B.Sc Engg.(M)/1st Sem — 05 December, 2022 (10:00 AM-1:00 PM)

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

Semester Final Examination
Course No.: ME 4101
Course Title: Introduction to Mechanical Engineering

Winter Semester: A.Y. 2021-2022
Time: 03 Hours
Full Marks: 150

There are 06 (Six) Questions. Answer all of them.

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.

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1. **(a)** Discuss the reason behind air being compressed before entering combustion chamber? **[7+8+10]**

(CO1)

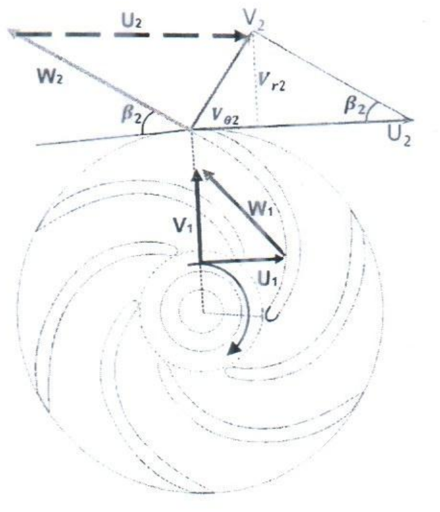
(b) "Gas turbine has lower efficiency than steam turbine"- Explain. How the cycle efficiency can be improved? **(PO1/PO7)**

(c) Write a short note on the working principal and differences between Turbofan and Turboprop engine with illustration.

2. **(a)** State Euler's turbomachinery equation of Torque and define each term. From the velocity triangle and the direction of velocity at the inlet (1) and outlet (2) characterize the following turbomachine (pump or turbine) and discuss the reason behind? **[10+7+8]**

(CO2)

(PO1/PO6)



(b) Explain the difference between impulse and reaction turbines using appropriate illustrations.

(c) Write a short description on gear pump and explain why priming is required in centrifugal pumps.

3. **(a)** Define the term Tons of refrigeration. Show the unit conversion in BTU to kW to TR. [7+8+10] (CO1) (PO1/PO7)

(b) State the principle of the basis of a refrigeration system. Explain with necessary diagrams.

(c) Explain all the thermodynamic processes of a simple vapor compression refrigeration system with simple schematic diagram and show the cycle on P-h diagram.

4. **(a)** Define and explain the term- "Psychrometry" and discuss the significance of the study of Psychrometry. [15+10] (CO2) (PO1/PO6)
List and define different psychrometric properties of moist air.

(b) Show constant lines of different psychrometric properties of the moist air with units.

5. **(a)** Describe different psychrometric processes of moist air. Explain with the system diagram along with their mass and energy balance equations. [10+15] (CO2) (PO1/PO6)

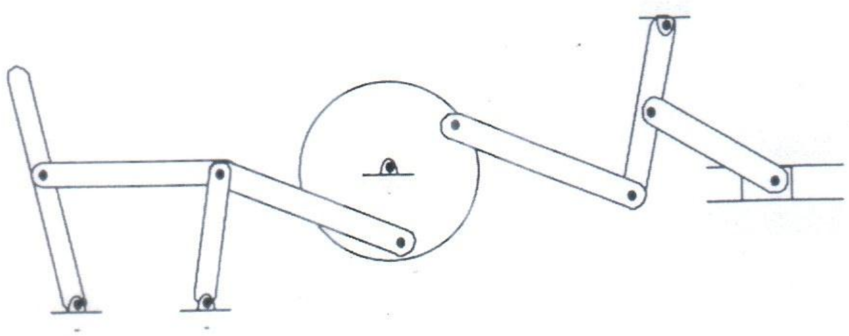
(b) Air flows through a chamber in which a cooling and dehumidification coil is located. The following data are applicable.

$V1 = 3.5\ m^3/s$	$DBT1 = 27^0C$
$RH_1 = 50\%$	$DBT2 = 13^0C$
$RH_2 = 90\%$	Pb = 1 atm

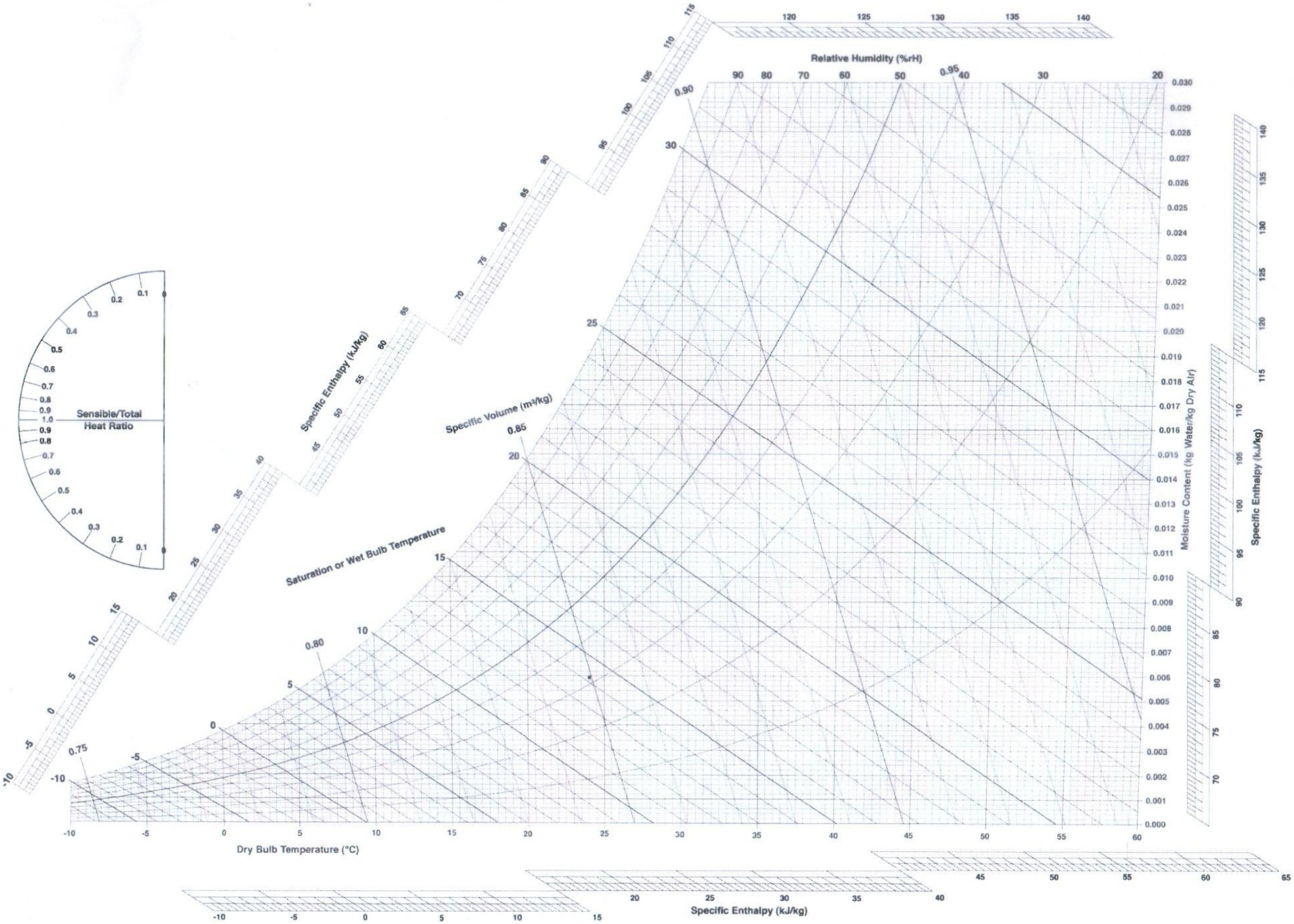
Condensate leaves the chamber at 10^0C. There is heat leakage of 200 W from the surroundings to the system. Calculate-

i. Cooling capacity of the coil, kW
ii. Rate of water removal from the air, kg_w/s

6. **(a)** Identify the number of links, full joint and half joint in the following mechanism. Determine the Degree of freedom of the mechanism using Gruebler's equation and draw associated diagram. [10+15] (CO2) (PO1/PO6)



(b) Describe a four-stroke gasoline engine with an illustration of each stroke and a schematic of the valve timing diagram.
Also discuss the primary differences between gasoline and diesel engines.



Relative Humidity (%rH)
Specific Enthalpy (kJ/kg)
Specific Volume (m³/kg)
Saturation or Wet Bulb Temperature
Moisture Content (kg Water/kg Dry Air)
Dry Bulb Temperature (°C)
Sensible/Total Heat Ratio

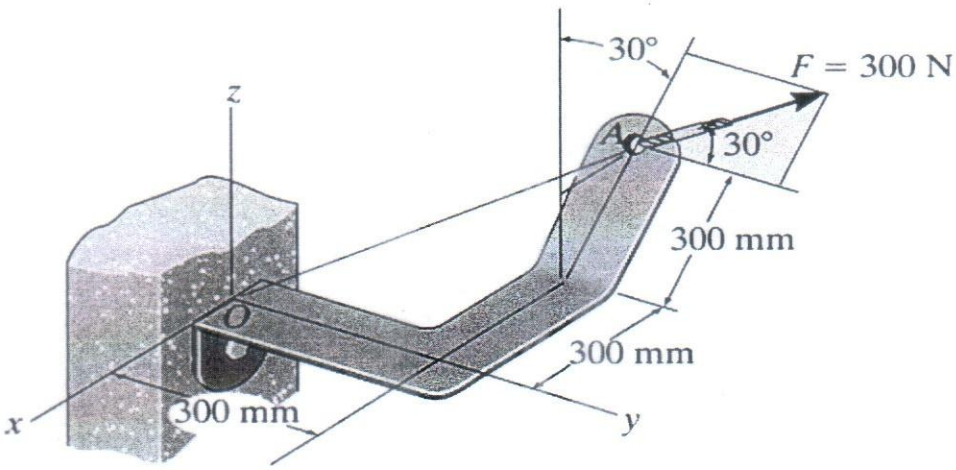
B.Sc.Engg. (M)/1st Sem. 01 December 2022 (Group-B)

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

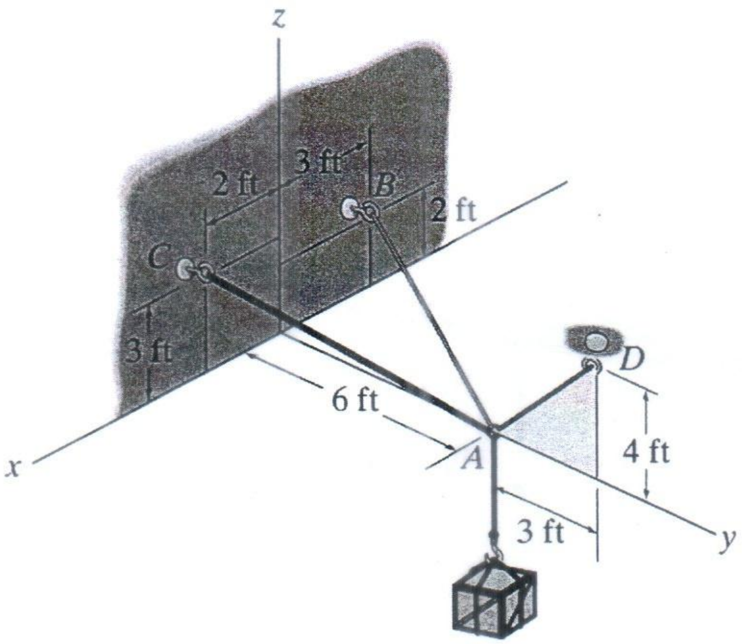
Semester Final Examination — Winter Semester, A.Y. 2021-2022
Course No. ME 4103 — TIME : 3 hours
Course Title: Statics — Full Marks : 150

Answer all Questions. Each question carries equal marks. Symbols have their usual meanings. Draw the free body diagram if required. The right column also indicates the course objective (CO) and Program Outcomes (PO) addressed by each question

Q-01(a). Determine the magnitude of the projected component of the force ***F = 300 N*** acting along line ***OA***. **(12.5) (CO1) (PO2)**



Q-01(b). Determine the maximum weight of the crate that can be suspended from cables ***AB, AC,*** and ***AD*** so that the tension developed in any one of the cables does not exceed ***250 lb***. **(12.5) (CO1) (PO3)**



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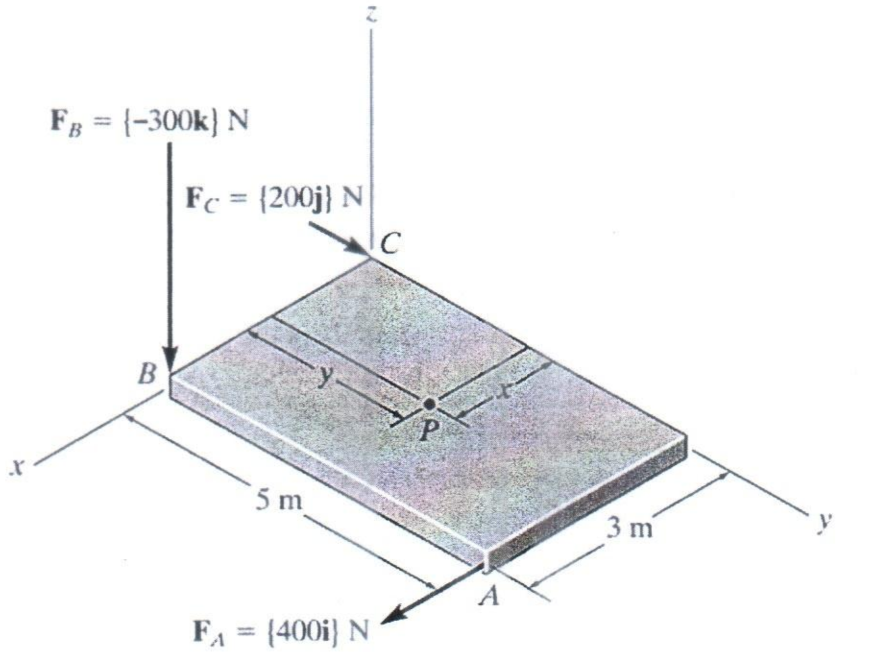
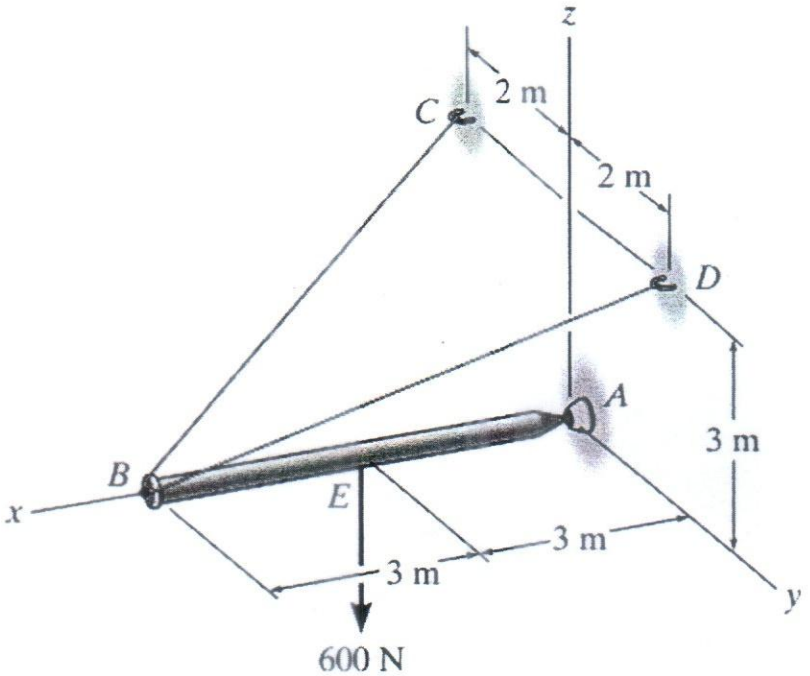
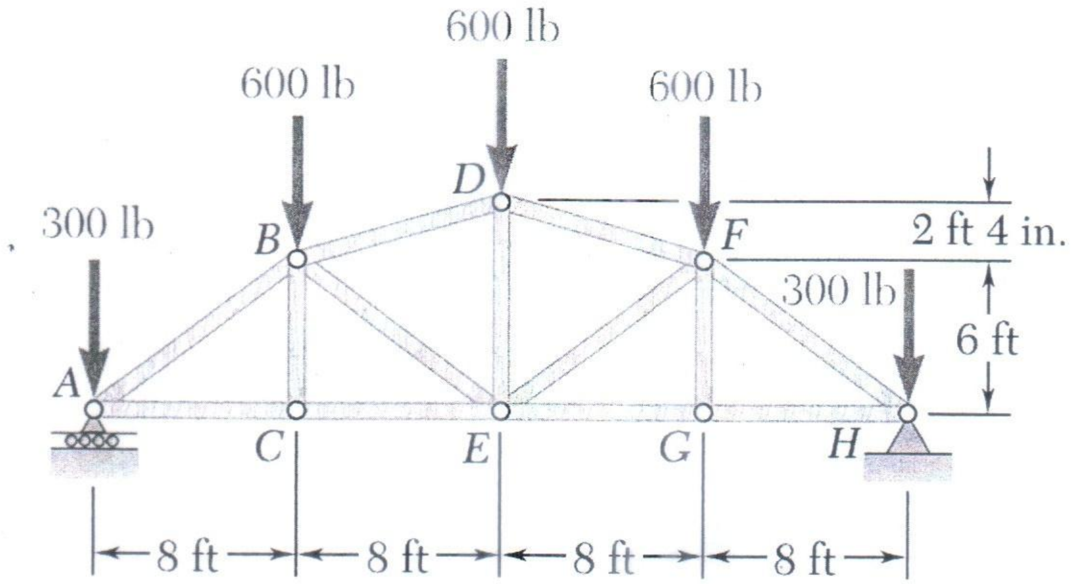
Q-02(a). Replace the three forces acting on the plate by a wrench. Specify the magnitude of the force and couple moment for the wrench and the point ***P (x, y)*** where the wrench intersects the plate. **(12.5) (CO2) (PO2)**



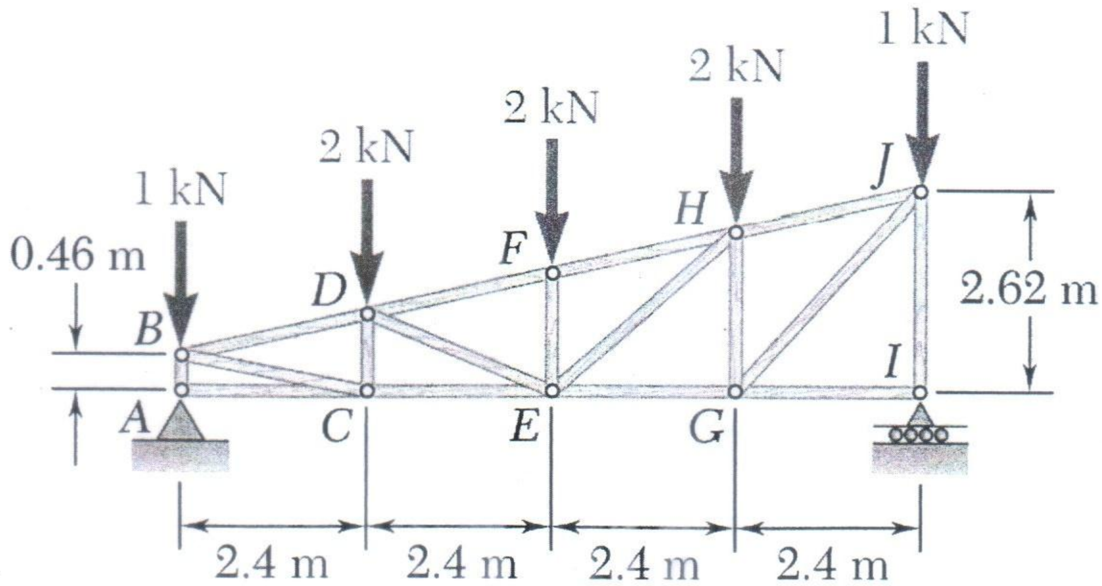
Q-02(b). Determine the components of reaction at the ball-and-socket joint *A* and the tension in each cable necessary for equilibrium of the rod. **(12.5) (CO2) (PO2)**



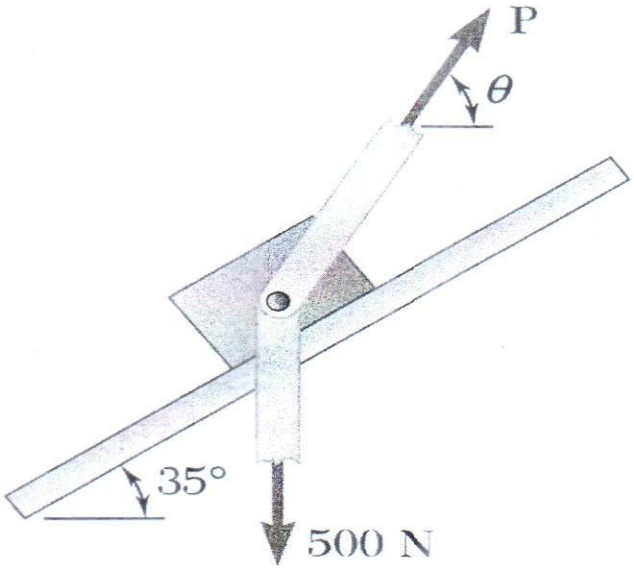
Q-03(a). Determine the force in each member of the Gambrel roof truss shown. State whether each member is in tension or compression. Use the **Method of joints** to solve the problem. **(12.5) (CO3) (PO3)**



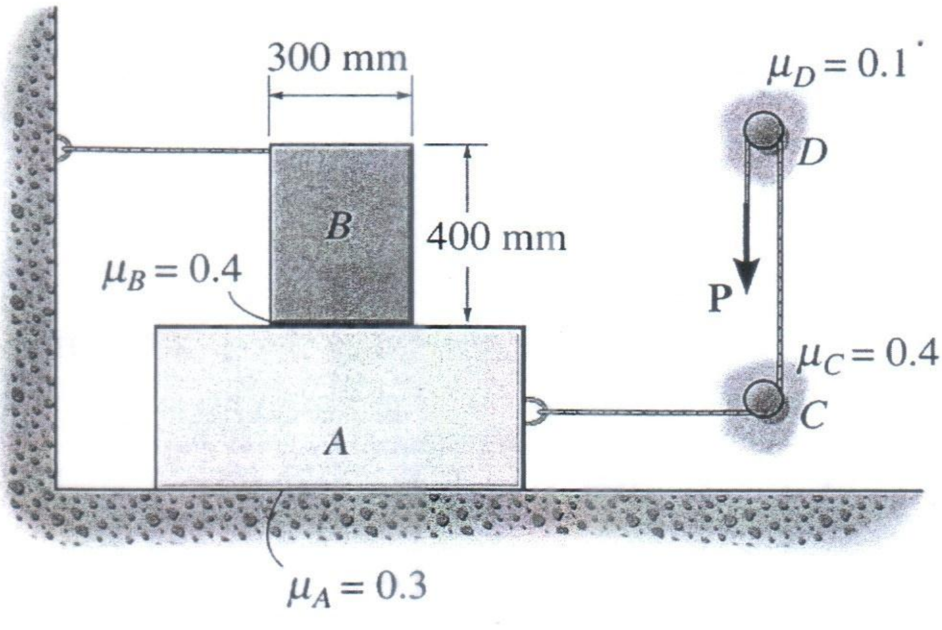
Q-03(b). A pitched flat roof truss is loaded as shown. Determine the force in members ***EG***, ***GH***, and ***HJ***. Use **Method of section** to solve the problem. **(12.5) (CO3) (PO2)**



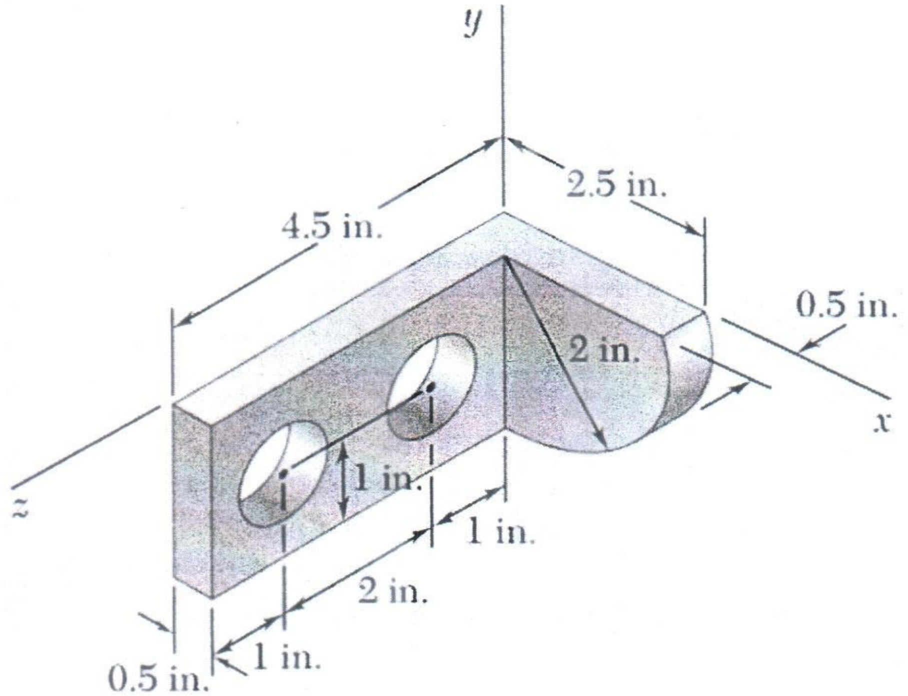
Q-04(a). The coefficients of friction between the block and the rail are $\mu_s = 0.30$ and $\mu_k = 0.25$. Knowing that $\theta = 65°$, determine the smallest value of ***P*** required (a) to start the block moving up the rail, (b) to keep it from moving down. **(12.5) (CO3) (PO2)**



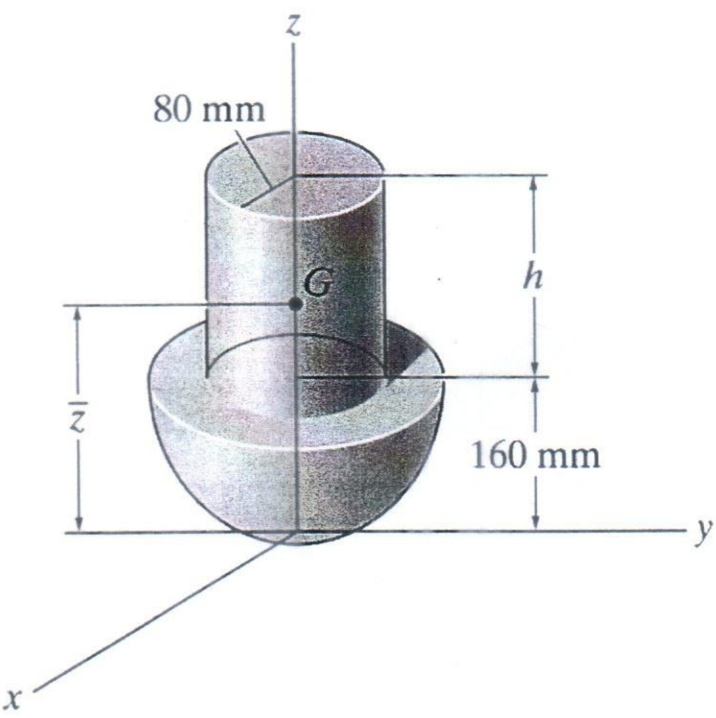
Q-04(b). Blocks ***A*** and ***B*** have a mass of ***7 kg*** and ***10 kg***, respectively. Using the coefficients of static friction indicated, determine the largest vertical force ***P*** which can be applied to the cord without causing motion. **(12.5) (CO3) (PO2)**



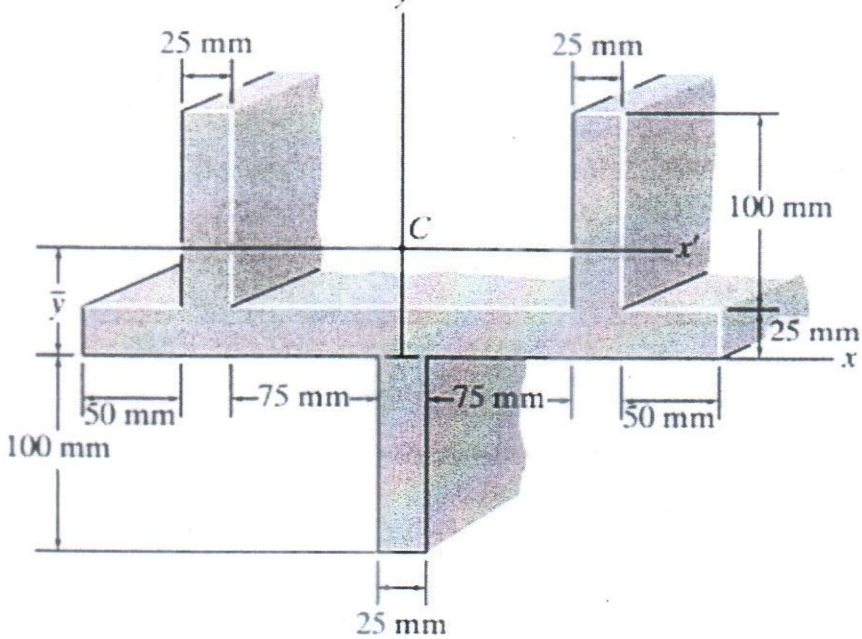
Q-05(a). Locate the center of gravity of the steel machine element shown below. The diameter of each hole is **1 inch**. **(12.5)** **(CO4)** **(PO2)**



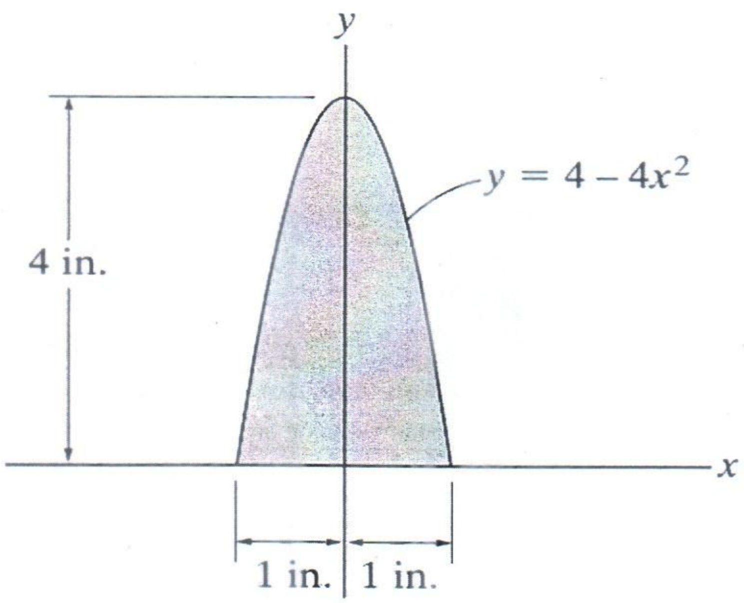
Q-05(b). The assembly is made from a steel hemisphere, $\rho_{st} = 7.8\ Mg/m^3$, and an aluminum cylinder, $\rho_{al} = 2.7\ Mg/m^3$. Determine the height h of the cylinder so that the mass center of the assembly is located at $\bar{z} = 160$ mm. **(12.5)** **(CO4)** **(PO2)**



Q-06(a). Determine the distance $\bar{y}$ to the centroid of the beam's cross-sectional area; then determine the moment of inertia about the x' axis. **(12.5) (CO4) (PO1)**

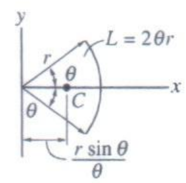


Q-06(b). Determine the moment of inertia of the area about the x axis. Solve the problem in two ways, using rectangular differential elements: (a) having a thickness of dx, and (b) having a thickness of dy. **(12.5) (CO4) (PO2)**

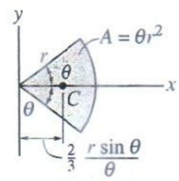


Geometric Properties of Line and Area Elements

Centroid Location | Centroid Location | Area Moment of Inertia



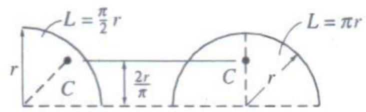
Circular arc segment



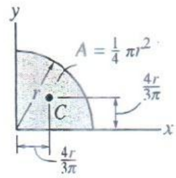
Circular sector area

$I_x = \frac{1}{4}r^4(\theta - \frac{1}{2}\sin 2)\theta$

$I_y = \frac{1}{4}r^4(\theta + \frac{1}{2}\sin 2)\theta$



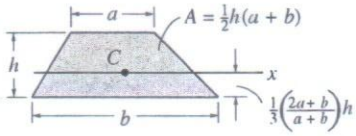
Quarter and semicircle arcs



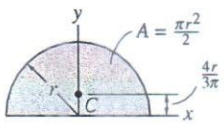
Quarter circle area

$I_x = \frac{1}{16}\pi r^4$

$I_y = \frac{1}{16}\pi r^4$



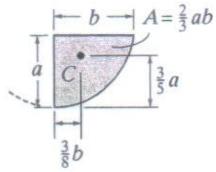
Trapezoidal area



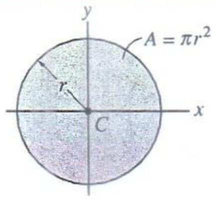
Semicircular area

$I_x = \frac{1}{8}\pi r^4$

$I_y = \frac{1}{8}\pi r^4$



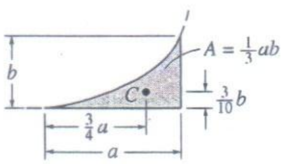
Semiparabolic area



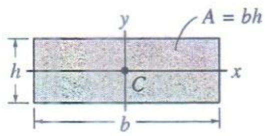
Circular area

$I_x = \frac{1}{4}\pi r^4$

$I_y = \frac{1}{4}\pi r^4$



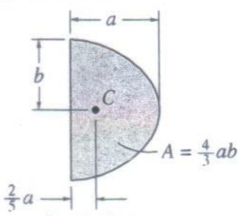
Exparabolic area



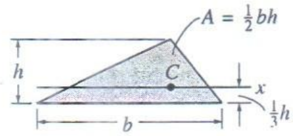
Rectangular area

$I_x = \frac{1}{12}bh^3$

$I_y = \frac{1}{12}hb^3$



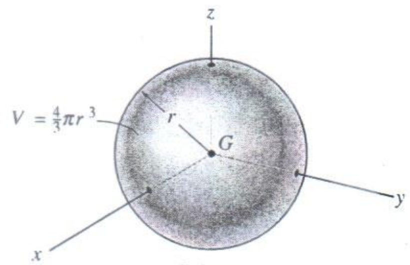
Parabolic area



Triangular area

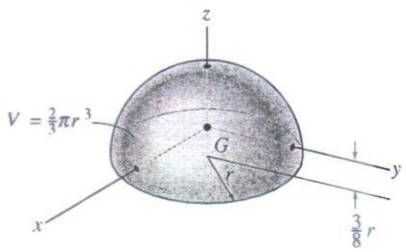
$I_x = \frac{1}{36}bh^3$

Center of Gravity and Mass Moment of Inertia of Homogeneous Solids



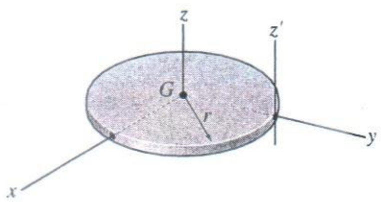
Sphere

$I_{xx} = I_{yy} = I_{zz} = \frac{2}{5}mr^2$



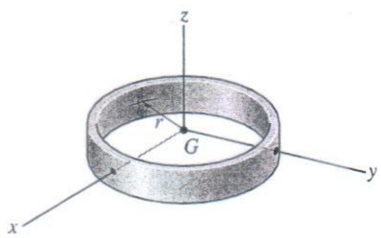
Hemisphere

$I_{xx} = I_{yy} = 0.259mr^2 \quad I_{zz} = \frac{2}{5}mr^2$



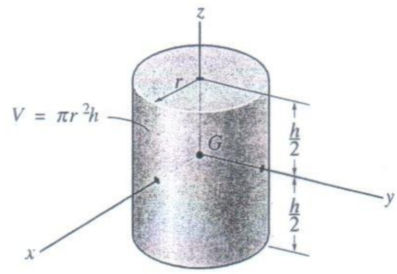
Thin Circular disk

$I_{xx} = I_{yy} = \frac{1}{4}mr^2 \quad I_{zz} = \frac{1}{2}mr^2 \quad I_{z'z'} = \frac{3}{2}mr^2$



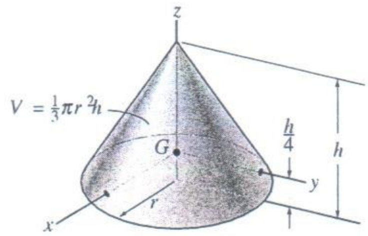
Thin ring

$I_{xx} = I_{yy} = \frac{1}{2}mr^2 \quad I_{zz} = mr^2$



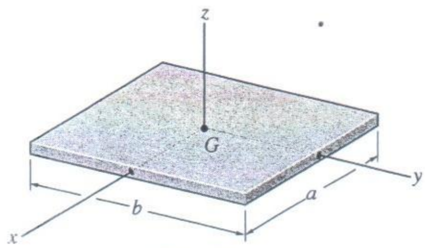
Cylinder

$I_{xx} = I_{yy} = \frac{1}{12}m(3r^2 + h^2) \quad I_{zz} = \frac{1}{2}mr^2$



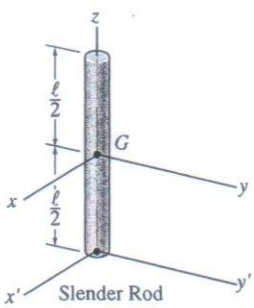
Cone

$I_{xx} = I_{yy} = \frac{3}{80}m(4r^2 + h^2) \quad I_{zz} = \frac{3}{10}mr^2$



Thin plate

$I_{xx} = \frac{1}{12}mb^2 \quad I_{yy} = \frac{1}{12}ma^2 \quad I_{zz} = \frac{1}{12}m(a^2 + b^2)$



Slender Rod

$I_{xx} = I_{yy} = \frac{1}{12}m\ell^2 \quad I_{x'x'} = I_{y'y'} = \frac{1}{3}m\ell^2 \quad I_{z'z'} = 0$

(12)

Program: B. Sc. Engg. (ME/IPE)
Semester: 1st Semester

Date: 13 December, 2022
Time: 10:00 AM – 1:00 PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Final Examination
Course Number: Math 4111
Course Title: Modelling with calculus and ODE

Winter Semester: 2021 - 2022
Full Marks: 150
Time : 3 Hours

There are **6 (six)** questions. Answer **all** questions. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets.

1. a) Consider the graph of the function *f* shown in Fig. Q 1(a). Use this graph to find the limit (if it exists) of the followings. If the limit does not exist, explain why. [10] CO1 PO1

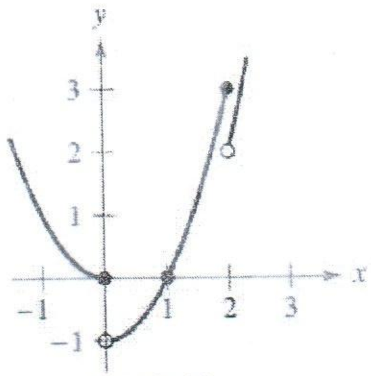


Fig. Q1(a)

$(i)\lim_{x\to 2} f(x)$, $(ii)\lim_{x\to 1} f(x)$, $(iii)\lim_{t\to 0} f(t)$, $(iv)\lim_{t\to -1} f(t)$

b) An airplane is flying on a flight path that will take it directly over a radar tracking station, as shown in Fig. Q 1(b). The distance s is decreasing at a rate of 400 miles per hour when $s = 10$ miles. What is the speed of the plane? [10] CO1 PO2

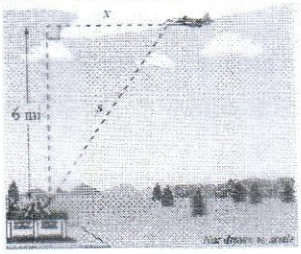


Fig. Q1(b)

2. a) Find the extrema of $f(x) = 2\sin x - \cos 2x$ on the interval [0, 2π] and the intervals for which *f(x)* is increasing or decreasing. 15 CO1 PO1

b) Analyze and sketch a graph of the following function *f(x)*. Label any intercepts, relative extrema, points of inflection, and asymptotes. [15] CO1 PO2

$$y = f(x) = \frac{x+1}{x^2 - 4}$$

3 a) A manufacturer wants to design an open box having a square base and a surface area of 108 square inches, as shown in Fig. 3(a). What dimensions will produce a box with maximum volume? [10] CO1 PO2

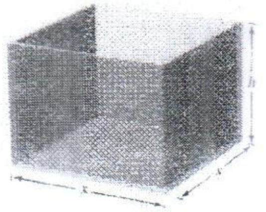


Fig. Q3(a)

b) Find the upper and lower sums for the region bounded by the graph of $f(x) = 9 - x^2$ and the x-axis between $x = 0$ and $x = 2$. [15] CO2 PO1

4. a) Find the volume of the solid formed by revolving the region bounded by the graphs of $y = \sqrt{x}$, and $y = x^2$ about the x-axis. [10] CO2 PO1

b) Determine the order, degree, of the given differential equation and state whether the equation is linear or nonlinear. [10] CO3 PO1

$$(i)\left(1-y^2\right)\frac{d^2y}{dt^2} + t\frac{dy}{dt} + y = e^t \quad (ii)\frac{d^2y}{dt^2} + \sin(t+y) = \sin t$$

$$(iii) t^2y'' + 4ty' + 2y = 0 \quad (iv) t^2\frac{d^2y}{dt^2} + y\frac{dy}{dt} + 2y = \sin t$$

5. a) Suppose a mouse colony at IUT reproduces at a rate proportional to the current population (p) with a rate constant of 0.5 mice per month (assuming no cats present). Additionally, suppose that cats eat an average of 15 mice every day while there is a cat population. 15 CO3 PO2
   (i) Find the time at which the population becomes extinct if $p(0) = 850$.
   (ii) Find the time of extinction if $p(0) = p_0$, where $0 < p_0 < 900$.
   (iii) Find the initial population p_0 if the population is to become extinct in 1 year.

b) Draw a direction field for the differential equation: $y' = 1 - 2y$, prime (') indicates the order of the differential equation. Based on the direction field, determine the behavior of y as $t \to \infty$. 10 CO3 PO1

6. a) A compound C is formed when two chemicals A and B are combined. The resulting reaction between the two chemicals is such that for each gram of A, 4 grams of B are used. It is observed that 30 grams of the compound C are formed in 10 minutes. Determine the amount of C at time t if the rate of the reaction is proportional to the amounts of A and B remaining and if initially there are 50 grams of A and 32 grams of B. How much of the compound C is present in 15 minutes? Interpret the solution as $t \to \infty$ 15 CO3 PO3

b) Find the solution of the following initial value problem. 15 CO3 PO1

$$y'' + 2y' + 5y = 4e^{-t}\cos(2t),\ y(0) = 1,\ y'(0) = 0$$

The End

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B Sc Eng. ME/IPE/1st Sem.

Date: 15 Dec. 2022
10:00 am - 1:00 pm

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

Semester Final Examination
Course Number: PHY 4113
Course Title: Structure of Matter, Electricity, Magnetism and Modern Physics

Winter Semester: 2021 - 2022
Full Marks: 150
Time: 3 Hours

There are **6 (Six)** questions. Answer **all 6 (Six)** questions. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets.

1. a) What do you understand by Miller indices? Outline the procedure employed in determination of the *h, k* and *l* index numbers? (5) (CO1) (PO1)

b) Explain the crystal structure of NaCl and then calculate its packing fraction to show that it has a comparatively loose structure. Given that $\frac{r_{Na^+}}{r_{Cl^-}} = 0.524$. (15) (CO2) (PO2)

c) Aluminium (atomic weight 27) has a fcc structure. Its density is 2.7×10^3 kg/m^3. Compute the unit cell dimensions and the atomic diameter. (05) (CO3) (PO2)

2. a) What do you understand by the capacitance of a capacitor? How do you define *1 farad (F)* of capacitance? (3+2) (CO1) (PO1)

b) Show that the capacitance of a spherical capacitor is given by, $C = 4\pi\varepsilon_0 \frac{ab}{b-a}$, where the symbols carry usual meanings. What would be the value of capacitance for an isolated sphere? (12+3) (CO2) (PO2)

c) What is the capacitance of a drop that results when two mercury spheres, each of radius $R = 2.00$ *mm*, merge? (05) (CO3) (PO2)

3. a) State and explain Kirchoff's current and voltage rules. (2.5+2.5) (CO1) (PO1)

b) Show that the drift speed of electrons in a conductor is related to the current density by $\vec{v}_d = \frac{1}{ne}\vec{J}$, where the symbols have their usual meanings. (15) (CO2) (PO2)

c) A *10 A* current is flowing through a *12 gauge* copper wire with radius *1.025 mm* and charge carrier (free electrons) density 8.5×10^{28} m^{-3}. Calculate the current density and the drift speed of electrons in the wire. (3+2) (CO3) (PO2)

4. a) What is electromagnetism? Explain the direction of magnetic field when a current is flowing along a conducting wire? (2+3) (CO1) (PO1)

b) Show that the total torque produced on a current carrying loop, immersed in a magnetic field $\vec{B}$, is given by $\vec{\tau} = \vec{\mu}\times\vec{B}$, where the symbols have their usual meanings. What is the vector $\vec{\mu}$ in here and what will be its direction? (10+5) (CO2) (PO2)

c) A circular wire loop of radius *15.0 cm* carries a current of *2.60 A*. It is placed so that the normal to its plane makes an angle of *30°* with a uniform magnetic field of magnitude *12.0 T*. (i) Calculate the magnitude of the magnetic dipole moment of the loop. (ii) What is the magnitude of the torque acting on the loop? (05) (CO3) (PO2)

5. a) State the postulates of special theory of relativity. (05) (CO1) (PO1)

b) Formulate the relativistic equation relating the total energy of a particle to its invariant mass and momentum. (15) (CO2) (PO2)

c) Demonstrate with mathematical argument whether a massless particle can exist or not. (05) (CO3) (PO2)

6. a) Write down the actual experimental observations/results of photoelectric effect. (05) (CO1) (PO1)

b) Discuss Compton's theory to show that $\Delta\lambda = \frac{h}{mc}(1-\cos\varphi)$, where the symbols have their usual meanings. (15) (CO2) (PO2)

c) X-rays of wavelength *10.0 pm* are scattered from a target electron. Compute (i) the wavelength of the x-rays scattered through *45°* and (ii) the maximum wavelength present in the scattered x-rays. (05) (CO3) (PO2)

-: End :-

Name of the Program: B.Sc. in IPE
Semester: 1st

Date: 09 December, 2022
Time: 10:00 am – 01:00 pm

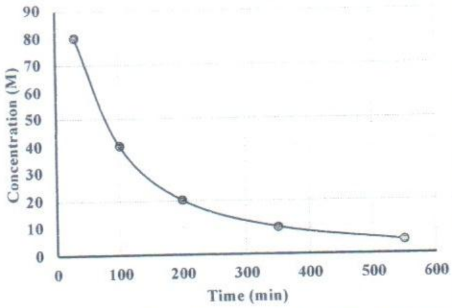
ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course No.: Chem 4115
Course Title: Engineering Chemistry

Winter Semester, A. Y. 2021-2022
Time: 3 Hours
Full Marks: 150

There are **6 (six)** questions. Answer all **6 (six))** questions. The symbols have their usual meanings. Programmable calculators are not allowed. Marks of each question and corresponding COs and POs are written in the brackets.

1.	a)	Determine an equation to calculate the radius of an orbital using Bohr's postulate and show the Bohr's radius. List up the features that can be calculated using Bohr's model.	12 (CO1, PO2)
	b)	Convert the equation of energy of electron to calculate (i) Transition energy from one orbit to other & (ii) Wavelength of spectral lines.	08 (CO1, PO1)
	c)	Applying the equations of energy and radius of orbit of electron in atom calculate the radius of 3rd orbit of H-atom and the emitted energy for $n_{4\ to\ 1}$.	05 (CO1, PO2)
2.	a)	Construct an equation to represent the relation between K_C & K_P for a gaseous reaction and show that K_C can be equal to K_P.	15 (CO2, PO2)
	b)	Write the K_C & K_P for the following equations: (I) $H_2\ (g) + I_2\ (g) \rightleftharpoons 2HI\ (g)$ (II) $CO\ (g) + 3H_2\ (g) \rightleftharpoons CH_4\ (g) + H_2O\ (g)$ (III) $CaCO_3\ (s) \rightleftharpoons CaO\ (s) + CO_2\ (g)$ (IV) $2NH_4Cl\ (s) + CaO\ (s) \rightleftharpoons 2NH_3\ (g) + CaCl_2\ (s) + H_2O\ (l)$ (V) $CH_3COOH\ (aq) + H_2O\ (l) \rightleftharpoons CH_3COO^-\ (aq) + H_3O^+\ (aq)$	05 (CO2, PO1)
	c)	$N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g)$; K_C of the reaction at 500^0 C is $6.0 \times 10^{-2}\ L^2 mol^{-2}$. What will be K_P of the reaction?	05 (CO2, PO1)
3.	a)	Formulate all possible Lewis structures of CO_2 & N_2O and find out the most stable structure with respect to formal charge.	11 (CO1, PO2)
	b)	Explain the molecular geometry of the following molecules according to the VSEPR model: BF_3, SO_2, H_2O, SF_4, PCl_5, IF_5, SF_6.	14 (CO1, PO1)

4.	a)	Identify the order of the reaction from the graph and hence determine an equation for rate constant of such kind of reaction. 	15 (CO2, PO2)
	b)	Examine that half-life of reactions can be inversely proportional and independent on its initial concentration.	10 (CO2, PO1)
5.	a)	Show the electronic configuration of noble gases and write their period number in the periodic table. Write the laws of periodic tables and find out the differences between Mendeleev's law and modern law.	12 (CO1, PO1)
	b)	Define pH. What will be the pH if 0.1 g HCl in 125 mL and 0.2 g H_2SO_4 in 150 mL solution. And, calculate the total number of H^+ ion present in these solutions.	13 (CO2, PO1)
6.	a)	What do you mean by electroplating. Draw an electrolytic cell to describe the coating of Ni on an Iron bar. Write the chemical reactions that take place in the cell.	15 (CO3, PO2)
	b)	Construct the conductance vs volume of NaOH curve for strong acid-strong base and explain it.	10 (CO3, PO2)

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Program: BSc.Eng in IPE
Semester: 1st

Date: 01 December 2022
Time: 10:00 am – 1:00 pm

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

Semester Final Examination
Course No. ME 4151
Course Title: Statics and Dynamics

Winter Semester : 2021-2022
Full Marks : 150
Time : 3 hours

There are **6** (Six) Questions. Answers to all the questions are compulsory. Marks of each question and corresponding CO and PO are written in the brackets.

1) a) For the machine element shown in Fig 1(a), locate the y coordinate of the center of gravity. **(15) (CO1) (PO2, PO3)**

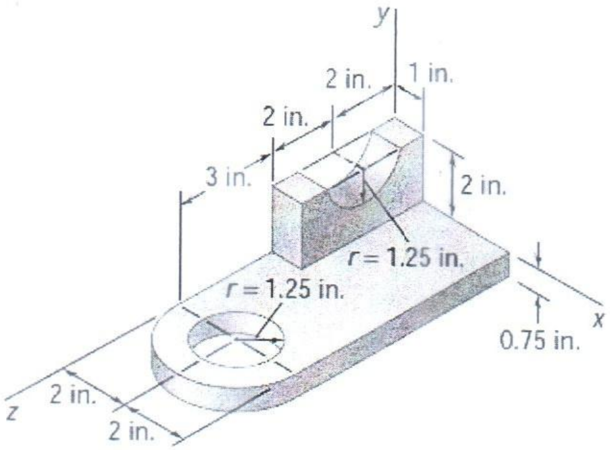

Fig 1(a)

b) Determine the moment of inertia and the radius of gyration of the shaded area as shown in Fig 1(b), with respect to the x axis. **(10) (CO2) (PO2)**

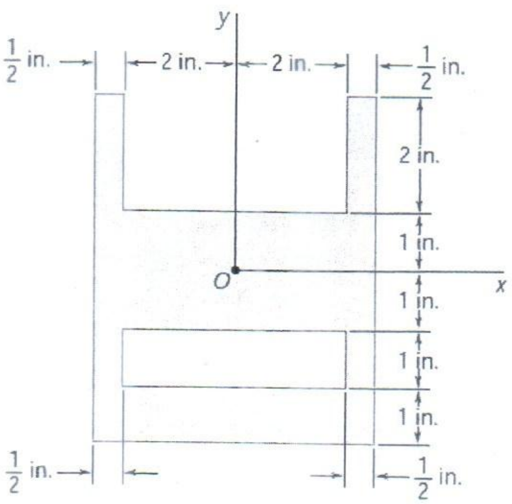

Fig 1(b)

2 a) Given Fig 2(a) is the cross section of a molded flat-belt pulley. Determine its mass moment of inertia with respect to the axis *AA'*. (The density of brass is 8650 kg/m^3 and the density of the fiber-reinforced polycarbonate used is 1250 kg/m^3.) **(18) (CO1) (PO1, PO2)**

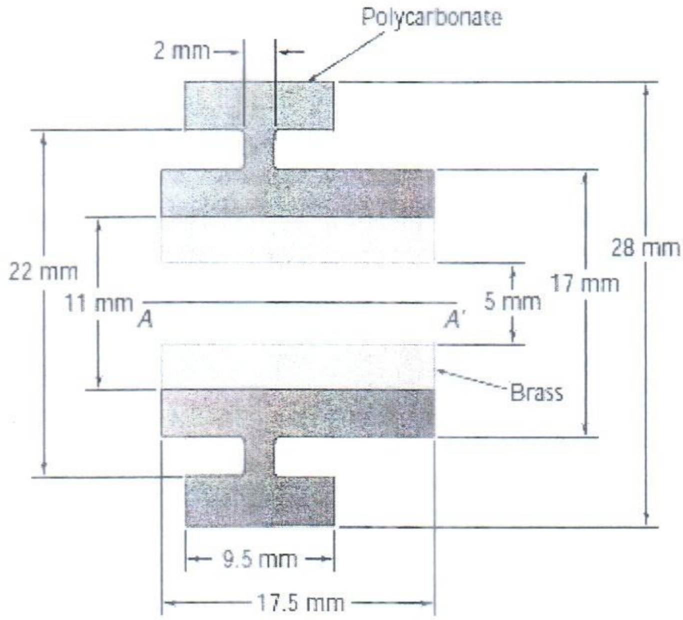

Fig 2(b)

b) Locate the centroid of the plane area shown in Fig 2(b). **(07) (CO2) (PO2)**

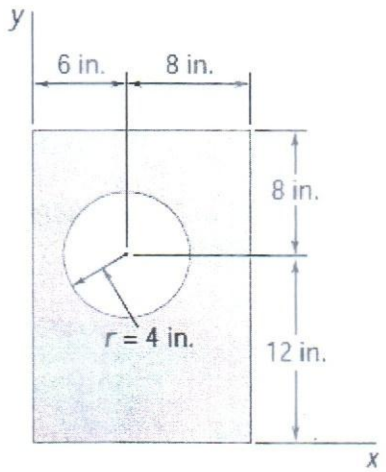

Fig 2(b)

3 a) Block B starts from rest and moves downward with a constant acceleration. Knowing that after slider block A has moved 9 in and its velocity is 6 ft/s, as shown in Fig 3(a). **(10) (CO3) (PO2)**

Determine- (a) the accelerations of A and B,

(b) the velocity of B after 2 s.

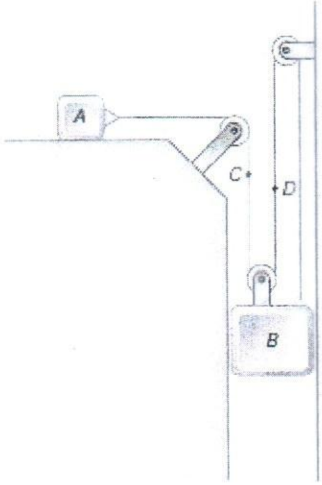

Fig 3(a)

b) The 15-kg block B is supported by the 25-kg block A and is attached to a cord to which a 225-N horizontal force is applied as shown in Fig 3(b). Neglecting friction, determine- (a) the acceleration of block A, **(15) (CO3) (PO2)**

(b) the acceleration of block B relative to A.

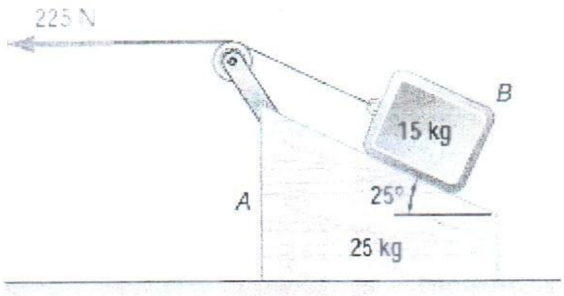

Fig 3(b)

4 A section of track for a roller coaster consists of two circular arcs AB and CD joined by a straight portion BC, as shown in Fig 4. The radius of AB is 27 m and the radius of CD is 72 m. The car and its occupants, of total mass 250 kg, reach point A with practically no velocity and then drop freely along the track. Determine the normal force exerted by the track on the car as the car reaches- **(25) (CO3) (PO3)**

(a) point B

(b) Point D.

Ignore air resistance and rolling resistance.

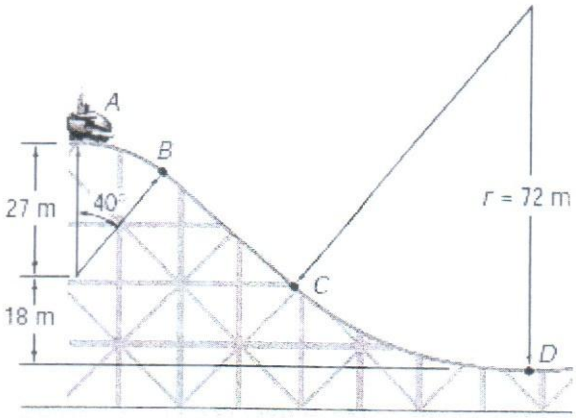

Fig 4

5 a) A 40-lb block *B* is suspended from a 6-ft cord attached to a 60-lb cart *A*, which may roll freely on a frictionless, horizontal track. If the system is released from rest in the position shown in Fig 5(a), when *B* passes directly under *A*, determine the velocities of *A* and *B* **(15) (CO4) (PO2)**

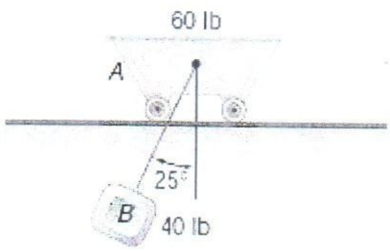

Fig 5(a)

b) A 2-kg collar is attached to a spring and slides without friction in a vertical plane along the curved rod *ABC*, as shown in Fig 5(b). The spring is undeformed when the collar is at *C* and its constant is 600 N/m. If the collar is released at *A* with no initial velocity, determine its velocity - as it passes through *B*. **(10) (CO4) (PO2)**

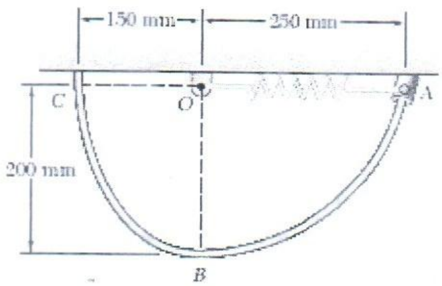

Fig 5(b)

6 a) Knowing that at the instant shown in Fig 6(a), the angular velocity of rod *DE* is 2.4 rad/s clockwise, determine (*a*) the velocity of collar *A*, (*b*) the velocity of point *B*. **(18) (CO4) (PO3)**

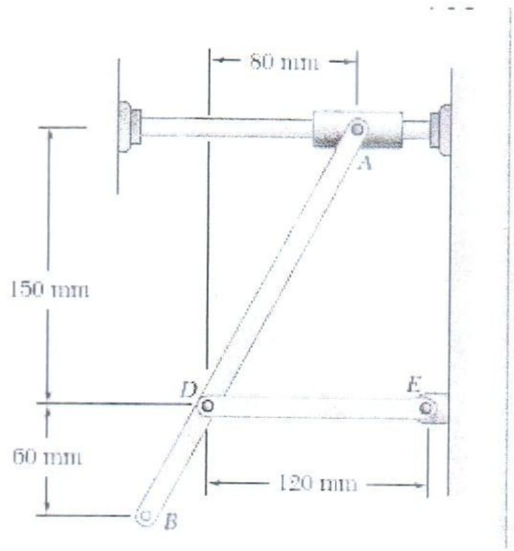

Fig 6(a)

b) The rotation of rod *OA* about *O*, as shown in Fig 6(b), is defined by the relation $\theta = t^3 - 4t$, where θ and t are expressed in radians and seconds, respectively. Collar *B* slides along the rod so that its distance from *O* is $r = 2.5t^3 - 5t^2$, where *r* and *t* are expressed in inches and seconds, respectively. When $t = 1$ s, determine - (*a*) the velocity of the collar, (*b*) the acceleration of the collar. **(7) (CO3) (PO2)**

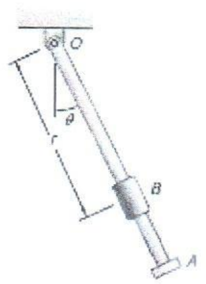

Fig 6(b)

Program: B.Sc.Engg. (IPE)
Semster: 3rd Semester

Date: 30 November 2022
Time: 10:00 AM-1:00 PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

FINAL SEMESTER EXAMINATION
IPE-4303 Manufacturing Process I

WINTER SEMESTER: 2021-2022
TIME: 3 HRS
FULL MARKS: 150

There are 6 (Six) questions. Answer all Questions. Marks in the Margin indicate full marks

01. (a) Write down the differences between thermosetting and thermoplastics. List the different types of thermoplastics and thermoplastics with their properties. (6+7) (CO1, PO1)

(b) If different types of packaging items like trays, dishes, toys need to be manufactured from plastics which process need to be recommended and hence explain with the necessary diagram the process description of recommended manufacturing technique. (12), (CO3, PO2)

02. (a) Explain the following welding processes with schematic illustrations.
    (i) Plasma Arc Welding Processes
    (ii) Gas Metal Arc Welding Processes. (6+6), (CO2, PO1)

(b) Define 'Resistance welding' and hence write down the differences between Resistance spot welding and Resistance seam welding processes. (5+8), (CO3, PO2)

03. (a) Explain the different types of components that will be required for defect free casting process with necessary diagram and hence discuss the different types of patterns available for making the mold cavity. (6+6), (CO2, PO1)

(b) Explain briefly with necessary diagram the different types of casting defects that may occurred in casting process with possible causes and remedies. (13), (CO2, PO4)

04. (a) Define the term drawing operation and hence explain in details the different processes with illustration and results for the fabrication of a sheet metal can. (13), (CO3, PO5)

(b) Explain the term forging. Explain the different steps involvement in open die forging and hence discuss the forging force calculation method. (5+7), (CO3, PO3)

05. (a) Explain with simplified flow chart the powder metallurgy process for the fabrication of powder metallurgy products. (12), (CO2, PO1)

(b) Discuss the finishing operations requirement in different machined products. List the different finishing operations and hence explain the lapping and honing processes with necessary diagram. (5+8), (CO2, PO1)

06. (a) In a sand-casting process, the molten metal is poured into the down sprue at a constant flow rate during the time it takes to fill the mold and at the end of pouring the sprue is filled with molten metal having negligible metal in the pouring cup. Different dimension and conditions for the casting process are furnished below:

Down sprue	Length=6 in Cross-sectional area at the top 0.8 in^2 and at the base 0.6 in^2.
Runner	Cross-sectional area leading from the sprue=0.6 in^2 Length before leading into mold cavity =8 in
Mold cavity	Volume=65 in^3
Riser volume	25 in^3
Total Filling time	3 sec

Total filling time is more than theoretical time required which indicates the loss of velocity due to friction in the sprue and runner. Calculate the following parameters.

(i) Theoretical velocity and flow rate at the base of the down sprue.
(ii) Total volume of the mold
(iii) Actual velocity and flow rate at the base of the sprue.
(iv) Head loss in the gating system due to friction.

(15) (CO3, PO4)

(b) Explain the Aspiration effect in casting and suggest prevention methods to remove impurities and turbulence in casting process. (3+7), (CO1, PO2)

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B.Sc. (ME) / 3rd Semester
DTE / 1st Semester

Date: 30th November 2022
(Group A)

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

Semester Final Examination — **Winter Semester:** 2021 – 2022
Course Number: ME 4305 — **Full Marks:** 150
Course Title: Basic Thermodynamics — **Time:** 3 Hours

There are **6 (Six)** questions. Answer **all** the questions. Marks of each question and corresponding COs/POs are written inside the square brackets. The symbols have their usual meanings. Assume any missing data if necessary.

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1. **(a)** Define the following terms from the context of classical thermodynamics: **[3]** [CO1] [PO1]
(i) Thermal energy reservoirs.
(ii) Kelvin–Planck Statement.
(iii) 3rd law of thermodynamics.

(b) Write a short note on the following topics: **[10]** [CO1] [PO2]
(i) Tds relations.
(ii) Carnot refrigeration cycle.

(c) Derive the energy balance equations for the following steady-flow devices: **[12]** [CO1] [PO1]
(i) Nozzle.
(ii) Turbine.
(iii) Throttling Valve.
Draw schematic figures and mention necessary assumptions.

2. **(a)** Stainless steel ball bearings (ρ = 8085 kg/m^3 and c_p = 0.480 kJ/kg.°C) having a diameter of 1.2 cm are to be quenched in water at a rate of 800 per minute. The balls leave the oven at a uniform temperature of 900°C and are exposed to air at 25°C for a while before they are dropped into the water. If the temperature of the balls drops to 850°C prior to quenching, determine the rate of heat transfer from the balls to the air. **[7]** [CO2] [PO2]

(b) An adiabatic compressor compresses air from 95 kPa and 27°C to 600 kPa and 277°C. Assuming variable specific heats and neglecting the changes in kinetic and potential energies, determine **[10]** [CO2] [PO2]
(i) the isentropic efficiency of the compressor and
(ii) the exit temperature of air if the process were reversible.

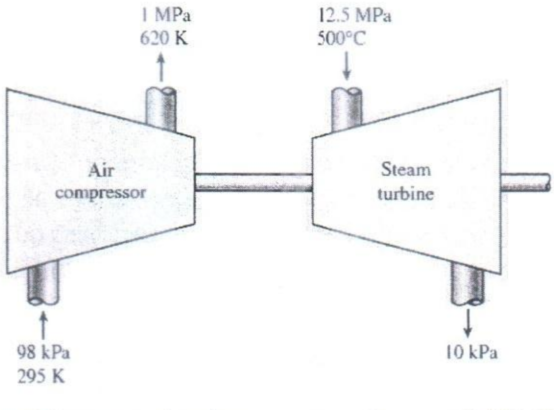
(c) An adiabatic gas turbine expands air at 1300 kPa and 500°C to 100 kPa and 127°C. Air enters the turbine through a 0.2 m^2 opening with an average velocity of 40 m/s and exhausts through a 1 m^2 opening. Determine **[13]** [CO2] [PO2]
(i) the mass flow rate of air through the turbine and
(ii) the power produced by the turbine. Consider c_p = 1.048 kJ/kg·K and R = 0.287 kPa.m^3/kg.K.

3. **(a)** In steam power plants, open feedwater heaters are frequently utilized to heat the feedwater by mixing it with steam bled off the turbine at some intermediate stage. Consider an open feedwater heater that operates at a **[10]** [CO2] [PO3] pressure of 1000 kPa. Feedwater at 50°C and 1000 kPa is to be heated with superheated steam at 200°C and 1000 kPa. In an ideal feedwater heater, the mixture leaves the heater as a saturated liquid at the feedwater pressure. Determine the ratio of the mass flow rates of the feedwater and the superheated vapor for this case.

(b) Hot exhaust gases of an internal combustion engine are to be used to produce saturated water vapor at 2 MPa pressure. The exhaust gases enter the heat exchanger at 400°C at a rate of 32 kg/min while water enters at 15°C. The heat exchanger is not well insulated, and it is estimated that 10% of the heat given up by the exhaust gases is lost to the surroundings. If the mass flow rate of the exhaust gases is 15 times that of the water, determine **[15]** [CO2] [PO2]
(i) the temperature of the exhaust gases at the heat exchanger exit and
(ii) the heat transfer rate to the water. Consider c_p = 1.045 kJ/kg·K.

4. **(a)** Steam enters an adiabatic turbine at 8 MPa and 500°C with a mass flow rate of 3 kg/s and leaves at 30 kPa. The isentropic efficiency of the turbine is 90%. Neglecting the kinetic energy change of the steam, determine **[13]** [CO2] [PO2]
(i) the temperature at the turbine exit and
(ii) the power output of the turbine.

(b) An adiabatic air compressor is to be powered by a direct-coupled adiabatic steam turbine that is also driving a generator. Steam enters the turbine at 12.5 MPa and 500°C at a rate of 25 kg/s and exits at 10 kPa and a quality of 0.92. Air enters the compressor at 98 kPa and 295 K at a rate of 10 kg/s and exits at 1 MPa and 620 K. Determine the net power delivered to the generator by the turbine. **[12]** [CO2] [PO3]



5. **(a)** A household refrigerator that has a power input of 450 W and a COP of 1.5 is to cool 5 large watermelons, 10 kg each, to 8°C. If the watermelons are initially at 28°C, determine how long it will take for the refrigerator to cool them. The watermelons can be treated as water whose specific heat is 4.2 kJ/kg·°C. Is your answer realistic or optimistic? Explain. **[5]** [CO3] [PO1]

(b) During an experiment conducted in a room at 25°C, a laboratory assistant measures that a refrigerator that draws 2 kW of power has removed 30,000 kJ of heat from the refrigerated space, which is maintained at –30°C. The running time of the refrigerator during the experiment was 20 min. Determine if these measurements are reasonable. **[5]** [CO3] [PO4]

(c) A heat pump is used to maintain a house at 25°C by extracting heat from the outside air on a day when the outside air temperature is 4°C. The house is **[5]** [CO3] estimated to lose heat at a rate of 110,000 kJ/h, and the heat pump consumes 4.75 kW of electric power when running. Is this heat pump powerful enough to do the job? [PO4]

(d) In a steam power plant, an engineer proposed to heat the steam by resistance heaters placed inside the boiler instead of by the energy supplied from fossil or nuclear fuels. Part of the electricity generated by the plant is to be used to power the resistors as well as the pump. The rest of the electric energy is to be supplied to the electric grid as the net work output. The engineer claims that once the system is started, this power plant will produce electricity indefinitely without requiring any energy input from the outside. Do you agree with this claim? Explain. **[10]** [CO3] [PO4]

6. **(a)** Draw schematic diagrams of a steam power plant and a refrigeration system showing all heat and work interactions, and briefly describe each associated component's function. For the refrigeration system, show typical operating conditions in the diagram. **[12]** [CO4] [PO1]

(b) Briefly describe the working principle of a Heat Pump with a schematic diagram. Show that $COP_{HP} = COP_R + 1$ when both the heat pump and the refrigerator have the same Q_L and Q_H values. Distinguish between air-source and ground-source heat pumps. **[8]** [CO4] [PO1]

TABLE A–5

Saturated water—Pressure table

		Specific volume, m³/kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg·K		
Press., *P* kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	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–5

Saturated water—Pressure table (*Concluded*)

		Specific volume, m^3/kg		*Internal energy,* kJ/kg			*Enthalpy,* kJ/kg			*Entropy,* kJ/kg·K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	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-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

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 = 0.20 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

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 0.50 MPa (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	7.1833	0.29321	2715.9	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 (*Concluded*)

T °C	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K
	P = 1.00 MPa (179.88°C)				*P* = 1.20 MPa (187.96°C)				*P* = 1.40 MPa (195.04°C)			
Sat.	0.19437	2582.8	2777.1	6.5850	0.16326	2587.8	2783.8	6.5217	0.14078	2591.8	2788.9	6.4675
200	0.20602	2622.3	2828.3	6.6956	0.16934	2612.9	2816.1	6.5909	0.14303	2602.7	2803.0	6.4975
250	0.23275	2710.4	2943.1	6.9265	0.19241	2704.7	2935.6	6.8313	0.16356	2698.9	2927.9	6.7488
300	0.25799	2793.7	3051.6	7.1246	0.21386	2789.7	3046.3	7.0335	0.18233	2785.7	3040.9	6.9553
350	0.28250	2875.7	3158.2	7.3029	0.23455	2872.7	3154.2	7.2139	0.20029	2869.7	3150.1	7.1379
400	0.30661	2957.9	3264.5	7.4670	0.25482	2955.5	3261.3	7.3793	0.21782	2953.1	3258.1	7.3046
500	0.35411	3125.0	3479.1	7.7642	0.29464	3123.4	3477.0	7.6779	0.25216	3121.8	3474.8	7.6047
600	0.40111	3297.5	3698.6	8.0311	0.33395	3296.3	3697.0	7.9456	0.28597	3295.1	3695.5	7.8730
700	0.44783	3476.3	3924.1	8.2755	0.37297	3475.3	3922.9	8.1904	0.31951	3474.4	3921.7	8.1183
800	0.49438	3661.7	4156.1	8.5024	0.41184	3661.0	4155.2	8.4176	0.35288	3660.3	4154.3	8.3458
900	0.54083	3853.9	4394.8	8.7150	0.45059	3853.3	4394.0	8.6303	0.38614	3852.7	4393.3	8.5587
1000	0.58721	4052.7	4640.0	8.9155	0.48928	4052.2	4639.4	8.8310	0.41933	4051.7	4638.8	8.7595
1100	0.63354	4257.9	4891.4	9.1057	0.52792	4257.5	4891.0	9.0212	0.45247	4257.0	4890.5	8.9497
1200	0.67983	4469.0	5148.9	9.2866	0.56652	4468.7	5148.5	9.2022	0.48558	4468.3	5148.1	9.1308
1300	0.72610	4685.8	5411.9	9.4593	0.60509	4685.5	5411.6	9.3750	0.51866	4685.1	5411.3	9.3036
	P = 1.60 MPa (201.37°C)				*P* = 1.80 MPa (207.11°C)				*P* = 2.00 MPa (212.38°C)			
Sat.	0.12374	2594.8	2792.8	6.4200	0.11037	2597.3	2795.9	6.3775	0.09959	2599.1	2798.3	6.3390
225	0.13293	2645.1	2857.8	6.5537	0.11678	2637.0	2847.2	6.4825	0.10381	2628.5	2836.1	6.4160
250	0.14190	2692.9	2919.9	6.6753	0.12502	2686.7	2911.7	6.6088	0.11150	2680.3	2903.3	6.5475
300	0.15866	2781.6	3035.4	6.8864	0.14025	2777.4	3029.9	6.8246	0.12551	2773.2	3024.2	6.7684
350	0.17459	2866.6	3146.0	7.0713	0.15460	2863.6	3141.9	7.0120	0.13860	2860.5	3137.7	6.9583
400	0.19007	2950.8	3254.9	7.2394	0.16849	2948.3	3251.6	7.1814	0.15122	2945.9	3248.4	7.1292
500	0.22029	3120.1	3472.6	7.5410	0.19551	3118.5	3470.4	7.4845	0.17568	3116.9	3468.3	7.4337
600	0.24999	3293.9	3693.9	7.8101	0.22200	3292.7	3692.3	7.7543	0.19962	3291.5	3690.7	7.7043
700	0.27941	3473.5	3920.5	8.0558	0.24822	3472.6	3919.4	8.0005	0.22326	3471.7	3918.2	7.9509
800	0.30865	3659.5	4153.4	8.2834	0.27426	3658.8	4152.4	8.2284	0.24674	3658.0	4151.5	8.1791
900	0.33780	3852.1	4392.6	8.4965	0.30020	3851.5	4391.9	8.4417	0.27012	3850.9	4391.1	8.3925
1000	0.36687	4051.2	4638.2	8.6974	0.32606	4050.7	4637.6	8.6427	0.29342	4050.2	4637.1	8.5936
1100	0.39589	4256.6	4890.0	8.8878	0.35188	4256.2	4889.6	8.8331	0.31667	4255.7	4889.1	8.7842
1200	0.42488	4467.9	5147.7	9.0689	0.37766	4467.6	5147.3	9.0143	0.33989	4467.2	5147.0	8.9654
1300	0.45383	4684.8	5410.9	9.2418	0.40341	4684.5	5410.6	9.1872	0.36308	4684.2	5410.3	9.1384
	P = 2.50 MPa (223.95°C)				*P* = 3.00 MPa (233.85°C)				*P* = 3.50 MPa (242.56°C)			
Sat.	0.07995	2602.1	2801.9	6.2558	0.06667	2603.2	2803.2	6.1856	0.05706	2603.0	2802.7	6.1244
225	0.08026	2604.8	2805.5	6.2629								
250	0.08705	2663.3	2880.9	6.4107	0.07063	2644.7	2856.5	6.2893	0.05876	2624.0	2829.7	6.1764
300	0.09894	2762.2	3009.6	6.6459	0.08118	2750.8	2994.3	6.5412	0.06845	2738.8	2978.4	6.4484
350	0.10979	2852.5	3127.0	6.8424	0.09056	2844.4	3116.1	6.7450	0.07680	2836.0	3104.9	6.6601
400	0.12012	2939.8	3240.1	7.0170	0.09938	2933.6	3231.7	6.9235	0.08456	2927.2	3223.2	6.8428
450	0.13015	3026.2	3351.6	7.1768	0.10789	3021.2	3344.9	7.0856	0.09198	3016.1	3338.1	7.0074
500	0.13999	3112.8	3462.8	7.3254	0.11620	3108.6	3457.2	7.2359	0.09919	3104.5	3451.7	7.1593
600	0.15931	3288.5	3686.8	7.5979	0.13245	3285.5	3682.8	7.5103	0.11325	3282.5	3678.9	7.4357
700	0.17835	3469.3	3915.2	7.8455	0.14841	3467.0	3912.2	7.7590	0.12702	3464.7	3909.3	7.6855
800	0.19722	3656.2	4149.2	8.0744	0.16420	3654.3	4146.9	7.9885	0.14061	3652.5	4144.6	7.9156
900	0.21597	3849.4	4389.3	8.2882	0.17988	3847.9	4387.5	8.2028	0.15410	3846.4	4385.7	8.1304
1000	0.23466	4049.0	4635.6	8.4897	0.19549	4047.7	4634.2	8.4045	0.16751	4046.4	4632.7	8.3324
1100	0.25330	4254.7	4887.9	8.6804	0.21105	4253.6	4886.7	8.5955	0.18087	4252.5	4885.6	8.5236
1200	0.27190	4466.3	5146.0	8.8618	0.22658	4465.3	5145.1	8.7771	0.19420	4464.4	5144.1	8.7053
1300	0.29048	4683.4	5409.5	9.0349	0.24207	4682.6	5408.8	8.9502	0.20750	4681.8	5408.0	8.8786

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	0.033524	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
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

TABLE A–6

Superheated water (*Concluded*)

T °C	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K
	P = 15.0 MPa (342.16°C)				*P* = 17.5 MPa (354.67°C)				*P* = 20.0 MPa (365.75°C)			
Sat.	0.010341	2455.7	2610.8	5.3108	0.007932	2390.7	2529.5	5.1435	0.005862	2294.8	2412.1	4.9310
350	0.011481	2520.9	2693.1	5.4438								
400	0.015671	2740.6	2975.7	5.8819	0.012463	2684.3	2902.4	5.7211	0.009950	2617.9	2816.9	5.5526
450	0.018477	2880.8	3157.9	6.1434	0.015204	2845.4	3111.4	6.0212	0.012721	2807.3	3061.7	5.9043
500	0.020828	2998.4	3310.8	6.3480	0.017385	2972.4	3276.7	6.2424	0.014793	2945.3	3241.2	6.1446
550	0.022945	3106.2	3450.4	6.5230	0.019305	3085.8	3423.6	6.4266	0.016571	3064.7	3396.2	6.3390
600	0.024921	3209.3	3583.1	6.6796	0.021073	3192.5	3561.3	6.5890	0.018185	3175.3	3539.0	6.5075
650	0.026804	3310.1	3712.1	6.8233	0.022742	3295.8	3693.8	6.7366	0.019695	3281.4	3675.3	6.6593
700	0.028621	3409.8	3839.1	6.9573	0.024342	3397.5	3823.5	6.8735	0.021134	3385.1	3807.8	6.7991
800	0.032121	3609.3	4091.1	7.2037	0.027405	3599.7	4079.3	7.1237	0.023870	3590.1	4067.5	7.0531
900	0.035503	3811.2	4343.7	7.4288	0.030348	3803.5	4334.6	7.3511	0.026484	3795.7	4325.4	7.2829
1000	0.038808	4017.1	4599.2	7.6378	0.033215	4010.7	4592.0	7.5616	0.029020	4004.3	4584.7	7.4950
1100	0.042062	4227.7	4858.6	7.8339	0.036029	4222.3	4852.8	7.7588	0.031504	4216.9	4847.0	7.6933
1200	0.045279	4443.1	5122.3	8.0192	0.038806	4438.5	5117.6	7.9449	0.033952	4433.8	5112.9	7.8802
1300	0.048469	4663.3	5390.3	8.1952	0.041556	4659.2	5386.5	8.1215	0.036371	4655.2	5382.7	8.0574
	P = 25.0 MPa				*P* = 30.0 MPa				*P* = 35.0 MPa			
375	0.001978	1799.9	1849.4	4.0345	0.001792	1738.1	1791.9	3.9313	0.001701	1702.8	1762.4	3.8724
400	0.006005	2428.5	2578.7	5.1400	0.002798	2068.9	2152.8	4.4758	0.002105	1914.9	1988.6	4.2144
425	0.007886	2607.8	2805.0	5.4708	0.005299	2452.9	2611.8	5.1473	0.003434	2253.3	2373.5	4.7751
450	0.009176	2721.2	2950.6	5.6759	0.006737	2618.9	2821.0	5.4422	0.004957	2497.5	2671.0	5.1946
500	0.011143	2887.3	3165.9	5.9643	0.008691	2824.0	3084.8	5.7956	0.006933	2755.3	2997.9	5.6331
550	0.012736	3020.8	3339.2	6.1816	0.010175	2974.5	3279.7	6.0403	0.008348	2925.8	3218.0	5.9093
600	0.014140	3140.0	3493.5	6.3637	0.011445	3103.4	3446.8	6.2373	0.009523	3065.6	3399.0	6.1229
650	0.015430	3251.9	3637.7	6.5243	0.012590	3221.7	3599.4	6.4074	0.010565	3190.9	3560.7	6.3030
700	0.016643	3359.9	3776.0	6.6702	0.013654	3334.3	3743.9	6.5599	0.011523	3308.3	3711.6	6.4623
800	0.018922	3570.7	4043.8	6.9322	0.015628	3551.2	4020.0	6.8301	0.013278	3531.6	3996.3	6.7409
900	0.021075	3780.2	4307.1	7.1668	0.017473	3764.6	4288.8	7.0695	0.014904	3749.0	4270.6	6.9853
1000	0.023150	3991.5	4570.2	7.3821	0.019240	3978.6	4555.8	7.2880	0.016450	3965.8	4541.5	7.2069
1100	0.025172	4206.1	4835.4	7.5825	0.020954	4195.2	4823.9	7.4906	0.017942	4184.4	4812.4	7.4118
1200	0.027157	4424.6	5103.5	7.7710	0.022630	4415.3	5094.2	7.6807	0.019398	4406.1	5085.0	7.6034
1300	0.029115	4647.2	5375.1	7.9494	0.024279	4639.2	5367.6	7.8602	0.020827	4631.2	5360.2	7.7841
	P = 40.0 MPa				*P* = 50.0 MPa				*P* = 60.0 MPa			
375	0.001641	1677.0	1742.6	3.8290	0.001560	1638.6	1716.6	3.7642	0.001503	1609.7	1699.9	3.7149
400	0.001911	1855.0	1931.4	4.1145	0.001731	1787.8	1874.4	4.0029	0.001633	1745.2	1843.2	3.9317
425	0.002538	2097.5	2199.0	4.5044	0.002009	1960.3	2060.7	4.2746	0.001816	1892.9	2001.8	4.1630
450	0.003692	2364.2	2511.8	4.9449	0.002487	2160.3	2284.7	4.5896	0.002086	2055.1	2180.2	4.4140
500	0.005623	2681.6	2906.5	5.4744	0.003890	2528.1	2722.6	5.1762	0.002952	2393.2	2570.3	4.9356
550	0.006985	2875.1	3154.4	5.7857	0.005118	2769.5	3025.4	5.5563	0.003955	2664.6	2901.9	5.3517
600	0.008089	3026.8	3350.4	6.0170	0.006108	2947.1	3252.6	5.8245	0.004833	2866.8	3156.8	5.6527
650	0.009053	3159.5	3521.6	6.2078	0.006957	3095.6	3443.5	6.0373	0.005591	3031.3	3366.8	5.8867
700	0.009930	3282.0	3679.2	6.3740	0.007717	3228.7	3614.6	6.2179	0.006265	3175.4	3551.3	6.0814
800	0.011521	3511.8	3972.6	6.6613	0.009073	3472.2	3925.8	6.5225	0.007456	3432.6	3880.0	6.4033
900	0.012980	3733.3	4252.5	6.9107	0.010296	3702.0	4216.8	6.7819	0.008519	3670.9	4182.1	6.6725
1000	0.014360	3952.9	4527.3	7.1355	0.011441	3927.4	4499.4	7.0131	0.009504	3902.0	4472.2	6.9099
1100	0.015686	4173.7	4801.1	7.3425	0.012534	4152.2	4778.9	7.2244	0.010439	4130.9	4757.3	7.1255
1200	0.016976	4396.9	5075.9	7.5357	0.013590	4378.6	5058.1	7.4207	0.011339	4360.5	5040.8	7.3248
1300	0.018239	4623.3	5352.8	7.7175	0.014620	4607.5	5338.5	7.6048	0.012213	4591.8	5324.5	7.5111

TABLE A–17

Ideal-gas properties of air

T K	h kJ/kg	P_r	u kJ/kg	v_r	$s°$ kJ/kg·K
200	199.97	0.3363	142.56	1707.0	1.29559
210	209.97	0.3987	149.69	1512.0	1.34444
220	219.97	0.4690	156.82	1346.0	1.39105
230	230.02	0.5477	164.00	1205.0	1.43557
240	240.02	0.6355	171.13	1084.0	1.47824
250	250.05	0.7329	178.28	979.0	1.51917
260	260.09	0.8405	185.45	887.8	1.55848
270	270.11	0.9590	192.60	808.0	1.59634
280	280.13	1.0889	199.75	738.0	1.63279
285	285.14	1.1584	203.33	706.1	1.65055
290	290.16	1.2311	206.91	676.1	1.66802
295	295.17	1.3068	210.49	647.9	1.68515
298	298.18	1.3543	212.64	631.9	1.69528
300	300.19	1.3860	214.07	621.2	1.70203
305	305.22	1.4686	217.67	596.0	1.71865
310	310.24	1.5546	221.25	572.3	1.73498
315	315.27	1.6442	224.85	549.8	1.75106
320	320.29	1.7375	228.42	528.6	1.76690
325	325.31	1.8345	232.02	508.4	1.78249
330	330.34	1.9352	235.61	489.4	1.79783
340	340.42	2.149	242.82	454.1	1.82790
350	350.49	2.379	250.02	422.2	1.85708
360	360.58	2.626	257.24	393.4	1.88543
370	370.67	2.892	264.46	367.2	1.91313
380	380.77	3.176	271.69	343.4	1.94001
390	390.88	3.481	278.93	321.5	1.96633
400	400.98	3.806	286.16	301.6	1.99194
410	411.12	4.153	293.43	283.3	2.01699
420	421.26	4.522	300.69	266.6	2.04142
430	431.43	4.915	307.99	251.1	2.06533
440	441.61	5.332	315.30	236.8	2.08870
450	451.80	5.775	322.62	223.6	2.11161
460	462.02	6.245	329.97	211.4	2.13407
470	472.24	6.742	337.32	200.1	2.15604
480	482.49	7.268	344.70	189.5	2.17760
490	492.74	7.824	352.08	179.7	2.19876
500	503.02	8.411	359.49	170.6	2.21952
510	513.32	9.031	366.92	162.1	2.23993
520	523.63	9.684	374.36	154.1	2.25997
530	533.98	10.37	381.84	146.7	2.27967
540	544.35	11.10	389.34	139.7	2.29906
550	555.74	11.86	396.86	133.1	2.31809
560	565.17	12.66	404.42	127.0	2.33685
570	575.59	13.50	411.97	121.2	2.35531
580	586.04	14.38	419.55	115.7	2.37348
590	596.52	15.31	427.15	110.6	2.39140
600	607.02	16.28	434.78	105.8	2.40902
610	617.53	17.30	442.42	101.2	2.42644
620	628.07	18.36	450.09	96.92	2.44356
630	638.63	19.84	457.78	92.84	2.46048
640	649.22	20.64	465.50	88.99	2.47716
650	659.84	21.86	473.25	85.34	2.49364
660	670.47	23.13	481.01	81.89	2.50985
670	681.14	24.46	488.81	78.61	2.52589
680	691.82	25.85	496.62	75.50	2.54175
690	702.52	27.29	504.45	72.56	2.55731
700	713.27	28.80	512.33	69.76	2.57277
710	724.04	30.38	520.23	67.07	2.58810
720	734.82	32.02	528.14	64.53	2.60319
730	745.62	33.72	536.07	62.13	2.61803
740	756.44	35.50	544.02	59.82	2.63280
750	767.29	37.35	551.99	57.63	2.64737
760	778.18	39.27	560.01	55.54	2.66176
780	800.03	43.35	576.12	51.64	2.69013
800	821.95	47.75	592.30	48.08	2.71787
820	843.98	52.59	608.59	44.84	2.74504
840	866.08	57.60	624.95	41.85	2.77170
860	888.27	63.09	641.40	39.12	2.79783
880	910.56	68.98	657.95	36.61	2.82344
900	932.93	75.29	674.58	34.31	2.84856
920	955.38	82.05	691.28	32.18	2.87324
940	977.92	89.28	708.08	30.22	2.89748
960	1000.55	97.00	725.02	28.40	2.92128
980	1023.25	105.2	741.98	26.73	2.94468
1000	1046.04	114.0	758.94	25.17	2.96770
1020	1068.89	123.4	776.10	23.72	2.99034
1040	1091.85	133.3	793.36	23.29	3.01260
1060	1114.86	143.9	810.62	21.14	3.03449
1080	1137.89	155.2	827.88	19.98	3.05608
1100	1161.07	167.1	845.33	18.896	3.07732
1120	1184.28	179.7	862.79	17.886	3.09825
1140	1207.57	193.1	880.35	16.946	3.11883
1160	1230.92	207.2	897.91	16.064	3.13916
1180	1254.34	222.2	915.57	15.241	3.15916
1200	1277.79	238.0	933.33	14.470	3.17888
1220	1301.31	254.7	951.09	13.747	3.19834
1240	1324.93	272.3	968.95	13.069	3.21751

TABLE A–17

Ideal-gas properties of air (*Concluded*)

T K	*h* kJ/kg	P_r	*u* kJ/kg	v_r	$s°$ kJ/kg·K	*T* K	*h* kJ/kg	P_r	*u* kJ/kg	v_r	$s°$ kJ/kg·K
1260	1348.55	290.8	986.90	12.435	3.23638	1600	1757.57	791.2	1298.30	5.804	3.52364
1280	1372.24	310.4	1004.76	11.835	3.25510	1620	1782.00	834.1	1316.96	5.574	3.53879
1300	1395.97	330.9	1022.82	11.275	3.27345	1640	1806.46	878.9	1335.72	5.355	3.55381
1320	1419.76	352.5	1040.88	10.747	3.29160	1660	1830.96	925.6	1354.48	5.147	3.56867
1340	1443.60	375.3	1058.94	10.247	3.30959	1680	1855.50	974.2	1373.24	4.949	3.58335
1360	1467.49	399.1	1077.10	9.780	3.32724	1700	1880.1	1025	1392.7	4.761	3.5979
1380	1491.44	424.2	1095.26	9.337	3.34474	1750	1941.6	1161	1439.8	4.328	3.6336
1400	1515.42	450.5	1113.52	8.919	3.36200	1800	2003.3	1310	1487.2	3.994	3.6684
1420	1539.44	478.0	1131.77	8.526	3.37901	1850	2065.3	1475	1534.9	3.601	3.7023
1440	1563.51	506.9	1150.13	8.153	3.39586	1900	2127.4	1655	1582.6	3.295	3.7354
1460	1587.63	537.1	1168.49	7.801	3.41247	1950	2189.7	1852	1630.6	3.022	3.7677
1480	1611.79	568.8	1186.95	7.468	3.42892	2000	2252.1	2068	1678.7	2.776	3.7994
1500	1635.97	601.9	1205.41	7.152	3.44516	2050	2314.6	2303	1726.8	2.555	3.8303
1520	1660.23	636.5	1223.87	6.854	3.46120	2100	2377.7	2559	1775.3	2.356	3.8605
1540	1684.51	672.8	1242.43	6.569	3.47712	2150	2440.3	2837	1823.8	2.175	3.8901
1560	1708.82	710.5	1260.99	6.301	3.49276	2200	2503.2	3138	1872.4	2.012	3.9191
1580	1733.17	750.0	1279.65	6.046	3.50829	2250	2566.4	3464	1921.3	1.864	3.9474

Note: The properties P_r (relative pressure) and v_r (relative specific volume) are dimensionless quantities used in the analysis of isentropic processes, and should not be confused with the properties pressure and specific volume.

Source of Data: Kenneth Wark, *Thermodynamics*, 4th ed. (New York: McGraw-Hill, 1983), pp. 785–86, table A–5. Originally published in J. H. Keenan and J. Kaye, *Gas Tables* (New York: John Wiley & Sons, 1948).

36

Name of the Program: B. Sc. (ME/IPE/BScTE)
Semester: 3rd Sem./2Y 1st Sem.

Date: 14 December, 2022
Time: 10:00AM – 1:00PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING (MPE)

Semester Final Examination
Course Code: Math 4311/Math 4599
Course Title: Vector Analysis, Multivariable Calculus and Complex Variables

Winter Semester: A.Y. 2021-2022
Full Marks: 150
Time: 3 Hours

Answer all the questions. Marks of each question and corresponding CO and PO are written in the brackets. The symbols used have their usual meaning.

1.	(a) A rigid body is spinning with an angular velocity of 6 radians per second about an axis of direction $-4\hat{j}+3\hat{k}$ and passes through the point $4\hat{i}+3\hat{j}-2\hat{k}$. Find the linear velocity of the particle at the point $5\hat{i}-3\hat{j}-7\hat{k}$.	[13] CO1 PO1
	(b) Show that the four points $\underline{a}$, $\underline{b}$, $\underline{c}$, $\underline{d}$ are coplanar if $[\underline{b}\ \underline{c}\ \underline{d}]+[\underline{c}\ \underline{a}\ \underline{d}]+[\underline{a}\ \underline{b}\ \underline{d}]=[\underline{a}\ \underline{b}\ \underline{c}]$.	[12] CO1 PO1
2.	(a) Find the work done by the force field $\mathbf{F}(x,y,z)=(x+y)\mathbf{i}+xy\,\mathbf{j}-z^2\,\mathbf{k}$ on a particle that moves along the line segment from $(1, 3, 1)$ to $(2, -1, 4)$.	[13] CO2 PO1
	(b) Use Green's Theorem to evaluate $\oint_C x^2y\,dx - xy^2\,dy$ where C is the boundary of the region in the first quadrant enclosed between the coordinate axes and the circle $x^2+y^2=16$.	[12] CO2 PO1
3.	(a) Use the Divergence Theorem to find the outward flux of the vector field $\mathbf{F}(x,y,z)=x^3\mathbf{i}+y^3\mathbf{j}+z^3\mathbf{k}$ across the surface of the cylindrical solid bounded by $x^2+y^2=4$, $z=0$ and $z=3$.	[13] CO2 PO1
	(b) Use Stokes' theorem to find the work performed by the force field $\mathbf{F}(x,y,z)=x^2\mathbf{i}+4xy^3\mathbf{j}+y^2x\mathbf{k}$ on a particle that traverses the rectangle C in the plane $z=y$.	[12] CO2 PO1
4.	(a) Find all roots of $(-8-8\sqrt{3}\,i)^{\frac{1}{4}}$ in rectangular coordinates and exhibit the distinct roots graphically.	[10] CO3 PO1

	(b) Test the function $$f(z)=\begin{cases}\frac{\lvert z\rvert^2}{z}, & z\neq 0\\ 0, & z=0\end{cases}$$ for continuity and differentiability at $z=0$.	**[15] CO3 PO1/PO2**
5.	(a) Prove that $u(x,y)=x^2-y^2-2xy-2x+3y$ is a harmonic function. Hence find its harmonic conjugate $v(x,y)$ so that $f(z)=u(x,y)+iv(x,y)$ is an analytic function. Also, write $f(z)$ in terms of z.	**[10] CO3 PO1/PO2**
	(b) Evaluate $\int_C \frac{4-3z}{z(z-1)(z-2)}dz$ by Cauchy's integral formula, where $C:\lvert z\rvert=\frac{3}{2}$, taken in the positive sense.	**[8] CO3 PO1/PO2**
	(c) Evaluate $\int_C (x^2-iy^2)dz$ along the straight line from (1,1) to (2,8).	**[7] CO3 PO1/PO2**
6.	(a) Expand $f(z)=\frac{3}{z(2-z-z^2)}$ in a Laurent series valid in the region $1<\lvert z\rvert<2$ and $\lvert z\rvert>2$.	**[8] CO3 PO1/PO2**
	(b) Use Cauchy's residue theorem to evaluate $\int_C \frac{1+z^2}{(z-1)^2(z+2i)}dz$ where C is the circle $\lvert z\rvert=3$.	**(7) CO3 PO1/PO2**
	(c) Evaluate $\int_0^\infty \frac{dx}{1+x^2}$ by using the method of contour integral.	**(10) CO3 PO1/PO2**

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B Sc. Engg. /3rd Sem. (ME) Thursday, 08 December 2022

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

Final Semester Examination
Course No. ME 4325
Course Title: Material Engineering

Winter Semester, A.Y. 2021-2022
Time : 3 hours
Full Marks : 150

There are **06 (Six)** Questions. Answer all of them. Marks in the margin indicate full marks. Do not write on this question paper. Symbols carry their usual meanings. Assume reasonable values for any missing data. Programmable calculators are not allowed.

1	Metals often show the crystal structure of SC, BCC or FCC. Explain why FCC metals are more ductile than BCC metals by calculating their packing density. Though FCC and HCP have similar packing factor, however, HCP is more brittle than FCC structure – defend this statement.	**(25)** (CO3,CO4) (PO3, PO4)
2	Crystal structure of ceramics is often complicated. Radius ratio of Cation to Anion controls the coordination number. With neat sketch explain how a Cation may fit a void within anions at the stability limit. Predict the crystal structures by means of predicting coordination number from different Cation to anion ratios.	**(25)** (CO3,CO4) (PO3, PO4)
3	Properties of polymers are highly controlled by their molecular structure. Structural features of the chain and the arrangement of monomers are very crucial. Explain how chain length and their position results different types of polymers. Design different types of composites where monomers will be arranged in completely different ways.	**(25)** (CO3,CO4) (PO3, PO4)
4	Draw an Iron-iron carbon diagram and label it completely; also identify the compositions for low, medium, and high carbon steel. With neat sketches, distinguish between the microstructures of low and high carbon steel. Rate these two types of steel considering their tensile strength and explain how to predict the strength from their microstructures.	**(25)** (CO3,CO4) (PO3, PO4)
5	Heat treatment is essential to tune mechanical properties of steel. If steel is cooled from austenitic temperature down to room temperature, their strength usually varies with different cooling rate. Link expected strength with microstructure for slow and fast cooling for a 0.25 wt. % carbon steel. Also, provide suitable argument to explain why this link is not valid for hyper-eutectoid steel.	**(25)** (CO3,CO4) (PO3, PO4)
6	Composites are designed to combine materials with the objective of getting a more desirable combination of properties. Matrix plays a crucial role here. Categorize the composites based on matrix types showing their advantages and disadvantages. If a composite is fabricated with aligned long fibers, deduce equations to predict young's modulus, E for the composite in both parallel and perpendicular directions to the fiber alignment direction.	**(25)** (CO3,CO4) (PO3, PO4)

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Program: B. Sc. in Industrial Production and Engineering
Semester: Winter semester

Date: 08 December, 2022

Time: 10:00 am – 01:00 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course Number: ME 4353
Course Title: Thermodynamics and Heat Transfer

Winter Semester: 2021 - 2022
Full Marks: 150
Time: 3.0 Hours

There are **06 (six)** questions. Answer all of the **06 (six)** questions. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets. Mark distribution for each question is not even. Assume any reasonable value for the missing data (Property tables are attached at page – 04)

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1. a) Distinguish between 'macroscopic' and 'microscopic' forms of energy with practical examples. **(05) (CO1) (PO1)**

b) State the "Clausius statement of thermodynamics" and explain it in terms of a common household refrigerator. **(05) (CO1) (PO1)**

c) A gas in a piston–cylinder assembly undergoes an expansion process for which the relationship between pressure and volume is given by $PV^n = C$. The initial pressure is 3.5 bar, the initial volume is 0.15 m^3, and the final volume is 0.3 m^3. Determine the work done for the process in kJ, if (a) $n = 1.7$, (b) $n = 1.0$, and (c) $n = 0$ and show that the work done is maximum for case "c". **(15) (CO1) (PO2)**

2. a) Differentiate between the 'actual valve timing' diagram and the 'theoretical valve diagram' for a 4-stroke petrol engine with the help of neat sketches. **(08) (CO2) (PO1)**

b) Describe the lubrication system of a 4-stroke ICE using a neat flowchart. **(06) (CO2) (PO1)**

c) Define 'SIT' and 'Ignition delay'. Explain the role of 'SIT' in combustion of fuels (e.g., Petrol, Diesel etc.). **(06) (CO2) (PO1)**

3. a) A 2-kW resistance heater wire (see Fig. 1) with thermal conductivity of $k = 20$ W/m·K, a diameter of $D = 4$ mm, and a length of $L = 0.9$ m is used to boil water. If the outer surface temperature of the resistance wire is $T_s = 230°C$ then, **(18) (CO3) (PO2)**

i) Obtain a relation for the variation of temperature inside the cylinder by solving the differential equation.

ii) Determine the temperature at the center of the wire.

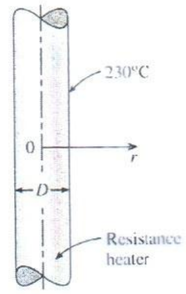


Figure 1: Resistance heater

b) Construct the resistance networking and find the expression for rate of heat transfer for the following cast iron pipe of length L (see Fig. 2). The thermal conductivity for the cast iron pipe and glass wool insulation (covering the pipe) are k_1 and k_2 respectively. **(07) (CO3) (PO2)**

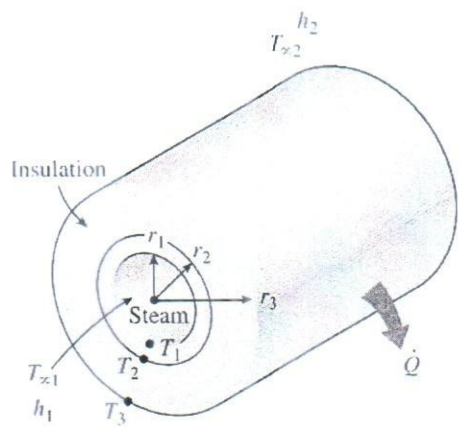


Figure 2: Steam flowing through a cast iron pipe

c) Distinguish among the different modes of heat transfer with practical examples. **(05) (CO3) (PO1)**

4. a) Using necessary assumptions for a "rectangular fin" show that the general differential equation is, **(12) (CO3) (PO1)**

$$\frac{d^2\theta}{dx^2} - m^2\theta = 0.$$

b) Draw the boiling curve and identify the different boiling regimes. Explain why heat transfer rate increases after the "Leidenfrost point". **(08) (CO3) (PO1)**

c) Justify the statement "Dropwise condensation is the preferred mode of condensation in heat transfer applications" with proper explanation. **(05) (CO3) (PO1)**

d) Discuss the characteristics of a "Blackbody". Estimate the values of emissivity and absorptivity for a perfect blackbody. **(05) (CO3) (PO1)**

5. a) A single shell and four tube passes STHX is to be designed to cool 8.7 kg/s ethyl alcohol solution [$C_{p,h}$ = 3840 J/kg°C, tube side] from 75°C to 45°C with cooling water [$C_{p,c}$ = 4180 J/kg°C, shell side] entering at 15°C at a rate of 9.6 kg/s. The overall heat transfer co-efficient is, U = 500 W/m^2°C and length of each tube pass is 4.0 m. The HX involves the use of a 1.2 kW pump and a 1.5 hp pump to circulate the fluids at 7.5h a day and 5 days a week. **(20) (CO4) (PO3)**

Estimate the following,

i) The rate of heat transfer

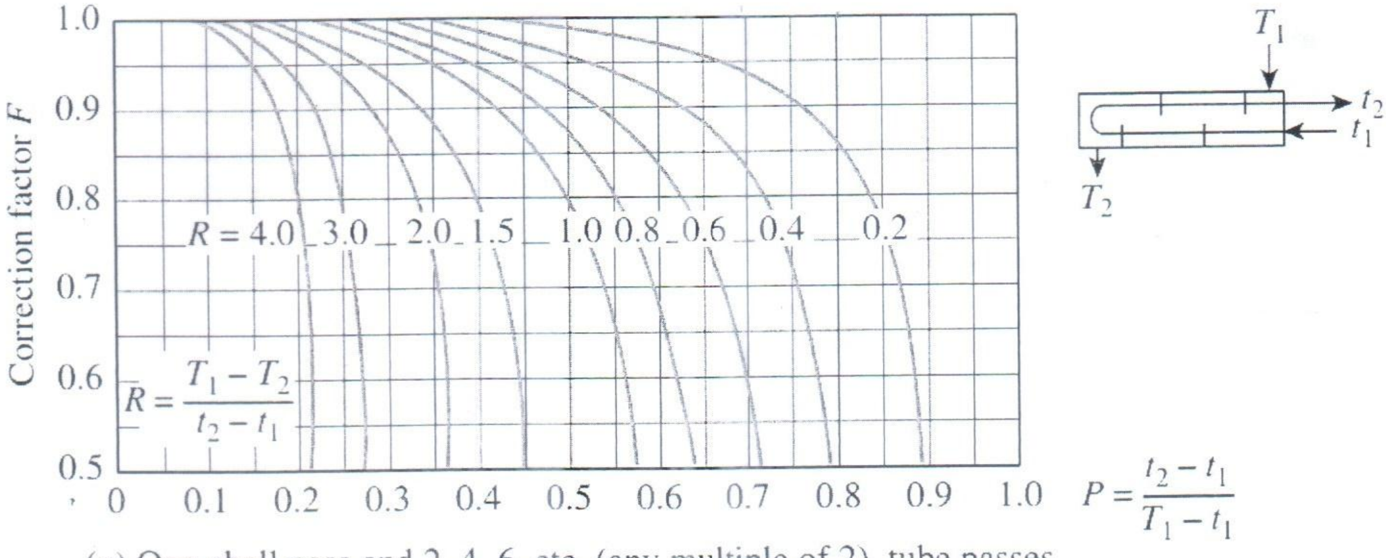
ii) The diameter of the tubes.

iii) The annual operating cost if the cost of electricity is 30 cents/kWh.

b) Differentiate between a 'parallel-flow' and 'counter-flow' DPHX with neat sketch. **(05) (CO4) (PO1)**

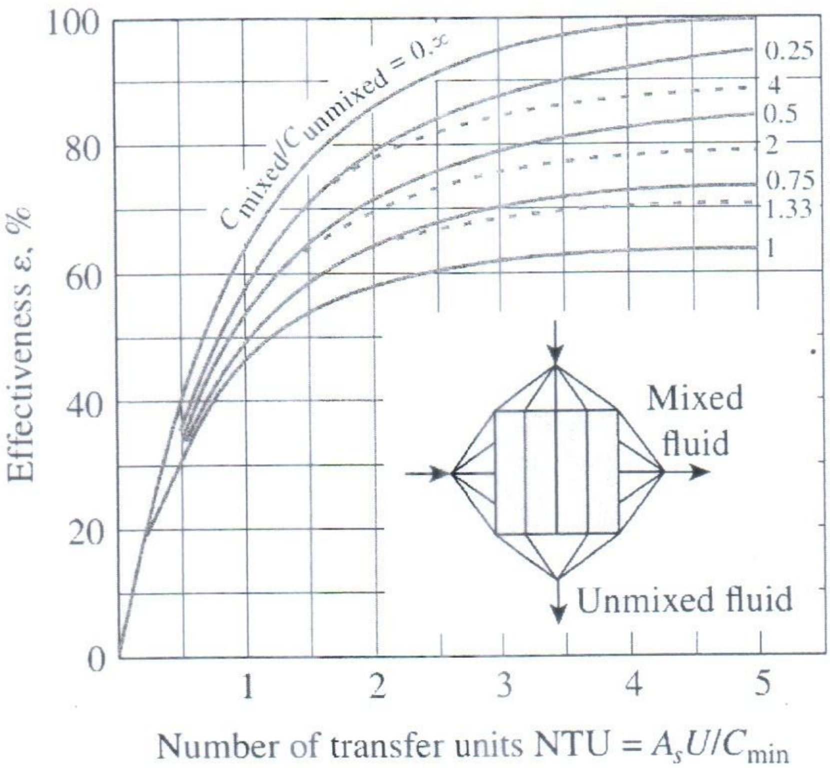
6. a) A cross-flow heat exchanger of area 9.83 m^2, with one fluid mixed and one unmixed, is used to heat an oil ($C_{p,c}$ = 1.93 kJ/kg°C, 15°C) in the tubes. Steam (4.2 kg/s, $C_{p,h}$ = 1.86 kJ/kg°C, 130°C) blows across the outside of the tube. The oil flow rate is 0.7 kg/s, overall heat transfer co-efficient based on surface area is U = 325 W/m^2°C. Rate the HX. **(15) (CO4) (PO2)**

b) Discuss the function of some key components of a water-cooled system in a typical automotive engine. **(05) (CO4) (PO1)**



(*a*) One-shell pass and 2, 4, 6, etc. (any multiple of 2), tube passes

Figure 3. Use of Correction factor, F



(*f*) Cross-flow with one fluid mixed and the other unmixed

Figure 4. ε-NTU method

Program: BBA in TM
Semester: 3rd Sem

Date: 08 December 2022
Time: 10:00 AM-1:00 PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course Code: **MCE 4361**
Course Title: **Mechanical Technology I**

Winter Semester : A.Y. 2021-2022
Time : **03 Hours**
Full Marks : 150

There are 06 (Six) Questions. Answer all of them.

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	**a)**	What is Refrigeration? Describe the Vapour Compression Refrigeration Cycle with the help of necessary P-V, T-S and schematic diagrams.	**10**
	b)	What is a Refrigerant? What are the types of different refrigerants and how the numbering of refrigerants are done?	**10**
	c)	What is ODP and what is the significance of ODP? Compare between refrigerants depending upon the values of their ODP.	**5**
2	**a)**	Explain the basic Vapour Absorption Refrigeration System with the help of necessary diagrams and example. What are the problems associated with Vapour Absorption system?	**12**
	b)	What is Air Conditioning? Compare between different types of Air Conditioning systems.	**7**
	c)	Define any three from below: i) Absolute Humidity ii) Relative Humidity iii) Wet Bulb Temperature iv) Dry Bulb Temperature	**6**
3	**a)**	Define Turbo-machines. Discuss about the classifications of turbo machines.	**5**
	b)	What is a steam turbine? Classify between different types of steam turbines.	**10**
	c)	What is a reaction turbine? Explain the operating principal of a reaction turbine with necessary diagrams and examples. Compare between Reaction and Impulse Turbine.	**10**

4 a) What is a pump? Discuss about different types of positive displacement pumps with necessary examples. 10

b) Describe the working principle of Centrifugal Pump sketching all necessary components. 10

c) What is cavitation? Why does it occur? 5

5 a) Compare between Refrigerator and Heat Pump with necessary diagrams. Develop the expressions for COP in both the systems and establish a mathematical relation. 10

b) Draw the P-V and T-S diagrams of Rankine Cycle and explain how the rankine cycle addresses the impracticalities associated with Carnot Vapour Cycle. 10

c) Describe the Thermo-Siphon Effect with the help of water steam circuit diagram of a boiler. 5

6 a) Explain the working principle of a CI Engine using relevant thermodynamic cycle and necessary valve and piston positions diagrams. 12

b) Write down the merits and demerits of Gaseous Fuels 6

c) What is the Calorific Value of a Fuel? Describe and compare between HCV and LCV 7

45

Program: B. Sc. in Electrical & Electronic Engineering
Semester: 3rd

Date: 7 December, 2022
Time: 10:00 am – 1:00 pm

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

Semester Final Examination
Course Number: MCE 4391
Course Title: Basic Mechanical Engineering (EEE)

Winter Semester: 2021 - 2022
Full Marks: 150
Time: 3 Hours

There are **six** questions. Answer **all the** questions. The symbols have their usual meanings. Marks of each question are mentioned with the questions and corresponding CO and PO and the total marks are written on the right side. Assume reasonable value of missing data.

---

1. a) A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between 0.14 MPa and 0.8 MPa. The mass flow rate of the refrigerant is 0.05 kg/s. **25 (CO2) (PO2)**

(i) Illustrate the system diagram along with P-h diagram. **(3 marks)**
(ii) Enthalpy at all points. **(4 marks)**
(iii) The rate of heat removal from the refrigerated space. **(2 marks)**
(iv) The power input to the compressor. **(2 marks)**
(v) The rate of heat rejection to the environment. **(2 marks)**
(vi) The COP of the refrigerator. **(2 marks)**

b) Explain how refrigeration system is related to the second law of thermodynamics? **(4 marks)**

c) Illustrate the vapor absorption refrigeration system showing different components, and describe its advantage over vapor compression refrigeration system. **(6 marks)**

2. a) (i) Describe the working principle of generating steam inside a steam generator. **(4 marks)** **25 (CO4) (PO1)**

(ii) Identify the essential characteristics of a boiler an engineer should look for, during selection of boiler. **(3 marks)**

b) (i) Illustrate the basic diagram of fire tube and water tube boiler, and show a side-by-side comparison between them. **(5 marks)**

(ii) Drawing a block diagram of a boiler plant, explain the function of any two accessories connected in the system. **(8 marks)**

(iii) Explain briefly, **any two** from the following terms: **(5 marks)**

a. Mountings
b. Water level indicator
c. Man hole

3. a) (i) Describe the no slip condition. **(2 marks)** **25**

(ii) Two water tanks are connected to each other through a mercury manometer with inclined tubes, as shown in **Fig.1**. If the pressure difference between the two tanks is 20 kPa, calculate a and angle theta. **(8 marks)** **(CO5)** **(PO1)** **(PO2)**

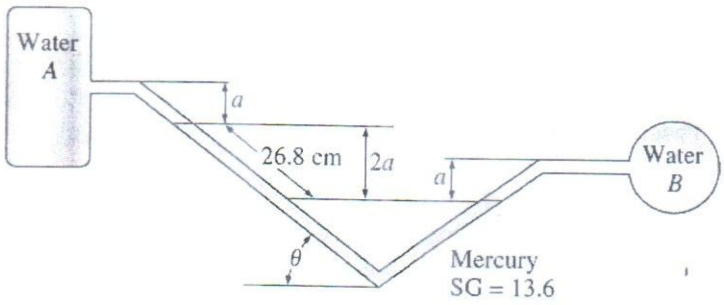


Fig. 1

b) A piezometer and a Pitot tube are tapped into a 4-cm diameter horizontal water pipe, and the height of the water columns are measured to be 26 cm in the piezometer and 35 cm in the Pitot tube (both measured from the top surface of the pipe).

(i) Draw the setup described above. **(4 marks)**

(ii) Determine the velocity at the center of the pipe. **(6 marks)**

c) Illustrate a simple figure of a turbojet engine and explain the mechanism briefly in light of gas turbine cycle. **(5 marks)**

4 a) Illustrate the construction details of an IC engine. **(4 marks)** **25** **(CO3)** **(PO1)**

b) Illustrate the engine terminologies in a single diagram and explain them briefly. **(8 marks)**

c) (i) Illustrate and explain the working principle of a two stroke engine. **(7 marks)**

(ii) Illustrate and explain briefly, **any three** from the following terms: **(6 marks)**

a. Cylinder block and Cylinder liner
b. Piston and Crankcase
c. Connecting Rod and Crankshaft
d. Intake and exhaust valve, Cylinder Head

5 a) (i) Identify the merits and demerits of liquid fuel over solid fuel. **(3 marks)** **25** **(CO1)** **(PO1)** **(PO2)**

(ii) Identify the types of solid fuel (natural) and explain them briefly. **(4 marks)**

b) Define natural gas? Identify the types of gaseous fuels and explain them briefly? **(4 marks)**

c) (i) Illustrate 'Bomb Calorimeter' and explain how to calculate HCV and LCV from using the device. **(6 marks)**

(ii) The following data were recorded during an experiment to find the calorific value of a sample of Bituminous coal.
Mass of coal burnt = 1 g
Mass of water in the calorimeter = 2.5 kg
Water equivalent of the calorimeter = 0.75 kg
Initial temperature of water = 17.5^0C
Final temperature of water = 20^0C
Cooling correction= +0.015⁰C

Determine the higher calorific value of the sample of the coal. If the fuel used contains 4% of hydrogen, calculate its lower calorific value as well. **(5 marks)**

(iii) A sample of Anthracite coal has the following composition by mass: Carbon 91%; hydrogen 3%; oxygen 2%; nitrogen 0.8%; Sulphur 0.8% and remainder is ash.
Calculate its higher and lower calorific values per kg of coal using Dulong's formula. **(3 marks)**

6 a) A steam power plant operates on the **reheat Rankine cycle**. Steam enters the high-pressure turbine at 12.5 MPa and 550^0C at a rate of 7.7 kg/s and leaves at 2 MPa. Steam is then reheated at constant pressure to 450^0C before it expands in the low-pressure (10 kPa) turbine. The isentropic efficiencies of the turbine and the pump are 85 percent and 100 percent, respectively. Steam leaves the condenser as a saturated liquid. If the moisture content of the steam at the exit of the turbine is not to exceed 5 percent. **25** **(CO2)** **(PO2)**

a. Illustrate the system diagram along with T-S diagram. **(4 marks)**
b. Determine the condenser pressure **(3 marks)**
c. Determine the net power output **(3 marks)**
d. Determine the thermal efficiency **(3 marks)**

b) Consider a steam power plant operating on the **ideal Rankine cycle**. Steam enters the turbine at 3 MPa and 350^{0}C and is condensed in the condenser at a pressure of 10 kPa.

(i) Determine the thermal efficiency of this power plant **(3 marks)**

(ii) Determine the thermal efficiency if steam is superheated to 600^{0}C instead of 350^{0}C **(3 marks)**

(iii) Determine the thermal efficiency if the boiler is raised to 15 MPa while the turbine inlet temperature is maintained at 600^{0}C. **(3 marks)**

(iv) Illustrate three T-S diagrams from conditions a,b and c. **(3 marks)**

Saturated Water-Pressure Table

TABLE A–5

Saturated water—Pressure table

		Specific volume, m^3/kg		*Internal energy,* kJ/kg			*Enthalpy,* kJ/kg			*Entropy,* kJ/kg·K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	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

Saturated Water-Pressure Table

TABLE A–5

Saturated water—Pressure table (*Concluded*)

		Specific volume, m^3/kg		*Internal energy,* kJ/kg			*Enthalpy,* kJ/kg			*Entropy,* kJ/kg·K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	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

Superheated Water

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	7.1833	0.29321	2715.9	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.

Superheated Water

TABLE A–6

Superheated water (*Concluded*)

T °C	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K
	P = 1.00 MPa (179.88°C)				*P* = 1.20 MPa (187.96°C)				*P* = 1.40 MPa (195.04°C)			
Sat.	0.19437	2582.8	2777.1	6.5850	0.16326	2587.8	2783.8	6.5217	0.14078	2591.8	2788.9	6.4675
200	0.20602	2622.3	2828.3	6.6956	0.16934	2612.9	2816.1	6.5909	0.14303	2602.7	2803.0	6.4975
250	0.23275	2710.4	2943.1	6.9265	0.19241	2704.7	2935.6	6.8313	0.16356	2698.9	2927.9	6.7488
300	0.25799	2793.7	3051.6	7.1246	0.21386	2789.7	3046.3	7.0335	0.18233	2785.7	3040.9	6.9553
350	0.28250	2875.7	3158.2	7.3029	0.23455	2872.7	3154.2	7.2139	0.20029	2869.7	3150.1	7.1379
400	0.30661	2957.9	3264.5	7.4670	0.25482	2955.5	3261.3	7.3793	0.21782	2953.1	3258.1	7.3046
500	0.35411	3125.0	3479.1	7.7642	0.29464	3123.4	3477.0	7.6779	0.25216	3121.8	3474.8	7.6047
600	0.40111	3297.5	3698.6	8.0311	0.33395	3296.3	3697.0	7.9456	0.28597	3295.1	3695.5	7.8730
700	0.44783	3476.3	3924.1	8.2755	0.37297	3475.3	3922.9	8.1904	0.31951	3474.4	3921.7	8.1183
800	0.49438	3661.7	4156.1	8.5024	0.41184	3661.0	4155.2	8.4176	0.35288	3660.3	4154.3	8.3458
900	0.54083	3853.9	4394.8	8.7150	0.45059	3853.3	4394.0	8.6303	0.38614	3852.7	4393.3	8.5587
1000	0.58721	4052.7	4640.0	8.9155	0.48928	4052.2	4639.4	8.8310	0.41933	4051.7	4638.8	8.7595
1100	0.63354	4257.9	4891.4	9.1057	0.52792	4257.5	4891.0	9.0212	0.45247	4257.0	4890.5	8.9497
1200	0.67983	4469.0	5148.9	9.2866	0.56652	4468.7	5148.5	9.2022	0.48558	4468.3	5148.1	9.1308
1300	0.72610	4685.8	5411.9	9.4593	0.60509	4685.5	5411.6	9.3750	0.51866	4685.1	5411.3	9.3036
	P = 1.60 MPa (201.37°C)				*P* = 1.80 MPa (207.11°C)				*P* = 2.00 MPa (212.38°C)			
Sat.	0.12374	2594.8	2792.8	6.4200	0.11037	2597.3	2795.9	6.3775	0.09959	2599.1	2798.3	6.3390
225	0.13293	2645.1	2857.8	6.5537	0.11678	2637.0	2847.2	6.4825	0.10381	2628.5	2836.1	6.4160
250	0.14190	2692.9	2919.9	6.6753	0.12502	2686.7	2911.7	6.6088	0.11150	2680.3	2903.3	6.5475
300	0.15866	2781.6	3035.4	6.8864	0.14025	2777.4	3029.9	6.8246	0.12551	2773.2	3024.2	6.7684
350	0.17459	2866.6	3146.0	7.0713	0.15460	2863.6	3141.9	7.0120	0.13860	2860.5	3137.7	6.9583
400	0.19007	2950.8	3254.9	7.2394	0.16849	2948.3	3251.6	7.1814	0.15122	2945.9	3248.4	7.1292
500	0.22029	3120.1	3472.6	7.5410	0.19551	3118.5	3470.4	7.4845	0.17568	3116.9	3468.3	7.4337
600	0.24999	3293.9	3693.9	7.8101	0.22200	3292.7	3692.3	7.7543	0.19962	3291.5	3690.7	7.7043
700	0.27941	3473.5	3920.5	8.0558	0.24822	3472.6	3919.4	8.0005	0.22326	3471.7	3918.2	7.9509
800	0.30865	3659.5	4153.4	8.2834	0.27426	3658.8	4152.4	8.2284	0.24674	3658.0	4151.5	8.1791
900	0.33780	3852.1	4392.6	8.4965	0.30020	3851.5	4391.9	8.4417	0.27012	3850.9	4391.1	8.3925
1000	0.36687	4051.2	4638.2	8.6974	0.32606	4050.7	4637.6	8.6427	0.29342	4050.2	4637.1	8.5936
1100	0.39589	4256.6	4890.0	8.8878	0.35188	4256.2	4889.6	8.8331	0.31667	4255.7	4889.1	8.7842
1200	0.42488	4467.9	5147.7	9.0689	0.37766	4467.6	5147.3	9.0143	0.33989	4467.2	5147.0	8.9654
1300	0.45383	4684.8	5410.9	9.2418	0.40341	4684.5	5410.6	9.1872	0.36308	4684.2	5410.3	9.1384
	P = 2.50 MPa (223.95°C)				*P* = 3.00 MPa (233.85°C)				*P* = 3.50 MPa (242.56°C)			
Sat.	0.07995	2602.1	2801.9	6.2558	0.06667	2603.2	2803.2	6.1856	0.05706	2603.0	2802.7	6.1244
225	0.08026	2604.8	2805.5	6.2629								
250	0.08705	2663.3	2880.9	6.4107	0.07063	2644.7	2856.5	6.2893	0.05876	2624.0	2829.7	6.1764
300	0.09894	2762.2	3009.6	6.6459	0.08118	2750.8	2994.3	6.5412	0.06845	2738.8	2978.4	6.4484
350	0.10979	2852.5	3127.0	6.8424	0.09056	2844.4	3116.1	6.7450	0.07680	2836.0	3104.9	6.6601
400	0.12012	2939.8	3240.1	7.0170	0.09938	2933.6	3231.7	6.9235	0.08456	2927.2	3223.2	6.8428
450	0.13015	3026.2	3351.6	7.1768	0.10789	3021.2	3344.9	7.0856	0.09198	3016.1	3338.1	7.0074
500	0.13999	3112.8	3462.8	7.3254	0.11620	3108.6	3457.2	7.2359	0.09919	3104.5	3451.7	7.1593
600	0.15931	3288.5	3686.8	7.5979	0.13245	3285.5	3682.8	7.5103	0.11325	3282.5	3678.9	7.4357
700	0.17835	3469.3	3915.2	7.8455	0.14841	3467.0	3912.2	7.7590	0.12702	3464.7	3909.3	7.6855
800	0.19722	3656.2	4149.2	8.0744	0.16420	3654.3	4146.9	7.9885	0.14061	3652.5	4144.6	7.9156
900	0.21597	3849.4	4389.3	8.2882	0.17988	3847.9	4387.5	8.2028	0.15410	3846.4	4385.7	8.1304
1000	0.23466	4049.0	4635.6	8.4897	0.19549	4047.7	4634.2	8.4045	0.16751	4046.4	4632.7	8.3324
1100	0.25330	4254.7	4887.9	8.6804	0.21105	4253.6	4886.7	8.5955	0.18087	4252.5	4885.6	8.5236
1200	0.27190	4466.3	5146.0	8.8618	0.22658	4465.3	5145.1	8.7771	0.19420	4464.4	5144.1	8.7053
1300	0.29048	4683.4	5409.5	9.0349	0.24207	4682.6	5408.8	8.9502	0.20750	4681.8	5408.0	8.8786

Superheated Water

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	0.033524	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
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

Superheated Water

TABLE A-6

Superheated water (*Concluded*)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 15.0 MPa (342.16°C)				P = 17.5 MPa (354.67°C)				P = 20.0 MPa (365.75°C)			
Sat.	0.010341	2455.7	2610.8	5.3108	0.007932	2390.7	2529.5	5.1435	0.005862	2294.8	2412.1	4.9310
350	0.011481	2520.9	2693.1	5.4438								
400	0.015671	2740.6	2975.7	5.8819	0.012463	2684.3	2902.4	5.7211	0.009950	2617.9	2816.9	5.5526
450	0.018477	2880.8	3157.9	6.1434	0.015204	2845.4	3111.4	6.0212	0.012721	2807.3	3061.7	5.9043
500	0.020828	2998.4	3310.8	6.3480	0.017385	2972.4	3276.7	6.2424	0.014793	2945.3	3241.2	6.1446
550	0.022945	3106.2	3450.4	6.5230	0.019305	3085.8	3423.6	6.4266	0.016571	3064.7	3396.2	6.3390
600	0.024921	3209.3	3583.1	6.6796	0.021073	3192.5	3561.3	6.5890	0.018185	3175.3	3539.0	6.5075
650	0.026804	3310.1	3712.1	6.8233	0.022742	3295.8	3693.8	6.7366	0.019695	3281.4	3675.3	6.6593
700	0.028621	3409.8	3839.1	6.9573	0.024342	3397.5	3823.5	6.8735	0.021134	3385.1	3807.8	6.7991
800	0.032121	3609.3	4091.1	7.2037	0.027405	3599.7	4079.3	7.1237	0.023870	3590.1	4067.5	7.0531
900	0.035503	3811.2	4343.7	7.4288	0.030348	3803.5	4334.6	7.3511	0.026484	3795.7	4325.4	7.2829
1000	0.038808	4017.1	4599.2	7.6378	0.033215	4010.7	4592.0	7.5616	0.029020	4004.3	4584.7	7.4950
1100	0.042062	4227.7	4858.6	7.8339	0.036029	4222.3	4852.8	7.7588	0.031504	4216.9	4847.0	7.6933
1200	0.045279	4443.1	5122.3	8.0192	0.038806	4438.5	5117.6	7.9449	0.033952	4433.8	5112.9	7.8802
1300	0.048469	4663.3	5390.3	8.1952	0.041556	4659.2	5386.5	8.1215	0.036371	4655.2	5382.7	8.0574
	P = 25.0 MPa				P = 30.0 MPa				P = 35.0 MPa			
375	0.001978	1799.9	1849.4	4.0345	0.001792	1738.1	1791.9	3.9313	0.001701	1702.8	1762.4	3.8724
400	0.006005	2428.5	2578.7	5.1400	0.002798	2068.9	2152.8	4.4758	0.002105	1914.9	1988.6	4.2144
425	0.007886	2607.8	2805.0	5.4708	0.005299	2452.9	2611.8	5.1473	0.003434	2253.3	2373.5	4.7751
450	0.009176	2721.2	2950.6	5.6759	0.006737	2618.9	2821.0	5.4422	0.004957	2497.5	2671.0	5.1946
500	0.011143	2887.3	3165.9	5.9643	0.008691	2824.0	3084.8	5.7956	0.006933	2755.3	2997.9	5.6331
550	0.012736	3020.8	3339.2	6.1816	0.010175	2974.5	3279.7	6.0403	0.008348	2925.8	3218.0	5.9093
600	0.014140	3140.0	3493.5	6.3637	0.011445	3103.4	3446.8	6.2373	0.009523	3065.6	3399.0	6.1229
650	0.015430	3251.9	3637.7	6.5243	0.012590	3221.7	3599.4	6.4074	0.010565	3190.9	3560.7	6.3030
700	0.016643	3359.9	3776.0	6.6702	0.013654	3334.3	3743.9	6.5599	0.011523	3308.3	3711.6	6.4623
800	0.018922	3570.7	4043.8	6.9322	0.015628	3551.2	4020.0	6.8301	0.013278	3531.6	3996.3	6.7409
900	0.021075	3780.2	4307.1	7.1668	0.017473	3764.6	4288.8	7.0695	0.014904	3749.0	4270.6	6.9853
1000	0.023150	3991.5	4570.2	7.3821	0.019240	3978.6	4555.8	7.2880	0.016450	3965.8	4541.5	7.2069
1100	0.025172	4206.1	4835.4	7.5825	0.020954	4195.2	4823.9	7.4906	0.017942	4184.4	4812.4	7.4118
1200	0.027157	4424.6	5103.5	7.7710	0.022630	4415.3	5094.2	7.6807	0.019398	4406.1	5085.0	7.6034
1300	0.029115	4647.2	5375.1	7.9494	0.024279	4639.2	5367.6	7.8602	0.020827	4631.2	5360.2	7.7841
	P = 40.0 MPa				P = 50.0 MPa				P = 60.0 MPa			
375	0.001641	1677.0	1742.6	3.8290	0.001560	1638.6	1716.6	3.7642	0.001503	1609.7	1699.9	3.7149
400	0.001911	1855.0	1931.4	4.1145	0.001731	1787.8	1874.4	4.0029	0.001633	1745.2	1843.2	3.9317
425	0.002538	2097.5	2199.0	4.5044	0.002009	1960.3	2060.7	4.2746	0.001816	1892.9	2001.8	4.1630
450	0.003692	2364.2	2511.8	4.9449	0.002487	2160.3	2284.7	4.5896	0.002086	2055.1	2180.2	4.4140
500	0.005623	2681.6	2906.5	5.4744	0.003890	2528.1	2722.6	5.1762	0.002952	2393.2	2570.3	4.9356
550	0.006985	2875.1	3154.4	5.7857	0.005118	2769.5	3025.4	5.5563	0.003955	2664.6	2901.9	5.3517
600	0.008089	3026.8	3350.4	6.0170	0.006108	2947.1	3252.6	5.8245	0.004833	2866.8	3156.8	5.6527
650	0.009053	3159.5	3521.6	6.2078	0.006957	3095.6	3443.5	6.0373	0.005591	3031.3	3366.8	5.8867
700	0.009930	3282.0	3679.2	6.3740	0.007717	3228.7	3614.6	6.2179	0.006265	3175.4	3551.3	6.0814
800	0.011521	3511.8	3972.6	6.6613	0.009073	3472.2	3925.8	6.5225	0.007456	3432.6	3880.0	6.4033
900	0.012980	3733.3	4252.5	6.9107	0.010296	3702.0	4216.8	6.7819	0.008519	3670.9	4182.1	6.6725
1000	0.014360	3952.9	4527.3	7.1355	0.011441	3927.4	4499.4	7.0131	0.009504	3902.0	4472.2	6.9099
1100	0.015686	4173.7	4801.1	7.3425	0.012534	4152.2	4778.9	7.2244	0.010439	4130.9	4757.3	7.1255
1200	0.016976	4396.9	5075.9	7.5357	0.013590	4378.6	5058.1	7.4207	0.011339	4360.5	5040.8	7.3248
1300	0.018239	4623.3	5352.8	7.7175	0.014620	4607.5	5338.5	7.6048	0.012213	4591.8	5324.5	7.5111

Ideal-gas specific heats of various common gases

Ideal–gas specific heats of various common gases

(a) At 300 K

Gas	Formula	Gas constant, R kJ/kg·K	c_p kJ/kg·K	c_v kJ/kg·K	k
Air	—	0.2870	1.005	0.718	1.400
Argon	Ar	0.2081	0.5203	0.3122	1.667
Butane	C_4H_{10}	0.1433	1.7164	1.5734	1.091
Carbon dioxide	CO_2	0.1889	0.846	0.657	1.289
Carbon monoxide	CO	0.2968	1.040	0.744	1.400
Ethane	C_2H_6	0.2765	1.7662	1.4897	1.186
Ethylene	C_2H_4	0.2964	1.5482	1.2518	1.237
Helium	He	2.0769	5.1926	3.1156	1.667
Hydrogen	H_2	4.1240	14.307	10.183	1.405
Methane	CH_4	0.5182	2.2537	1.7354	1.299
Neon	Ne	0.4119	1.0299	0.6179	1.667
Nitrogen	N_2	0.2968	1.039	0.743	1.400
Octane	C_8H_{18}	0.0729	1.7113	1.6385	1.044
Oxygen	O_2	0.2598	0.918	0.658	1.395
Propane	C_3H_8	0.1885	1.6794	1.4909	1.126
Steam	H_2O	0.4615	1.8723	1.4108	1.327

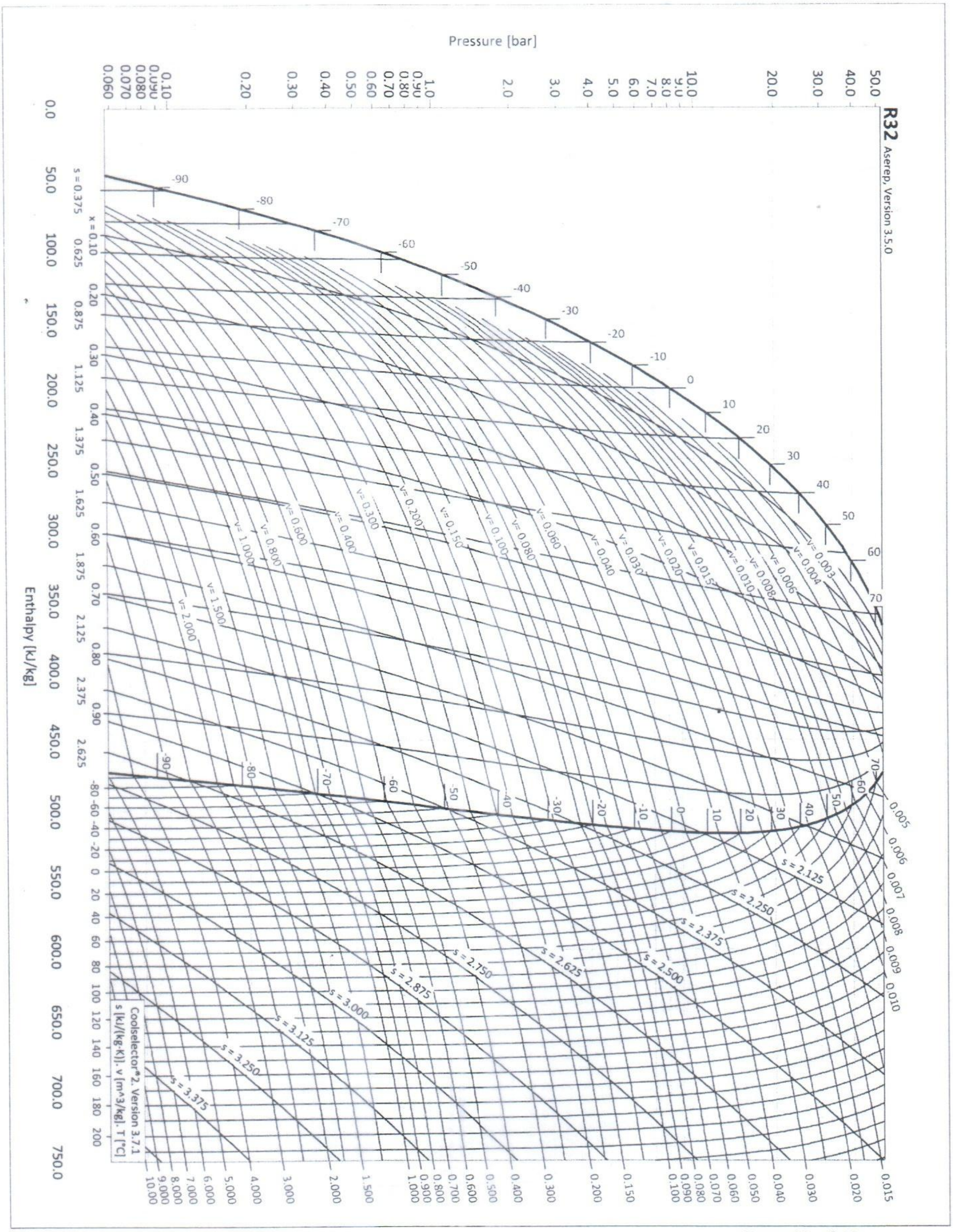
Ideal–gas specific heats of various common gases (*Concluded*)

(c) As a function of temperature

$$\bar{c}_p = a + bT + cT^2 + dT^3$$

(T in K, c_p in kJ/kmol·K)

Substance	Formula	a	b	c	d	Temperature range, K	% error Max.	% error Avg.
Nitrogen	N_2	28.90	-0.1571×10^{-2}	0.8081×10^{-5}	-2.873×10^{-9}	278–1800	0.59	0.34
Oxygen	O_2	25.48	1.520×10^{-2}	-0.7155×10^{-5}	1.312×10^{-9}	273–1800	1.19	0.28
Air	—	28.11	0.1967×10^{-2}	0.4802×10^{-5}	-1.966×10^{-9}	273–1800	0.72	0.33
Hydrogen	H_2	29.11	-0.1916×10^{-2}	0.4003×10^{-5}	-0.8704×10^{-9}	273–1800	1.01	0.26
Carbon monoxide	CO	28.16	0.1675×10^{-2}	0.5372×10^{-5}	-2.222×10^{-9}	273–1800	0.89	0.37
Carbon dioxide	CO_2	22.26	5.981×10^{-2}	-3.501×10^{-5}	7.469×10^{-9}	273–1800	0.67	0.22
Water vapor	H_2O	32.24	0.1923×10^{-2}	1.055×10^{-5}	-3.595×10^{-9}	273–1800	0.53	0.24
Nitric oxide	NO	29.34	-0.09395×10^{-2}	0.9747×10^{-5}	-4.187×10^{-9}	273–1500	0.97	0.36
Nitrous oxide	N_2O	24.11	5.8632×10^{-2}	-3.562×10^{-5}	10.58×10^{-9}	273–1500	0.59	0.26
Nitrogen dioxide	NO_2	22.9	5.715×10^{-2}	-3.52×10^{-5}	7.87×10^{-9}	273–1500	0.46	0.18
Ammonia	NH_3	27.568	2.5630×10^{-2}	0.99072×10^{-5}	-6.6909×10^{-9}	273–1500	0.91	0.36
Sulfur	S_2	27.21	2.218×10^{-2}	-1.628×10^{-5}	3.986×10^{-9}	273–1800	0.99	0.38
Sulfur dioxide	SO_2	25.78	5.795×10^{-2}	-3.812×10^{-5}	8.612×10^{-9}	273–1800	0.45	0.24
Sulfur trioxide	SO_3	16.40	14.58×10^{-2}	-11.20×10^{-5}	32.42×10^{-9}	273–1300	0.29	0.13
Acetylene	C_2H_2	21.8	9.2143×10^{-2}	-6.527×10^{-5}	18.21×10^{-9}	273–1500	1.46	0.59
Benzene	C_6H_6	−36.22	48.475×10^{-2}	-31.57×10^{-5}	77.62×10^{-9}	273–1500	0.34	0.20
Methanol	CH_4O	19.0	9.152×10^{-2}	-1.22×10^{-5}	-8.039×10^{-9}	273–1000	0.18	0.08
Ethanol	C_2H_6O	19.9	20.96×10^{-2}	-10.38×10^{-5}	20.05×10^{-9}	273–1500	0.40	0.22
Hydrogen chloride	HCl	30.33	-0.7620×10^{-2}	1.327×10^{-5}	-4.338×10^{-9}	273–1500	0.22	0.08
Methane	CH_4	19.89	5.024×10^{-2}	1.269×10^{-5}	-11.01×10^{-9}	273–1500	1.33	0.57
Ethane	C_2H_6	6.900	17.27×10^{-2}	-6.406×10^{-5}	7.285×10^{-9}	273–1500	0.83	0.28
Propane	C_3H_8	−4.04	30.48×10^{-2}	-15.72×10^{-5}	31.74×10^{-9}	273–1500	0.40	0.12
n–Butane	C_4H_{10}	3.96	37.15×10^{-2}	-18.34×10^{-5}	35.00×10^{-9}	273–1500	0.54	0.24
i–Butane	C_4H_{10}	−7.913	41.60×10^{-2}	-23.01×10^{-5}	49.91×10^{-9}	273–1500	0.25	0.13
n–Pentane	C_5H_{12}	6.774	45.43×10^{-2}	-22.46×10^{-5}	42.29×10^{-9}	273–1500	0.56	0.21
n–Hexane	C_6H_{14}	6.938	55.22×10^{-2}	-28.65×10^{-5}	57.69×10^{-9}	273–1500	0.72	0.20
Ethylene	C_2H_4	3.95	15.64×10^{-2}	-8.344×10^{-5}	17.67×10^{-9}	273–1500	0.54	0.13
Propylene	C_3H_6	3.15	23.83×10^{-2}	-12.18×10^{-5}	24.62×10^{-9}	273–1500	0.73	0.17


Pressure [bar]
R32 Aserep, Version 3.5.0
Enthalpy [kJ/kg]
Coolselector®2, Version 3.7.1
s [kJ/(kg·K)], v [m^3/kg], T [°C]

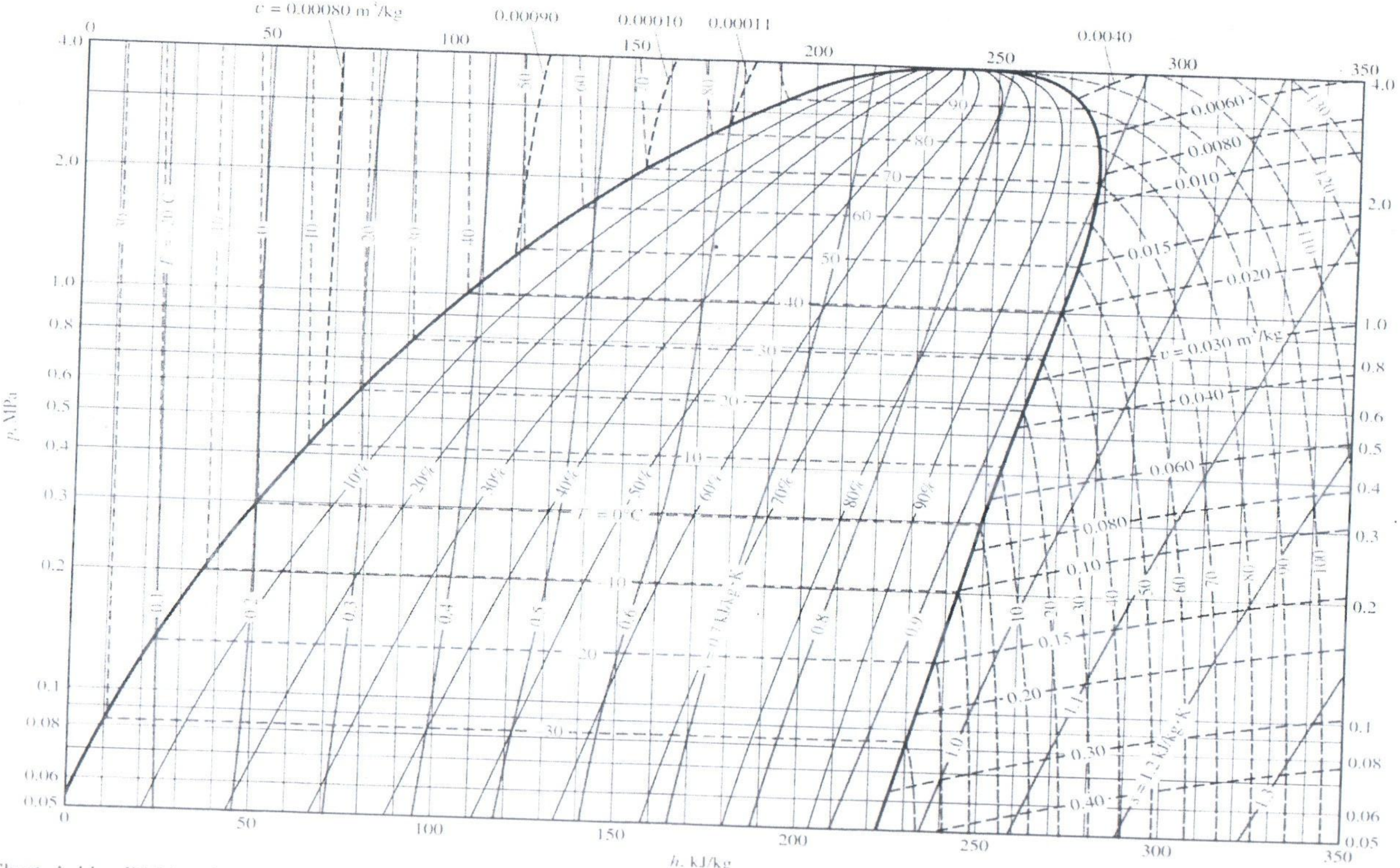


Chart A-11 R134a *ph* diagram. (*Source:* Based on *Thermodynamic Properties of HFC-134a (1,1,1, 2-tetrafluoroethane)*, DuPont Company, Wilmington, Delaware, 1993, with permission.)

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Program: B. Sc. in IPE
Semester: Winter

Date: 12 December, 2022
Time: 10:00 a.m.– 01:00 p.m.

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course Number: ME 4503
Course Title: Mechanics of Machines

Winter Semester: 2021 - 2022
Full Marks:150
Time: 3 Hours

There are 6 (**Six**) questions. Answer **all** of them.

The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets. Assume reasonable value for any missing data. **Use a single graph paper for question no.6**

1. **a.** Determine the mobility of the mechanisms shown in **Figure 1** using Kutzbach equation. State the number of links, higher pairs and lower pairs. Label and number all the links. **(5) (CO1) (PO2)**

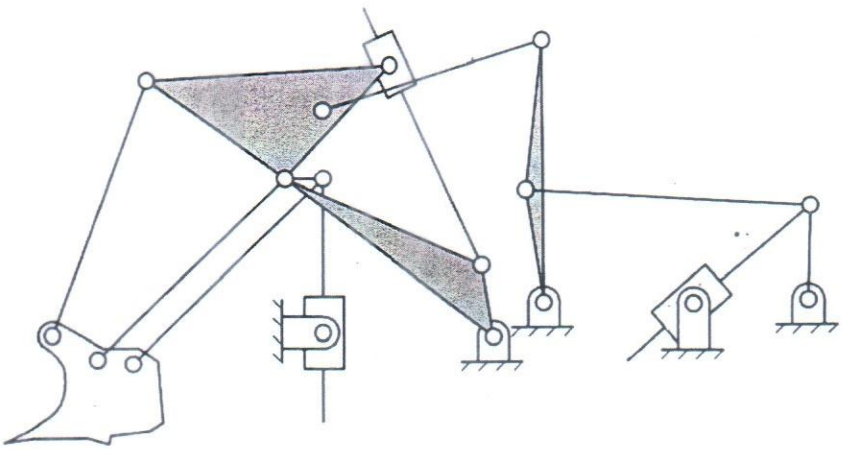

Figure 1

b. The two rotors **A** and **B** are attached to the end of a shaft 500 mm long. The mass of the rotor **A** is 200 kg and its radius of gyration is 300 mm. The corresponding values of the rotor **B** are 450 kg and 450 mm, respectively. The shaft is 80 mm in diameter for the first 250 mm; 120 mm for the next 90 mm and 100 mm diameter for the remaining length. The modulus of rigidity for the shaft material is 90 GN/m^2. Find: **(20) (CO5) (PO4)**

i. The position of the node in the original shaft.
ii. The frequency of torsional vibration.

2. A gear reducer is to be designed as shown in **Figure 2**. Determine the diametral pitch and number of teeth on gears 4 and 5 if the speed of gear 2 (ω_2) is to be 10 times the speed of gear 5 (ω_5). The pitches of the two gears should be as nearly equal as possible, and no gear should have fewer than 15 teeth. **(25) (CO2) (PO5)**

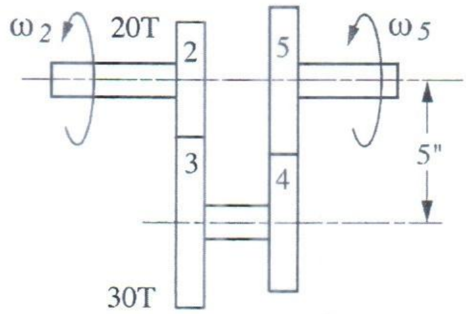

Figure 2

3. Determine the displacement schedule for a follower that rises through a total displacement of **1.5** inches with constant acceleration for $\frac{1}{4}$th revolution, constant velocity for $\frac{1}{8}$th revolution, and constant deceleration for $\frac{1}{4}$th revolution of the cam. The cam then dwells for $\frac{1}{8}$th revolution and returns with simple harmonic motion in $\frac{1}{4}$th revolution of the cam. Draw the displacement schedule. **(25) (CO3) (PO3/ PO4)**

4. **Figure 3** shows an offset slider-crank mechanism with a crank length r, connecting rod length l, and offset δ. If the crank has a mass and mass moment of inertia of m_r and J_r respectively, at its center of mass A, the connecting rod has a mass and mass moment of inertia of m_c and J_c respectively, at its center of mass C, and the piston has a mass m_p. Determine the equivalent rotational inertia of the system about the center of rotation of the crank, point O. **(25) (CO5) (PO4)**

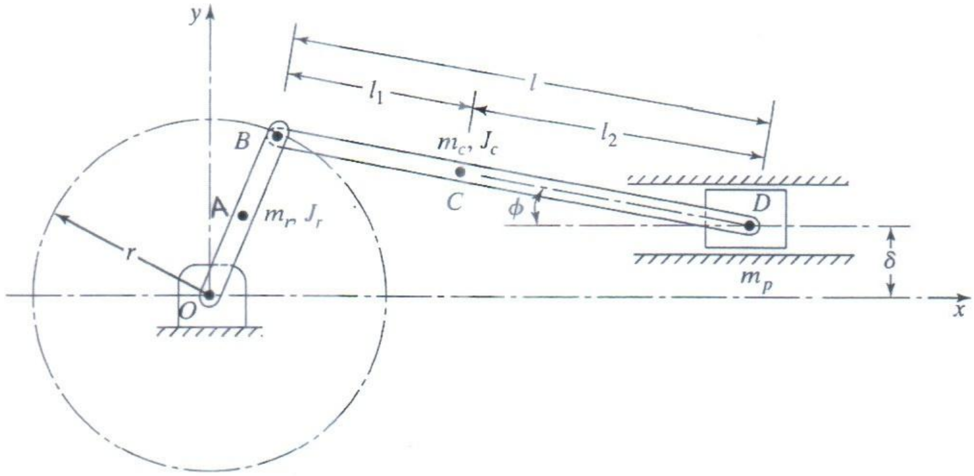

Figure 4

5. a. The system shown in **Figure 5(a)** has a natural frequency of 5 Hz for the following data: $m = 10$ kg, $J_0 = 5$ kg-m^2, $r_1 = 10$ cm, $r_2 = 25$ cm. When the system is disturbed by giving it an initial displacement, the amplitude of free vibration is reduced by 80 percent in 10 cycles. Determine the values of k and c. **(15) (CO5) (PO4)**

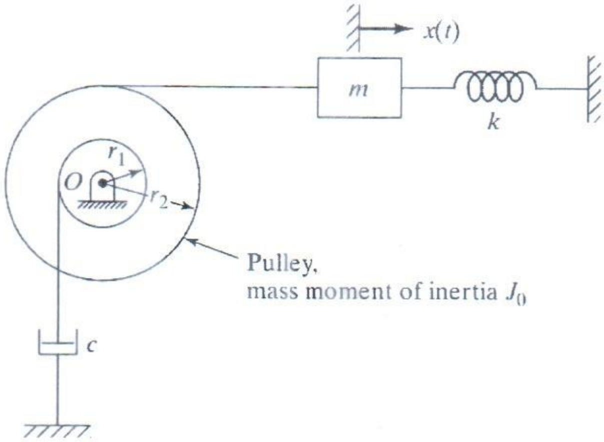

Figure 5(a)

b. A cylinder of mass $\boldsymbol{m}$ and mass moment of inertia $\boldsymbol{J_0}$ is free to roll without slipping but is restrained by two springs of stiffnesses $\boldsymbol{k_1}$ and $\boldsymbol{k_2}$ as shown in **Figure 5(b).** Find its natural frequency of vibration. Also find the value of '$\boldsymbol{a}$' that maximizes the natural frequency of vibration. **(10) (CO5) (PO4)**

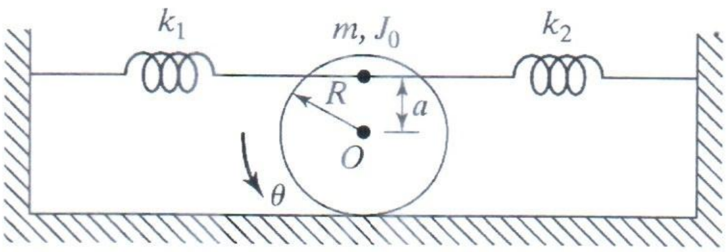

Figure 5(b)

6. Four masses **A**, **B**, **C** and **D** as shown below are to be completely balanced. **(25) (CO4) (PO3)**

	A	B	C	D
Mass (kg)	-----	30	50	40
Radius (mm)	180	240	120	150

The planes containing masses **B** and **C** are 300 mm apart. The angle between planes containing **B** and **C** is 90°. **B** and **C** make angles of 210° and 120° respectively with **D** in the same sense. Find the following graphically with required calculations:

i. The magnitude and the angular position of mass **A**.

ii. The position of planes **A** and **D**.

-END-

Program: B. Sc. in ME
B.Sc. in IPE
Semester: 5th

Date: 14 December, 2022

Time: 10:00 a.m. – 1:00 p.m.

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course Number: Math 4511
Course Title: Numerical Analysis

Winter Semester: 2021 - 2022
Full Marks:150
Time : 3 Hours

There are **6 (Six)** questions. Answer all questions. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets. Assume reasonable value for missing data

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1. Water is flowing in a trapezoidal channel at a rate of $Q = 20$ m^3/s. The critical depth y for such a channel must satisfy the equation **(25) (CO1) (PO2)**

$$0 = 1 - \frac{Q^2}{gA_c^3} B$$

Where, g=9.81 m/s^2, A_c = the cross-sectional area (m^2), and B =the width of the channel at the surface (m). For this case, the width and the cross-sectional area can be related to depth y by,

$$B = 3 + y \quad \text{and} \quad A_c = 3y + \frac{y^2}{2}$$

Solve for the critical depth using (a) bisection, and (b) false position. Use initial guesses of x_l = 0.5 and x_u = 2.5, and iterate until the approximate error falls below 1% .

2. The following data is given: **(25) (CO1) (PO2)**

x	1	2.2	3.4	4.8	6	7
y	2	2.8	3	3.2	4	5

a) Write the polynomial in *Lagrange form* that passes through the points; then use it to calculate the interpolated value of y at $x = 4.4$

b) Write the polynomial in *Newton's form* that passes through the points; then use it to calculate the interpolated value of y at x = 4.4

No need to expand the polynomials

3. **a)** Solve the following set of equations with *LU* decomposition (15) (CO1) (PO2)

$$3x_1 - 2x_2 + x_3 = -10$$
$$2x_1 + 6x_2 - 4x_3 = 44$$
$$-x_1 - 2x_2 + 5x_3 = -26$$

b) Perform a *Cholesky decomposition* of the following symmetric system (10) (CO1) (PO2)

$$\begin{bmatrix} 8 & 20 & 15 \\ 20 & 80 & 50 \\ 15 & 50 & 60 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \end{Bmatrix} = \begin{Bmatrix} 50 \\ 250 \\ 100 \end{Bmatrix}$$

4. **a)** Water solubility in jet fuel, W_s, as a function of temperature, T, can be modeled by an exponential function of the form $W_s = be^{mT}$. The following are values of water solubility measured at different temperatures. Using linear regression, determine the constants m and b that best fit the data. Use the equation to estimate the water solubility at a temperature of 10° C (15) (CO2) (PO4/ PO5)

T (° C)	-40	-20	0	20	40
W_s(%wt.)	0.0012	0.002	0.0032	0.006	0.0118

b) Use zero- through third-order Taylor series expansions to predict $f(3)$ for (10) (CO1) (PO1)

$$f(x) = 25x^3 - 6x^2 + 7x - 88$$

using a base point at $x = 1$. Compute the true percent relative error for each approximation.

Use forward and backward difference approximations and a centered difference approximation to estimate the first derivative of the function. Evaluate the derivative at $x = 2$ using a step size of $h = 0.2$. Compare your results with the true value of the derivative.

5 **a)** To estimate the surface area and volume of a barrel in **Figure 1**, the diameter of the barrel is measured at different points along the barrel. The surface area, *S*, and volume, *V*, can be determined by: **15 (CO2) (PO4/ PO5)**

$$S = 2\pi\int_0^L r\,dz \quad \textbf{and} \quad V = \pi\int_0^L r^2 dz$$

Use the data given in the table to determine the volume and surface area of the barrel.

z (in.)	-18	-12	-6	0	6	12	18
d (in.)	0	2.6	3.2	4.8	5.6	6	6.2

(a) Use the trapezoidal method.
(b) Use the Simpson's 1/3 method.
(c) Use the Simpson's 3/8 method.

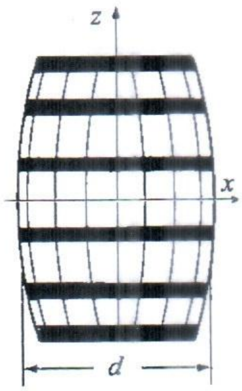

Figure 1

b) Use the following data to find the velocity and acceleration at t = 10 seconds: **10 (CO2) (PO4/ PO5)**

Time, t ,s	0	2	4	6	8	10	12	14	16
Position, x, m	0	0.7	1.8	3.4	5.1	6.3	7.3	8.0	8.4

Use second-order correct **(a)** centered fnite-difference, **(b)** forward fnite-difference, and **(c)** backward fnite-difference methods.

6 Assuming that drag is proportional to the square of velocity, we can model the velocity of a falling object like a parachutist with the following differential equation: **(25) (CO3) (PO4/ PO5)**

$$\frac{dv}{dt} = g - \frac{c_d}{m}v^2$$

where v is velocity (m/s), t = time (s), g is the acceleration due to gravity (9.81 m/s^2), c_d = a second-order drag coeffcient (kg/m), and m = mass (kg). Solve for the velocity and distance fallen by a 90-kg object with a drag coefficient of 0.225 kg/m. If the initial height is 1 km, determine when it hits the ground. Obtain your solution with (a) Euler's method and (b) the fourth-order RK method.

Name of the Program: B. Sc. in ME
Semester: 5th (Winter)

Date: 02 December, 2022
Time: 10:00 AM – 01:00 PM

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

Semester Final Examination
Course Number: MCE 4511
Course Title: Fluid Mechanics II

Winter Semester: 2021 - 2022
Full Marks: 150
Time: 03 Hours

There are **06 (six)** questions. Answer **all** questions. The symbols have their usual meanings. Assume reasonable condition and data for any missing information and values

1. State Boundary Layer Theory, Define Boundary Layer Thickness, Displacement Thickness, Momentum Thickness and Energy Thickness. **(10+15)**
Derive an expression for momentum thickness. (C1, C6)

$$\frac{u}{U_\infty} = 3\left(\frac{y}{\delta}\right) - 2\left(\frac{y}{\delta}\right)^{3/2}$$

For the above velocity distribution, find Displacement thickness and Momentum thickness. (C1, C2, C4)

2. Consider a cylindrical pipe of uniform cross-section so that geometry of the pipe is completely defined by the inner diameter (D) of the pipe and its axial length (L). Let the fluid motion be steady and consider the inertia and viscosity as represented by the fluid density (ρ) and dynamic viscosity (μ). In addition, the experimental measurement show that it depends on the gravity (g) and the composition of the inner surface affects the flow, particularly the pressure drops along with the axis of the pipe. Let the composition of the inner surface be donated as absolute roughness (e). Lastly, the average fluid velocity (v) over the pipe cross-section can vary in the experiment. **(25)**
Using the Buckingham Π Theorem, find the empirical relationship for the experimental problem. (C1, C2, C4)

3. (a) Describe the rules of similarity studies. (C1, C2, C5) **(10+15)**

(b) A 200 m long sea vessel moves in ocean is to be tested in a wind tunnel at the scale of 1:50. The model is tested in the tunnel at a velocity of 30 m/s. The model offers drag force of 60 N. Determine the velocity and the drag force of the prototype. Take the Kinematic viscosity of seawater and air as 1.2×10^{-6} m²/s and 1.8×10^{-6} m²/s, respectively. The density of air is 1.24 kg/m³ and seawater density is 1030 kg/m³. (C4, C5)

4. (a) Consider a case of flow through parallel plates, one stationary and other moving at velocity U. Write the governing equation for such flow and derive dimensionless form of the equation. (C6) **(25)**

   (b) Show with an example that a function of two pi's is related to a function of another two pi's. (C3)

5. Define Prandtl Mixing Length Theory. Derive expression for Universal velocity distribution for turbulent flow in in pipes. (C1, C6) **(25)**

6. (a) A rough pipe is of 80 mm diameter. The velocity at a point 30 mm from the wall is 30% more than the velocity at a point 10 mm from the pipe wall. Find the average height of roughness. (C1, C2) **(25)**

   (b) A smooth pipe of diameter 300 mm and length 600 m carries water at the rate of 0.4 m^3/s. Determine the head loss due to friction, wall shear stress, centerline velocity and thickness of laminar sub-layer. Take kinematic viscosity of water as 0.018 stokes. (C4)

Program: B.Sc. Engg. (IPE)
Semester: 5th Sem.

Date: 06 December 2022
Time: 10:00 am – 01:00 pm

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

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course No.: IPE 4513
Course Title: CAD/CAM/CAE

Winter Semester, A. Y. 2021-2022
Time: 3 Hours 00 Min(s)
Full Marks: 150

There are 6 (Six) questions. Answer all the questions.
Marks of each question and corresponding CO and PO are written in the brackets.
Do not write on this question paper.

---

1. a) Draw a flow diagram of design processes involved in a product cycle and describes its steps. [15] (CO1) (PO3)

   b) What is PDM? Draw the networking structure of design and manufacturing process. [10] (CO1) (PO1)

2. a) There are two coordinate systems $X_1Y_1Z_1$ and $X_2Y_2Z_2$, where Z_2 is opposite of Y_1, X_2 is parallel with Z_1, and Y_2 is opposite of X_1. The origin O_2 when measured in $X_1Y_1Z_1$ is (9, 2, 0). The $X_1Y_1Z_1$ coordinates of point P is (3, 0, 2). [15] (CO1) (PO3)
   - *(i)* With respect to $X_1Y_1Z_1$, using the standard $Rot(x,\theta)$, $Rot(y,\theta)$, $Rot(z,\theta)$ and $Trans(a,b,c)$ to derive the transformation T^* that will transform the rigid body of $X_2Y_2Z_2$ to coincide with $X_1Y_1Z_1$.
   - *(ii)* Calculate $P^* = T^* \cdot [3\ \ 0\ \ 2\ \ 1]^T$.
   - *(iii)* Is T^* the $T_{1\to2}$ or $T_{2\to1}$?

   b) What is shearing? Explain, can a cube become a curved barrel after a shearing transformation? [10] (CO1) (PO2)

3. 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. [15] (CO1) (PO3)

   b) Write down the steps of constructing the skin surface over a circle and a square. [10] (CO1) (PO3)

4. a) Which rapid prototyping process (Fused Deposition Modeling / Selective Laser Sintering) will you choose to fabricate the door handle as shown in Figure 1? Select a handle material and explain the product manufacturing process in detail. [13] (CO4) (PO3)

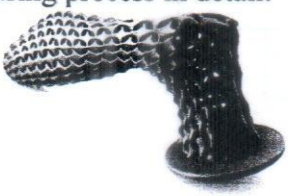

Figure 1

   b) What is reverse engineering? Briefly describe the steps involve in reverse engineering in order to get a CAD model from a physical model. [12] (CO4) (PO1)

5. a) During the Turning of Inconel 718 under minimum quantity lubrication (MQL), the values of cutting parameters are given for two different cases as follows: [18] (CO2) (PO4)

Machining parameters	Values (Case 1)	Values (Case 2)
Cutting speed (m/min)	50-100	50, 75, 100
Depth of cut (mm)	0.05-0.15	0.05, 0.10, 0.15
Feed rate (mm/rev)	0.10-0.20	0.10, 0.15, 0.20

To optimize the cutting parameters for surface roughness using particle swarm optimization (PSO), how the Case 2 will vary from Case 1? Explain the optimization algorithm for the optimization of Case 2.

b) Write down the pros and cons of deterministic optimized algorithms compared to stochastic optimized algorithms. [7] (CO2) (PO2)

6. What is work co-ordinate system in CNC programming? Write down a CNC part program for cutting the outer profile, straight slot, four tap drills and fifteen through holes (Design shown in Figure 2). 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] (CO3) (PO3)

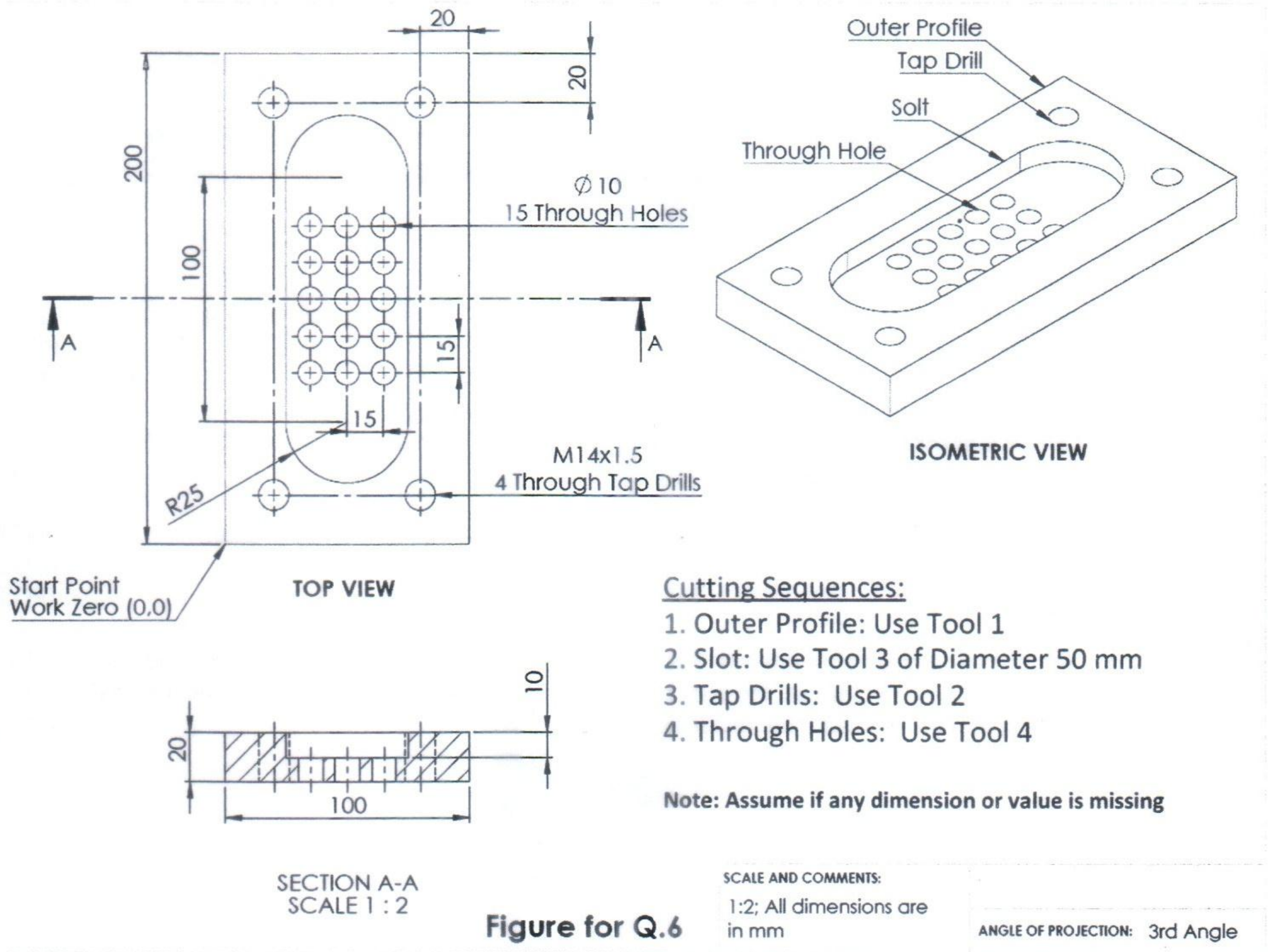

Figure 2

B.Sc Engg. (ME)/5th Sem, B Sc. TE (2 Yr) (TVE)/ 1st Sem — 30 November, 2022

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

FINAL Semester Examination — Winter Semester: A.Y. 2021-2022
Course No.: ME 4513 — Time: 3.0 Hours
Course Title: *Principle of Heat and Mass Transfer* — Full Marks: 150

There are **06 (Six)** Questions. Answer all of them. Marks in the margin indicate full marks. Do not write on this question paper. Symbols carry their usual meanings. Assume reasonable values for any missing data. Programmable calculators are not allowed.

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1. **(a)** Differentiate between heat transfer and Thermodynamics. **[15]**
(b) Differentiate fin efficiency and fin effectiveness. **[CO1]**
(c) What are the different boundary conditions in heat transfer? **[PO1]**

2. **(a)** Discuss the Wien's displacement law for electromagnetic spectrum. **[15]**
(b) Discuss the fundamental relations for calculating the view factors. **[CO2]**
(c) Discuss the effect of radiation shield considering large parallel plates with one shield. **[PO2]**

3 **(a)** What is purpose of finned surface? Derive the differential fin equation for heat transfer. **[30]**
(b) Derive an expression for Fourier-Biot equation considering the general heat conduction for rectangular coordinates and reduce it to Poisson, Diffusion and Laplace equations. **[CO2]** **[PO2]**

4. **(a)** Consider a 5-m-high, 8-m-long, and 0.22-m-thick wall whose representative cross section is as given in **Fig. 1**. The thermal conductivities of various materials used, in W/m.°C, are k_A=k_F=2, k_B=8, k_C=20, k_D=15, and k_E=35. The left and right surfaces of the wall are maintained at uniform temperatures of 300°C and 100°C, respectively. Assuming heat transfer through the wall to be one-dimensional, determine (*a*) the rate of heat transfer through the wall; (*b*) the temperature at the point where the sections *B*, *D*, and *E* meet; and (*c*) the temperature drop across the section *F*. Disregard any contact resistances at the interfaces. **[10]** **[CO3]** **[PO3]**

(b) The temperature of a gas stream is to be measured by a thermocouple whose junction can be approximated as a 1-mm-diameter sphere, as shown in **Fig. 2**. The properties of the junction are k = 35 W/m·°C, ρ= 8500 kg/m^3, and Cp = 320 J/kg·°C, and the convection heat transfer coefficient between the junction and the gas is h = 210 W/m^2·°C. Determine how long it will take for the thermocouple to read 99 percent of the initial temperature difference. **[05]** **[CO3]** **[PO3]**

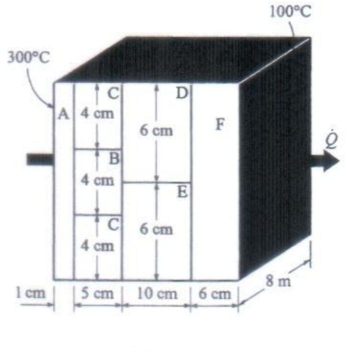

Figure: 1

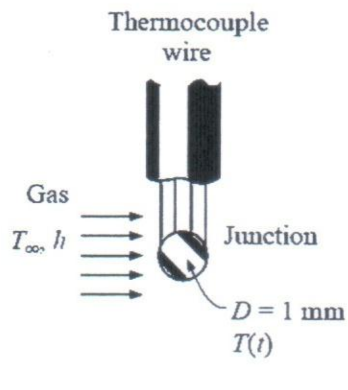

Figure: 2

5. (a) Consider a large uranium plate of thickness L=8 cm, thermal conductivity k = 28 W/m·°C, and thermal diffusivity, α = 12.5x10^{-6} m^2/s that is initially at a uniform temperature of 100°C. Heat is generated uniformly in the plate at a constant rate of g = 10^6 W/m^3. At time t = 0, the left side of the plate is insulated while the other side is subjected to convection with an environment at T_α = 20°C with a heat transfer coefficient of h = 35 W/m^2·°C. Using the explicit finite difference approach with a uniform nodal spacing of Δx = 2 cm, determine (*a*) the temperature distribution in the plate after 5 min and (*b*) how long it will take for steady conditions to be reached in the plate. [15] [CO3] [PO3]

(b) Consider a long concrete dam (k= 0.6 W/m·°C, α=0.7 m^2/s) of triangular cross section as shown in **Fig. 3** whose exposed surface is subjected to solar heat flux of q_s=800 W/m^2 and to convection and radiation to the environment at 25°C with a combined heat transfer coefficient of 30 W/m^2·°C. The 2-m-high vertical section of the dam is subjected to convection by water at 15°C with a heat transfer coefficient of 150 W/m^2·°C, and heat transfer through the 2-m-long base is considered to be negligible. Using the finite difference method with a mesh size of Δx=Δy= 1 m and assuming steady two-dimensional heat transfer, *determine* the temperature of the top, middle, and bottom of the exposed surface of the dam. [15] [CO3] [PO3]

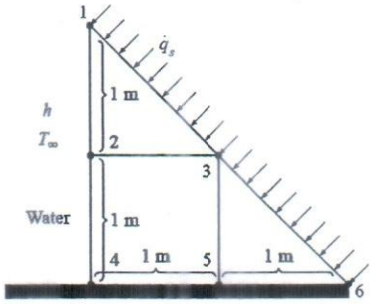

Figure: 3

6 A 0.2-cm-thick, 10-cm-high, and 15-cm-long circuit board houses electronic components on one side that dissipate a total of 15 W of heat uniformly as shown in **Fig. 4**. The board is impregnated with conducting metal fillings and has an effective thermal conductivity of 12 W/m·°C. All the heat generated in the components is conducted across the circuit board and is dissipated from the back side of the board to a medium at 37°C, with a heat transfer coefficient of 45 W/m^2 ·°C. (*a*) Determine the surface temperatures on the two sides of the circuit board. (*b*) Now a 0.1-cm-thick, 10-cm-high, and 15-cm-long aluminum plate (k = 237 W/m·°C) with 20, 0.2-cm-thick, 2-cm-long, and 15-cm-wide aluminum fins of rectangular profile are attached to the back side of the circuit board with a 0.03–cm thick epoxy adhesive (k= 1.8 W/m ·°C). Determine the new temperatures on the two sides of the circuit board. Again, repeat the design using a copper plate with copper fins (k = 386 W/m · °C) instead of aluminum ones. [45] [CO4] [PO4]

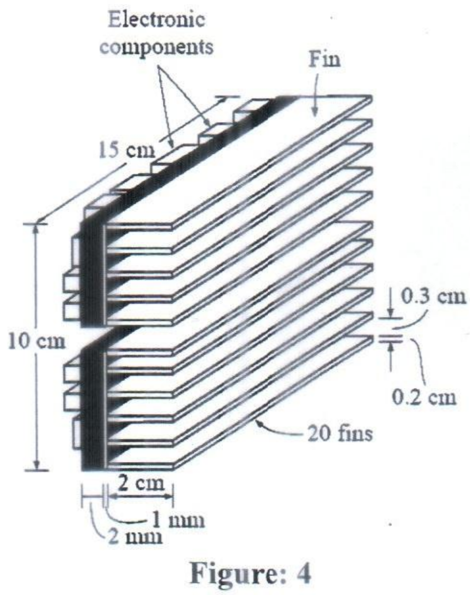

Figure: 4

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Program: B.Sc. Engg. (EEE)
Semester: 5th

Date: 14 December 2022
Time: 10 AM to 1:00 PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course Number: Hum 4521
Course Title: Engineering Management

Winter Semester: 2021 - 2022
Full Marks: 150
Time: 3 Hours

There are **6 (six)** questions. Answer **all the** questions. The symbols have their usual meanings. Marks of each question and the corresponding CO and PO are written in brackets. Assume reasonable values, if required.

---

1. (a) What are the categories of industrial accidents? Describe, briefly, the main ways to prevent industrial accidents. **(07) (CO1) (PO1)**

(b) Explain, briefly, the Harvard model of human resource management. Analyze the high-performance work practice specifying its major characteristics in the context of human resource management. **(10) (CO2) (PO2)**

(c) Illustrate various recruiting sources with their major advantages and disadvantages in human resource management. **(08) (CO2) (PO2)**

2. (a) What is the fourth industrial revolution? Clarify the major roles of trade unions in a factory system in the context of the Bangladesh Labor Act. **(07) (CO1) (PO2)**

(b) Explain, briefly, the basic types of plant layout with practical interpretation. Illustrate the main factors to be considered for the plant layout design of a factory. **(10) (CO2) (PO2)**

(c) Illustrate, briefly, the number of steps required to develop effective teamwork specifying their major characteristics. **(08) (CO2) (PO2)**

3. (a) What is work study? Differentiate between the time study and method study with physical interpretation. **(07) (CO1) (PO1)**

(b) Describe the performance appraisal process specifying its objectives and various methods with physical significance. **(10) (CO2) (PO2)**

(c) Illustrate various incentive pay plans for individuals, groups and organizations with their advantages and disadvantages. **(08) (CO2) (PO2)**

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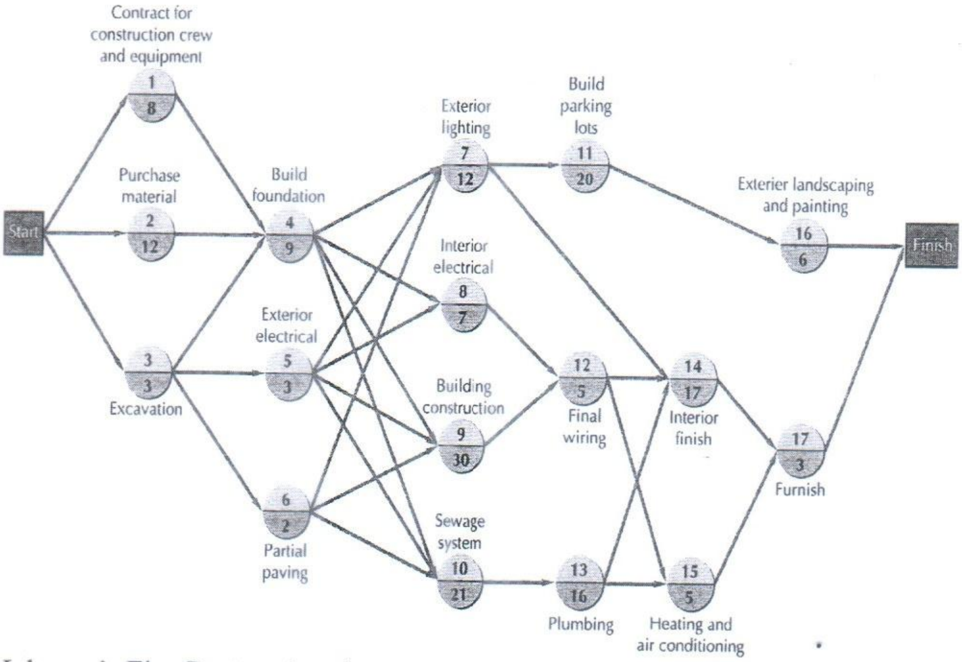
4. (a) A group of developers is building a new shopping center. A consultant for the developers has constructed the network below and assigned activity times in weeks. Determine the earliest start and finish times, latest start and finish times, critical path and duration of the project. If activity 8 and activity 9 are reduced by 1 and 3 weeks respectively then what will be the change in the critical path and duration of the project? [Here upper and lower numbers on each node indicate the Activity number and duration of each activity, respectively]. **(12) (CO3) (PO11)**



(b) Johnson's Fine Restorations has received a rush order to refinish five carousels animals-an alligator, a bear, a cat, a deer, and an elephant. The restoration involves two major processes: sanding and painting. Mr. Johnson takes care of sanding; his son does the painting. The time required for each refinishing job differs by the state of disrepair and degree of detail of each animal. Given the following processing times (in hours), determine the order in which the jobs should be processed so that the rush order can be completed as soon as possible. Also, determine the all-job completion time and idle times. **(08) (CO3) (PO4)**

Job	Process 1	Process 2
A	6	8
B	11	4
C	7	3
D	9	7
E	5	10

(c) What is the basic difference between a formal leader and an informal leader? Explain with examples. **(05) (CO1) (PO2)**

5. (a) Assign the tasks to the employees such that each employee will be assigned only one job to minimize the total cost. Find at least two multiple solutions if there are any. **(10) (CO3) (PO11)**

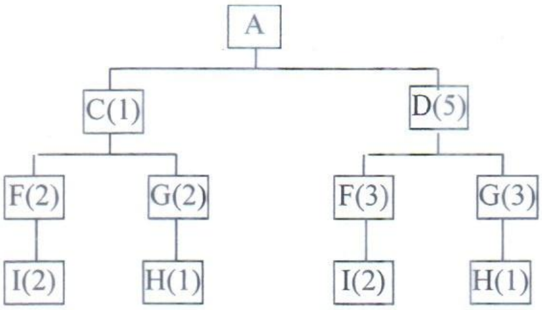
Machines

Jobs	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

(b) Annual Demand = 10,000 units **(08) (CO3) (PO4)**
Days per year considered in average daily demand = 365
Cost to place an order = \$10
Holding cost per unit per day = 0.01% of the 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.

(c) What do you mean by Supplies Inventory and Work in Process inventory? What are the items included in the Holding cost and Ordering Cost? **(07) (CO1) (PO1)**

6. (a) Brown and Brown Electronics manufacture a line of digital audiotape (DAT) players. While there are differences among the various products, there are a number of common parts within each player. The bill of materials, showing the number of each item required, lead times and the current inventory on hand for the parts and components, follows: **(12) (CO4) (PO3)**



Demand of products A demand of spares components are shown below:

Item	Demand on 9th week	Demand on 7th week	On-Hand	Lead Time (Weeks)
A	1050	-----	50	1
C	-----	270	75	1
D	320	----	80	2
F	-----	100	150	1
G	500	300	40	1
H	-----	-----	200	1
I	700	-----	300	1

Prepare a MRP schedule to satisfy demand (Use the supplied sheet)

(b) The following table contains figures on the annual usage and unit costs for a random sample of 12 items. Develop an A-B-C classification for these items **(08) (CO3) (PO4)**

Item Name	Annual Usage (No. of Items)	Unit Cost
1	500	TK 4300
2	3000	720
3	1900	500
4	1000	710
5	4500	250
6	2500	192
7	400	200
8	500	100
9	200	210
10	1000	35
11	3000	10
12	19000	3

(c) What is the objective of MRP? How does it work in a practical situation? **(05) (CO1) (PO1)**

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Program: B. Sc. in Mechanical Engineering/
B. Sc. in Technical Education (2-Year)
Semester: 5th/ 1st

Date: 06th December, 2022

Time: 10:00 am – 01:00 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Final Examination
Course Number: IPE 4521
Course Title: Manufacturing Process

Winter Semester: 2021 - 2022
Full Marks: 150
Time: 3 Hours

There are **7 (Seven)** questions. Question no. **3** is alternative to question no. **4**. Answer **6 (Six)** questions. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets.

---

1. a) Describe the mechanism used for table feed in a shaper machine with proper illustration. **(10) (CO1) (PO1)**

b) Illustrate different types of imperfect shape welding defects mentioning reasons with remedies. **(10) (CO1) (PO1)**

c) What is a keyhole technique used in plasma arc welding? **(05) (CO1) (PO1)**

2. a) Describe with necessary diagram some of the work holding devices used on a lathe. **(10) (CO1) (PO1)**

b) Briefly discuss any two types of resistance welding process with proper illustration. **(10) (CO1) (PO1)**

c) Explain why cold rolling process gives better surface finish than hot rolling process. **(05) (CO1) (PO1)**

3. a) What do you mean by tool signature? Design a single point cutting tool mentioning different angles of tool geometry for cutting high tensile strength materials. **(10) (CO3) (PO3)**

b) Which of the moulding method would you use for producing a thick sectioned thermosetting plastic material? Explain the method with proper justification. **(10) (CO3) (PO3)**

c) How can you redesign a straight cylindrical roll to prevent bending caused by roll forces? (05) (CO3) (PO3)

Or

4. a) Mentioning some disadvantages of Electron Beam Welding (EBM) and hence recommend other welding technique that would be suitable for obtaining a better quality welding? Explain the suggested technique with proper diagram. (10) (CO3) (PO3)

b) Design a good quality, economical, defect free manufacturing process for producing a connecting rod of an internal combustion engine. (10) (CO3) (PO3)

c) For cold rolling thin sheets of high-strength metal which type of rolling mill would you suggest? Give justification of your answer. (05) (CO3) (PO3)

5. a) Explain the gear arrangement used in a lathe head to perform thread cutting operation. (10) (CO2) (PO2)

b) To avoid friction of billet metal which type of extrusion method is used? Briefly discuss the proposed method with necessary diagram. (10) (CO2) (PO2)

c) A gear is to have 14 teeth. What is the indexing movement required? (05) (CO2) (PO2)

6. a) Which casting procedure will be recommended if an expandable pattern made of molten wax is needed to be used? Explain the procedure with proper figure. Also mention the pros and cons of the method. (10) (CO2) (PO2)

b) How can you manufacture a plastic bottle? Explain the procedure. (10) (CO2) (PO2)

c) Mention the parameters used for specifying a lathe machine and milling machine. (05) (CO2) (PO2)

7. a) Write the working principle of an Electrochemical machining process with necessary diagram. (10) (CO1) (PO1)

b) How an abrasive jet machining process works? Mention the different pros, cons and applications of abrasive jet machining process. (10) (CO1) (PO1)

c) Explain the atomization method of metal powder production used in powder metallurgy process. (05) (CO1) (PO1)

Program: BSc. Eng. (ME/IPE)
Semester: 5th Semester

Date: 8 December 2022
Time: 10:00 am – 01:00 pm

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

Semester Final Examination
Course Number: IPE 4531
Course Title: Probability and Statistics

Winter Semester, A.Y. 2021-2022
Full Marks : 150
Time : 3 hours

There are 6 **(Six)** questions. Answer all of them. Be noted that Question 1 and Question 4 have options. In question 1, answer 1 (a) or 1(b+c). The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the right column. Assume reasonable values if required. Selected formulas and charts are provided at the end of the question.

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1 a A factory produces engine oil. Raw data on the weight(gm) this engine oil product collected from that factory is tabled below: 25 CO1 PO1, PO2

199	147	286
155	236	267
213	224	191
257	193	208
170	181	227

i. Make the data into appropriate classes and then prepare a frequency table.
ii. Determine the Range, Mean, Median, Mode and Standard Deviation from grouped data.
iii. Draw a box and whisker plot using the above data set.

Or

b A new process has started and Range for 10 subgroups data are collected as shown in the table. Here sample size is 4. If the specification is 700 ± 60 mm, determine the process capability index and suggest if any action is required. 10 CO1 PO1, PO2

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 Draw a House of Quality figure for a basic feature mobile phone showing appropriate correlation. 15 CO1 PO1, PO2

2 a A class in advanced physics is composed of 10 juniors, 30 seniors, and 10 graduate students. The final grades show that 3 of the juniors, 10 of the seniors, and 5 of the graduate students received an A grade for the course. If a student is chosen at random from this class and is found to have earned an A, what is the probability that he or she is a senior? 6 CO2 PO3

b In a TV game show, a contestant selects one of three doors, behind one of the doors there is a price, and behind the other two doors there are no prizes. After a contestant selects a door, the game show host opens one of the remaining doors, and reveals there is no prize behind it. The host then asks the contestant whether he wants to switch to other door or stick to the door he is about to open. Using probability analysis, determine the optimal choice for the contestant. 7 CO2 PO3

c In establishing warranties on HDTV sets, the manufacturer wants to set the limits so that few sets will need repair at manufacturer expense. On the other hand, the warranty period must be long enough to make the purchase attractive to the buyer. For a new HDTV the mean number of months until repairs are needed is 36.84 with a standard deviation of 3.34 months. Find the warranty limit that will ensure that only 10 percent of the HDTVs need repairs at the manufacturer's expense. 6 CO2 PO3

d The probability that a lathe machine could be repaired from a major fault is 0.9. Calculate the probability that exactly 5 of the next 7 lathe machines having this major fault could be repaired. 6 CO2 PO3

3 a The production manager at Bellevue Steel, a manufacturer of wheelchairs, wants to compare the number of defective wheelchairs produced on the day shift with the number on the afternoon shift. A sample of the production from 6 day shifts and 8 afternoon shifts revealed the following number of defects. 10 CO2 PO3

Day shift 5, 8, 7, 6, 9, 7
Afternoon shift 8, 10, 7, 11, 9, 12, 14, 9
At .05 significance level, find whether there is a difference in the mean number of defects per shift between day and afternoon shift.

b Advertisements by S Fitness Center claim that completing its course will result in losing weight. A random sample of eight recent participants showed the following weights before and after completing the course. At the .01 significance level, can we conclude the students lost weight? 15 CO2 PO3

Name	Weight Before, pound	Weight After, pound
P	155	154
Q	222	207
R	162	157
S	141	147

4 Mention two usage of chi square analysis. Does a male released from federal prison make a different adjustment to civilian life if he returns to his hometown or if he goes elsewhere to live? The two variables are adjustment to civilian life and place of residence. Note that both variables are measured on the nominal scale. The .01 level of significance will be used. The agency's psychologists interviewed 200 randomly selected former prisoners. Using a series of questions, the psychologists classified the adjustment of each individual to civilian life as outstanding, good, fair, or unsatisfactory. The classifications for the 200 former prisoners were presented in the table. 25 CO2 PO3

Residence after release	Adjustment to Civilian Life				
	Outstanding	Good	Fair	Unsatisfactory	Total
Hometown	27	35	34	24	120
Not Hometown	13	15	26	26	80
Total	40	50	60	50	200

Or

A Professor had the 22 students in his. Introduction to Statistics class. They rated his performance as Excellent, Good, Fair, or Poor. A graduate student collected the ratings and assured the students that Professor would not receive them until after course grades had been sent to the Registrar's office. The rating (ie., the treatment) a student gave the professor was matched with his or her course grade, which could range from 0 to 100. The sample information is reported below. Is there a difference in the mean score of the students in each of the four rating categories? Use the .01 significance level. 25 CO2 PO3

Graduate Grades			
Excellent	Good	Fair	Poor
94	75	70	69
90	68	73	70
85	77	76	72
80	83	78	65
	88	80	74
		68	64
		65	

5 a PP 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. 13 CO2 PO3

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 Briefly explain multiple linear regression. The demand for cars over the past 4 years and the corresponding population in a small town are shown below. Using regression method, forecast the demand of the car in future (i.e. 2023) 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. 12 CO2 PO3

Year	Car demand (no of copies)	Population (no of people)
2019	3500	24567
2020	5100	29333
2021	5400	32000
2022	5600	33500

6 a Explain control group, placebo and blinding with respect to design of experiments. 10 CO3 PO4

b Differentiate and explain between completely randomized design and blocked design. 10 CO3 PO4

c Briefly explain a stochastic process 5 CO3 PO4

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

Median:

$$s = \sqrt{\frac{n\sum_{i}^{n}(f_i X_i^2) - (\sum_{i}^{n} f_i X_i)^2}{n-1}}$$

$$M_d = L + \left(\frac{\frac{N}{2} - n_b}{n_w}\right) i$$

i = R / (1 + 3.322 logn)

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

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

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

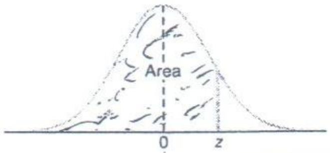


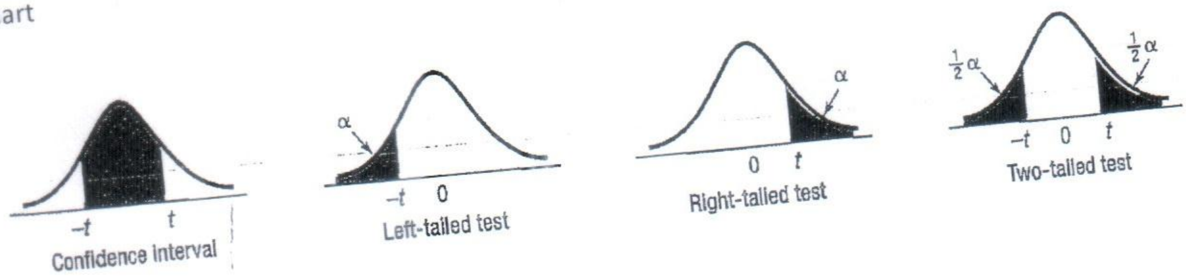
Table A.3 Areas under the Normal Curve

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

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

t chart



	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
19	1.328	1.729	2.093	2.539	2.861	3.883
20	1.325	1.725	2.086	2.528	2.845	3.850

21	1.323	1.721	2.080	2.518	2.831	3.819
22	1.321	1.717	2.074	2.508	2.819	3.792
23	1.319	1.714	2.069	2.500	2.807	3.768
24	1.318	1.711	2.064	2.492	2.797	3.745
25	1.316	1.708	2.060	2.485	2.787	3.725
26	1.315	1.706	2.056	2.479	2.779	3.707
27	1.314	1.703	2.052	2.473	2.771	3.690
28	1.313	1.701	2.048	2.467	2.763	3.674
29	1.311	1.699	2.045	2.462	2.756	3.659
30	1.310	1.697	2.042	2.457	2.750	3.646
40	1.303	1.684	2.021	2.423	2.704	3.551
60	1.296	1.671	2.000	2.390	2.660	3.460
120	1.289	1.658	1.980	2.358	2.617	3.373
∞	1.282	1.645	1.960	2.326	2.576	3.291

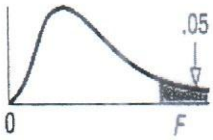
Factors for control chart

Number of Items in Sample	Chart for Averages	Chart for Ranges		
	Factors for Control Limits	Factors for Central Line	Factors for Control Limits	
n	A_2	d_2	D_3	D_4
2	1.880	1.128	0	3.267
3	1.023	1.693	0	2.575
4	.729	2.059	0	2.282
5	.577	2.326	0	2.115
6	.483	2.534	0	2.004
7	.419	2.704	.076	1.924
8	.373	2.847	.136	1.864
9	.337	2.970	.184	1.816
10	.308	3.078	.223	1.777
11	.285	3.173	.256	1.744
12	.266	3.258	.284	1.716
13	.249	3.336	.308	1.692
14	.235	3.407	.329	1.671
15	.223	3.472	.348	1.652

Chi square chart

Degrees of Freedom, *df*	Right-Tail Area 0.10	0.05	0.02	0.01
1	2.706	3.841	5.412	6.635
2	4.605	5.991	7.824	9.210
3	6.251	7.815	9.837	11.345
4	7.779	9.488	11.668	13.277
5	9.236	11.070	13.388	15.086
6	10.645	12.592	15.033	16.812
7	12.017	14.067	16.622	18.475
8	13.362	15.507	18.168	20.090
9	14.684	16.919	19.679	21.666
10	15.987	18.307	21.161	23.209
11	17.275	19.675	22.618	24.725
12	18.549	21.026	24.054	26.217
13	19.812	22.362	25.472	27.688
14	21.064	23.685	26.873	29.141
15	22.307	24.996	28.259	30.578
16	23.542	26.296	29.633	32.000
17	24.769	27.587	30.995	33.409
18	25.989	28.869	32.346	34.805
19	27.204	30.144	33.687	36.191
20	28.412	31.410	35.020	37.566
21	29.615	32.671	36.343	38.932
22	30.813	33.924	37.659	40.289
23	32.007	35.172	38.968	41.638
24	33.196	36.415	40.270	42.980
25	34.382	37.652	41.566	44.314
26	35.563	38.885	42.856	45.642
27	36.741	40.113	44.140	46.963
28	37.916	41.337	45.419	48.278
29	39.087	42.557	46.693	49.588
30	40.256	43.773	47.962	50.892

F chart



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

$$UCL = \bar{\bar{x}} + A_2\bar{R}$$

$$LCL = \bar{\bar{x}} - A_2\bar{R}$$

$$UCL = D_4\bar{R}$$

$$LCL = D_3\bar{R}$$

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

Capability Index, C_p= USL – LSL / 6 * σ

where$\sigma = \bar{R}$ / d_2

CONFIDENCE INTERVAL FOR A POPULATION PROPORTION

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

CONFIDENCE INTERVAL FOR THE POPULATION MEAN, σ UNKNOWN

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

SMALL SAMPLE TEST FOR MEAN

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

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

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

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

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

PAIRED *t* TEST

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

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

POOLED VARIANCE

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

TWO-SAMPLE TEST OF MEANS—SMALL SAMPLES

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{s_p^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

VARIANCE OF THE DISTRIBUTION OF DIFFERENCES IN MEANS

$$s^2_{\bar{X}_1 - \bar{X}_2} = \frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}$$

TEST STATISTIC FOR THE DIFFERENCE BETWEEN TWO MEANS

$$z = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

CORRELATION COEFFICIENT

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

SLOPE OF THE REGRESSION LINE

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

Y-INTERCEPT

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

TEST STATISTIC FOR COMPARING TWO VARIANCES

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

ANOVA Table

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Treatments	SST	$k-1$	SST/$(k-1)$ = MST	MST/MSE
Error	SSE	$n-k$	SSE/$(n-k)$ = MSE	
Total	SS total	$n-1$		

Bayes formula

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} = \frac{P(B|A)P(A)}{\sum_{i=1}^{n}[P(B|A_i)P(A_i)}$$

Regression another formula:

$$a = \frac{\sum y_i}{n} - b\,\frac{\sum x_i}{n}$$

$$b = \frac{n\sum x_i y_i - [(\sum x_i)(\sum y_i)]}{n\sum x_i^2 - (\sum x_i)^2}$$

$$r^2 = \frac{[n\sum x_i y_i - (\sum x_i)(\sum y_i)]^2}{[n\sum x_i^2 - (\sum x_i)^2]\,[n\sum y_i^2 - (\sum y_i)^2]}$$

CHI-SQUARE TEST STATISTIC

$$\chi^2 = \Sigma\left[\frac{(f_o - f_e)^2}{f_e}\right]$$

EXPECTED FREQUENCY

$$f_e = \frac{\text{(Row total)(Column total)}}{\text{Grand total}}$$

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Program: B. Sc. in Industrial and Production Engineering
Semester: Winter

Date: 02 December, 2022

Time: 10:00 am – 1:00 pm

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

Semester Final Examination
Course Number: IPE 4539
Course Title: Engineering Economy and Finance

Winter Semester: 2021 - 2022
Full Marks: 150
Time : 3.0 Hours

There are 6 **(SIX)** questions. Answer all 6 **(SIX)** questions. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets.

---

1. a) The cash flow associated with production of a self-locking mechanism is shown below. **(CO 2) (PO 2)**

i. Construct the cash-flow diagram. **(5 Marks)**

ii. Solve for the net present worth (year 0) at an interest rate of 10% per year. **(10 Marks)**

Year	0	1	2	3	4	5	6	7	8	9
Income, \$1000	20	20	20	20	30	30	30	30	30	30
Cost, \$1000	8	8	8	8	12	12	12	12	12	25

b) Two engineering graduates who recently got married are planning for their early retirement 20 years from now. They believe that they will need \$2,000,000 in year 2042. Their plan is to live on one of their salaries and invest the other. They already have \$25,000 in their investment account. **(PO 6)**

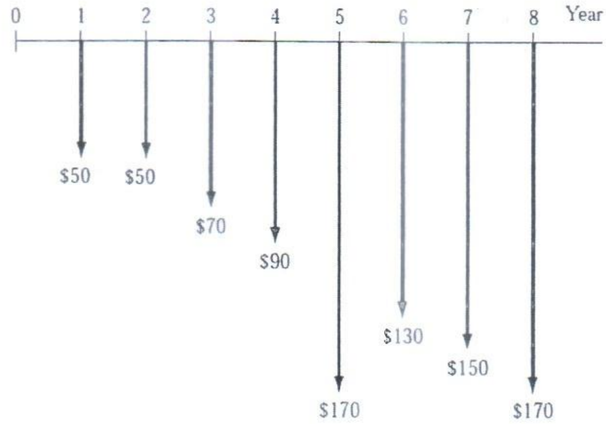
i. Calculate the amount of investment each year that they must commit if the account grows at a rate of 10% per year. **(7 Marks)**

ii. Evaluate the prospect of them achieving their dream if the maximum they have available to invest each year is \$40,000. **(3 Marks)**

2\. a) Calculate the future worth in year 8 using $i = 10\%$ per year for the cash flow shown below. **(10 Marks)** **(CO 2)** **(PO 2)**

Year	0	1	2	3	4	5	6
Cash Flow,$	100	100	100	100	100	300	300

b) Solve for the present worth in year 0 for the cash flows shown below. Let $i = 10\%$ per year. **(15 Marks)**



3\. a) Two alternatives are to be considered. The first alternative has a first cost of USD50,000, an annual operating cost of USD10,000, and a USD5,000 salvage value. While the second alternative has an initial cost of USD45,000 with an annual operating cost of USD3,000 and a salvage value of USD9,000. Consider a period of five years. **(10 Marks)** **(CO 3)** **(PO 2)**

Select the best alternative for a MARR value of 12% per year based on the Present Worth analysis.

b) A robotic engineer is considering two robots to be purchased. The first robot type (X) will have a first cost of $80,000, an annual maintenance and operation (M&O) cost of $30,000, and a $40,000 salvage value. The second robot type, (Y) will have a first cost of $97,000, an annual M&O cost of $27,000, and a $50,000 salvage value. **(15 Marks)**

Select the most appropriate robot type to be purchased using a future worth comparison at an interest rate of 12% per year.

Use a 3-year study period.

4. a) An asset has a first cost of USD30,000, an annual operating cost of USD10,000 and a salvage value of USD5,000 after 3 years. A two-life cycle is to be considered. **(CO 3)** **(PO 5)**

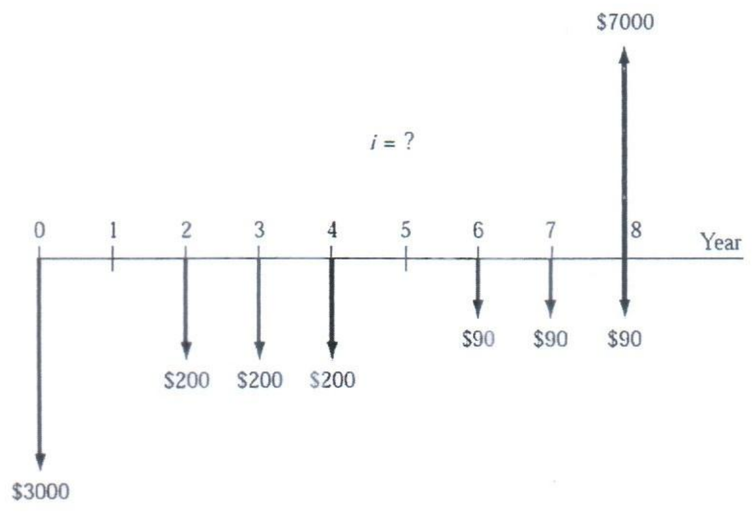
   i. Construct the cash flow diagram for the two-life cycle. **(5 Marks)**

   ii. Calculate the Annual Worth for the two life cycles at $i = 12\%$ per year **(5 Marks)**

   b) The cost of maintenance and operation (M&O) for a CNC machine is expected to increase by a constant amount of $1,200 per year for the first 5 years of operation. The machine has a first cost of $39,000 and a first-year M&O cost of $17,000. **(15 Marks)**

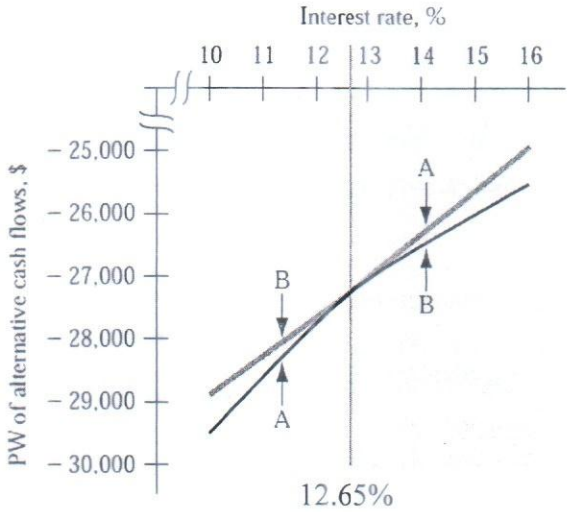
   Compare the equivalent Annual Worth of the machine kept for 4 years with one that is kept for 5 years at an interest rate of 12% per year. The salvage value of a used machine is $23,000 after 4 years and $18,000 after 5 years.

5. a) Solve for the rate of return for the cash flows shown below. **(15 Marks)** **(CO 4)** **(PO 2)**



   b) Consider the following figure that illustrates Present Worth of two alternatives (A and B) against the MARR values. **(10 Marks)**

   Comments on the selection of the alternative based on the results presented in this diagram.



6. a) The estimates shown below refer to the proposal for the construction of a bridge. **(15 Marks) (CO 4) (PO 11)**
Evaluate the proposal using the Benefit/Cost ratio method at an interest rate of 5% per year to determine the best alternative.

	A	B
Initial cost, $	$11x10^6$	$27x10^6$
Annual M&O, $/year	100,000	90,000
Benefits, $/year	990,000	2,400,000
Disbenefits, $/year	120,000	100,000
Life, years	∞	∞

b) Consider that the inflation rate is 7% per year. **(5 Marks) (PO6)**
Solve for the number of years that will be required for the cost of some asset to double when prices increase at exactly the same rate as the inflation.

c) IUT Instruments Ltd. is considering an investment of $500,000 in a new product line. The company will make the investment only if it will result in a rate of return of 12% per year or higher. The revenue is expected to be between $135,000 and $165,000 per year for 5 years. Analyse the sensitivity of the decision in relation to the projected range of income using a present worth analysis. **(5 Marks) (PO11)**

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5%	TABLE 10 Discrete Cash Flow: Compound Interest Factors							5%
	Single Payments		Uniform Series Payments				Arithmetic Gradients	
n	Compound Amount F/P	Present Worth P/F	Sinking Fund A/F	Compound Amount F/A	Capital Recovery A/P	Present Worth P/A	Gradient Present Worth P/G	Gradient Uniform Series A/G
1	1.0500	0.9524	1.00000	1.0000	1.05000	0.9524		
2	1.1025	0.9070	0.48780	2.0500	0.53780	1.8594	0.9070	0.4878
3	1.1576	0.8638	0.31721	3.1525	0.36721	2.7232	2.6347	0.9675
4	1.2155	0.8227	0.23201	4.3101	0.28201	3.5460	5.1028	1.4391
5	1.2763	0.7835	0.18097	5.5256	0.23097	4.3295	8.2369	1.9025
6	1.3401	0.7462	0.14702	6.8019	0.19702	5.0757	11.9680	2.3579
7	1.4071	0.7107	0.12282	8.1420	0.17282	5.7864	16.2321	2.8052
8	1.4775	0.6768	0.10472	9.5491	0.15472	6.4632	20.9700	3.2445
9	1.5513	0.6446	0.09069	11.0266	0.14069	7.1078	26.1268	3.6758
10	1.6289	0.6139	0.07950	12.5779	0.12950	7.7217	31.6520	4.0991
11	1.7103	0.5847	0.07039	14.2068	0.12039	8.3064	37.4988	4.5144
12	1.7959	0.5568	0.06283	15.9171	0.11283	8.8633	43.6241	4.9219
13	1.8856	0.5303	0.05646	17.7130	0.10646	9.3936	49.9879	5.3215
14	1.9799	0.5051	0.05102	19.5986	0.10102	9.8986	56.5538	5.7133
15	2.0789	0.4810	0.04634	21.5786	0.09634	10.3797	63.2880	6.0973

10%	TABLE 15 Discrete Cash Flow: Compound Interest Factors							10%
	Single Payments		Uniform Series Payments				Arithmetic Gradients	
n	Compound Amount F/P	Present Worth P/F	Sinking Fund A/F	Compound Amount F/A	Capital Recovery A/P	Present Worth P/A	Gradient Present Worth P/G	Gradient Uniform Series A/G
1	1.1000	0.9091	1.00000	1.0000	1.10000	0.9091		
2	1.2100	0.8264	0.47619	2.1000	0.57619	1.7355	0.8264	0.4762
3	1.3310	0.7513	0.30211	3.3100	0.40211	2.4869	2.3291	0.9366
4	1.4641	0.6830	0.21547	4.6410	0.31547	3.1699	4.3781	1.3812
5	1.6105	0.6209	0.16380	6.1051	0.26380	3.7908	6.8618	1.8101
6	1.7716	0.5645	0.12961	7.7156	0.22961	4.3553	9.6842	2.2236
7	1.9487	0.5132	0.10541	9.4872	0.20541	4.8684	12.7631	2.6216
8	2.1436	0.4665	0.08744	11.4359	0.18744	5.3349	16.0287	3.0045
9	2.3579	0.4241	0.07364	13.5795	0.17364	5.7590	19.4215	3.3724
10	2.5937	0.3855	0.06275	15.9374	0.16275	6.1446	22.8913	3.7255
11	2.8531	0.3505	0.05396	18.5312	0.15396	6.4951	26.3963	4.0641
12	3.1384	0.3186	0.04676	21.3843	0.14676	6.8137	29.9012	4.3884
13	3.4523	0.2897	0.04078	24.5227	0.14078	7.1034	33.3772	4.6988
14	3.7975	0.2633	0.03575	27.9750	0.13575	7.3667	36.8005	4.9955
15	4.1772	0.2394	0.03147	31.7725	0.13147	7.6061	40.1520	5.2789

12%	TABLE 17 Discrete Cash Flow: Compound Interest Factors							12%
	Single Payments		Uniform Series Payments				Arithmetic Gradients	
n	Compound Amount F/P	Present Worth P/F	Sinking Fund A/F	Compound Amount F/A	Capital Recovery A/P	Present Worth P/A	Gradient Present Worth P/G	Gradient Uniform Series A/G
1	1.1200	0.8929	1.00000	1.0000	1.12000	0.8929		
2	1.2544	0.7972	0.47170	2.1200	0.59170	1.6901	0.7972	0.4717
3	1.4049	0.7118	0.29635	3.3744	0.41635	2.4018	2.2208	0.9246
4	1.5735	0.6355	0.20923	4.7793	0.32923	3.0373	4.1273	1.3589
5	1.7623	0.5674	0.15741	6.3528	0.27741	3.6048	6.3970	1.7746
6	1.9738	0.5066	0.12323	8.1152	0.24323	4.1114	8.9302	2.1720
7	2.2107	0.4523	0.09912	10.0890	0.21912	4.5638	11.6443	2.5512
8	2.4760	0.4039	0.08130	12.2997	0.20130	4.9676	14.4714	2.9131
9	2.7731	0.3606	0.06768	14.7757	0.18768	5.3282	17.3563	3.2574
10	3.1058	0.3220	0.05698	17.5487	0.17698	5.6502	20.2541	3.5847
11	3.4785	0.2875	0.04842	20.6546	0.16842	5.9377	23.1288	3.8953
12	3.8960	0.2567	0.04144	24.1331	0.16144	6.1944	25.9523	4.1897
13	4.3635	0.2292	0.03568	28.0291	0.15568	6.4235	28.7024	4.4683
14	4.8871	0.2046	0.03087	32.3926	0.15087	6.6282	31.3624	4.7317
15	5.4736	0.1827	0.02682	37.2797	0.14682	6.8109	33.9202	4.9803

FORMULA SHEET

$F = P(1 + i)^n$

$P = F(1 + i)^{-n}$

$P = A \frac{(1+i)^n - 1}{i(1+i)^n}$

$A = P \frac{i(1+i)^n}{(1+i)^n - 1}$

$F = A \frac{(1+i)^n - 1}{i}$

$A = F \frac{i}{(1+i)^n - 1}$

$f = f_1 + \frac{(x - x_1)}{(x_2 - x_1)}(f_2 - f_1)$

$P_G = (P/G,i,n) = \frac{(1+i)^n - in - 1}{i^2(1+i)^n}$

$P_G = A \frac{1 - \left(\frac{1+g}{1+i}\right)^n}{i - g}$

$F_G = G\left[\left(\frac{1}{i}\right)\left(\frac{(1+i)^n - 1}{i}\right) - n\right]$

$A_G = G \left[\frac{1}{i} - \frac{n}{(1+i)^n - 1}\right]$

Constant value dollar = future dollars / $(1+f)^n$

$P = \frac{F}{(1 + i_f)^n}$

$i_f = i + f + if$

B.Sc Engg. (IPE)/5th Sem | Wednesday, 30 November, 2022

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

Final Semester Examination | Winter Semester: A.Y. 2021-2022
Course No.: ME 4555 | Time: 3.0 Hours
Course Title: *Fluid Mechanics and Machinery* | Full Marks: 150

There are **06 (Six)** Questions. Answer all of them. 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.

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1. **(a)** Differentiate between Cascade and Meridional view of simple turbine with neat sketch. **[15] [CO1] [PO1]**

(b) Differentiate between forced vortex motion and Capillary effect with neat sketch.

(c) Draw the variation of specific energy Es with depth y for a specified flow rate.

2. Deduce the principles of Obstruction flowmeters and Pitot static tube. Write down the constructions, advantages and limitations of Venturimeter in the application of Fluid Mechanics. **[15] [CO2] [PO2]**

3. **(a)** Classify the types of pump. Explain the construction and working principle of centrifugal and single acting positive displacement pump. **[15] [CO2] [PO2]**

(b) Classify the types of turbine. Explain the construction and working principle of Pelton wheel and Kaplan turbine. **[15] [CO2] [PO2]**

4. Consider a steady, laminar, incompressible flow of fluid with constant properties in the fully developed region of a straight circular pipe. By applying a momentum balance to a differential volume element, obtain the velocity profile by solving it and prove that the average velocity in fully developed laminar pipe flow is one half of the maximum velocity. **[20] [CO3] [PO3]**

5. What is best hydraulic cross section for open channel flow? Determine the best hydraulic cross section, hydraulic radius for the best cross section, best trapezoid angle considering liquid flow in an open channel of trapezoidal cross section of bottom width b, flow depth y, and trapezoid angle θ measured from the horizontal. **[25] [CO3] [PO3]**

6. (a) A reaction turbine having an overall efficiency of 76%, works under a head of 126 m at 430 rpm. If the specific speed of this turbine is 185 rpm, find out the flow rate of the water. Find also the flow rate of water when the head is 90 m. [10] [CO4] [PO4]

(b) Freshwater and seawater flowing in parallel horizontal Pipelines are connected to each other by a double U-tube manometer, as shown in **Fig. 1**. Determine the pressure difference between the two pipelines. Take the density of seawater at that location to be ρ=1035 kg/m^3. Can the air column be ignored in the analysis? [15] [CO4] [PO4]

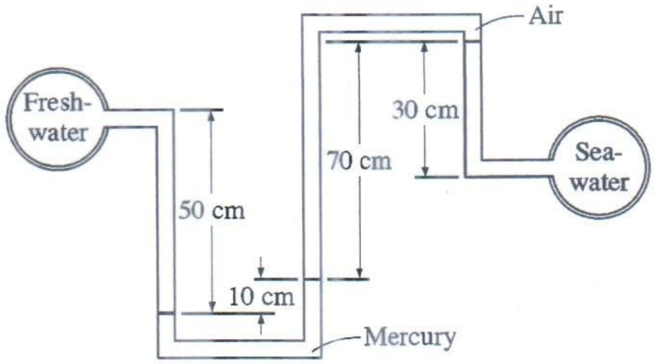

Figure 1

(c) A water jet of *32 mm* diameter strikes horizontally at the centre of a *250 mm* x *250 mm* plate of uniform thickness. The mass of the plate is *8 kg* and the plate is suspended vertically from hinge at its top edge as shown in **Fig.2**. Calculate (a). Force to be applied at the lower edge of the plate to keep it vertical. Also calculate (b). The inclination of the plate with vertical under the action of the jet if the plate is allowed to swing freely. The velocity of the jet is *9 m/s*. [20] [CO4] [PO4]

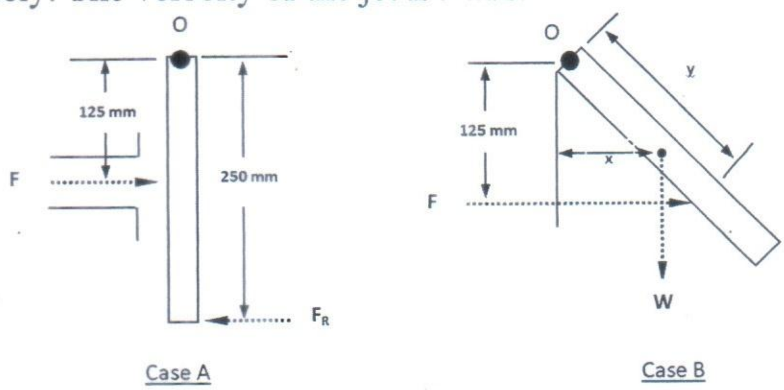

Figure 2

(100)

Programme: B.Sc. in Mechanical Engineering **13 December 2022**

Semester: 7th **Time: 10:00 AM-1:00 PM**

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

FINAL SEMESTER EXAMINATION

WINTER SEMESTER: 2021-2022

Course Number: MCE-4703

Course Name: Vibration and System Dynamics

FULL MARKS : 150

TIME : 3.0 Hours

There are **SIX** Questions. Answer **All** Questions.
Figures in the Right Margin indicate full marks. CO and POs of the corresponding questions are written in the right most margin. (Assume reasonable value of any data missing)
Programmable calculators are not allowed. Do not write on this question paper

1.	a)	What is whirling or critical speed of a shaft? How the eccentricity of a shaft/rotor-shaft system enhances the vibration.	(5)	CO1 PO1
	b)	How the dunkerley's method determine the natural frequency of free transverse vibration for a shaft subjected to a number of point loads and distributed loads.	(5)	CO1 PO1
	c)	A shaft 12.5 mm diameter rotates in short bearings and a disc of mass 16 kg is secured to a shaft at the middle of its length. The span of the shaft between the bearing is 0.5 m. The mass center of the disc is 0.5 mm from the axis of the shaft. Neglecting the mass of the shaft and taking E=200 GPa, determine: i) the critical speed of rotation in rpm, and ii) the range of speed over which the stress in the shaft due to bending will not exceed 120 MPa. The static deflection of the shaft for beam freely supported at both ends is $\delta = \frac{Wl^3}{48\,EI}$ and for beam fixed at both ends is $\delta = \frac{Wl^3}{192\,EI}$.	(15)	CO2 PO2
2.	a)	i) Let an engine or propeller rotates in the anticlockwise direction when seen from the rear or tail end of an aeroplane, and the aeroplane takes a turn to the right. Write down the effect of reactive gyroscopic couple. ii) A rotor or propeller of a naval ship rotates in clockwise direction when viewed from the fore-end and the ship is pitching in upward direction. Write down the effect of reactive gyroscopic couple.	(3.5 +3.5)	CO1 PO1
	b)	A four wheeled motor car of mass 2500 kg has a wheel base of 2.5 m, track width 1.5 m and height of center of gravity 600 mm above the ground level and lies at 0.9 m from the front axle. Each wheel has an effective diameter of 0.75 m and a moment of inertia of 0.75 kg-m^2. The drive shaft, engine flywheel and transmission are rotating at 3 times the speed of road wheel, in an anticlockwise direction when viewed from the front, and is equivalent to a mass of 75 kg having a radius of gyration of 110 mm. If the car is taking a left turn of 50 m radius at 50 km/h, determine the load on each wheel.	(18)	CO2 PO2
3.	a)	Derive the expression of piston effort and crank effort of a reciprocating parts of an engine.	(10)	CO1 PO1

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b) A horizontal steam engine running at 240 rpm has a bore of 300 mm and stroke 600 mm. The connecting rod is 1.05 m long and the mass of reciprocating parts is 60 kg. When the crank is 60^0 past its inner dead center, the steam pressure on the cover side of the piston is 1.125 N/mm^2 while that on the crank side is 0.125 N/mm^2. The diameter of the piston rod is 20 mm. Determine i) the force in the piston rod; and ii) the turning moment on the crankshaft. The acceleration of the piston is expressed as with the usual meaning of the symbols: $a_R = \omega^2 r\left[\cos\theta + \frac{\cos 2\theta}{n}\right]$. (15) CO2 PO2

4\. a) Write down the classification of followers with neat sketches according to the surface in contact for the cam-follower system. (7) CO1 PO1

b) 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: (18) CO2 CO3 PO2 PO5

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 simple harmonic motion;

iv) Follower 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 follower on the out stroke and the return stoke. The maximum velocity and acceleration of the follower for simple harmonic motion and for uniform acceleration and retardation are respectively for outstroke: $v_O = \frac{\pi\omega S}{2\theta_O}$ and $a_O = \frac{\pi^2\omega^2 S}{2(\theta_O)^2}$, and $v_O = \frac{2\omega S}{2\theta_O}$ and $a_O = \frac{4\omega^2 S}{(\theta_O)^2}$. Symbols have usual meanings.

5 A shaft carries four masses in parallel planes *A*, *B*, *C* and *D* in this order along its length. The masses at *B* and *C* are 18 kg and 12.5 kg respectively, and each has an eccentricity of 60 mm. The masses at *A* and *D* have an eccentricity of 80 mm. The angle between the masses at *B* and *C* is 100^0 and that between the masses at *B* and *A* is 190^0, both being measured in the same direction. The axial distance between the planes *A* and *B* is 100 mm and that between *B* and *C* is 200 mm. If the shaft is in complete dynamic balance, determine: i) The magnitude of the masses at *A* and *D*; ii) The distance between planes *A* and *D*; and iii) the angular position of the mass at *D*. (25) CO2 CO3 PO2 PO5

6\. a) Derive the expression for balancing of a single rotating mass (disturbing mass) by two masses rotating in different planes when the plane of disturbing mass lies on one end of the planes of the balancing masses. (10) CO2 PO2

b) An inside cylinder locomotive has its cylinder center lines 0.7 m apart and has a stroke of 0.6 m. The rotating masses per cylinder are equivalent to 150 kg at the crank pin, and the reciprocating masses per cylinder to 180 kg. The wheel center lines are 1.5 m apart. The cranks are at right angles. The whole of the rotating and 2/3 of the reciprocating masses are to be balanced by masses placed at a radius of 0.6 m. Determine: i) The magnitude and direction of the balancing masses; ii) The fluctuation rail pressure under one wheel, variation of tractive effort and the magnitude of swaying couple at a crank speed of 300 rpm. (15) CO2 CO3 PO2 PO3

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Program: B.Sc.Engg.(M)/B.Sc.TE (2 Year)
Semester: 7th/3rd

Date: 01 December 2022
Group: B

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course Number: MCE 4705/91
Course Title: Applied Thermodynamics

Winter Semester: 2021 - 2022
Full Marks: 150
Time: 3 Hours

There are **6 (six)** questions. Answer **all the** questions. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets. Assume the reasonable values if required.

---

1. (a) A steam power plant operates on a reheat Rankine cycle and has a net power output of 80 MW. Steam enters the high-pressure turbine at 10 MPa and 500°C and the low-pressure turbine at 1 MPa and 500°C. Steam leaves the condenser as a saturated liquid at a pressure of 10 kPa. The isentropic efficiency of the turbines is 80 percent, and that of the pump is 95 percent. Show the cycle on a *T-s* diagram with respect to saturation lines, and compute **(15) (CO3) (PO4)**

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

(b) 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 compute the mass flow rate of steam through the boiler and the thermal efficiency of the cycle. **(15) (CO3) (PO4)**

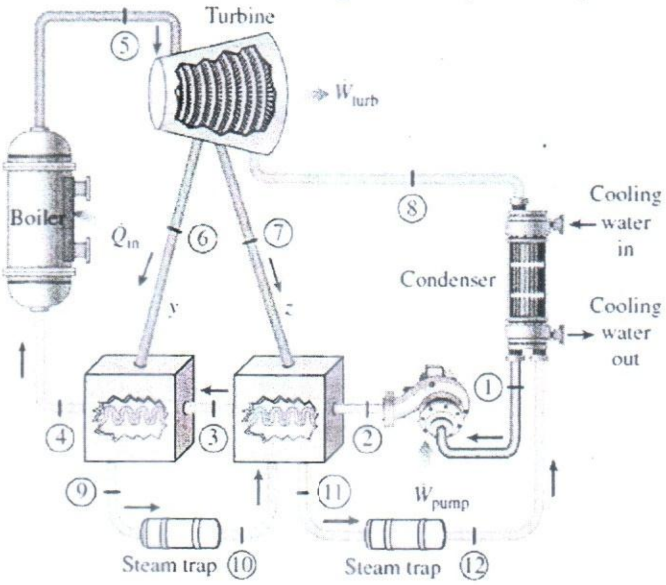
(c) n-Octane (C_8H_{18}) is burned with 50 percent excess air. Determine the mass fraction of each product and the mass of water in the products per unit mass of fuel burned. Also, calculate the mass fraction of each reactant. Assume the molar mass of air to be 29kg/kmol. **(12) (CO3) (PO4)**

2. (a) Elucidate the reason of using a second pump after the open feed water heater in an ideal regenerative Rankine cycle with the help of a *T-s* diagram. **(07) (CO2) (PO2)**

(b) "N_2 in air does not affect the outcome of the combustion process at all."– Examine the statement and write reasoning that supports your judgement. Which is more likely to be found in the products of an incomplete combustion of a hydrocarbon fuel, CO or OH? Why? **(05) (CO2) (PO2)**

(c) "If the number of compression and expansion stages is increased, the ideal gas-turbine cycle with intercooling, reheating, and regeneration approaches the Ericsson cycle." – Interpret. **(05) (CO2) (PO2)**

(d) Illustrate the *T-s* diagram of the following thermodynamic cycle. **(08) (CO2) (PO2)**



3. (a) Explain how Orsat gas analyzer analyze the composition of combustion gases. **(04) (CO1) (PO1)**

(b) Describe the significance of utilization factor, $\in_u$. **(04) (CO1) (PO1)**

4. (a) Consider two systems that are at the same pressure as the environment. The first system is at the same temperature as the environment, whereas the second system is at a lower temperature than the environment. Compare the exergies of these two systems? **(05) (CO1) (PO1)**

(b) What do you mean by the decrease of exergy principle and exergy destruction? **(05) (CO1) (PO1)**

(c) What is adiabatic flame temperature? A fuel is completely burned first with the stoichiometric amount of air and then with the stoichiometric amount of pure oxygen. For which case will the adiabatic flame temperature be higher? **(05) (CO1) (PO1)**

5. (a) Analyze the *P-v-T* surface diagrams for a pure substance that contracts and expands on freezing. **(10) (CO2)**

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(PO2)

(b) Formulate the Exergy Balance Equation for a closed system and a control volume. (10) (CO2) (PO2)

(c) How does useful work differ from actual work? For what kind of systems are these two identical? Analyze the irreversibilities with physical significance. (10) (CO2) (PO2)

6. (a) A piston-cylinder device contains 0.05 kg of steam at 1 MPa and 300°C. Steam now expands to a final state of 200 kPa and 150°C, doing work. Heat losses from the system to the surroundings are estimated to be 2 kJ during this process. Assuming the surroundings to be at $T_0 = 25°C$ and $P_0 = 100$ kPa, determine (15) (CO3) (PO4)

i. the exergy of the steam at the initial and the final states,
ii. the exergy changes of the steam,
iii. the exergy destroyed, and
iv. the second-law efficiency for the process.

(b) Consider a steam power plant operating on the simple ideal Rankine cycle. Steam enters the turbine at 3 MPa and 350°C and is condensed in the condenser at a pressure of 75 kPa. Heat is supplied to the steam in a furnace maintained at 800K, and waste heat is rejected to the surroundings at 300K. Determine (15) (CO3) (PO4)

i. the exergy destruction associated with each of the four processes and the whole cycle and
ii. the second-law efficiency of this cycle.

Property Tables

TABLE A–5

Saturated water—Pressure table

		Specific volume, m^3/kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg·K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	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
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

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	7.1833	0.29321	2715.9	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

TABLE A–6

Superheated water (*Concluded*)

T °C	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K	*v* m³/kg	*u* kJ/kg	*h* kJ/kg	*s* kJ/kg·K
	P = 1.00 MPa (179.88°C)				*P* = 1.20 MPa (187.96°C)				*P* = 1.40 MPa (195.04°C)			
Sat.	0.19437	2582.8	2777.1	6.5850	0.16326	2587.8	2783.8	6.5217	0.14078	2591.8	2788.9	6.4675
200	0.20602	2622.3	2828.3	6.6956	0.16934	2612.9	2816.1	6.5909	0.14303	2602.7	2803.0	6.4975
250	0.23275	2710.4	2943.1	6.9265	0.19241	2704.7	2935.6	6.8313	0.16356	2698.9	2927.9	6.7488
300	0.25799	2793.7	3051.6	7.1246	0.21386	2789.7	3046.3	7.0335	0.18233	2785.7	3040.9	6.9553
350	0.28250	2875.7	3158.2	7.3029	0.23455	2872.7	3154.2	7.2139	0.20029	2869.7	3150.1	7.1379
400	0.30661	2957.9	3264.5	7.4670	0.25482	2955.5	3261.3	7.3793	0.21782	2953.1	3258.1	7.3046
500	0.35411	3125.0	3479.1	7.7642	0.29464	3123.4	3477.0	7.6779	0.25216	3121.8	3474.8	7.6047
600	0.40111	3297.5	3698.6	8.0311	0.33395	3296.3	3697.0	7.9456	0.28597	3295.1	3695.5	7.8730
700	0.44783	3476.3	3924.1	8.2755	0.37297	3475.3	3922.9	8.1904	0.31951	3474.4	3921.7	8.1183
800	0.49438	3661.7	4156.1	8.5024	0.41184	3661.0	4155.2	8.4176	0.35288	3660.3	4154.3	8.3458
900	0.54083	3853.9	4394.8	8.7150	0.45059	3853.3	4394.0	8.6303	0.38614	3852.7	4393.3	8.5587
1000	0.58721	4052.7	4640.0	8.9155	0.48928	4052.2	4639.4	8.8310	0.41933	4051.7	4638.8	8.7595
1100	0.63354	4257.9	4891.4	9.1057	0.52792	4257.5	4891.0	9.0212	0.45247	4257.0	4890.5	8.9497
1200	0.67983	4469.0	5148.9	9.2866	0.56652	4468.7	5148.5	9.2022	0.48558	4468.3	5148.1	9.1308
1300	0.72610	4685.8	5411.9	9.4593	0.60509	4685.5	5411.6	9.3750	0.51866	4685.1	5411.3	9.3036
	P = 2.50 MPa (223.95°C)				*P* = 3.00 MPa (233.85°C)				*P* = 3.50 MPa (242.56°C)			
Sat.	0.07995	2602.1	2801.9	6.2558	0.06667	2603.2	2803.2	6.1856	0.05706	2603.0	2802.7	6.1244
225	0.08026	2604.8	2805.5	6.2629								
250	0.08705	2663.3	2880.9	6.4107	0.07063	2644.7	2856.5	6.2893	0.05876	2624.0	2829.7	6.1764
300	0.09894	2762.2	3009.6	6.6459	0.08118	2750.8	2994.3	6.5412	0.06845	2738.8	2978.4	6.4484
350	0.10979	2852.5	3127.0	6.8424	0.09056	2844.4	3116.1	6.7450	0.07680	2836.0	3104.9	6.6601
400	0.12012	2939.8	3240.1	7.0170	0.09938	2933.6	3231.7	6.9235	0.08456	2927.2	3223.2	6.8428
450	0.13015	3026.2	3351.6	7.1768	0.10789	3021.2	3344.9	7.0856	0.09198	3016.1	3338.1	7.0074
500	0.13999	3112.8	3462.8	7.3254	0.11620	3108.6	3457.2	7.2359	0.09919	3104.5	3451.7	7.1593
600	0.15931	3288.5	3686.8	7.5979	0.13245	3285.5	3682.8	7.5103	0.11325	3282.5	3678.9	7.4357
700	0.17835	3469.3	3915.2	7.8455	0.14841	3467.0	3912.2	7.7590	0.12702	3464.7	3909.3	7.6855
800	0.19722	3656.2	4149.2	8.0744	0.16420	3654.3	4146.9	7.9885	0.14061	3652.5	4144.6	7.9156
900	0.21597	3849.4	4389.3	8.2882	0.17988	3847.9	4387.5	8.2028	0.15410	3846.4	4385.7	8.1304
1000	0.23466	4049.0	4635.6	8.4897	0.19549	4047.7	4634.2	8.4045	0.16751	4046.4	4632.7	8.3324
1100	0.25330	4254.7	4887.9	8.6804	0.21105	4253.6	4886.7	8.5955	0.18087	4252.5	4885.6	8.5236
1200	0.27190	4466.3	5146.0	8.8618	0.22658	4465.3	5145.1	8.7771	0.19420	4464.4	5144.1	8.7053
1300	0.29048	4683.4	5409.5	9.0349	0.24207	4682.6	5408.8	8.9502	0.20750	4681.8	5408.0	8.8786
	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
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

Program: B. Sc. Eng. ME
Semester: 7th Sem

Date: 05 December 2022 (Monday)
Time: 10:00 AM – 1:00 PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course Number: MCE 4709
Course Title: Machine Design II

Winter Semester: 2021 - 2022
Full Marks: 100
Time: 3 Hours

There are **six** questions. Answer **all** of them. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets. This is an **OPEN BOOK Exam** (Only Textbook allowed). **Assume reasonable design data when necessary.** State all assumptions very clearly. Programmable calculators are not allowed.

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1. For the screw clamp shown in **Figure 1**, a force is applied at the end of the handle 4 in from the screw centerline. The $\frac{2}{5}$ in diameter handle is made of AISI 1010 CD steel. The screw is $\frac{7}{8}$ in-10 UNC and is 8.5 in long, overall. The maximum possible length of screw in the clamping region is 6.5 in. **(15) (CO1) (PO2)**

   (*a*) Determine the screw torque which will cause the handle to bend permanently?
   (*b*) Find the clamping force that this torque [part (*a*)] will cause if the collar friction is present and if the thread friction is 0.2?
   (*c*) Estimate the clamping force which will cause the screw to be buckled?
   (*d*) Comment if there are any other stresses or possible failures to be checked?

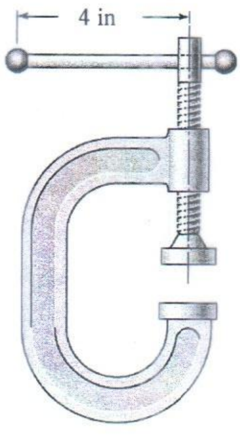

Figure 1

2. Design a compact roller chain drive to transmit power from a dynamometer to a test stand for evaluation of aircraft auxiliary gear boxes. The chain drive must transmit 90 hp at a small sprocket speed of 1000 rpm. The optimum range of center distances is about 30 – 50 chain pitches. **(20) (CO2) (PO3)**

   (a) Select the most appropriate roller chain size.
   (b) Determine the minimum sprocket size to be used.
   (c) Specify appropriate lubrication.

3. A vertical column of 1030 HR steel with an attachment has been designed to the point shown in **Figure 2**. The static load of 25 kip is applied, and the clearance a of 5.8 in has to be equaled or exceeded. The attachment is made of 1018 HR steel, to be made from 12 -in plate with weld-on bosses when all dimensions are known. **(15) (CO1) (PO3)**

Design the weldment (give the pattern, electrode number, type of weld, length of weld bead, and leg size). Specify also the length l_1 for the attachment.

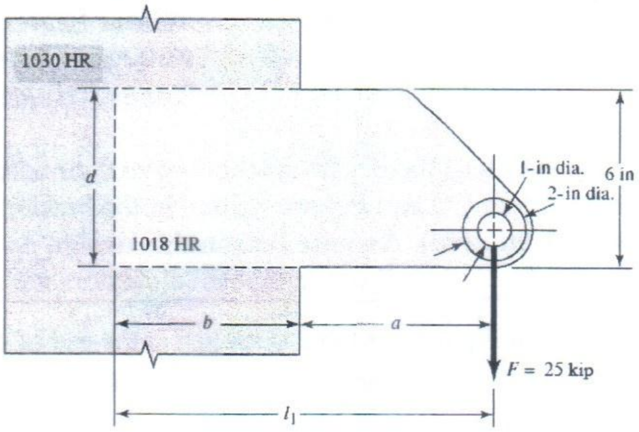

Figure 2

4. The **Figure 3** shows a 10 diametral pitch 16T 20° straight bevel pinion driving a 32T gear. The transmitted load is 24 lbf. Find the bearing reactions at C and D on the output shaft if D is to take both radial and thrust loads. **(15) (CO3) (PO3)**

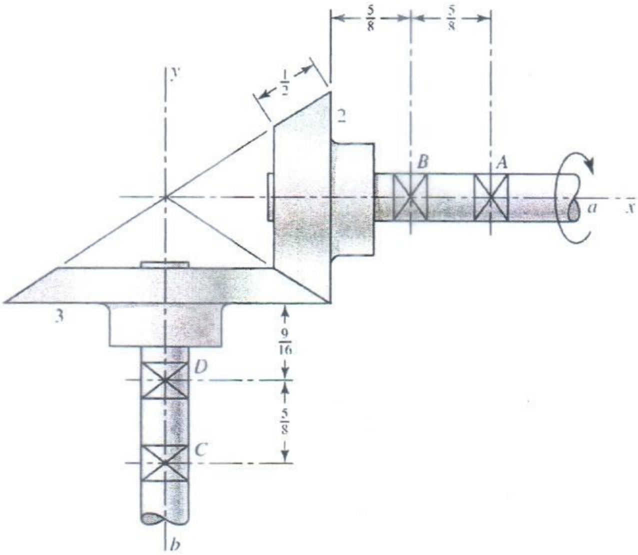

Figure 3
(Dimensions in inches)

5. The **Figure 4** shows a 430 mm diameter brake drum with four internally expanding shoes. Each of the hinge pins ***A*** and ***B*** supports a pair of shoes. The actuating mechanism is to be designed to produce the same force ***F*** on each shoe. The face width of the shoes is 80 mm. The material to be used is dry molded asbestos. The dimensions in figure (in mm) are, a=155, c=170 and d=52 as shown. **(17) (CO2) (PO3)**

(a) Determine the maximum actuating force.
(b) Estimate the brake capacity.
(c) Estimate the hinge-pin reactions considering rotation in both directions.

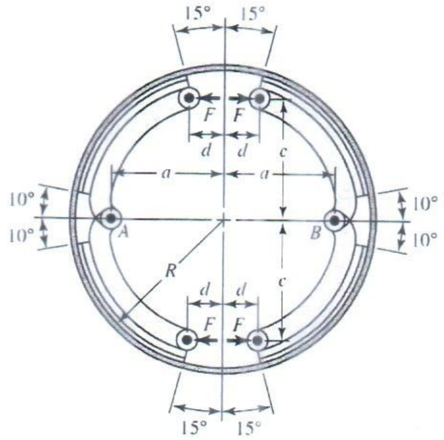

Figure 4

6. A flat belt drive system is to be designed for an application in which the input motor shaft speed (driving pulley) is 1725 rpm, the driven shaft speed is to be approximately 960 rpm, and the power to be transmitted has been estimated as 3.0 hp. The driven machine has been evaluated and found to have the characteristics of moderate shock loading during operation. The desired center distance between driving and driven pulleys is approximately 458 mm. **(18) (CO2) (PO3)**

(a) Selecting Polyamide belt material with minimum 3 mm thickness, determine the belt width required.
(b) Estimate the initial tension required for proper operation?

~End~

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Program: B. Sc. in ME (7^{th} Semester)

Date: 15 December, 2022
Time: 10:00am – 1:00 pm

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

Semester Final Examination
Course Number: Hum 4717
Course Title: Engineering Economy and Finance

Winter Semester: 2021 - 2022
Full Marks: 150
Time: 3 hours

*There are 5 (**five**) questions. Answer **all** of them. Provide cash flow diagram/s whenever applicable. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets. Necessary formula and interest tables (interpolation/extrapolation acceptable) are provided.*

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1. Differentiate between the following (write adequately with the relevant formulas/laws/statements) **6x6=36 (CO1,2) (PO1)**

i. IRR and ERR
ii. Normal payback period and discounted payback period
iii. Straight line and 150% declining balance method for depreciation
iv. Nominal and effective interest rate
v. Traditional and Islamic finance
vi. Profit and loss sharing vs. Lender-borrower relationship

2. (a) A piece of new equipment has been proposed by engineers to increase the productivity of a certain manual welding operation. The investment cost is$25,000, and the equipment will have a market value of $5,000 at the end of a study period of five years. Increased productivity attributable to the equipment will amount to $8,000 per year after extra operating costs have been subtracted from the revenue generated by the additional production. Draw the cash-flow diagram for this investment opportunity. If the firm's MARR is 20% per year, is this proposal a sound one? Use the PW method to justify your answer. **3x9=27 (CO4) (PO2)**

(b) ABC Assets Management has the opportunity to purchase a certain U.S. Treasury bond that matures in eight years and has a face value of $10,000. The bond stipulates a fixed nominal interest rate of 8% per year, but interest payments are made to the bondholder every three months. ABC would like to earn 10% nominal interest (compounded quarterly) per year on his investment, because interest rates in the economy have risen since the bond was issued. How much should Stan be willing to pay for the bond? Show all calculations.

(c) In 1915, Albert Epstein allegedly borrowed $7,000 from a large New York bank on the condition that he would repay 7% of the loan every three months, until a total of 50 payments had been made. At the time of the 50th payment, the$7,000 loan would be completely repaid. Albert computed his annual interest rate to be [0.07($7,000) × 4]/$7,000 = 0.28 (28%).
(i) What true effective annual interest rate did Albert pay?
(ii) What, if anything, was wrong with his calculation? Give convincing answer.

3. (a)The La Salle Bus Company has decided to purchase a new bus for $85,000 with a trade-in of their old bus. The old bus has a BV of $10,000 at the time of the trade-in. The new bus will be kept for 10 years before being sold. Its estimated SV at that time is expected to be $5,000. Calculate depreciation amount and book values at the end of each year by using 200% DB with switchover to SL method. Show all results for the methods in tabular forms. **2x15=30 (CO3) (PO3)**

(b) Suppose that you are analyzing the following six mutually exclusive alternatives for a small investment project, using the IRR method. The useful life of each alternative is 10 years, and the MARR is 10% per year. If the study period is 10 years, and the market (salvage) values are zero, which alternative should be chosen? Specify the reasons.

Alternatives

	A	B	C	D	E	F
Capital investment	$900	$1,500	$2,500	$4,000	$5,000	$7,000
Annual revenues less expenses	150	276	400	925	1,125	1,425

4. (a) Tempe is considering four mutually exclusive public-works projects. Their costs and benefits are presented in the table below. Each project has a useful life of 50 years and the MARR is 12% per year. Which of the projects, if any, should be selected? Use incremental B-C (PW Conventional) analysis. **14 (CO4) (PO3)**

	A	B	C	D
Capital investment	$23,000,000	$18,000,000	$31,000,000	$26,000,000
Annual op. &maint. exp.	1,800,000	1,200,000	2,100,000	2,000,000
Market value	2,400,000	2,200,000	4,000,000	3,100,000
Annual benefit	5,000,000	4,500,000	6,500,000	5,800,000

(b) Consider a proposal to enhance the vision system used by a postal service to sort mail. The new system is estimated to cost $1.1 million and will incur an additional $200,000 per year in maintenance costs. The system will produce annual savings of $500,000 each year primarily by decreasing the percentage of misdirected mail and reducing the amount of mail that must be sorted manually. The MARR is 10% per year, and the study period is five years at which time the system will be technologically obsolete (worthless). Determine how sensitive the decision to invest in the system is to the estimates of investment cost and annual savings. **13 (CO4) (PO3)**

5. (a) Based on the following information for Mara Corporation, prepare an income statement for 2002 and balance sheets for 2001 and 2002. Next, calculate cash flow from assets, cash flow to creditors, and cash flow to stockholders for Mara for 2002. Use a 35 percent tax rate throughout. **2x15=30 (CO4) (PO3)**

	2001	2002
Sales	$4,203	$4,507
Cost of goods sold	2,422	2,633
Depreciation	785	952
Interest	180	196
Dividends	225	250
Current assets	2,205	2,429
Net fixed assets	7,344	7,650
Current liabilities	1,003	1,255
Long-term debt	3,106	2,085

(b) What are the principal criteria of Islamic investment? Provide a list of activities that are impermissible to invest and give financing according to the Sharia. Discuss the main challenges of Sharia-based banks and other financial institutions currently facing.

APPENDIX C

Interest and Annuity Tables for Discrete Compounding

For various values of i from 1/4% to 25%,

i = effective interest rate per period (usually one year);
N = number of compounding periods;

$$(F/P, i\%, N) = (1+i)^N;$$

$$(P/F, i\%, N) = \frac{1}{(1+i)^N};$$

$$(F/A, i\%, N) = \frac{(1+i)^N - 1}{i};$$

$$(P/A, i\%, N) = \frac{(1+i)^N - 1}{i(1+i)^N};$$

$$(A/F, i\%, N) = \frac{i}{(1+i)^N - 1};$$

$$(A/P, i\%, N) = \frac{i(1+i)^N}{(1+i)^N - 1};$$

$$(P/G, i\%, N) = \frac{1}{i}\left[\frac{(1+i)^N - 1}{i(1+i)^N} - \frac{N}{(1+i)^N}\right];$$

$$(A/G, i\%, N) = \frac{1}{i} - \frac{N}{(1+i)^N - 1}.$$

TABLE C-13 Discrete Compounding; $i = 10\%$

	Single Payment		Uniform Series				Uniform Gradient		
	Compound Amount Factor	Present Worth Factor	Compound Amount Factor	Present Worth Factor	Sinking Fund Factor	Capital Recovery Factor	Gradient Present Worth Factor	Gradient Uniform Series Factor	
N	To Find F Given P F/P	To Find P Given F P/F	To Find F Given A F/A	To Find P Given A P/A	To Find A Given F A/F	To Find A Given P A/P	To Find P Given G P/G	To Find A Given G A/G	N
1	1.1000	0.9091	1.0000	0.9091	1.0000	1.1000	0.000	0.0000	1
2	1.2100	0.8264	2.1000	1.7355	0.4762	0.5762	0.826	0.4762	2
3	1.3310	0.7513	3.3100	2.4869	0.3021	0.4021	2.329	0.9366	3
4	1.4641	0.6830	4.6410	3.1699	0.2155	0.3155	4.378	1.3812	4
5	1.6105	0.6209	6.1051	3.7908	0.1638	0.2638	6.862	1.8101	5
6	1.7716	0.5645	7.7156	4.3553	0.1296	0.2296	9.684	2.2236	6
7	1.9487	0.5132	9.4872	4.8684	0.1054	0.2054	12.763	2.6216	7
8	2.1436	0.4665	11.4359	5.3349	0.0874	0.1874	16.029	3.0045	8
9	2.3579	0.4241	13.5795	5.7590	0.0736	0.1736	19.422	3.3724	9
10	2.5937	0.3855	15.9374	6.1446	0.0627	0.1627	22.891	3.7255	10
11	2.8531	0.3505	18.5312	6.4951	0.0540	0.1540	26.396	4.0641	11
12	3.1384	0.3186	21.3843	6.8137	0.0468	0.1468	29.901	4.3884	12
13	3.4523	0.2897	24.5227	7.1034	0.0408	0.1408	33.377	4.6988	13
14	3.7975	0.2633	27.9750	7.3667	0.0357	0.1357	36.801	4.9955	14
15	4.1772	0.2394	31.7725	7.6061	0.0315	0.1315	40.152	5.2789	15
16	4.5950	0.2176	35.9497	7.8237	0.0278	0.1278	43.416	5.5493	16
17	5.0545	0.1978	40.5447	8.0216	0.0247	0.1247	46.582	5.8071	17
18	5.5599	0.1799	45.5992	8.2014	0.0219	0.1219	49.640	6.0526	18
19	6.1159	0.1635	51.1591	8.3649	0.0195	0.1195	52.583	6.2861	19
20	6.7275	0.1486	57.2750	8.5136	0.0175	0.1175	55.407	6.5081	20
21	7.4002	0.1351	64.0025	8.6487	0.0156	0.1156	58.110	6.7189	21
22	8.1403	0.1228	71.4027	8.7715	0.0140	0.1140	60.689	6.9189	22
23	8.9543	0.1117	79.5430	8.8832	0.0126	0.1126	63.146	7.1085	23
24	9.8497	0.1015	88.4973	8.9847	0.0113	0.1113	65.481	7.2881	24
25	10.8347	0.0923	98.3471	9.0770	0.0102	0.1102	67.696	7.4580	25
30	17.4494	0.0573	164.4940	9.4269	0.0061	0.1061	77.077	8.1762	30
35	28.1024	0.0356	271.0244	9.6442	0.0037	0.1037	83.987	8.7086	35
40	45.2593	0.0221	442.5926	9.7791	0.0023	0.1023	88.953	9.0962	40
45	72.8905	0.0137	718.9048	9.8628	0.0014	0.1014	92.454	9.3740	45
50	117.3909	0.0085	1163.9085	9.9148	0.0009	0.1009	94.889	9.5704	50
60	304.4816	0.0033	3034.8164	9.9672	0.0003	0.1003	97.701	9.8023	60
80	2048.4002	0.0005	20474.0021	9.9951	[a]	0.1000	99.561	9.9609	80
100	13780.6123	0.0001	137796.1234	9.9993	[a]	0.1000	99.920	9.9927	100
∞				10.0000		0.1000			∞

[a] Less than 0.0001.

TABLE C-14 Discrete Compounding; $i = 12\%$

	Single Payment		Uniform Series				Uniform Gradient		
	Compound Amount Factor	Present Worth Factor	Compound Amount Factor	Present Worth Factor	Sinking Fund Factor	Capital Recovery Factor	Gradient Present Worth Factor	Gradient Uniform Series Factor	
N	To Find F Given P F/P	To Find P Given F P/F	To Find F Given A F/A	To Find P Given A P/A	To Find A Given F A/F	To Find A Given P A/P	To Find P Given G P/G	To Find A Given G A/G	N
1	1.1200	0.8929	1.0000	0.8929	1.0000	1.1200	0.000	0.0000	1
2	1.2544	0.7972	2.1200	1.6901	0.4717	0.5917	0.797	0.4717	2
3	1.4049	0.7118	3.3744	2.4018	0.2963	0.4163	2.221	0.9246	3
4	1.5735	0.6355	4.7793	3.0373	0.2092	0.3292	4.127	1.3589	4
5	1.7623	0.5674	6.3528	3.6048	0.1574	0.2774	6.397	1.7746	5
6	1.9738	0.5066	8.1152	4.1114	0.1232	0.2432	8.930	2.1720	6
7	2.2107	0.4523	10.0890	4.5638	0.0991	0.2191	11.644	2.5515	7
8	2.4760	0.4039	12.2997	4.9676	0.0813	0.2013	14.471	2.9131	8
9	2.7731	0.3606	14.7757	5.3282	0.0677	0.1877	17.356	3.2574	9
10	3.1058	0.3220	17.5487	5.6502	0.0570	0.1770	20.254	3.5847	10
11	3.4785	0.2875	20.6546	5.9377	0.0484	0.1684	23.129	3.8953	11
12	3.8960	0.2567	24.1331	6.1944	0.0414	0.1614	25.952	4.1897	12
13	4.3635	0.2292	28.0291	6.4235	0.0357	0.1557	28.702	4.4683	13
14	4.8871	0.2046	32.3926	6.6282	0.0309	0.1509	31.362	4.7317	14
15	5.4736	0.1827	37.2797	6.8109	0.0268	0.1468	33.920	4.9803	15
16	6.1304	0.1631	42.7533	6.9740	0.0234	0.1434	36.367	5.2147	16
17	6.8660	0.1456	48.8837	7.1196	0.0205	0.1405	38.697	5.4353	17
18	7.6900	0.1300	55.7497	7.2497	0.0179	0.1379	40.908	5.6427	18
19	8.6128	0.1161	63.4397	7.3658	0.0158	0.1358	42.998	5.8375	19
20	9.6463	0.1037	72.0524	7.4694	0.0139	0.1339	44.968	6.0202	20
21	10.8038	0.0926	81.6987	7.5620	0.0122	0.1322	46.819	6.1913	21
22	12.1003	0.0826	92.5026	7.6446	0.0108	0.1308	48.554	6.3514	22
23	13.5523	0.0738	104.6029	7.7184	0.0096	0.1296	50.178	6.5010	23
24	15.1786	0.0659	118.1552	7.7843	0.0085	0.1285	51.693	6.6406	24
25	17.0001	0.0588	133.3339	7.8431	0.0075	0.1275	53.105	6.7708	25
30	29.9599	0.0334	241.3327	8.0552	0.0041	0.1241	58.782	7.2974	30
35	52.7996	0.0189	431.6635	8.1755	0.0023	0.1223	62.605	7.6577	35
40	93.0510	0.0107	767.0914	8.2438	0.0013	0.1213	65.116	7.8988	40
45	163.9876	0.0061	1358.2300	8.2825	0.0007	0.1207	66.734	8.0572	45
50	289.0022	0.0035	2400.0182	8.3045	0.0004	0.1204	67.762	8.1597	50
60	897.5969	0.0011	7471.6411	8.3240	0.0001	0.1201	68.810	8.2664	60
80	8658.4831	0.0001	72145.6925	8.3324	[a]	0.1200	69.359	8.3241	80
100	83522.2657	[a]	696010.5477	8.3332	[a]	0.1200	69.434	8.3321	100
∞				8.3333		0.1200			∞

[a] Less than 0.0001.

TABLE C-15 Discrete Compounding; $i = 15\%$

	Single Payment		Uniform Series				Uniform Gradient		
	Compound Amount Factor	Present Worth Factor	Compound Amount Factor	Present Worth Factor	Sinking Fund Factor	Capital Recovery Factor	Gradient Present Worth Factor	Gradient Uniform Series Factor	
N	To Find F Given P F/P	To Find P Given F P/F	To Find F Given A F/A	To Find P Given A P/A	To Find A Given F A/F	To Find A Given P A/P	To Find P Given G P/G	To Find A Given G A/G	N
1	1.1500	0.8696	1.0000	0.8696	1.0000	1.1500	0.000	0.0000	1
2	1.3225	0.7561	2.1500	1.6257	0.4651	0.6151	0.756	0.4651	2
3	1.5209	0.6575	3.4725	2.2832	0.2880	0.4380	2.071	0.9071	3
4	1.7490	0.5718	4.9934	2.8550	0.2003	0.3503	3.786	1.3263	4
5	2.0114	0.4972	6.7424	3.3522	0.1483	0.2983	5.775	1.7228	5
6	2.3131	0.4323	8.7537	3.7845	0.1142	0.2642	7.937	2.0972	6
7	2.6600	0.3759	11.0668	4.1604	0.0904	0.2404	10.192	2.4498	7
8	3.0590	0.3269	13.7268	4.4873	0.0729	0.2229	12.481	2.7813	8
9	3.5179	0.2843	16.7858	4.7716	0.0596	0.2096	14.755	3.0922	9
10	4.0456	0.2472	20.3037	5.0188	0.0493	0.1993	16.980	3.3832	10
11	4.6524	0.2149	24.3493	5.2337	0.0411	0.1911	19.129	3.6549	11
12	5.3503	0.1869	29.0017	5.4206	0.0345	0.1845	21.185	3.9082	12
13	6.1528	0.1625	34.3519	5.5831	0.0291	0.1791	23.135	4.1438	13
14	7.0757	0.1413	40.5047	5.7245	0.0247	0.1747	24.973	4.3624	14
15	8.1371	0.1229	47.5804	5.8474	0.0210	0.1710	26.693	4.5650	15
16	9.3576	0.1069	55.7175	5.9542	0.0179	0.1679	28.296	4.7522	16
17	10.7613	0.0929	65.0751	6.0472	0.0154	0.1654	29.783	4.9251	17
18	12.3755	0.0808	75.8364	6.1280	0.0132	0.1632	31.157	5.0843	18
19	14.2318	0.0703	88.2118	6.1982	0.0113	0.1613	32.421	5.2307	19
20	16.3665	0.0611	102.4436	6.2593	0.0098	0.1598	33.582	5.3651	20
21	18.8215	0.0531	118.8101	6.3125	0.0084	0.1584	34.645	5.4883	21
22	21.6447	0.0462	137.6316	6.3587	0.0073	0.1573	35.615	5.6010	22
23	24.8915	0.0402	159.2764	6.3988	0.0063	0.1563	36.499	5.7040	23
24	28.6252	0.0349	184.1678	6.4338	0.0054	0.1554	37.302	5.7979	24
25	32.9190	0.0304	212.7930	6.4641	0.0047	0.1547	38.031	5.8834	25
30	66.2118	0.0151	434.7451	6.5660	0.0023	0.1523	40.753	6.2066	30
35	133.1755	0.0075	881.1702	6.6166	0.0011	0.1511	42.359	6.4019	35
40	267.8635	0.0037	1779.0903	6.6418	0.0006	0.1506	43.283	6.5168	40
45	538.7693	0.0019	3585.1285	6.6543	0.0003	0.1503	43.805	6.5830	45
50	1083.6574	0.0009	7217.7163	6.6605	0.0001	0.1501	44.096	6.6205	50
60	4383.9987	0.0002	29219.9916	6.6651	[a]	0.1500	44.343	6.6530	60
80	71750.8794	[a]	478332.5293	6.6666	[a]	0.1500	44.436	6.6656	80
100	1174313.4507	[a]	7828749.6713	6.6667	[a]	0.1500	44.444	6.6666	100
∞				6.6667		0.1500			∞

[a] Less than 0.0001.

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Program: B. Sc. in Mechanical Engineering / 7th Semester
Semester: Winter

Date: 07 December, 2022
Time: 10:00 am – 1:00 pm

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

Semester Final Examination
Course Number: MPE 4721
Course Title: Manufacturing System and Automation

Winter Semester: 2021 - 2022
Full Marks: 150
Time : 3.0 Hours

There are 6 **(SIX)** questions. Answer all 6 **(SIX)** questions. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in brackets. A formula sheet is provided at the end of this question paper. Show all steps and calculations.

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1. a) Figure 1 shows an Automatic Storage and Retrieval System (ASRS) where among the activities is the pick-and-place of the storage items. Elaborate on the types of sensors and control system that are in-place to realise this fully automated ASRS system. **(10 Marks)** **(CO 3)** **(PO 2)**

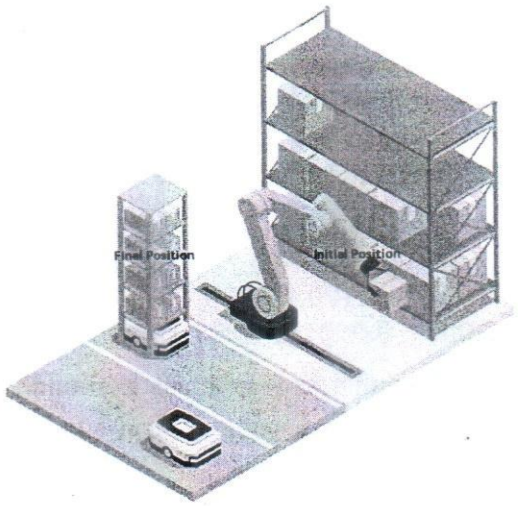

Figure1: An ASRS System

b) Propose and discuss FIVE (5) automation technologies that will convert a semi-automated CNC machining centre in Figure 2 into a fully automated system with self-inspection for dimension and surface integrity. Only occasional attention of the human labor is required. **(15 Marks)**

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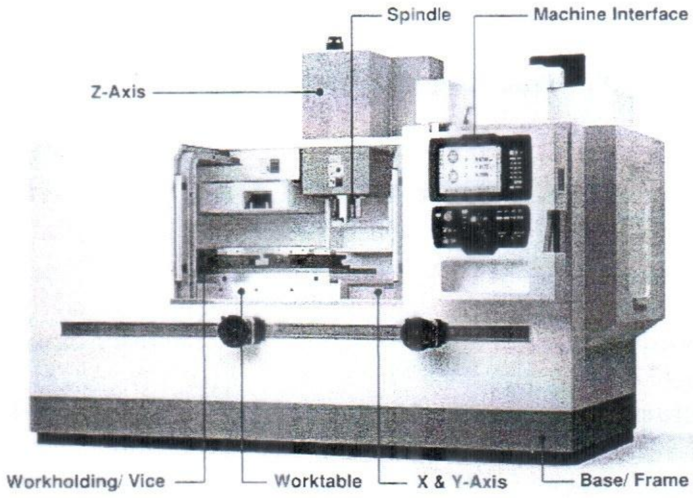

https://www.cncmasters.com/

Figure 2: An example of a CNC machine

2. a) A frame moves along its n-axis a distance of 4 units and is then rotated about the o-axis an angle of 90°. It is then translated about the n-axis and o by 4 units and 5 units respectively before finally being rotated about the a-axis by 90°. **(CO 3) (PO 2)**

i. Construct the transformation matrix. **(5 Marks)**

ii. Compute the final position of a point initially at $[1\ 3\ 5]^T$ location. **(5 Marks)**

b) The final frame orientation and positions are as follows, **(15 Marks)**

$$\begin{bmatrix} 0.579 & -0.548 & -0.604 & 8.33 \\ 0.540 & 0.813 & -0.220 & 4.50 \\ 0.611 & -0.199 & 0.766 & 12.00 \\ 0.000 & 0.000 & 0.000 & 1.000 \end{bmatrix}$$

Compute the joint variables that had to be made if similar location and orientation were to be created using spherical and RPY robot configurations.

3. a) Analyse the position, velocity, and acceleration of a robot joint in a six-degree-of-freedom industrial robot shown in Figure 3. **(10 Marks) (CO 3) (PO 2)**

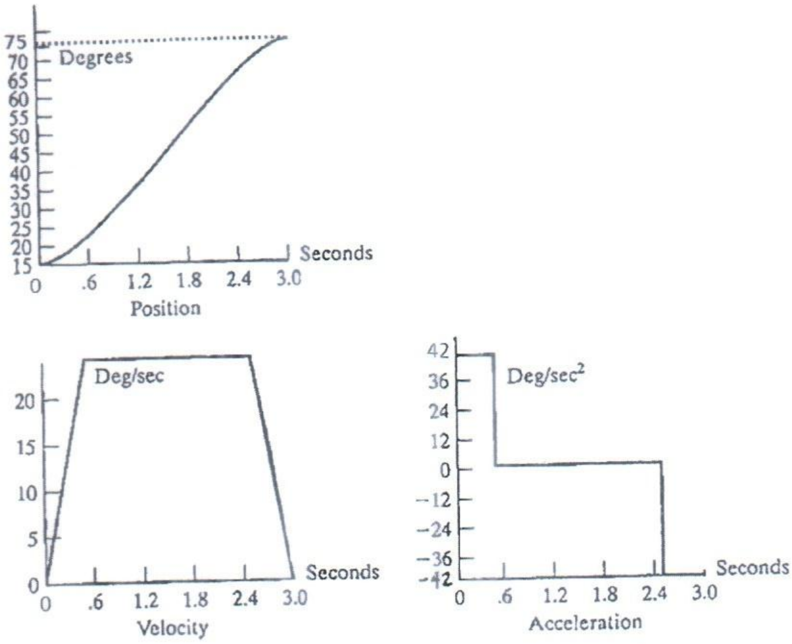

Figure 3: Position, velocity and acceleration of a robot joint

b) i. Construct a third order polynomial trajectory representing motions in part (a). **(8 Marks)**

ii. Calculate the position and velocity at 10 seconds. Comments on your answers. **(7 Marks)**

4. a) An AGVS has an average loaded travel distance per delivery = 300m. The average empty travel distance is not known. Required number of deliveries / hr = 50. Load and unload times are each 0.5min and the AGV speed =100m/min. Anticipated traffic factor = 0.85 and availability = 0.95. **(15 Marks)**

(CO 3)
(PO 2)

Develop an equation that relates the number of vehicles required to operate the system as a function of the average empty travel distance L_e.

b) An automotive assembly manufacturing plant decides to improve its work efficiency by upgrading the storage facilities. **(10 Marks)**

Suggest the appropriate storage design and configuration that suit the manufacturer requirements.

Note:

Name the part/component to be stored.

Sketch the main structure of the type of storage proposed.

5. a) A stamping plant must supply an automotive final assembly plant with sheet metal stampings. The plant operates one 8-hr shift for 250 days/yr and must produce 5,000,000 goods quality stampings annually. The batch size = 8,000 goods stampings produced per batch. Scrap rate = 3%. On average it takes 4.0 sec to produce each stamping when the presses are running. The setup time for the press equals 2.5 hr per setup. Availability of the presses is 96% during production and 100% during setup. **(15 Marks)** **(CO 4)** **(PO 2)**

i. Calculate the number of stamping presses that will be required to accomplish the specified production.

ii. Solve for the proportion of time spent setting up each batch.

b) A transfer line has six stations that function as listed in the table below. Transfer time = 0.18min. The average downtime per occurrence = 8.0min. A total of 20,000 parts must be processed through the transfer machine.

Solve for,

i. proportion downtime, **(5 Marks)**

ii. average hourly production rate, **(2 Marks)**

iii. hours of operation required to produce the 20,000 parts. **(3 Marks)**

Table 1: Process operations data

Station	Operation	Process Time	p_i
1	Load part	0.78 min	0
2	Drill three holes	1.25 min	0.02
3	Ream two holes	0.90 min	0.01
4	Tap two holes	0.85 min	0.04
5	Mill flats	1.32 min	0.01
6	Unload parts	0.45 min	0

6. a) A six-station dial-indexing machine assembles components to a base part. Table 2 tabulates the operations, element times, q and m values for components added (NA means q and m are not applicable to the operation). The indexing time is 2 sec. When a jam occurs, it requires 1.5 min to release the jam and put the machine back in operation. **(CO 4)** **(PO 2)**

Solve for the,

i. hourly production rate for the assembly machine, **(5 Marks)**

ii. yield of good product **(5 Marks)**

iii. proportion uptime of the system **(5 Marks)**

Table 2: Details of operations data

Station	Operation	Element time	q	m
1	Add part A	4 sec	0.015	0.6
2	Fasten part A	3 sec	NA	NA
3	Assemble part B	5 sec	0.01	0.8
4	Add part C	4 sec	0.02	1.0
5	Fasten part C	3 sec	NA	NA
6	Assemble part D	6 sec	0.01	0.5

(10 Marks)

b) Figure 4 shows an example of a part delivery system for an assembly process. The part delivery system is to be design for effective part delivery and assembly process.
Suggest elements that must be incorporate in the delivery system to ensure complete and effective part delivery process.

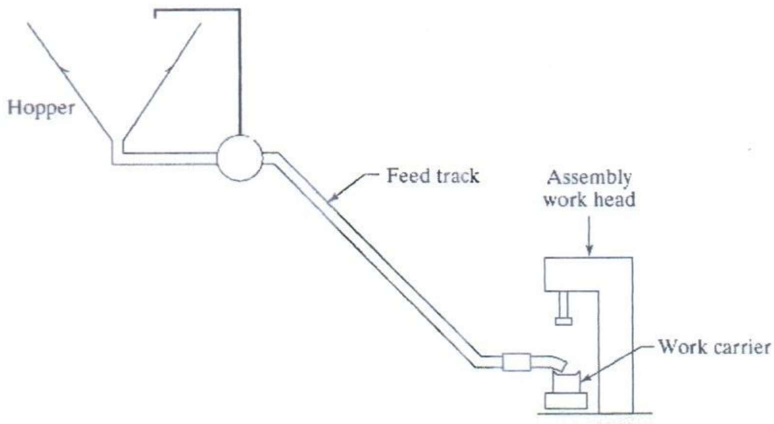

Figure 4: A part delivery system for an assembly process

FORMULA SHEET

$T_c = T_o + T_h + T_{th}$

$T_c = \text{Max}\{T_{si}\} + T_r$

$T_b = T_{su} + QT_c$

$$P_{ap} = \prod_{i=1}^{n}(1 - q_i + m_i q_i)$$

$R_p = 1/T_p$

$$P_{qp} = 1 - P_{ap} = 1 - \prod_{i=1}^{n}(1 - q_i + m_i q_i)$$

$PC_w = n\, S_w\, H_s\, R_p$

$$F = \sum_{i=1}^{n} p_i = \sum_{i=1}^{n} m_i q_i$$

$$PC_w = \frac{nS_w H_s R_p}{n_o}$$

$$D = \frac{FT_d}{T_p} = \frac{FT_d}{T_c + FT_d}$$

$U = Q / PC$

$A = (\text{MTBF} - \text{MTTR}) / \text{MTBF}$

$E + D = 1.0$

$$E = \frac{R_p}{R_c} = \frac{T_c}{T_p}$$

$MLT = n_o\,(T_{su} + QT_c + T_{no})$

$$T_p = T_c + \sum_{i=1}^{n} m_i q_i T_d$$

$$AT = 60\,AF_t E_w; \qquad R_{dv} = \frac{AT}{T_c}; \qquad WL = R_f T_c; \qquad n_c = \frac{WL}{AT}$$

$$R_{ap} = P_{ap} R_p = \frac{P_{ap}}{T_p} = \frac{\prod_{i=1}^{n}(1 - q_i + m_i q_i)}{T_p}$$

$$\boldsymbol{Rot(y,\theta)} = \begin{vmatrix} C\theta & 0 & S\theta \\ 0 & 1 & 0 \\ -S\theta & 0 & C\theta \end{vmatrix} \qquad \boldsymbol{Rot(z,\theta)} = \begin{vmatrix} C\theta & -S\theta & 0 \\ S\theta & C\theta & 0 \\ 0 & 0 & 1 \end{vmatrix} \qquad \boldsymbol{Rot(x,\theta)} = \begin{vmatrix} 1 & 0 & 0 \\ 0 & cos\theta & -sin\theta \\ 0 & sin\theta & cos\theta \end{vmatrix}$$

$$\begin{bmatrix} n_x C\phi_a + n_y S\phi_a & o_x C\phi_a + o_y S\phi_a & a_x C\phi_a + a_y S\phi_a & 0 \\ n_y C\phi_a - n_x S\phi_a & o_y C\phi_a - o_x S\phi_a & a_y C\phi_a - a_x S\phi_a & 0 \\ n_z & o_z & a_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} =$$

$$^{R}T_P = T_{\text{sph}} = \begin{bmatrix} C\beta \cdot C\gamma & -S\gamma & S\beta \cdot C\gamma & rS\beta \cdot C\gamma \\ C\beta \cdot S\gamma & C\gamma & S\beta \cdot S\gamma & rS\beta \cdot S\gamma \\ -S\beta & 0 & C\beta & rC\beta \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

$$\begin{bmatrix} C\phi_o & S\phi_o S\phi_n & S\phi_o C\phi_n & 0 \\ 0 & C\phi_n & -S\phi_n & 0 \\ -S\phi_o & C\phi_o S\phi_n & C\phi_o C\phi_n & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

$$^{R}T_P = T_{\text{cyl}} = \begin{bmatrix} C\alpha & -S\alpha & 0 & rC\alpha \\ S\alpha & C\alpha & 0 & rS\alpha \\ 0 & 0 & 1 & l \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

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BSc.Eng/7th Sem.(EEE) 9 December 2022 (Friday/Jummat 10:00 am)

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

Semester-Final Examination — Winter Semester, A.Y. 2021-2022
Course No. Hum 4721 — Time : 3 hours
Course Title: Engineering Economics — Full Marks : 100

There are **6** (Six) Questions. Answers to questions 1, 2, 3, and 6 are compulsory. Answer either question 4 or 5. Answer 5 (Five) questions altogether.
Use the graph paper wherever necessary. Marks in the margin indicate the full marks.

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1 a) Now-a-days engineering education needs to fulfill the 12 programme outcomes (PO), briefed in your class. An engineering graduate must integrate knowledge and for that should put heart-brain-and-body to be a dynamic and successful individual. In this context, relate the following statement from the perspectives of the aforesaid ground for acquiring the right knowledge that will bring positive impact to society, "*Verily, it is not the eyes that grow (human) blind, but it is the hearts (that earns knowledge) which are in the breasts that grow blind*". 5 CO1/PO8

b) After finishing Engineering Economy subject, point out the importance of time-value money and cost of money (write at least five points). 5 CO1/PO1

c) State the moral and ethics on prohibition of Riba from the point of injustice to humanity. Give references from the authentic sources in favor of your answer. 5 CO2/PO8

2 a) Narrate three main differences between present value and annuity. Show a cash flow diagram for an engineering plant having cash inflows in terms of income and cash outflows in terms of O&M costs for 10 years, with components like annuity, uniform gradient, and salvage value. Describe the significance of finding the present value for your diagram. 10 CO2/PO2

b) Suppose a researcher in IUT would like to undertake a project on energy generation for fuel-cell systems that are hydrogen and methanol-based. During lab research, three equal service providing machines need to be evaluated economically. The MARR is 10% per year. Perform the present worth analysis and select the best machine type with the costs shown in Table below. Give reason/s. 15 CO2/PO11

Items	Solar-powered Tk	Electric-powered Tk	Gas-powered Tk
Initial cost	500,000	350,000	300,000
Annual operating costs	3,000	65,000	50,000
Annual maintenance costs	1,000	10,000	10,000
Salvage value	9,000	17,000	25,000
Life, years	8	8	8

3 a) State the acronyms IRR and RoR (full meanings and practical implications) and describe how to calculate IRR for a cash flow (inflows and outflows) diagram. 8 CO3 PO2

b) The annual equivalent costs have two components, namely capital costs, and operating costs. Now, the capital recovery costs can be found by 12 CO3 PO11

$CR(i\%) = I(A/P, i\%, n) - S(A/F, i\%, n) = (I - S)(A/P, i\%, n) + iS$

Given: I = \$20,000, S = \$4,000, n = 5 yr, and i = 10%. Applying the above formula, evaluate the project and see if an annual revenue of \$4,400 is large enough to cover the capital costs or need additional revenue. Draw the necessary cash flow diagrams.

Q4 is an alternative to Q5. Answer either one.

4 a) Compare and contrast declining balance methods of depreciation from modified accelerated method and justify their naming and use with examples. 5 CO4 PO11

b) An electronic good manufacturing company has purchased a piece of equipment whose first cost is Tk.1 million with an estimated life of six years. The estimated salvage value of the equipment at the end of its lifetime is Tk. 20,000 plus thousands of the last digit of your student ID (for instance, if your ID is 180021021, add 1,000). Determine the depreciation charge and book value at the end of various years using the straight-line method of depreciation and demonstrate the calculations of the double declining balance method of depreciation. Show the results in separate tables and put your comments. 15 CO4 PO11

5 a) Depreciation and depletion are concerning issues in engineering. State their distinguishing features with specific examples. 5 CO4 PO11

b) Determine the allowable depletion charge using the 15 CO4 PO11

i. cost depletion method for year 1 only of the coal mine investment described below: Cost to acquire mine rights = \$30,000; estimated mine size = 2,000,000 kg, and amount sold in year 1 = 700,000 kg

ii. percentage depletion method for year 1 only of the coal mine investment described above. The applicable rate for the percentage depletion method is 10%. The selling price = \$0.18 per kg in year 1, and operating cost in year 1 = \$104,000.

6 You have been assigned to evaluate the sensitivity of an engineering project. Its estimated initial investment is Tk15 million at the present time, where an expected annual income of Tk3,600,000 plus thousands of the last two digits of your student ID (for instance, if your ID is 180021020, add 20,000) for five years (starting from the first year). The salvage value at the end would be Tk7.2 million. Evaluate the sensitivity of the project when RoR range is 15% to 30% increase and decrease in initial investment, annual income, project life, and salvage value. Appraise the manager between 15% and 30% increase and 15% and 30% decrease for each of the following): 20 CO4 PO11

i. Sensitivity analysis of initial investment.
ii. Sensitivity analysis of project life.
iii. Sensitivity analysis of annual income.
iv. Sensitivity analysis of salvage value.

--- End of the Question Paper ---

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

Time Value of money

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

$$Estimated \quad n - \frac{72}{RoR\%} - \frac{72}{i}$$

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

$$r = ln(1+i)$$

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

$$F = \frac{G}{i}\left[\frac{(1+i)^{n} - 1}{i}\right] - \frac{nG}{i} = \frac{G}{i}(F/G, i\%, n) - \frac{nG}{i}$$

$$A = \frac{G}{i} - \frac{nG}{i}\left[\frac{i}{(1+i)^{n} - 1}\right] = G\left[\frac{1}{i} - \frac{n}{(1+i)^{n} - 1}\right] = G\left(\frac{A}{G}, i\%, n\right)$$

$$P = A\left(\frac{P}{A}, i\%, n\right) = G\left[\frac{1}{i} - \frac{n}{(1+i)^{n} - 1}\right]\left[\frac{(1+i)^{n} - 1}{i(1+i)^{n}}\right]$$

$$= G\left\{\frac{1}{i}\left[\frac{(1+i)^{n} - 1}{i(1+i)^{n}} - \frac{n}{(1+i)^{n}}\right]\right\} = G\frac{1}{i}\left(\frac{P}{G}, i\%, n\right)$$

$$= G\frac{1}{i}\left[\left(\frac{P}{A}, i\%, n\right) - n\left(\frac{P}{F}, i\%, n\right)\right]$$

Internal rate of return:

$PW(i\%) = PV(i\%) = \sum_{t=0}^{n} F_t (1+i)^{-t}$

$FW(i\%) = FV(i\%) = \sum_{t=0}^{n} F_t (1+i)^{n-t}$ $AW(i\%) = R - E - CR(i\%)$

$CR(i\%) = I(A/P, i\%, n) - S(A/F, i\%, n)$

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

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

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

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

Benefit cost ratio:

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

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

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

Depreciation:

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

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

$$BV_t = B(1-r)^t$$

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

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

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

$$d_t^* = B - BV_t$$

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

Income tax

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

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

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

ATCF is

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

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

Thus

$ATCF_k = BTCF_k + T_k =($

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

Below are the Compound Interest Tables.

Appendix A. *10% Interest Rate Factors*

	Single Payment		Equal-Payment Series				Uniform Gradient Series
N	Compound Amount Factor, (F/P, i, N)	Present-Worth Factor, (P/F, i, N)	Compound Amount Factor, (F/A, i, N)	Sinking-Fund Factor, (A/F, i, N)	Present-Worth Factor, (P/A, i, N)	Capital Recovery Factor, (A/P, i, N)	Uniform Gradient Series Factor, (A/G, i, N)
1	1.10000	0.9090909	1.00000	1.0000000	0.9090909	1.1000000	0.0000000
2	1.21000	0.8264463	2.10000	0.4761905	1.7355372	0.5761905	0.4761905
3	1.33100	0.7513148	3.31000	0.3021148	2.4868520	0.4021148	0.9365559
4	1.46410	0.6830135	4.64100	0.2154708	3.1698654	0.3154708	1.3811679
5	1.61051	0.6209213	6.10510	0.1637975	3.7907868	0.2637975	1.8101260
6	1.77156	0.5644739	7.71561	0.1296074	4.3552607	0.2296074	2.2235572
7	1.94872	0.5131581	9.48717	0.1054055	4.8684188	0.2054055	2.6216150
8	2.14359	0.4665074	11.43589	0.0874440	5.3349262	0.1874440	3.0044786
9	2.35795	0.4240976	13.57948	0.0736405	5.7590238	0.1736405	3.3723515
10	2.59374	0.3855433	15.93742	0.0627454	6.1445671	0.1627454	3.7254605

Appendix A *15% Interest Rate Factors*

	Single Payment		Equal-Payment Series				Uniform Gradient Series
N	Compound Amount Factor, (F/P, i, N)	Present-Worth Factor, (P/F, i, N)	Compound Amount Factor, (F/A, i, N)	Sinking-Fund Factor, (A/F, i, N)	Present-Worth Factor, (P/A, i, N)	Capital Recovery Factor, (A/P, i, N)	Uniform Gradient Series Factor, (A/G, i, N)
1	1.15000	0.8695652	1.00000	1.0000000	0.8695652	1.1500000	0.0000000
2	1.32250	0.7561437	2.15000	0.4651163	1.6257089	0.6151163	0.4651163
3	1.52088	0.6575162	3.47250	0.2879770	2.2832251	0.4379770	0.9071274
4	1.74901	0.5717532	4.99338	0.2002654	2.8549784	0.3502654	1.3262573
5	2.01136	0.4971767	6.74238	0.1483156	3.3521551	0.2983156	1.7228149
6	2.31306	0.4323276	8.75374	0.1142369	3.7844827	0.2642369	2.0971904
7	2.66002	0.3759370	11.06680	0.0903604	4.1604197	0.2403604	2.4498497
8	3.05902	0.3269018	13.72682	0.0728501	4.4873215	0.2228501	2.7813286
9	3.51788	0.2842624	16.78584	0.0595740	4.7715839	0.2095740	3.0922258
10	4.04556	0.2471847	20.30372	0.0492521	5.0187686	0.1992521	3.3831958

Appendix A *20% Interest Rate Factors*

	Single Payment		Equal-Payment Series				Uniform Gradient Series
N	Compound Amount Factor, (F/P, i, N)	Present-Worth Factor, (P/F, i, N)	Compound Amount Factor, (F/A, i, N)	Sinking-Fund Factor, (A/F, i, N)	Present-Worth Factor, (P/A, i, N)	Capital Recovery Factor, (A/P, i, N)	Uniform Gradient Series Factor, (A/G, i, N)
1	1.20000	0.8333333	1.00000	1.0000000	0.8333333	1.2000000	0.0000000
2	1.44000	0.6944444	2.20000	0.4545455	1.5277778	0.6545455	0.4545455
3	1.72800	0.5787037	3.64000	0.2747253	2.1064815	0.4747253	0.8791209
4	2.07360	0.4822531	5.36800	0.1862891	2.5887346	0.3862891	1.2742176
5	2.48832	0.4018776	7.44160	0.1343797	2.9906121	0.3343797	1.6405074
6	2.98598	0.3348980	9.92992	0.1007057	3.3255101	0.3007057	1.9788276
7	3.58318	0.2790816	12.91590	0.0774239	3.6045918	0.2774239	2.2901626
8	4.29982	0.2325680	16.49908	0.0606094	3.8371598	0.2606094	2.5756231
9	5.15978	0.1938067	20.79890	0.0480795	4.0309665	0.2480795	2.8364242
10	6.19174	0.1615056	25.95868	0.0385228	4.1924721	0.2385228	3.0738622

Appendix A *25% Interest Rate Factors*

	Single Payment		Equal-Payment Series				Uniform Gradient Series
N	Compound Amount Factor, (F/P, i, N)	Present-Worth Factor, (P/F, i, N)	Compound Amount Factor, (F/A, i, N)	Sinking-Fund Factor, (A/F, i, N)	Present-Worth Factor, (P/A, i, N)	Capital Recovery Factor, (A/P, i, N)	Uniform Gradient Series Factor, (A/G, i, N)
1	1.25000	0.8000000	1.00000	1.0000000	0.8000000	1.2500000	0.0000000
2	1.56250	0.6400000	2.25000	0.4444444	1.4400000	0.6944444	0.4444444
3	1.95313	0.5120000	3.81250	0.2622951	1.9520000	0.5122951	0.8524590
4	2.44141	0.4096000	5.76563	0.1734417	2.3616000	0.4234417	1.2249322
5	3.05176	0.3276800	8.20703	0.1218467	2.6892800	0.3718467	1.5630652
6	3.81470	0.2621440	11.25879	0.0888195	2.9514240	0.3388195	1.8683320
7	4.76837	0.2097152	15.07349	0.0663417	3.1611392	0.3163417	2.1424337
8	5.96046	0.1677722	19.84186	0.0503985	3.3289114	0.3003985	2.3872478
9	7.45058	0.1342177	25.80232	0.0387562	3.4631291	0.2887562	2.6047768
10	9.31323	0.1073742	33.25290	0.0300726	3.5705033	0.2800726	2.7970975
11	11.64153	0.0858993	42.56613	0.0234929	3.6564026	0.2734929	2.9663143

Appendix A *30% Interest Rate Factors*

	Single Payment		Equal-Payment Series				Uniform Gradient Series
N	Compound Amount Factor, (F/P, i, N)	Present-Worth Factor, (P/F, i, N)	Compound Amount Factor, (F/A, i, N)	Sinking-Fund Factor, (A/F, i, N)	Present-Worth Factor, (P/A, i, N)	Capital Recovery Factor, (A/P, i, N)	Uniform Gradient Series Factor, (A/G, i, N)
1	1.30000	0.7692308	1.00000	1.0000000	0.7692308	1.3000000	0.0000000
2	1.69000	0.5917160	2.30000	0.4347826	1.3609467	0.7347826	0.4347826
3	2.19700	0.4551661	3.99000	0.2506266	1.8161129	0.5506266	0.8270677
4	2.85610	0.3501278	6.18700	0.1616292	2.1662407	0.4616292	1.1782770
5	3.71293	0.2693291	9.04310	0.1105815	2.4355698	0.4105815	1.4903075
6	4.82681	0.2071762	12.75603	0.0783943	2.6427460	0.3783943	1.7654474
7	6.27485	0.1593663	17.58284	0.0568736	2.8021123	0.3568736	2.0062818
8	8.15731	0.1225895	23.85769	0.0419152	2.9247018	0.3419152	2.2155945
9	10.60450	0.0942996	32.01500	0.0312354	3.0190013	0.3312354	2.3962725
10	13.78585	[illegible]	[illegible]				

Program: B. Sc. in ME/BSc.TE

Date: 09 December, 2022
Time: 10:00 am – 1:00 pm

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

Semester-Final Examination
Course Number: MCE 4729/MCE 4793
Course Title: Production and Operations Management

Winter Semester: 2021 - 2022
Full Marks: 150
Time : 3.0 hours

There are **5 (Five)** questions. Answer **all** questions. The symbols have their usual meanings. Marks of each question and corresponding CO and PO are written in the brackets. Assume reasonable value/s for missing data.

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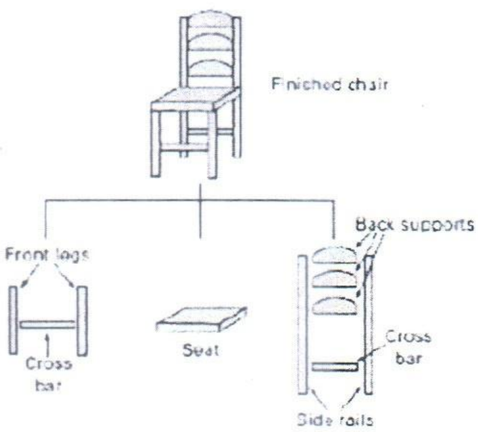
1 A company decided to manufacture following chairs. Item wise details are given below. 40 CO3 (PO3/PO7)



Item	
X	Chair
A	Leg assembly
B	Seat
C	Back assembly
D	Legs
E	Cross bar
F	Slide rails
G	Back supports

Item	Scheduled Receipts	Available	Lead time
X	Week #1 = 100	20	1
A	Week #1 =120, Week #2 = 120	50	1
B	Week #1 =250	250	2
C	Week #1 =80, Week #2 = 100	40	2
D		60	2
E		50	1
F	Week #1 = 300	150	2
G	Week #1 = 500	400	3

MPS: (Quantities must be made available in the given week)

Week:	1	2	3	4	5	6
MPS for X	80	120	100	120	120	100

i. Prepare a bill of materials tree.
ii. Prepare time-phase diagram (Overall Lead time).
ii. Develop a net material requirement plan for the given MPS for the chair using the following table format. Use separate table for each item.

Item	LT =					
Week:	1	2	3	4	5	6
Gross requirement						
Scheduled receipts						
Projected on-hand						
Net Requirement						
Planned receipts						
Planned order releases						

MRP Formulas:

Gross requirements (GR)	The total expected demand for an item or raw material during each time period without regard to the amount on hand. (For end items it is MPS; for components, these quantifies are derived from the planned-order releases of their immediate "parents."
Scheduled receipts (SR)	Open orders that have been placed and are scheduled to arrive from vendors or elsewhere in the pipeline by the beginning of a period.
Projected on hand (POH)	Expected inventory available on hand at the beginning of each time period
Net requirements (NR)	The actual amount needed in each time period.
Planned-order receipts (PORT)	The quantity expected to be received by the beginning of the period in which it is shown.
Planned-order releases (PORL)	Equals planned-order receipts offset by lead time. This amount generates gross requirements at the next level in the assembly or production chain. When an order is executed, it is removed from "planned-order releases" and entered under "scheduled receipts."

GR	Planned-order releases of immediate "parents" x No. required per unit
SR	Given
POH	POH of previous period + SR + PORT – GR
NR	GR – (POH + SR + PORT) if positive, otherwise zero
PORT	NR, in the case of Lot for Lot
PORL	PORT offset by lead time

2. Manufacturing produces a product which has a 6 months' demand cycle as shown in the table. Each unit requires 10 worker hour to be produced, at a labour cost of $6 per hour regular rate and $9 per hour for over time. The total cost per unit is estimated $ 200, but units can be subcontracted at a cost of $208 per unit. There are currently 20 workers employed in the subject departments and hiring and training cost for additional workers are $ 300 per person, whereas layoff costs are $ 400 per person. Company policy is to retain a safety stock equal to 20 percent of monthly forecast, and each month safety stock becomes the beginning inventory for next month. There are currently 50 units in stock carried at a cost of $2 per unit/month. Stock outs have been assigned a cost of $20 per unit/month. 30 CO3 (PO7)

Description	Jan	Feb	Mar	Apr	May	Jun
Forecast Demand	300	500	400	100	200	300
Workdays	22	19	21	21	22	20
Worker Hour at 8hr/day	176	152	168	168	178	160

Three aggregate plans are proposed.
Plan I. Vary the work-force size to accommodate demand.
Plan II. Maintain a constant work-force of 20 and use overtime and idle time to meet demand.

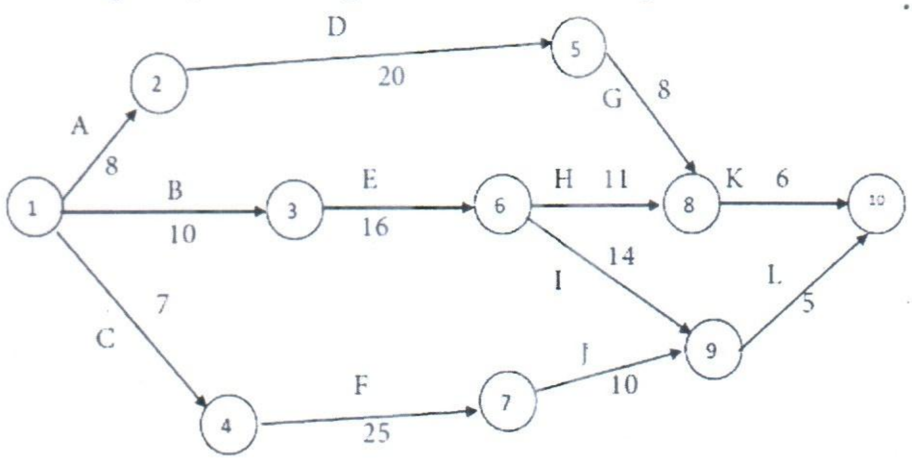
Plan – II. Maintain a constant work-force of 20 and build inventory or incur a stock out cost. The firm must begin January with the 50-unit inventory on hand.
Compare the costs of the three plans.

3. a) An R&D project has a list of tasks to be performed whose time estimates are given in the Table, as follows. 15 CO2 (PO3/PO5)

Activity i j	Activity Name	T_0	t_m (in days)	t_p
1-2	A	4	6	8
1-3	B	2	3	10
1-4	C	6	8	16
2-4	D	1	2	3
3-4	E	6	7	8
3-5	F	6	7	14
4-6	G	3	5	7
4-7	H	4	11	12
5-7	I	2	4	6
6-7	J	2	9	10

i) Draw the project network.
ii) Find the critical path.
iii)Find the probability that the project is completed in 19 days. If the probability is less than 20%, find the probability of completing it in 24 days.

3. b) Find out the completion time and the critical activities for the following project: Show in the chart earliest starting time, earliest finishing time finishing time, late starting time and late finishing time. 15 CO2 (PO3/PO5)



4. a) A job has been sub-divided into five elements. The time for each element and respective rating are given below: 10 CO4 (PO2/PO5)

Element Number	Observed Time	Rating Factor %
1	0.7	80
2	0.8	100
3	1.3	120
4	0.5	90
5	1.2	100

Calculate the normal time and standard time for each element and for the job if the allowance is 15%.

b) A manufacturer of a wet grinder tested its product to assess the maintenance performance measures. Fifty wet grinders were put in test for running time of 1000 hours. It was found that there were totally 60 failures during the testing phase. Totally 1350 hours were lost on account of identifying the problem on restoring it back to working condition. Based on this compute:
   i) Failure rate of wet grinders
   ii) MTBF and MTTR 10
   iii) Availability of wet grinder

5. An assembly consists of the following elements as given in table below. There are 345 working days and 8 hours working time per day. The schedule production is 11200 pieces per year. 30 CO2 (PO3/PO5)

   a) Draw a precedence diagram.
   b) Calculate the required work station cycle time
   c) Calculate the theoretical minimum number of work station
   d) Determine the minimum number of work-station required so as to minimize the Balance-Delay. Find the Balance-Delay station wise and put the result in tabular form.
   e) Evaluate the efficiency of line balancing.

Task	A	B	C	D	E	F	G	H	I	J	K	L
Immediate Predecessor	Nil	A	B	B	B	B	C,D	G	E	I,F	H,J	K
Task Time	12	6	6	2	2	12	7	5	1	4	6	7

Confidence Interval Critical Values, $z_{\alpha/2}$

Level of Confidence	Critical Value, $z_{\alpha/2}$
0.90 or 90%	1.645
0.95 or 95%	1.96
0.98 or 98%	2.33
0.99 or 99%	2.575

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Program: B.Sc. Engg. (ME)
Semester: 7th Sem.

Date: 07 December 2022
Time: 10:00 am – 01:00 pm

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

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

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

Winter Semester, A. Y. 2021-2022
Time: 3 Hours 00 Min(s)
Full Marks: 150

There are 6 (Six) questions. Answer all the questions.
Marks of each question and the corresponding CO and PO are written in brackets.
Do not write on this question paper.

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1. a) What is an Automobile? Discuss the general layout of a front-wheel drive automobile. [10] (CO1) (PO2)

   b) In order to convert a petrol-driven car into a CNG driven, you need to purchase a CNG kit. Explain the different components present in a CNG kit and the steps involved in its installation. [15] (CO1) (PO2)

2. a) Why the torque of an engine drops with the increase of engine speed after a certain point? Also, explain why the horsepower of the engine still keeps increasing at that point. [10] (CO1) (PO2)

   b) Spark plugs usually require a voltage of 12,000–25,000 volts or more to 'fire' properly, although it can go up to 45,000 volts. However, the output of the installed battery is only 12 volts. Explain in detail how an ignition system of an automobile generates such high voltages for the complete combustion of air-fuel mixture. [15] (CO1) (PO2)

3. a) [18] (CO2) (PO2)

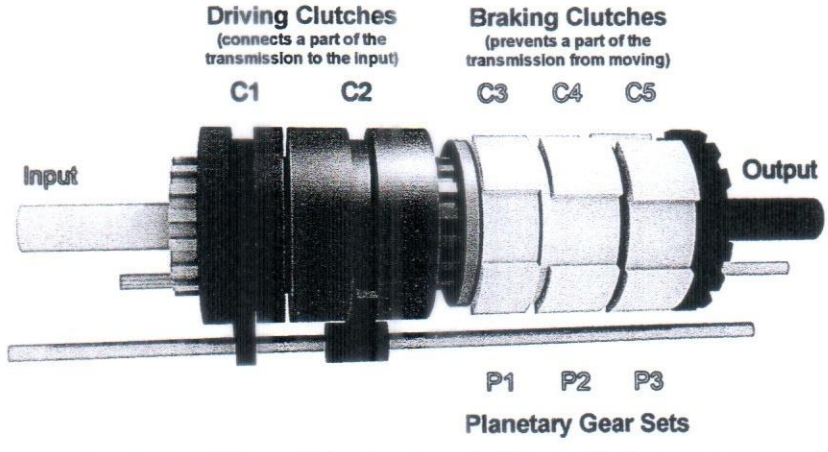

Figure 1: Allison 1000 Automatic Transmission system

Figure 1 shows the Allison 1000 Automatic Transmission system with three planetary gear sets and five different types of clutches. The internal links are connected conventionally. Different gear ratios can be achieved from various combination of clutches. Explain the functionality of the speed gears that needs to engage the C3 clutch in addition to other clutches.

   b) Explain the most common type of clutch used for the transmission system shown in Figure 1. [7] (CO2) (PO2)

4. a) What are the advantages of using Thompson Coupling over standard U joint and Rzeppa joint? [10] (CO2) (PO2)

   b) Limited slip differentials compensate for the loss of traction in one wheel and offer more control even when driving on slippery or rough roads. Torsen limited slip differentials are recently used by many automobile companies. Explain its working principle with the necessary diagram. [15] (CO2) (PO2)

5. a) What are the constructional and functional differences between Radial-ply and Cross-ply tires? [10] (CO2) (PO2)

   b) How does an air suspension system work? What are the advantages of air suspension systems over others? [15] (CO2) (PO2)

6. a) Conventional braking systems are not sufficient to stop a vehicle in an emergency situation, especially on wet or slippery surfaces. Describe any technology that can be used to increase the stability and prevent the car from spinning out of control. [10] (CO2) (PO2)

   b) What is the difference between a hybrid electric vehicle (HEV) and a plug-in hybrid electric vehicle (PHEV)? Explain with a flow diagram how a series-parallel hybrid vehicle functionally differs from a conventional vehicle. [15] (CO2) (PO2)

Programme: M.Sc.in Mechanical Engineering

15 December 2022
Time: 10:00 AM to 1:00 PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

FINAL SEMESTER EXAMINATION
Course Number : MCE 6109
Course Name : Mechanical Vibrations

WINTER SEMESTER: 2021-2022
TIME : 3 HRS
FULL MARKS : 150

There are **Six** Questions. Answer **All** 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 schematic representation of an automobile is shown in Fig.1. If the automobile weighs 2000 kg and has a radius of gyration about the center of gravity of 1.2 m, determine the natural frequencies and modes shapes with neat sketches of the automobile. Spring stiffness k_1 = 10 kN/m and k_2 = 15 kN/m. Determine the natural frequencies and mode shapes with neat sketches. Write down also the free vibration solution or motion in time for initial conditions: translational motion and velocity are 0.01 m and 0 m/s and rotational motion and velocity are 0.09 rad and 0 rad/s. (35)

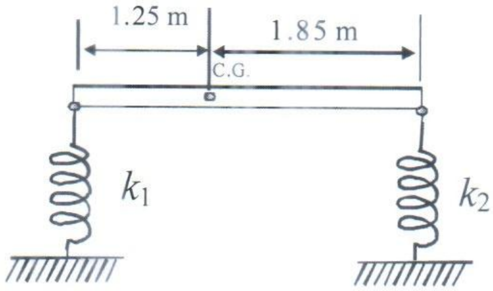

Fig. 1

2. Derive the equation of motion by Lagrange's equation for the system shown in Fig.2. (20)

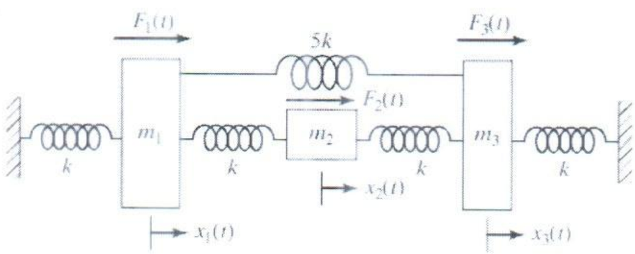

Fig.2

3. Consider the eigenvalue problem $[[k] - \omega^2[m]]\vec{X} = \vec{0}$, (30)

Where $[k] = 10000\begin{bmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix}$ and, $[m] = 10\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$.

Determine the natural frequency and the mode shapes.

4. Rigid Foundation is isolated from the machine by a resilient member shown in Fig. 3. Derive the expression of total force transmitted (F_T) to foundation, and the transmissibility ratio (T_f). Using this derived transmissibility expression, draw a figure of transmissibility vs. frequency ratio. (20)

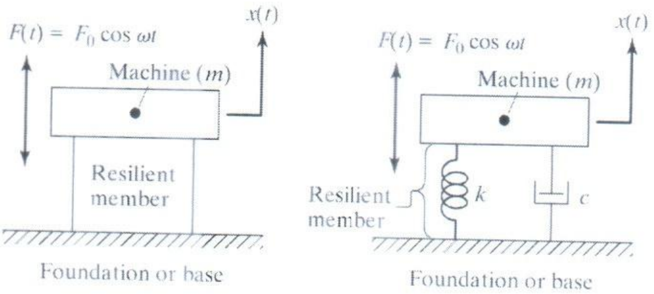

Fig. 3

5. A motor-generator set, shown in Fig. 4, is designed to operate in the speed range of 4000 to 8000 rpm. However, the set is found to vibrate violently at a speed of 6000 rpm due to a slight unbalance in the rotor. It is proposed to attach a cantilever mounted lumped-mass absorber system to eliminate the problem. When a cantilever carrying a trial mass of 3 kg tuned to 6000 rpm is attached to the set, the resulting natural frequencies of the system are found to be 5000 rpm and 7000 rpm. Design the absorber to be attached (by specifying its mass and stiffness) so that the natural frequencies of the total system fall outside the operating-speed range of the motor-generator set. (30)

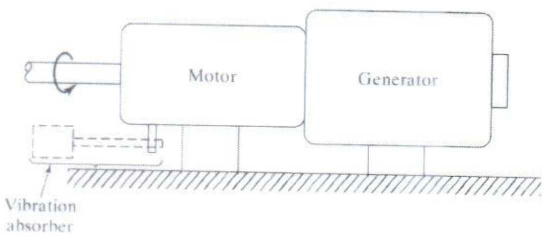

Fig. 4

The resonant frequencies may be expressed as:

$$\left.\begin{matrix} \left(\dfrac{\Omega_1}{\omega_2}\right)^2 \\ \left(\dfrac{\Omega_2}{\omega_2}\right)^2 \end{matrix}\right\} = \frac{\left\{\left[1 + \left(1 + \dfrac{m_2}{m_1}\right)\left(\dfrac{\omega_2}{\omega_1}\right)^2\right] \mp \left\{\left[1 + \left(1 + \dfrac{m_2}{m_1}\right)\left(\dfrac{\omega_2}{\omega_1}\right)^2\right]^2 - 4\left(\dfrac{\omega_2}{\omega_1}\right)^2\right\}^{1/2}\right\}}{2\left(\dfrac{\omega_2}{\omega_1}\right)^2}$$

The symbols have usual meanings.

6. A weight of 50 N is suspended from a spring of stiffness 4000 N/m and is subjected to a harmonic force of amplitude 60 N and frequency 6 Hz. Find (a) the extension of the spring due to the suspended weight, (b) the static displacement of the spring due to the maximum applied force, and (c) the amplitude of forced motion of the weight. (15)

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MSc.Eng/PhD (ME) 9 Dec 2022 (Friday/Jummat 10:00 am)

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

Semester-Final Examination — Winter Semester, A.Y. 2021-2022
Course No. MCE 6221 — Time : 3 hours
Course Title: Quality Assurance and Management — Full Marks : 150

There are **7** (Seven) Questions. Answers any 6 (six) of them.
Marks in the margin indicate the full marks.

1a "Effective quality improvement can be instrumental in increasing productivity and reducing cost". Justify this statement with examples. 8

1b What does it mean to say that product quality is multidimensional? For these dimensions give the quality characteristic of a product best known to you. 5

1c A manufacturing company has gathered the following quality related costs. Suppose you are hired as a consultant to evaluate these costs and make recommendations to management. 12

Annual quality cost factors	Amount in USD
Failure costs:	
Defective products	4,234
Engineered scrap	21,265
Non-engineered scrap	224,123
Consumer adjustments	125,654
Downgrading products	2,125,328
Lost goodwill	n/a
Customer policy changes	n/a
Appraisal costs:	
Receiving inspection	24,138
Line 1 inspection	7,256
Line 2 inspection	8,453
Spot checking	2,766
Preventive costs:	
Quality training	25,500
Process engineering:	
Corporate	132,678
Plant	44,124
Product redesign	10,422

i. Compare the ratios of prevention and appraisal costs to failure costs.
ii. Identify the strategies for reducing failure costs

2a Stating the practical meaning of quality assurance, justify why it is an integral part of an organization's processes and functions. Make credible remarks. 4

2b Draw the distinguishing features between quality assurance and quality management. 5

2c Write a comprehensive note on quality assurance and management system according to Islam. 10

2d What is value engineering? What steps should be followed in a value engineering exercise? 6

3a The "Magnificent Seven" statistical process control (SPC) tools should be widely taught throughout an organization and used routinely. What are these tools and why are they called so? Point a case and explain why these should be used. 10

3b Suppose you have collected data on a variable quality characteristic. What should be the first attempt to proceed with this data for quality analysis? How can you do that (only brief procedure)? 8

3c Draw the necessary figures and highlight the differences between specification limits and control limits. What are their practical implications under three possible circumstances? 7

4a State the hypotheses on which a process is generally evaluated and monitored. How does statistical process control (SPC) charts relate to hypothesis testing? Explain with the necessary figure(s). 7

4b Why are the Shewhart control charts insensitive to small sustained process shifts? Compare a Shewhart control chart with the one that is appropriate for such shifts. 7

4a What is rational sub-grouping concept? What role does it play in control chart construction and analysis? Explain. 6

4b What practical implication in terms of process operation do the type I and type II errors have? Illustrate this by using the necessary diagrams. 5

5a A process is to be monitored with the standard values, $\mu = 10$ and $\sigma = 2.5$. The sample size is 9

i. Find the center line and control limits for the X-bar chart.
ii. Find the center line and control limits for the R chart.
iii. Find the center line and control limits for the s chart.

5b Samples of $n = 5$ items are taken from a process at regular intervals. A normally distributed quality characteristic is measured and x-bar and s values are calculated for each sample. After 50 subgroups have been analyzed, we have 9

$$\sum_{i=1}^{50} x_i = 1{,}000 \quad \text{and} \quad \sum_{i=1}^{50} s_i = 72$$

i. Compute the control limits for x-bar and s control charts.
ii. Assume that all points on both charts plot within the control limits. What are the natural tolerance limits of the process?

5c The following x-bar and s charts information are based on $n = 4$ and have shown statistical control. 7

***x*-bar chart**	***s* chart**
UCL = 710 Center line = 700 LC = 690	UCL = 18.08 Center line = 7.979 LC = 0

i. If the specifications are at 705±15, and the process output is normally distributed, estimate the fraction nonconforming.
ii. Is the process centered to the specifications?

6a Explain six-sigma to your superior who didn't know it (what is it, why, where and how). 12

6b Suppose you recommend to a company to implement six-sigma methodology. The company asked you to describe the major challenges in six-sigma application and the main five reasons for its failure. Summarize your answers in these regards in point form but clearly and adequately. 13

7 Five methods are applied to test the performance of process output (higher is better). The data are below: 25

Method	Output/hour produced by different workers				
Method 1	17	14	24	20	24
Method 2	21	23	13	19	13
Method 3	28	30	29	24	27
Method 4	19	28	26	26	19
Method 5	21	14	13	19	15

i. What is the response variable of this exercise?
ii. What is the exploratory variable of this exercise?
iii. Is the data called balanced? Why?
iv. How many factor levels or treatments are there?
v. How many replicates are there?
vi. What is the sample size?
vii. Is it a single-factor experiment? Why?
viii. Is the analysis takes the name one-way ANOVA?
ix. Can you assume it a *completely randomized design*?
x. What could be the null and alternate hypotheses?
xi. Can the hypotheses be tested using the mean value? Why?
xii. Write the mathematical model of data with treatment component.
xiii. Find the overall mean, all treatment means, and treatment effects.
xiv. Prepare the ANOVA table and make the conclusions if a method is significant.
(Marks distribution 1 + 1 + 1 + 1 + 1 + 1 + 2 + 1 + 1 + 1 + 2 + 1 + 3 + 9 = 25)

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	x-charts				*s*-Charts				*R*-charts					
n	A	A_2	A_3	c_4	B_3	B_4	B_5	B_6	d_2	d_3	D_1	D_2	D_3	D_4
2	2.121	1.880	2.659	0.7979	0	3.267	0	2.606	1.128	0.853	0	3.686	0	3.267
3	1.732	1.023	1.954	0.8862	0	2.568	0	2.276	1.693	0.888	0	4.358	0	2.574
4	1.500	0.729	1.628	0.9213	0	2.266	0	2.088	2.059	0.880	0	4.698	0	2.282
5	1.342	0.577	1.427	0.9400	0	2.089	0	1.964	2.326	0.864	0	4.918	0	2.114
6	1.225	0.483	1.287	0.9515	0.030	1.970	0.029	1.874	2.534	0.848	0	5.078	0	2.004
7	1.134	0.419	1.182	0.9594	0.118	1.882	0.113	1.806	2.704	0.833	0.204	5.204	0.076	1.924
8	1.061	0.373	1.099	0.9650	0.185	1.815	0.179	1.751	2.847	0.820	0.388	5.306	0.136	1.864
9	1.000	0.337	1.032	0.969	0.239	1.761	0.232	1.707	2.970	0.808	0.547	5.393	0.184	1.816
10	0.949	0.308	0.975	0.9727	0.284	1.716	0.276	1.669	3.078	0.797	0.687	5.469	0.223	1.777
11	0.905	0.285	0.927	0.9754	0.321	1.679	0.313	1.637	3.173	0.787	0.811	5.535	0.256	1.744
12	0.866	0.266	0.886	0.9776	0.354	1.646	0.346	1.610	3.258	0.778	0.922	5.594	0.283	1.717
13	0.832	0.249	0.850	0.9794	0.382	1.618	0.374	1.585	3.336	0.770	1.025	5.647	0.307	1.693
14	0.802	0.235	0.817	0.9810	0.406	1.594	0.399	1.563	3.407	0.763	1.118	5.696	0.328	1.672
15	0.775	0.223	0.789	0.9823	0.428	1.572	0.421	1.544	3.472	0.756	1.203	5.741	0.347	1.653
16	0.750	0.212	0.763	0.9835	0.448	1.552	0.440	1.526	3.532	0.750	1.282	5.782	0.363	1.637
17	0.728	0.203	0.739	0.9845	0.466	1.534	0.458	1.511	3.588	0.744	1.356	5.820	0.378	1.622
18	0.707	0.194	0.718	0.9854	0.482	1.518	0.475	1.496	3.640	0.739	1.424	5.856	0.391	1.608
19	0.688	0.187	0.698	0.9862	0.497	1.503	0.490	1.483	3.689	0.734	1.487	5.891	0.403	1.597
20	0.671	0.180	0.680	0.9869	0.510	1.490	0.504	1.470	3.735	0.729	1.549	5.921	0.415	1.585
21	0.655	0.173	0.663	0.9876	0.523	1.477	0.516	1.459	3.778	0.724	1.605	5.951	0.425	1.575
22	0.640	0.167	0.647	0.9882	0.534	1.466	0.528	1.448	3.819	0.720	1.659	5.979	0.434	1.566
23	0.626	0.162	0.633	0.9887	0.545	1.455	0.539	1.438	3.858	0.716	1.710	6.006	0.443	1.557
24	0.612	0.157	0.619	0.9892	0.555	1.445	0.549	1.429	3.895	0.712	1.759	6.031	0.451	1.548
25	0.600	0.153	0.606	0.9896	0.565	1.435	0.559	1.420	3.931	0.708	1.806	6.056	0.459	1.541

Source: Adapted from Table 27 of ASTM STP 15D ASTM *Manual on Presentation of Data and Control Chart Analysis.* © 1976 American Society for Testing and Materials, Philadelphia, PA.

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Program: M. Sc./PhD (ME) / M.Sc.TE
Semester: Winter

Date: 5 December, 2022
Time: 10:00 am – 01:00 pm

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

Semester Final Examination
Course Number: MCE 6231
Course Title: Technology Management

Winter Semester: 2021 - 2022
Full Marks: 150
Time : 3 Hours

There are **6 (Six)** questions. Answer all **6 (Six)** questions. The symbols have their usual meanings. Marks in the margin indicate full marks.

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1. (a) Define Technology and describe any two latest trends in Technology Development. If you were the CEO of a manufacturing company, explain how you would adapt to the any of such two latest trends. (20+5)
   (b) Briefly elaborate the concept of civilization and identify any one major break through of technology that imparted huge impact towards the advancement of civilization.
2. (a) Briefly describe hardware development chain of Technology. If you were a high government official in the Ministry of Science and Technology, select the most vital one and explain with reasons. (20+5)
   (b)Briefly explain any one of the Technology Promotion Agents citing its importance when you are trying to foster technological development of your country as a VC of a renowned university.
3. (a) Briefly describe trademark, patent and industrial design. Also illustrate these three aspects in a fountain pen. (15+10)
   (b) Write down five differences between e-commerce and e-business. If you would like to set up a new 3D printing business, briefly point out atleast four opportunities and four threats.
4. (a) Write down the names of all stages of Technology Innovation. Select any two of them and describe their features. If you were a CEO of a manufacturing plant, identify the most prominent stages for your organization with reasons. (15+10)
   (b) Explain in short about the Greenhouse Effect in respect to impact of technology on ecology and suggest any one remedial measure that you think would be the best considering local situations.
5. (a) Write down any five key points from UNIDO's guidelines for technology transfer. Also suggest any one point from your thoughts that may be included in the guideline. (7+10+8)

(b) Illustrate the key features of Export Processing Zone including a few drawbacks. If you were a decision maker in your country, mention with logic about your viewpoint on setting up exporting processing zones.
(c) Explain UNIDO's method of pricing of technology with the mention of relevant formulas and examples.

6. (a) Define Technology Assessment and write down the steps mentioned by Porter on Technology Assessment. Among them, describe any two of them. (12+13)
(b)Describe six categories for technology climate assessment and provide an analysis of your country on its technology climate based on these six categories..