2.898	3.965
18	1.330	1.734	2.101	2.552	2.878	3.922

Degrees of Freedom for the Denominator	Degrees of Freedom for the Numerator															
	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40
1	161	200	216	225	230	234	237	239	241	242	244	246	248	249	250	251
2	18.5	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.5	19.5	19.5
3	10.1	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91



$$G(c; n, p) = \sum_{i=0}^{c} \binom{n}{i} p^i (1-p)^{n-i}$$

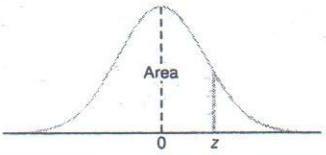


Table A.3 Areas under the Normal Curve

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
−3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
−3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
−3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
−3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
−2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
−2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
−2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
−2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
−2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
−2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
−2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
−2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
−2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
−2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
−1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
−1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
−1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
−1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
−1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
−1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
−1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
−1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
−1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
−1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
−0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
−0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
−0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
−0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
−0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
−0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
−0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
−0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
−0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
−0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

(6)

Table A.3 (continued) Areas under the Normal Curve

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0,8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

45

B.Sc Engg.(M)/5th Sem
B.ScTE/1st Sem (2Yr)

15 May, 2019

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

Semester Final Examination
Course No. MCE 4511/MCE 4591
Course Title: Fluid Machinery

Winter Semester: A.Y. 2018-2019
Time: 3 hours
Full Marks: 150

There are 8 (Eight) Questions. Answer any 6 (Six) Questions.

Marks in the Margin indicate full marks. Don't write on this question paper. Symbols carry their usual meanings. Assume reasonable values for any missing data. Programmable calculators are not allowed.

1. Upon listing the major types of *Positive displacement pumps*, discuss the working principles of any five of them with neat diagrams. [25]

2. a) Elaborate the velocity and pressure change for compounding of *impulse* and *reaction turbines* with appropriate figures. [20]

   b) What is *blade twist angle* for *wind turbines*? Derive an intuitive expression for this angle from the velocity triangle. [05]

3. An *axial flow turbine stage* is tested with air. The result is reported as below: [25]
   i) Total power developed, P_s= 320 kW with mass flow rate $\dot{m}$ = 2.0 kg/s
   ii) Inlet condition: p_{01} = 2000 kPa, T_{01}= 1650 K
   iii) Axial flow velocity V_x is constant throughout the stage
   iv) No whirl at inlet and outlet of the stage, i.e. $V_1=V_3=V_x$
   v) Condition between stator and rotor: p_2 = 1525 kPa, $\alpha_2=62^0$
   vi) Estimated loss coefficients: ξ_s = 9% and ξ_r = 13%

   Determine the *axial flow velocity, degree of reaction, static temperatures* and *relative flow angles* at the rotor inlet and outlet and the stage efficiency (using three different equations). Draw the corresponding *h-s* diagrams and velocity diagrams as required.

4. Design a *double-suction impeller* for a proposed water pumping station with the following requirements: [25]
   Head required: 70 m
   Flow rate required: 120 liters/second
   Speed required: 1650 rpm
   The design of vanes can be ignored.
   Assume σ_s= 68.95 MPa for the shaft material.

5. a) Discuss the different flow types commonly encountered in turbomachineries. [09]

   b) Determine the flow velocities and energy transfer for each rotor of a *Curtis stage* under the condition of *maximum utilization factor*. The following data are given: $\alpha_1=65^0$ with respect to the axial direction, r_m = 0.18 m, and N = 7800 rpm. Neglect all friction losses. Show that *the energy transfer of the rotors is equal to eight times the peripheral velocity squared* for this condition. Draw the corresponding *h-s* and velocity diagrams. [16]

6. a) Using *Method of Repeating Variables*, derive dimensionless parameters for correlating test data for output shaft power of a *hydraulic turbine*. [10]

   b) Select the type of *pump* to pump water of 25 l/s to overcome a resistance of 7.5 m water head in the pipe if a motor of 1800 rpm is available. Also estimate the approximate efficiency. [08]

   c) A hydraulic turbine running at 1500 rpm with an estimated efficiency of 88% is to be designed for a hydropower site with a net head of 75 m, flow rate of 39 m^3/min. The model of 1:6 scale running at 2850 rpm is to be tested in the laboratory. Estimate its flow rate, head and output power. [07]

7. a) Using two alternative approaches, develop *Euler Turbomachinery equation*. [12]

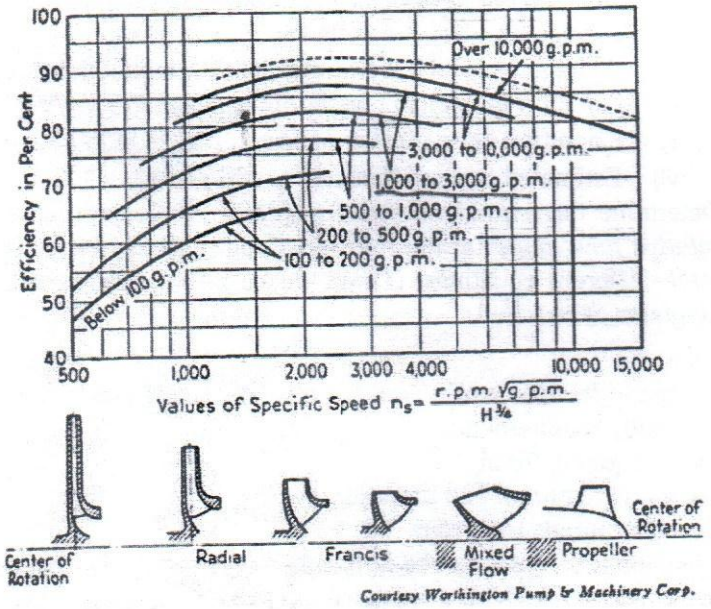
   b) Write short notes on *Cavitation* and *NPSH*. [10]

   c) Reason why *backward leaning* is preferred to *forward leaning* while designing *radial pumps*. [03]

8. a) Show that pump power can be expressed as $P=\rho[\frac{\omega tan\beta_2}{2\pi b_2(1-t_2)}Q^2+\omega^2 r_2^2 Q]$ [10]

   b) For an axial flow turbine, show that the degree of reaction can be written as [15]

$$R=\frac{1}{2}-\frac{\phi}{2}(tan\alpha_2+tan\beta_3)$$



Approximate relative impeller shapes and efficiencies as related to specific speed

1 gallon (US) = 3.78541 liters, 1 ft = 0.3048 m

47

B.Sc. Engg. (M)/5th Sem. (Prod.) 28 May 2019

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

SEMESTER FINAL EXAMINATION — WINTER SEMESTER: 2018-2019
COURSE NO. MCE 4521 — TIME: 3 HRS
COURSE TITLE: Materials Engineering — FULL MARKS: 150

There are EIGHT (08) Questions. Answer any SIX (06) Questions.
Marks in the Margin indicate full marks.

1. (a) Distinguish between 'composite' and 'ceramics'. Classify composites depending on the size and shape of the reinforcing phase. Describe them briefly. (18)
   (b) Give a flow sheet showing the production process of insulator goods. (7)

2. (a) Draw a neat sketch of the basic electric arc furnace. Describe briefly how stainless steel is produced by the basic electric arc furnace process. (17)
   (b) Suggest suitable materials with approximate composition for the production of any four of the following machine components:
   (i) cam, (ii) piston pin, (iii) leaf spring, (iv) liner of a ball mill of a cement factory, (v) crank shaft (vi) landing gear used in an aeroplane, and (vii) turbine blade of a power plant. (8)

3. (a) "Normalized mild steel shows finer grain size than annealed mild steel." Explain in details how the grain size becomes finer in normalized mild steel. (10)
   (b) Draw the microstructure of a full annealed file steel. Is this structure desireable? Give reasons for your answer. (10)
   (c) Suggest a suitable annealing heat treatment process for the file steel (5)

4. (a) Draw the I.T. diagram for a hypereutectoid steel and label the diagram completely. Show the continuous cooling curve superimposed on the I.T. diagram to produce a microstructure consisting of:
   (i) Cementite + Pearlite, (ii) Martensite, (iii) Bainite, (iv) Cementite + Pearlite + Bainite+ Martensite and (v) Bainite + Martensite. (17)
   (b) What is austempering? Mention the advantages and limitation of austempering as compared to conventional quench and temper method. (8)

5. (a) Distinguish between martensitic stainless steel and austenitic stainless steel with respect to composition and transformation characteristics. (12)
   (b) What problem is generally encountered during welding of austenitic stainless steel? Suggest some probable remedial measures of this problem. (8)
   (c) Which stainless steel is best suited for (i) surgical instrument and (ii) combustion chamber and why? (5)

6. (a) What is carburization? What is the purpose of carburization? (5)
   (b) Describe briefly how a mild steel gear is carburized by the process of pack carburization stating the mechanism involved in the process. (12)
   (c) Suggest with a neat sketch a suitable heat treatment method for the pack carburized gear. Give an outline of the process. (8)

7. (a) Define 'nitriding'. With reference to the iron-nitrogen equilibrium diagram explain the mechanism by which a nitrided case is formed. Mention the effect of alloying element on the hardness and depth of nitrided case. (15)
   (b) Distinguish between ferritic malleable cast iron and ferritic ductile cast iron. Mention at least three applications of each of them. Describe briefly how ferritic malleable cast iron is produced. (10)

8. Answer any **two** of the following: (12.5x2)
   (a) What is high speed tool steel? Give the important types of high speed tool steel. Describe briefly how the 18-4-1 grade of high speed tool steel is hardened by heat-treatment.
   (b) Draw and discuss the industrially important part of the Cu-Zn equilibrium diagram. Show by means of sketch how the tensile strength and the percentage of elongation of plain brass vary with the zinc content.
   (c) Write short notes on any **four** of the following:
   (i) Naval brass, (ii) Admiralty brass, (iii) Gun metal, (iv) Phosphor bronze, (v) Bearing metal, and (vi) Duralumin'and (vii) Aerospace application of powder metallurgy.

49

B.Sc. Engg. (EEE)-5th Sem. 25 May 2019 (Saturday)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

SEMESTER FINAL EXAMINATION — WINTER SEMISTER: 2018 - 2019
Course No. HUM- 4521 — TIME : 3 HRS
Course Title: Engineering Management — FULL MARKS: 150

There are two sections of the question paper. **Please use separate answer scripts for each section.** There are **Eight** (08) Questions in total. Answer any **Six** (06) of them.
Marks in the margin indicate full marks.
Programmable calculators are not allowed. Do not write on the question paper.

Section A

1(a) Briefly describe the six basic management theories. (09)

1(b) Write down the advantages and disadvantages of the matrix structured management system. (06)

1(c) What are the specific techniques an engineering manager uses to enhance the motivation for the professionals? (05)

1(d) Write down the organizational objectives of the IUT. (05)

2(a) What are the basic differences between management system and human resource management system? (04)

2(b) What would be the goals, policies and procedures of human resource management in IUT? (06)

2(c) Write down, briefly, the objectives, components and functions of human resource management in an international electro-mechanical company. (12)

2(d) Why is human resource management so important? (03)

3(a) Why is a teamwork in research so important? How many numbers of steps generally taken out to have an effective teamwork and why? (09)

3(b) What are the factors that promote and hinder the good working relationships in a teamwork for a collaborative research? (10)

3(c) How can you classify the personel system considering the value orientation? (06)

4(a) How can the performance appraisal system be modelled in practice? Describe briefly. (08)

4(b) How is the modern performance appraisal process applied in industries? (07)

4(c) Briefly describe the general framework for the potential collaboration between university, industry and government. (05)

4(d) How and what would you take as measures for the industrial accident prevention? (05)

Section B

5(a) The President, Chip Monk, of the Tim Burr Company wants to best utilize the wood resources in one of its forest regions. Within this region, there is a sawmill and a plywood mill; thus timber can be converted to lumber or plywood. (09)

Producing marketable mix of 1000 broad feet of lumber products requires 1000 broad feet of spruce and 4000 broad feet of Douglas fir. Producing 1000 square feet of plywood requires 2000 broad feet spruce and 4000 broad feet of Douglas fir. This region has available 32000 broad feet of spruce and 72000 broad feet of Douglas fir.

Sales commitments require that at least 5000 broad feet of lumber 12000 square feet of plywood be produced during the planning period. The profit contributions are $45 per 1000 broad feet of lumber products and $60 per 1000 square feet of plywood. Express the problem as a linear programming model.

5(b) Solve the following problem by simplex method: (12)

Maximize $Z = 6x + y + 2z$

Subject to

$$2x + 2y + \frac{1}{2}z \leq 2$$

$$-4x - 2y - \frac{3}{2}z \leq 3$$

$$x + 2y + \frac{1}{2}z \leq 1$$

$$x \geq 0,\ y \geq 0,\ z \geq 0$$

5(c) "All managers are leaders but all leaders are not managers." Explain the statement. (04)

6(a) National Mixer Inc., sells can openers. Monthly sales for a seven-month period were as follows: (12)

Month	Sales (000 units)
February	19
March	18
April	15
May	20
June	18
July	22
August	20

I. Forecast September sales volume using each of the following
   a. A linear trend equation
   b. A five-month moving average
   c. Exponential smoothing with a smoothing constant equal to 0.20, assuming a march forecast of 19(000)
   d. The naïve approach
   e. A weighted average using 0.60 for August, 0.30 and 0.10 for June

II. Which method seems least appropriate? Why?
III. What does use of the term sales rather than demand presume?

6(b) What are the important traits of Leadership? Do the traits alone sufficient to become a leader? Explain with an example. (07)

6(c) Explain the management grit in respect of concern for production and people. What grit status do you feel better? Justify your answer. (06)

7(a) There are following seven jobs and they must pass through Machine 1 and Machine 2. Operating time for both the machines is shown below for each of the job. (12)

Job	Operations Time for machine 1	Operations Time for machine 2
A	9	6
B	8	5
C	7	7
D	6	3
E	1	2
F	2	6
G	4	7

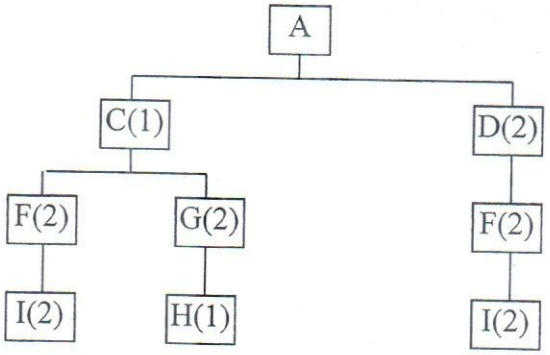
I. Schedule (job sequence and show the arrangement in diagram for machine 1 & 2) the seven jobs through two machines in sequence to minimize the flow time using Johnson's rule.
II. Find the job completion time.
III. Find the slack time or idle time for machine 1 & 2, separately.

7(b) Assign the tasks to the employees such that each employee will be assigned by only one job to minimize the total cost. Find at least two multiple solutions if there is any (13)

Jobs	Machine 1	2	3	4	5
A	10	9	9	18	11
B	13	9	9	18	11
C	3	2	4	18	10
D	18	9	12	17	11
E	11	11	14	18	13

X

8(a) Brown and Brown Electronics manufactures a line of digital audiotape (DAT) players. The bill of materials, showing the number of each item required is shown below follows: (12)



Data for A : Gross requirement is100 units on 9th week, Lead time is 2 weeks, Lot for lot
Data for C : Lead time is 1 weeks, Lot for lot
Data for D : Lead time is 2 weeks, schedule receipt is 30 on 1st week, lot size 170 units
Data for F : Lead time is 1 weeks, scheduled receipt is 60 on 1st week, on hand inventory is 15, lot for lot
Data for G : Lead time is 1 weeks, scheduled receipt is 100 on 1st week, on hand inventory is 50, lot for lot
Data for H : Lead time is 1 weeks, scheduled receipt is 50 on 1st week, lot size is 200
Data for I : Lead time is 1 weeks, scheduled receipt is 60 on 1st week, on hand inventory is 15, lot for lot

Prepare an MRP schedule to satisfy the demand.

8(b) Annual Demand = 10,000 units (09)

Days per year considered in average daily demand = 365
Cost to place an order = $10
Holding cost per unit per month = 0.01% of cost per unit
Lead time = 3 days
Cost per unit = $15
Determine the economic order quantity and the reorder point. Also find the Annual Ordering and Holding cost. State some significance of the obtained results.

8(c) Distinguish the differences between Fiedler and path goal approach of Contingency theory of leadership. (04)

53

B.Sc. Eng. (CSE)/ 5th Sem. 29 May 2019

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination — Winter Semester: 2018-2019
Course No.: Math-4541 — Time: 3 Hours
Course Title: Multivariable Calculus and Complex Variables — Full Marks: 150

There are **8 (Eight)** questions. Answer any **6 (Six)** of them. Programmable calculators are not allowed. Do not write anything on this question paper. The figures in the right margin indicate full marks. The Symbols have their usual meaning.

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1. a) (i) What is a graph of a function of two variables? How is it interpreted geometrically? Describe level curves. **12**

(ii) Explain, why $z^2 = x + 3y$ is not a function of x and y.

Consider a function $f(x,y) = \sqrt{9 - x^2 - y^2}$

(iii) Find the domain and range of the function.

(iv) Sketch a contour map of this surface using level curves corresponding to $k = 0, 1, 2, 3, \ldots 8$.

b) (i) If $\lim_{(x,y)\to(2,3)} f(x,y) = 4$, can you conclude anything about $f(2, 3)$? Explain. **13**

(ii) Discuss the continuity of $f(x,y,z) = \dfrac{1}{x^2 + y^2 - z^2}$

2. a) (i) Sketch the graph of a function $z = f(x, y)$ whose derivatives f_x and f_y are always positive. **12**

(ii) Explain the geometrical interpretation of partial derivatives.

(iii) Find the slopes of the surface $f(x,y) = 1 - (x-1)^2 - (y-2)^2$ at the point (1, 2, 1) in the x-direction and in the y-direction.

b) (i) What is meant by a linear approximation of $z = f(x, y)$ at the point $P(x_0, y_0)$? **13**

A function is given $z = f(x,y) = x^2 + 3xy - y^2$,

(ii) Find the differential dz.

(iii) If x changes from 2 to 2.05 and y changes from 3 to 2.96, compare the values of Δz and dz.

3. a) (i) Consider a point (x_0, y_0, z_0) on a surface given by $F(x, y, z) = 0$. What is the relationship between $\nabla F(x_o, y_0, z_0) = 0$ and any tangent vector v at (x_0, y_0, z_0)? How do you represent this relationship mathematically? **13**

(ii) Find the tangent plane to the elliptic paraboloid $z = 2x^2 + y^2$ at the point $(1, 1, 3)$.

b) (i) What is the meaning of the gradient of a function f at a point (x, y)? **12**

(ii) Find the directional derivative of the function $f(x,y) = x^2y^3 - 4y$ at the Point $(2, -1)$ in the direction of the vector $\vec{v} = 2\hat{i} + 5\hat{j}$

4. a) (i) For a function of two variables, describe (a) relative minimum, (b) relative maximum, (c) critical point, and (d) saddle point **12**

(ii) A rectangular box without a lid is to be made from 12 m of cardboard. Find the maximum volume of such a box.

b) (i) Explain what is meant by constrained optimization problems. **13**
(ii) In your own words, describe the Method of Lagrange Multipliers for solving constrained optimization problems.
(iii) Under what condition does the Second Partials Test fail?

5. a) Find the maximum value of the function $f(x,y,z)=x+2y+3z$ on the curve **13** of intersection of the plane $x-y+z=1$ and the cylinder $x^2+y^2=1$.

b) (i) What does it mean for *f(z)* to be continuous at z_0 or on a domain *D*? **12**
(ii) Show that the function e^x *(cos y + i sin y)* is an analytic function, find its derivative.

6. a) (i) What are the Cauchy-Riemann Equations? **13**
(ii) What does it mean for a function *f(z)* to be analytic?
(iii) Show that the function $f(z) = u + iv$,

$$\text{where } f(z)=\begin{cases}\dfrac{x^3(1+i)-y^3(1-i)}{x^2+y^2}; z\neq 0\\ 0 \qquad\qquad ; z=0\end{cases}$$

satisfies the Cauchy-Riemann equations at $z = 0$. Is the function analytic at $z = 0$? Justify your answer.

b) (i) What is the relationship between harmonic and analytic functions? **12**
(ii) Prove that $u=x^2-y^2-2xy-2x+3y$ is harmonic. Find a function *v* such that $f(z) = u + iv$ is analytic. Also, express $f(z)$ in terms of *z*.

7. a) (i) What is Cauchy's Integral Formula? **12**
(ii) Use Cauchy's integral formula to evaluate

$$\int_c \frac{z}{(z^2-3z+2)}dz, \text{ where } c \text{ is the circle } |z-2|=\frac{1}{2}$$

b) (i) What is the ratio test? **13**
(ii) Find the Taylor series and radius of convergence of the following function:

$z\sinh(z^2)$ at $z=0$

8. a) (i) What is a Laurent series expansion of *f(z)* and where is it defined? **12**
(ii) Find the Laurent series of the function

$$f(z)=\frac{z+4}{z^2\left(z^2+3z+2\right)} \text{ valid for the region } 1<|z|<2 \text{ and } |z|>2$$

b) (i) State Cauchy's Residue Theorem? **13**
(ii) Using Residue theorem, evaluate

$$\frac{1}{2\pi i}\int_c \frac{e^{zt}}{z^2(z^2+2z+2)}dz, \text{ where } c \text{ is the circle } |z|=3$$

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B.Sc. Engg. (ME)/HDME, 5th Sem. May 20, 2019

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

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination
Course No.: MCE 4547
Course Title: Principles of CAD/CAM/CAE

Winter Semester, A. Y. 2018-2019
Time: 3 Hours 00 Min(s)
Full Marks: 150

There are 8 (Eight) questions. Answer any 6 (Six) 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) Why CAD, CAE and CAM are required? Describe the steps for CAD and CAE in the design process of a product cycle. Describe the difference between a CAD model and a CAE model? 13
   b) Classify and describe different types of orthographic projections. 12

2. a) In Figure 1, axis t goes through the origin and a point $q = (1,2,1)$. Point $p = (0,-1,1)$ is rotated about t by an angle 60° (Counter clock wise). What are the coordinates of p after rotation? 15

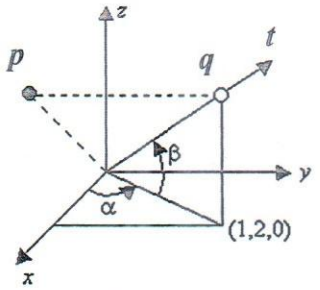

Figure 1

   b) In describing the shape of an object, what is the main reason for using the object's model coordinate system? 10

3. a) Suppose a solid model is stored in computer with CSG data structure. When it is displayed on the screen, computer needs its faces to triangulate them and render those triangles on the screen. Does CSG have those faces and why? If not, how does the computer get those faces? What is the main disadvantage of this? What is the main advantage of CSG? 13
   b) Establish the relationship between V, E, F, H, P, and W using Euler-Poincare formula for the Figure 2. Where, V be the number of vertices, E the number of Edges, F the number of Faces, H the number of hole inner loops, P the number of through holes and W be the number of voids in the solid (The small cube is a hollow part, also called a void) 12

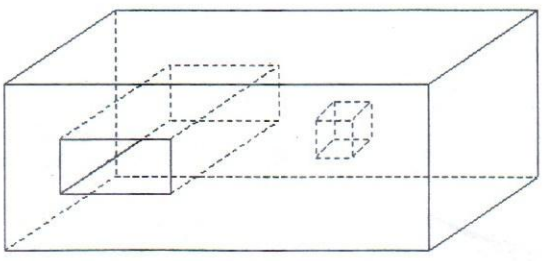

Figure 2

4. a) Why reverse engineering is necessary for manufacturing industries? Briefly explain the working principle of electromagnetic digitizer and sonic digitizer? 13
   b) Classify CNC machine tools based on motion types and the number of axes, and explain them with necessary diagram. 12

5. Expand the equation of a non-periodic uniform B-spline curve of order 3 in polynomial form. Assume that the control points of the curve are $\mathbb{P}_0$, $\mathbb{P}_1$ and $\mathbb{P}_2$. 25

6. a) Derive a general surface expression of $S(u, v)$, where four corner points $S(0,0)$, $S(0,1)$, $S(1,0)$ and $S(1,1)$ are given. 13
   b) Write down the properties and drawbacks of Bezier Surface. 12

7. a) Describe SLA and LOM rapid prototyping processes with necessary diagram. 20
   b) What are the basic differences between rapid prototyping and traditional machining? 5

8. What is work co-ordinate system in CNC programming? Write down a CNC part program for cutting the outer profile, outside pocket, one straight slot and ten counterbore drills (Design shown below in Figure 3). Selected feed rate, spindle speed and necessary tools for the mentioned operations with proper dimensions and compensation values (if needed). Follow the cutting sequences as shown in the design below. Assume if any dimension or value is missing. 25

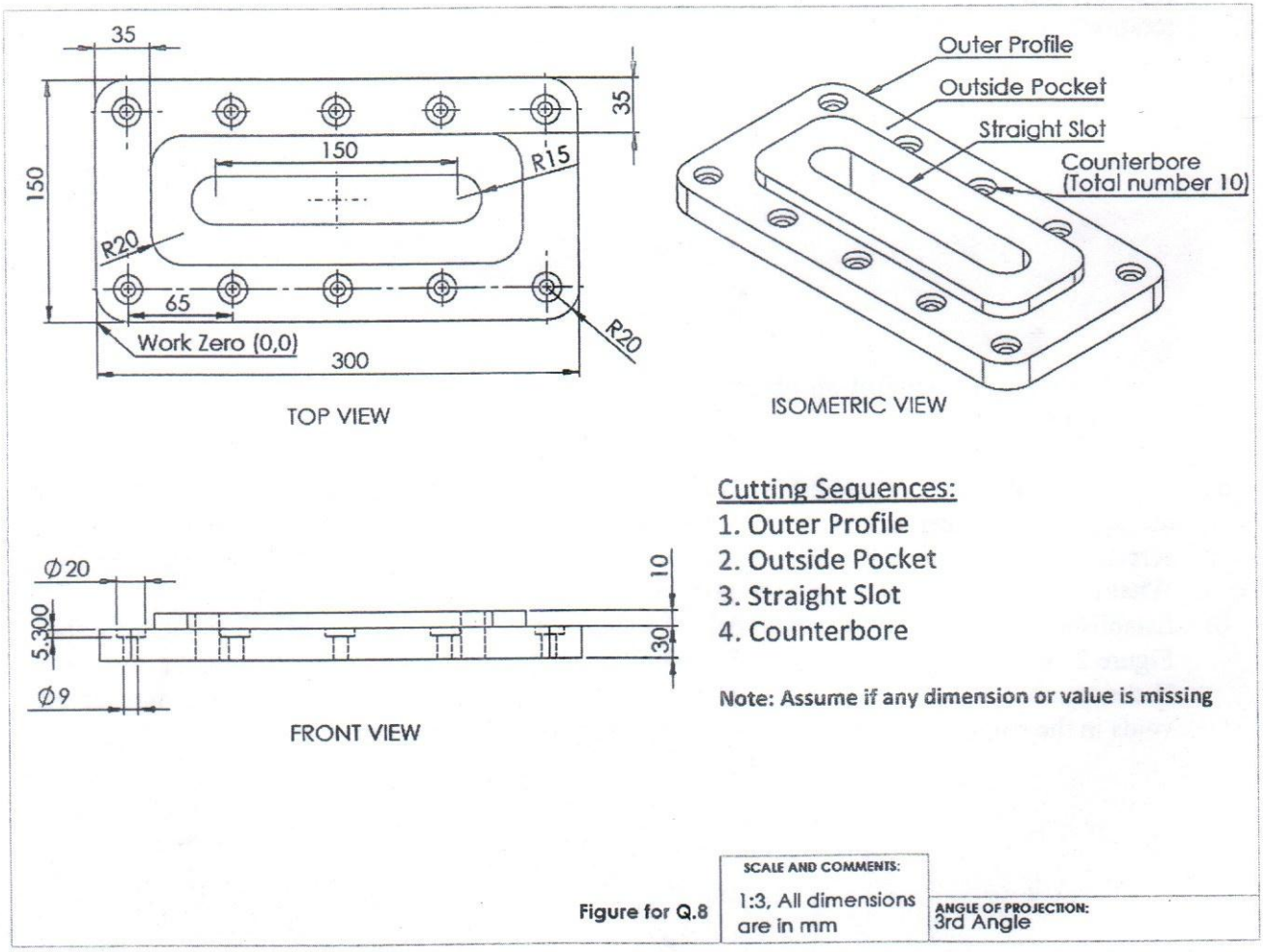

Figure 3

BSc. Engg. (M) 5th Sem/HDME 5th Sem/DTE 1st Sem — 20 May 2019

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

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

SEMESTER FINAL EXAMINATION — Winter Semester: 2018-2019
Course No: MCE-4551 — TIME : 03 HRS
Course Name: Refrigeration — FULL MARKS: 150

There are **EIGHT** Questions. Answer any **SIX** Questions.
Assume reasonable value for missing data. Marks in the margin indicate full marks.

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1. a) Write a short note on Refrigeration under the light of thermodynamic principles. (10)

   b) A Carnot refrigeration cycle absorbs heat at **-12^{0}C** and rejects it at **40^{0}C**. (a) Calculate the coefficient of performance of this refrigeration cycle. (b) If the cycle is absorbing **15 kW** at the **-12^{0}C** temperature, how much power is required? (c) If a Carnot heat pump operates between the same temperatures as the above refrigeration cycle, what is the performance factor? (d) What is the rate of heat rejection at the **40^{0}C** temperature if the heat pump absorbs **15 kW** at the **-12^{0}C** temperature? (15)

2. a) Explain different processes of reverse Brayton cycle. Derive an expression for COP of the reverse Brayton cycle. Draw the cycle on both ***P-v*** and ***T-s*** diagrams. (10)

   b) An air refrigerator system operating on Bell Coleman cycle, takes in air from cold room at **268 K** and compresses it from **1 bar** to **5.5 bar** the index of compression being **1.25**. the compressed air is cooled to **300 K**. the ambient temperature is **20°C**. Air expands in expander where the index of expansion is **1.35**. Latent heat of fusion of Ice is **335 kJ/kg**. (15)
   Calculate:
   i) C.O.P of the system, ii) Quantity of air circulated per minute for production of **1500 kg** of ice per day at **0°C** from water at **20°** and iii) Capacity of the plant.

3. a) What are the ways of improving VCR cycle? Explain them with necessary diagrams. (10)

   b) A refrigeration system using **R-22** is to have a refrigerating capacity of **80 kW.** The cycle is a standard vapor-compression cycle in which the evaporating temperature is **-8^{0}C** and the condensing temperature is **42^{0}C**. (a) Determine the volume flow of refrigerant measured in cubic meter per second at the inlet to the compressor. (b) Calculate the power required by the compressor. (c) At the entrance to the evaporator what is the fraction of vapor in the mixture expressed both on a mass basis and a volume basis? (15)

4. a) Make comparison between Vapour Absorption and Vapour Compression refrigeration system. (10)

   b) The basic LiBr-Water absorption cycle operates at the following temperatures: generator, **105^{0}C**; condenser, **35^{0}C**; evaporator, **5^{0}C**; and absorber, **30^{0}C**. The flow rate of solution delivered by the pump is **0.4 kg/s.** (a) What are the mass flow rates of solution returning from the generator to the absorber and of the refrigerant? (b) What are the rates of heat transfer of each component, and the **COP_{abs}**? (15)

5. a) Explain the reasons for using LMTD in the condenser design. "For increasing condensing temperature the heat rejection ratio (HRR) also increases at a given evaporating temperature"- explain using a chart for at least three different evaporating temperatures. Show the difference of HRR for hermetically sealed and open type of compressors with proper reasoning. (10)

b) Determine the length of tubes in a two-pass, shell and tube **R-22** condenser with **28 tubes** with data as follows (15)
Cooling capacity = **10 TR**; Condensing temperature = **45°C;** HRR = **1.32,** Entering temperature of water = **30 °C**; Leaving Temperature of water = **34.8 °C**, OD and ID of copper tubes are **1.27 cm** and **1.12 cm** respectively.

It is given that the film heat transfer co-efficient for **R-22** condensing outside the tubes is **1360 W/m^{2}K**, water properties at mean temperature are **0.623 W/m.K**, **7.83×10-4 kg/m.s** and **4.186 kJ/kg.K**.

6. a) What are the purposes of expansion devices in refrigeration system? Explain working principle of the thermostatic expansion device using necessary diagrams. (10)

b) Write the pros and cons of using the capillary tube expansion device. Show analytical methods of finding the capillary tube length for required expansion. (15)

7. a) Make a list of Air cycle refrigeration used for Aircraft. Explain the Bootstrap system using simple diagram and show the thermodynamic processes on a T-s diagram. (10)

b) A boot-strap cooling system of **10 TR** capacity is used in an aeroplane. The ambient air temperature and pressure are **20°C** and **0.85 Bar** respectively. The pressure of air increases from **0.85 Bar** to **1 Bar** due to ramming action of air. The pressure of air discharged from the main compressor is **3 Bar**. The discharge pressure of air from the auxiliary compressor is **4 Bar**. The isentropic efficiency of each of the compressor is **80%,** while that of turbine is **85%. 50%** of the enthalpy of air discharged from the main compressor is removed in the first heat exchanger and **30%** of the enthalpy of air discharged from the auxiliary compressor is removed in the second heat exchanger using rammed air. Assuming ramming action to be isentropic, the required cabin pressure of **0.9 Bar** and temperature of the air leaving the cabin not more than **20° C**. Calculate- (15)
   1. The power required to operate the system, and
   2. The **C.O.P.** of the system.

Draw the schematic and *T-s* diagram of the system. Take γ **=1.4** and **C*p* =1 kJ/kg K**.

8. A two-stage **R-22** system that uses flash-gas removal and intercooling serves a single low-temperature evaporator as shown in Figure 1. The evaporator temperature is **-40^{0}C**, and the condensing temperature is **30^{0}C**. The pumping capacity of the high- and low-stage compressors is shown in Figure 2. What is (a) the refrigerating capacity of the system and (b) the intermediate pressure? (25)

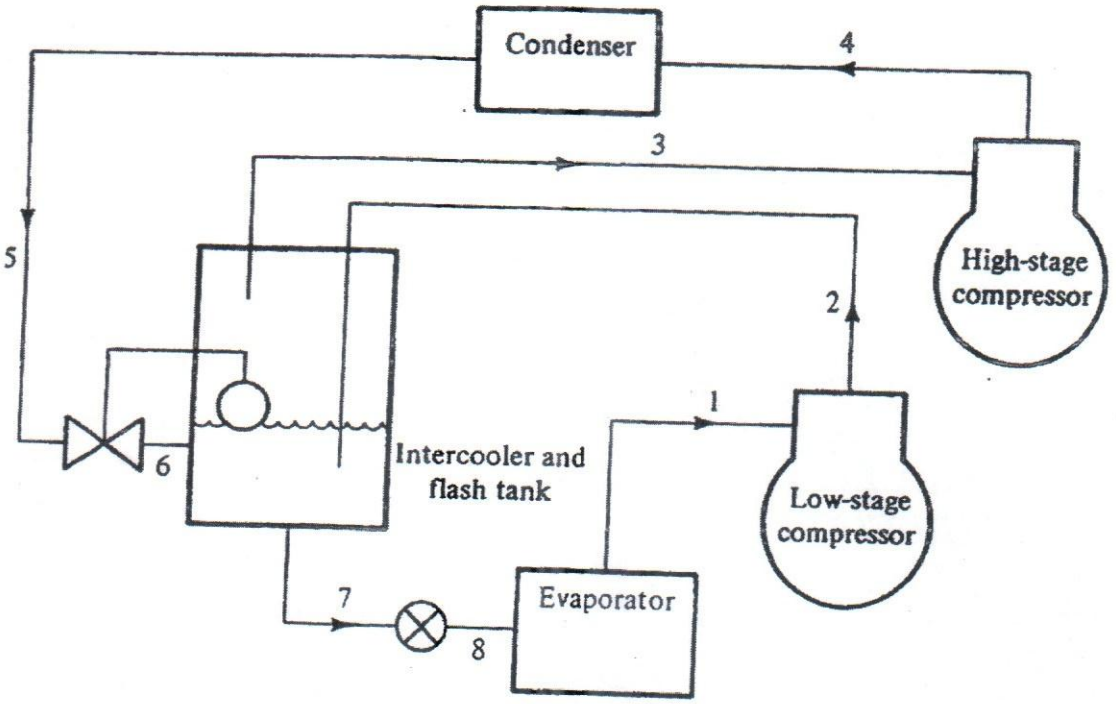


Figure 1

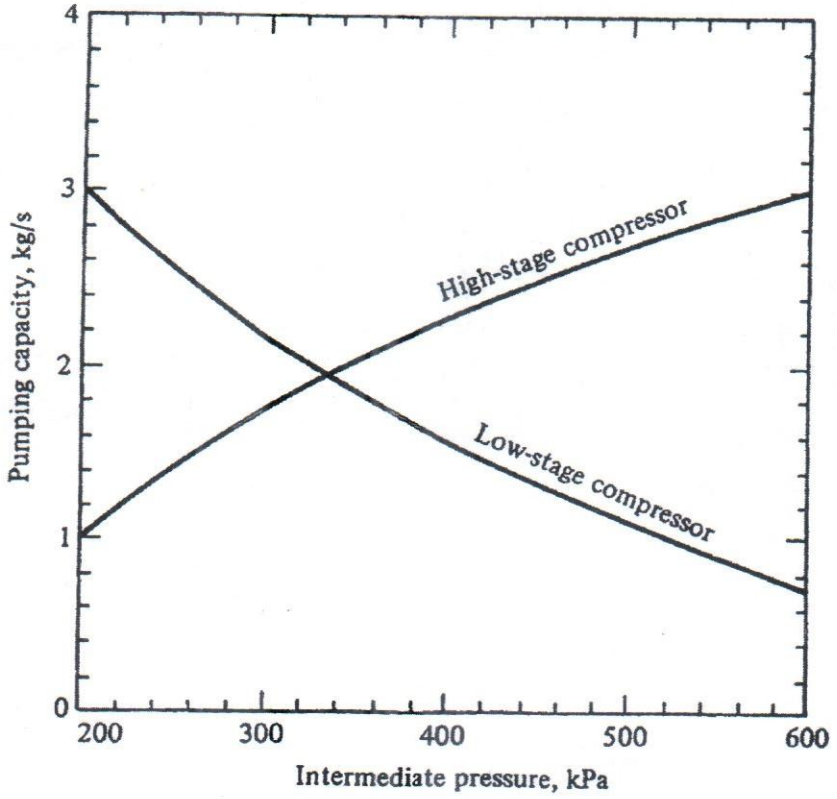
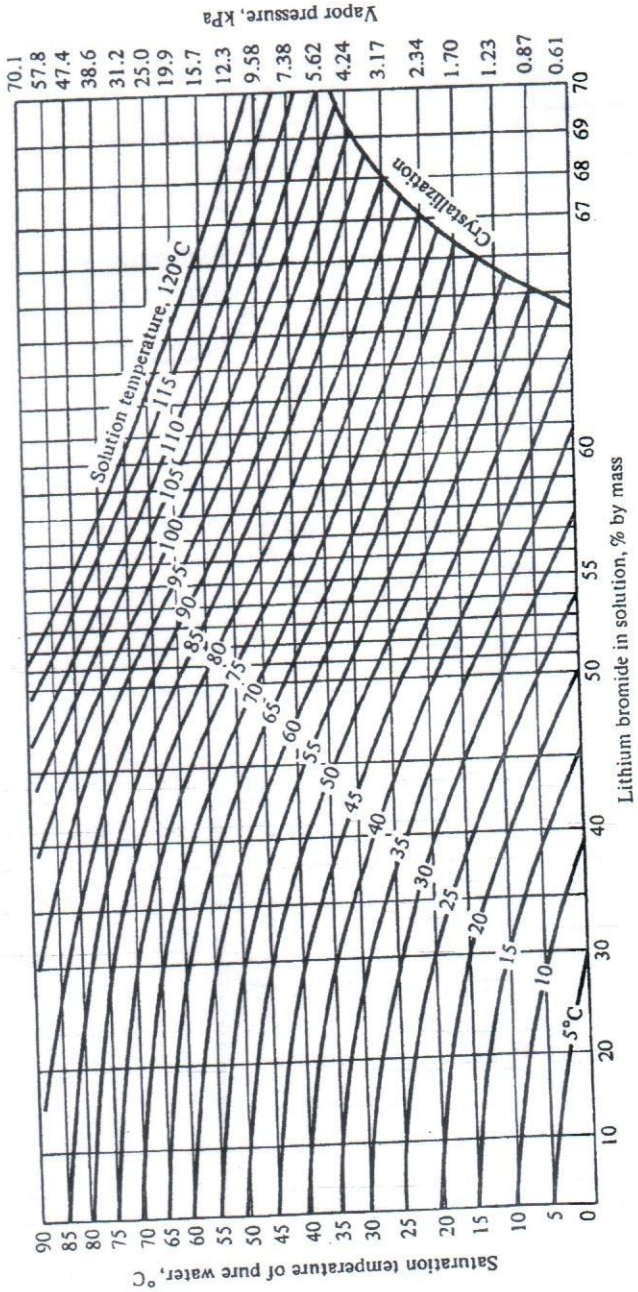


Figure 2


Vapor pressure, kPa
70.1
57.8
47.4
38.6
31.2
25.0
19.9
15.7
12.3
9.58
7.38
5.62
4.24
3.17
2.34
1.70
1.23
0.87
0.61
Crystallization
Solution temperature, 120°C
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5°C
Lithium bromide in solution, % by mass
Saturation temperature of pure water, °C

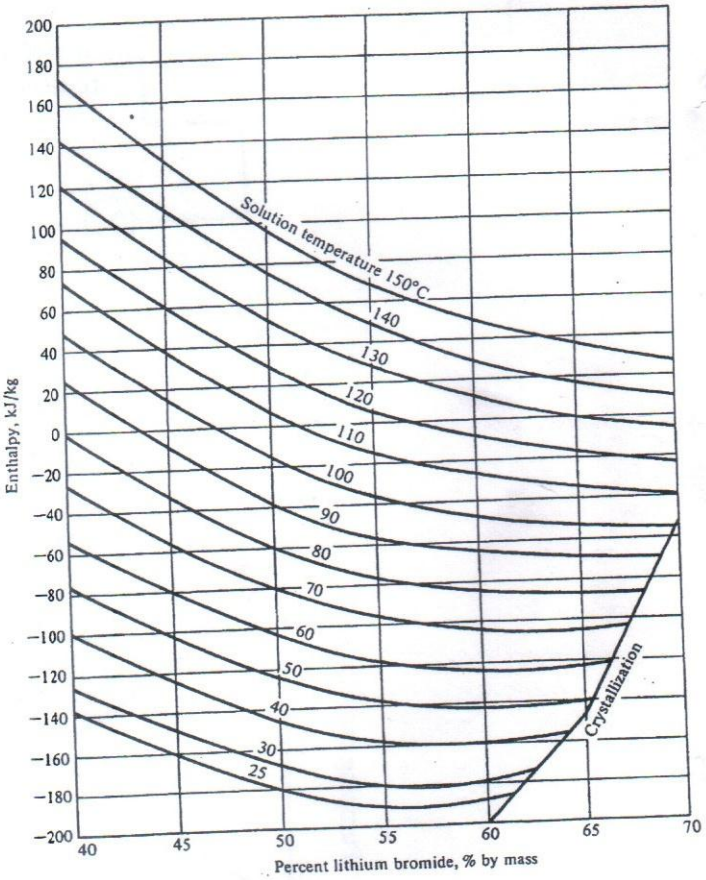

Enthalpy, kJ/kg
Solution temperature 150°C
140
130
120
110
100
90
80
70
60
50
40
30
25
Crystallization
Percent lithium bromide, % by mass

Table A-1 Water: properties of liquid and saturated vapor

	Saturation pressure,	Specific volume, m^3/kg		Enthalpy, kJ/kg		Entropy, kJ/kg · K	
t, °C	kPa	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor
0	0.6108	0.0010002	206.3	-0.04	2501.6	-0.0002	9.1577
2	0.7055	0.0010001	179.9	8.39	2505.2	0.0306	9.1047
4	0.8129	0.0010000	157.3	16.80	2508.9	0.0611	9.0526
6	0.9345	0.0010000	137.8	25.21	2512.6	0.0913	9.0015
8	1.0720	0.0010001	121.0	33.60	2516.2	0.1213	8.9513
10	1.2270	0.0010003	106.4	41.99	2519.9	0.1510	8.9020
12	1.4014	0.0010004	93.84	50.38	2523.6	0.1805	8.8536
14	1.5973	0.0010007	82.90	58.75	2527.2	0.2098	8.8060
16	1.8168	0.0010010	73.38	67.13	2530.9	0.2388	8.7593
18	2.062	0.0010013	65.09	75.50	2534.5	0.2677	8.7135
20	2.337	0.0010017	57.84	83.86	2538.2	0.2963	8.6684
22	2.642	0.0010022	51.49	92.23	2541.8	0.3247	8.6241
24	2.982	0.0010026	45.93	100.59	2545.5	0.3530	8.5806
26	3.360	0.0010032	41.03	108.95	2549.1	0.3810	8.5379
28	3.778	0.0010037	36.73	117.31	2552.7	0.4088	8.4959
30	4.241	0.0010043	32.93	125.66	2556.4	0.4365	8.4546
32	4.753	0.0010049	29.57	134.02	2560.0	0.4640	8.4140
34	5.318	0.0010056	26.60	142.38	2563.6	0.4913	8.3740
36	5.940	0.0010063	23.97	150.74	2567.2	0.5184	8.3348
38	6.624	0.0010070	21.63	159.09	2570.8	0.5453	8.2962
40	7.375	0.0010078	19.55	167.45	2574.4	0.5721	8.2583
42	8.198	0.0010086	17.69	175.31	2577.9	0.5987	8.2209
44	9.100	0.0010094	16.04	184.17	2581.5	0.6252	8.1842
46	10.086	0.0010103	14.56	192.53	2585.1	0.6514	8.1481

Table A-1 (continued)

	Saturation pressure,	Specific volume, m^3/kg		Enthalpy, kJ/kg		Entropy, kJ/kg · K	
t, °C	kPa	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor
48	11.162	0.0010112	13.23	200.89	2588.6	0.6776	8.1125
50	12.335	0.0010121	12.05	209.26	2592.2	0.7035	8.0776
52	13.613	0.0010131	10.98	217.62	2595.7	0.7293	8.0432
54	15.002	0.0010140	10.02	225.98	2599.2	0.7550	8.0093
56	16.511	0.0010150	9.159	234.35	2602.7	0.7804	7.9759
58	18.147	0.0010161	8.381	242.72	2606.2	0.8058	7.9431
60	19.920	0.0010171	7.679	251.09	2609.7	0.8310	7.9108
62	21.84	0.0010182	7.044	259.46	2613.2	0.8560	7.8790
64	23.91	0.0010193	6.469	267.84	2616.6	0.8809	7.8477
66	26.15	0.0010205	5.948	276.21	2620.1	0.9057	7.8168
68	28.56	0.0010217	5.476	284.59	2623.5	0.9303	7.7864
70	31.16	0.0010228	5.046	292.97	2626.9	0.9548	7.7565
72	33.96	0.0010241	4.646	301.35	2630.3	0.9792	7.7270
74	36.96	0.0010253	4.300	309.74	2633.7	1.0034	7.6979
76	40.19	0.0010266	3.976	318.13	2637.1	1.0275	7.6693
78	43.65	0.0010279	3.680	326.52	2640.4	1.0514	7.6410
80	47.36	0.0010292	3.409	334.92	2643.8	1.0753	7.6132
82	51.33	0.0010305	3.162	343.31	2647.1	1.0990	7.5858
84	55.57	0.0010319	2.935	351.71	2650.4	1.1225	7.5588
86	60.11	0.0010333	2.727	360.12	2653.6	1.1460	7.5321
88	64.95	0.0010347	2.536	368.53	2656.9	1.1693	7.5058
90	70.11	0.0010361	2.361	376.94	2660.1	1.1925	7.4799
92	75.61	0.0010376	2.200	385.36	2663.4	1.2156	7.4543
94	81.46	0.0010391	2.052	393.78	2666.6	1.2386	7.4291
96	87.69	0.0010406	1.915	402.20	2669.7	1.2615	7.4042
98	94.30	0.0010421	1.789	410.63	2672.9	1.2842	7.3796
100	101.33	0.0010437	1.673	419.06	2676.0	1.3069	7.3554
102	108.78	0.0010453	1.566	427.50	2679.1	1.3294	7.3315
104	116.68	0.0010469	1.466	435.95	2682.2	1.3518	7.3078
106	125.04	0.0010485	1.374	444.40	2685.3	1.3742	7.2845
108	133.90	0.0010502	1.289	452.85	2688.3	1.3964	7.2615
110	143.26	0.0010519	1.210	461.32	2691.3	1.4185	7.2388
112	153.16	0.0010536	1.137	469.78	2694.3	1.4405	7.2164
114	163.62	0.0010553	1.069	478.26	2697.2	1.4624	7.1942
116	174.65	0.0010571	1.005	486.74	2700.2	1.4842	7.1723
118	186.28	0.0010588	0.9463	495.23	2703.1	1.5060	7.1507
120	198.54	0.0010606	0.8915	503.72	2706.0	1.5276	7.1293

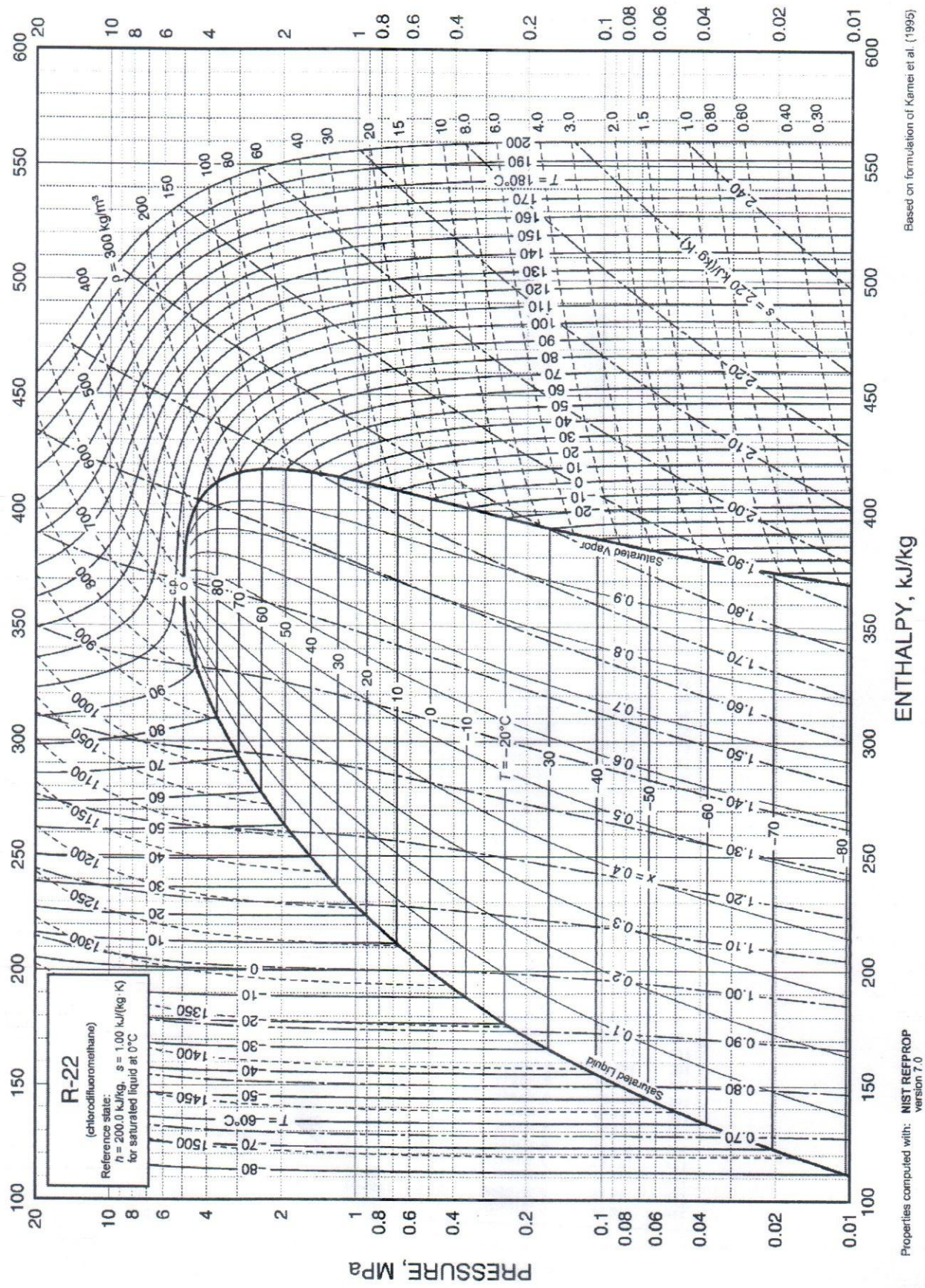


Fig. 2 Pressure-Enthalpy Diagram for Refrigerant 22

G3

BSc.ME/ HDME (5th Sem)/ DTE (1st Sem) 28 May 2019 (Tuesday)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING (MCE)

Semester Final Examination	Winter Semester	: A.Y. 2018-2019
Course Code: **MCE 4573**	Time	: 3 Hours
Course Title: **Renewable Energy Resources**	Full Marks	: 150

There are 08 (Eight) Questions. Answer any 04 (Four) of them.

Figures in the margin indicate the full marks. Assume reasonable data if necessary.
The symbols have their usual meaning. Do not write on the Question Paper.

1	a)	Define renewable energy and non-renewable (conventional) energy. Make a comparison between renewable and conventional energy systems.	12
	b)	What is a solar collector? Describe the working principle of a solar flate plate thermal collector with neat sketch. Also write down the basic flat plate energy balance equation.	13
2	a)	Define clearness index. The day's total irradiation on a horizontal surface for Dhaka, Bangladesh (latitude 23.8°), on May 28 is 32.0 MJ/m^2. Estimate the fraction and amount that is diffused.	10
	b)	With neat sketch describe the working principle of pyrheliometer and pyranometer.	15
3	a)	What is a solar cell? Discuss different types of solar cells with their manufacturing process and applications.	15
	b)	Explain the I-V characteristic curve of a solar cell with the effects of temperature and irradiance on it.	10
4	a)	Briefly discuss how wind energy can be extracted? What type of machines are used? Draw neat sketches.	7
	b)	What is Betz criterion? Derive an expression to show that the maximum power coefficient of a wind turbine is 0.59 (16/27). State all assumptions.	18
5	a)	Explain blade element theory of wind turbines.	5
	b)	Find the maximum power co-efficient of a drag type wind turbine. List all assumptions.	10
	c)	A wind turbine maintains a tip-speed ratio of 6 at all wind speeds. At which wind speed will the blade tip exceed the speed of sound? If the blade diameter is given 120m. At what rotor speed (frequency) will the tip-speed exceed the speed of sound?	10
6	a)	Discuss different types of hydro turbines used for hydropower extraction.	5
	b)	Show that the efficiency of an impulse turbine in ideal case is 100%.	10
	c)	A Pelton wheel is to be installed in a site with H= 25m, Q_{min}= 0.1 m^3 s^{-1}. Neglecting friction find (i) the jet velocity, (ii) the maximum power available and (iii) the radius of the nozzles (assuming there are two nozzles).	10

7 a) What is geothermal energy? Discuss the classification of geothermal regions and explain how heat can be obtained from it. 12

b) Explain hot dry rock extraction technique with neat sketch. 7

c) Write a short note on 'Ground-source heat pump'. 6

8 a) Discuss how bioenergy is forming in nature. What are their types? 5

b) Briefly discuss different thermochemical, bio-chemical and agrochemical processes for bioenergy production. 10

c) What is anaerobic digestion process? Explain the working principle of a biogas plant with neat sketch. 10

Formula Sheet

$$\delta = 23.45 \sin\left(360\frac{284+n}{365}\right)$$

$$\begin{aligned}\cos\theta = {} & \sin\delta \sin\phi \cos\beta - \sin\delta \cos\phi \sin\beta \cos\gamma \\ & + \cos\delta \cos\phi \cos\beta \cos\omega + \cos\delta \sin\phi \sin\beta \cos\gamma \cos\omega \\ & + \cos\delta \sin\beta \sin\gamma \sin\omega\end{aligned}$$

$$\cos\omega_s = -\frac{\sin\phi \sin\delta}{\cos\phi \cos\delta} = -\tan\phi \tan\delta$$

$$\cos\theta_z = \cos\phi \cos\delta \cos\omega + \sin\phi \sin\delta$$

$$\gamma_S = \text{sign}(\omega)\left|\cos^{-1}\left(\frac{\cos\theta_z \sin\phi - \sin\delta}{\sin\theta_z \cos\phi}\right)\right|$$

$$\begin{aligned}H_o = {} & \frac{24 \times 3600 G_{sc}}{\pi}\left(1 + 0.033\cos\frac{360n}{365}\right) \\ & \times\left(\cos\phi \cos\delta \sin\omega_s + \frac{\pi\omega_s}{180}\sin\phi \sin\delta\right)\end{aligned}$$

For $\omega_s \leq 81.4°$

$$\frac{H_d}{H} = \begin{cases} 1.0 - 0.2727K_T + 2.4495K_T^2 - 11.9514K_T^3 + 9.3879K_T^4 & \text{for } K_T < 0.715 \\ 0.143 & \text{for } K_T \geq 0.715 \end{cases}$$

and for $\omega_s > 81.4°$

$$\frac{H_d}{H} = \begin{cases} 1.0 + 0.2832K_T - 2.5557K_T^2 + 0.8448K_T^3 & \text{for } K_T < 0.722 \\ 0.175 & \text{for } K_T \geq 0.722 \end{cases}$$

65

HDME/6th Sem 20 May, 2019

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

SEMESTER FINAL EXAMINATION WINTER SEMESTER: 2018-2019

Course No: MCE 4585 TIME: 3 Hours

Course Name: Automotive Technology-I FULL MARKS: 150

There are **eight(8)**Questions. Answer any **six(6)**Questions.
Marks in the margin indicate full marks. Do not write on this question paper.

1	a)	Explain the working principle of a solenoid operated starting motor used in automotive vehicle with necessary diagrams.	**(15)**
	b)	Why a thermostat is used in water cooling system? Explain how it works.	**(10)**
2	a)	Describe the working principle of an automotive battery during charging and discharging showing the chemical reactions associated with the systems.	**(10)**
	b)	Explain the working principle of a generator, used for charging of battery in the car, with necessary diagrams. Describe how the rectification from AC to DC is done.	**(15)**
3	a)	Draw a schematic diagram of the battery ignition system showing all the components and describe how the ignition system works.	**(12)**
	b)	Show the classification of cooling systems in automotive engine. Describe the water-cooling system in an automotive engine with necessary diagram.	**(13)**
4	a)	List the functions of lubricating system in automotive engine. Show the path of lubricating oil flow to various parts of the engine and describe accordingly.	**(13)**
	b)	What is an overrunning clutch? Describe the functions and operations of overrunning clutch.	**(12)**
5.	a)	What is an EFI system? Describe different types of sensors used in the EFI system.	**(13)**
	b)	With the help of necessary diagrams explain the carburetor operations while an automotive is at low speed and at normal driving speed.	**(12)**
6.	a)	Draw the valve timing diagram and valve indicator diagram for a 4-stroke diesel engine and explain them.	**(15)**
	b)	Write down the differences between a SI engine and CI engine.	**(10)**

7. **a)** What is an Engine? Describe the working procedure of a 2-stroke engine with simple diagrams. **(13)**

   b) Explain the operating procedure of the mechanical fuel pump with necessary diagrams. **(12)**

8. **a)** Describe the CNG injection technology in an automobile mentioning the main parts of the system with simple diagram. **(13)**

   b) Write down small notes on the following components: **(12)**

   i) Radiator Pressure Cap
   ii) Contact Breaker
   iii) Anti-Freeze Mixture

G7

HDME/5th Sem 28 May, 2019

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

Semester Final Examination — Winter Semester: A.Y. 2018-2019
Course No. MCE 4587 — TIME: 3 Hours
Course Title: Automotive Maintenance Engineering (I) — Full Marks: 150

There are 8 (Eight) Questions. Answer any 6 (Six) Questions.
Marks in the Margin indicate full marks. Don't write on this question paper.

1. a) What are the common and non-common problems in ignition system? Briefly classify them. [07]
   b) What are the symptoms caused by ignition system problems? Explain. [08]
   c) How electromagnetic interference (EMI) is induced in automobiles? How does it affect the vehicles performance? [04]
   d) Before performing preliminary checks on the engine's fuel injection and control system what are the necessary steps needs to be considered? Explain. [06]
2. a) Write down the necessary steps for no-start engine diagnosis? Provide detailed explanation. [12]
   b) Write down the possible causes and remedies for following conditions; [13]
      I. Firing voltage lines the same, but abnormally high.
      II. Cylinders not firing
      III. Firing voltage lines the same, but abnormally low
3. a) Provide detailed explanation for rectifying spark plug problems. What are different types of fouling in spark plugs? Explain. [15]
   b) Explain the maintenance procedure for Fuel injector. Briefly explain the injector cleaning procedure. [10]
4. a) What are the reasons for excessive oil consumption in engine? Explain. [10]
   b) Write down the necessary steps for throttle body inspection. Explain. [15]
5. a) Explain the reason and impact of sludge on engine performance. How to examine the oil condition in engine. [10]
   b) Write down the common causes for the following conditions of engine overheating; [15]
      I. Overheats in heavy traffic or after idling for a long time.
      II. Overheats anytime or erratically.
      III. Overheats when driving at speed or after repeated heavy acceleration.
6. a) Write down the complete inspection procedure for following cooling devices; [18]
      I. Radiator (including its components).
      II. Water pump.
   b) How the battery load test is conducted? Explain [07]
7. a) Provide necessary steps and explanation to measure the parasitic drain on battery. [15]
   b) How the maintenance of cylinder head is performed? Explain. [10]
8. a) Write down all the steps for voltage drop testing of a starter circuit. [13]
   b) What are different types of contaminants? Demonstrate all the cleaning methods with reasonable explanation. [12]

B.Sc.Engg. (M)/7th Sem /B.Sc.TE(2 Yr-Prog)/4th Sem/B.Sc.TE(1 Yr-Prog.)/2nd Sem

May 24, 2019

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

FINAL SEMESTER EXAMINATION

MCE 4703 Vibration & System Dynamics

WINTER SEMESTER: 2018-2019

TIME : 3.00 Hrs

FULL MARKS : 150

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

1. (a) Derive the equation of motion for the small oscillation, and determine the natural frequency of the system shown in Fig.1 using the energy method. (13)

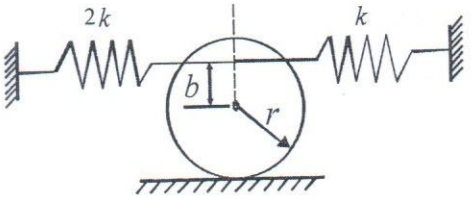


Fig. 1

(b) If the mass of the pulley shown in Fig. 2 is small and the cord is inextensible, determine the natural Frequency of the system. (12)

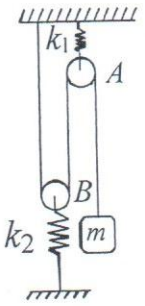


Fig. 2

2. Determine the natural frequencies of torsional oscillation for the following system. The system is a reciprocating I.C. engine coupled to a centrifugal pump through a pair of gears. The shaft from the flywheel of the engine to the gear wheel is of 60 mm diameter and 950 mm length. The shaft from the pinion to the pump is of 40 mm diameter and 300 mm lenth. The engine speed is 1/3 rd of the pump speed. Take moment of inertia of the flywheel =800 kg-m^2 ; moment of inertia of the gear wheel = 15 kg-m^2; moment of inertia of the pinion = 4 kg-m^2; moment of inertia of the pump = 17 kg-m^2 ; modulus of rigidity for the shaft material is 90 GPa. (25)

3. a) A shaft 1.5 m long is supported in flexible bearings at the ends and carries two wheels each of 50 kg mass. One wheel is situated at the centre of the shaft and the other at a distance of 0.4 m from the centre towards right. The shaft is hollow of external diameter 75 mm and inner diameter 37.5 mm. The density of the shaft material is 8000 kg/m^3. The Young's modulus for the shaft material is 200 GPa. Determine the frequency of transverse vibration. (15)

b) Derive the expression of tractive force for the partial balancing of loacomotives. (10)

4. A cam with 30 mm as minimum diameter is rotating clockwise at a uniform speed of 1200 rpm and has to give the following motion to a roller follower 10 mm in diameter: (25)

(i) Follower to complete outward stroke of 25 mm during 120^0 of cam rotation with equal uniform acceleration and retardation;
(ii) Follower to dwell for 60^0 of cam rotation;
(iii) Follower to return to its initial position during 90^0 of cam rotation with equal uniform acceleration and retardation;
(iv) Follweer to dwell for the remaining 90^0 of cam rotation.

Draw the cam profile if the axis of the roller follower passes through the axis of the cam. Determine the maximum velocity of the follower during the outstroke and return stroke and also the uniform acceleration of the follwer on the out stroke and the return stroke.

5. a) Derive the expression of displacement and velocity for the symmetric tangent cam when the roller has contact with straight flanks. (10)

b) In a symmetrical tangent cam operating a roller follower, the least radius of the cam is 35 mm and roller radius is 17.5 mm. The angle of ascent is 75^0 and the total lift is 17.5 mm. The speed of the cam shaft is 500 rpm. Calculate: i) the principal dimensions of the cam; ii) the accelerations of the follower at the beginning of the lift, where straight flank merges into the circular nose and at the apex of the circular nose. Assume that there is no dwell between ascent and descent. (15)

6. a) Derive the expression of gyroscopic couple for a two wheel vehicle taking a turn. (12)

b) An aeroplane makes a copmplete half circle of 50 metres radius, towards left, when flying at 200 km per hour. The rotary engine and the propeller of the plane has a mass of 400 kg with a radius of gyration of 300 mm. The engine runs at 2400 rpm clockwise when viewed from the rear. Determine the gyroscopic couple on the aricraft and state its effect on it. What will be the effect, if the aeroplane turns to its right instead of to the left? (13)

7. A 2.2 tonne racing car has a wheel base of 2.4 m and a track of 1.4 m from the rear axle. The equivalent mass of engine parts is 140 kg with radius of gyration of 150 mm. The back axle ratio is 5. The engine shaft and flywheel rotate clockwise when viewed from the front. Each wheel has a diameter of 0.8 m and a moment of inertia of 0.7 kg-m^2. Determine the reactions on the wheels when the car is rounding a curve of 100 m radius at a speed of 72 km/hr to the left. (25)

8. In a four cylinder inline engine, the cylinders are placed symmetrically along the longitudinal axis, with a center distance of 2.4 m between the outside cylinders and 0.6 m, between the inside cylinders. The cranks between the two inside cylinders are at 90^0 to each other and the mass of reciprocating parts of each of these is 225 kg. All the four cranks are of 0.3 m radius. If the system is to be completely balanced for the primary effects, determine: (25)

i) The mass of the reciprocating parts of each of the outside cranks;
ii) The angular position of the outside cranks with reference to the nearest inside cranks, measured in clockwise direction and draw an end view of the four primary cranks marking these angles therein;
iii) The secondary unbalanced couple, if any.

The engine is running at 180 rpm and the length of each connecting rod is 1.2 m.

Notes:

Acceleration of the roller when roller has contact with straight flank:

$$= \omega^2 (r_1 + r_2)\left(\frac{2-\cos^2\theta}{\cos^3\theta}\right)$$

Displacement, velocity and acceleration when the roller has contact with nose

$$x = L + r - r\cos\theta_1 - (L^2 - r^2\sin^2\theta_1)^{\frac{1}{2}}$$

Velocity:

$$= \omega . r\left[\sin\theta_1 + \frac{r\sin 2\theta_1}{2(L^2 - r^2\sin^2\theta_1)^{\frac{1}{2}}}\right]$$

Acceleration:

$$= \omega . r\left[\cos\theta_1 + \frac{r\sin 2\theta_1 \times \frac{1}{2}(L^2 - r^2\sin^2\theta_1)^{-\frac{1}{2}}(r^2 \times 2\sin\theta_1\cos\theta_1)}{2(L^2 - r^2\sin^2\theta_1)}\right]\frac{d\theta_1}{dt}$$

B.Sc Engg.(M)/8th Sem 16 May, 2019

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

Semester Final Examination
Course No. MCE 4705
Course Title: Applied Thermodynamics

Winter Semester: A.Y. 2018-2019
Time: 3 hours
Full Marks: 150

There are 8 (Eight) Questions. Answer any 6 (Six) Questions.

Marks in the Margin indicate full marks. Don't write on this question paper. Symbols carry their usual meanings. Thermodynamic property data are given on separate pages with the question. Assume reasonable values for any missing data. Programmable calculators are not allowed.

1. The gas-turbine portion of a combined gas–steam power plant has a pressure ratio of 16. Air enters the compressor at 300 K at a rate of 14 kg/s and is heated to 1500 K in the combustion chamber. The combustion gases leaving the gas turbine are used to heat the steam to 400°C at 10 MPa in a heat exchanger. The combustion gases leave the heat exchanger at 420 K. The steam leaving the turbine is condensed at 15 kPa. Assuming all the compression and expansion processes to be isentropic, determine (i) the mass flow rate of the steam, (ii) the net power output, and (iii) the thermal efficiency of the combined cycle. For air, assume constant specific heats at room temperature. [25]

2. a) n-Octane (C_8H_{18}) is burned with 50 percent excess air. Calculate the mass fraction of each product and the mass of water in the products per unit mass of fuel burned. Also, calculate the mass fraction of each reactant. The molar masses of C, H_2, O_2, and air are 12 kg/kmol, 2 kg/kmol, 32 kg/kmol, and 29 kg/kmol, respectively. [17]
   b) Using the Clapeyron equation, estimate the enthalpy of vaporization of steam at 300 kPa, and compare it to the tabulated value. [08]

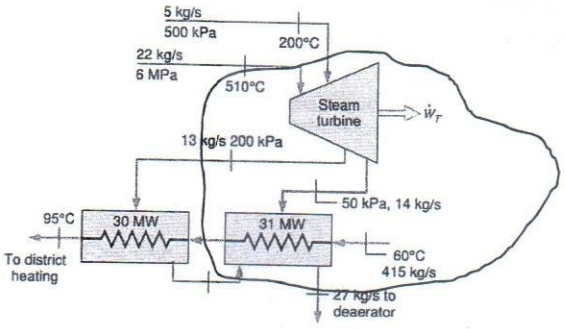
3. a) A pure jet engine propels an aircraft at 240 m/s through air at 45 kPa and -13°C. The inlet diameter of this engine is 1.6 m, the compressor pressure ratio is 13, and the temperature at the turbine inlet is 557°C. Determine the velocity at the exit of this engine's nozzle and the thrust produced. Assume ideal operation for all components and constant specific heats at room temperature. [20]
   b) With the help of a schematic diagram, explain *dead state, surroundings, immediate surroundings* and *environment*. [05]

4. An insulated piston–cylinder device contains 0.8 L of saturated liquid water at a constant pressure of 120 kPa. An electric resistance heater inside the cylinder is turned on, and electrical work is done on the water in the amount of 1400 kJ. Assuming the surroundings to be at 25°C and 100 kPa, determine (i) the minimum work with which this process could be accomplished and (ii) the exergy destroyed during this process. [25]

5. a) During the isothermal heat addition process of a Carnot cycle, 900 kJ of heat is added to the working fluid from a source at 400°C. Determine (i) the entropy change of the working fluid, (ii) the entropy change of the source, and (iii) the total entropy change for the process. [06]
   b) State the *third law of thermodynamics*. How the *absolute entropy* is related to this law? [06]

c) A rigid tank is divided into two equal parts by a partition. One part of the tank contains 2.5 kg of compressed liquid water at 400 kPa and 60°C while the other part is evacuated. The partition is now removed, and the water expands to fill the entire tank. Determine the entropy change of water during this process, if the final pressure in the tank is 40 kPa. [08]

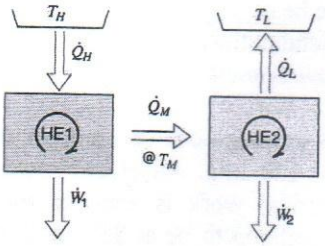
d) Write down SFEE equation for control surface bounded by the line. [05]



6. A steam power plant operates on an ideal reheat–regenerative Rankine cycle and has a net power output of 80 MW. Steam enters the high-pressure turbine at 10 MPa and 550°C and leaves at 0.8 MPa. Some steam is extracted at this pressure to heat the feedwater in an open feedwater heater. The rest of the steam is reheated to 500°C and is expanded in the low-pressure turbine to the condenser pressure of 10 kPa. Show the cycle on a T-s diagram with respect to saturation lines, and determine (i) the mass flow rate of steam through the boiler and (ii) the thermal efficiency of the cycle. [25]

7. a) Steam is usually accelerated in the nozzle of a turbine before it strikes the turbine blades. Steam enters an adiabatic nozzle at 7 MPa and 500°C with a velocity of 70 m/s and exits at 5 MPa and 450°C. Assuming the surroundings to be at 25°C, determine (i) the exit velocity of the steam, (ii) the isentropic efficiency, and (iii) the exergy destroyed within the nozzle. [20]

b) A combination of two heat engines is shown in Fig. Find the overall thermal efficiency as a function of the two individual efficiencies. [05]



8. a) Air enters a gas turbine with two stages of compression and two stages of expansion at 100 kPa and 17°C. This system uses a regenerator as well as reheating and intercooling. The pressure ratio across each compressor is 4; 300 kJ/kg of heat are added to the air in each combustion chamber; and the regenerator operates perfectly while increasing the temperature of the cold air by 20°C. Determine this system's thermal efficiency. Assume isentropic operations for all compressor and the turbine stages and use constant specific heats at room temperature. [20]

b) Draw the *P-v* and *T-s* diagram for *Stirling cycle*. [05]

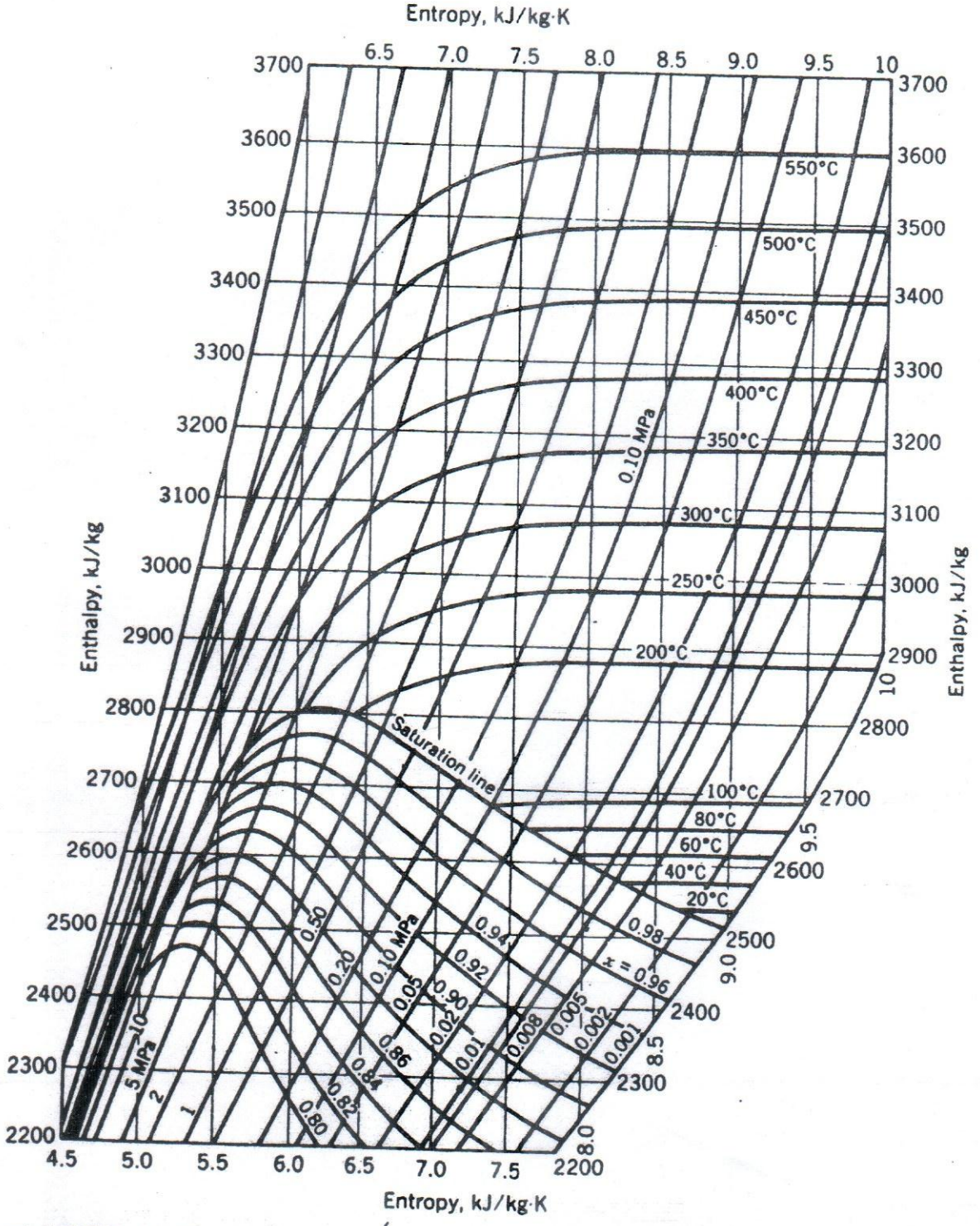


Chart A·3(SI). Mollier (hs) chart for water (SI). Adapted from Joseph H. Keenan, Frederick G. Keyes, Philip G. Hill, and Joan G. Moore, *Steam Tables*, SI Units, Wiley, New York, 1978.

TABLE A–5

Saturated water—Pressure table (*Concluded*)

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
800	170.41	0.001115	0.24035	719.97	1856.1	2576.0	720.87	2047.5	2768.3	2.0457	4.6160	6.6616
850	172.94	0.001118	0.22690	731.00	1846.9	2577.9	731.95	2038.8	2770.8	2.0705	4.5705	6.6409
900	175.35	0.001121	0.21489	741.55	1838.1	2579.6	742.56	2030.5	2773.0	2.0941	4.5273	6.6213
950	177.66	0.001124	0.20411	751.67	1829.6	2581.3	752.74	2022.4	2775.2	2.1166	4.4862	6.6027
1000	179.88	0.001127	0.19436	761.39	1821.4	2582.8	762.51	2014.6	2777.1	2.1381	4.4470	6.5850
1100	184.06	0.001133	0.17745	779.78	1805.7	2585.5	781.03	1999.6	2780.7	2.1785	4.3735	6.5520
1200	187.96	0.001138	0.16326	796.96	1790.9	2587.8	798.33	1985.4	2783.8	2.2159	4.3058	6.5217
1300	191.60	0.001144	0.15119	813.10	1776.8	2589.9	814.59	1971.9	2786.5	2.2508	4.2428	6.4936
1400	195.04	0.001149	0.14078	828.35	1763.4	2591.8	829.96	1958.9	2788.9	2.2835	4.1840	6.4675
1500	198.29	0.001154	0.13171	842.82	1750.6	2593.4	844.55	1946.4	2791.0	2.3143	4.1287	6.4430
1750	205.72	0.001166	0.11344	876.12	1720.6	2596.7	878.16	1917.1	2795.2	2.3844	4.0033	6.3877
2000	212.38	0.001177	0.099587	906.12	1693.0	2599.1	908.47	1889.8	2798.3	2.4467	3.8923	6.3390
2250	218.41	0.001187	0.088717	933.54	1667.3	2600.9	936.21	1864.3	2800.5	2.5029	3.7926	6.2954
2500	223.95	0.001197	0.079952	958.87	1643.2	2602.1	961.87	1840.1	2801.9	2.5542	3.7016	6.2558
3000	233.85	0.001217	0.066667	1004.6	1598.5	2603.2	1008.3	1794.9	2803.2	2.6454	3.5402	6.1856
3500	242.56	0.001235	0.057061	1045.4	1557.6	2603.0	1049.7	1753.0	2802.7	2.7253	3.3991	6.1244
4000	250.35	0.001252	0.049779	1082.4	1519.3	2601.7	1087.4	1713.5	2800.8	2.7966	3.2731	6.0696
5000	263.94	0.001286	0.039448	1148.1	1448.9	2597.0	1154.5	1639.7	2794.2	2.9207	3.0530	5.9737
6000	275.59	0.001319	0.032449	1205.8	1384.1	2589.9	1213.8	1570.9	2784.6	3.0275	2.8627	5.8902
7000	285.83	0.001352	0.027378	1258.0	1323.0	2581.0	1267.5	1505.2	2772.6	3.1220	2.6927	5.8148
8000	295.01	0.001384	0.023525	1306.0	1264.5	2570.5	1317.1	1441.6	2758.7	3.2077	2.5373	5.7450
9000	303.35	0.001418	0.020489	1350.9	1207.6	2558.5	1363.7	1379.3	2742.9	3.2866	2.3925	5.6791
10,000	311.00	0.001452	0.018028	1393.3	1151.8	2545.2	1407.8	1317.6	2725.5	3.3603	2.2556	5.6159
11,000	318.08	0.001488	0.015988	1433.9	1096.6	2530.4	1450.2	1256.1	2706.3	3.4299	2.1245	5.5544
12,000	324.68	0.001526	0.014264	1473.0	1041.3	2514.3	1491.3	1194.1	2685.4	3.4964	1.9975	5.4939
13,000	330.85	0.001566	0.012781	1511.0	985.5	2496.6	1531.4	1131.3	2662.7	3.5606	1.8730	5.4336
14,000	336.67	0.001610	0.011487	1548.4	928.7	2477.1	1571.0	1067.0	2637.9	3.6232	1.7497	5.3728
15,000	342.16	0.001657	0.010341	1585.5	870.3	2455.7	1610.3	1000.5	2610.8	3.6848	1.6261	5.3108
16,000	347.36	0.001710	0.009312	1622.6	809.4	2432.0	1649.9	931.1	2581.0	3.7461	1.5005	5.2466
17,000	352.29	0.001770	0.008374	1660.2	745.1	2405.4	1690.3	857.4	2547.7	3.8082	1.3709	5.1791
18,000	356.99	0.001840	0.007504	1699.1	675.9	2375.0	1732.2	777.8	2510.0	3.8720	1.2343	5.1064
19,000	361.47	0.001926	0.006677	1740.3	598.9	2339.2	1776.8	689.2	2466.0	3.9396	1.0860	5.0256
20,000	365.75	0.002038	0.005862	1785.8	509.0	2294.8	1826.6	585.5	2412.1	4.0146	0.9164	4.9310
21,000	369.83	0.002207	0.004994	1841.6	391.9	2233.5	1888.0	450.4	2338.4	4.1071	0.7005	4.8076
22,000	373.71	0.002703	0.003644	1951.7	140.8	2092.4	2011.1	161.5	2172.6	4.2942	0.2496	4.5439
22,064	373.95	0.003106	0.003106	2015.7	0	2015.7	2084.3	0	2084.3	4.4070	0	4.4070

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
75	91.76	0.001037	2.2172	384.36	2111.8	2496.1	384.44	2278.0	2662.4	1.2132	6.2426	7.4558
100	99.61	0.001043	1.6941	417.40	2088.2	2505.6	417.51	2257.5	2675.0	1.3028	6.0562	7.3589
101.325	99.97	0.001043	1.6734	418.95	2087.0	2506.0	419.06	2256.5	2675.6	1.3069	6.0476	7.3545
125	105.97	0.001048	1.3750	444.23	2068.8	2513.0	444.36	2240.6	2684.9	1.3741	5.9100	7.2841
150	111.35	0.001053	1.1594	466.97	2052.3	2519.2	467.13	2226.0	2693.1	1.4337	5.7894	7.2231
175	116.04	0.001057	1.0037	486.82	2037.7	2524.5	487.01	2213.1	2700.2	1.4850	5.6865	7.1716
200	120.21	0.001061	0.88578	504.50	2024.6	2529.1	504.71	2201.6	2706.3	1.5302	5.5968	7.1270
225	123.97	0.001064	0.79329	520.47	2012.7	2533.2	520.71	2191.0	2711.7	1.5706	5.5171	7.0877
250	127.41	0.001067	0.71873	535.08	2001.8	2536.8	535.35	2181.2	2716.5	1.6072	5.4453	7.0525
275	130.58	0.001070	0.65732	548.57	1991.6	2540.1	548.86	2172.0	2720.9	1.6408	5.3800	7.0207
300	133.52	0.001073	0.60582	561.11	1982.1	2543.2	561.43	2163.5	2724.9	1.6717	5.3200	6.9917
325	136.27	0.001076	0.56199	572.84	1973.1	2545.9	573.19	2155.4	2728.6	1.7005	5.2645	6.9650
350	138.86	0.001079	0.52422	583.89	1964.6	2548.5	584.26	2147.7	2732.0	1.7274	5.2128	6.9402
375	141.30	0.001081	0.49133	594.32	1956.6	2550.9	594.73	2140.4	2735.1	1.7526	5.1645	6.9171
400	143.61	0.001084	0.46242	604.22	1948.9	2553.1	604.66	2133.4	2738.1	1.7765	5.1191	6.8955
450	147.90	0.001088	0.41392	622.65	1934.5	2557.1	623.14	2120.3	2743.4	1.8205	5.0356	6.8561
500	151.83	0.001093	0.37483	639.54	1921.2	2560.7	640.09	2108.0	2748.1	1.8604	4.9603	6.8207
550	155.46	0.001097	0.34261	655.16	1908.8	2563.9	655.77	2096.6	2752.4	1.8970	4.8916	6.7886
600	158.83	0.001101	0.31560	669.72	1897.1	2566.8	670.38	2085.8	2756.2	1.9308	4.8285	6.7593
650	161.98	0.001104	0.29260	683.37	1886.1	2569.4	684.08	2075.5	2759.6	1.9623	4.7699	6.7322
700	164.95	0.001108	0.27278	696.23	1875.6	2571.8	697.00	2065.8	2762.8	1.9918	4.7153	6.7071
750	167.75	0.001111	0.25552	708.40	1865.6	2574.0	709.24	2056.4	2765.7	2.0195	4.6642	6.6837

TABLE A–6

Superheated water

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 = 0.01 MPa (45.81°C)*				P = 0.05 MPa (81.32°C)				P = 0.10 MPa (99.61°C)			
Sat.†	14.670	2437.2	2583.9	8.1488	3.2403	2483.2	2645.2	7.5931	1.6941	2505.6	2675.0	7.3589
50	14.867	2443.3	2592.0	8.1741								
100	17.196	2515.5	2687.5	8.4489	3.4187	2511.5	2682.4	7.6953	1.6959	2506.2	2675.8	7.3611
150	19.513	2587.9	2783.0	8.6893	3.8897	2585.7	2780.2	7.9413	1.9367	2582.9	2776.6	7.6148
200	21.826	2661.4	2879.6	8.9049	4.3562	2660.0	2877.8	8.1592	2.1724	2658.2	2875.5	7.8356
250	24.136	2736.1	2977.5	9.1015	4.8206	2735.1	2976.2	8.3568	2.4062	2733.9	2974.5	8.0346
300	26.446	2812.3	3076.7	9.2827	5.2841	2811.6	3075.8	8.5387	2.6389	2810.7	3074.5	8.2172
400	31.063	2969.3	3280.0	9.6094	6.2094	2968.9	3279.3	8.8659	3.1027	2968.3	3278.6	8.5452
500	35.680	3132.9	3489.7	9.8998	7.1338	3132.6	3489.3	9.1566	3.5655	3132.2	3488.7	8.8362
600	40.296	3303.3	3706.3	10.1631	8.0577	3303.1	3706.0	9.4201	4.0279	3302.8	3705.6	9.0999
700	44.911	3480.8	3929.9	10.4056	8.9813	3480.6	3929.7	9.6626	4.4900	3480.4	3929.4	9.3424
800	49.527	3665.4	4160.6	10.6312	9.9047	3665.2	4160.4	9.8883	4.9519	3665.0	4160.2	9.5682
900	54.143	3856.9	4398.3	10.8429	10.8280	3856.8	4398.2	10.1000	5.4137	3856.7	4398.0	9.7800
1000	58.758	4055.3	4642.8	11.0429	11.7513	4055.2	4642.7	10.3000	5.8755	4055.0	4642.6	9.9800
1100	63.373	4260.0	4893.8	11.2326	12.6745	4259.9	4893.7	10.4897	6.3372	4259.8	4893.6	10.1698
1200	67.989	4470.9	5150.8	11.4132	13.5977	4470.8	5150.7	10.6704	6.7988	4470.7	5150.6	10.3504
1300	72.604	4687.4	5413.4	11.5857	14.5209	4687.3	5413.3	10.8429	7.2605	4687.2	5413.3	10.5229
	P = 0.20 MPa (120.21°C)				P = 0.30 MPa (133.52°C)				P = 0.40 MPa (143.61°C)			
Sat.	0.88578	2529.1	2706.3	7.1270	0.60582	2543.2	2724.9	6.9917	0.46242	2553.1	2738.1	6.8955
150	0.95986	2577.1	2769.1	7.2810	0.63402	2571.0	2761.2	7.0792	0.47088	2564.4	2752.8	6.9306
200	1.08049	2654.6	2870.7	7.5081	0.71643	2651.0	2865.9	7.3132	0.53434	2647.2	2860.9	7.1723
250	1.19890	2731.4	2971.2	7.7100	0.79645	2728.9	2967.9	7.5180	0.59520	2726.4	2964.5	7.3804
300	1.31623	2808.8	3072.1	7.8941	0.87535	2807.0	3069.6	7.7037	0.65489	2805.1	3067.1	7.5677
400	1.54934	2967.2	3277.0	8.2236	1.03155	2966.0	3275.5	8.0347	0.77265	2964.9	3273.9	7.9003
500	1.78142	3131.4	3487.7	8.5153	1.18672	3130.6	3486.6	8.3271	0.88936	3129.8	3485.5	8.1933
600	2.01302	3302.2	3704.8	8.7793	1.34139	3301.6	3704.0	8.5915	1.00558	3301.0	3703.3	8.4580
700	2.24434	3479.9	3928.8	9.0221	1.49580	3479.5	3928.2	8.8345	1.12152	3479.0	3927.6	8.7012
800	2.47550	3664.7	4159.8	9.2479	1.65004	3664.3	4159.3	9.0605	1.23730	3663.9	4158.9	8.9274
900	2.70656	3856.3	4397.7	9.4598	1.80417	3856.0	4397.3	9.2725	1.35298	3855.7	4396.9	9.1394
1000	2.93755	4054.8	4642.3	9.6599	1.95824	4054.5	4642.0	9.4726	1.46859	4054.3	4641.7	9.3396
1100	3.16848	4259.6	4893.3	9.8497	2.11226	4259.4	4893.1	9.6624	1.58414	4259.2	4892.9	9.5295
1200	3.39938	4470.5	5150.4	10.0304	2.26624	4470.3	5150.2	9.8431	1.69966	4470.2	5150.0	9.7102
1300	3.63026	4687.1	5413.1	10.2029	2.42019	4686.9	5413.0	10.0157	1.81516	4686.7	5412.8	9.8828
	P = 0.50 MPa (151.83°C)				P = 0.60 MPa (158.83°C)				P = 0.80 MPa (170.41°C)			
Sat.	0.37483	2560.7	2748.1	6.8207	0.31560	2566.8	2756.2	6.7593	0.24035	2576.0	2768.3	6.6616
200	0.42503	2643.3	2855.8	7.0610	0.35212	2639.4	2850.6	6.9683	0.26088	2631.1	2839.8	6.8177
250	0.47443	2723.8	2961.0	7.2725	0.39390	2721.2	2957.6	7.1893	0.29321	2716.9	2950.4	7.0402
300	0.52261	2803.3	3064.6	7.4614	0.43442	2801.4	3062.0	7.3740	0.32416	2797.5	3056.9	7.2345
350	0.57015	2883.0	3168.1	7.6346	0.47428	2881.6	3166.1	7.5481	0.35442	2878.6	3162.2	7.4107
400	0.61731	2963.7	3272.4	7.7956	0.51374	2962.5	3270.8	7.7097	0.38429	2960.2	3267.7	7.5735
500	0.71095	3129.0	3484.5	8.0893	0.59200	3128.2	3483.4	8.0041	0.44332	3126.6	3481.3	7.8692
600	0.80409	3300.4	3702.5	8.3544	0.66976	3299.8	3701.7	8.2695	0.50186	3298.7	3700.1	8.1354
700	0.89696	3478.6	3927.0	8.5978	0.74725	3478.1	3926.4	8.5132	0.56011	3477.2	3925.3	8.3794
800	0.98966	3663.6	4158.4	8.8240	0.82457	3663.2	4157.9	8.7395	0.61820	3662.5	4157.0	8.6061
900	1.08227	3855.4	4396.6	9.0362	0.90179	3855.1	4396.2	8.9518	0.67619	3854.5	4395.5	8.8185
1000	1.17480	4054.0	4641.4	9.2364	0.97893	4053.8	4641.1	9.1521	0.73411	4053.3	4640.5	9.0189
1100	1.26728	4259.0	4892.6	9.4263	1.05603	4258.8	4892.4	9.3420	0.79197	4258.3	4891.9	9.2090
1200	1.35972	4470.0	5149.8	9.6071	1.13309	4469.8	5149.6	9.5229	0.84980	4469.4	5149.3	9.3898
1300	1.45214	4686.6	5412.6	9.7797	1.21012	4686.4	5412.5	9.6955	0.90761	4686.1	5412.2	9.5625

*The temperature in parentheses is the saturation temperature at the specified pressure.
† Properties of saturated vapor at the specified pressure.

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
	P = 6.0 MPa (275.59°C)				P = 7.0 MPa (285.83°C)				P = 8.0 MPa (295.01°C)			
Sat.	0.03245	2589.9	2784.6	5.8902	0.027378	2581.0	2772.6	5.8148	0.023525	2570.5	2758.7	5.7450
300	0.03619	2668.4	2885.6	6.0703	0.029492	2633.5	2839.9	5.9337	0.024279	2592.3	2786.5	5.7937
350	0.04225	2790.4	3043.9	6.3357	0.035262	2770.1	3016.9	6.2305	0.029975	2748.3	2988.1	6.1321
400	0.04742	2893.7	3178.3	6.5432	0.039958	2879.5	3159.2	6.4502	0.034344	2864.6	3139.4	6.3658
450	0.05217	2989.9	3302.9	6.7219	0.044187	2979.0	3288.3	6.6353	0.038194	2967.8	3273.3	6.5579
500	0.05667	3083.1	3423.1	6.8826	0.048157	3074.3	3411.4	6.8000	0.041767	3065.4	3399.5	6.7266
550	0.06102	3175.2	3541.3	7.0308	0.051966	3167.9	3531.6	6.9507	0.045172	3160.5	3521.8	6.8800
600	0.06527	3267.2	3658.8	7.1693	0.055665	3261.0	3650.6	7.0910	0.048463	3254.7	3642.4	7.0221
700	0.07355	3453.0	3894.3	7.4247	0.062850	3448.3	3888.3	7.3487	0.054829	3443.6	3882.2	7.2822
800	0.08165	3643.2	4133.1	7.6582	0.069856	3639.5	4128.5	7.5836	0.061011	3635.7	4123.8	7.5185
900	0.08964	3838.8	4376.6	7.8751	0.076750	3835.7	4373.0	7.8014	0.067082	3832.7	4369.3	7.7372
1000	0.09756	4040.1	4625.4	8.0786	0.083571	4037.5	4622.5	8.0055	0.073079	4035.0	4619.6	7.9419
1100	0.10543	4247.1	4879.7	8.2709	0.090341	4245.0	4877.4	8.1982	0.079025	4242.8	4875.0	8.1350
1200	0.11326	4459.8	5139.4	8.4534	0.097075	4457.9	5137.4	8.3810	0.084934	4456.1	5135.5	8.3181
1300	0.12107	4677.7	5404.1	8.6273	0.103781	4676.1	5402.6	8.5551	0.090817	4674.5	5401.0	8.4925
	P = 9.0 MPa (303.35°C)				P = 10.0 MPa (311.00°C)				P = 12.5 MPa (327.81°C)			
Sat.	0.020489	2558.5	2742.9	5.6791	0.018028	2545.2	2725.5	5.6159	0.013496	2505.6	2674.3	5.4638
325	0.023284	2647.6	2857.1	5.8738	0.019877	2611.6	2810.3	5.7596				
350	0.025816	2725.0	2957.3	6.0380	0.022440	2699.6	2924.0	5.9460	0.016138	2624.9	2826.6	5.7130
400	0.029960	2849.2	3118.8	6.2876	0.026436	2833.1	3097.5	6.2141	0.020030	2789.6	3040.0	6.0433
450	0.033624	2956.3	3258.0	6.4872	0.029782	2944.5	3242.4	6.4219	0.023019	2913.7	3201.5	6.2749
500	0.036793	3056.3	3387.4	6.6603	0.032811	3047.0	3375.1	6.5995	0.025630	3023.2	3343.6	6.4651
550	0.039885	3153.0	3512.0	6.8164	0.035655	3145.4	3502.0	6.7585	0.028033	3126.1	3476.5	6.6317
600	0.042861	3248.4	3634.1	6.9605	0.038378	3242.0	3625.8	6.9045	0.030306	3225.8	3604.6	6.7828
650	0.045755	3343.4	3755.2	7.0954	0.041018	3338.0	3748.1	7.0408	0.032491	3324.1	3730.2	6.9227
700	0.048589	3438.8	3876.1	7.2229	0.043597	3434.0	3870.0	7.1693	0.034612	3422.0	3854.6	7.0540
800	0.054132	3632.0	4119.2	7.4606	0.048629	3628.2	4114.5	7.4085	0.038724	3618.8	4102.8	7.2967
900	0.059562	3829.6	4365.7	7.6802	0.053547	3826.5	4362.0	7.6290	0.042720	3818.9	4352.9	7.5195
1000	0.064919	4032.4	4616.7	7.8855	0.058391	4029.9	4613.8	7.8349	0.046641	4023.5	4606.5	7.7269
1100	0.070224	4240.7	4872.7	8.0791	0.063183	4238.5	4870.3	8.0289	0.050510	4233.1	4864.5	7.9220
1200	0.075492	4454.2	5133.6	8.2625	0.067938	4452.4	5131.7	8.2126	0.054342	4447.7	5127.0	8.1065
1300	0.080733	4672.9	5399.5	8.4371	0.072667	4671.3	5398.0	8.3874	0.058147	4667.3	5394.1	8.2819

B.Sc.Engg. (M)7th Sem./B.Sc. TE(1 Yr. Prog.),1st Sem./
B.Sc. TE(2 Yr. Prog), 3rd Sem.

21 May 2019

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

SemesterFinalExamination
Course No. MCE 4709/MCE 4797
Course Title: Machine Design - II

Winter Semester A.Y. 2018-2019
TIME : 3 Hours
Full Marks :100

There are 8 (Eight) Questions. Answer any 6 (Six) Questions.

Marks in the margin indicate full marks. Tables and graphs along with some important formula are attached. All questions carry equal marks.

Assume reasonable value for missing data (if any)

1. Fig.1 shows an internal rim-type brake having an inside rim diameter of 300 mm and adimension R=125 mm. The shoes have a face width of 40 mm and are both actuated by aforce of 2.2 kN. The drum rotates clockwise. The mean coefficient of friction is 0.28.
   (a) Find the maximum pressure and indicate the shoe on which it occurs.
   (b) Estimate the braking torque effected by each shoe, and find the total braking torque.
   (c) Estimate the resulting hinge-pin reactions.

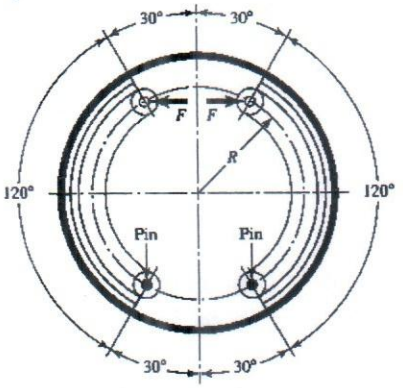


Fig. 1

2. The shoes on the brake depicted in the Fig.2 subtend a 90° arc on the drum of this external pivoted-shoe brake. The actuation force P is applied to the lever. The rotation direction of the drum is clockwise, and the coefficient of friction is 0.30.
   (a) What should the dimension e be, in order to eliminate frictional moments on each shoe?
   (b) Draw the free-body diagrams of the handle lever and both shoe levers, with forces expressed in terms of the actuation force P.

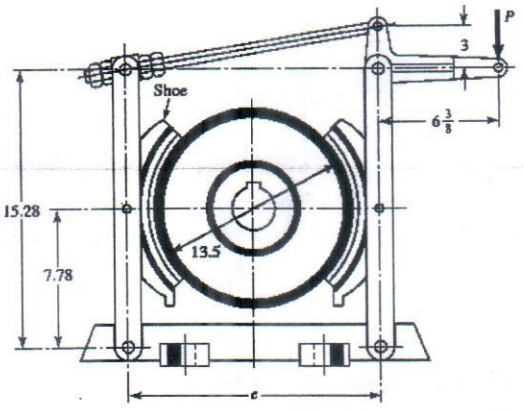


Fig. 2

3. A helical compression spring is made of hard-drawn spring steel wire 0.080-in in diameter and has an outside diameter of 0.880 in. The ends are plain and ground, and there are 8 total coils.
   (a) The spring is wound to a free length, which is the largest possible with a solid-safe property. Find this free length.
   (b) What is the pitch of this spring?
   (c) What force is needed to compress the spring to its solid length?
   (d) Estimate the spring rate.
   (e) Will the spring buckle in service?

4. For the screw clamp shown in Fig. 3, a force is applied at the end of the handle 3.5 in from the screw centerline. The 3/8 in diameter handle is made of cold-drawn AISI 1006 steel. The screw is 3/4 in-10 UNC and is 8 in long, overall. The maximum possible length of screw in the clamping region is 6 in.
   (a) What screw torque will cause the handle to bend permanently?
   (b) What clamping force will the answer to part (a) cause if the collar friction is neglected and if the thread friction is 0.15?
   (c) What clamping force will cause the screw to buckle?
   For the screw S_y= 41kpsi, E= $30x10^6$ psi

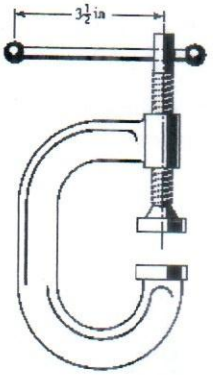


Fig. 3

5. A cone clutch has D=12 in, d =11 in, a cone length of 2.25 in, and a coefficient of friction of 0.28. A torque of 1.8 kip.in is to be transmitted. For this requirement, estimate the actuating
   force and maximum pressure by both models.
6. A 16T 20° straight bevel pinion (Fig. 4) driving a 32T gear, and the location of the bearing centerlines. Pinion shaft a receives 2.5 hp at 240 rev/min. Determine the bearing reactions at A and B if A is to take both radial and thrust loads.

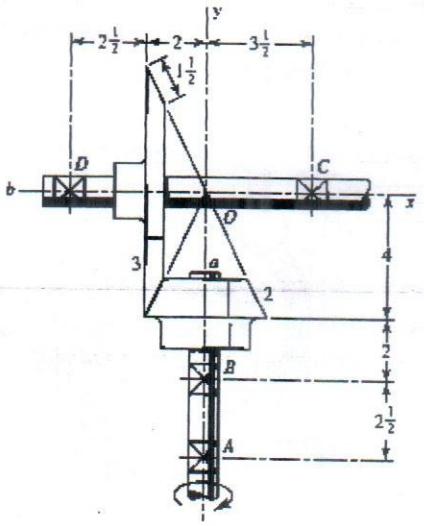


Fig. 4

7. A double-reduction helical gearset(Fig. 5). Pinion 2 is the driver, and it receives a torque of 1200 lbf .in from its shaft in the direction shown. Pinion 2 has a normal diametralpitch of 8 teeth/in, 14 teeth, and a normal pressure angle of 20° and is cut right-handed witha helix angle of 30°. The mating gear 3 on shaft b has 36 teeth. Gear 4, which is the driverfor the second pair of gears in the train, has a normal diametral pitch of 5 teeth/in, 15 teeth,and a normal pressure angle of 20° and is cut left-handed with a helix angle of 15°. Matinggear 5 has 45 teeth. Find the magnitude and direction of the force exerted by the bearings Cand D on shaft b if bearing C can take only a radial load while bearing D is mounted to takeboth radial and thrust loads.

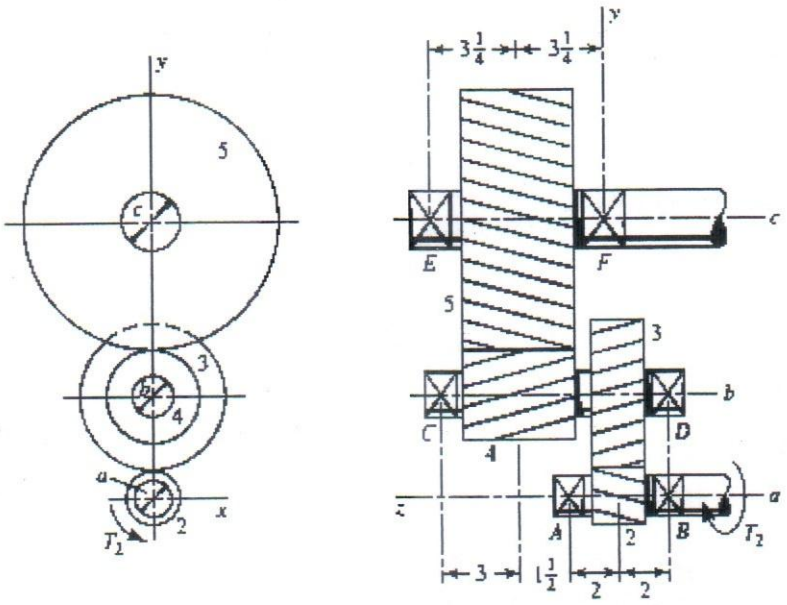


Fig. 5

8. A square-thread power screw has a major diameter of 32 mm and a pitch of 4 mm with double threads, and it is to be used in an application similar to that in Fig. 8–4. The given data include f =fc=0.08, dc=40 mm, and F=6.4 kN per screw.
   (a) Find the thread depth, thread width, pitch diameter, minor diameter, and lead.
   (b) Find the torque required to raise and lower the load.
   (c) Find the efficiency during lifting the load.
   (d) Find the body stresses, torsional and compressive.
   (e) Find the bearing stress.
   (f) Find the thread bending stress at the root of the thread.
   (g) Determine the von Mises stress at the root of the thread.
   (h) Determine the maximum shear stress at the root of the thread.

$$a = \frac{4r \sin \theta_2}{2\theta_2 + \sin 2\theta_2}$$

$$M_f = \int f dN(r - a \cos \theta) = \frac{f p_a b r}{\sin \theta_a} \int_{\theta_1}^{\theta_2} \sin \theta (r - a \cos \theta)\, d\theta$$

$$M_N = \int dN(a \sin \theta) = \frac{p_a b r a}{\sin \theta_a} \int_{\theta_1}^{\theta_2} \sin^2 \theta \, d\theta$$

$$T = \int f r dN = \frac{f p_a b r^2}{\sin \theta_a} \int_{\theta_1}^{\theta_2} \sin \theta \, d\theta$$

$$= \frac{f p_a b r^2 (\cos \theta_1 - \cos \theta_2)}{\sin \theta_a}$$

$$R_x = \frac{p_a b r}{\sin \theta_a}(A + fB) - F_x$$

$$R_y = \frac{p_a b r}{\sin \theta_a}(B - fA) - F_y$$

$$A = \int_{\theta_1}^{\theta_2} \sin \theta \cos \theta \, d\theta = \left(\frac{1}{2} \sin^2 \theta\right)_{\theta_1}^{\theta_2}$$

$$B = \int_{\theta_1}^{\theta_2} \sin^2 \theta \, d\theta = \left(\frac{\theta}{2} - \frac{1}{4} \sin 2\theta\right)_{\theta_1}^{\theta_2}$$

$$S_{ut} = \frac{A}{d^m}$$

$$K_W = \frac{4C - 1}{4C - 4} + \frac{0.615}{C}$$

$$K_B = \frac{4C + 2}{4C - 3}$$

$$\tau = K_B \frac{8FD}{\pi d^3}$$

$$k \approx \frac{d^4 G}{8D^3 N}$$

$$L_0 < 2.63 \frac{D}{\alpha}$$

Table 10–1

Formulas for the Dimensional Characteristics of Compression-Springs. (N_a = Number of Active Coils)

Source: From *Design Handbook*, 1987, p. 32. Courtesy of Associated Spring.

Term	Type of Spring Ends			
	Plain	Plain and Ground	Squared or Closed	Squared and Ground
End coils, N_e	0	1	2	2
Total coils, N_t	N_a	$N_a + 1$	$N_a + 2$	$N_a + 2$
Free length, L_0	$pN_a + d$	$p(N_a + 1)$	$pN_a + 3d$	$pN_a + 2d$
Solid length, L_s	$d(N_t + 1)$	dN_t	$d(N_t + 1)$	dN_t
Pitch, p	$(L_0 - d)/N_a$	$L_0/(N_a + 1)$	$(L_0 - 3d)/N_a$	$(L_0 - 2d)/N_a$

Table 10–2

End-Condition Constants α for Helical Compression Springs*

End Condition	Constant α
Spring supported between flat parallel surfaces (fixed ends)	0.5
One end supported by flat surface perpendicular to spring axis (fixed); other end pivoted (hinged)	0.707
Both ends pivoted (hinged)	1
One end clamped; other end free	2

*Ends supported by flat surfaces must be squared and ground.

$$T_R = \frac{Fd_m}{2}\left(\frac{l + \pi f d_m \sec\alpha}{\pi d_m - fl\sec\alpha}\right) \qquad \left(\frac{l}{k}\right)_1 = \left(\frac{2\pi^2 CE}{S_y}\right)^{1/2}$$

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

$$T = \int rfp\,dA = \int_{d/2}^{D/2} (rf)\left(p_a\frac{d}{2r}\right)\left(\frac{2\pi r\,dr}{\sin\alpha}\right)$$

$$= \frac{\pi f p_a d}{\sin\alpha}\int_{d/2}^{D/2} r\,dr = \frac{\pi f p_a d}{8\sin\alpha}(D^2 - d^2)$$

$$F = \int p\,dA\sin\alpha = \int_{d/2}^{D/2}\left(p_a\frac{d}{2r}\right)\left(\frac{2\pi r\,dr}{\sin\alpha}\right)(\sin\alpha)$$

$$= \pi p_a d\int_{d/2}^{D/2} dr = \frac{\pi p_a d}{2}(D - d)$$

$$F = \int p_a\,dA\sin\alpha = \int_{d/2}^{D/2}(p_a)\left(\frac{2\pi r\,dr}{\sin\alpha}\right)(\sin\alpha) = \frac{\pi p_a}{4}(D^2 - d^2)$$

$$T = \int rfp_a\,dA = \int_{d/2}^{D/2}(rfp_a)\left(\frac{2\pi r\,dr}{\sin\alpha}\right) = \frac{\pi f p_a}{12\sin\alpha}(D^3 - d^3)$$

$$T_R = \frac{Fd_m}{2}\left(\frac{l + \pi f d_m}{\pi d_m - fl}\right)$$

$$T_L = \frac{Fd_m}{2}\left(\frac{\pi f d_m - l}{\pi d_m + fl}\right)$$

$$T_c = \frac{F f_c d_c}{2}$$

$$e = \frac{T_0}{T_R} = \frac{Fl}{2\pi T_R}$$

$$\sigma' = \frac{1}{\sqrt{2}}[(\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2 + 6(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2)]^{1/2}$$

$$\sigma_1, \sigma_2 = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\phi_t = \tan^{-1}\left(\frac{\tan \phi_n}{\cos \psi}\right)$$

$$d_2 = \frac{N}{P_n \cos \psi}$$

Table 10–5

Mechanical Properties of Some Spring Wires

Material	Elastic Limit, Percent of S_{ut} Tension	Torsion	Diameter d, in	E Mpsi	E GPa	G Mpsi	G GPa
Music wire A228	65–75	45–60	<0.032	29.5	203.4	12.0	82.7
			0.033–0.063	29.0	200	11.85	81.7
			0.064–0.125	28.5	196.5	11.75	81.0
			>0.125	28.0	193	11.6	80.0
HD spring A227	60–70	45–55	<0.032	28.8	198.6	11.7	80.7
			0.033–0.063	28.7	197.9	11.6	80.0
			0.064–0.125	28.6	197.2	11.5	79.3
			>0.125	28.5	196.5	11.4	78.6
Oil tempered A239	85–90	45–50		28.5	196.5	11.2	77.2
Valve spring A230	85–90	50–60		29.5	203.4	11.2	77.2
Chrome-vanadium A231	88–93	65–75		29.5	203.4	11.2	77.2
A232	88–93			29.5	203.4	11.2	77.2
Chrome-silicon A401	85–93	65–75		29.5	203.4	11.2	77.2
Stainless steel							
A313*	65–75	45–55		28	193	10	69.0
17-7PH	75–80	55–60		29.5	208.4	11	75.8
414	65–70	42–55		29	200	11.2	77.2
420	65–75	45–55		29	200	11.2	77.2
431	72–76	50–55		30	206	11.5	79.3
Phosphor-bronze B159	75–80	45–50		15	103.4	6	41.4
Beryllium-copper B197	70	50		17	117.2	6.5	44.8
	75	50–55		19	131	7.3	50.3
Inconel alloy X-750	65–70	40–45		31	213.7	11.2	77.2

*Also includes 302, 304, and 316.

Note: See Table 10–6 for allowable torsional stress design values.

Table 10–6

Maximum Allowable Torsional Stresses for Helical Compression Springs in Static Applications

Source: Robert E. Joerres, "Springs," Chap. 6 in Joseph E. Shigley, Charles R. Mischke, and Thomas H. Brown, Jr. (eds.), *Standard Handbook of Machine Design*, 3rd ed., McGraw-Hill, New York, 2004.

Material	Maximum Percent of Tensile Strength: Before Set Removed (includes K_W or K_B)	After Set Removed (includes K_s)
Music wire and cold-drawn carbon steel	45	60–70
Hardened and tempered carbon and low-alloy steel	50	65–75
Austenitic stainless steels	35	55–65
Nonferrous alloys	35	55–65

BSc.Engg.ME (7th Sem) 27 May 2019 (Monday)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

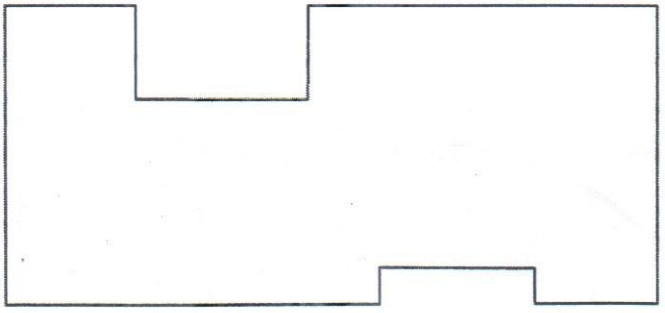
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination — Winter Semester: **A.Y. 2018-2019**
Course Code: **MCE 4711** — Time : **3 Hours**
Course Title : **Computational Fluid Dynamics** — Full Marks : **150**

There are 08 (Eight) Questions. Answer any 06 (Six) of them.
Figures in the margin indicate the full marks. Do not write on the Question Paper.

1	a)	What are the basic approaches for solving problems in fluid dynamics and heat transfer? Discuss how Computational Fluid Dynamics (CFD) is helping us to solve such problems.	5
	b)	Discuss the application of CFD in automotive engineering and biomedical scince.	10
	c)	What is the main purpose of the postprocessing stage in CFD? Briefly discuss different graphical representation that are used in post-processing.	10
2	a)	Derive the momentum equation for a two-dimensional case of fluid flow between parallel plates assuming constant fluid property starting from Newton's second law of motion.	18
	b)	Briefly explain how the local acceleration and advection terms contribute to the overall transport of the fluid.	7
3	a)	What is turbulence? How turbulence can be modelled in CFD? Briefly discuss the basic numerical methods for turbulence flow calculations.	10
	b)	What are the models for predicting turbulent viscosity? Describe the k-ε model in details with model equations, advantages and disadvantages.	15
4	a)	Describe finite volume method for discretization of the governing equations with an example.	15
	b)	Briefly discuss the segregated and coupled solution procedure of finite volume method.	10
5	a)	Why grid generation is needed? Describe different grid types that are used in CFD with advantages and disadvantages.	15
	b)	For the geometry below, discuss how using a block-structured mesh has advantages over a single-structured or unstructured mesh.	10

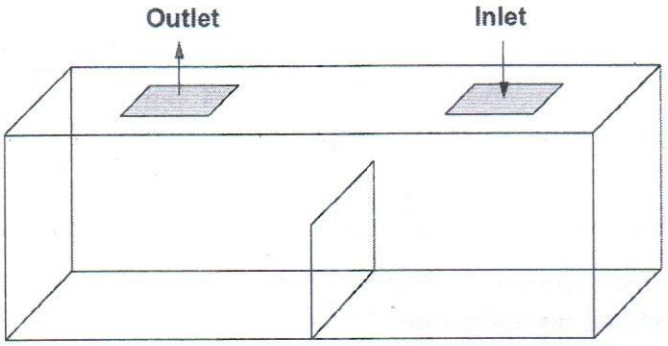


6 a) Define the under-relaxation factor. State its advantages and disadvantages when using a small value. **10**

b) What is convergence? Discuss its significance on numerical solution. How convergence can be monitored? **15**

7 a) What are the Neumann and Dirichlet boundary condition? Discuss pressure boundary condition for inlet and outlet with its application. **15**

b) The geometry for an air-conditioning problem in two rooms separated by a partitioned wall is shown below. Label the boundaries that must be defined and discuss what types of conditions may be applied. **10**



8 Write short notes about following topics: **6.25 x4 =25**

a) Turbulent viscosity and turbulent Schmidt number

b) First order upwind scheme and central differencing scheme

c) Symmetry and periodic boundaries

d) Skewness, smoothness and aspect ratio of mesh.

B.Sc. Engg. (ME), 7th Sem. 29 May 2019

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

Semester Final Examination — Winter Semester, A. Y. 2018-2019
Course No Hum 4717 — Time: 3 Hours
Course Title: Engineering Economics and Finance — Full Marks: 150

There are **8** (Eight) questions. Answer any **6** (Six) of them.

Marks in the margin indicate full marks. Programmable calculators are not allowed. Do not write on this question paper. Factor Table is provided at the end of this question.

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1. a) Define any five Business ratios with their guide values. If you would like to apply for entrepreneurship loan for your startup business, write the typical headings that you should mention in the plan. [12]
   b) Write three main differences between conventional and Islamic insurance (Takaful). Describe any one type of Islamic insurance(Takaful) with a numeric example. [8]
   c) What do you understand by Sensitivity analysis? Write down the general procedure to conduct sensitivity analysis. [5]
2. a) Select the appropriate bundle of proposals using capital budgeting method. Here MARR is 12% per year and available capital budget is $30,000 [12]

		Net Cash Flow(NCF), $					
Proposal	Initial Investment, $	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6
P1	7,000	1,000	1,700	2,400	3,100	3,800	4,500
P2	11,000	500	600	700	800	600	
P3	9,000	5,000	5,000	2,000	3,000		

   b) KUKO Ltd has purchased a generator unit for $90,000. The unit has an anticipated life of 6 years and a salvage value of $16,000. Find out schedule of depreciation and book value for each year using Double Declining Balance method and present in a table. [13]

3. a) Compare the alternatives shown below on the basis of their capitalized costs, using an interest rate 12% per year and provide a decision about which one should be selected. [15]

	Project X	Project Y	Project Z
Initial Cost, $	250,000	100,000	300,000
AOC, $/year	130,000	65,000	Not Applicable
Maintenance Cost,$	Not Applicable	$ 6000, at year 2,then increases by $500 every year	$ 36000, at year 3,then increases by 4% every year
Annual Revenue, $/year	400,000	270,000	370,000
Painting cost in every 5th year,$	2,000	Not applicable	1,500
Salvage value, $	N/A	70,000	100,000
Life, years	infinity	6	9

b) BKSP Ltd, leases excavators. The net profit (i.e. net cash flow) from the equipment for each of the last 4 years has been decreasing, as shown below in the table. Also shown are the annual rates of return on invested capital. Determine the equivalent present worth(PW).. [10]

	Year 1	Year 2	Year 3	Year 4
Net Profit	$70,000	$70,000	$35,000	$25,000
Rate of return	15% per year	12% per year	15% per year	12% per year

4. a) Write down Descartes' rule and Nostrom's criterion. Use Descartes' rule to determine the maximum number of possible rate of return and values and Norstrom's criterion to determine if there is only one positive rate of return value from the information provided below. Also find out composite rate of return if net reinvestment rate is 12% per year. Then comment on whether the project is acceptable if MARR is equal to net reinvestment rate(i.e. 12% per year) [12]

Year	0	1	2	3
Net cash flow,$	+2000	-500	-8100	+6800

b) A company that manufactures fixtures is trying to decide between the machines shown below. Compare them on the basis of their Present Worth(PW) values, using an interest rate of 12% per year [13]

	Machine A	Machine B
First cost, $	290,000	320,000
Annual Operating Cost,$/year	200,000	300,000
Onetime overhauling cost in year 2, $	10,000	26,000
Servicing cost, $	$ 500 at year 1 and then increases by $50 every year	$ 300 at year 3 and then increases by 5% every year
Salvage value	20,000	30,000
Life, years	4	6

5. a) The Water Service Authority of Dhaka is considering fo ur sizes of pipe for a new water line. The costs per kilometer ($/km) for each size are given in the table. Assuming that all pipes will last 15 years and the MARR is 12% per year, which size pipe should be purchased based on a B/C analysis? [12]

	Size A	Size B	Size C	Size D
Initial equipment Cost, $/km	9,180	10,510	13,180	15,850
Installation Cost, $/km	600	800	1,400	1,500
Usage cost, $/km per year	6,000	5,800	5,200	4,900

b) An equipment was purchased 3 years ago. Its current market value is $13,000. Estimated future market values and annual operating costs for the next 5 years are given in the following table. What is the Economic service life of equipment if a 12% per year return is required? [13]

Year	Market Value,$	Annual Operating cost,$
1	10000	2600
2	8000	2700
3	6000	3000
4	2000	3500
5	0	4900

6. a) A lumber company that cuts fine woods is evaluating whether it should retain the current bleaching system or replace it with a new one. The relevant costs for each system are known or estimated as provided in the table below. Use an interest rate of 12% per year to perform the replacement analysis to determine whether the company should retain the old system or replace with the new one. [11]

	Current System	New System
First cost 7 years ago, $	450,000	N/A
First Cost,$/	N/A	700,000
Remaining life, years	5	10
Current Market Value, $	50,000	N/A
AOC, $/per year	160,000	150,000
Salvage value, $	0	50,000

b) BOROX Inc. is considering three machines to use in the production line. Which should be selected on the basis of Annual Worth(AW) analysis at an interest rate of 12% per year? [14]

	Machine X	Machine Y	Machine Z
Initial Cost, $	200,000	235,000	195,000
Maintenance Cost, $	$ 29,000 at year 4,then increases by 4% every year	$ 27,000, at year 2,then increases by $1100 every year	$30,000 every year
Annual income, $/year	140,000	150,000	250,000
One time overhauling cost at year 3	Not applicable	$ 9,500	$2,000
Salvage value, $	70,000	Not Applicable	80,000
Life, years	9	5	infinity

7. a) What is the use of depletion method? A gold mine was purchased for $10 million. It has an anticipated gross income of $5.0million per year for years 1 to 5 and $3.0 million per year after year 5. Assume that depletion charges do not exceed 50% of taxable income. Compute annual depletionamounts for the mine. How long will it take to recover the initial investment at i = 0% (zero)per year? Annual percentage depletion for gold is 15%. [7]

b) A remotely located air sampling station can be powered by solar cells or by running an electric line to the site and using conventional power. Solar cells will cost $12,600 to install and will have a useful life of 4 years with no salvage value. Annual costs for inspection, cleaning, etc., are expected to be $1400. A new power line will cost $11,000 to install , with power costs expected to be $800 per year. Since the air sampling project will end in 4 years , the salvage value of the line is considered to be zero. At an interest rate of 12% per year, which alternative should be selected on the basis of a future worth analysis? [10]

c) A businessman is planning to provide scholarship of $20,000 every year starting from year 7 to forever. To do so, he has decided to deposit $50,000 now and equal amount of money for next four years starting from year 1. What is the equal amount of money the businessman should deposit each year of those four years for the scholarship? Use i = 12% per year [8]

8. a) What do you understand by nominal and effective interest rates? How much money would be in the account of a person who deposited $1,000 now and $100 every month and withdrew $100 every 2 months for 3 years? Use an interest rate of 11.66% per year compounded half yearly with no interperiod interest paid. Use the closest interest rate provided in the factor table after getting effective rate. [15]

b) A new process for a manufacturing plant will have a first cost of $39,000 with annual cost of $19,000. Extra income associated with the new process is expected to be $23,000 per year. There is onetime licensing cost of $2600 at year 2. Find simple payback period and then payback period when MARR is 12% per year. [10]

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Formula:

Geometric gradient:

$$(P/A,g,i,n) = \frac{1-\left(\frac{1+g}{1+i}\right)^n}{i-g} \quad \text{when } g \neq i \quad \text{and} \quad \frac{n}{1+i} \quad \text{when } g = i$$

12% Compound Interest Factors 12%

n	Single Payment: Compound Amount Factor — Find F Given P F/P	Single Payment: Present Worth Factor — Find P Given F P/F	Uniform Payment Series: Sinking Fund Factor — Find A Given F A/F	Uniform Payment Series: Capital Recovery Factor — Find A Given P A/P	Uniform Payment Series: Compound Amount Factor — Find F Given A F/A	Uniform Payment Series: Present Worth Factor — Find P Given A P/A	Arithmetic Gradient: Gradient Uniform Series — Find A Given G A/G	Arithmetic Gradient: Gradient Present Worth — Find P Given G P/G	n
1	1.120	.8929	1.0000	1.1200	1.000	0.893	0	0	1
2	1.254	.7972	.4717	.5917	2.120	1.690	0.472	0.797	2
3	1.405	.7118	.2963	.4163	3.374	2.402	0.925	2.221	3
4	1.574	.6355	.2092	.3292	4.779	3.037	1.359	4.127	4
5	1.762	.5674	.1574	.2774	6.353	3.605	1.775	6.397	5
6	1.974	.5066	.1232	.2432	8.115	4.111	2.172	8.930	6
7	2.211	.4523	.0991	.2191	10.089	4.564	2.551	11.644	7
8	2.476	.4039	.0813	.2013	12.300	4.968	2.913	14.471	8
9	2.773	.3606	.0677	.1877	14.776	5.328	3.257	17.356	9
10	3.106	.3220	.0570	.1770	17.549	5.650	3.585	20.254	10
11	3.479	.2875	.0484	.1684	20.655	5.938	3.895	23.129	11
12	3.896	.2567	.0414	.1614	24.133	6.194	4.190	25.952	12
13	4.363	.2292	.0357	.1557	28.029	6.424	4.468	28.702	13
14	4.887	.2046	.0309	.1509	32.393	6.628	4.732	31.362	14
15	5.474	.1827	.0268	.1468	37.280	6.811	4.980	33.920	15
16	6.130	.1631	.0234	.1434	42.753	6.974	5.215	36.367	16
17	6.866	.1456	.0205	.1405	48.884	7.120	5.435	38.697	17
18	7.690	.1300	.0179	.1379	55.750	7.250	5.643	40.908	18
19	8.613	.1161	.0158	.1358	63.440	7.366	5.838	42.998	19
20	9.646	.1037	.0139	.1339	72.052	7.469	6.020	44.968	20
21	10.804	.0926	.0122	.1322	81.699	7.562	6.191	46.819	21
22	12.100	.0826	.0108	.1308	92.503	7.645	6.351	48.554	22
23	13.552	.0738	.00956	.1296	104.603	7.718	6.501	50.178	23
24	15.179	.0659	.00846	.1285	118.155	7.784	6.641	51.693	24
25	17.000	.0588	.00750	.1275	133.334	7.843	6.771	53.105	25
26	19.040	.0525	.00665	.1267	150.334	7.896	6.892	54.418	26
27	21.325	.0469	.00590	.1259	169.374	7.943	7.005	55.637	27
28	23.884	.0419	.00524	.1252	190.699	7.984	7.110	56.767	28
29	26.750	.0374	.00466	.1247	214.583	8.022	7.207	57.814	29
30	29.960	.0334	.00414	.1241	241.333	8.055	7.297	58.782	30
31	33.555	.0298	.00369	.1237	271.293	8.085	7.381	59.676	31
32	37.582	.0266	.00328	.1233	304.848	8.112	7.459	60.501	32
33	42.092	.0238	.00292	.1229	342.429	8.135	7.530	61.261	33
34	47.143	.0212	.00260	.1226	384.521	8.157	7.596	61.961	34
35	52.800	.0189	.00232	.1223	431.663	8.176	7.658	62.605	35
40	93.051	.0107	.00130	.1213	767.091	8.244	7.899	65.116	40
45	163.988	.00610	.00074	.1207	1 358.2	8.283	8.057	66.734	45
50	289.002	.00346	.00042	.1204	2 400.0	8.304	8.160	67.762	50
55	509.321	.00196	.00024	.1202	4 236.0	8.317	8.225	68.408	55
60	897.597	.00111	.00013	.1201	7 471.6	8.324	8.266	68.810	60
65	1 581.9	.00063	.00008	.1201	13 173.9	8.328	8.292	69.058	65
70	2 787.8	.00036	.00004	.1200	23 223.3	8.330	8.308	69.210	70
75	4 913.1	.00020	.00002	.1200	40 933.8	8.332	8.318	69.303	75
80	8 658.5	.00012	.00001	.1200	72 145.7	8.332	8.324	69.359	80
85	15 259.2	.00007	.00001	.1200	127 151.7	8.333	8.328	69.393	85
90	26 891.9	.00004		.1200	224 091.1	8.333	8.330	69.414	90
95	47 392.8	.00002		.1200	394 931.4	8.333	8.331	69.426	95
100	83 522.3	.00001		.1200	696 010.5	8.333	8.332	69.434	100

15% Compound Interest Factors 15%

n	Single Payment: Compound Amount Factor — Find F Given P F/P	Single Payment: Present Worth Factor — Find P Given F P/F	Uniform Payment Series: Sinking Fund Factor — Find A Given F A/F	Uniform Payment Series: Capital Recovery Factor — Find A Given P A/P	Uniform Payment Series: Compound Amount Factor — Find F Given A F/A	Uniform Payment Series: Present Worth Factor — Find P Given A P/A	Arithmetic Gradient: Gradient Uniform Series — Find A Given G A/G	Arithmetic Gradient: Gradient Present Worth — Find P Given G P/G	n
1	1.150	.8696	1.0000	1.1500	1.000	0.870	0	0	1
2	1.322	.7561	.4651	.6151	2.150	1.626	0.465	0.756	2
3	1.521	.6575	.2880	.4380	3.472	2.283	0.907	2.071	3
4	1.749	.5718	.2003	.3503	4.993	2.855	1.326	3.786	4
5	2.011	.4972	.1483	.2983	6.742	3.352	1.723	5.775	5
6	2.313	.4323	.1142	.2642	8.754	3.784	2.097	7.937	6
7	2.660	.3759	.0904	.2404	11.067	4.160	2.450	10.192	7
8	3.059	.3269	.0729	.2229	13.727	4.487	2.781	12.481	8
9	3.518	.2843	.0596	.2096	16.786	4.772	3.092	14.755	9
10	4.046	.2472	.0493	.1993	20.304	5.019	3.383	16.979	10
11	4.652	.2149	.0411	.1911	24.349	5.234	3.655	19.129	11
12	5.350	.1869	.0345	.1845	29.002	5.421	3.908	21.185	12
13	6.153	.1625	.0291	.1791	34.352	5.583	4.144	23.135	13
14	7.076	.1413	.0247	.1747	40.505	5.724	4.362	24.972	14
15	8.137	.1229	.0210	.1710	47.580	5.847	4.565	26.693	15
16	9.358	.1069	.0179	.1679	55.717	5.954	4.752	28.296	16
17	10.761	.0929	.0154	.1654	65.075	6.047	4.925	29.783	17
18	12.375	.0808	.0132	.1632	75.836	6.128	5.084	31.156	18
19	14.232	.0703	.0113	.1613	88.212	6.198	5.231	32.421	19
20	16.367	.0611	.00976	.1598	102.444	6.259	5.365	33.582	20
21	18.822	.0531	.00842	.1584	118.810	6.312	5.488	34.645	21
22	21.645	.0462	.00727	.1573	137.632	6.359	5.601	35.615	22
23	24.891	.0402	.00628	.1563	159.276	6.399	5.704	36.499	23
24	28.625	.0349	.00543	.1554	184.168	6.434	5.798	37.302	24
25	32.919	.0304	.00470	.1547	212.793	6.464	5.883	38.031	25
26	37.857	.0264	.00407	.1541	245.712	6.491	5.961	38.692	26
27	43.535	.0230	.00353	.1535	283.569	6.514	6.032	39.289	27
28	50.066	.0200	.00306	.1531	327.104	6.534	6.096	39.828	28
29	57.575	.0174	.00265	.1527	377.170	6.551	6.154	40.315	29
30	66.212	.0151	.00230	.1523	434.745	6.566	6.207	40.753	30
31	76.144	.0131	.00200	.1520	500.957	6.579	6.254	41.147	31
32	87.565	.0114	.00173	.1517	577.100	6.591	6.297	41.501	32
33	100.700	.00993	.00150	.1515	664.666	6.600	6.336	41.818	33
34	115.805	.00864	.00131	.1513	765.365	6.609	6.371	42.103	34
35	133.176	.00751	.00113	.1511	881.170	6.617	6.402	42.359	35
40	267.864	.00373	.00056	.1506	1 779.1	6.642	6.517	43.283	40
45	538.769	.00186	.00028	.1503	3 585.1	6.654	6.583	43.805	45
50	1 083.7	.00092	.00014	.1501	7 217.7	6.661	6.620	44.096	50
55	2 179.6	.00046	.00007	.1501	14 524.1	6.664	6.641	44.256	55
60	4 384.0	.00023	.00003	.1500	29 220.0	6.665	6.653	44.343	60
65	8 817.8	.00011	.00002	.1500	58 778.6	6.666	6.659	44.390	65
70	17 735.7	.00006	.00001	.1500	118 231.5	6.666	6.663	44.416	70
75	35 672.9	.00003		.1500	237 812.5	6.666	6.665	44.429	75
80	71 750.9	.00001		.1500	478 332.6	6.667	6.666	44.436	80
85	144 316.7	.00001		.1500	962 104.4	6.667	6.666	44.440	85

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

Semester Final Examination — Winter Semester, A.Y. 2018-2019
Course No. Hum 4721 — Time : 3 hours
Course Title: Engineering Economics — Full Marks : 100

There are 8 (EIGHT) Questions. Answer any 6 (SIX) of them.

Use the graph paper wherever necessary. Marks in the Margin indicate the full marks.

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1. a) Why do economic projections for a future event tend to vary more widely than engineering estimates of performance for a new design? 5

   b) Spark Electric Company is evaluating whether to manufacture a part in the own facility or to subcontract it from the Automack Company. Spark estimates its start-up costs (equipment, fixtures, facility readying) to be Tk85,000. The material-and-labor cost to produce each part is estimated to be Tk150. Automack submits a bid of Tk280 per part delivered to Spark's plant. Assume that no other data are needed; draw a break-even chart in a graph paper to show the total minimum number of parts that would have to be produced to justify Spark's producing in its own facility. What other information you can use from this chart? What is the name of this decision situation? $11^2/_3$

2. a) In a company's renovation of a small office building, two feasible alternatives for upgrading the heating, ventilation, and air conditioning (HVAC) system have been identified. One of these alternatives must be implemented. The relevant costs are: $16^2/_3$

Items	Alternative A	Alternative B
Equipment, labor and materials to upgrade	Tk18,000	Tk60,000
Annual cost of electricity	32,000	9,000
Annual maintenance expenses	2,400	16,000
Replacement of a major component 4 years hence	-	9,400
Estimated market value at the end of 8 years	2,000	8,000

   i. Use a cash flow table and end-of-year convention to tabulate the net cash flows for both alternatives from year zero to year 8.

   ii. Determine the annual net cash flow difference between the alternatives, that is (B – A).

   iii. Compute the cumulative differences, (B – A), from years zero through eight.

   iv. Show the cash-flow diagrams for both alternatives.

   v. What is meant by *feasible* alternatives?

3. a) The effective annual interest rate, i, is stated to be 19.2%. What is the nominal interest rate per year, r, if continuous compounding is being used? 5

   b) Suppose that one project has cash flows as follows: $11^2/_3$

Table for Q3b)

End-of-year	Cash flows (USD)
1	- 5,000
2	- 6,000
3	- 7,000
4	- 8,000

i. Find the present value at i = 15% per year using arithmetic gradient formulas. Show the cash flow diagrams.
ii. Now, consider a uniform series of $5,000 payments and then an arithmetic gradient series for the rest, then find the present worth. Also draw the cash flow diagram. Are these results same?

4. a) Suppose there are several project proposals but constrained amount of money for investment. Assume any reasonable internal/annual rates of return for different projects. Being a student of this subject how can you come up with a reasonable MARR on the investment? Show the relevant diagram. 7

b) An investment company is considering building a new production plant for 25 production lines for renting. Because of the long-term growth potential of the plant, it is felt that the company could average 90% of the full use of the plant each year. If the following items are reasonably accurate estimates, what is the minimum monthly rent that should be charged per production line if a 10% MARR per year is desired? Use the annual worth (AW) method. Assume that annual upkeep is directly proportional to 90% use of the plant. $9^2/_3$

Items	Money ($)
Land cost	50,000
Plant building cost	225,000
Study period, n	20 years
Upkeep expense for unit production line per month	35
Property taxes and insurance per year	10% of the *total* initial investment

5. a) What do you understand by *present worth*, *capital recovery amount*, and *internal rate of return*? Give convincing example/s on each. 6

b) You are faced with a decision on an investment proposal. Specifically, the estimated additional income from the investment is Tk12.6 million per year; the investment cost is Tk44.8 million; and the estimated annual expenses are Tk3.08 million, which being decreasing by Tk280,000 per year starting at the end of the third year. Assume an 8-year analysis period, no salvage value, and MARR is 10% per year. $10^2/_3$
   i. What is the PW of the proposal?
   ii. What is the IRR of this proposal?

6. a) How are depreciation deductions different from other production or service expenses such as labor, material and electricity? 4

b) Bhuyan-and-Bhuyan corporation has purchased some equipment for online document imaging with an estimated useful life of 5 years. It's cost-basis is BDT100,000. Compute the annual capital recovery and compare the present worth of total depreciation for $12^2/_3$
   i. The straight-line method.
   ii. The DDB method
   iii. DDB-to-SL switching.

Use a market rate of i = 10% per year for all the relevant calculations.

7. a) What is the implication of sensitivity analysis in engineering economy? Give a convincing example. Name some techniques used in engineering economy on sensitivity analyses. 4

b) For a new equipment, the initial investment is $20,000. The expected revenue per year is $10,000. The estimated life of the equipment is 10 years. Cost of annual operating and maintenance is estimated to be $3,000 and at the end of 10 years, the machine may be sold at $1,500. MARR for this equipment is set 10% per year. Investigate PW over a range of ±20%in the estimates for: $12^2/_3$
   i. Capital investment
   ii. Annual net cash flow, and
   iii. Useful life

Plot a diagram that summarizes the sensitivity of PW to the given percent deviation changes in each factor estimate.

8. a) A corporate situation for last year is described below: $11^2/_3$

1) A machine was purchased and had a depreciation of Tk768,000.
2) The company estimates that it will report a Tk6,000,000.
3) An asset with a book value of Tk640,000 was retired and sold for Tk676,000.
4) The asset in part 1) will have Tk336,000 per -year interest cost to pay off the loan taken to purchase it.
5) An asset that had a life of 8 years has been owned for 14 years and has a final book value of zero. It was sold this year for Tk22,000.
6) The cost of goods sold in the past year was Tk37.5 million.
7) Revenue from the international sales was Tk144 million, of which tk64 million is the sot for foreign licenses.

Classify these monetary items under gross income, taxable income, depreciation recapture, capital gain, capital loss, and operating loss.

b) If the revenue from a project is Tk8 million during a tax year, out-of-pocket expenses are Tk2 million, and depreciation deductions for income tax purposes are Tk1 million, what is the after-tax-cash-flow (ATCF), when effective tax rate is 40%? What is the credit amount contributed by depreciation to ATCF? What is the net-income-after-tax (NIAT)? 5

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Formulas: Hum 4721: All notations carry their usual meanings.

Time Value of money

$$i_{effective} = \left(1+\frac{r}{m}\right)^m - 1 \qquad i_{con/effective} = e^r - 1 \qquad i = \sqrt[n]{\frac{F}{P}} - 1$$

$$Estimated \quad n = \frac{72}{ROR\%} = \frac{72}{i}$$

$$F = P\left(1+\frac{1}{k}\right)^{rkn} = P\left[\left(1+\frac{1}{k}\right)^{k}\right]^{rn} \qquad F = Pe^{rn} = p(factor). \qquad r = ln(1+i)$$

Factor by which to multiply the "Given"	Factor functional symbol
$(1+i)^n$	$(F/P, i\%, n)$
$(1+i)^{-n}$	$(P/F, i\%, n)$
$[(1+i)^n - 1]/i$	$(F/A, i\%, n)$
$[(1+i)^n - 1] \Big/ i(1+i)^n$	$(P/A, i\%, n)$
$\frac{i}{(1+i)^n - 1}$	$(A/F, i\%, n)$
$\frac{i(1+i)^n}{(1+i)^n - 1}$	$(A/P, i\%, n)$
$\frac{e^{rn} - 1}{r}$	$(F/\bar{A}, r\%, n)$
$\frac{e^{rn} - 1}{re^{rn}}$	$(P/\bar{A}, r\%, n)$
$\frac{r}{e^{rn} - 1}$	$(\bar{A}/F, r\%, n)$
$\frac{re^{rn}}{e^{rn} - 1}$	$(\bar{A}/P, r\%, n)$

Internal rate of return:

$PW(i\%) = PV(i\%) = \sum_{t=0}^{n} F_t(1+i)^{-t}$ $FW(i\%) = FV(i\%) = \sum_{t=0}^{n} F_t(1+i)^{n-t}$ $AW(i\%) = R \ddot{-} E - CR(i\%)$ $CR(i\%) = I(A/P, i\%, n) - S(A/F, i\%, n)$

$$AW = PW(A/P, i\%, n) = FW(A/F, i\%, n)$$

$\sum_{t=0}^{n} R_t(\frac{P}{F}, i'\%, t) = \sum_{t=0}^{n} E_t(\frac{P}{F}, i'\%, t)$

$$PW = \sum_{t=0}^{n} R_t(\frac{P}{F}, i'\%, t) - \sum_{t=0}^{n} E_t(\frac{P}{F}, i'\%, t) = 0$$

$$FW = \sum_{t=0}^{n} R_t(F/P, i'\%, n-t) - \sum_{t=0}^{n} E_t(F/P, i'\%, n-t) = 0$$

Benefit cost ratio:

$B/C = \frac{PW(B)-PW(O\&M)}{I}$ $B/C = \frac{AW(B)}{CR+AW(O\&M)}$

$B/C = \frac{AW(B)-AW(O\&M)}{CR}$ $B/C = \frac{PW(B)}{I-PW(S)+PW(O\&M)}$ $B/C = \frac{PW(B)-PW(O\&M)}{I-PW(S)}$

Depreciation:

$d_t = \frac{B-S_n}{n}$ $d_t^* = td_t$ $BV_t = B - d_t^*$

$d_1 = B.r$ $d_t = B(1-r)^{t-1}.r$ $d_t^* = B[1-(1-r)^{t-1}]$ $BV_t = B(1-r)^t$

$$BV_n = B(1-r)^n$$

$$d_t = (B - S_n).\left[\frac{2(n-t+1)}{n(n+1)}\right]$$

$$BV_t = B - \left[\frac{2(B-S_n)}{n}\right](t) + \left[\frac{(B-S_n)}{n(n+1)}\right]t(t+1)$$

$$d_t^* = B - BV_t$$

$d_t = B.r_t$ $BV_t = BV_{t-1} - d_t$ $BV_t = B - \sum_{j=1}^{t} d_j$

Income tax

$$T_k = -T_e(R_k - E_k - d_k)$$

$$(NIAT_k) = taxable\ income - income\ tax = (R_k - E_k - d_k) - T_e(R_k - E_k - d_k)$$

$$= (R_k - E_k - d_k)(1 - T_e)$$

ATCF is $ATCF_k = NIAT_k + d_k = (R_k - E_k - d_k)(1-T_e) + d_k = (1-T_e)(R_k - E_k) + T_e d_k$

ATCFs in year k in terms of $BTCF_k$, $BTCF_k = R_k - E_k$

Thus $ATCF_k = BTCF_k + T_k = (R_k - E_k) - T_e(R_k - E_k - d_k) = (1-T_e)(R_k - E_k) + T_e d_k$

TABLE D-15
10% compound interest factors

	Single Payment		Uniform Series				Uniform Gradient		
n	Compound amount factor F/P	Present worth factor P/F	Sinking fund factor A/F	Capital recovery factor A/P	Compound amount factor F/A	Present worth factor P/A	Gradient conversion factor A/G	Present worth factor P/G	n
1	1.1000	0.9091	1.000 00	1.100 00	1.000	0.909	0.000	0.000	1
2	1.2100	0.8264	0.476 19	0.576 19	2.100	1.736	0.476	0.826	2
3	1.3310	0.7513	0.302 11	0.402 11	3.310	2.487	0.937	2.329	3
4	1.4641	0.6830	0.215 47	0.315 47	4.641	3.170	1.381	4.378	4
5	1.6105	0.6209	0.163 80	0.263 80	6.105	3.791	1.810	6.862	5
6	1.7716	0.5645	0.129 61	0.229 61	7.716	4.355	2.224	9.684	6
7	1.9487	0.5132	0.105 41	0.205 41	9.487	4.868	2.622	12.763	7
8	2.1436	0.4665	0.087 44	0.187 44	11.436	5.335	3.004	16.029	8
9	2.3579	0.4241	0.073 64	0.173 64	13.579	5.759	3.372	19.421	9
10	2.5937	0.3855	0.062 75	0.162 75	15.937	6.144	3.725	22.891	10
11	2.8531	0.3505	0.053 96	0.153 96	18.531	6.495	4.064	26.396	11
12	3.1384	0.3186	0.046 76	0.146 76	21.384	6.814	4.388	29.901	12
13	3.4523	0.2897	0.040 78	0.140 78	24.523	7.103	4.699	33.377	13
14	3.7975	0.2633	0.035 75	0.135 75	27.975	7.367	4.996	36.800	14
15	4.1772	0.2394	0.031 47	0.131 47	31.772	7.606	5.279	40.152	15
16	4.5950	0.2176	0.027 82	0.127 82	35.950	7.824	5.549	43.416	16
17	5.0545	0.1978	0.024 66	0.124 66	40.545	8.022	5.807	46.582	17
18	5.5599	0.1799	0.021 93	0.121 93	45.599	8.201	6.053	49.640	18
19	6.1159	0.1635	0.019 55	0.119 55	51.159	8.365	6.286	52.583	19
20	6.7275	0.1486	0.017 46	0.117 46	57.275	8.514	6.508	55.407	20
21	7.4002	0.1351	0.015 62	0.115 62	64.002	8.649	6.719	58.110	21
22	8.1403	0.1228	0.014 01	0.114 01	71.403	8.772	6.919	60.689	22
23	8.9543	0.1117	0.012 57	0.112 57	79.543	8.883	7.108	63.146	23
24	9.8497	0.1015	0.011 30	0.111 30	88.497	8.985	7.288	65.481	24
25	10.8347	0.0923	0.010 17	0.110 17	98.347	9.077	7.458	67.696	25
26	11.9182	0.0839	0.009 16	0.109 16	109.182	9.161	7.619	69.794	26
27	13.1100	0.0763	0.008 26	0.108 26	121.100	9.237	7.770	71.777	27
28	14.4210	0.0693	0.007 45	0.107 45	134.210	9.307	7.914	73.650	28
29	15.8631	0.0630	0.006 73	0.106 73	148.631	9.370	8.049	75.415	29
30	17.4494	0.0573	0.006 08	0.106 08	164.494	9.427	8.176	77.077	30
31	19.1943	0.0521	0.005 50	0.105 50	181.943	9.479	8.296	78.640	31
32	21.1138	0.0474	0.004 97	0.104 97	201.138	9.526	8.409	80.108	32
33	23.2252	0.0431	0.004 50	0.104 50	222.252	9.569	8.515	81.486	33
34	25.5477	0.0391	0.004 07	0.104 07	245.477	9.609	8.615	82.777	34
35	28.1024	0.0356	0.003 69	0.103 69	271.024	9.644	8.709	83.987	35
40	45.2593	0.0221	0.002 26	0.102 26	442.593	9.779	9.096	88.953	40
45	72.8905	0.0137	0.001 39	0.101 39	718.905	9.863	9.374	92.454	45
50	117.3909	0.0085	0.000 86	0.100 86	1 163.909	9.915	9.570	94.889	50
55	189.0591	0.0053	0.000 53	0.100 53	1 880.591	9.947	9.708	96.562	55
60	304.4816	0.0033	0.000 33	0.100 33	3 034.816	9.967	9.802	97.701	60
65	490.3707	0.0020	0.000 20	0.100 20	4 893.707	9.980	9.867	98.471	65
70	789.7470	0.0013	0.000 13	0.100 13	7 887.470	9.987	9.911	98.987	70
75	1 271.8952	0.0008	0.000 08	0.100 08	12 708.954	9.992	9.941	99.332	75
80	2 048.4002	0.0005	0.000 05	0.100 05	20 474.002	9.995	9.961	99.561	80
85	3 298.9690	0.0003	0.000 03	0.100 03	32 979.690	9.997	9.974	99.712	85
90	5 313.0226	0.0002	0.000 02	0.100 02	53 120.226	9.998	9.983	99.812	90
95	8 556.6760	0.0001	0.000 01	0.100 01	85 556.760	9.999	9.989	99.877	95
100	13 780.6123	0.0001	0.000 01	0.100 01	137 796.123	9.999	9.993	99.920	100

TABLE D-23
20% compound interest factors

	Single Payment		*Uniform Series*				*Uniform Gradient*		
n	Compound amount factor *F/P*	Present worth factor *P/F*	Sinking fund factor *A/F*	Capital recovery factor *A/P*	Compound amount factor *F/A*	Present worth factor *P/A*	Gradient conversion factor *A/G*	Present worth factor *P/G*	*n*
1	1.2000	0.8333	1.000 00	1.200 00	1.000	0.833	0.000	0.000	1
2	1.4400	0.6944	0.454 55	0.654 55	2.200	1.528	0.455	0.694	2
3	1.7280	0.5787	0.274 73	0.474 73	3.640	2.106	0.879	1.852	3
4	2.0736	0.4823	0.186 29	0.386 29	5.368	2.589	1.274	3.299	4
5	2.4883	0.4019	0.134 38	0.334 38	7.442	2.991	1.641	4.906	5
6	2.9860	0.3349	0.100 71	0.300 71	9.930	3.326	1.979	6.581	6
7	3.5832	0.2791	0.077 42	0.277 42	12.916	3.605	2.290	8.255	7
8	4.2998	0.2326	0.060 61	0.260 61	16.499	3.837	2.576	9.883	8
9	5.1598	0.1938	0.048 08	0.248 08	20.799	4.031	2.836	11.434	9
10	6.1917	0.1615	0.038 52	0.238 52	25.959	4.192	3.074	12.887	10
11	7.4301	0.1346	0.031 10	0.231 10	32.150	4.327	3.289	14.233	11
12	8.9161	0.1122	0.025 26	0.225 26	39.581	4.439	3.484	15.467	12
13	10.6993	0.0935	0.020 62	0.220 62	48.497	4.533	3.660	16.588	13
14	12.8392	0.0779	0.016 89	0.216 89	59.196	4.611	3.817	17.601	14
15	15.4070	0.0649	0.013 88	0.213 88	72.035	4.675	3.959	18.509	15
16	18.4884	0.0541	0.011 44	0.211 44	87.442	4.730	4.085	19.321	16
17	22.1861	0.0451	0.009 44	0.209 44	105.931	4.775	4.198	20.042	17
18	26.6233	0.0376	0.007 81	0.207 81	128.117	4.812	4.298	20.680	18
19	31.9480	0.0313	0.006 46	0.206 46	154.740	4.844	4.386	21.244	19
20	38.3376	0.0261	0.005 36	0.205 36	186.688	4.870	4.464	21.739	20
21	46.0051	0.0217	0.004 44	0.204 44	225.026	4.891	4.533	22.174	21
22	55.2061	0.0181	0.003 69	0.203 69	271.031	4.909	4.594	22.555	22
23	66.2474	0.0151	0.003 07	0.203 07	326.237	4.925	4.647	22.887	23
24	79.4968	0.0126	0.002 55	0.202 55	392.484	4.937	4.694	23.176	24
25	95.3962	0.0105	0.002 12	0.202 12	471.981	4.948	4.735	23.428	25
26	114.4755	0.0087	0.001 76	0.201 76	567.377	4.956	4.771	23.646	26
27	137.3706	0.0073	0.001 47	0.201 47	681.853	4.964	4.802	23.835	27
28	164.8447	0.0061	0.001 22	0.201 22	819.223	4.970	4.829	23.999	28
29	197.8136	0.0051	0.001 02	0.201 02	984.068	4.975	4.853	24.141	29
30	237.3763	0.0042	0.000 85	0.200 85	1 181.882	4.979	4.873	24.263	30
31	284.8516	0.0035	0.000 70	0.200 70	1 419.258	4.982	4.891	24.368	31
32	341.8219	0.0029	0.000 59	0.200 59	1 704.109	4.985	4.906	24.459	32
33	410.1863	0.0024	0.000 49	0.200 49	2 045.931	4.988	4.919	24.537	33
34	492.2235	0.0020	0.000 41	0.200 41	2 456.118	4.990	4.931	24.604	34
35	590.6682	0.0017	0.000 34	0.200 34	2 948.341	4.992	4.941	24.661	35
40	1 469.7716	0.0007	0.000 14	0.200 14	7 343.858	4.997	4.973	24.847	40
45	3 657.2620	0.0003	0.000 05	0.200 05	18 281.310	4.999	4.988	24.932	45
50	9 100.4382	0.0001	0.000 02	0.200 02	45 497.191	4.999	4.995	24.970	50
∞				0.200 00		5.000	5.000	25.000	∞

97

BSc.Eng/7th Sem.(ME)/BScTE (1st-yr/2nd-yr) 18 May 2019 (Saturday)

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

Semester Final Examination — Winter Semester, A.Y. 2018-2019
Course No. MCE 4729/MCE4793 — Time : 3 hours
Course Title: Production and Operations Management — Full Marks : 150

There are **8** (Eight) Questions. Answer any **6** (Six) of them.
Use the graph paper wherever necessary. Marks in the Margin indicate the full marks.

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1 a) Provide examples of *make-to-stock* (MTS), *make-to-order* (MTO), and *assemble-to-order* (ATO) type of products available in your country (Bangladesh/Pakistan/Yemen/…). Give reason(s) in support of each example. What advantages do you see in moving from MTS to MTO or ATO? Give adequate and convincing answer. 10

b) "Manufacturing integrates all activities of three participants". Who are these participants? What functions or activities are covered in manufacturing? Give examples by taking any product. 7

c) With a diagram, describe demand management in a*manufacturing planning and control* (MPC) system to go ahead to *master production schedule* (MPS). Use a figure. 8

2 a) Suppose you are thinking to produce an electronic timing switch, the direct material, direct labor and direct overhead costs per unit have been estimated to be Tk50, Tk8 and Tk4 respectively. The selling price is decided to be 138 percent of the variable cost per unit. The maximum capacity of the firm is 160,000 units per year. Its fixed cost is Tk2,024,000 per year. For this firm: 15

i. Find the breakeven quantity in units and in percentage of total capacity.
ii. What is the percentage reduction in breakeven point if fixed costs are reduced 10 percent; if variable cost per unit is reduced 10 percent; if both costs are reduced 10 percent; and if the selling price is increased by 10 percent?

b) When the revenue and the total cost functions are respectively $R = 1000Q - 0.001Q^2$, and $TC = 0.005Q^2 + 4Q + 20000$. 10

i. What is the profit function?
ii. What quantity you must produce to maximize profit?
iii. What is the BEP(Q)?
iv. Find the quantity to be produced to maintain the average cost. Make comment on acceptable result.

3 a) From the company records, the demand of a certain product for the corresponding period is as below: 15

Table Q3a)Demand of the product

Period (x)	1	2	3	4	5	6
Demand (y)	45 k	48 k	50 k	53 k	57 k	62 k

Use exponential smoothing with trend to forecast next period's demand for exponential smoothing constant $\alpha = 0.1$ and trend smoothing constant $\beta = 0.1$ and 0.5. Start the analysis from period 2 and assume that exponential smoothing value for that period is equal to the actual demand of the same period, and trend component for period 2 is the difference between actual demands for period 2 and period 1. What role does β play?

b) What determines the acceptance of a method of demand forecasting over several other methods? The Table Q3b) shows the forecasts by three models. Which models would you prefer based on SSE and MAD? 10

Table Q3b) Forecast values

	Forecast value		
Actual value	Model 1	Model 2	Model 3
360	353	343	357
327	331	358	345
375	369	330	379
405	395	371	407
396	391	403	401

4 a) List the distinguishing features of product and process (functional) layouts. Cite the type of production each of them is appropriate. 8

b) A manufacturing firm wants to design a repetitive production line to produce one of its products. The production process requires 14 tasks, which are listed in Table Q4b), along with estimated task times and predecessors for each task. The company wants to produce 270 units of product per day. It expects the production line to operate 450 minutes per day. 17

Table Q4b)Task list

Task	Task time (sec)	Predecessor tasks
A	10	-
B	25	-
C	10	-
D	35	A
E	65	B, C
F	35	A, E
G	30	-
H	20	D, G
I	45	A
J	50	-
K	20	-
L	40	J, K
M	30	A, L
N	70	F, H, I, M

i. Draw a network/precedence diagram for the tasks.
ii. Compute the maximum cycle time the line can have and still produce at least 720 units per day
iii. Compute the theoretical minimum number of work stations needed.

5 a) What is the goal of an aggregate production planning (APP)? State at least five features of APP. What are its major decision areas? 8

b) State all possible options to change the capacity in a production plant under APP. Give examples. 7

c) Using the appropriate figures/diagrams, explain two pure aggregate planning strategies. 10

6 a) Should a manufacturing plant allow holding inventory? State the importance of inventory in manufacturing. 8

b) At its current capacity, a manufacturing firm cannot avoid shortage or backorders. To ease its computation, the company is still trying to apply the *economic order quantity* (EOQ) model. Assume that the company is considering an important item for its inventory to be purchased where shortage is allowed. By listing the other necessary assumptions and showing the structure of this model in a figure, derive the expressions for optimum order quantity, optimum inventory level just after an EOQ is added to the existing inventory, maximum shortages that may occur at this state, and the optimum cycle time that could be considered for the next replenishment. Show all steps. 17

7 a) An EOQ model can be expressed as $EOQ = \sqrt{\frac{2Dk}{h}}$, where D is the annual demand of an item, k is the ordering cost/order and h is the holding cost/unit/period. Why does a company need to conduct a sensitivity analysis on this model? How does such analysis affect the order quantity and total variable cost? Show all derivations and explain their physical meanings. 13

b) A plant manager of a parts manufacturing plant has to determine the lot size for a particular part that has a steady demand of 30 units per day. The manager has determined that 190 units can be produced per day. The estimated annual demand is 10,500 units. The setup cost per production run and the holding cost per unit per unit time are Tk4,000 and Tk5 respectively. The plant operates 350 days a year. Determine the 12

i. Economic production lot size
ii. Total annual cost
iii. Production time during each cycle (i.e., per lot)

8 a) A company manufactures product Z, using four basic components and performing two additional machining operations and three assembly operations. Components A and B are made by the company, and components B and D are purchased from the suppliers. The *bill of material* (BOM) for the product Z is given in Table Q8a). The product is made as follows: 20

- A unit of component A is machined and converted into component E.
- A unit of E is then assembled with two units of B to make F.

- A unit of C is machined and converted into G.
- A unit of A and three units of D are assembled into H.
- One unit of F, two units of G, two units of H, and four units of B are then assembled into product Z.

i. Construct a product structure for product Z.

ii. Construct a production time chart for product Z

iii. Derive the material requirements plans for product Z and components F and E using lot-for-lot procurement. Assume the requirements for product Z from the MPS are as follows (Table Q8a2)):

Table Q8a): BOM for the final product

Level	Item no.	Item description	No. required	Make/buy	Lead time (week)
00		Product Z		Make	1
01	F231	Assembly F	1	Make	1
02	E110	Machined E	1	Make	2
03	A324	Component A	1	Make	2
02	B278	Fastener B	2	Buy	2
01	G386	Machined G	2	Make	1
02	C190	Component C	1	Make	3
01	H486	Assembly H	2	Make	1
02	A324	Component A	1	Make	2
02	D752	Component D	3	Buy	4
01	B278	Fastener B	4	Buy	2

Table Q8a2): Final products' demand

Week	1	2	3	4	5	6	7	8	9	10
Requirements	0	0	0	0	5000	200	0	400	300	

b) Write a short note on lot sizing rules in manufacturing. 5

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B.Sc. Engg. (M)/7th Sem

27 May 2019

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

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination
Course No.: MCE 4787
Course Title: Automobile Engineering

Winter Semester, A. Y. 2018-2019
Time: 3 Hours 00 Min(s)
Full Marks: 150

There are 8 (Eight) questions. Answer any 6 (Six) 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) What is an Automobile? Discuss the basic structure of an automobile. 15

   b) What is stoichiometric air fuel ratio? How does the engine efficiency and power vary with the change of air fuel ratio? 10

2. a) Why mixture correction is necessary for a carburetor operation? Explain how you can achieve mixture correction by using an air bleed. 15

   b) Explain how a fuel injector works in an automobile engine with necessary diagram. 10

3. a) Explain the essential parts and working of a battery ignition system. 15

   b) What are the effects of compression ratio on engine performance? What is the compression ratio of an engine with 63.75-cu. in. displacement in one cylinder and a combustion chamber volume of 8.5 cu. in.? 10

4. a) What is a synchronizer? How the synchronizer does work in a manual transmission system for changing gears? 15

   b) Explain direct drive, under drive and overdrive with proper example. 10

5. a) 15

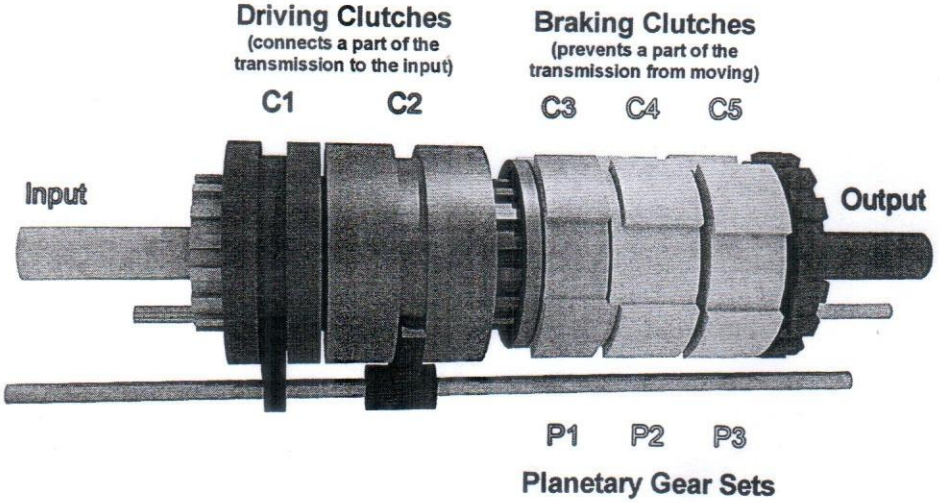

Figure 1: Allison 1000 Automatic Transmission system

Figure 1, shows Allison 1000 Automatic Transmission system of having 3 planetary gear sets and 5 different types of clutches. Explain how you can achieve 2nd and Reverse gear from this automatic transmission system.

b) What is the main function of a stator in a torque converter? Explain the torque multiplication phase of a torque converter. 10

6. a) Why limited slip differential is necessary? Explain the working principle of a pressure ring based limited slip differential. 15
   b) How does the speed difference on the output of a typical U-joint vary with the speed and the angle of the U-joint for 10° and 30° joint angle? 10

7. a) Explain the cycles of a shock absorbers with necessary diagram. 15
   b) Write down the working principle of a disc brake. How a driver will understand that the brake pads are needs to be replaced? 10

8. a) What is a hybrid car? Explain the major components of a hybrid car apart from the engine and fuel supply system. 15
   b) Write down the steering linkage flow diagram for rigid axle and independent suspension system. 10

M.Sc.Engg. (M) /MScTE (1st Sem) 21 May 2019

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

SEMESTER FINAL EXAMINATION
MCE 6109 Mechanical Vibrations

WINTER SEMESTER: 2018-2019
TIME : 3 HRS
FULL MARKS : 150

There are **6** Questions. Answer any **5** 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. Consider the stepped bar shown in Fig.1 with the following data: $A_1=16\times10^{-4}$ m^2, $A_2=9\times10^{-4}$ m^2, $A_3=4\times10^{-4}$ m^2, $E_i=20\times10^{10}$ Pa, $i=1,2,3$, $\rho_i=7.8\times10^3$ kg/m^3, $i=1,2,3$, $l_1=1$ m, $l_2=0.5$ m, $l_3=0.25$ m. Take bar element for FEM analysis and determine i) dispalcements u_1, u_2 and u_3 under load $p_3=1000$ N and ii) Natural frequencies of bar. (30)

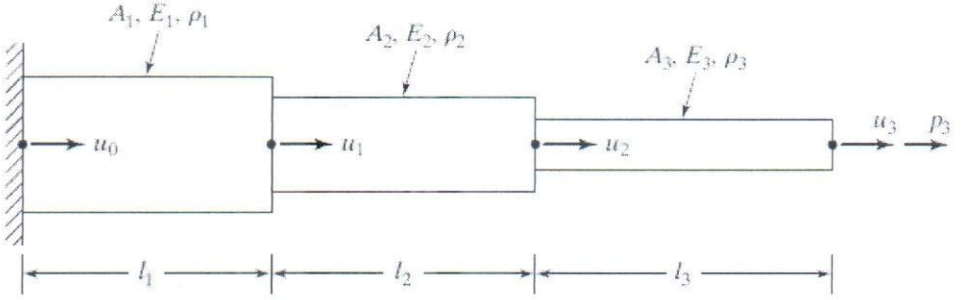

Fig.1

2. Find the tip deflection of the cantilever beam shown in Fig. 2 when a vertical load of $P=500$ N is applied at point Q using a) a one beam element approximation and b) a two-beam-element approximation (for answering (b) only write the matrx. Assume $l=0.25$ m, $h=25$ mm, $b=50$ mm, $E=2.07\times10^{11}$ Pa, and $k=10^5$ N/m. (30)

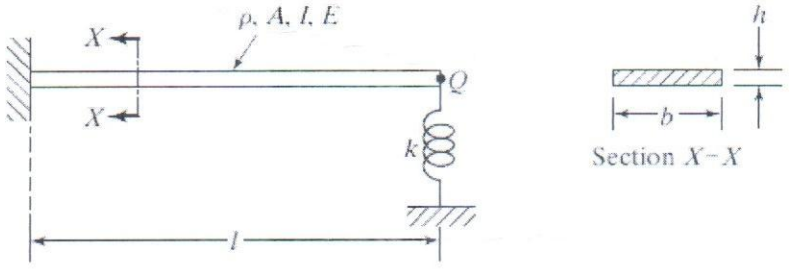

Fig. 2

3. Determine the natural frequencies and mode shapes of the system where the dynamical matrix is given by (30)

$$[D] = [k]^{-1}[m] = \frac{m}{k}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 2 & 2 \\ 1 & 2 & 3 \end{bmatrix}$$

4. Derive the stiffnes influence coefficients of the spring-mass system shown in Fig.3 asuming that all the contacting surfaces are frictionless. (30)

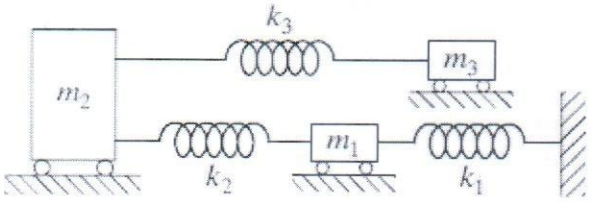

Fig.3

5. Determine the equation of motions, the natural frequencies and the mode shapes of the system shown in Fig. 4. From the mode shape determine the general solution of the system. (30)

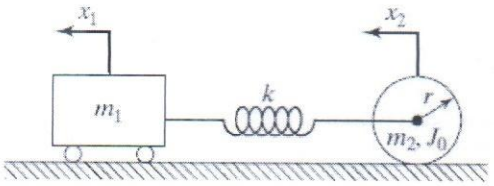

Fig. 4

6. Determine the free vibration response of the system shown in Fig.5 with k_1=30 N/m, k_2=5 N/m, k_3=0, m_1=10 kg, m_2=1 kg, and c_1=c_2=c_3=0 for the initial conditions $x_1(0) = 1,\ \dot{x}_1(0) = x_2(0) = \dot{x}_2(0)$. (30)

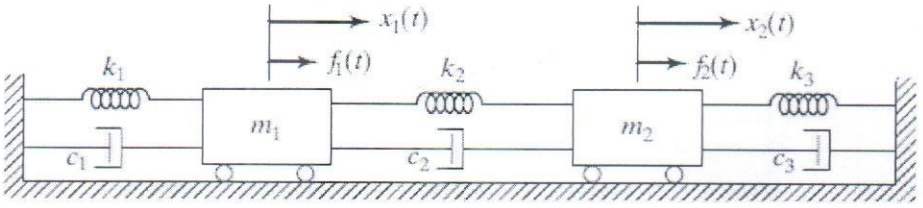

Fig. 5

Some formulas:

For the one bar element mass and stiffness matrices are:

$$[m] = \frac{\rho A l}{6}\begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \text{ and } [k] = \frac{EA}{l}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

For beam element mass and stiffness matrices are:

$$[m] = \frac{\rho A l}{420}\begin{bmatrix} 156 & 22l & 54 & -13l \\ 22l & 4l^2 & 13l & -3l^2 \\ 54 & 13l & 156 & -22l \\ -13l & -3l^2 & -22l & 4l^2 \end{bmatrix}$$

$$[k] = \frac{EI}{l^3}\begin{bmatrix} 12 & 6l & -12 & 6l \\ 6l & 4l^2 & -6l & 2l^2 \\ -12 & -6l & 12 & -6l \\ 6l & 2l^2 & -6l & 4l^2 \end{bmatrix}.$$

M Sc TE(2 Year) / M Sc.Engg. (MCE) 16 May 2019

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

Semester Final Examination
Course Code: **MCE 6145**
Course Title: **Convective Heat Transfer**

Winter Semester: **A.Y. 2018-2019**
Time : **3.0 Hours**
Full Marks : **150**

OPEN BOOK

There are **08 (Eight)** Questions. Answer any **06 (Six)** of them.
Do not write on the question paper. Marks in the margin indicate the full marks.

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1. a) Discuss the different heat transfer augmentation techniques. **(10)**

   b) A spherical storage tank of diameter D=1.5 m contains a cold liquid at $T_1 = 15°C$. To reduce the heat losses, this storage tank is enclosed inside another spherical shell, and the gap spacing is 3 cm. The temperature of the outer sphere is $T_2 = 25°C$. Determine the rate of heat loss by free convection across the gap filled with air at (a) $\frac{1}{20}$, (b) $\frac{1}{10}$ and (c) 1 atm. **(15)**

2. a) Discuss the physical significance of velocity boundary layer concept for flow along a flat plate. **(10)**

   b) The velocity profile u(x,y) for boundary layer flow over aflat plate is given by $\frac{u(x,y)}{u_\infty} = \frac{3}{2}\left[\frac{y}{\delta(x)}\right] - \frac{1}{2}\left[\frac{y}{\delta(x)}\right]^3$ where the boundary layer thickness is $\delta(x) = \sqrt{\frac{280}{13}\frac{\vartheta x}{u_\infty}}$. **(15)**

   Develop an expression for the local drag coefficient. Also develop an expression for the average drag coefficient over a distance x=L from the leading edge of the plate.

3. a) Differentiate the characteristics between Condensation on Inclined surfaces and Horizontal tubes. **(10)**

   b) The exact expression for the local Nusselt number for laminar flow along a flat plate is given by $Nu_x = \frac{h(x)x}{k} = 0.332\, Pr^{\frac{1}{3}}\, Re^{\frac{1}{2}}$ .Develop a relation for the average heat transfer coefficient h(x) from x=0 to x=L. Atmospheric air at $T_\infty = 400K$ with a velocity $u_\infty = 2.5\ m/s$ flows over a flat plate L=2m long maintained at a uniform temperature $T_w = 333K$. **(15)**

   i. Calculate the average heat transfer coefficient h_m from x=0 to x=L=2 m.
   ii. Calculate the heat transfer rate from airstream to the plate from x=0 to x=L=2 m for w=0.5 m.

4. a) Discuss the principle boiling regime in pool boiling of water at atmospheric pressure and saturation temperature. **(10)**

   b) Saturated water at $T_{sat} = 210°C$ flows with a mass flow rates of $M = 0.17 kg/s$ through a 2.0 cm internal diameter. Subjected to a uniform wall heat flux of $q_w = 139\frac{W}{m^2}$. Calculate the tube wall temperature T_w and the two phase heat transfer coefficient h_{TP}, at the location where the vapor mass is 0.37. **(15)**

5. a) Discuss the basic principle of von Karman integral method for the determination of the velocity boundary layer thickness. **(10)**

   b) Consider a square plate 0.5 m by 0.5 m with one surface insulated and the other surface maintained at a uniform temperature of $T_w = 385$ K which is placed in quiescent air at atmosphere pressure and $T_\alpha = 315$ K. **(15)**
   The physical properties of atmospheric air at 375 K are taken as
   $v = 2.076 \times 10^{-5}$ m^2/s), k = 0.03 W/(m. °C), Pr = 0.697, $\beta = 2.86 \times 10^{-3}$ K^{-1}
   Calculate the average heat transfer coefficient for free convection for the following three orientations of the hot surface:
   (i). The plate is horizontal and the hot surface faces up.
   (ii). The plate is horizontal and the hot surface faces down.
   (iii). The plate is vertical.

6. a) Discuss the physical significance of Nu, St, E, Re. **(10)**

   b) Water at atmospheric pressure and saturation temperature is boiled in a 25 cm diameter, electrically heated, mechanically polished, stainless-steel pan. The heated surface of the pan is maintained at a uniform temperature of $T_w = 116°C$. **(15)**
   The physical properties of saturated water and vapor are taken as:
   $c_{pl} = 4216$ J/(kg. °C), $h_{fg} = 2257$ kJ/kg, $\rho_l = 960$ kg/m^3, $\rho_v = 0.60$ kg/m^3, $Pr_l = 1.74$, $\mu_l = 0.282 \times 10^{-3}$ kg/(m. s), $\sigma^* = 58.8 \times 10^{-3}$ N/m, $\Delta T = T_w - T_v = 16°C$.
   (i) Calculate the surface heat flux.
   (ii) Calculate the rate of evaporation from the pan.
   (iii) Calculate the peak heat flux.

7. Water flows with a mean velocity of 2 m/s inside a circular pipe of inside diameter of 5 cm. The pipe is of commercial steel and its wall is maintained at a uniform temperature of 100°C by condensing steam on its outer surface. At a location where the fluid is hydrodynamically and thermally developed, the bulk mean temperature of water is 60°C. **(25)**
   Properties at bulk mean temperature for water are given as follows: ρ=985 kg/m^3, Pr=3.02, $\mu_b = 4.71 \times 10^{-4} \frac{kg}{m.s}$, $\mu_w = 2.82 \times 10^{-4}$ kg/(m. s), f=0.0152
   Calculate the heat transfer coefficient h for a smooth pipe by using the following correlations:
   (i). The Notter and Sleicher equation.
   (ii). The Petukhov equation.
   (iii). The Sieder and Tate equation.
   (iv). The Dittus and Boelter equation.

8. a) Write down the physical significance of Reynolds number and Grashof number. **(10)**

   b) A square plate $\frac{1}{2}$ m by $\frac{1}{2}$ m is thermally insulated on one side and subjected to a solar radiation flux $q = 600$ Wm^{-2} on the other side which is considered a black surface. The plate makes an angle $\theta = -50°$ with the vertical, so that hot surface is facing upward. The heated surface dissipates heat by free convection into atmospheric air at $T_\infty = 333$K. Calculate the equilibrium temperature of the plate. **(15)**