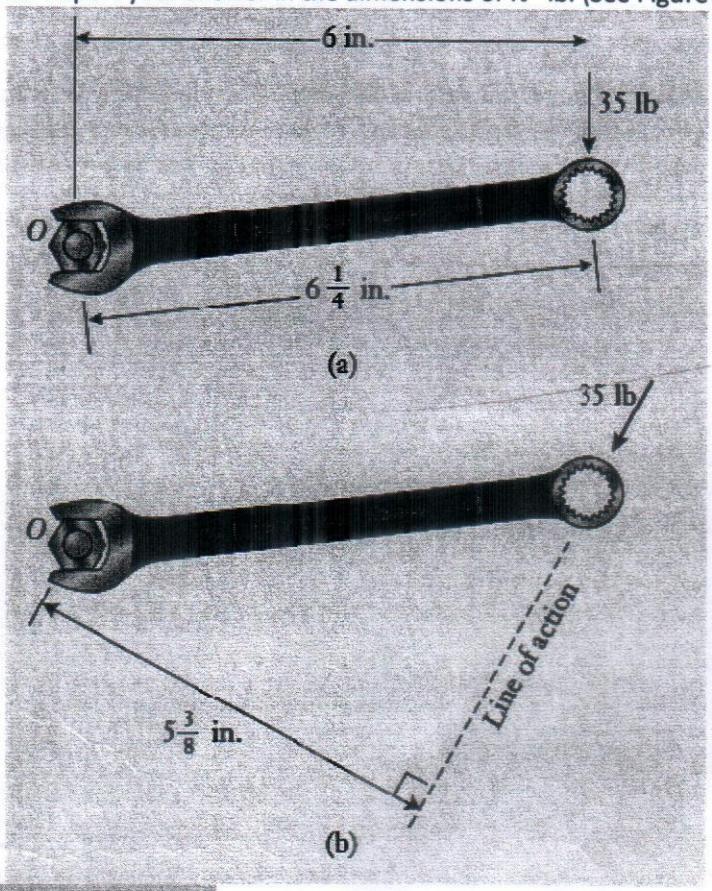
B.Sc.Engg. (M)/1st Year 30 May 2018

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

Semester Final Examination — Winter Semester, A.Y. 2017-2018
Course No. MCE 4101 — TIME : 3.0 Hours
Course Title: Introduction to Mechanical Engineering — Full Marks : 100

There are 8 (Eight) Questions. Answer any 6(six) Questions.
Marks in the margin indicate full marks. Tables and Graphs required for solving problems are attached.

1. a) The machinist's wrench is being used to tighten a hexagonal nut. Calculate the moments produced by the 35-lb force about the center of the nut when the force is applied to the wrench in the orientations (a) and (b) as shown. The overall length of the handle, which is inclined slightly upward, is 6 1/ 4 in. long between centers of the open and closed ends. Report your answer in the dimensions of ft · lb. (See Figure 1.) (8)



lb	oz	N
1	16	4.448
0.0625	1	0.2780
0.2248	3.597	1

Figure 1

b) A hydraulic-lift truck carries a shipping container on the inclined loading ramp in a warehouse (Figure 2). The 12-kN and 2-kN forces act on a rear tire as shown in the directions perpendicular and parallel to the ramp. (8-2/3)

(i) Express the resultant of those two forces as a vector using the unit vectors i and j.
(ii) Determine the magnitude of the resultant and its angle relative to the incline.

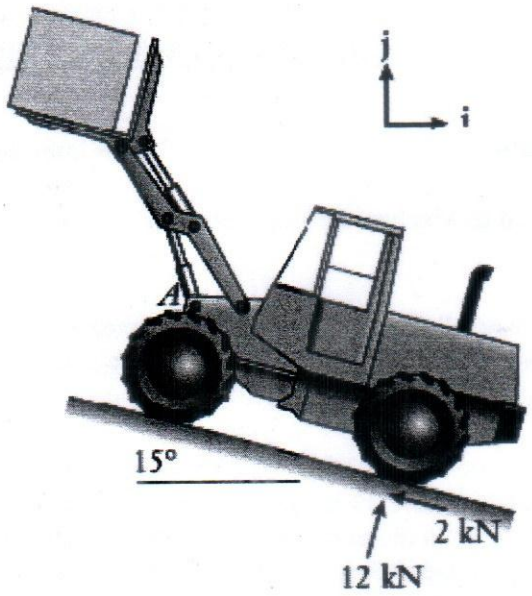


Figure 2

2 a) The U-bolt is used to attach the body (formed with I-beam construction) of a commercial moving van to its chassis (formed from hollow box channel). (See Figure 3 The U-bolt is made from a 10-mm-diameter rod, and the nuts on it are tightened until the tension in each straight section of the U-bolt is 4 kN. (9)

(i) Show how forces are transferred through this assembly by drawing free body diagrams of the U-bolt and its nuts, the body and chassis stack, and the clamping plate.

(ii) In the units of MPa, calculate the tensile stress in a straight section of the U-bolt.

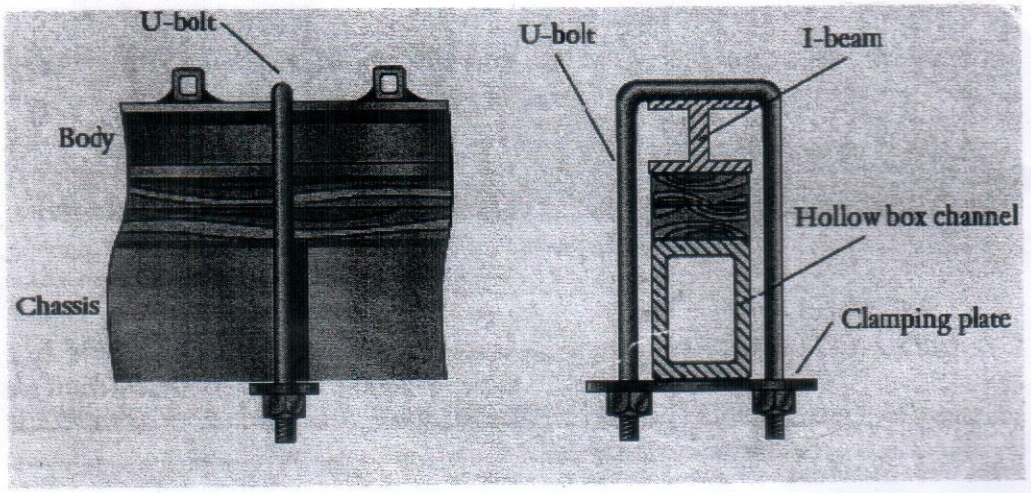


Figure 3

b) For the 10-mm-diameter steel U-bolt in above problem, determine the (a) strain, (b) change in length, and (c) change in diameter of the bolt's 325-mm-long straight section. Use the rule-of-thumb value E = 210 GPa for the elastic modulus, and take the Poisson's ratio as v = 0.3. (See Figure 4) (7- 2/3)

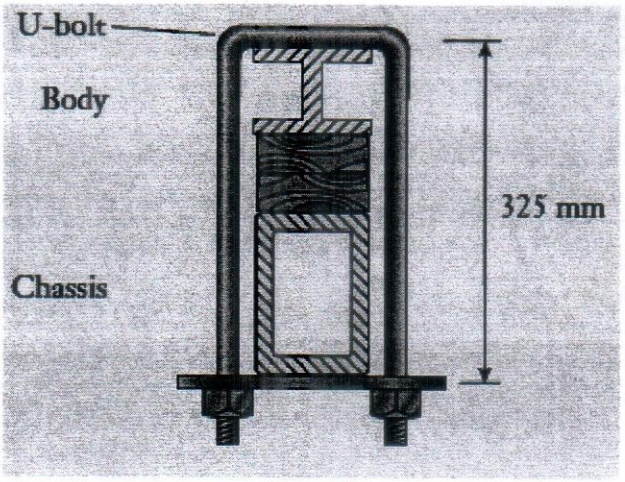


Figure 4

3. a) What do you mean by potential energy? Differentiate between Gravitational Potential Energy and Elastic Potential Energy. Write down the formula for calculating both the energy. Illustrate the components of the formulae. What are the values of gravitational acceleration in USCS and SI. (6-2/3)

   b) A lawn mower engine is started by pulling a cord wrapped around a hub of radius 6.0 cm. If a constant tension of 80 N is maintained in the cord and the hub makes three revolutions before the motor starts, how much work is done? (4)

   c) In the movie *Back to the Future*, Doc Brown and the young Marty McFly need a speed of 1000 m^2 /sec for their time machine. The mass of the machine is 242 kg. (6)
   (a) Find the required energy for the machine.
   (b) Convert that power requirement to horsepower.
   (c) If a stock DeLorean sports car produces 145 hp, how many times more power does the time machine need?

4. a) What is Heating Value of a fuel? Define British thermal unit (Btu). (4-2/3)

   b) How to calculate the heat gain and heat loss of an object? Define specific heat and latent heat. (6)

   c) A gasoline-powered engine generates an average power output of 50 kW. Neglecting any inefficiency that may be present, calculate the volume of fuel consumed each hour. Express your result in the dimensions of liters and gallons. (6)

5. a) Give examples of situations where heat is transferred through conduction, convection, and radiation. Define the term "thermal conductivity." (7-2/3)

   b) A small office has 3x 4-ft window on one wall. The window is made from single-pane glass that is 1/ 8 in. thick. While evaluating the building's heating and ventilation system, an engineer needs to calculate the heat loss through the window on a winter day. Although the temperature difference of the air inside and outside the office is much larger, the two surfaces of the glass differ by only 3°F. In units of watts, what quantity of heat is lost through the window each hour? (9)

6. a) What are the conventional USCS and SI dimensions for the density and viscosity of a fluid? In what manner does the pressure within a fluid increase with depth? (7-2/3)

   b) Blood pressure is conventionally measured in the dimensions of millimeters in a column of mercury, and the readings are expressed as two numbers, for example, 120 and 80. The first number is called the systolic value, and it is the maximum pressure developed as the heart contracts. The second number (called the diastolic reading) is the pressure when the heart is at rest. In the units of kPa and psi, what is the difference in pressure between the given systolic and diastolic readings? The density of mercury is 13.54Mg/m^3. (9)

7. a) Describe some of the differences between laminar and turbulent flows of a fluid. What is the definition of the Reynolds number, and what is its significance? (6)

b) The average velocity of blood flowing in a certain 4-mm-diameter artery in the human body is 0.28 m/s. Calculate the Reynolds number and determine whether the flow is laminar or turbulent. The viscosity and density of blood are approximately 4 cP and 1.06 Mg/m^3, respectively. (10-2/3)

8. a) Give examples of situations where fluids produce buoyancy, drag, and lift forces, and explain how those forces can be calculated. (8-2/3)

b) A low-altitude meteorological research balloon, temperature sensor, and radio transmitter together weigh 2.5 lb. When inflated with helium, the balloon is spherical with a diameter of 4 ft. The volume of the transmitter can be neglected when compared to the balloon's size. The balloon is released from ground level and quickly reaches its terminal ascent velocity. Neglecting variations in the atmosphere's density, how long does it take the balloon to reach an altitude of 1000 ft? (8)

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Tables and Graphs required for solving the problems

Quantity	Conventional Symbols	Conventional Units	
		USCS	SI
Force vector	F	lb	N
Force components	F_x, F_y, $F_{x,i}$, $F_{y,i}$	lb	N
Force magnitude	F	lb	N
Force direction	θ	deg, rad	deg, rad
Resultant	R, R, R_x, R_y	lb	N
Moment about O	M_o, $M_{o,i}$	in · lb, ft · lb	N · m
Perpendicular lever arm	d	in., ft	m
Moment component offset	Δx, Δy	in., ft	m

psi	ksi	Pa	kPa	MPa
1	10^{-3}	6.895×10^3	6.895	6.895×10^{-3}
10^3	1	6.895×10^6	6.895×10^3	6.895
1.450×10^{-4}	1.450×10^{-7}	1	10^{-3}	10^{-6}
0.1450	1.450×10^{-4}	10^3	1	10^{-3}
145.0	0.1450	10^6	10^3	1

Material	Elastic Modulus, E		Poisson's Ratio, ν	Weight Density, ρ_w	
	Mpsi	GPa		lb/ft³	kN/m³
Aluminum alloys	10	72	0.32	172	27
Copper alloys	16	110	0.33	536	84
Steel alloys	30	207	0.30	483	76
Stainless steels	28	190	0.30	483	76
Titanium alloys	16	114	0.33	276	43

*The numerical values given are representative, and values for specific materials could vary with composition and processing.

Material		Ultimate Strength, S_u		Yield Strength, S_y	
		ksi	MPa	ksi	MPa
Aluminum alloys	3003-A	16	110	6	41
	6061-A	18	124	8	55
	6061-T6	45	310	40	276
Copper alloys	Naval brass-A	54	376	17	117
	Cartridge brass-CR	76	524	63	434
Steel alloys	1020-HR	66	455	42	290
	1045-HR	92	638	60	414
	4340-HR	151	1041	132	910
Stainless steels	303-A	87	600	35	241
	316-A	84	579	42	290
	440C-A	110	759	70	483
Titanium alloy	Commercial	80	551	70	482

*The numerical values given are representative, and values for specific materials could vary with composition and processing. A = annealed, HR = hot-rolled, CR = cold-rolled, and T = tempered.

Material	E/ρ_w (m)
Steel	2.724×10^6
Aluminum	2.667×10^6
Titanium	2.651×10^6

Quantity	Conventional Symbols	Conventional Units	
		USCS	SI
Tensile stress	σ	psi, ksi, Mpsi	Pa, kPa, MPa
Shear stress	τ	psi, ksi, Mpsi	Pa, kPa, MPa
Elastic modulus	E	Mpsi	GPa
Yield strength			
Tension	S_y	ksi	MPa
Shear	S_{sy}	ksi	MPa
Ultimate strength	S_u	ksi	MPa
Strain	ε	—	—
Poisson's ratio	ν	—	—
Factor of safety	n_{tension}, n_{shear}	—	—
Stiffness	k	lb/in.	N/m

Tension and compression

Stress	$\sigma = \frac{F}{A}$
Strain	$\varepsilon = \frac{\Delta L}{L}$
Material response	$\sigma = E\varepsilon$

Rod deformation

Elongation	$\Delta L = \frac{FL}{EA}$
Diameter change	$\Delta d = -\nu d\frac{\Delta L}{L}$
Hooke's law	$F = k\Delta L$
Stiffness	$k = \frac{EA}{L}$

Shear

Stress	$\tau = \frac{V}{A}$
Yield strength	$S_{sy} = \frac{S_y}{2}$

Factor of safety

Tension	$n_{\text{tension}} = \frac{S_y}{\sigma}$
Shear	$n_{\text{shear}} = \frac{S_{sy}}{\tau}$

Fluid	Density, ρ		Viscosity, μ	
	kg/m³	slug/ft³	kg/(m · s)	slug/(ft · s)
Air	1.20	2.33×10^{-3}	1.8×10^{-5}	3.8×10^{-7}
Helium	0.182	3.53×10^{-4}	1.9×10^{-5}	4.1×10^{-7}
Freshwater	1000	1.94	1.0×10^{-3}	2.1×10^{-5}
Seawater	1026	1.99	1.2×10^{-3}	2.5×10^{-5}
Gasoline	680	1.32	2.9×10^{-4}	6.1×10^{-6}
SAE 30 oil	917	1.78	0.26	5.4×10^{-3}

Pa (N/m²)	psi (lb/in²)	psf (lb/ft²)	atm
1	1.450×10^{-4}	2.089×10^{-2}	9.869×10^{-6}
6895	1	144	6.805×10^{-2}
47.88	6.944×10^{-3}	1	4.725×10^{-4}
1.013×10^{5}	14.70	2116	1

m³/s	L/s	ft³/s	gal/s
1	1000	35.31	264.2
10^{-3}	1	3.531×10^{-2}	0.2642
2.832×10^{-2}	28.32	1	7.481
3.785×10^{-3}	3.785	0.1337	1

System	Frontal Area, A		Drag Coefficient, C_D
	ft²	m²	
Economy sedan (60 mph)	20.8	1.9	0.34
Sports car (60 mph)	22.4	2.1	0.29
Sport-utility vehicle (60 mph)	29.1	2.7	0.45
Bicycle and rider (racing)	4.0	0.37	0.9
Bicycle and rider (upright)	5.7	0.53	1.1
Person (standing)	6.7	0.62	1.2

Quantity	Conventional Symbols	Conventional Units	
		USCS	SI
Area	A	ft^2	m^2
Coefficient of drag	C_D	—	—
Coefficient of lift	C_L	—	—
Density	ρ	$slug/ft^3$	kg/m^3
Force			
Buoyancy	F_B	lb	N
Drag	F_D	lb	N
Lift	F_L	lb	N
Weight	w	lb	N
Length			
Characteristic length	l	ft	m
Pipe length	L	ft	m
Mach number	Ma	—	—
Pressure	p	psi, psf	Pa
Reynolds number	Re	—	—
Shear stress	τ	psi	Pa
Time interval	Δt	s	s
Velocity	v, v_{avg}, v_{max}	ft/s	m/s
Viscosity	μ	slug/(ft · s)	kg/(m · s)
Volume	V, ΔV	gal, ft^3	L, m^3
Volumetric flow rate	q	gal/s, ft^3/s	L/s, m^3/s

ft · lb	J	Btu	kW · h
1	1.356	1.285×10^{-3}	3.766×10^{-7}
0.7376	1	9.478×10^{-4}	2.778×10^{-7}
778.2	1055	1	2.930×10^{-4}
2.655×10^6	3.600×10^6	3413	1

Quantity	Conversion		
Work, energy, or heat	1 ft · lb	=	1.356 J
	1 Btu	=	1055 J
	1 J	=	0.7376 ft · lb
	1 J	=	9.478×10^{-4} Btu
Power	1 (ft · lb)/s	=	1.356 W
	1 hp	=	0.7457 kW
	1 W	=	0.7376 (ft · lb)/s
	1 kW	=	1.341 hp

Type	Fuel	Heating Value, H	
		MJ/kg	Btu/lbm
Gas	Natural gas	47	20.2×10^3
	Propane	46	19.8×10^3
Liquid	Gasoline	45	19.3×10^3
	Diesel	43	18.5×10^3
	Fuel oil	42	18.0×10^3
Solid	Coal	30	12.9×10^3
	Wood	20	8.6×10^3

*The numerical values are representative, and values for specific fuels could vary with their chemical composition.

Type	Substance	Specific Heat, c	
		kJ/(kg · °C)	Btu/(lbm · °F)
Liquid	Oil	1.9	0.45
	Water	4.2	1.0
Solid	Aluminum	0.90	0.21
	Copper	0.39	0.093
	Steel	0.50	0.11
	Glass	0.84	0.20

Material	Thermal Conductivity, κ	
	W/(m · °C)	(Btu/h)/(ft · °F)
Steel	45	26
Copper	390	220
Aluminum	200	120
Glass	0.85	0.50
Wood	0.3	0.17

Quantity	Conversion		
Length	1 in.	=	25.4 mm
	1 in.	=	0.0254 m
	1 ft	=	0.3048 m
	1 mi	=	1.609 km
	1 mm	=	3.9370×10^{-2} in.
	1 m	=	39.37 in.
	1 m	=	3.2808 ft
	1 km	=	0.6214 mi
Area	1 in^2	=	645.16 mm^2
	1 ft^2	=	9.2903×10^{-2} m^2
	1 mm^2	=	1.5500×10^{-3} in^2
	1 m^2	=	10.7639 ft^2
Volume	1 ft^3	=	2.832×10^{-2} m^3
	1 ft^3	=	28.32 L
	1 gal	=	3.7854×10^{-3} m^3
	1 gal	=	3.7854 L
	1 m^3	=	35.32 ft^3
	1 L	=	3.532×10^{-2} ft^3
	1 m^3	=	264.2 gal
	1 L	=	0.2642 gal
Mass	1 slug	=	14.5939 kg
	1 lbm	=	0.45359 kg
	1 kg	=	6.8522×10^{-2} slugs
	1 kg	=	2.2046 lbm
Force	1 lb	=	4.4482 N
	1 N	=	0.22481 lb
Pressure or stress	1 psi	=	6895 Pa
	1 psi	=	6.895 kPa
	1 Pa	=	1.450×10^{-4} psi
	1 kPa	=	0.1450 psi

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DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

SEMESTER FINAL EXAMINATION — WINTER SEMESTER: 2017-2018
Course No: MCE-4103 — TIME : 3HRS
Course Name: Engineering Mechanics — FULL MARKS: 200

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

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1. a) The man as shown in Fig. 1 pulls on the cord with a force of **70 lb.** Represent this force acting on the support *A* as a Cartesian vector and determine its direction. (16⅔)

   b) Romeo tries to reach Juliet by climbing with constant velocity up a rope which is knotted at point *A* as shown in Fig. 2. Any of the three segments of the rope can sustain a maximum force of **2 kN** before it breaks. Determine if Romeo, who has a mass of **65 kg,** can climb the rope, and if so, can he along with Juliet, who has a mass of **60 kg,** climb down with constant velocity? (16⅔)

2. a) The tower crane as shown in Fig. 3 is used to hoist a **2-Mg** load upward at constant velocity. The **1.5-Mg** jib *BD* and **0.5-Mg** jib *BC* have centers of mass at G_1 and G_2, respectively. Determine the required mass of the counterweight *C* so that the resultant moment produced by the load and the weight of the tower crane jibs about point *A* is zero. The center of mass for the counterweight is located at G_3. (16⅔)

   b) The wing of the jet aircraft as shown in Fig. 4 is subjected to a thrust of **T = 8 kN** from its engine and the resultant lift force **L = 45 kN.** If the mass of the wing is **2.1 Mg** and the mass center is at *G,* determine the *x, y, z* components of reaction where the wing is fixed to the fuselage *A.* (16⅔)

3. Determine the force in each member of the truss as shown in Fig. 5 and state if the members are in tension or compression. (33⅓)

4. a) The three bars as shown in Fig. 6 have a weight of $\mathbf{W_A = 20\ lb}$, $\mathbf{W_B = 40\ lb}$ and $\mathbf{W_C = 60\ lb}$, respectively. If the coefficients of static friction at the surfaces of contact are as shown, determine the smallest horizontal force *P* needed to move block *A.* (16⅔)

   b) Determine the location $(\bar{x}, \bar{y})$ of the center of gravity of the three-wheeler as shown in Fig. 7. The location of the center of gravity of each component and its weight are tabulated in the figure. If the three-wheeler is symmetrical with respect to the x–y plane, determine the normal reaction each of its wheels exerts on the ground. (16⅔)

5. a) Measurements of a shot recorded on a videotape during a basketball game as shown in Fig. 8. The ball passed through the hoop even though it barely cleared the hands of the player *B* who attempted to block it. Neglecting the size of the ball, determine the magnitude V_A of its initial velocity and the height *h* of the ball when it passes over player *B*. (16⅔)

   b) Determine the maximum height on the wall to which the firefighter can project water from the hose as shown in Fig. 9, if the speed of the water at the nozzle is $\mathbf{V_C = 48\ ft/s.}$ (16⅔)

6. a) Two planes, *A* and *B*, as shown in Fig. 10 are flying at the same altitude. If their velocities are $\mathbf{V_A = 600\ km/h,\ V_B = 500\ km/h}$ and such that the angle between their straight-line courses is $\mathbf{\theta = 75°}$. Determine the velocity of plane *B* with respect to plane *A*. (16⅔)

   b) Determine the required mass of block *A* as shown in Fig. 11 so that when it is released from rest it moves the **5-kg** block *B* a distance of **0.75 m** up along the smooth inclined plane in $\mathbf{t = 2s.}$ Neglect the mass of the pulleys and cords. (16⅔)

7. a) The girl as shown in Fig. 12 has a mass of **40 kg** and center of mass at *G*. If she is swinging to a maximum height defined by $\mathbf{\theta = 60°,}$ determine the force developed along each of the four supporting posts such as *AB* at the instant $\mathbf{\theta = 0°}$, The swing is centrally located between the posts. (16⅔)

   b) The **30-Mg** freight car *A* and **15-Mg** freight car *B* as shown in Fig. 13 are moving towards each other with the velocities shown. Determine the maximum compression of the spring mounted on car *A*. Neglect rolling resistance. (16⅔)

8. a) The driving belt as shown in Fig. 14 is twisted so that pulley *B* rotates in the opposite direction to that of drive wheel *A*. If the angular displacement of *A* is $\theta_A = (5t^3 + 10t^2)$ rad, where *t* is in seconds, determine the angular velocity and angular acceleration of *B* when $\mathbf{t = 3s.}$ (16⅔)

   b) The pendulum as shown in Fig. 15 consists of two slender rods *AB* and *OC* which have a mass of **3 kg/m.** The thin plate has a mass of **12 kg/m²** Determine the moment of inertia of the pendulum about an axis perpendicular to the page and passing through the pin at *O*. (16⅔)

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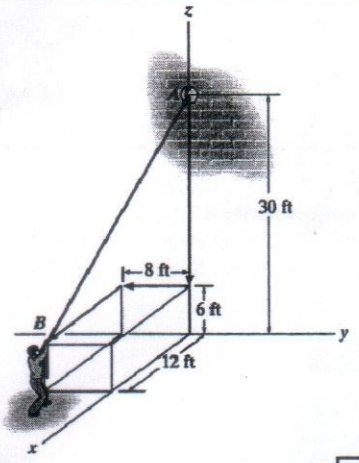

Figure 1

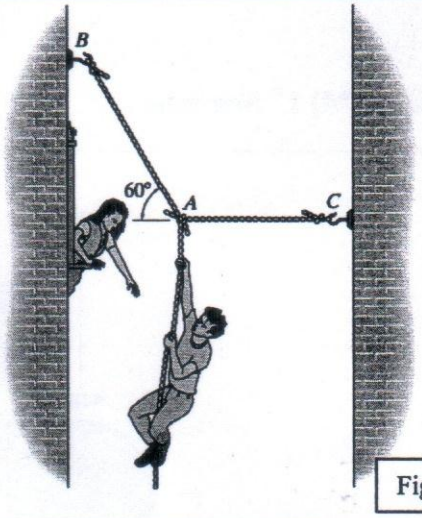

Figure 2

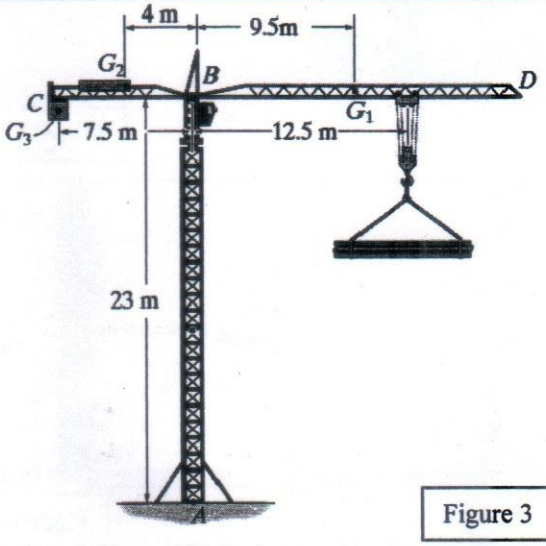

Figure 3

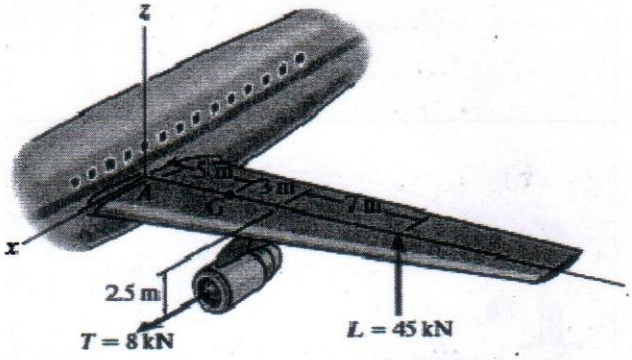

Figure 4

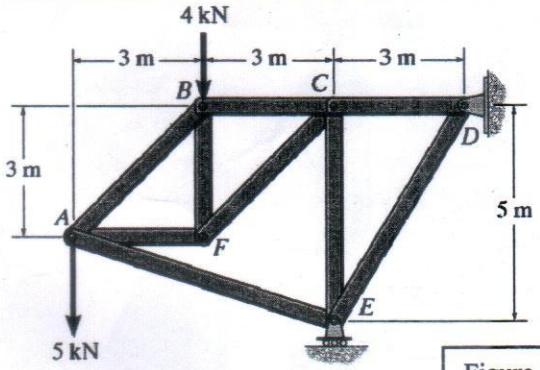

Figure 5

Figure 6

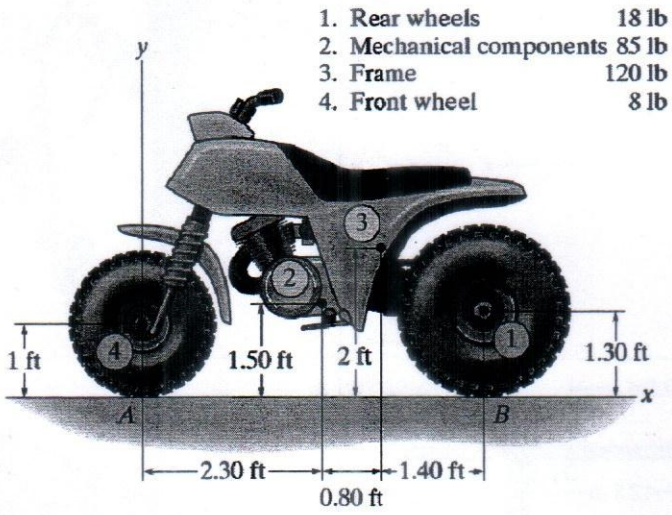

Figure 7

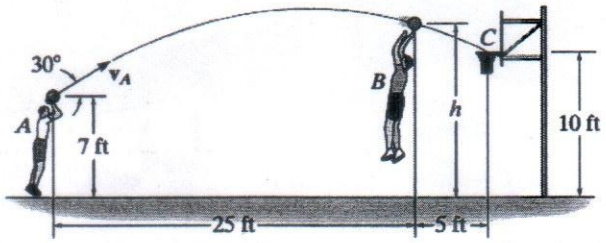

Figure 8

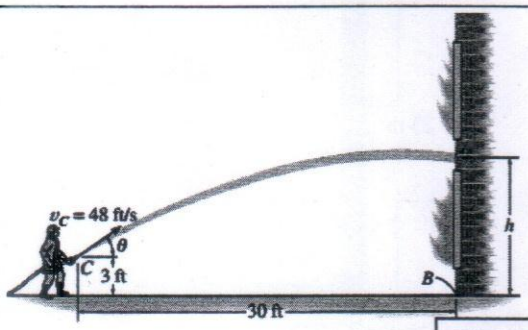

Figure 9

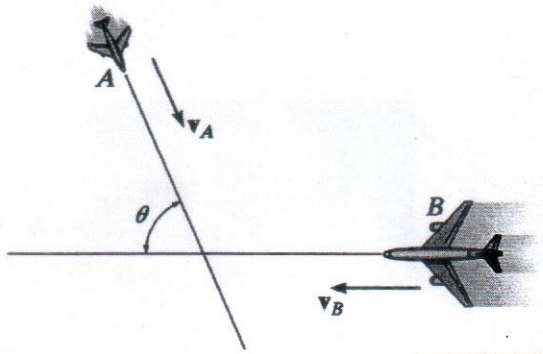

Figure 10

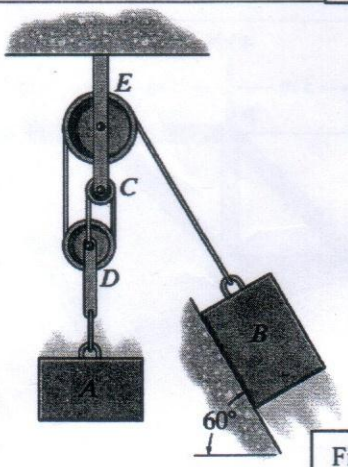

Figure 11

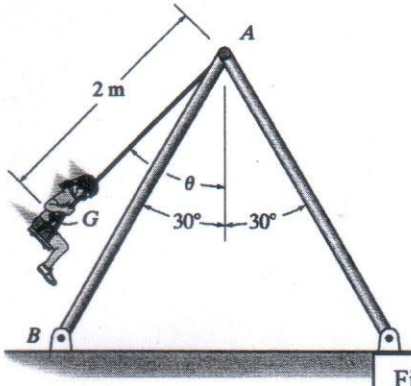

Figure 12

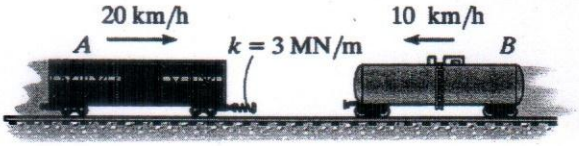

Figure 13

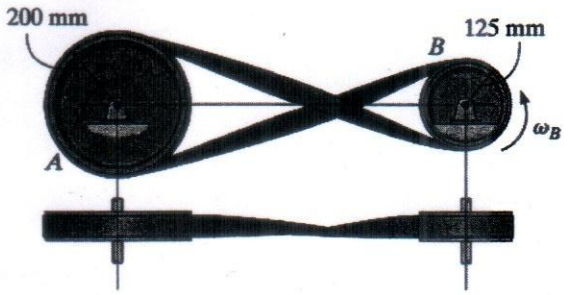

Figure 14

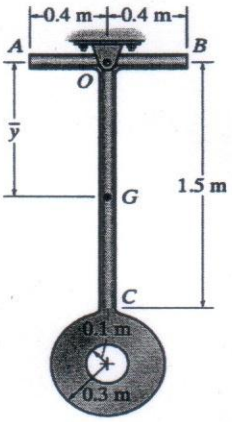

Figure 15

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B Sc. Eng.(M) (1st Semester) 28 May 2018

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

Semester Final Examination — Winter Semester, A.Y. 2017-2018
Course Code:Math 4111 — Time : 3 hours
Course Title: Solid Geometry, Differential and Integral Calculus — Full Marks: 200

There are **8 (Eight)** Questions. Answer any **6 (Six)** of them. All Questions carry equal Marks. Programmable calculators are not allowed. Do not write on this question paper.The Symbols have their usual meaning.

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1. a) Figure: 01 shows the graph of a function $g(t)$ with domain [-4, 0] and range [-3, 0]. Find the domains andranges of the following functions, and sketch their graphs.

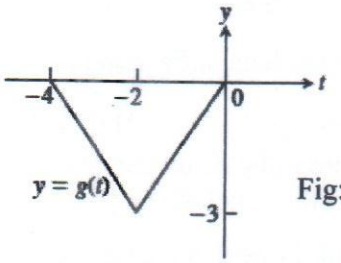

Fig: 01

(i) $g(-t)$ (ii) $-g(t)$ (iii) $g(t)+3$ (iv) $1-g(t)$ (v) $g(-t+2)$ (vi) $g(1-t)$.

b) Figure: 02 shows the graph of $f(x)$. For each of the given points determine the value of $f(a)$, $\lim_{x\to a^+} f(x)$, $\lim_{x\to a^-} f(x)$ *and* $\lim_{x\to a} f(x)$. If any of the quantities do not exist clearly explain why.(i) a = -4, (ii) a = -1 (iii) a = 2 and (iv) a = 4

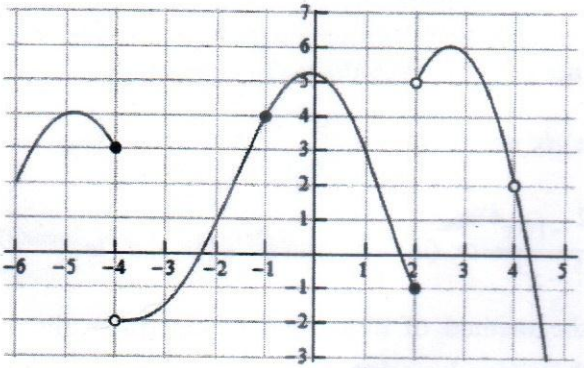
Fig: 02

2. a) (i) A rocket, rising vertically, is tracked by a radar station that is on the ground 5 mi from the Launchpad. How fast is the rocket rising when it is 4 mi high and its distance from the radar station is increasing at a rate of 2000 mi/h?

(ii) Find the critical points of $f(x) = (x^2 - 3)e^x$. Identify the open intervals on which f is increasing and decreasing. Find the function's local and absolute extreme values.

b) (i) A drilling rig 12 mile offshore is to be connected by pipe to a refinery onshore, 20 mile straight down the coast from the rig. If underwater pipe costs Tk.500, 000 per mile and land based pipe costs Tk.300, 000 per mile, what combination of the two will give the least expensive connection?

(ii) State Leibnitz's theorem and using this theorem prove that $x^2y_{n+2}+(2n-1)xy_{n+1}+(n^2+1)y_n=0$ when $y=a\cos(\ln x)+b\sin(\ln x)$

3. a) (i) Write six different indeterminate forms.

(ii) State L'Hospital's rule and evaluate the followings:

$$\lim_{x\to 1}\left(\frac{1}{\ln x}-\frac{1}{x-1}\right) \text{ and } \lim_{x\to 0}(\sin x)^x$$

b) (i) Sketch the graph of the equation $f(x)=\dfrac{x^2-2x+4}{x-2}$ and identify the locations of the intercepts, relative extrema, inflection points and asymptotes.

(ii) A function $f(x)=\ln(4+2x-x^2)$;$[-1,3]$ is given. Verify that the hypotheses of Rolle's Theorem are satisfied on the given interval, and find all values of c in that interval that satisfy the conclusion of the theorem.

4. a) Estimate the area of the region between the function $f(x)=8\ln x-x$ and the x-axis on the interval [2, 6] using n =6 and using,

(i) the right end points of the subintervals for the height of the rectangles.

(ii) the left end points of the subintervals for the height of the rectangles and.

(iii) the midpoints of the subintervals for the height of the rectangles.

(iv) And justify your answer with exact solution.

b) Evaluate each of the following integrals, if possible. If it is not possible clearly explain why it is not possible to evaluate the integral.

(i) $\int_{-2}^{4} g(x)dx$ *where* $g(x)=\begin{cases}9-2e^x; x\rangle 0\\ 8\sin(x); x\le 0\end{cases}$

(ii) $\int\dfrac{6x^2-10x^4}{x^5-x^3}dx$ (iii) $\int_0^1 e^{2z}\sin(e^{2z}-1)+\sin(z)e^{2-\cos(z)}dz$

5. a) (i) Use the method of disks/rings to determine the volume of the solid obtained by rotating the region bounded by $y=7-x^2, x=-2, x=2$ and the x-axis about the x-axis.

(ii) Determine the area of the region bounded by the set of curves
$x=3+y^2$, x =2-y^2,y = -1 and y = -2.

b) (i) Find f_{avg} for $f(x)=4x^2-x+5$ on [-2, 3] and determine the value(s) of c in [-2, 3] for which $f(c)=f_{avg}$

(ii) Use the method of cylinders to determine the volume of the solid obtained by rotating the region bounded by $y = 4x$ *and* $y = x^3$ about the y-axis assuming that $x \geq 0$.

6. a) (i) A spring has a natural length of 18 inches and a force of 20 lbs is required to stretch and hold the spring to a length of 24 inches. What is the work required to stretch the spring from a lengthof 21 inches to a length of 26 inches?

(ii) A cable that weighs ½ kg/meter is lifting a load of 150 kg that is initially at the bottom of a 50 meter shaft. How much work is required to lift the load ¼ of the way up the shaft?

b) Find the volume of a pyramid whose base is a square with sides of length L and whose height is h.

7. a) (i) Direction cosines of lines are given by the relations
$al + bm + cn = 0$ *and* $mn + nl + lm = 0$, prove that the lines are perpendicular if $a^{-1} + b^{-1} + c^{-1} = 0$ and parallel if $\sqrt{a} + \sqrt{b} + \sqrt{c} = 0$

(ii) Find the equation of the plane which passes through the point (3, -3, 1) and normal to the line joining to the points (3, 2, -1) and (2, -1, 5)

b) (i) Find the distance of the point (1, -2, 3) from the plane $x - y + z = 5$, measured parallel to the line $\frac{x}{2} = \frac{y}{3} = \frac{z}{-6}$.

(ii) Show that the lines $\frac{x+4}{3} = \frac{y+6}{5} = \frac{z-1}{-2}$ *and* $3x - 2y + z + 5 = 0 = 2x + 3y + 4z - 4$ are coplanar. Also find their point of intersection and the plane in which they lie.

8. a) (i) Find the equation of the sphere passing through the circle is $x^2 + y^2 + z^2 - 6x - 2z + 5 = 0$, $y = 0$ and touches the plane $3x + 4z + 5 = 0$.

(ii) Find the equation of the right circular cone whose vertex is at the origin, whose axis is the line $\frac{x}{1} = \frac{y}{2} = \frac{z}{3}$ and which has semi-vertical angle of 30^0.

b) (i) Find the equation of the cone whose vertex is at the origin and guiding curve is $\frac{x^2}{4} + \frac{y^2}{9} + \frac{z^2}{1} = 1,\ x + y + z = 1$.

(ii) The radius of a normal section of a right circular cylinder is 2 units, the axis lies along the straight line $\frac{x-1}{2} = \frac{y+3}{-1} = \frac{z-2}{5}$. Find its equation.

B.Sc. Engg.(M)/1st Sem. 20 05 June, 2018

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination — Winter Semester 2017-2018
Course Code: Phy 4113 — Time: 3 HRS.
Course Title : Structure of Matter, Electricity & Magnetism and Modern Physics — Full Marks: 150

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

1. (a) Define electric flux. State Gauss's law in electrostatics and hence obtain the expression for the Coulomb's law of electrostatic force between two electric charges from it. (18 + 7)
   (b) Using Gauss's law calculate the electric field strength, E, at a distance 'r' from a nonconducting infinite line of charge of linear charge density λ(C/m).

2. (a) Derive the expressions for the growth and decay of charges when a capacitor is charged and discharged, respectively through a resistor. What is capacitive time constant? (18 + 7)
   (b) A capacitor of 2.0 μF has been charged through a shunted high resistor. If half the charge leaks away in 60 s, find the value of the resistor.

3. (a) State and explain Ampere's law. Obtain an expression for the torque acting on a current carrying rectangular coil placed in a uniform magnetic field **B** perpendicularly to the plane of the coil. (18 + 7)
   (b) A long straight wire carries a current 30 A. An electron is travelling at 10^8 m/s is 3.0 cm from the wire. Find the force acts on the electron if its motion is directed towards the wire and parallel to the wire. ($\mu_o = 4\pi \times 10^{-7}$ wb/A-m).

4. (a) What is length contraction in special theory of relativity? Obtain an expression for length contraction. (18 + 7)
   (b) What would be the speed of a passenger who wishes to pass a spacecraft, whose speed with respect to the earth is 0.95c, at a relative speed of 0.6c?

5. (a) State the postulates of special theory of relativity. Derive Einstein's Mass-energy relation. (18 + 7)
   (b) Show that at low speeds the relativistic kinetic energy expression reduces to classical kinetic energy expression? Draw the kinetic energy/m_0c^2 (relativistic and classical) against v/c curves.

6. (a) What do you mean by Compton effect? Derive an expression for the change in wavelength of an incident X-ray photon on an electron at rest. What is Compton wavelength? (18 + 7)

(b) X-rays of wavelength 1.0 nm are scattered from a carbon target. The scattered x-rays are observed at an angle of 55° with the direction of the incident x-rays. What is the wavelength of the scattered X-rays? Calculate the energies of the incident and scattered photons. (Electron rest mass = 9.11×10^{-31} kg, h = 6.63×10^{-34} J-s, c = 3×10^{8} m/s).

7. (a) How many crystal systems are there? Write down the names of the crystal systems along with their lattice constants and interfacial angles. (10+9+6)
(b) Briefly discuss different types of bonds in solids.
(c) Draw the following planes in a cubic crystal structure: (010), (011) (101) and (111).

8. Write short notes on the followings: (25/3x3=25)
(a) Charge is conserved.
(b) Discuss galilean transformation and its limitations.
(c) Matter wave and wave function.

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B.Sc Engg.(M)/1st Sem 07 June 2018

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

THE ORGANIZATION OF THE ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICALAND CHEMICAL ENGINEERING

SEMESTER FINAL EXAMINATION **WINTER SEMESTER 2017-2018**

Course No.:Chem-4115 Time: 3 hours

Course title: Physical and Inorganic Chemistry Full Marks: 150

Programmable calculators are not allowed. Do not write anything on the question paper

There are **8(eight)** questions. Answer any **6(six)** of them

Figures in the right margin indicate full marks.

Q1. a) Name and define Chemical bonds. Give a comparative picture of Ionic and Covalent Compounds. [10]

b) Draw the molecular diagram of NO and CN and explain the bond order and magnetic properties of them. [10]

c) Show the hybridization in Carbon. [5]

Q2. a) Define chemical potential and Gibb's free energy. [6]

b) Derive a mathematical equation relating the free energy change (ΔG) and equilibrium constant (K). Mention the significance of the obtained equation. [12]

c) Calculate Kp for the reaction $N_2(g) + O_2(g) \leftrightarrow 2NO(g)$ at 25^0C, when the value of standard free energy (ΔG^o) is 173 KJ. Comment on the result. [7]

[5]

Q3. a) What are the fundamental particles of an atom? Briefly describe them. [6]

b) Discuss Bohr's theory of hydrogen atom. What modifications were proposed by Sommerfeld and why? [10]

c) Derive the equation for calculating the Energy of electron in the orbit of hydrogen atom and calculate energy of the electron in the 4^{th} Orbit. [9]

Q4. a) Name the types of Enthalpy change(ΔH). Find out the relationship between Temperature and Equilibrium Constant(K).Use diagram. [10]

b) What do you understand by Electrochemical cell? Draw and explain Galvanic cell. What is salt bridge? [10]

c) Discuss briefly hydrogen bonds with examples. [5]

Q5. a) What is energy of activation(Ea)? Derive an equation showing the relationship between temperature and rate constant (k). [10]

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

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

Q6. a) Define modern periodic table. Classify elements in terms of electronic configuration. [8]

b) Discuss the variation of properties of elements within periods and groups with reference to their (i) Ionization potential (ii) Electro negativity. [9]

c) What is the unit of equilibrium constant(K)? Derive the relationship between Kp and Kc and show it's application. [8]

Q7. a) Define heat of solution and heat of combustion with suitable examples. How can you determine the heat of combustion in a laboratory ? [8]

b) Derive mathematical equation showing the effect of temperature on the heat of reaction. At constant volume and at constant pressure. Name the equation. [10]

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

Q8 Write short notes: [5x5=25]

a) Quantum Number

b) Relationship between "Kp" and "Kc"

c) Electrical conductance with classification

d) Rutherford's Atom Model

e) Isober , Isotope and Isotone

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

Semester Final Examination — Winter Semester, A.Y. 2017-2018
Course Code: Chem 4121 — Time: 3 hours
Course Title: Engineering Chemistry — Full Marks: 150

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

1 a) List the various factors that affect the rate of reactions? Elaborate the effect of temperature on the rate of reaction with the aid of Boltzmann distribution curve. 8

b) Derive an equation for rate constant of a second order reaction. Show that half-life of second order reaction is inversely proportional to the initial concentration of reactant. 9

c) The decomposition of nitrogen dioxide, 8

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

has a rate constant of 0.498 M/s at 319°C and a rate constant of 1.81 M/s at 354°C. What are the values of the activation energy and the frequency factor for this reaction? What is the rate constant at 420°C?

2 a) What is standard cell electromotive force (emf)? Derive Nernst equation. 8

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

c) Consider a cell constructed of the following two half-reactions. 8

$$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s) \quad E_{Zn2+(aq)|Zn(s)} = -0.76\ V$$

$$2Ag^{+}(aq) + 2e^- \rightarrow 2Ag(s) \quad E_{Ag+(aq)|Ag(s)} = 0.80\ V$$

(i) Write down the possible cell notations for the above cell.
(ii) Calculate the standard cell potential. Describe whether the cell reaction will occur spontaneously or not.
(iii) Write down the half-cell reaction and total cell reaction.
(iv) If concentration of Zn^{2+} and Ag^{+} are 1.00×10^{-6}M and 0.010M, calculate the cell potential at 25°C temperature.

3 a) What is osmotic pressure? Derive van't Hoff equation of osmotic pressure. How molecular mass of solute can be determined by measuring osmotic pressure of solution? 8

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

c) The melting point of pure Naphthalene is 82.2°C and its freezing-point-depression constant is 6.85 °C/m. (i) 2.0 g of a compound was dissolved in 20.0 g of Naphthalene. The solution melted at 77.52°C. What is the molecular mass of the compound? (ii) If the empirical formula of the compound is CH, what is the molecular formula? 7

4 a) Define pH. Derive Henderson-Hasselbalch equation for calculating the pH of a buffer solution. 8

b) State and explain Kohlrausch's law. Write at least three application of Kohlrausch's law. 9

c) The equivalent conductance of a 0.014 N solution of chloro-acetic acid is 109.0 $ohm^{-1}\ cm^2$. At infinite dilution, the ion conductance of chloro-acetic acetate and hydrogen ion are 40.2 and 349.8 $ohm^{-1}\ cm^2$, respectively. Calculate (a) degree of dissociation and (b) dissociation constant of the acid. 8

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

b) State and explains Pauli exclusion principle. State whether each of the following sets of quantum numbers is permissible for an electron in an atom. If a set is not permissible, explain why. 8

(i) $n = 1, l = 0, m_l = 0, m_s = +\frac{1}{2}$

(ii) $n = 3, l = 1, m_l = =2, m_s = =-\frac{1}{2}$

(iii) $n = 2, l = 1, m_l = 0, m_s = +\frac{1}{2}$

(iv) $n = 2, l = 0, m_l = 0, m_s = 1$

c) What is de-Broglie equation? Show that de-Broglie equation is applicable only for microscopic particle like electron. Electron has a mass = 9.10×10^{-28} g and moves with a velocity 2.188×10^{-8} cm/sec, $h = 6.625 \times 10^{-27}$ J.S. 5

6 a) What is hydrogen bond? Discuss different types of hydrogen bond with suitable examples. 5

b) Describe the main features of Valence-Shell Electron-Pair Repulsion (VSEPR) model for predicting the shape of molecules (two, three and four electron pairs). Predict the shape of the following molecules according to VSEPR model (i) SiF_4, (ii) SF_4, (iii) XeF_4, and (iv) IF_5. 12

c) Describe molecular orbital theory (MOT). With the aid of MOT describe whether **NO** is formed or not. State the bond order and magnetic properties of **NO**. 8

7 a) State and explain first law of thermodynamic. Prove that at constant pressure $\mathbf{dH = q_p}$. 13

b) What is electron affinity? What are the factors affecting electron affinity of the molecule? Briefly discuss them. 12

c) (i) Show the electronic configuration of oxygen (**O**) and phosphorus (**P**) atoms according to Hund's rule.
(ii) Find out the position of iron (**Si**) and nickel (**Ni**) atoms in the periodic table from the electronic configuration.

8 a) Define phase, degree of freedom, and component. Derive phase rule. 13

b) Discuss different types of organic reaction with suitable examples. 12

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

Semester Final Examination — Winter Semester, A.Y. 2017-2018
Course Code: Chem 4153 — Time: 3 hours
Course Title: Chemistry-I — Full Marks: 150

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

1 a) Define order of the reaction. Describe differential method for the determination of reaction order. 8

b) Discuss the effect of temperature on the rate of reaction with the aid of Boltzmann distribution curve and Arrhenius equation. 9

c) The decomposition of nitrogen dioxide, 8

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

has a rate constant of 0.775 L/(mol.s). If the reaction is second order, what is the concentration of NO_2 after 2.5×10^2 seconds if the starting concentration was 0.050 *M*? What is the half-life of this reaction?

2 a) What is electroplating and galvanizing? How electroplating is performed over a metal trip? What are the purpose of electroplating? 9

b) Discuss the working principle of alkaline dry cell. 8

c) Consider a cell constructed of the following two half-reactions. 8

$$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s) \quad E_{Zn2+(aq)|Zn(s)} = -0.76\ V$$

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s) \quad E_{Cu2+(aq)|Cu(s)} = 0.34\ V$$

(i) Write down the possible cell notations for the above cell.
(ii) Calculate the standard cell potential. Describe whether the cell reaction will occur spontaneously or not.
(iii) Write down the half-cell reaction and total cell reaction.
(iv) If concentration of Zn^{2+} and Ag^+ are 1.00×10^{-5}M and 0.100 M, calculate the cell potential at 25°C temperature.

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

b) Derive thermodynamically the relationship between the boiling point elevation of the dilute solution and the molality of the dissolved solute using vapour pressure vs. temperature diagram. 10

c) The melting point of pure Naphthalene is 82.2°C and its freezing-point-depression constant is 6.85 °C/*m*. (i) 2.0 g of a compound was dissolved in 20.0 g of Naphthalene. The solution melted at 77.52°C. What is the molecular mass of the compound? (ii) If the empirical formula of the compound is CH, what is the molecular formula? 7

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

b) State and explain Kohlrausch's law. Write at least three application of Kohlrausch's law. 9

c) The equivalent conductance of a 0.014 N solution of chloro-acetic acid is 109.0 $ohm^{-1}\ cm^2$. At infinite dilution, the ion conductance of chloro-acetic acetate 8

and hydrogen ion are 40.2 and 349.8 ohm^{-1} cm^2, respectively. Calculate (a) degree of dissociation and (b) dissociation constant of the acid.

5 a) Derive Schrödinger's Wave Equation. What is the significance of wave function ψ and ψ^2? 12

b) State Heisenberg's Uncertainty principle? Show that Uncertainty principle is applicable only for the microscopic particle like electron. Electron of mass m $= 9.109 \times 10^{-28}$ g and $h = 6.625 \times 10^{-27}$J.S. 5

c) State and explains Pauli exclusion principle. State whether each of the following sets of quantum numbers is permissible for an electron in an atom. If a set is not permissible, explain why. 8

(i) $n = 1, l = 0, m_l = 0, m_s = +\frac{1}{2}$

(ii) $n = 3, l = 1, m_l = =2, m_s = =-\frac{1}{2}$

(iii) $n = 2, l = 1, m_l = 0, m_s = +\frac{1}{2}$

(iv) $n = 2, l = 0, m_l = 0, m_s = 1$

6 a) What is hydrogen bond? Discuss different types of hydrogen bond with suitable examples. 5

b) What are the main features of valence shell electron pair repulsion theory for predicting the shape of molecules (two, three, four, five and six electron pairs)? Predict the shape of the following molecules according to VSEPR model 12

(i) SF_4, (ii) IF_3, and (iii) PCl_3.

c) Describe bonding and antibonding molecular orbitals according to Molecular Orbital Theory (MOT). With the aid of (MOT) describe whether N_2 molecule is formed or not. State the bond order and magnetic properties of N_2. 8

7 a) What is reversible and irreversible process? Deduce the expression for isothermal reversible expansion work done by an ideal gas. 8

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

c) i)) Show the electronic configuration of nitrogen (**N**) and Sulphur (**S**) according to Hund's rule. 8

(ii) Find out the position of **Fe** and **Al** atoms in the periodic table from the electronic configuration.

8 a) Discuss different types of organic reactions with suitable examples. 12

b) Discuss phase diagram of water system. 13

B.Sc. Engg (M)/HDME 3rd Sem 28 29 May 2018

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

Semester Final Examination
Course Code: MCE 4305
Course Title : Basic Thermodynamics

Winter Semester: A.Y. 2017-2018
Time : 3.0 Hours
Full Marks : 150

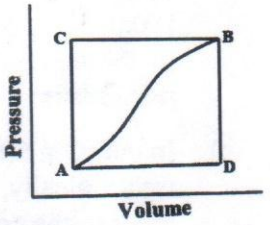
There are 8 (Eight) Questions. Answer any 6 (Six) Questions.
Figures in the right margin indicate full marks. Don't write on this question paper.

1. a) An engineer claims his engine to develop 3.00 kW. On testing, the engine consumes 0.44 kg of fuel per hour having a calorific value of 42000 kJ/kg. The maximum temperature recorded in the cycle is 1400 °C and minimum is 350 °C. Find if the engineer is justified in his claim. **10**

   b) Our normal understanding says that heat does not flow from lower temperature to higher temperature. Is there any way to transfer heat from lower temperature to higher temperature? Justify your answer using laws of thermodynamics. **7**

   c) Prove that Carnot engine is the most efficient engine within specified temperature limits. **8**

2. a) When a system is taken from the state A to the state B, in the figure, along the path ACB, 99 kJ of heat flows into the system and the system does 34 kJ of work. **8**
   i) How much heat flows into the system along the path ADB, if the work done by the system is 9 kJ?
   ii) When the system is returned from the state B to the state A along the curved path, the work done on the system is 25 kJ. How much heat is absorbed or liberated?
   iii) If the internal energy at A (U_A) is 0 kJ and at D (U_D) is 40 kJ, find the heat absorbed in the processes AD and DB.



   b) Gas at 1.5 bar and 300 K in a closed vessel is compressed to 10 bar. Its temperature then becomes 565 K. If the compression follows the law $pv^n = C$, find the value of n. **5**

   c) Air at the rate of 12 kg/min flows steadily through a nozzle. The pressure and temperature of air at the inlet to the nozzle are 20 bar and 390 K respectively. The pressure of air at the exit of nozzle is 5 bar. Assuming adiabatic flow with initial velocity of 100 m/s, determine the exit velocity and the inlet area. **12**

3. a) Draw a schematic diagram of an ideal gas turbine engine with regenerator and show the states on T-s diagram. Write the equation of effectiveness. What would happen if the regenerator was 100% effective? **10**

   b) If a gas turbine engine working on ideal Brayton cycle is allowed to work between two temperature limits of 670 °C and 37 °C, what will be the optimized pressure ratio (r_p) to get maximum net work from the cycle? **5**

   c) An actual gas turbine cycle working at a pressure ratio of 8 has a temperature of 300K at the inlet of compressor. If the isentropic efficiency of the compressor is 80%, what is the actual temperature of the gas at the outlet of the compressor? **10**

4. a) Is it possible to use Carnot cycle as the ideal vapor power cycle? If not, suggest the modifications which are needed in Carnot cycle to be used as vapor power cycle, with proper reasons. **7**

b) Consider a steam power plant operating on the ideal reheat Rankine cycle. Steam enters the high-pressure turbine at 15 MPa and 600 °C and is condensed in the condenser at a pressure of 10 kPa. If the moisture content of the steam at the exit of the low-pressure turbine is not to exceed 10.4 percent, determine - **12**
(a) pressure at which the steam should be reheated and
(b) thermal efficiency of the cycle.
Assume the steam is reheated to the inlet temperature of the high-pressure turbine.

c) In question 4(b), the low pressure turbine is removed and steam is only expanded isentropically through high pressure turbine with inlet at 15 MPa and 600 °C, and outlet at 10 kPa in the condenser. Determine- **6**
(a) dryness fraction of steam at the outlet of the turbine
(b) thermal efficiency of the cycle.

5. a) Draw a schematic diagram of a boiler plant. **7**

b) Draw a Benson Boiler with proper labelling. **8**

c) Show the relation between COP of heat pump and COP of refrigerator. **5**

d) Explain if water can be used as refrigerant. **5**

6. a) Draw the schematic diagram of absorption refrigeration cycle. **7**

b) A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between 0.14 and 0.8 MPa. If the mass flow rate of the refrigerant is 0.05 kg/s, determine (a) the rate of heat removal from the refrigerated space and the power input to the compressor, (b) the rate of heat rejection to the environment, and (c) the COP of the refrigerator. **10**

c) In question 6(b), if the expansion valve is replaced by a turbine where refrigerant can be expanded isentropically, determine (a) the rate of heat removal from the refrigerated space and the power input to the compressor, (b) the rate of heat rejection to the environment, and (c) the COP of the refrigerator. **8**
Give suggestions if we can use turbine instead of expansion valve.

7. a) Explain how a constant relative humidity curve is drawn in psychrometric chart. **5**

b) What are the conditions at which steam acts more like an ideal gas? **5**

c) Air at 14 °C and 60 percent relative humidity at a rate of 49.20 m^3/min is mixed adiabatically with another stream of air at 33 °C and 60 percent relative humidity at a rate of 26.4 m^3/min. Assuming that the mixing process occurs at a pressure of 1 atm, determine the specific humidity, the relative humidity, the dry-bulb temperature, and the volume flow rate of the mixture. **15**

8. a) Explain what happens when we keep going in the direction of decreasing dry bulb temperature with a fixed amount of water content (ω) in air, in psychrometric chart. **5**

b) What is the significance of measuring wet bulb temperature? **5**

c) The atmosphere is at a pressure of 1 atm and relative humidity of 10 percent. If you wrap your head with a water-soaked porous cloth and the temperature of the cloth is found to be 11 °C, what is the atmospheric temperature? **5**

d) An air-conditioning system is to take in outdoor air at 11 °C and 50 percent relative humidity at a steady rate of 32.4 m^3/min and to condition it to 25°C and 70 percent relative humidity. The outdoor air is first heated to 25 °C in the heating section and then humidified by the injection of water in the humidifying section. Assuming the entire process takes place at a pressure of 100 kPa, determine (*a*) the rate of heat supply in the heating section and (*b*) the mass flow rate of the steam required in the humidifying section. **10**

Saturated water—Pressure table

Press., kPa	Sat. temp., T_{sat} °C	Specific volume, m³/kg: Sat. liquid, v_f	Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
10	45.81	0.001010	14.670	191.79	2245.4	2437.2	191.81	2392.1	2583.9	0.6492	7.4996	8.1488
15	53.97	0.001014	10.020	225.93	2222.1	2448.0	225.94	2372.3	2598.3	0.7549	7.2522	8.0071
75	91.76	0.001037	2.2172	384.36	2111.8	2496.1	384.44	2278.0	2662.4	1.2132	6.2426	7.4558
100	99.61	0.001043	1.6941	417.40	2088.2	2505.6	417.51	2257.5	2675.0	1.3028	6.0562	7.3589
700	164.95	0.001108	0.27278	696.23	1875.6	2571.8	697.00	2065.8	2762.8	1.9918	4.7153	6.7071
750	167.75	0.001111	0.25552	708.40	1865.6	2574.0	709.24	2056.4	2765.7	2.0195	4.6642	6.6837
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

Superheated water (*Continued*)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 4.0 MPa (250.35°C)			
Sat.	0.04978	2601.7	2800.8	6.0696
275	0.05461	2668.9	2887.3	6.2312
300	0.05887	2726.2	2961.7	6.3639
350	0.06647	2827.4	3093.3	6.5843
400	0.07343	2920.8	3214.5	6.7714
450	0.08004	3011.0	3331.2	6.9386
500	0.08644	3100.3	3446.0	7.0922
600	0.09886	3279.4	3674.9	7.3706
700	0.11098	3462.4	3906.3	7.6214
800	0.12292	3650.6	4142.3	7.8523
900	0.13476	3844.8	4383.9	8.0675
1000	0.14653	4045.1	4631.2	8.2698

Superheated water (*Concluded*)

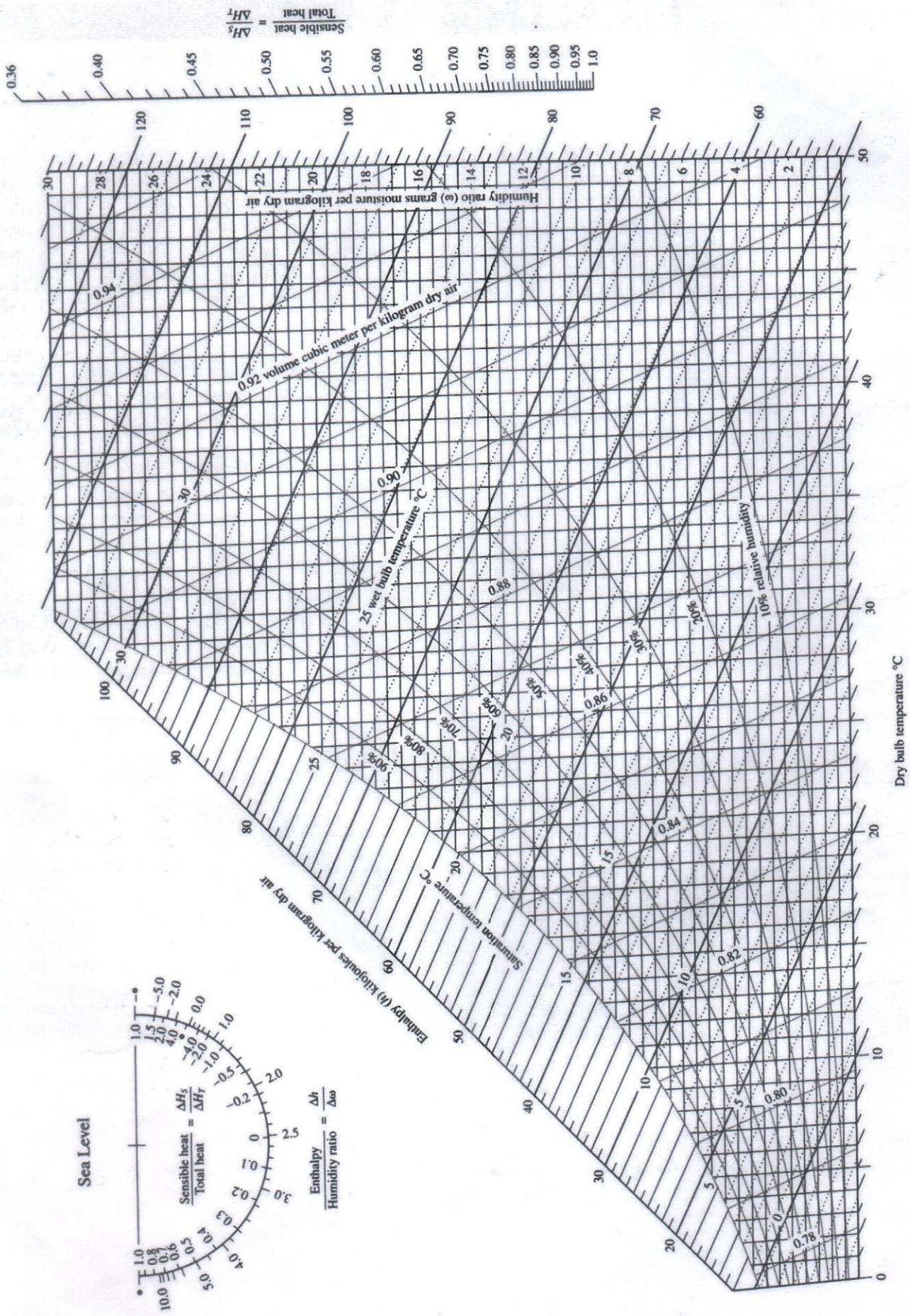
T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 15.0 MPa (342.16°C)			
Sat.	0.010341	2455.7	2610.8	5.3108
350	0.011481	2520.9	2693.1	5.4438
400	0.015671	2740.6	2975.7	5.8819
450	0.018477	2880.8	3157.9	6.1434
500	0.020828	2998.4	3310.8	6.3480
550	0.022945	3106.2	3450.4	6.5230
600	0.024921	3209.3	3583.1	6.6796
650	0.026804	3310.1	3712.1	6.8233
700	0.028621	3409.8	3839.1	6.9573
800	0.032121	3609.3	4091.1	7.2037
900	0.035503	3811.2	4343.7	7.4288
1000	0.038808	4017.1	4599.2	7.6378

Superheated refrigerant-134a (*Concluded*)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 0.80 MPa (T_{sat} = 31.31°C)			
Sat.	0.025645	246.82	267.34	0.9185
40	0.027035	254.84	276.46	0.9481
50	0.028547	263.87	286.71	0.9803
60	0.029973	272.85	296.82	1.0111
70	0.031340	281.83	306.90	1.0409
80	0.032659	290.86	316.99	1.0699
90	0.033941	299.97	327.12	1.0982
100	0.035193	309.17	337.32	1.1259
110	0.036420	318.47	347.61	1.1531
120	0.037625	327.89	357.99	1.1798
130	0.038813	337.42	368.47	1.2062
140	0.039985	347.08	379.07	1.2321

Saturated refrigerant-134a—Pressure table

Press., P kPa	Sat. temp., T_{sat} °C	Specific volume, m³/kg: Sat. liquid, v_f	Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
120	−22.32	0.0007323	0.16216	22.38	195.15	217.53	22.47	214.52	236.99	0.09269	0.85520	0.94789
140	−18.77	0.0007381	0.14020	26.96	192.60	219.56	27.06	212.13	239.19	0.11080	0.83387	0.94467
160	−15.60	0.0007435	0.12355	31.06	190.31	221.37	31.18	209.96	241.14	0.12686	0.81517	0.94202
750	29.06	0.0008395	0.027398	91.59	154.11	245.70	92.22	174.03	266.25	0.34348	0.57582	0.91930
800	31.31	0.0008457	0.025645	94.80	152.02	246.82	95.48	171.86	267.34	0.35408	0.56445	0.91853
850	33.45	0.0008519	0.024091	97.88	150.00	247.88	98.61	169.75	268.36	0.36417	0.55362	0.91779


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

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

Semester Final Examination		Winter Semester	: **A.Y. 2017-2018**
Course Code: **MCE 4311**		Time	: **3 hours**
Course Title: **Fluid Mechanics I**		Full Marks	: **200**

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

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1 a) Discuss the stability of Immersed and Floating Bodies considering Metacentric Height. Prove that the buoyant force acting on a body of uniform density immersed in a fluid is equal to the weight of the fluid displaced by the body, and it acts upward through the centroid of the displaced volume. **(16)**

b) The Titanic (length *269 m*, maximum width *28 m*, and height *30.5 m*) sank on April 14, 1912, hitting an iceberg and sinking *160 minutes* later. Recently, a sonar study of the bow of the Titanic on the ocean floor has revealed that the holes caused by the iceberg are much smaller than originally thought. **(17.33)**

Until this study, it was assumed that a large, *100 m* long gash was ripped in the Titanic's side, but now the sonar reveals that the area of the hole was only *1.4* m^2 (the size of a typical door) as shown in **Fig.1**. The hole of the Titanic was approximately *6.1 m* below sea level at the start of the sinking. Was the hole large enough to sink the Titanic in *160 minutes*?

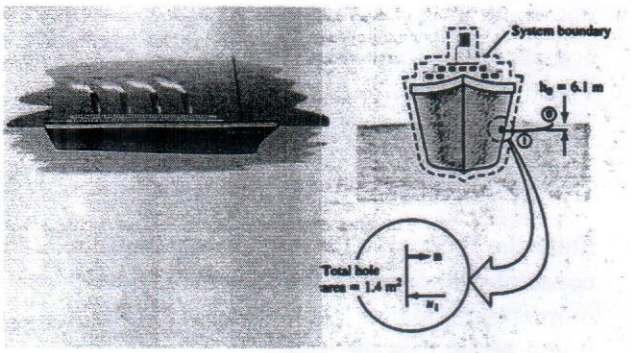


Figure 1

2 a) Draw the variation of specific energy Es with depth y for a specified flow rate. Derive an expression for minimum specific energy for rectangular open channel and hence show that the point of minimum specific energy is indeed the critical point, and the flow becomes critical when the specific energy reaches its minimum value. **(16)**

b) A swimmer having mass of *55 kg* is diving in a swimming pool has an effective body area of *0.76* m^2 as shown in **Fig.2**. The tension in the direction of swimmer's leg is 1.5kN when the legs make an inclination of 30° with the vertical direction. If the swimmer's hands bend about *40°* with the flow of water and the magnitude of wave is *2.5 m/s*. Determine the lift and drag forces and their coefficients and discuss on the results. **(17.33)**

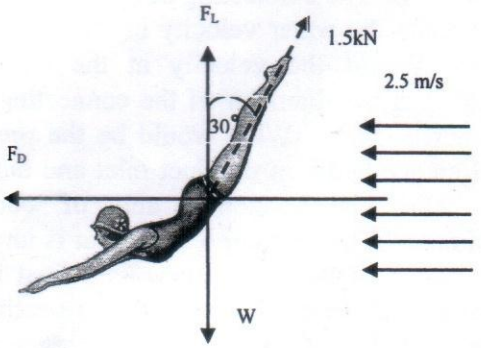


Figure 2

3 a) What is the principle of jet propulsion? A jet of water issues from vertical side of a tank which maintains a constant head of water over the orifice. The vessel is moving in the opposite direction of jet. Show that the maximum efficiency of propulsion is 50%. (16)

b) In a jet propelled boat (**Fig. 3**), water enters through orifices at right angles to the direction of motion of the ship. The velocity of boat is *5.5 m/s*. The water is discharged through two jets provided at the back of the ship. If the propulsive force of the boat is *5 kN* and the efficiency of jet propulsion is *46.97%*, calculate the diameter of each jet and the volume of water discharged through the back side. (17.33)

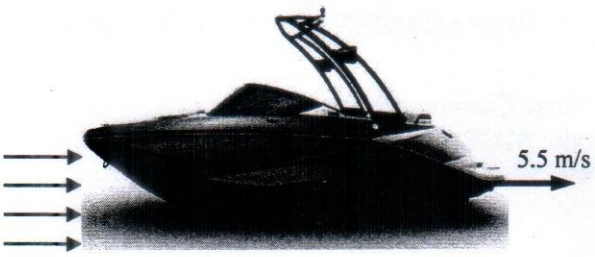


Figure 3

4 a) A jet of water strikes tangentially on a smooth curved vane moving in the same direction of the jet. If the vane deflects the jet through an angle of 180° in the opposite direction of the jet. Find the value of maximum efficiency. (16)

b) A *14 mm* diameter jet of water having an absolute velocity of 25 m/s strikes a curved fixed blade as shown in **Fig.4**. The blade deflects the jet through an angle of *160°*. Find the horizontal resultant force acting on the blade along the direction of jet, considering following cases: (i). There will be no frictional loss, (ii). The ratio of final velocity and initial velocity of jet is *0.8* due to friction. (17.33)

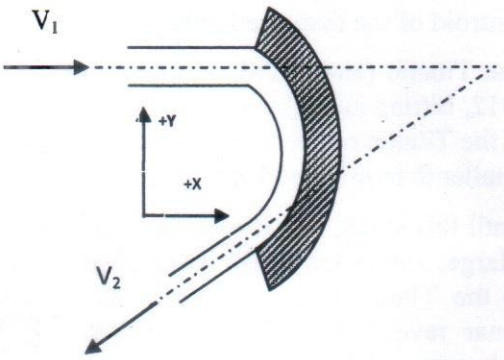


Figure 4

5 a) State the Poiseuille's Law. 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. (16)

b) A water reservoir, A, whose free-surface is kept at a pressure of $2x10^5$ *Pa* above the atmospheric pressure, discharges to another reservoir, B, open to the atmosphere shown in **Fig. 5**. The water free-surface level at the second reservoir is *0.5 m* above the pressurized reservoir A. Neglect the energy dissipation in the connecting duct between the two reservoirs. The connecting duct has constant diameter. (17.33)

Compute the water velocity in the connecting duct. Would the velocity at the duct exit change if the diameter of the connecting duct is not constant? What would be the pressure difference between the duct inlet and outlet if the duct is horizontal and of constant diameter? The pressure in the duct is imposed by which of the two reservoirs? What is the essential difference between the streamlines in the upstream (0-1) and downstream (2-3) reservoirs that justifies the response to the previous question?

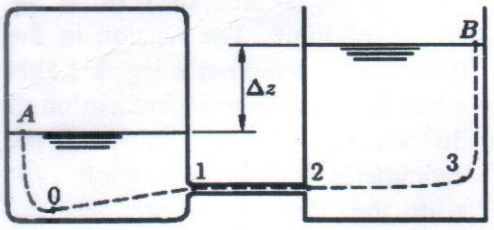
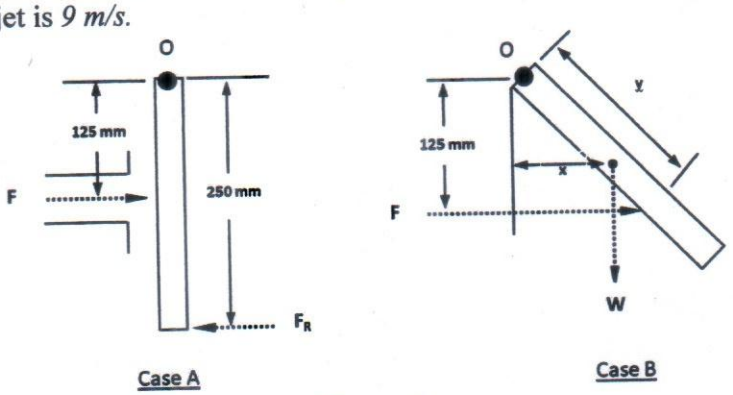


Figure 5

6 a) Derive expression for maximum wheel efficiency during the development of power to a wheel by a jet of fluid when the wheel is made of symmetrical curved vanes. (16)

b) 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.6**. 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*. (17.33)



Case A Case B

Figure 6

7 a) Deduce the principles of Obstruction flowmeters and Pitot static tube. Write down the constructions, advantages and limitations of Venturimeter. (16)

b) Water at *15°C* is drained from a large reservoir using two horizontal plastic pipes connected in series as shown in **Fig.7**. The first pipe is *20 m* long and has a *10 cm* diameter, while the second pipe is *35 m* long and has a *4 cm* diameter. The water level in the reservoir is *18 m* above the centerline of the pipe. The pipe entrance is sharp-edged, and the contraction between the two pipes is sudden. Neglecting the effect of the kinetic energy correction factor, determine the discharge rate of water from the reservoir. (17.33)

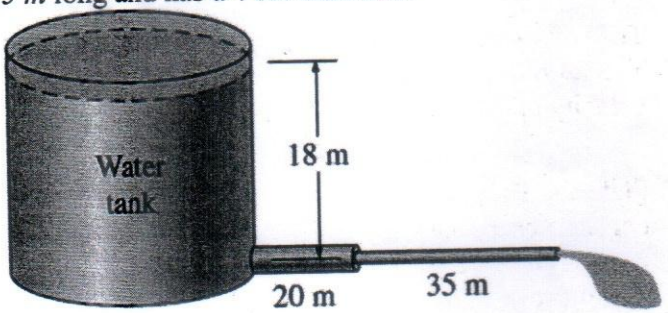
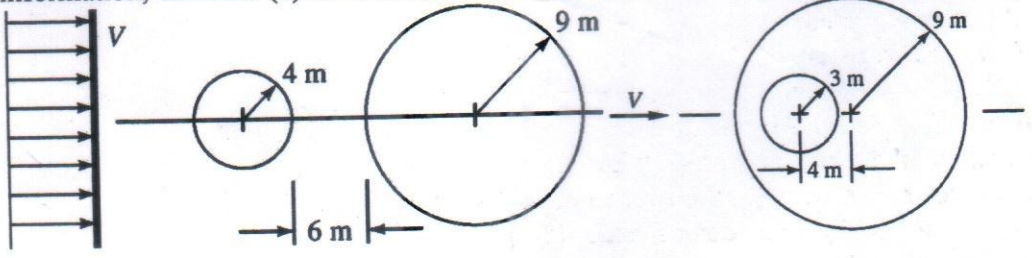


Figure 7

8 a) 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. (16)

b) Pebbles dropped successively at the same point, into a water channel flow of depth (for case (i) *42 cm* and for case (ii) *65 cm*), create two circular ripples, as in **Fig.8**. From this information, estimate (a) the Froude number and (b) the stream velocity for the two cases. (17.33)



Case (i) Case (ii)

Figure 8

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DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination — Winter Semester, A. Y. 2017-2018
Course No.: Math-4311/ Math-4599 — Time: 3 Hours
Course Title: Vector Analysis — Full Marks: 150

There are **8 (eight)** questions. Answer **any 6 (six)** questions. All questions carry equal marks. Marks in the margin indicate full marks. Programmable calculators are not allowed. Do not write on this question paper. The Symbols have their usual meaning.

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1. a) Find the volume of parallelepiped if $\bar{a} = -3i + 7j + 5k, \bar{b} = -3i + 7j - 3k$ and $\bar{c} = 7i - 5j - 3k$ are the three co-terminous edges of the parallelepiped. 5

   b) A particle moves along a curve $x = e^{-t}$, $y = 2cos3t$, $z = 2sin3t$, where t is the time. (i) Determine its velocity and acceleration at any time t (ii) find their magnitudes at $t = 0$. 6

   c) The position vector of a particle at time t is $\bar{r} = cos(t-1)i + sinh(t-1)j + \alpha t^3 k$. Find the condition imposed on α by requiring that at time $t = 1$, the acceleration is normal to the position vector. 6

   d) Show that $\bar{F} = 3yz^2i + 4x^3z^2j - 3x^2y^2k$ is solenoidal and $G = (siny + z)i + (xcosy - z)j + (x - y)k$ is irrotational. 8

2. a) If $\bar{F} = (3t^2 + 4t)i + (2t - 5)j + 4t^3k$, calculate $\int_1^3 \bar{F}\,dt$ 5

   b) Compute the directional derivative of $\phi = x^2z + 2xy^2 + yz^2$ at the point *(1, 2, -1)* in the direction of the vector: $2i + 3j - 4k$. 6

   c) (i) If $\underline{A} = (xy^3 - y^2z^2)i + (x^2 + z^2)j - x^2yz^2k$, determine *curl* $\underline{A}$ at the point (1, 2, 3). 8

   (ii) If $\phi = x^2yz^3 + xy^2z^2$, determine grad ϕ at the point *(1, 3, 2)*

   d) If $V = x^2yz^2$ and the curve C is given by $x = 4u$, $y = 3u^3$, $z = 2u^2$, then calculate $\int_C V dr$ along the curve C from *A (0, 0, 0)*, to *B(4, 3, 2)*. 6

3. a) Calculate $\int_c \underline{F}.d\underline{r}$ from A(0, 0, 0) to B(4, 2, 1) along the curve $x = 4t$, $y = 2t^2$, $z = t^3$ if $\underline{F} = x^2yi + xzj - 2yzk$. 7

   b) Evaluate $\int_V \underline{F}\,dV$, where V is a region bounded by $x = 0, y = 0, z = 0$ and $2x + y + z = 2$, and also given $\underline{F} = 2zi + yk$ 10

   c) Scalar function $F = 2x$ defeated in one cube that has been built by planes $x = 0$, $x = 1$, $y = 0$, $y = 3$, $z = 0$ and $z = 2$. Evaluate volume integral F of the cube. 8

4. a) State Green's theorem and hence verify the theorem for $\oint_c [(x^2 + y^2)dx + (x + 2y)dy]$ which has been evaluated by boundary that defined as $x = 0, y = 0$ *and* $x^2 + y^2 = 4$ in the first quarter. 15

b) Using Stoke's theorem, evaluate $\int_c [(2x-y)dx - yz^2dy - y^2zdz]$, where c is the circle $x^2+y^2=1$, corresponding to the surface of sphere of unit radius. 10

5. a) Find complex numbers, except z = 0 that satisfies the condition $\overline{z} = z^2$. 5

b) For any two complex numbers z_1 and z_2, prove that 6
$(i)|z_1+z_2| \le |z_1|+|z_2|$; $(ii)|z_1-z_2| \le |z_1|+|z_2|$

c) Find the bilinear transformation that maps the points $z_1=-i, z_2=0, z_3=i$ into the points $w_1=-1, w_2=i, w_3=1$ respectively, and hence find the image of the y-axis. 10

d) Find the image of $|z-3i|=3$ under the transformation $w=\frac{1}{z}$ and sketch of the image. 4

6. a) Derive Cauchy-Riemann equations $\frac{\partial u}{\partial x}=\frac{\partial v}{\partial y}$ *and* $\frac{\partial u}{\partial y}=-\frac{\partial v}{\partial x}$. Also find the polar form of the Cauchy-Riemann equations. 12

b) Prove that $u=e^{-x}(x\sin y - y\cos y)$ is harmonic, and find v, such that $f(z)=u+iv$ is analytic. 8

c) Let $f(z)=\ln(1+z)$, (i) expand $f(z)$ in a Taylor series about z = 0, (ii) Determine the region of convergence for the series in (i). 5

7. a) Expand $f(z)=\frac{1}{(z+1)(z+3)}$ in Laurent's series valid for $(i)1<|z|<3$ *and* $(ii)0<|z+1|<2$. 8

b) Evaluate $\int_C f(z)dz$, where C is the contour consisting of the lines joining the points $z=0$ to $z=1+i$ and then to $z=i$, given that $f(z)=y-x-i3x^2$. 5

c) Show that $\frac{1}{2\pi i}\oint_c \frac{e^{zt}}{(z^2+1)^2}dz=\frac{1}{2}(\sin t - t\cos t)$ *if* $t>0$ *and* $c:|z|=\frac{3}{2}$. 7

d) Determine the residue at each singularity of $f(z)=\frac{e^{1/z}}{1-z}$ 5

8. a) Evaluate the following (using Cauchy's residue theorem) 10
$(i)\oint_C \frac{4-3z}{z(z-1)(z-2)}dz$; where $c:|z|=\frac{3}{2}$, $(ii)\oint_C \frac{1}{\cosh z}dz$; where $C:|z|=2$.

b) Evaluate the following by using the method of contour integration: 15
$(i)\int_0^\infty \frac{dx}{x^4+1}$ $(ii)\int_0^\infty \frac{\cos mx}{x^2+1}dx$

B.Sc. Engg. (ME)/HDME (3rd Sem) 08 June 2018 (Group-A)

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

Semester Final Examination — Winter Semester, A.Y. 2017-2018
Course Code: MCE 4321 — Time : 3 hours
Course Title: Manufacturing Process — Full Marks : 200

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

Marks in the Margin indicate the full marks.

1.	a)	Write down the differences between thermosetting and thermoplastic materials. List the different thermosetting and thermoplastic materials.	13
	b)	Explain with neat sketches the blow moulding and plastic vacuum forming processes?	20.33
2	a)	Explain with flow diagram the details process description of powder metallurgy process.	17.33
	b)	Write down the design consideration factors for the powder metallurgy parts to be manufactured.	12
	c)	Write down the advantages and disadvantages of powder metallurgy process.	06
3	a)	What is pattern? Write down in details the different pattern allowances that need to be considered for the casting processes?	18
	b)	Explain with neat sketches the sand moulding making procedure used in casting process.	15.33
4	a)	Explain the different types of casting defects that may exist in any casting process.	15
	b)	Write down the differences between brazing and soldering operations and hence explain the different types of brazing operation.	18.33
5	a)	Explain briefly with neat sketches the working mechanism of resistance projection welding and stud welding process.	20.33
	b)	Explain the gas metal arc welding process and hence describe the different types of metal transferring methods with necessary diagram.	13
6	a)	Explain the constructional details of a horizontal spindle column knee type milling machine with schematic illustration.	13
	b)	Explain briefly with necessary diagram the hydraulic quick return mechanism. Determine the speed ratio (q) in a planning operation using a hydraulic system. The oil pressure is 1.1 kp/mm^2 and flow of 0.1 m^3/min. The piston diameter is 50 mm with a rod of a 30 mm diameter.	20.33
7	a)	Explain briefly with neat sketches the following processes (i) Trepanning (ii) Broaching and (iii) Spot facing operations.	18
	b)	List the different types of cutting operations that can be performed on a lathe machine and write a short note on the following operations (i) Contour turning (ii) Taper turning	15.33
8	a)	Write a short note with neat sketches on the following mass conserving processes (i) spinning process; (ii) electro-hydraulic forming process and (iii) thread rolling process.	18
	b)	Write down the fundamentals of metal forming processes and explain the state of the materials behavior, different stresses behavior and materials properties changes during the metal forming processes and hence differentiate the bulk forming and sheet metal working processes.	15.33

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

Semester Final Examination — Winter Semester, A.Y. 2017-2018
Course Code: MCE 4391 — Time : 3.0 Hours
Course Title: Basic Mechanical Engineering — Full Marks : 150

There are **Eight (08)** Questions. Answer any **Six (06)** of them.
Assume reasonable data if necessary. Use the thermodynamic charts attached if necessary.
Programmable calculators are not allowed. Don't write on this question paper.

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1. **(a)** Explain the following statements with correct reasoning- **(15)**
   i. In SI engine, intake valve is closed after the piston reached BDC.
   ii. The compression ratio of CI engine is higher than that of SI engine.
   iii. Exhaust valve is smaller than intake valve.
   iv. There is no exhaust and intake stroke in an air standard cycle.
   v. IC engine is not used for aircraft vehicles.

   (b) For an air standard Diesel cycle, prove that, **(10)**

$$\eta_{th} = 1 - \frac{r_c^k - 1}{k r_v^{k-1}(r_c - 1)}$$

   Where, symbols have usual meanings and interpretations.

2. **(a)** How the combustion of SI engine is different from that of CI engine? **(04)**
   (b) Describe the effect of pressure ratio on the efficiency of a gas turbine with the help of suitable graphs and illustrations. **(06)**
   (c) Write down the working principle of a Turbojet gas turbine with the help of necessary schematic diagrams. **(08)**
   (d) In a Brayton cycle based power plant, the air at the inlet has 27^0C and 0.1 MPa. The pressure ratio is 6.25 and the maximum temperature of the cycle is 800^0C. Find the compressor work and the cycle efficiency. **(07)**

3. **(a)** Justify the following statements with correct logic and briefly describe their economic effects. **(07)**
   i. In vapor compression refrigeration cycle, turbine is replaced by a throttling valve.
   ii. In a reverse Carnot cycle, pump is replaced by compressor.
   (b) What is refrigerant? Mention the desirable properties that should be present in a refrigerant. **(06)**
   (c) Briefly describe the vapor absorption cycle with the necessary diagrams and write down the advantages and disadvantages of vapor absorption cycle over vapor compression cycle. **(12)**

4. **(a)** How does a refrigerator not violate the 2nd law of thermodynamics when it definitely transfers heat from a colder space to a hotter space? Illustrate with necessary diagrams. **(05)**
   (b) A simple vapor refrigeration cycle using R134a as refrigerant operates between condensing temperature 40^0C and evaporating temperature -6^0C. The system produces 50 KW of cooling effect. Calculate the coefficient of performance and the mass flow rate of the refrigerant. **(10)**
   (c) Consider a practical scenario of a room in a flat which has no window or wall attached with the outside environment. Which type of air conditioner would you choose for that room as an engineer and why? Briefly describe the working principle of that kind of air conditioner with a schematic diagram. **(10)**

5 (a) Write down the difference between impulse and reaction turbine. **(05)**

(b) What is negative slip? When does it happen in a reciprocating pump and why? **(06)**

(c) Why are spear valve and deflector used in the pelton wheel? **(04)**

(d) A centrifugal pump impeller runs at 950 rpm. Its external and internal diameters are 500 mm and 250 mm respectively. The vanes are set back at an angle of 35^0 to the outer rim. If the radial velocity of the water through the impeller is maintained at 2 m/s. Find the angle of the vanes at inlet, the velocity and direction of water at outlet and the work done by the impeller per kg of water. **(10)**

6 (a) What is classical and statistical thermodynamics? **(03)**

(b) Show with necessary diagrams that the violation of Kelvin-Planck statement is equivalent to the violation of Clausius statement and vice-versa. **(07)**

(c) What is a Perpetual Motion Machine of 1^{st} kind (PPM1)? Give an example and describe how it is an example of PPM1. **(07)**

(d) Consider a water cooled condenser in a large refrigeration system, in which R-134a is the refrigeration fluid. The refrigerant enters the condenser at 1 MPa and 60°C, at the rate of 0.2 kg/s, and exits as a saturated liquid at 35°C. Cooling water enters the condenser at 10°C and exits at 20°C. Determine the rate at which cooling water flows through the condenser. **(08)**

7 (a) What is phase diagram? Draw and describe a T-s diagram indicating different regions, lines and notations. **(08)**

(b) Briefly describe the ways to increase the efficiency of a Rankine cycle with the suitable diagrams and demonstrate their effects on the net work output of Rankine cycle. **(10)**

(c) Write down about binary cycle with necessary diagrams. Why a superheater is used in a binary cycle? **(7)**

8 (a) Briefly describe the reheat Rankine cycle with necessary diagrams. A steam power plant operates on an ideal reheat Rankine cycle between the pressure limits of 15 Mpa and 10 kPa. The mass flow rate of steam through the cycle is 1.2 kg/s. Steam enters both stages of the turbine at 500°C. If the moisture content of the steam at the exit of the low-pressure turbine is not to exceed 10 percent, determine- **(25)**

(i) the pressure at which reheating takes place,

(ii)the total rate of heat input in the boiler, and

(iii) the thermal efficiency of the cycle.

Also, show the cycle on a T-s diagram with respect to saturation lines.

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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

TABLE A–5

Saturated water—Pressure table (*Continued*)

		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
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

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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 = 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

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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

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TABLE A–11

Saturated refrigerant-134a—Temperature table

Temp., T °C	Sat. press., P_{sat} kPa	*Specific volume, m³/kg* Sat. liquid, v_f	Sat. vapor, v_g	*Internal energy, kJ/kg* Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	*Enthalpy, kJ/kg* Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	*Entropy, kJ/kg · K* Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
−40	51.25	0.0007054	0.36081	−0.036	207.40	207.37	0.000	225.86	225.86	0.00000	0.96866	0.96866
−38	56.86	0.0007083	0.32732	2.475	206.04	208.51	2.515	224.61	227.12	0.01072	0.95511	0.96584
−36	62.95	0.0007112	0.29751	4.992	204.67	209.66	5.037	223.35	228.39	0.02138	0.94176	0.96315
−34	69.56	0.0007142	0.27090	7.517	203.29	210.81	7.566	222.09	229.65	0.03199	0.92859	0.96058
−32	76.71	0.0007172	0.24711	10.05	201.91	211.96	10.10	220.81	230.91	0.04253	0.91560	0.95813
−30	84.43	0.0007203	0.22580	12.59	200.52	213.11	12.65	219.52	232.17	0.05301	0.90278	0.95579
−28	92.76	0.0007234	0.20666	15.13	199.12	214.25	15.20	218.22	233.43	0.06344	0.89012	0.95356
−26	101.73	0.0007265	0.18946	17.69	197.72	215.40	17.76	216.92	234.68	0.07382	0.87762	0.95144
−24	111.37	0.0007297	0.17395	20.25	196.30	216.55	20.33	215.59	235.92	0.08414	0.86527	0.94941
−22	121.72	0.0007329	0.15995	22.82	194.88	217.70	22.91	214.26	s237.17	0.09441	0.85307	0.94748
−20	132.82	0.0007362	0.14729	25.39	193.45	218.84	25.49	212.91	238.41	0.10463	0.84101	0.94564
−18	144.69	0.0007396	0.13583	27.98	192.01	219.98	28.09	211.55	239.64	0.11481	0.82908	0.94389
−16	157.38	0.0007430	0.12542	30.57	190.56	221.13	30.69	210.18	240.87	0.12493	0.81729	0.94222
−14	170.93	0.0007464	0.11597	33.17	189.09	222.27	33.30	208.79	242.09	0.13501	0.80561	0.94063
−12	185.37	0.0007499	0.10736	35.78	187.62	223.40	35.92	207.38	243.30	0.14504	0.79406	0.93911
−10	200.74	0.0007535	0.099516	38.40	186.14	224.54	38.55	205.96	244.51	0.15504	0.78263	0.93766
−8	217.08	0.0007571	0.092352	41.03	184.64	225.67	41.19	204.52	245.72	0.16498	0.77130	0.93629
−6	234.44	0.0007608	0.085802	43.66	183.13	226.80	43.84	203.07	246.91	0.17489	0.76008	0.93497
−4	252.85	0.0007646	0.079804	46.31	181.61	227.92	46.50	201.60	248.10	0.18476	0.74896	0.93372
−2	272.36	0.0007684	0.074304	48.96	180.08	229.04	49.17	200.11	249.28	0.19459	0.73794	0.93253
0	293.01	0.0007723	0.069255	51.63	178.53	230.16	51.86	198.60	250.45	0.20439	0.72701	0.93139
2	314.84	0.0007763	0.064612	54.30	176.97	231.27	54.55	197.07	251.61	0.21415	0.71616	0.93031
4	337.90	0.0007804	0.060338	56.99	175.39	232.38	57.25	195.51	252.77	0.22387	0.70540	0.92927
6	362.23	0.0007845	0.056398	59.68	173.80	233.48	59.97	193.94	253.91	0.23356	0.69471	0.92828
8	387.88	0.0007887	0.052762	62.39	172.19	234.58	62.69	192.35	255.04	0.24323	0.68410	0.92733
10	414.89	0.0007930	0.049403	65.10	170.56	235.67	65.43	190.73	256.16	0.25286	0.67356	0.92641
12	443.31	0.0007975	0.046295	67.83	168.92	236.75	68.18	189.09	257.27	0.26246	0.66308	0.92554
14	473.19	0.0008020	0.043417	70.57	167.26	237.83	70.95	187.42	258.37	0.27204	0.65266	0.92470
16	504.58	0.0008066	0.040748	73.32	165.58	238.90	73.73	185.73	259.46	0.28159	0.64230	0.92389
18	537.52	0.0008113	0.038271	76.08	163.88	239.96	76.52	184.01	260.53	0.29112	0.63198	0.92310

TABLE A–11

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

Temp., T °C	Sat. press., P_{sat} kPa	*Specific volume, m³/kg* Sat. liquid, v_f	Sat. vapor, v_g	*Internal energy, kJ/kg* Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	*Enthalpy, kJ/kg* Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	*Entropy, kJ/kg · K* Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
20	572.07	0.0008161	0.035969	78.86	162.16	241.02	79.32	182.27	261.59	0.30063	0.62172	0.92234
22	608.27	0.0008210	0.033828	81.64	160.42	242.06	82.14	180.49	262.64	0.31011	0.61149	0.92160
24	646.18	0.0008261	0.031834	84.44	158.65	243.10	84.98	178.69	263.67	0.31958	0.60130	0.92088
26	685.84	0.0008313	0.029976	87.26	156.87	244.12	87.83	176.85	264.68	0.32903	0.59115	0.92018
28	727.31	0.0008366	0.028242	90.09	155.05	245.14	90.69	174.99	265.68	0.33846	0.58102	0.91948
30	770.64	0.0008421	0.026622	92.93	153.22	246.14	93.58	173.08	266.66	0.34789	0.57091	0.91879
32	815.89	0.0008478	0.025108	95.79	151.35	247.14	96.48	171.14	267.62	0.35730	0.56082	0.91811
34	863.11	0.0008536	0.023691	98.66	149.46	248.12	99.40	169.17	268.57	0.36670	0.55074	0.91743
36	912.35	0.0008595	0.022364	101.55	147.54	249.08	102.33	167.16	269.49	0.37609	0.54066	0.91675
38	963.68	0.0008657	0.021119	104.45	145.58	250.04	105.29	165.10	270.39	0.38548	0.53058	0.91606
40	1017.1	0.0008720	0.019952	107.38	143.60	250.97	108.26	163.00	271.27	0.39486	0.52049	0.91536
42	1072.8	0.0008786	0.018855	110.32	141.58	251.89	111.26	160.86	272.12	0.40425	0.51039	0.91464
44	1130.7	0.0008854	0.017824	113.28	139.52	252.80	114.28	158.67	272.95	0.41363	0.50027	0.91391
46	1191.0	0.0008924	0.016853	116.26	137.42	253.68	117.32	156.43	273.75	0.42302	0.49012	0.91315
48	1253.6	0.0008996	0.015939	119.26	135.29	254.55	120.39	154.14	274.53	0.43242	0.47993	0.91236
52	1386.2	0.0009150	0.014265	125.33	130.88	256.21	126.59	149.39	275.98	0.45126	0.45941	0.91067
56	1529.1	0.0009317	0.012771	131.49	126.28	257.77	132.91	144.38	277.30	0.47018	0.43863	0.90880
60	1682.8	0.0009498	0.011434	137.76	121.46	259.22	139.36	139.10	278.46	0.48920	0.41749	0.90669
65	1891.0	0.0009750	0.009950	145.77	115.05	260.82	147.62	132.02	279.64	0.51320	0.39039	0.90359
70	2118.2	0.0010037	0.008642	154.01	108.14	262.15	156.13	124.32	280.46	0.53755	0.36227	0.89982
75	2365.8	0.0010372	0.007480	162.53	100.60	263.13	164.98	115.85	280.82	0.56241	0.33272	0.89512
80	2635.3	0.0010772	0.006436	171.40	92.23	263.63	174.24	106.35	280.59	0.58800	0.30111	0.88912
85	2928.2	0.0011270	0.005486	180.77	82.67	263.44	184.07	95.44	279.51	0.61473	0.26644	0.88117
90	3246.9	0.0011932	0.004599	190.89	71.29	262.18	194.76	82.35	277.11	0.64336	0.22674	0.87010
95	3594.1	0.0012933	0.003726	202.40	56.47	258.87	207.05	65.21	272.26	0.67578	0.17711	0.85289
100	3975.1	0.0015269	0.002630	218.72	29.19	247.91	224.79	33.58	258.37	0.72217	0.08999	0.81215

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

TABLE A–13

Superheated refrigerant-134a (*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 = 0.50 MPa (T_{sat} = 15.71°C)				P = 0.60 MPa (T_{sat} = 21.55°C)				P = 0.70 MPa (T_{sat} = 26.69°C)			
Sat.	0.041118	238.75	259.30	0.9240	0.034295	241.83	262.40	0.9218	0.029361	244.48	265.03	0.9199
20	0.042115	242.40	263.46	0.9383								
30	0.044338	250.84	273.01	0.9703	0.035984	249.22	270.81	0.9499	0.029966	247.48	268.45	0.9313
40	0.046456	259.26	282.48	1.0011	0.037865	257.86	280.58	0.9816	0.031696	256.39	278.57	0.9641
50	0.048499	267.72	291.96	1.0309	0.039659	266.48	290.28	1.0121	0.033322	265.20	288.53	0.9954
60	0.050485	276.25	301.50	1.0599	0.041389	275.15	299.98	1.0417	0.034875	274.01	298.42	1.0256
70	0.052427	284.89	311.10	1.0883	0.043069	283.89	309.73	1.0705	0.036373	282.87	308.33	1.0549
80	0.054331	293.64	320.80	1.1162	0.044710	292.73	319.55	1.0987	0.037829	291.80	318.28	1.0835
90	0.056205	302.51	330.61	1.1436	0.046318	301.67	329.46	1.1264	0.039250	300.82	328.29	1.1114
100	0.058053	311.50	340.53	1.1705	0.047900	310.73	339.47	1.1536	0.040642	309.95	338.40	1.1389
110	0.059880	320.63	350.57	1.1971	0.049458	319.91	349.59	1.1803	0.042010	319.19	348.60	1.1658
120	0.061687	329.89	360.73	1.2233	0.050997	329.23	359.82	1.2067	0.043358	328.55	358.90	1.1924
130	0.063479	339.29	371.03	1.2491	0.052519	338.67	370.18	1.2327	0.044688	338.04	369.32	1.2186
140	0.065256	348.83	381.46	1.2747	0.054027	348.25	380.66	1.2584	0.046004	347.66	379.86	1.2444
150	0.067021	358.51	392.02	1.2999	0.055522	357.96	391.27	1.2838	0.047306	357.41	390.52	1.2699
160	0.068775	368.33	402.72	1.3249	0.057006	367.81	402.01	1.3088	0.048597	367.29	401.31	1.2951
	P = 0.80 MPa (T_{sat} = 31.31°C)				P = 0.90 MPa (T_{sat} = 35.51°C)				P = 1.00 MPa (T_{sat} = 39.37°C)			
Sat.	0.025621	246.79	267.29	0.9183	0.022683	248.85	269.26	0.9169	0.020313	250.68	270.99	0.9156
40	0.027035	254.82	276.45	0.9480	0.023375	253.13	274.17	0.9327	0.020406	251.30	271.71	0.9179
50	0.028547	263.86	286.69	0.9802	0.024809	262.44	284.77	0.9660	0.021796	260.94	282.74	0.9525
60	0.029973	272.83	296.81	1.0110	0.026146	271.60	295.13	0.9976	0.023068	270.32	293.38	0.9850
70	0.031340	281.81	306.88	1.0408	0.027413	280.72	305.39	1.0280	0.024261	279.59	303.85	1.0160
80	0.032659	290.84	316.97	1.0698	0.028630	289.86	315.63	1.0574	0.025398	288.86	314.25	1.0458
90	0.033941	299.95	327.10	1.0981	0.029806	299.06	325.89	1.0860	0.026492	298.15	324.64	1.0748
100	0.035193	309.15	337.30	1.1258	0.030951	308.34	336.19	1.1140	0.027552	307.51	335.06	1.1031
110	0.036420	318.45	347.59	1.1530	0.032068	317.70	346.56	1.1414	0.028584	316.94	345.53	1.1308
120	0.037625	327.87	357.97	1.1798	0.033164	327.18	357.02	1.1684	0.029592	326.47	356.06	1.1580
130	0.038813	337.40	368.45	1.2061	0.034241	336.76	367.58	1.1949	0.030581	336.11	366.69	1.1846
140	0.039985	347.06	379.05	1.2321	0.035302	346.46	378.23	1.2210	0.031554	345.85	377.40	1.2109
150	0.041143	356.85	389.76	1.2577	0.036349	356.28	389.00	1.2467	0.032512	355.71	388.22	1.2368
160	0.042290	366.76	400.59	1.2830	0.037384	366.23	399.88	1.2721	0.033457	365.70	399.15	1.2623
170	0.043427	376.81	411.55	1.3080	0.038408	376.31	410.88	1.2972	0.034392	375.81	410.20	1.2875
180	0.044554	386.99	422.64	1.3327	0.039423	386.52	422.00	1.3221	0.035317	386.04	421.36	1.3124
	P = 1.20 MPa (T_{sat} = 46.29°C)				P = 1.40 MPa (T_{sat} = 52.40°C)				P = 1.60 MPa (T_{sat} = 57.88°C)			
Sat.	0.016715	253.81	273.87	0.9130	0.014107	256.37	276.12	0.9105	0.012123	258.47	277.86	0.9078
50	0.017201	257.63	278.27	0.9267								
60	0.018404	267.56	289.64	0.9614	0.015005	264.46	285.47	0.9389	0.012372	260.89	280.69	0.9163
70	0.019502	277.21	300.61	0.9938	0.016060	274.62	297.10	0.9733	0.013430	271.76	293.25	0.9535
80	0.020529	286.75	311.39	1.0248	0.017023	284.51	308.34	1.0056	0.014362	282.09	305.07	0.9875
90	0.021506	296.26	322.07	1.0546	0.017923	294.28	319.37	1.0364	0.015215	292.17	316.52	1.0194
100	0.022442	305.80	332.73	1.0836	0.018778	304.01	330.30	1.0661	0.016014	302.14	327.76	1.0500
110	0.023348	315.38	343.40	1.1118	0.019597	313.76	341.19	1.0949	0.016773	312.07	338.91	1.0795
120	0.024228	325.03	354.11	1.1394	0.020388	323.55	352.09	1.1230	0.017500	322.02	350.02	1.1081
130	0.025086	334.77	364.88	1.1664	0.021155	333.41	363.02	1.1504	0.018201	332.00	361.12	1.1360
140	0.025927	344.61	375.72	1.1930	0.021904	343.34	374.01	1.1773	0.018882	342.05	372.26	1.1632
150	0.026753	354.56	386.66	1.2192	0.022636	353.37	385.07	1.2038	0.019545	352.17	383.44	1.1900
160	0.027566	364.61	397.69	1.2449	0.023355	363.51	396.20	1.2298	0.020194	362.38	394.69	1.2163
170	0.028367	374.78	408.82	1.2703	0.024061	373.75	407.43	1.2554	0.020830	372.69	406.02	1.2421
180	0.029158	385.08	420.07	1.2954	0.024757	384.10	418.76	1.2807	0.021456	383.11	417.44	1.2676

B.Sc.Engg. (M)/ 5th Sem. **May 23, Wednesday, 2018**
HDME /5th Sem. /B.Sc.TE(2 Yr-Prog.)/1st Sem.

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

SEMESTER FINAL EXAMINATION — SEMESTER: 2017-2018
COURSE NO: MCE 4503/MCE 4595 — TIME: 3.00 HRS
COURSE TITLE: MECHANICS OF MACHINES — **FULL MARKS : 150**

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

1. (a) Prove that the common normal at the point of contact between a pair of teeth must always pass through the pitch point. (15)

   (b) A pinion having 30 teeth drives a gear having 80 teeth. The profile of the gears is involute with 20^0 pressure angle, 12 mm module and 10 mm addendum. Determine the length of path of contact, arc of contact and the contact ratio. (10)

2. a) Differentiate between compound gear train and reverted gear train. (5)

   b) A compound epicyclic gear is shown diagrammatically in Fig. 1. The gears *A*, *D* and *E* are free to rotate on the axis *P*. The compound gear *B* and *C* rotate together on the axis *Q* at the end of arm *F*. All the gears have equal pitch. The number of external teeth on the gears *A*, *B* and *C* are 18, 45 and 21 respectively. The gears *D* and *E* are annular gears. The gear *A* rotates at 100 rpm in the anticlockwise direction and the gear *D* rotates at 450 rpm clockwise. Find the speed and direction of the arm and the gear *E*. (20)

3. a) Derive the expression of the forces and torque on the reciprocating parts of a horizontal engine neglecting the weight of the connecting rod. (13)

   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. Neglecting the area of the piston rod, determine: i) the force in the piston rod; and ii) the turning moment on the crankshaft. (12)

4. During forward stroke of the piston of the double acting steam engine, the turning moment has the maximum value of 2500 N-m when the crank makes an angle of 80^0 with the inner dead center. During the backward stroke, the maximum turning moment is 2000 N-m when the crank makes an angle of 80^0 with the outer dead center. The turning moment diagram for the engine may be assumed for simplicity to be represented by two triangles.
   If the crank makes 150 rpm and the radius of gyration of the flywheel is 1.75 m, find the coefficient of fluctuation of energy and the mass of the flywheel to keep the speed within ± 0.75% of the mean speed. Also determine the crank angle at which the speed has its minimum and maximum values. (25)

5. a) The arms of a Porter governor are 300 mm long. The upper arms are pivoted on the axis of rotation and the lower arms are attached to the sleeve at a distance of 35 mm from the axis of rotation. The load on the sleeve is 54 kg and the mass of each ball is 7 kg. Determine the equilibrium speed when the radius of rotation of the balls is 225 mm. What will be the range (12)

of speed for this position, if the frictional resistances to the motion of the sleeve are equivalent to a force of 30 N?

b) Four masses *A*, *B*, *C* and *D* are attached to a shaft and revolve in the same plane. The masses are 12 kg, 10 kg, 18 kg and 15 kg respectively and their radii of rotations are 40 mm, 50 mm, 60 mm and 30 mm. The angular position of the masses *B*, *C* and *D* are 60^0, 135^0 and 270^0 from the mass *A*. Find the magnitude and position of the balancing mass at a radius of 100 mm. (13)

6. In a spring-loaded governor of the Hartnell type, the mass of each ball is 6 kg and the lift of the sleeve is 50 mm. The speed at which the governor begins to float is 250 rpm and at this speed the radius of the ball path is 110 mm. The mean working speed of the governor is 25 times the range of speed when friction is neglected. If the lengths of ball and roller arm of the bell crank lever are 120 mm and 100 mm respectively and if the distance between the center of pivot of bell crank lever and axis of governor spindle is 140 mm, determine the initial compression of the spring taking into account the obliquity of arms.
If friction is equivalent to a force of 35 N at the sleeve, find the total alteration in speed before the sleeve begins to move from mid-position. (25)

7. A rotating shaft carries four unbalanced masses 18 kg, 14 kg, 16 kg and 12 kg at radii 50 mm, 60 mm, 70 mm and 60 mm respectively. The 2nd, 3rd and 4th masses revolve in planes 80 mm, 160 mm and 280 mm respectively measured from the plane of the first mass and are angularly located at 60^0, 135^0, and 270^0 respectively measured clockwise from the first mass looking from this mass end of the shaft. The shaft is dynamically balanced by two masses, both located at 50 mm radii and revolving in planes mid-way between those of 1st and 2nd masses and midway between those of 3rd and 4th masses. Determine the magnitudes of the masses and their respective angular positions. (25)

8. A mechanism of a crank and slotted lever quick return motion is shown in Fig. 2. If the crank rotates counter clockwise at 120 rpm., determine for the configuration shown, the velocity and acceleration of the ram *D*. Also determine the angular acceleration of the slotted lever. Crank, AB =150 mm; Slotted arm, OC=700 mm and link CD = 200 mm. (25)

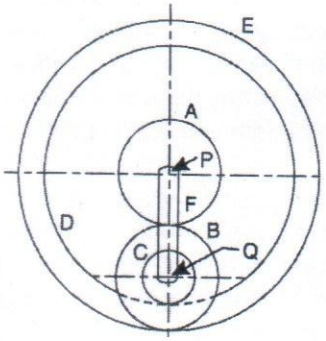

Fig.1

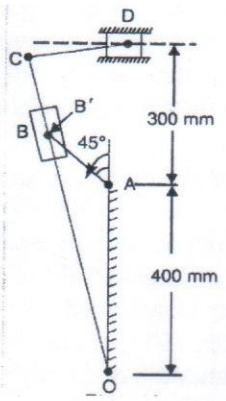

Fig.2

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

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29 May 2018(Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination — Winter Semester A.Y. 2017-2018
Course Code: MCE 4507/MCE 4593 — Time : 3 hours
Course Title: **Control system and Automation** — Full Marks : 100

There are **8 (Eight)** Questions. Answer any **6(Six)** of them.
Assume reasonable data if necessary.
Programmable calculators are not allowed. Don't write on this question paper.

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1. a) Name the six basic components required in a Hydraulic and a Pneumatic circuit? Define *fluid power actuators*. (4)

   b) Discuss the applications of hydraulic cylinder in First-Class, Second-Class and Third-Class lever systems. ($7\frac{2}{3}$)

   c) For the toggle mechanism of Fig. 1, determine the output load force for a hydraulic cylinder force of 1500lb. (5)

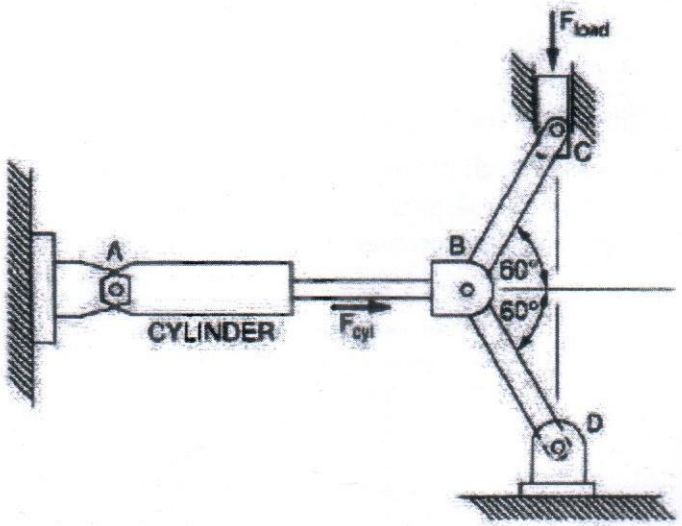

Fig.1 System for Question 1(c)

2. a) Define *control components* in a hydraulic system. Discuss the basic types of valves that are used in a Hydraulic system. (3)

   b) Briefly explain the operations of following valves ($8\frac{2}{3}$)
      a) Check valve
      b) Needle valve
      c) Simple Pressure Relief Valve

   c) Drawing only the simple diagrams briefly explain various center flow paths for three-position, four way valves. (5)

3. a) Defining *accumulators* discuss the classification of it. (5)

   b) With the help of sketches describe the four basic applications where accumulators are used in hydraulic circuits ($11\frac{2}{3}$)

4. a) With sketch briefly discuss on *Hydraulic motor braking system.* (6)

   b) For the circuit of following figure give the sequence of operation of cylinders 1 and 2 when the pump is turned on. Assume both cylinders are initially fully retracted. ($10\frac{2}{3}$)

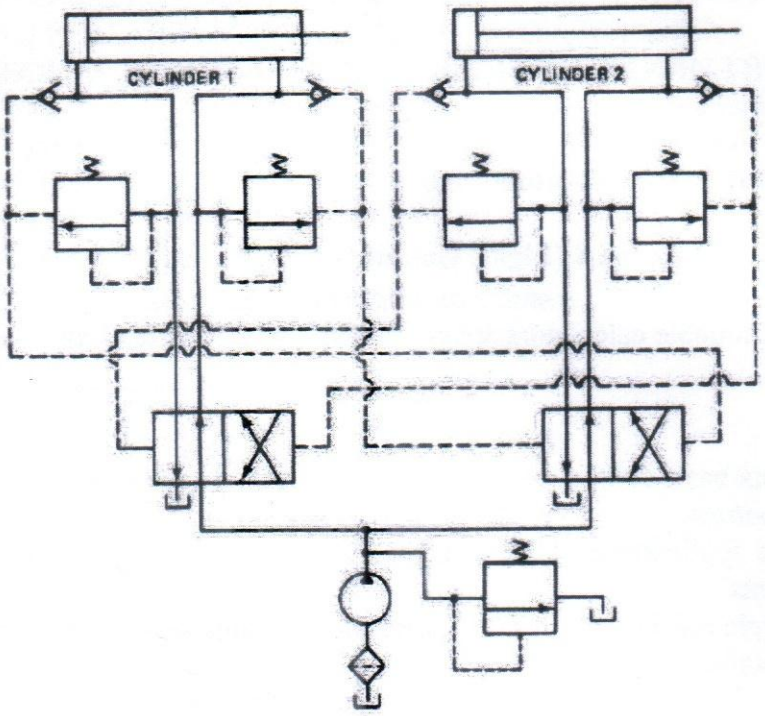

Fig.2 Circuit for question 4(b)

5. a) Design a pneumatic circuit for Two-Step Speed Control System. (8)

   b) Consider the pneumatic circuit of following figure. What happens to the cylinder ($8\frac{2}{3}$)
      i) When valve V4 is depressed?
      ii) When valve V5 is depressed?

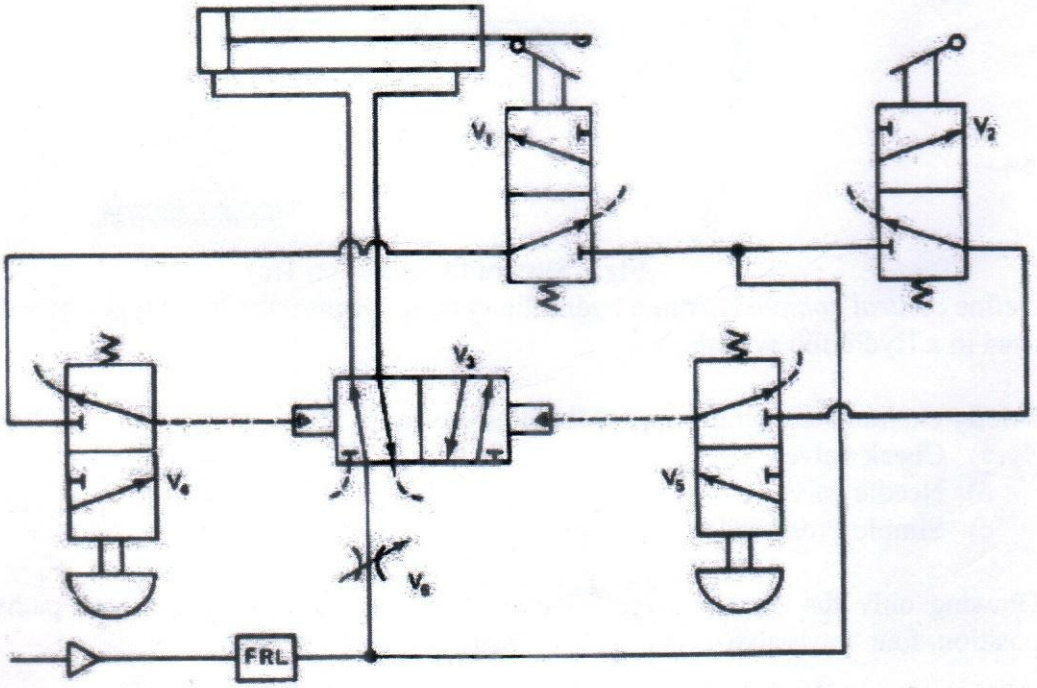

Fig.3 Circuit for question 5(b)

6. a) With sketches describe the reciprocation of a cylinder using pressure or limit switches (9)

b) For the system of following figure, what happens to the two cylinders in each case? ($7\frac{2}{3}$)

i) Push button 1-PB is momentarily depressed

ii) Push button 2-PB is momentarily depressed

Note that cylinder 2 does not actuate 1-LS at the end of the extension stroke

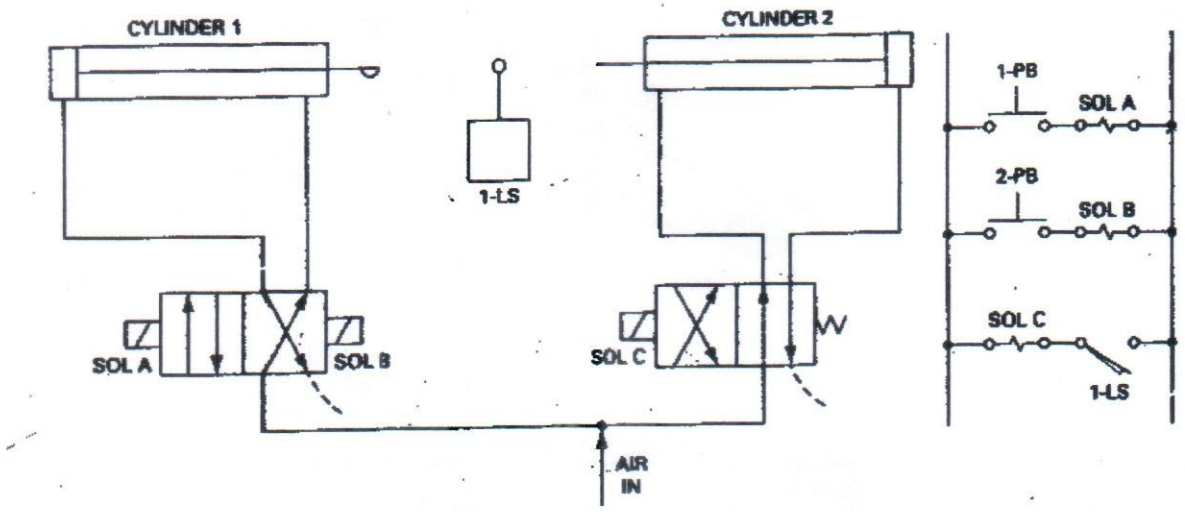

Fig.4 Circuit for question 6(b)

7. a) From the following system of figure 5, form the differential equation of motions. (8)

b) Then using Laplace Transformation find out the step response $x_3(t)$ ($8\frac{2}{3}$)

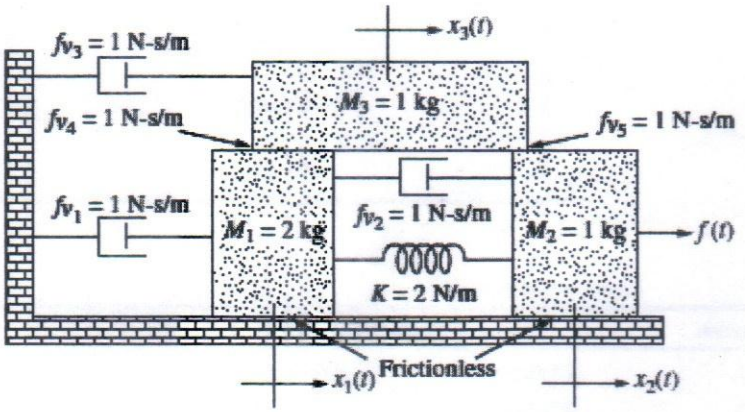

Fig.5 System for question 7(b)

8. a) The human eye has a biological control system that varies the pupil diameter to maintain constant light intensity to the retina. As the light intensity increases, the optical nerve sends a signal to the brain, which commands internal eye muscles to decrease the pupil's eye diameter. When the light intensity decreases, the pupil diameter increases. ($9\frac{2}{3}$)

a. Draw a functional block diagram of the light-pupil system indicating the input, output, and intermediate signals, the sensor, the controller and the actuator.

b. Under normal conditions the incident light will be larger than the pupil. If the incident light is smaller than the diameter of the pupil, the feedback path is broken. Modify your block diagram from Part a. to show where the loop is broken.

b) An aircraft's attitude varies in roll, pitch, and yaw as defined in Figure 6. Draw a functional block diagram for a closed-loop system that stabilizes the roll as follows: The system measures the actual roll angle with a gyro and compares the actual roll angle with the desired roll angle. The ailerons respond to the roll-angle error by undergoing an angular deflection. The aircraft responds to this angular deflection, producing a roll angle rate. Identify the input and output transducers, the controller, and the plant. Further, identify the nature of each signal (7)

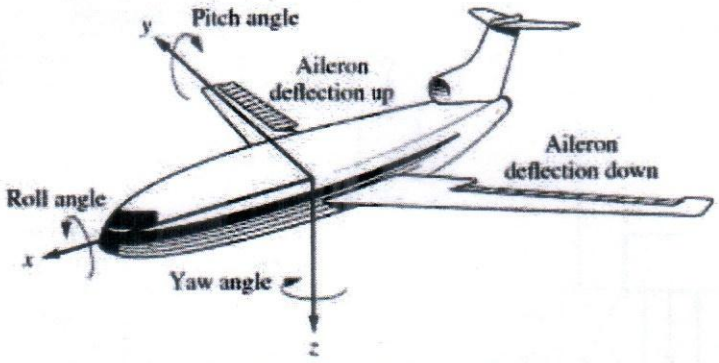

Fig.6 Aircraft attitude defined

Laplace transform table

Item no.	$f(t)$	$F(s)$
1.	$\delta(t)$	1
2.	$u(t)$	$\frac{1}{s}$
3.	$tu(t)$	$\frac{1}{s^2}$
4.	$t^n u(t)$	$\frac{n!}{s^{n+1}}$
5.	$e^{-at}u(t)$	$\frac{1}{s+a}$
6.	$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
7.	$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$

Laplace transform theorems

Item no.	Theorem	Name
1.	$\mathcal{L}[f(t)] = F(s) = \int_{0-}^{\infty} f(t)e^{-st}dt$	Definition
2.	$\mathcal{L}[kf(t)] = kF(s)$	Linearity theorem
3.	$\mathcal{L}[f_1(t)+f_2(t)] = F_1(s)+F_2(s)$	Linearity theorem
4.	$\mathcal{L}[e^{-at}f(t)] = F(s+a)$	Frequency shift theorem
5.	$\mathcal{L}[f(t-T)] = e^{-sT}F(s)$	Time shift theorem
6.	$\mathcal{L}[f(at)] = \frac{1}{a}F\left(\frac{s}{a}\right)$	Scaling theorem
7.	$\mathcal{L}\left[\frac{df}{dt}\right] = sF(s)-f(0-)$	Differentiation theorem
8.	$\mathcal{L}\left[\frac{d^2f}{dt^2}\right] = s^2F(s)-sf(0-)-f'(0-)$	Differentiation theorem
9.	$\mathcal{L}\left[\frac{d^nf}{dt^n}\right] = s^nF(s)-\sum_{k=1}^{n}s^{n-k}f^{k-1}(0-)$	Differentiation theorem
10.	$\mathcal{L}\left[\int_{0-}^{t} f(\tau)d\tau\right] = \frac{F(s)}{s}$	Integration theorem
11.	$f(\infty) = \lim_{s\to 0} sF(s)$	Final value theorem[1]
12.	$f(0+) = \lim_{s\to\infty} sF(s)$	Initial value theorem[2]

B.Sc. Engg (M)/HDME 5th Sem
BScTE/1st Sem

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8 June 2018

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

Semester Final Examination — Winter Semester: A.Y. 2017-2018
Course Code: MCE 4511/4591 — TIME : 3 Hours
Course Title: Fluid Machinery — Full Marks : 150

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

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1. a) Define fluid machines. Illustrate the classification of fluid machines with brief description. 12

   b) What is specific speed (N_s) of centrifugal pump? Find the expression for the minimum starting speed of a centrifugal pump. 13

2. a) Using Buckingham's π- theorem derive an expression for the resistance to the motion of a sphere of diameter D falling through a viscous fluid of viscosity μ at velocity V is given by, 15

$$F_d = \rho v^2 D^2 \varphi \left(\frac{\mu}{\rho v D}\right)$$

   b) The period of a simple pendulum time T depends on its length L and acceleration due to gravity g. Obtain an expression T by the Rayleigh method. 10

3. a) What is manometric efficiency? Derive the expression for energy conversion in the impeller of a centrifugal pump. 12

   b) The outer diameter of a centrifugal pump is equal to two times the inner diameter. The pump runs at 1200 rpm and works against the total head of 75 m. The velocity of flow through the impeller is constant and equal to 3 m/s. The vanes are set back at an angle of 30^0 at the outlet. If the outer diameter of the impeller is 60 cm and width at the outlet 5 cm,determine: 13

      i. Vane angle at the inlet
      ii. Work done by the impeller per second and
      iii. Manometric efficiency.

4. a) What is hydraulic turbine? Write down the differences between impulse and reaction turbine. Draw a simple schematic of hydraulic turbine plant. 12

   b) A conical draft tube having inlet and outlet diameters of 0.8 m and 1.2 m, respectively, discharges water at the outlet with a velocity of 3 m/s. The total length of the draft tube is 8 m and 2 m if it is immersed in water. If the atmospheric pressure 10.3 m of water and loss of head due to friction is 0.25 times the velocity head at the outlet of the tube, find the pressure head at the inlet and efficiency of the draft tube. 13

5. a) Prove that for a Pelton wheel turbine the hydraulic efficiency is the maximum when the velocity of wheel u is half the velocity of the jet V. 10

   b) A inward flow reaction turbine discharging radially at the outlet having an overall efficiency of 80% is required to develop 147.2 kW. The head is 9m. The velocity of the periphery of the wheel is $0.9\sqrt{2gH}$ and the radial velocity of the flow is $0.8\sqrt{2gH}$. The wheel rotates with 200 rpm and hydraulic efficiency is 85%. Determine i) Angle of guide blade at inlet, ii) wheel vane angle at inlet, iii) Diameter of the wheel, iv) Width of the wheel at the inlet. 15

6. a) Derive the equation of dynamic force of a jet for the following condition 12

   i. When the plate is stationary and vertical
   ii. When the plate is stationary and inclined
   iii. When the symmetrical plate is curved and jet strikes at one end tangentially.

   b) A jet of water with a velocity of 40 m/s strikes a curve vane which moves with a velocity of 20 m/s. The jet makes an angle of 30° with the direction of the motion of the vane at the inlet and leaves at 90° to the direction of motion of the vane at the outlet. Determine vane angle at the inlet and the outlet if water enters and leaves the vane without shock. 13

7. a) Write down the differences between fan, compressor and blower. 10

   b) The discharge Q through an orifice depends on diameter d of the orifice, area a, head H above the orifice, density ρ and viscosity μ of liquid and acceleration g due to gravity. Show by dimensional analysis that $Q=C_d a\sqrt{2gH}$ where C_d is non-dimensional coefficient of discharge. 15

8. a) An inward flow reaction turbine works under a head of 8m. The inlet guide blade angle is 30° and the inlet tip of runner vanes makes an angle of 110° with the tangent at the periphery. The velocity of flow is constant. If the discharge is radial at the outlet, find the hydraulic efficiency and the velocity of flow. 12

   b) A centrifugal pump is required to work against a head of 10m and it runs at 550 rpm. The outside and inside diameters of the impeller are 500mm and 225mm respectively. Blades are curved backward at an angle of 45° at the outlet. The constant velocity of flow is 2.3 m/s. Find the manometric efficiency and the blade angle at inlet. Water enters radially at the inlet. Find also the minimum starting speed of the pump. 13

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

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination — Winter Semester, A. Y. 2017-2018
Course No Math 4511 — Time: 3 Hours
Course Title: Statistics and Quality Control — Full Marks: 150

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

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

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1. a) Raw data on strength of certain material in allowable stress, GPa is tabled below: [25]

215	147	296	230	215
155	236	267	192	204
213	224	191	210	231
257	193	208	271	244
170	181	226	178	173
218	217	284	158	250
210	260	137	139	205

i. Make the data into appropriate classes and then prepare a frequency table.
ii. Determine Range, Mean, Median, Mode, Standard Deviation and Skewness.
iii. Prepare a stem-and-leaf diagrams

2. a) A customer survey has been completed in KPK airlines. Before that the managers came into consensus that 'Delayed flight' and 'Slow Check in' as the primary causes. The table provides data on the complaints received in the survey: [15]

Cause	*No. of Complaints*
Delayed Flights	3500
Lost Luggage	2100
Bad Food	1300
Dirty Planes	500
Rude Attendants	150
Slow Check In	100

Convert the data into Pareto Table and draw a Pareto Diagram. Then find the vital few causes of complaints and comment about the consensus versus fact.

b) In a transport company there are 15 trucks. Among these, 6 have brake problems. A sample of 5 trucks have been selected randomly without replacement. What is the probability that 2 of these have brake problems? What is the probability that atleast 3 of these have brake problems? [6]

c) There are 10 rolls of film in a box, 3 of which are defective. Two rolls are to be selected, one after the other. What is the probability of selecting a defective roll followed by another defective roll? [4]

3. a) What do you understand by stratified and cluster sampling? The Metropolitan Gas Station Dealers' Association estimates that the mean number of gallons of gasoline sold per day at a gas station is 20,000. The shape of this distribution is unknown. A sample of 70 dealers yesterday revealed the mean number of gallons sold was 19,480. The standard deviation of the sample of 70 dealers was 4,250 gallons. Is the assertion that the population mean is 20,000 gallons reasonable? What is the likelihood of finding a sample with the given statistics from the proposed population? What assumptions do you need to make? [4+4]

   b) The speed at which utility companies can resolve problems are very important on customer perspective. DM Electricity Distribution Company reports that it can resolve customer problems on the same day it is lodged for 70 percent of the cases. Suppose that 15 cases reported today are representative of all complaints. What is the probability 10 of the problems resolved today? What is the probability 10 or 11 or 12 of the problems resolved today? What is the probability less than 10 of the problems resolved today? [8]

   c) In establishing warranties on HDTV sets, the manufacturer wants to set the limits so that few 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. Where should the warranty limits be set so that only 10 percent of the HDTVs need repairs at the manufacturer's expense? [9]

4. a) What does Bayes Theorem infer? One disease is found in 10% people of the world. A test to detect is 92% accurate. However the test has 5% false alarm rate. If you are tested positive, what is the probability that you have the disease? If you are tested negative, what is the probability that you have the disease? [9]

   b) DP Biscuit Ltd bakes and sells cookies at 50 different locations in Gazipur area. The Operations Manager is concerned about absenteeism among her workers. The information below reports the number of days absent for a sample of 10 workers during the last two-week pay period[Each week comprise of 5 working days]. [10]

   4 1 2 2 1 2 2 1 0 3

   (a) Determine the mean and the standard deviation of the sample.
   (b) What is the population mean? What is the best estimate of that value?
   (c) Develop a 95 percent confidence interval for the population mean.
   (d) Is it reasonable to conclude that the typical worker does not miss any days during a pay period?

   c) A manufacturer of computer chips claims that the probability of a defective chip is 2%. The manufacturer sells chips in batches of 1000 to major computer companies such as Dell and Gateway. [6]

      i. How many defective chips would you expect in a batch?
      ii. What is the probability that none of the chips are defective in a batch?
      iii. What is the probability at least one chip is defective in a batch?

5. a) Define AQL, LTPD, Type I error and Type II error. The ITU hardware store has just received the shipment of 2000 wrenches. If the AQL is 50 defective items in the shipment and the LTPD is 8 percent, find a sampling plan(n and c using the nomograph. Please attach the nomograph with your answer script. [15]

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

Subgroup no	Range, R
1	8
2	9
3	7
4	9
5	8
6	16
7	21
8	32
9	17
10	29

6. a) KJP Casting Ltd. Produces steel pipes 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 cm 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 the table. From this table, draw the trial x and R chart and comment. [15]

Day	Average diameter of the sample(cm)	Range, R
1	10.724	0.040
2	10.730	0.016
3	10.718	0.040
4	10.728	0.014
5	10.730	0.027
6	10.720	0.020
7	10.711	0.038
8	10.713	0.026
9	10.718	0.008
10	10.717	0.039

b) Draw a cause and effect(Ishikawa) diagram using any method for the faulty cars produced by your automobile manufacturing company [10]

7. a) The Manelli Perfume Company recently developed a new fragrance that they plan to market under the name "Heavenly." A number of market studies indicate that Heavenly has very good market potential. The Sales Department at Manelli is particularly interested in whether there is a difference in the proportions of younger and older women who would purchase Heavenly if it were marketed. There are two independent populations, a population consisting of the younger women and a population consisting of the older women. Each sampled woman will be asked to smell Heavenly and indicate whether she likes the fragrance well enough to purchase a bottle. A random sample of 100 young women revealed 20 liked the Heavenly fragrance well enough to purchase it. Similarly, a sample of 200 older women revealed 100 of them liked the fragrance well enough to make a purchase. Using 5% significance level, comment on whether there is a difference in the proportions of younger and older women who would purchase [10]

b) The Jamestown Steel Company manufactures and assembles desks and other office equipment at several plants in western New York State. The weekly production of the Model A325 desk at the Fredonia Plant follows the normal distribution, with a mean of 200 and a standard deviation of 16. Recently, because of market expansion, new production methods have been introduced and new employees hired. The vice president of manufacturing would like to investigate whether there has been a change in the weekly production of the Model A325 desk. To put it another way, is the mean number of desks produced at the Fredonia Plant different from 200 at the 0.01 significance level? For this purpose, 50 weeks production number in each of those 50 weeks are taken and their sample mean comes up as 204. [10]

c) A student in public administration wants to determine the mean amount members of city councils in large cities earn per month as remuneration for being a council member. The error in estimating the mean is to be less than $100 with a 95 percent level of confidence. The student found a report by the Department of Labor that estimated the standard deviation to be $1,000. What is the required sample size? [5]

8. a) Suppose samples of 200 cards are taken form a keypunch operation at 2 hour intervals to quality control the keypunch process. The percentage of cards in error for the past 10 samples is found to be 0.7%, 1.2%, 1.6%, 2%,1.5%, 1.8%,1.4%, 1.8% 0.9% and 1.2%. Draw the *p* chart using the above data. Now if you have taken a sample of 200 cards today and found the percentage of cards in error as 4 percent. So what would you do as a production engineer? [10]

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

c) SP Electronics sells expensive brands of stereo equipment in several shopping malls in a country. The Marketing Research Department reports that 30 percent of the customers entering the store that indicate they are browsing will, in the end, make a purchase. Let the last 20 customers who enter the store be a sample. [7]

i. What is the probability that exactly five of these customers make a purchase?
ii. What is the probability ten or more make a purchase?
iii. Does it seem likely at least one will make a purchase?

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B.Sc. Engg. (M)/HDME/5th Sem. 31 May 2018

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

SEMESTER FINAL EXAMINATION — WINTER SEMESTER: 2017-2018
COURSE NO. MCE 4521 — TIME: 3 HRS
COURSE TITLE: Materials Engineering — FULL MARKS: 150

There are EIGHT Questions. Answer any SIX Questions.
Figures in the Margin indicate full marks.

1. (a) What is meant by the terms 'composite' and 'ceramics'? Distinguish between 'particle reinforced composite' and 'laminated composite'. (18)
   (b) Give a flow sheet showing the production process of tiles. (7)

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

3. (a) Distinguish between full annealing and normalizing. "Normalized mild steel shows finer grain size than annealed mild steel." Explain in details how the grain size becomes finer in normalized mild steel. (10)
   (b) "Full annealing is not the final heat treatment for hypereutectoid steel"- why? Suggest a suitable heat treatment process to improve the machinability of hypereutectoid steel. (10)
   (c) "Hardening a high carbon steel part by quenching is almost always immediately followed by tempering"- why? (5)

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

5. (a) Distinguish between martensitic stainless steel and austenitic stainless steel with respect to composition and transformation characteristics. (12)
   (b) What is meant by the term 18/8 steel? Can this steel be hardened by heat treatment? Give reasons for your answer. (8)
   (c) Which stainless steel is best suited for (i) combustion chamber and (ii) razor blade and why? (5)

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

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

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

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B.Sc. Eng. (CSE)/ 5th Sem. 24 May 2018

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Term: Semester Final Examination — Winter Semester: 2017-2018
Course No.: Math-4541 — Time: 3 Hours
Course Title: Multivariable Calculus and Complex Variables — Full Marks: 150

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

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1. a) Define a harmonic function and conjugate harmonic function. Compute the Laplacian, where it exists, of the following functions and indicate where a function is harmonic. **12**

(i) $x^2 + y^2$ (ii) $e^{ax}\cos\beta y$ (iii) $\ln\sqrt{(x^2+y^2)}$

b) Prove that $u = x^2 - y^2 - 2xy - 2x + 3y$ is harmonic. Find a function v such that $f(z) = u + iv$ is analytic. Also express $f(z)$ in terms of z. **13**

2. a) (i) Find the following functions in the form of $u + iv$ **12**

$$e^{2+3\pi i} \text{ and } \cosh(-1+2i)$$

(ii) Find all solutions and graph in the complex plane

$$e^{z=1} \text{ and } \sinh z = 0$$

b) Evaluate the following integrals along the mentioned path. **13**

(i) $\int_0^{1+i} (x^2 - iy)dz$, along the parabola $y = x^2$

(ii) $\int_c (12z^2 - 4iz)dz$, along the curve C joining the points (1, 1) and (2, 3).

3. a) State Cauchy integral formula and Evaluate the following integral using Cauchy integral formula: **13**

$(i)\int_c \frac{4-3z}{z(z-1)(z-2)}dz$, where c is the circle $|z| = \frac{3}{2}$.

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

b) Define the singularity of a function. Find out the zeros and discuss the nature of the singularities of **12**

$$(i)\sin\frac{1}{z}\ (ii)\ \frac{e^{\frac{1}{z}}}{z^2}(iii)\frac{(z-2)}{z^2}\sin\left(\frac{1}{z-1}\right)$$

4. a) Using Residue theorem, evaluate $\frac{1}{2\pi i}\int_c \frac{e^{zt}dz}{z^2(z^2+2z+2)}$. **12**

b) Find the Laurent's series that converges for $0<|z-z_0|<R$ and determine the precise region of convergence of $\frac{\cos z}{(z-\pi)^2}, z_0=\pi$. **13**

5. a) (i) What is a graph of a function of two variables? How is it interpreted geometrically? Describe level curves. **13**

If $T(x, y)$ is the temperature at a point (x, y) on a thin metal plate in the xy-plane, then the level curves of T are called *isothermal curves*. All points on such a curve are at the same temperature. Suppose that a plate occupies the first quadrant and

$$T(x, y) = xy.$$

(ii) Sketch the isothermal curves on which $T = 1$, $T = 2$, and $T = 3$.
(iii) An ant, initially at (1, 4), wants to walk on the plate so that the temperature along its path remains constant. What path should the ant take and what is the temperature along that path?

b) (i) State the definition of continuity of a function of two variables. **12**

Let, $f(x,y)=\begin{cases}-\frac{xy}{x^2+y^2};(x,y)\neq(0,0)\\ 0\qquad\quad;(x,y)=(0,0)\end{cases}$

(ii) Show that $f_x(x,y)$ and $f_x(x,y)$ exist at all points *(x, y)*
(iii) Explain why f is not continuous at (0, 0).

6. a) (i) Define the total differentials of a function of two variables. **13**
(ii) When using differentials, what is meant by the terms propagated error and relative error?

(iii) Use the differential *dz* to approximate the change in $z=\sqrt{4-x^2-y^2}$ as *(x, y)* moves from the point (1, 1) to the point (1.01, 0.97). Compare this approximation with the exact change in z.

(iv) The possible error involved in measuring each dimension of a rectangular box is ± 0.1 millimeter. The dimensions of the box are $x = 50$ centimeters, $y = 20$ centimeters and $z = 15$ centimeters as shown in Fig.: 01. Use dv to estimate the propagated error and the relative error in the calculated volume of the box.

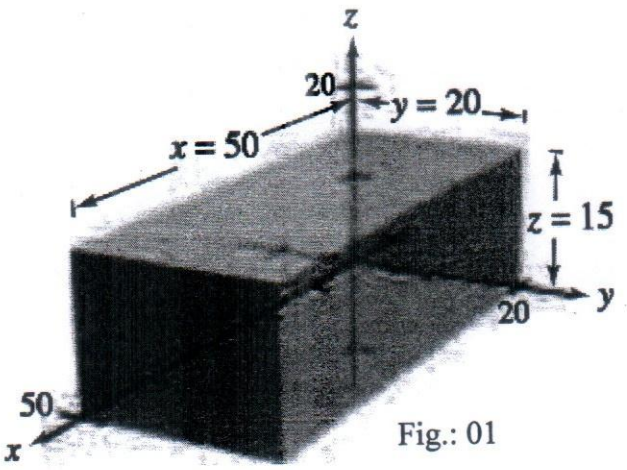

Fig.: 01

12

b) (i) If $f(x,y)=0$, give the rule for finding $\frac{dy}{dx}$ implicitly.

(ii) If $f(x,y,z)=0$, give the rule for finding $\partial z/\partial x$ *and* $\partial z/\partial y$ implicitly.

(iii) Find $\partial z/\partial x$ *and* $\partial z/\partial y$, given $3x^2z - x^2y^2 + 2z^3 + 3yz - 5 = 0$

(iv) Find the directional derivative of $f(x,y) = 4 - x^2 - \frac{1}{4}y^2$, at (1, 2) in the direction of $\bar{u} = \left(\cos\frac{\pi}{3}\right)\hat{i} + \left(\sin\frac{\pi}{3}\right)\hat{j}$.

7. a) (i) Write a paragraph describing the directional derivative of the function f in the direction $\bar{u} = \cos\theta\hat{i} + \sin\theta\hat{j}$, when $\theta = 0^\circ$ *and* $\theta = 90^\circ$. **12**

(ii) A heat–seeking particle is located at the point (2, -3) on a metal plate whose temperature at *(x, y)* is $T(x,y) = 20 - 4x^2 - y^2$. Find the path of the particle as it continuously moves in the direction of maximum temperature increase.

b) Consider the ellipsoid $x^2 + 4y^2 + z^2 = 18$. **13**

(i) Find an equation of the tangent plane to the ellipsoid at the point (1, 2, 1).

(ii) Find parametric equations of the line that is normal to the ellipsoid at the point (1, 2, 1).

(iii) Find the acute angle that the tangent plane at the point (1, 2, 1) makes with the *xy*-plane.

8. a) A delivery company accepts only rectangular boxes, the sum of whose length and girth (perimeter of a cross-section) does not exceed 108 inches and shown in Fig.: 02. Find the dimensions of an acceptable box of largest volume. **12**

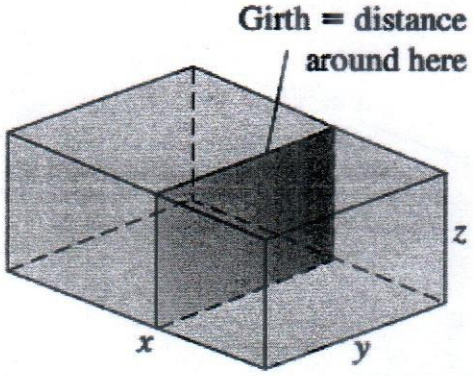

Fig.: 02

b) (i) Explain what is meant by constrained optimization problems. **13**
(ii) The operators of the Viking Princess, a luxury cruise liner are contemplating the addition of another swimming pool to the ship. The chief engineer has suggested that an area of the form of an ellipse located in the rear of the promenade deck would be suitable for this purpose. It has been determined that the shape of the ellipse may be described by the equation $x^2 + 4y^2 = 3600$ where x and y are measured in feet. Viking's operators would like to know the dimensions of the rectangular pool with the largest possible area that would meet these requirements.

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B.Sc. Engg. (ME)/HDME, 5th Sem. June 04, 2018

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

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

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

Winter Semester, A. Y. 2017-2018
Time: 3 Hours 00 Min(s)
Full Marks: 150

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

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

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1. a) What are the major four steps in the design and manufacturing of a mechanical product? In this four steps, which one uses CAD tool, which one uses CAE tool, and which one uses CAM tool? 15
   b) What are the purpose of using the following file formats? 10
   (i) IGES, *(ii)* STL, *(iii)* SLDPRT, *(iv)* SLDASM, *(v)* SLDDRW

2. a) Corresponding to the viewpoint $(-10,0,1)$, the viewsite $(0,0,1)$, and the up vector $(0,0,1)$, the viewing coordinate system is drawn as shown in the accompanying Figure 1. Note that all the coordinate and component values are given in world coordinates. From the relative position between the viewing coordinate system and the world coordinate system, (i) calculate the mapping transformation $\boldsymbol{T_{w-v}}$ and (ii) calculate the coordinates of a point in viewing coordinates if it has world coordinates $(5,0,1)$. 15

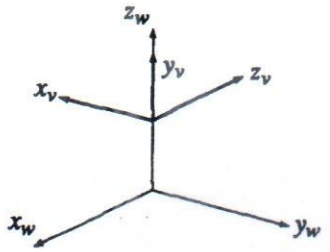

Figure 1

   b) What is shearing? Explain, can a cube become a curved barrel after a shearing transformation? 10

3. a) Write down the steps of constructing the skin surface over a circle and a square. 13
   b) Describe CGS data structure with a schematic example? What are its advantages and disadvantages? 12

4. a) What is reverse engineering? Briefly describe the steps involve in reverse engineering in order to get a CAD model from a physical model. 13
   b) Classify CNC machine tools based on control loops and explain them with necessary diagram. 12

5. Expand the equation of a non-periodic uniform B-spline curve of order 3 in polynomial form. Assume that the control points of the curve are $\boldsymbol{P_0}$, $\boldsymbol{P_1}$ and $\boldsymbol{P_2}$. 25

6. a) Write down the general expression of Bi-cubic patch. Calculate the values of all algebraic vectors of Bi-cubic patch for the following surface equation. 13

$$S(u,v) = \begin{bmatrix} x(u,v) \\ y(u,v) \\ z(u,v) \end{bmatrix} = \begin{bmatrix} 0.5 + 2v + v^3 - uv^2 - 4u^3v^3 \\ 3v^2 + 5u^2v \\ 1 + 2.5u - 1.5u^2v^3 \end{bmatrix}$$

b) Prove that boundary curves of a Hermite patch are Hermite curves. 12

7. a) Describe SLS and FDM rapid prototyping processes with necessary diagram. 20
b) What is the main difference between direct and indirect rapid tooling? 5

8. What is absolute and incremental programming? Write down a CNC part program for cutting the outer profile, four tap drill, one circular slot and one center drill (Design shown below). For the outer profile and circular slot use same tool of radius compensation 5 mm and length compensation 3 mm, and for the drilling and tapping operations assume the compensation values. Follow the cutting sequences as shown in the design below. Assume if any dimension or value is missing. 25

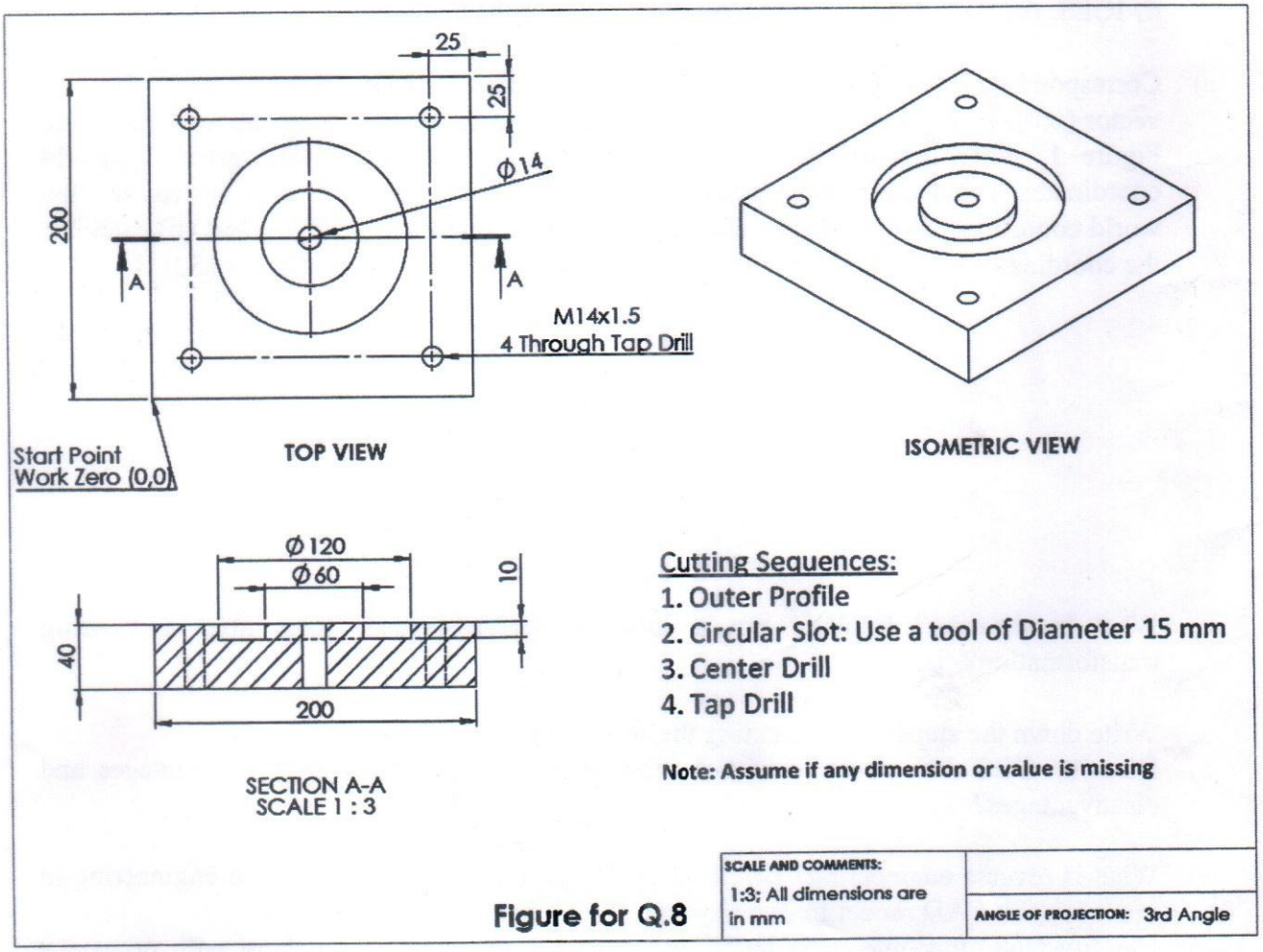

Figure for Q.8

B.Sc. Engg. (M)/ HDME -5th Sem./ /DTE 1st Sem 04 June 2018

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

SEMESTER FINAL EXAMINATION — WINTER SEMESTER: 2017-2018

Course No: MCE-4551 — TIME : 3HRS

Course Name: Refrigeration — FULL MARKS: 150

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

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1. (a) Explain the principle of Reversed Carnot engine. Show the cycle on T-S diagram. Establish the following relationship, (12)

$$(COP)_{hp}=(COP)_{ref}+1$$

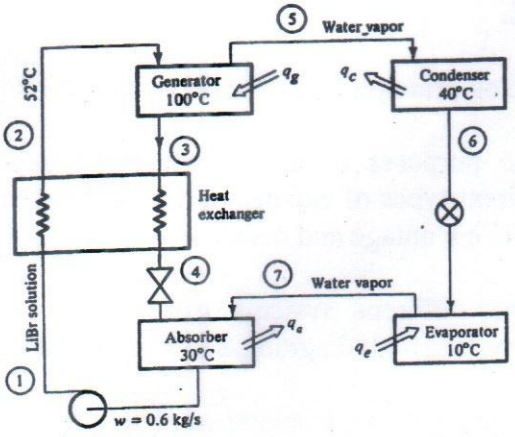
(b) An engine receives heat (Q_4) from a temperature source of **200°C** and rejects heat (Q_3) to a sink of **40°C**. A refrigerating compressor receives **60%** of the work (W) produced by the engine. The refrigeration cycle absorbs heat (Q_1) from a **-20°C** source and reject heat (Q_2) to **40°C** sink. Calculate (13)

i. The work done by the compressor
ii. Heat quantities (Q_4 & Q_3) for the engine.
iii. Heat quantities (Q_1 & Q_2) for the refrigerator.

Draw the system diagram.

2. (a) Explain performance characteristics of ideal compressor with necessary diagram for varying evaporating temperature. (12)

(b) An absorption system with a heat exchanger as shown in figure. The Li-Br solution leaves the heat exchanger at a temperature of **52 °C.** The mass rate of flow delivered by the solution pump is **0.6 kg/s.** What are the rates of energy transfer at each of the components and the COP of the cycle? (13)



3. An actual refrigerator operates on the vapor compression refrigeration cycle with **refrigerant-22** as the working fluid. The refrigerant evaporates at **-15°C** and condenses at **40°C.** The isentropic efficiency of the compressor is **83%.** The refrigerant is superheated by **5 °C** at the compressor inlet and sub cooled by **5 °C** at the exit of the condenser. Determine (*a*) the heat removed from the cooled space and the work input, in kJ/kg and the COP of the cycle. Determine (*b*) the same parameters if the cycle operated on the ideal vapor-compression refrigeration cycle between the same evaporating and condensing temperatures. (25)

   Draw cycles on P-h diagrams.

4. (a) List some major desirable properties of refrigerant. Explain with an example how the refrigerant is designated with a unique number followed by R. (12)

   (b) Explain different effects observed when the current is passed through a circuit whose junctions are formed by two dissimilar metals. Elaborate the concept of Thermoelectric refrigerator with proper diagram. (13)

5. Determine the length of tubes in a two-pass, shell and tube **R-22** condenser with 28 tubes with data as follows: (25)

   Cooling capacity = **10 TR**
   Condensing temperature = **45 °C**
   Heat rejection ratio = **1.32**
   Entering temperature of water = **30 °C**
   Leaving temperature of water = **34.8 °C**
   O.D and I.D of copper tubes = **1.27 cm** and **1.12 cm**, respectively.
   It is given that the film heat transfer co-efficient for R-12 condensing outside the tubes is **1360 W/m^{2}K.**

6. a) Explain working principle of Evaporative type condenser with necessary diagram. (10)

   b) What are the purposes of using expansions devices with the refrigeration system? Classify different types of expansion device. Explain Thermostatic expansion valve with diagram. Write advantage and disadvantages of Capillary tubes used for expansion. (15)

7. a) What are the different systems used for Aircraft air conditioning? Explain the regenerative system with diagram. Show the cycle on T-s diagram. (10)

   b) In air conditioning of a passenger airplane, the bootstrap air cycle is to be used. The ambient pressure and temperature are **90 kPa** and **25°C** respectively. Cabin pressure and temperature are to be maintained at **101 kPa** and **20°C**. The primary compressor compresses the air to **280 kPa**. The air enters the turbine at **700 kPa** and **200°C**. The flow (15)

rate need for the cabin is **1.2 m^3/s** of conditioned air. Calculate

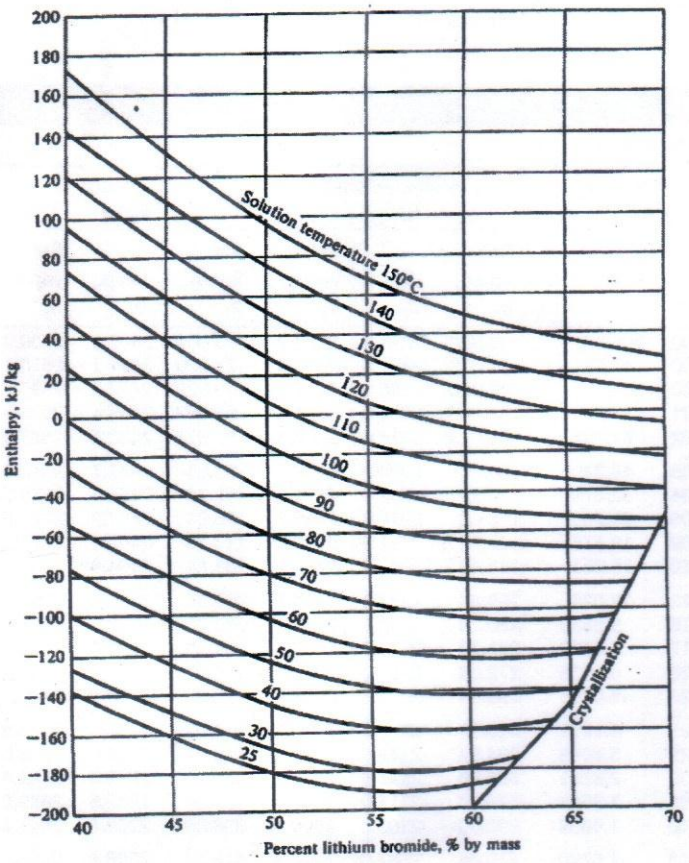
i. Cooling capacity of the system, and
ii. Temperature rise of the air in the secondary compressor.

Assume that there is no bypassing of the air around the turbine. Draw T-s diagram.

8. a) Draw schematic of Flash vapor removal type multi pressure system. Show that inter-cooling multi-pressure system can save work of compression. (10)

b) The required refrigeration capacity of a vapour compression refrigeration system (with **R22** as refrigerant) is **100 kW** at **–30°C** evaporator temperature. Initially the system was single-stage with a single compressor compressing the refrigerant vapour from evaporator to a condenser operating at **1500 kPa** pressure. Later the system was modified to a two-stage system operating on the cycle shown below. At the intermediate pressure of **600 kPa** there is intercooling but no removal of flash gas. Find (15)

i. Power requirement of the original single stage system;
ii. Total power requirement of the two compressors in the revised two-stage system. Assume that the state of refrigerant at the exit of evaporator, condenser and intercooler is saturated, and the compression processes are isentropic.



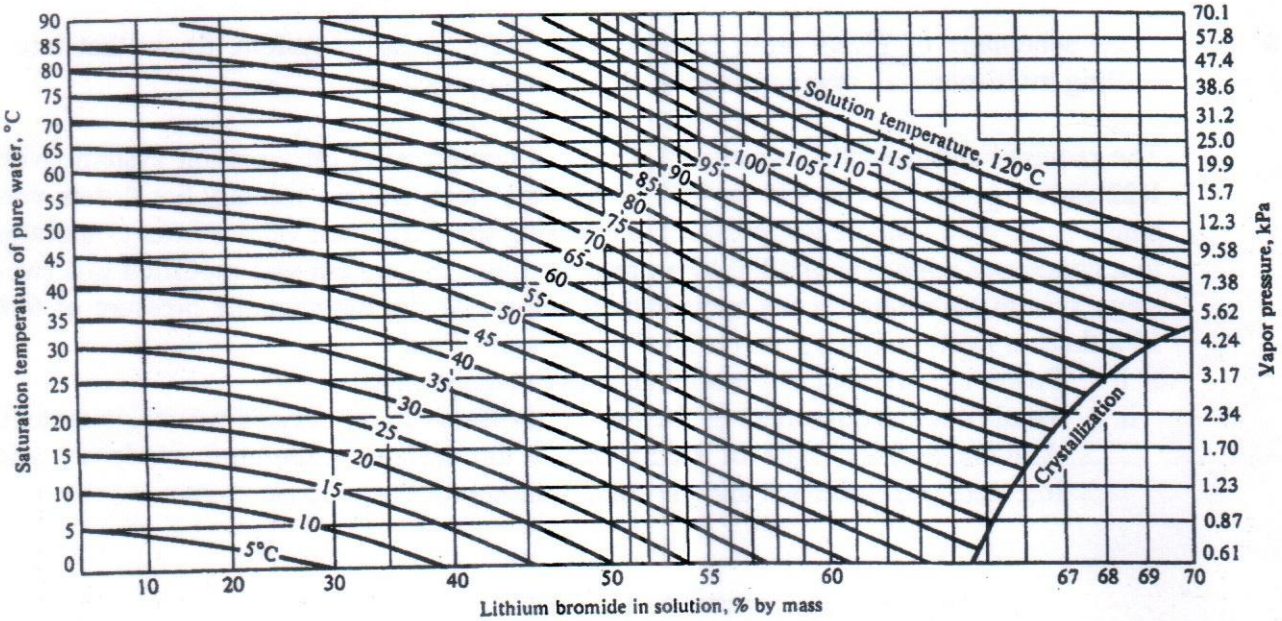


TABLE A–4

Saturated water—Temperature table

Temp., T °C	Sat. press., P_{sat} kPa	Specific volume, m³/kg: Sat. liquid, v_f	Specific volume, m³/kg: Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Internal energy, kJ/kg: Evap., u_{fg}	Internal energy, kJ/kg: Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Enthalpy, kJ/kg: Evap., h_{fg}	Enthalpy, kJ/kg: Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Entropy, kJ/kg·K: Evap., s_{fg}	Entropy, kJ/kg·K: Sat. vapor, s_g
0.01	0.6117	0.001000	206.00	0.000	2374.9	2374.9	0.001	2500.9	2500.9	0.0000	9.1556	9.1556
5	0.8725	0.001000	147.03	21.019	2360.8	2381.8	21.020	2489.1	2510.1	0.0763	8.9487	9.0249
10	1.2281	0.001000	106.32	42.020	2346.6	2388.7	42.022	2477.2	2519.2	0.1511	8.7488	8.8999
15	1.7057	0.001001	77.885	62.980	2332.5	2395.5	62.982	2465.4	2528.3	0.2245	8.5559	8.7803
20	2.3392	0.001002	57.762	83.913	2318.4	2402.3	83.915	2453.5	2537.4	0.2965	8.3696	8.6661
25	3.1698	0.001003	43.340	104.83	2304.3	2409.1	104.83	2441.7	2546.5	0.3672	8.1895	8.5567
30	4.2469	0.001004	32.879	125.73	2290.2	2415.9	125.74	2429.8	2555.6	0.4368	8.0152	8.4520
35	5.6291	0.001006	25.205	146.63	2276.0	2422.7	146.64	2417.9	2564.6	0.5051	7.8466	8.3517
40	7.3851	0.001008	19.515	167.53	2261.9	2429.4	167.53	2406.0	2573.5	0.5724	7.6832	8.2556
45	9.5953	0.001010	15.251	188.43	2247.7	2436.1	188.44	2394.0	2582.4	0.6386	7.5247	8.1633
50	12.352	0.001012	12.026	209.33	2233.4	2442.7	209.34	2382.0	2591.3	0.7038	7.3710	8.0748
55	15.763	0.001015	9.5639	230.24	2219.1	2449.3	230.26	2369.8	2600.1	0.7680	7.2218	7.9898
60	19.947	0.001017	7.6670	251.16	2204.7	2455.9	251.18	2357.7	2608.8	0.8313	7.0769	7.9082
65	25.043	0.001020	6.1935	272.09	2190.3	2462.4	272.12	2345.4	2617.5	0.8937	6.9360	7.8296
70	31.202	0.001023	5.0396	293.04	2175.8	2468.9	293.07	2333.0	2626.1	0.9551	6.7989	7.7540
75	38.597	0.001026	4.1291	313.99	2161.3	2475.3	314.03	2320.6	2634.6	1.0158	6.6655	7.6812
80	47.416	0.001029	3.4053	334.97	2146.6	2481.6	335.02	2308.0	2643.0	1.0756	6.5355	7.6111
85	57.868	0.001032	2.8261	355.96	2131.9	2487.8	356.02	2295.3	2651.4	1.1346	6.4089	7.5435
90	70.183	0.001036	2.3593	376.97	2117.0	2494.0	377.04	2282.5	2659.6	1.1929	6.2853	7.4782
95	84.609	0.001040	1.9808	398.00	2102.0	2500.1	398.09	2269.6	2667.6	1.2504	6.1647	7.4151
100	101.42	0.001043	1.6720	419.06	2087.0	2506.0	419.17	2256.4	2675.6	1.3072	6.0470	7.3542
105	120.90	0.001047	1.4186	440.15	2071.8	2511.9	440.28	2243.1	2683.4	1.3634	5.9319	7.2952
110	143.38	0.001052	1.2094	461.27	2056.4	2517.7	461.42	2229.7	2691.1	1.4188	5.8193	7.2382
115	169.18	0.001056	1.0360	482.42	2040.9	2523.3	482.59	2216.0	2698.6	1.4737	5.7092	7.1829
120	198.67	0.001060	0.89133	503.60	2025.3	2528.9	503.81	2202.1	2706.0	1.5279	5.6013	7.1292

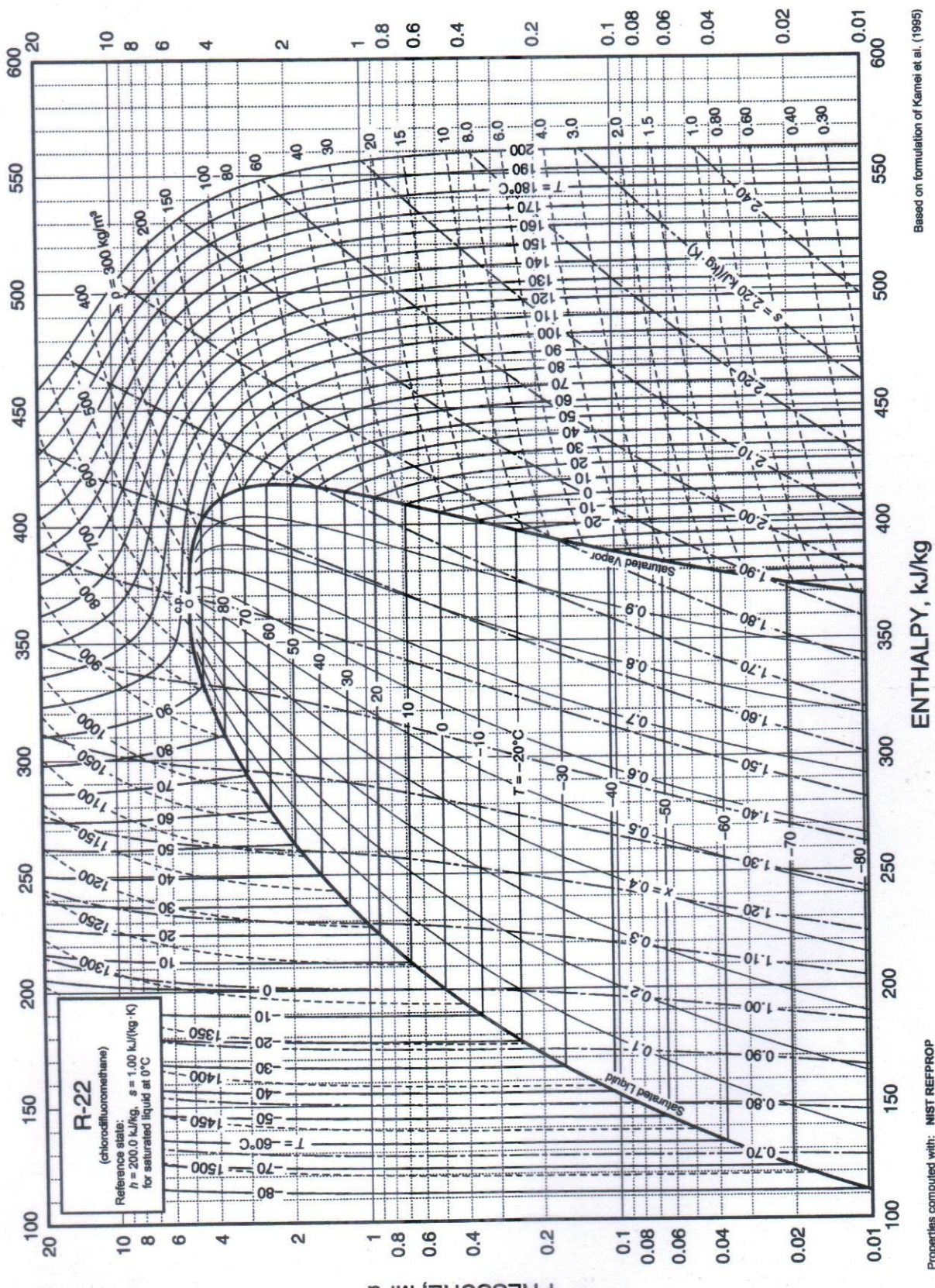


Fig. 2 Pressure-Enthalpy Diagram for Refrigerant 22

B.Sc. Engg. (M)/ HDME, 5th Semester 31 May 2018 (Thursday)

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

Semester Final Examination — Winter Semester, A.Y. 2017-2018
Course Code: MCE 4573 — Time : 3 Hours
Course Title: Renewable Energy Resources — Full Marks : 150

There are **8 (eight)** Questions. Answer any **6 (six)** of them.
Marks in the Margin indicate the full marks. The symbols have their usual meaning.

1. a) With the help of neat sketches, discuss the latitude, declination, zenith angle and solar azimuth angle. 16

   b) At Madison, Wisconsin, what is the solar time corresponding to 10:30 AM central time on February 3? At Madison, the longitude is 89.4° and the standard meridian is 90°. 9

2. a) Define solar constant, beam radiation, irradiance and profile angle. 10

   b) Calculate the time of sunrise, solar altitude, zenith, solar azimuth, and profile angles for a 60° sloped surface facing 25° west of south at 4:00 PM solar time on March 16 at a latitude of 43°. 15

3. a) With the help of neat sketches, describe any two instruments used for measuring solar radiation. 8

   b) Discuss the attenuation of solar radiation. 7

   c) What is H_0, the day's solar radiation on a horizontal surface in the absence of the atmosphere, at latitude 43° N on April 15? 10

4. a) Draw simple sketches of different wind turbines. 7

   b) Show that the maximum power coefficient of a wind turbine is 16/27 (List all assumptions). 18

5. a) Write down the control strategies that are used to protect wind turbines at high wind speed. 7

   b) Show that the maximum axial force coefficient of a wind turbine is 8/9 at maximum power output (List all assumptions). 18

6. a) Find the maximum power coefficient of a drag-type wind turbine (List all assumptions). 13

   b) Write down the advantages and disadvantages of offshore wind farms. Also mention the special requirements to be considered for offshore wind farms. 12

7. a) Show that the efficiency of an impulse turbine in ideal case is 100%. 15

   b) Write short notes on: (i) Reaction turbine and (ii) Pumped hydro energy storage. 10

8. a) Write down the applications of geothermal energy. 7

   b) Briefly mention different geothermal regions. 6

   c) Write short notes on: (i) Photo-synthesis and (ii) Pyrolysis 12

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Equations:

$$Solar\ time - standard\ time = 4(L_{st} - L_{loc}) + E$$

$$E = 229.2(0.000075 + 0.001868\cos B - 0.032077\sin B - 0.014615\cos 2B - 0.04089\sin 2B)$$

$$B = (n-1)\frac{360}{365}$$

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

$$\omega = (T - 12) \times 15°$$

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

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

$$R_b = \frac{\cos(\phi-\beta)\cos\delta\cos\omega + \sin(\phi-\beta)\sin\delta}{\cos\phi\cos\delta\cos\omega + \sin\phi\sin\delta}$$

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

$$\tan\alpha_p = -\frac{\tan\alpha_s}{\cos(\gamma_s - \gamma)}$$

$$H_0 = \frac{24\times 3600 G_{sc}}{\pi}\left(1 + 0.033\cos\frac{360n}{365}\right)\times\left(\cos\phi\cos\delta\sin\omega_s + \frac{\pi\omega_s}{180}\sin\phi\sin\delta\right)$$

$$K_T = \frac{H}{H_0}$$

HDME 5th Sem **31 May 2018**

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

Semester Final Examination — Winter Semester : A.Y. 2017-2018
Course Code: MCE 4585 — Time : 3 Hours
Course Title : Automotive Technology-I — Full Marks : 150

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

1. a) What precautions should be observed when charging a battery? 06

b) Write down the principle of generation of alternating current. Show the outputs generator when multi-pole magnets are used with necessary diagrams. 07

c) Explain how half-wave and full-wave rectifications of alternating current into direct current are done while charging a battery. 12

2. a) Draw a simple diagram showing the constructional details of pre-engaged type-starter motor. 09

b) Briefly describe the following components of automotive starting system with necessary diagrams. 16

i. Pinion and overrunning clutch
ii. Neutral safety switch

3. a) Write down the principle of starter motor showing how the bending of magnetic flux causes the rotation of motor armature. 10

b) Draw a schematic diagram of starting system of automotive engine. 10

c) Show the arrangement for passing the current through the armature and field windings in compound-wound DC motor. 05

4. a) Draw a schematic diagram of battery ignition system showing all the components. 08

b) Explain why advancing in ignition is required. Describe the centrifugal advance mechanism. 12

c) Write down five advantages of electronic ignition system. 05

5. a) What are the types of lubrication systems? What is meant by SAE numbers? 05

b) Describe the function of Pressure Relief Valve in lubrication with necessary diagram. 10

c) Describe the two types of oil filters. 10

6. a) Draw a schematic diagram of water cooling system of 4-cylinder engine. 10

   b) Describe the following components of cooling system of automotive engine with necessary diagrams. 10

      i. Radiator Pressure Cap
      ii. Expansion Tank

   c) Write down the classification of radiators based on the direction of coolant flow. 05

7. a) How is the amount of fuel controlled by reciprocation and rotation of plunger in the fuel pump of diesel engine? Explain with diagrams. 15

   b) Describe the mechanical governor in diesel engine fuel system. 10

8. a) What do we understand about the 'Exhaust and Inlet Valve Overlap'? Why is it needed? 08

   b) What are the basic differences between Four stroke and two stroke engine? Write down the advantages of four stroke engine over two stroke engine. 10

   c) Draw the valve timing diagram of 4-stroke automotive CI engine. 07

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DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination — Winter Semester: A.Y. 2017-2018
Course Code: MCE 4587 — TIME : 3 Hours
Course Title: Automotive Maintenance Engineering-I — Full Marks : 150

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

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1. a) Explain the importance of automotive maintenance engineering in your own language. 13

b) Describe the following measuring instruments in brief 12

I. Inside and outside calipers
II. Dial indicator
III. Piston ring expander
IV. Multimeter
V. Vacuum gauge

2. a) What are the cooling systems available in an automobile vehicle? Explain briefly. 10

b) Explain the following tests in engine cooling system- 15
i. Cooling system pressure test
ii. Combustion leak test
iii. Thermostat test

3. a) What is engine tune-up? Discuss the importance of tune-up process. Mention the tools and equipment names that are used for tune up. 10

b) Describe a systematic tune-up procedure for automotive engine. Mention the precautions need to be taken. 15

4. a) Why lubrication system is important? Describe the steps to diagnosis the fault of the lubrication system. 12

b) Write a short note on 'spark plug installation'. 13

5. a) Briefly explain the governing factor that is responsible for a braking system. 9

b) How to perform the antifreeze servicing? 8

c) How to replace the filter element of the two known filters in lubricating system. 8

6. a) Why maintenance of battery is important in an automobile vehicle? What are the important steps regarding disconnecting the battery? 12

   b) Write a short note on following battery testing procedure 13

      i. Hydrometer
      ii. Electric load tester

7. a) What are the requirements of valve operation in engine? Explain different types of valve troubles and describe in brief the valve servicing with diagrams if needed. 12

   b) Describe diesel engine overhauling procedure in details. 13

8. a) Write down the differences between the modern electric car and conventional car. 10

   b) Write down the possible causes of the following starting problems with action needed to solve these problems- 15

      i. Starter spins but engine will not crank
      ii. Engine cranks too slowly to start
      iii. Starter keeps running

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination — Winter Semester A.Y. 2017-2018
Course Code: MCE 4705 — Time : 3 hours
Course Title: **Thermodynamics-III** — Full Marks : 150

There are **8(Eight)** Questions. Answer any **6(Six)** of them.
Assume reasonable data if necessary.
Programmable calculators are not allowed. Don't write on this question paper.

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1. a) The rate of heat transfer between a certain electric motor and its surroundings varies with time as (12)

$$\dot{Q} = -0.2[1 - e^{-0.06t}]$$

Where, t is in seconds and $\dot{Q}$ is in kW.
The shaft of the motor rotates at a constant speed of ω= 100 rad/s and applies a constant torque of 25 Nm to an external load. The motor draws a constant electric power input equal to 4.0 kW. For the motor, find out the change in energy, in kJ, from time t = 0 to t =150 s.

b) Water in a piston–cylinder assembly, initially at a temperature of 99.63°C and a quality of 65%, is heated at constant pressure to a temperature of 200°C. If the work during the process is +300 kJ, determine (13)
(a) the mass of water, in kg, and
(b) the heat transfer, in kJ. Changes in kinetic and potential energy are negligible.

2. a) State Second Law of Thermodynamics. Write down the Corollaries of the Second Law for Power Cycles. (8)

b) Classify the following processes of a closed system as *possible, impossible,* or *indeterminate.* (10)

	Entropy Change	Entropy Transfer	Entropy Production
(a)	>0	0	
(b)	<0		>0
(c)	0	>0	
(d)	>0	>0	
(e)	0	<0	
(f)	>0		<0
(g)	<0	<0	

c) The data listed below are claimed for a power cycle operating between hot and cold reservoirs at 1500 K and 450 K, respectively. For each case, determine whether the cycle operates *reversibly*, operates *irreversibly*, or is *impossible*. (7)
(a) Q_H =600 kJ, W_{cycle} =300 kJ, Q_C = 300 kJ
(b) Q_H = 400 kJ, W_{cycle} =280 kJ, Q_C = 120 kJ
(c) Q_H =700 kJ, W_{cycle} =300 kJ, Q_C = 500 kJ

3. Steam enters the first-stage turbine shown in figure 1 at 30 bar and 450°C with a volumetric flow rate of 90 m^3/min. Steam exits the turbine at 10 bar and 350°C. The steam is then reheated at constant pressure to 500°C before entering the second-stage turbine. Steam leaves the second stage as saturated vapor at 0.7 bar. For operation at steady state, and ignoring stray heat transfer and kinetic and potential energy effects, determine the (25)
(a) mass flow rate of the steam, in kg/h.
(b) total power produced by the two stages of the turbine,in kW.
(c) rate of heat transfer to the steam flowing through the reheater, in kW.

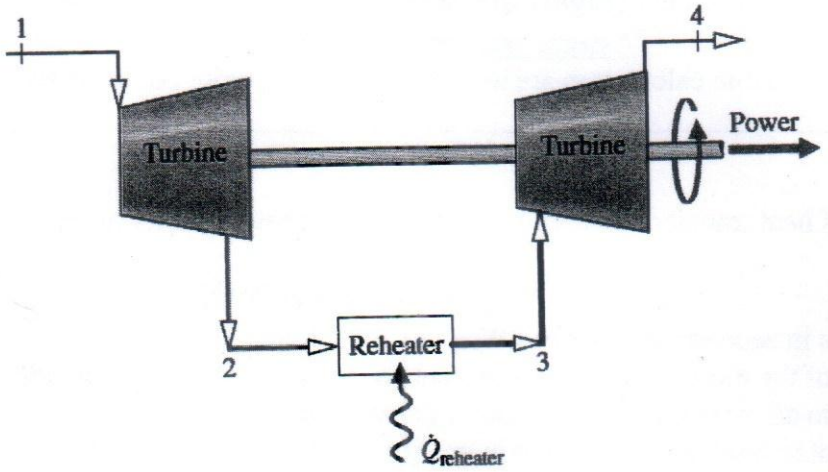

Figure: 1

4. A quantity of water within a piston–cylinder assembly executes a Carnot power cycle. During isothermal expansion, the water is heated from saturated liquid at 50 bar until it is a saturated vapor. The vapor then expands adiabatically to a pressure of 5 bar while doing 364.31 kJ/kg of work. (25)
(a) Sketch the cycle on p–v coordinates.
(b) Evaluate the heat transfer per unit mass and work per unit mass for each process, in kJ/kg.
(c) Evaluate the thermal efficiency.

5. Air flows through an insulated circular duct having a diameter of 4 cm. Steady-state pressure and temperature data obtained by measurements at two locations, denoted as 1 and 2, are given in the accompanying table. Modeling air as an ideal gas with c_p =1.005 kJ/kg.K, determine (25)
(a) the direction of the flow,
(b) the velocity of the air, in m/s, at each of the two locations, and
(c) the mass flow rate of the air, in kg/hr.

Measurement Location	1	2
Pressure (kPa)	200	600
Temperature(°C)	30	60

6. Air as an ideal gas flows through the turbine and heat exchanger arrangement shown in Fig. 2. Steady-state data are given on the figure. Stray heat transfer and kinetic and potential energy effects can be ignored. Determine (25)
(a) temperature T_3, in K.
(b) the power output of the second turbine, in kW.
(c) the rates of entropy production, each in kW/K, for the turbines and heat exchanger.
(d) Using the result of part (c), place the components in rank order, beginning with the component contributing most to inefficient operation of the overall system.

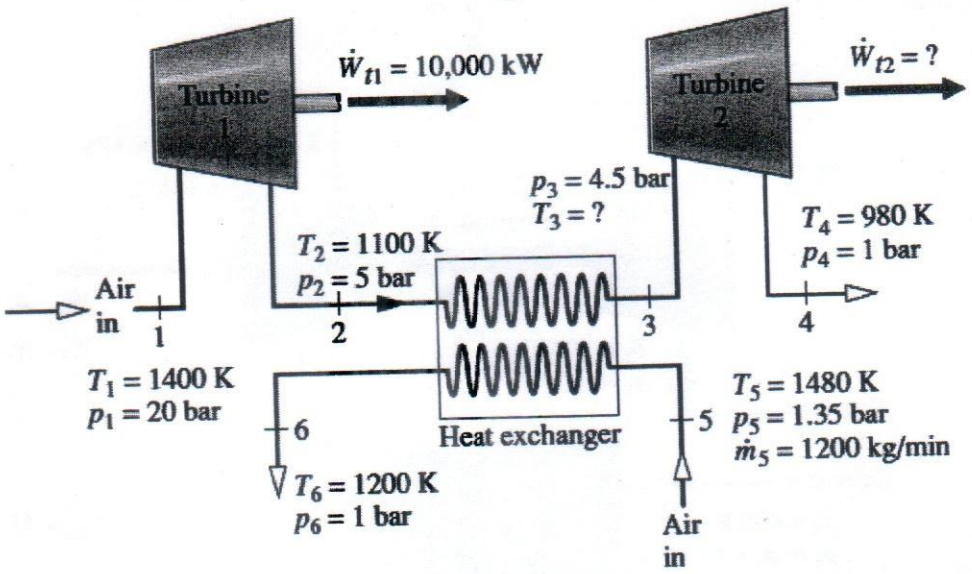

Figure: 2

7. Air enters an insulated turbine operating at steady state with a pressure of 5 bar, a temperature of 500 K, and a volumetric flow rate of 3 m^3/s. At the exit, the pressure is 1 bar. The isentropic turbine efficiency is 76.7%. Assuming the ideal gas model and ignoring the effects of motion and gravity, determine (25)

(a) the power developed and the exergy destruction rate, each in kW.

(b) the exergetic turbine efficiency.

Let T_o =20°C, p_0=1 bar.

8. Figure 3 shows a combined gas turbine–vapor power plant operating at steady state. The gas turbine is numbered 1–5. The vapor power plant is numbered 6–9. The accompanying table gives data at these numbered states. The total net power output is 45 MW and the mass flow rate of the water flowing through the vapor power plant is 15.6 kg/s. Air flows through the gas turbine power plant, and the ideal gas model applies to the air. Stray heat transfer and the effects of motion and gravity can be ignored. Let T_0 =300 K, p_0 =100 kPa. Determine (25)

a) the mass flow rate of the air flowing through the gas turbine, in kg/s.

b) the net rate exergy is carried out with the exhaust air stream, ($\dot{E}_{f5}$-$\dot{E}_{f1}$) in MW.

c) the rate of exergy destruction in the compressor and pump, each in MW.

d) the net rate of exergy increase of the air flowing through the combustor, ($\dot{E}_{f3}$-$\dot{E}_{f2}$), in MW

Devise and evaluate an exergetic efficiency for the overall combined power plant.

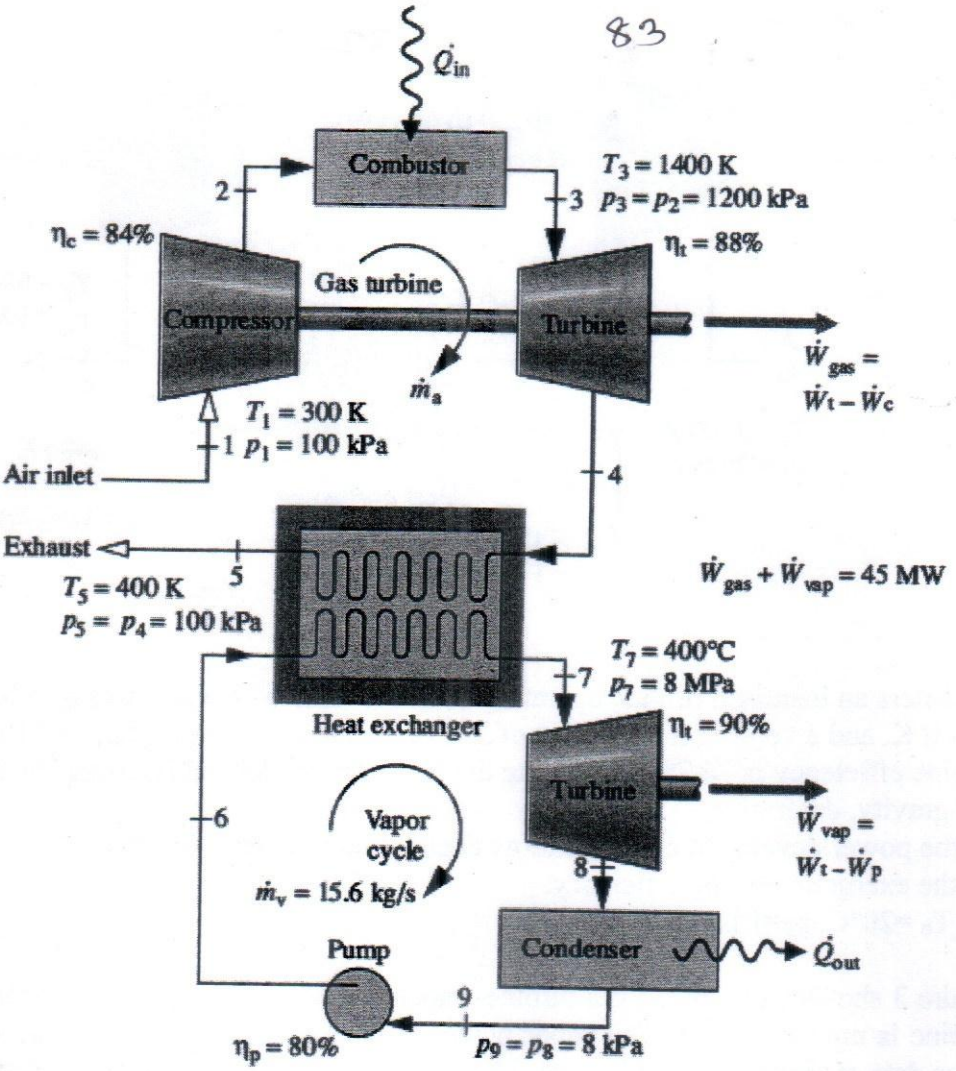

Figure: 3

Gas Turbine			Vapor Cycle		
State	h(kJ/kg)	$s°$(kJ/kg · K)[a]	State	h(kJ/kg)	s(kJ/kg · K)
1	300.19	1.7020	6	183.96	0.5975
2	669.79	2.5088	7	3138.30	6.3634
3	1515.42	3.3620	8	2104.74	6.7282
4	858.02	2.7620	9	173.88	0.5926
5	400.98	1.9919			

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TABLE A-3

Properties of Saturated Water (Liquid–Vapor): Pressure Table

Pressure Conversions: 1 bar = 0.1 MPa = 10^2 kPa

Press. bar	Temp. °C	Specific Volume m^3/kg Sat. Liquid $v_f \times 10^3$	Specific Volume m^3/kg Sat. Vapor v_g	Internal Energy kJ/kg Sat. Liquid u_f	Internal Energy kJ/kg Sat. Vapor u_g	Enthalpy kJ/kg Sat. Liquid h_f	Enthalpy kJ/kg Evap. h_{fg}	Enthalpy kJ/kg Sat. Vapor h_g	Entropy kJ/kg · K Sat. Liquid s_f	Entropy kJ/kg · K Sat. Vapor s_g	Press. bar
0.04	28.96	1.0040	34.800	121.45	2415.2	121.46	2432.9	2554.4	0.4226	8.4746	0.04
0.06	36.16	1.0064	23.739	151.53	2425.0	151.53	2415.9	2567.4	0.5210	8.3304	0.06
0.08	41.51	1.0084	18.103	173.87	2432.2	173.88	2403.1	2577.0	0.5926	8.2287	0.08
0.10	45.81	1.0102	14.674	191.82	2437.9	191.83	2392.8	2584.7	0.6493	8.1502	0.10
0.20	60.06	1.0172	7.649	251.38	2456.7	251.40	2358.3	2609.7	0.8320	7.9085	0.20
0.30	69.10	1.0223	5.229	289.20	2468.4	289.23	2336.1	2625.3	0.9439	7.7686	0.30
0.40	75.87	1.0265	3.993	317.53	2477.0	317.58	2319.2	2636.8	1.0259	7.6700	0.40
0.50	81.33	1.0300	3.240	340.44	2483.9	340.49	2305.4	2645.9	1.0910	7.5939	0.50
0.60	85.94	1.0331	2.732	359.79	2489.6	359.86	2293.6	2653.5	1.1453	7.5320	0.60
0.70	89.95	1.0360	2.365	376.63	2494.5	376.70	2283.3	2660.0	1.1919	7.4797	0.70
0.80	93.50	1.0380	2.087	391.58	2498.8	391.66	2274.1	2665.8	1.2329	7.4346	0.80
0.90	96.71	1.0410	1.869	405.06	2502.6	405.15	2265.7	2670.9	1.2695	7.3949	0.90
1.00	99.63	1.0432	1.694	417.36	2506.1	417.46	2258.0	2675.5	1.3026	7.3594	1.00
1.50	111.4	1.0528	1.159	466.94	2519.7	467.11	2226.5	2693.6	1.4336	7.2233	1.50
2.00	120.2	1.0605	0.8857	504.49	2529.5	504.70	2201.9	2706.7	1.5301	7.1271	2.00
2.50	127.4	1.0672	0.7187	535.10	2537.2	535.37	2181.5	2716.9	1.6072	7.0527	2.50
3.00	133.6	1.0732	0.6058	561.15	2543.6	561.47	2163.8	2725.3	1.6718	6.9919	3.00
3.50	138.9	1.0786	0.5243	583.95	2546.9	584.33	2148.1	2732.4	1.7275	6.9405	3.50
4.00	143.6	1.0836	0.4625	604.31	2553.6	604.74	2133.8	2738.6	1.7766	6.8959	4.00
4.50	147.9	1.0882	0.4140	622.25	2557.6	623.25	2120.7	2743.9	1.8207	6.8565	4.50
5.00	151.9	1.0926	0.3749	639.68	2561.2	640.23	2108.5	2748.7	1.8607	6.8212	5.00
6.00	158.9	1.1006	0.3157	669.90	2567.4	670.56	2086.3	2756.8	1.9312	6.7600	6.00
7.00	165.0	1.1080	0.2729	696.44	2572.5	697.22	2066.3	2763.5	1.9922	6.7080	7.00
8.00	170.4	1.1148	0.2404	720.22	2576.8	721.11	2048.0	2769.1	2.0462	6.6628	8.00
9.00	175.4	1.1212	0.2150	741.83	2580.5	742.83	2031.1	2773.9	2.0946	6.6226	9.00
10.0	179.9	1.1273	0.1944	761.68	2583.6	762.81	2015.3	2778.1	2.1387	6.5863	10.0
15.0	198.3	1.1539	0.1318	843.16	2594.5	844.84	1947.3	2792.2	2.3150	6.4448	15.0
20.0	212.4	1.1767	0.09963	906.44	2600.3	908.79	1890.7	2799.5	2.4474	6.3409	20.0
25.0	224.0	1.1973	0.07998	959.11	2603.1	962.11	1841.0	2803.1	2.5547	6.2575	25.0
30.0	233.9	1.2165	0.06668	1004.8	2604.1	1008.4	1795.7	2804.2	2.6457	6.1869	30.0
35.0	242.6	1.2347	0.05707	1045.4	2603.7	1049.8	1753.7	2803.4	2.7253	6.1253	35.0
40.0	250.4	1.2522	0.04978	1082.3	2602.3	1087.3	1714.1	2801.4	2.7964	6.0701	40.0
45.0	257.5	1.2692	0.04406	1116.2	2600.1	1121.9	1676.4	2798.3	2.8610	6.0199	45.0
50.0	264.0	1.2859	0.03944	1147.8	2597.1	1154.2	1640.1	2794.3	2.9202	5.9734	50.0
60.0	275.6	1.3187	0.03244	1205.4	2589.7	1213.4	1571.0	2784.3	3.0267	5.8892	60.0
70.0	285.9	1.3513	0.02737	1257.6	2580.5	1267.0	1505.1	2772.1	3.1211	5.8133	70.0
80.0	295.1	1.3842	0.02352	1305.6	2569.8	1316.6	1441.3	2758.0	3.2068	5.7432	80.0
90.0	303.4	1.4178	0.02048	1350.5	2557.8	1363.3	1378.9	2742.1	3.2858	5.6772	90.0
100.	311.1	1.4524	0.01803	1393.0	2544.4	1407.6	1317.1	2724.7	3.3596	5.6141	100.
110.	318.2	1.4886	0.01599	1433.7	2529.8	1450.1	1255.5	2705.6	3.4295	5.5527	110.

v_f = (table value)/1000

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TABLE A-3

(Continued)

Pressure Conversions: 1 bar = 0.1 MPa = 10^2 kPa

Press. bar	Temp. °C	Specific Volume m^3/kg Sat. Liquid $v_f \times 10^3$	Specific Volume m^3/kg Sat. Vapor v_g	Internal Energy kJ/kg Sat. Liquid u_f	Internal Energy kJ/kg Sat. Vapor u_g	Enthalpy kJ/kg Sat. Liquid h_f	Enthalpy kJ/kg Evap. h_{fg}	Enthalpy kJ/kg Sat. Vapor h_g	Entropy kJ/kg · K Sat. Liquid s_f	Entropy kJ/kg · K Sat. Vapor s_g	Press. bar
120.	324.8	1.5267	0.01426	1473.0	2513.7	1491.3	1193.6	2684.9	3.4962	5.4924	120.
130.	330.9	1.5671	0.01278	1511.1	2496.1	1531.5	1130.7	2662.2	3.5606	5.4323	130.
140.	336.8	1.6107	0.01149	1548.6	2476.8	1571.1	1066.5	2637.6	3.6232	5.3717	140.
150.	342.2	1.6581	0.01034	1585.6	2455.5	1610.5	1000.0	2610.5	3.6848	5.3098	150.
160.	347.4	1.7107	0.009306	1622.7	2431.7	1650.1	930.6	2580.6	3.7461	5.2455	160.
170.	352.4	1.7702	0.008364	1660.2	2405.0	1690.3	856.9	2547.2	3.8079	5.1777	170.
180.	357.1	1.8397	0.007489	1698.9	2374.3	1732.0	777.1	2509.1	3.8715	5.1044	180.
190.	361.5	1.9243	0.006657	1739.9	2338.1	1776.5	688.0	2464.5	3.9388	5.0228	190.
200.	365.8	2.036	0.005834	1785.6	2293.0	1826.3	583.4	2409.7	4.0139	4.9269	200.
220.9	374.1	3.155	0.003155	2029.6	2029.6	2099.3	0	2099.3	4.4298	4.4298	220.9

v_f = (table value)/1000

TABLE A-4

Properties of Superheated Water Vapor

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
	$p = 0.06$ bar $= 0.006$ MPa ($T_{sat} = 36.16$°C)				$p = 0.35$ bar $= 0.035$ MPa ($T_{sat} = 72.69$°C)			
Sat.	23.739	2425.0	2567.4	8.3304	4.526	2473.0	2631.4	7.7158
80	27.132	2487.3	2650.1	8.5804	4.625	2483.7	2645.6	7.7564
120	30.219	2544.7	2726.0	8.7840	5.163	2542.4	2723.1	7.9644
160	33.302	2602.7	2802.5	8.9693	5.696	2601.2	2800.6	8.1519
200	36.383	2661.4	2879.7	9.1398	6.228	2660.4	2878.4	8.3237
240	39.462	2721.0	2957.8	9.2982	6.758	2720.3	2956.8	8.4828
280	42.540	2781.5	3036.8	9.4464	7.287	2780.9	3036.0	8.6314
320	45.618	2843.0	3116.7	9.5859	7.815	2842.5	3116.1	8.7712
360	48.696	2905.5	3197.7	9.7180	8.344	2905.1	3197.1	8.9034
400	51.774	2969.0	3279.6	9.8435	8.872	2968.6	3279.2	9.0291
440	54.851	3033.5	3362.6	9.9633	9.400	3033.2	3362.2	9.1490
500	59.467	3132.3	3489.1	10.1336	10.192	3132.1	3488.8	9.3194
	$p = 0.70$ bar $= 0.07$ MPa ($T_{sat} = 89.95$°C)				$p = 1.0$ bar $= 0.10$ MPa ($T_{sat} = 99.63$°C)			
Sat.	2.365	2494.5	2660.0	7.4797	1.694	2506.1	2675.5	7.3594
100	2.434	2509.7	2680.0	7.5341	1.696	2506.7	2676.2	7.3614
120	2.571	2539.7	2719.6	7.6375	1.793	2537.3	2716.6	7.4668
160	2.841	2599.4	2798.2	7.8279	1.984	2597.8	2796.2	7.6597
200	3.108	2659.1	2876.7	8.0012	2.172	2658.1	2875.3	7.8343
240	3.374	2719.3	2955.5	8.1611	2.359	2718.5	2954.5	7.9949
280	3.640	2780.2	3035.0	8.3162	2.546	2779.6	3034.2	8.1445
320	3.905	2842.0	3115.3	8.4504	2.732	2841.5	3114.6	8.2849
360	4.170	2904.6	3196.5	8.5828	2.917	2904.2	3195.9	8.4175
400	4.434	2968.2	3278.6	8.7086	3.103	2967.9	3278.2	8.5435
440	4.698	3032.9	3361.8	8.8286	3.288	3032.6	3361.4	8.6636
500	5.095	3131.8	3488.5	8.9991	3.565	3131.6	3488.1	8.8342
	$p = 1.5$ bar $= 0.15$ MPa ($T_{sat} = 111.37$°C)				$p = 3.0$ bar $= 0.30$ MPa ($T_{sat} = 133.55$°C)			
Sat.	1.159	2519.7	2693.6	7.2233	0.606	2543.6	2725.3	6.9919
120	1.188	2533.3	2711.4	7.2693				
160	1.317	2595.2	2792.8	7.4665	0.651	2587.1	2782.3	7.1276
200	1.444	2656.2	2872.9	7.6433	0.716	2650.7	2865.5	7.3115
240	1.570	2717.2	2952.7	7.8052	0.781	2713.1	2947.3	7.4774
280	1.695	2778.6	3032.8	7.9555	0.844	2775.4	3028.6	7.6299
320	1.819	2840.6	3113.5	8.0964	0.907	2838.1	3110.1	7.7722
360	1.943	2903.5	3195.0	8.2293	0.969	2901.4	3192.2	7.9061
400	2.067	2967.3	3277.4	8.3555	1.032	2965.6	3275.0	8.0330
440	2.191	3032.1	3360.7	8.4757	1.094	3030.6	3358.7	8.1538
500	2.376	3131.2	3487.6	8.6466	1.187	3130.0	3486.0	8.3251
600	2.685	3301.7	3704.3	8.9101	1.341	3300.8	3703.2	8.5892

Pressure Conversions:
1 bar = 0.1 MPa
= 10^2 kPa

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Pressure Conversions:
1 bar = 0.1 MPa
= 10^2 kPa

TABLE A-4

(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
	p = 5.0 bar = 0.50 MPa (T_{sat} = 151.86°C)				p = 7.0 bar = 0.70 MPa (T_{sat} = 164.97°C)			
Sat.	0.3749	2561.2	2748.7	6.8213	0.2729	2572.5	2763.5	6.7080
180	0.4045	2609.7	2812.0	6.9656	0.2847	2599.8	2799.1	6.7880
200	0.4249	2642.9	2855.4	7.0592	0.2999	2634.8	2844.8	6.8865
240	0.4646	2707.6	2939.9	7.2307	0.3292	2701.8	2932.2	7.0641
280	0.5034	2771.2	3022.9	7.3865	0.3574	2766.9	3017.1	7.2233
320	0.5416	2834.7	3105.6	7.5308	0.3852	2831.3	3100.9	7.3697
360	0.5796	2898.7	3188.4	7.6660	0.4126	2895.8	3184.7	7.5063
400	0.6173	2963.2	3271.9	7.7938	0.4397	2960.9	3268.7	7.6350
440	0.6548	3028.6	3356.0	7.9152	0.4667	3026.6	3353.3	7.7571
500	0.7109	3128.4	3483.9	8.0873	0.5070	3126.8	3481.7	7.9299
600	0.8041	3299.6	3701.7	8.3522	0.5738	3298.5	3700.2	8.1956
700	0.8969	3477.5	3925.9	8.5952	0.6403	3476.6	3924.8	8.4391
	p = 10.0 bar = 1.0 MPa (T_{sat} = 179.91°C)				p = 15.0 bar = 1.5 MPa (T_{sat} = 198.32°C)			
Sat.	0.1944	2583.6	2778.1	6.5865	0.1318	2594.5	2792.2	6.4448
200	0.2060	2621.9	2827.9	6.6940	0.1325	2598.1	2796.8	6.4546
240	0.2275	2692.9	2920.4	6.8817	0.1483	2676.9	2899.3	6.6628
280	0.2480	2760.2	3008.2	7.0465	0.1627	2748.6	2992.7	6.8381
320	0.2678	2826.1	3093.9	7.1962	0.1765	2817.1	3081.9	6.9938
360	0.2873	2891.6	3178.9	7.3349	0.1899	2884.4	3169.2	7.1363
400	0.3066	2957.3	3263.9	7.4651	0.2030	2951.3	3255.8	7.2690
440	0.3257	3023.6	3349.3	7.5883	0.2160	3018.5	3342.5	7.3940
500	0.3541	3124.4	3478.5	7.7622	0.2352	3120.3	3473.1	7.5698
540	0.3729	3192.6	3565.6	7.8720	0.2478	3189.1	3560.9	7.6805
600	0.4011	3296.8	3697.9	8.0290	0.2668	3293.9	3694.0	7.8385
640	0.4198	3367.4	3787.2	8.1290	0.2793	3364.8	3783.8	7.9391
	p = 20.0 bar = 2.0 MPa (T_{sat} = 212.42°C)				p = 30.0 bar = 3.0 MPa (T_{sat} = 233.90°C)			
Sat.	0.0996	2600.3	2799.5	6.3409	0.0667	2604.1	2804.2	6.1869
240	0.1085	2659.6	2876.5	6.4952	0.0682	2619.7	2824.3	6.2265
280	0.1200	2736.4	2976.4	6.6828	0.0771	2709.9	2941.3	6.4462
320	0.1308	2807.9	3069.5	6.8452	0.0850	2788.4	3043.4	6.6245
360	0.1411	2877.0	3159.3	6.9917	0.0923	2861.7	3138.7	6.7801
400	0.1512	2945.2	3247.6	7.1271	0.0994	2932.8	3230.9	6.9212
440	0.1611	3013.4	3335.5	7.2540	0.1062	3002.9	3321.5	7.0520
500	0.1757	3116.2	3467.6	7.4317	0.1162	3108.0	3456.5	7.2338
540	0.1853	3185.6	3556.1	7.5434	0.1227	3178.4	3546.6	7.3474
600	0.1996	3290.9	3690.1	7.7024	0.1324	3285.0	3682.3	7.5085
640	0.2091	3362.2	3780.4	7.8035	0.1388	3357.0	3773.5	7.6106
700	0.2232	3470.9	3917.4	7.9487	0.1484	3466.5	3911.7	7.7571

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TABLE A-22

Ideal Gas Properties of Air

				T(K), h and u(kJ/kg), $s°$ (kJ/kg · K)							
				when $\Delta s = 0$[1]						when $\Delta s = 0$	
T	h	u	$s°$	p_r	v_r	T	h	u	$s°$	p_r	v_r
200	199.97	142.56	1.29559	0.3363	1707.	450	451.80	322.62	2.11161	5.775	223.6
210	209.97	149.69	1.34444	0.3987	1512.	460	462.02	329.97	2.13407	6.245	211.4
220	219.97	156.82	1.39105	0.4690	1346.	470	472.24	337.32	2.15604	6.742	200.1
230	230.02	164.00	1.43557	0.5477	1205.	480	482.49	344.70	2.17760	7.268	189.5
240	240.02	171.13	1.47824	0.6355	1084.	490	492.74	352.08	2.19876	7.824	179.7
250	250.05	178.28	1.51917	0.7329	979.	500	503.02	359.49	2.21952	8.411	170.6
260	260.09	185.45	1.55848	0.8405	887.8	510	513.32	366.92	2.23993	9.031	162.1
270	270.11	192.60	1.59634	0.9590	808.0	520	523.63	374.36	2.25997	9.684	154.1
280	280.13	199.75	1.63279	1.0889	738.0	530	533.98	381.84	2.27967	10.37	146.7
285	285.14	203.33	1.65055	1.1584	706.1	540	544.35	389.34	2.29906	11.10	139.7
290	290.16	206.91	1.66802	1.2311	676.1	550	554.74	396.86	2.31809	11.86	133.1
295	295.17	210.49	1.68515	1.3068	647.9	560	565.17	404.42	2.33685	12.66	127.0
300	300.19	214.07	1.70203	1.3860	621.2	570	575.59	411.97	2.35531	13.50	121.2
305	305.22	217.67	1.71865	1.4686	596.0	580	586.04	419.55	2.37348	14.38	115.7
310	310.24	221.25	1.73498	1.5546	572.3	590	596.52	427.15	2.39140	15.31	110.6
315	315.27	224.85	1.75106	1.6442	549.8	600	607.02	434.78	2.40902	16.28	105.8
320	320.29	228.42	1.76690	1.7375	528.6	610	617.53	442.42	2.42644	17.30	101.2
325	325.31	232.02	1.78249	1.8345	508.4	620	628.07	450.09	2.44356	18.36	96.92
330	330.34	235.61	1.79783	1.9352	489.4	630	638.63	457.78	2.46048	19.84	92.84
340	340.42	242.82	1.82790	2.149	454.1	640	649.22	465.50	2.47716	20.64	88.99
350	350.49	250.02	1.85708	2.379	422.2	650	659.84	473.25	2.49364	21.86	85.34
360	360.58	257.24	1.88543	2.626	393.4	660	670.47	481.01	2.50985	23.13	81.89
370	370.67	264.46	1.91313	2.892	367.2	670	681.14	488.81	2.52589	24.46	78.61
380	380.77	271.69	1.94001	3.176	343.4	680	691.82	496.62	2.54175	25.85	75.50
390	390.88	278.93	1.96633	3.481	321.5	690	702.52	504.45	2.55731	27.29	72.56
400	400.98	286.16	1.99194	3.806	301.6	700	713.27	512.33	2.57277	28.80	69.76
410	411.12	293.43	2.01699	4.153	283.3	710	724.04	520.23	2.58810	30.38	67.07
420	421.26	300.69	2.04142	4.522	266.6	720	734.82	528.14	2.60319	32.02	64.53
430	431.43	307.99	2.06533	4.915	251.1	730	745.62	536.07	2.61803	33.72	62.13
440	441.61	315.30	2.08870	5.332	236.8	740	756.44	544.02	2.63280	35.50	59.82

1. p_r and v_r data for use with Eqs. 6.41 and 6.42, respectively.

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TABLE A-22

(Continued)

T(K), h and u(kJ/kg), $s°$ (kJ/kg · K)											
				when $\Delta s = 0$[1]						when $\Delta s = 0$	
T	h	u	$s°$	p_r	v_r	T	h	u	$s°$	p_r	v_r
750	767.29	551.99	2.64737	37.35	57.63	1300	1395.97	1022.82	3.27345	330.9	11.275
760	778.18	560.01	2.66176	39.27	55.54	1320	1419.76	1040.88	3.29160	352.5	10.747
770	789.11	568.07	2.67595	41.31	53.39	1340	1443.60	1058.94	3.30959	375.3	10.247
780	800.03	576.12	2.69013	43.35	51.64	1360	1467.49	1077.10	3.32724	399.1	9.780
790	810.99	584.21	2.70400	45.55	49.86	1380	1491.44	1095.26	3.34474	424.2	9.337
800	821.95	592.30	2.71787	47.75	48.08	1400	1515.42	1113.52	3.36200	450.5	8.919
820	843.98	608.59	2.74504	52.59	44.84	1420	1539.44	1131.77	3.37901	478.0	8.526
840	866.08	624.95	2.77170	57.60	41.85	1440	1563.51	1150.13	3.39586	506.9	8.153
860	888.27	641.40	2.79783	63.09	39.12	1460	1587.63	1168.49	3.41247	537.1	7.801
880	910.56	657.95	2.82344	68.98	36.61	1480	1611.79	1186.95	3.42892	568.8	7.468
900	932.93	674.58	2.84856	75.29	34.31	1500	1635.97	1205.41	3.44516	601.9	7.152
920	955.38	691.28	2.87324	82.05	32.18	1520	1660.23	1223.87	3.46120	636.5	6.854
940	977.92	708.08	2.89748	89.28	30.22	1540	1684.51	1242.43	3.47712	672.8	6.569
960	1000.55	725.02	2.92128	97.00	28.40	1560	1708.82	1260.99	3.49276	710.5	6.301
980	1023.25	741.98	2.94468	105.2	26.73	1580	1733.17	1279.65	3.50829	750.0	6.046
1000	1046.04	758.94	2.96770	114.0	25.17	1600	1757.57	1298.30	3.52364	791.2	5.804
1020	1068.89	776.10	2.99034	123.4	23.72	1620	1782.00	1316.96	3.53879	834.1	5.574
1040	1091.85	793.36	3.01260	133.3	22.39	1640	1806.46	1335.72	3.55381	878.9	5.355
1060	1114.86	810.62	3.03449	143.9	21.14	1660	1830.96	1354.48	3.56867	925.6	5.147
1080	1137.89	827.88	3.05608	155.2	19.98	1680	1855.50	1373.24	3.58335	974.2	4.949
1100	1161.07	845.33	3.07732	167.1	18.896	1700	1880.1	1392.7	3.5979	1025	4.761
1120	1184.28	862.79	3.09825	179.7	17.886	1750	1941.6	1439.8	3.6336	1161	4.328
1140	1207.57	880.35	3.11883	193.1	16.946	1800	2003.3	1487.2	3.6684	1310	3.944
1160	1230.92	897.91	3.13916	207.2	16.064	1850	2065.3	1534.9	3.7023	1475	3.601
1180	1254.34	915.57	3.15916	222.2	15.241	1900	2127.4	1582.6	3.7354	1655	3.295
1200	1277.79	933.33	3.17888	238.0	14.470	1950	2189.7	1630.6	3.7677	1852	3.022
1220	1301.31	951.09	3.19834	254.7	13.747	2000	2252.1	1678.7	3.7994	2068	2.776
1240	1324.93	968.95	3.21751	272.3	13.069	2050	2314.6	1726.8	3.8303	2303	2.555
1260	1348.55	986.90	3.23638	290.8	12.435	2100	2377.4	1775.3	3.8605	2559	2.356
1280	1372.24	1004.76	3.25510	310.4	11.835	2150	2440.3	1823.8	3.8901	2837	2.175
						2200	2503.2	1872.4	3.9191	3138	2.012
						2250	2566.4	1921.3	3.9474	3464	1.864

Source: Table A-22 is based on J. H. Keenan and J. Kaye, *Gas Tables*, Wiley, New York, 1945.

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

Semester Final Examination	Winter Semester	:A.Y. 2017-2018
Course Code: MCE 4711	Time	: 3 hours
Course Title: Fluid Mechanics III	Full Marks	: 150

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

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1. **(a)** Liquid ammonia at -20°C is flowing through a 20 m long section of a 5 mm diameter copper tube at a rate of 0.09 kg/s. Determine the pressure drop, the head loss, and the pumping power required to overcome the frictional losses in the tube. **10**

   (b) Consider the fully developed flow of glycerin at 40°C through a 70 m long, 4 cm diameter, horizontal, circular pipe. If the flow velocity at the centerline is measured to be 6 m/s, determine the velocity profile and the pressure difference across this 70 m long section of the pipe, and the useful pumping power required to maintain this flow. For the same useful pumping power input, determine the percent increase of the flow rate if the pipe is inclined 15° downward and the percent decrease if it is inclined 15° upward. The pump is located outside this pipe section. **15**

2. **(a)** Discuss whether fully developed pipe flow is one, two or three dimensional. What is the physical mechanism that causes the friction factor to be higher in turbulent flow? **10**

   (b) Prove that for a specified flow rate, the pressure drops and thus the required pumping power is proportional to the length of the pipe and the viscosity of the fluid, but it is inversely proportional to the fourth power of the radius (or diameter) of the pipe. **15**

3. **(a)** Define subcritical and supercritical flow in terms of critical depth. Prove that the speed of infinitesimal surface waves is proportional to the square root of liquid depth. **10**

   (b) Water is flowing steadily in a 0.4 m wide rectangular open channel at a rate of 0.2 m^3/s. If the flow depth is 0.15 m, determine the flow velocity and if the flow is subcritical or supercritical. Also determine the alternate flow depth if the character of flow were to change. **15**

4. **(a)** What is flow separation and wake? Discuss different methods for controlling the boundary layer. **15**

   (b) It is required to determine the frictional drag of a submarine, the length of the hull is 75 m and its surface area is 3000m^2.the submarine is travelling at a constant speed of 5 m/s. Critical Reynolds number at which the flow changes from laminar to turbulent is 5×10^6. Assuming that the boundary layer at the leading edge is laminar obtain the frictional drag and the power required to propel the submarine at 5 m/s. take kinematic viscosity to be 1×10^{-6} m^2/s and density 1000 kg/m^3. **10**

5. **(a)** Define boundary layer and explain the fundamental causes of its existence. What do you understand by displacement thickness and momentum thickness? **10**

   (b) Derive the momentum integral equation of the boundary layer. **15**

6. (a) Imagine an axis inclined at 45° to the x axis. A uniform flow is parallel to this axis. And a source and a sink are placed very closely at a place nearby. Notably their strengths are equally very high in magnitude. And a vortex with anti-clock wise rotation is placed nearby. All these sources, sinks and vortexes are aligned to your inclined axis. Show the resulting patterns of flows and the conditions with their change. **10**

(b) Derive the stream function for a source (strength λ) and a sink (strength $-\lambda$) placed together at a distance of 2a, and a uniform flow is flowing with a velocity V. What happens when the distance is infinitesimal and the strength is close to infinity? Show all the figures precisely. **15**

7. (a) What are circulation and vorticity? Show and describe their mathematical definitions and relations. The velocity in a flow field is given by $\vec{V} = 3(y^2 - x^2)\hat{\imath} + 6xy\,\hat{\jmath}$ **13**

i. Does a stream function exist? If a stream function exists, what is it?

ii. Does a potential function exist? If it does, what is it?

(b) A source of strength 30 m^2/s is situated at the origin, and another sink of 20 m^2/s is situated at (1, 0). Find the velocity components at (-1, 0) and (1, 1). **12**

8. (a) Write short notes on the following: **15**
Alternate depths, Hydraulic jump, Critical depth, Froude Number, Chezy coefficient.

(b) Water is flowing in a weedy excavated earth channel of trapezoidal cross section with a bottom width of 0.8 m, trapezoid angle of 60°, and a bottom slope angle of 0.3°. If the flow depth is measured to be 0.52 m, determine the flow rate of water through the channel. What would your answer be if the bottom angle were 1°? **10**

B.Sc. Engg. (M) / 7th Semester 92 7 June 2018 (Thursday)

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

Semester Final Examination — Winter Semester, A.Y. 2017-2018
Course Code: MCE 4717 — Time : 3 hours
Course Title: Engineering Economy — Full Marks : 100

There are **8 (eight)** Questions. Answer any **6 (six)** of them.
Figures in the Margin indicate the full marks. The symbols have their usual meaning.

1. a) A low-cost noncontact temperature measuring tool may be able to identify railroad car wheels that are in need of repair long before a costly structural failure occurs. If BNF Railroad saves \$100,000 in years 1 through 5, \$110,000 in year 6, and constant amounts increasing by \$10,000 each year through year 20, what is the equivalent annual worth over the 20 years of the savings? The interest rate is 10% per year. 7⅔

   b) Chemical engineers at a Coleman Industries plant in the Midwest have determined that a small amount of a newly available chemical additive will increase the water repellency of Coleman's tent fabric by 20%. The plant superintendent has arranged to purchase the additive through a 5-year contract at \$7000 per year, starting 1 year from now. He expects the annual price to increase by 12% per year thereafter for the next 8 years. Additionally, an initial investment of \$35,000 was made now to prepare a site suitable for the contractor to deliver the additive. Use i = 15% per year to determine the equivalent total present worth for all these cash flows. 9

2. a) National Homebuilders, Inc., plans to purchase new cut-and-finish equipment. Two manufacturers offered the estimates below. Determine which vendor should be selected on the basis of a present worth comparison, if the MARR is 15% per year. 7⅔

	Vendor A	Vendor B
First cost, \$	–15,000	–18,000
Annual M&O cost, \$ per year	–3,500	–3,100
Salvage value, \$	1,000	2,000
Life, years	6	9

   b) A chemical processing corporation is considering three methods to dispose of a non-hazardous chemical sludge: land application, fluidized-bed incineration, and private disposal contract. The estimates for each method are shown. Determine which has the least cost on the basis of a present worth comparison at 10% per year for the following scenarios: 9

	Land Application	Incineration	Contract
First cost, \$	–130,000	–900,000	0
Annual operating cost, \$ per year	–95,000	–60,000	–120,000
Salvage value, \$	25,000	300,000	0
Life, years	3	6	2

3. a) A British food distribution conglomerate purchased a Canadian food store chain for £75 million 3 years ago. There was a net loss of £10 million at the end of year 1 of ownership. Net cash flow is increasing with an arithmetic gradient of £5 million per year starting the second year, and this pattern is expected to continue for the foreseeable future. This means that breakeven net cash flow was achieved this year. 7⅔

Because of the heavy debt financing used to purchase the Canadian chain, the international board of directors expects a MARR of 15% per year from any sale. The British conglomerate has just been offered £159.5 million by a French company wishing to get a foothold in Canada. Use FW analysis to determine if the MARR will be realized at this selling price.

b) Two processes can be used for producing a polymer that reduces friction loss in engines. Process T will have a first cost of $750,000, an operating cost of $60,000 per year, and a salvage value of $80,000 after its 2-year life. Process W will have a first cost of $1,350,000, an operating cost of $25,000 per year, and a $120,000 salvage value after its 4-year life. Process W will also require updating at the end of year 2 at a cost of $90,000. Which process should be selected on the basis of a future worth analysis at an interest rate of 12% per year? 9

4. a) A patriotic group of firefighters is raising money to erect a permanent (i.e., infinite life) monument in New York City to honor those killed in the line of duty. The initial cost of the monument will be $150,000, and the annual maintenance will cost $5000. There will be an additional one-time cost of $20,000 in 2nd year to add names of those who were missed initially. At an interest rate of 8% per year, how much money must they raise now in order to construct and maintain the monument forever? 7⅔

b) Compare the alternatives shown on the basis of their capitalized costs using an interest rate of 10% per year. 9

	Alternative M	Alternative N
First cost, $	–150,000	–800,000
Annual operating cost, $ per year	–50,000	–12,000
Salvage value, $	8,000	1,000,000
Life, years	5	∞

5. a) Heavenly Pizza, which is located in Toronto, fares very well with its competition in offering fast delivery. Many students at the area universities and community colleges work part-time delivering orders made via the web. The owner, Jerry, a software engineering graduate, plans to purchase and install five portable, in-car systems to increase delivery speed and accuracy. The systems provide a link between the web order-placement software and the On-Star system for satellite-generated directions to any address in the area. The expected result is faster, friendlier service to customers and larger income.
Each system costs $4600, has a 5-year useful life, and may be salvaged for an estimated $300. Total operating cost for all systems is $1000 for the first year, increasing by $100 per year thereafter. The MARR is 10%. How much new annual net income is necessary to recover the investment at the MARR of 10% per year? 7⅔

b) For the cash flows shown, use an annual worth comparison and an interest rate of 10% per year; determine the alternative that is economically best. 9

	X	Y	Z
First cost, $	–90,000	–400,000	–650,000
Annual cost, $ per year	–40,000	–20,000	–13,000
Overhaul every 10 years, $	–	–	–80,000
Salvage value, $	7,000	25,000	200,000
Life, years	3	10	∞

6. a) For the cash flows shown, determine the rate of return. 8⅔

Year	0	1	2	3	4	5
Expense, $	–17,000	–2,500	–2,500	–2,500	–2,500	–2,500
Revenue, $	0	5,000	6,000	7,000	8,000	12,000

b) Five mutually exclusive revenue alternatives that have infinite lives are under consideration for increasing productivity in a manufacturing operation. The initial costs and cash flows of each project are shown. If the MARR is 14.9% per year, which alternative should be selected using the incremental ROR method? 8

Alternative	A	B	C	D	E
Initial cost, $	–7,000	–23,000	–9,000	–3,000	–16,000
Cash flow, $ per year	1,000	3,500	1,400	500	2,200
Rate of return (vs. DN), %	14.3	15.2	15.6	16.7	13.8

7. a) The city of Garden Ridge, Florida, has received designs for a new patient room wing to the municipal hospital from two architectural consultants. One of the two designs must be accepted in order to announce it for construction bids. The costs and benefits are the same in most categories, but the city financial manager decided that the estimates below should be considered to determine which design to recommend at the city council meeting next week and to present to the citizenry in preparation for an upcoming bond referendum next month. 8⅔

	Design A	Design B
Construction cost, $	10,000,000	15,000,000
Building maintenance cost, $/ year	35,000	55,000
Patient usage copay, $/year	600,000	100,000

The patient usage copay is an estimate of the amount paid by patients over the insurance coverage generally allowed for a hospital room. The discount rate is 8%, and the life of the building is estimated at 30 years. Use incremental B/C analysis to select design A or B.

b) A consulting engineer is currently evaluating four different projects for the Department of Housing and Urban Development. The future worth of costs, benefits, dis-benefits, and cost savings is shown. The interest rate is 10% per year, compounded continuously. Determine which of the projects, if any, should be selected according to B/C ratio, if the projects are mutually exclusive. 8

	Project ID			
	Good	Better	Best	Best of All
FW of first costs, $	10,000	8,000	20,000	14,000
FW of benefits, $	15,000	11,000	25,000	42,000
FW of dis-benefits, $	6,000	1,000	20,000	32,000
FW of cost savings, $	1,500	2,000	16,000	3,000

8. a) An effective method to recover water used for regeneration of ion exchange resins is to use a reverse osmosis system in a batch treatment mode. Such a system involves recirculation of the partially treated water back into the feed tank, causing the water to heat up. The water can be cooled using one of two systems: a single-pass heat exchanger or a closed-loop heat exchange system. The single-pass system, good for 3 years, requires a small chiller costing $920 plus stainless steel tubing, connectors, valves, etc. costing $360. The cost of water, treatment charges, electricity, etc. will be $3.10 per hour. The closed-loop system will cost $3850 to buy, will have a useful life of 5 years, and will cost $1.28 per hour to operate. What is the minimum number of hours per year that the cooling system must be used in order to justify purchase of 7⅔

the closed-loop system? The MARR is 10% per year, and the salvage values are negligible.

b) Two equivalent pieces of quality inspection equipment are being considered for purchase by Square D Electric. Machine 2 is expected to be versatile and technologically advanced enough to provide net income longer than machine 1. 9

	Machine 1	**Machine 2**
First cost, $	12,000	8,000
Annual NCF, $	3,000	1,000 (years 1–5)
		3,000 (years 6–14)
Maximum life, years	3	14

Now from the given information above,

(a) Find the payback periods of these two alternatives at $i = 15\%$ per year.

(b) Use a PW analysis to compare the machines at $i = 15\%$ per year.

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Formulas:

$$(P_g/A_1, g, i, n) = \frac{1 - \left(\frac{1+g}{1+i}\right)^n}{i - g} \quad when\ g \neq i$$

$$(P_g/A_1, g, i, n) = \frac{n}{1+i} \quad when\ g = i$$

8% Compound Interest Factors 8%

	Single Payment		Uniform Payment Series				Arithmetic Gradient		
n	Compound Amount Factor Find *F* Given *P* *F/P*	Present Worth Factor Find *P* Given *F* *P/F*	Sinking Fund Factor Find *A* Given *F* *A/F*	Capital Recovery Factor Find *A* Given *P* *A/P*	Compound Amount Factor Find *F* Given *A* *F/A*	Present Worth Factor Find *P* Given *A* *P/A*	Gradient Uniform Series Find *A* Given *G* *A/G*	Gradient Present Worth Find *P* Given *G* *P/G*	n
1	1.080	.9259	1.0000	1.0800	1.000	0.926	0	0	1
2	1.166	.8573	.4808	.5608	2.080	1.783	0.481	0.857	2
3	1.260	.7938	.3080	.3880	3.246	2.577	0.949	2.445	3
4	1.360	.7350	.2219	.3019	4.506	3.312	1.404	4.650	4
5	1.469	.6806	.1705	.2505	5.867	3.993	1.846	7.372	5
6	1.587	.6302	.1363	.2163	7.336	4.623	2.276	10.523	6
7	1.714	.5835	.1121	.1921	8.923	5.206	2.694	14.024	7
8	1.851	.5403	.0940	.1740	10.637	5.747	3.099	17.806	8
9	1.999	.5002	.0801	.1601	12.488	6.247	3.491	21.808	9
10	2.159	.4632	.0690	.1490	14.487	6.710	3.871	25.977	10
11	2.332	.4289	.0601	.1401	16.645	7.139	4.240	30.266	11
12	2.518	.3971	.0527	.1327	18.977	7.536	4.596	34.634	12
13	2.720	.3677	.0465	.1265	21.495	7.904	4.940	39.046	13
14	2.937	.3405	.0413	.1213	24.215	8.244	5.273	43.472	14
15	3.172	.3152	.0368	.1168	27.152	8.559	5.594	47.886	15
16	3.426	.2919	.0330	.1130	30.324	8.851	5.905	52.264	16
17	3.700	.2703	.0296	.1096	33.750	9.122	6.204	56.588	17
18	3.996	.2502	.0267	.1067	37.450	9.372	6.492	60.843	18
19	4.316	.2317	.0241	.1041	41.446	9.604	6.770	65.013	19
20	4.661	.2145	.0219	.1019	45.762	9.818	7.037	69.090	20
21	5.034	.1987	.0198	.0998	50.423	10.017	7.294	73.063	21
22	5.437	.1839	.0180	.0980	55.457	10.201	7.541	76.926	22
23	5.871	.1703	.0164	.0964	60.893	10.371	7.779	80.673	23
24	6.341	.1577	.0150	.0950	66.765	10.529	8.007	84.300	24
25	6.848	.1460	.0137	.0937	73.106	10.675	8.225	87.804	25
26	7.396	.1352	.0125	.0925	79.954	10.810	8.435	91.184	26
27	7.988	.1252	.0114	.0914	87.351	10.935	8.636	94.439	27
28	8.627	.1159	.0105	.0905	95.339	11.051	8.829	97.569	28
29	9.317	.1073	.00962	.0896	103.966	11.158	9.013	100.574	29
30	10.063	.0994	.00883	.0888	113.283	11.258	9.190	103.456	30
31	10.868	.0920	.00811	.0881	123.346	11.350	9.358	106.216	31
32	11.737	.0852	.00745	.0875	134.214	11.435	9.520	108.858	32
33	12.676	.0789	.00685	.0869	145.951	11.514	9.674	111.382	33
34	13.690	.0730	.00630	.0863	158.627	11.587	9.821	113.792	34
35	14.785	.0676	.00580	.0858	172.317	11.655	9.961	116.092	35
40	21.725	.0460	.00386	.0839	259.057	11.925	10.570	126.042	40
45	31.920	.0313	.00259	.0826	386.506	12.108	11.045	133.733	45
50	46.902	.0213	.00174	.0817	573.771	12.233	11.411	139.593	50
55	68.914	.0145	.00118	.0812	848.925	12.319	11.690	144.006	55
60	101.257	.00988	.00080	.0808	1 253.2	12.377	11.902	147.300	60
65	148.780	.00672	.00054	.0805	1 847.3	12.416	12.060	149.739	65
70	218.607	.00457	.00037	.0804	2 720.1	12.443	12.178	151.533	70
75	321.205	.00311	.00025	.0802	4 002.6	12.461	12.266	152.845	75
80	471.956	.00212	.00017	.0802	5 887.0	12.474	12.330	153.800	80
85	693.458	.00144	.00012	.0801	8 655.7	12.482	12.377	154.492	85
90	1 018.9	.00098	.00008	.0801	12 724.0	12.488	12.412	154.993	90
95	1 497.1	.00067	.00005	.0801	18 701.6	12.492	12.437	155.352	95
100	2 199.8	.00045	.00004	.0800	27 484.6	12.494	12.455	155.611	100

10% Compound Interest Factors 10%

n	Single Payment: Compound Amount Factor Find F Given P F/P	Single Payment: Present Worth Factor Find P Given F P/F	Uniform Payment Series: Sinking Fund Factor Find A Given F A/F	Uniform Payment Series: Capital Recovery Factor Find A Given P A/P	Uniform Payment Series: Compound Amount Factor Find F Given A F/A	Uniform Payment Series: Present Worth Factor Find P Given A P/A	Arithmetic Gradient: Gradient Uniform Series Find A Given G A/G	Arithmetic Gradient: Gradient Present Worth Find P Given G P/G	n
1	1.100	.9091	1.0000	1.1000	1.000	0.909	0	0	1
2	1.210	.8264	.4762	.5762	2.100	1.736	0.476	0.826	2
3	1.331	.7513	.3021	.4021	3.310	2.487	0.937	2.329	3
4	1.464	.6830	.2155	.3155	4.641	3.170	1.381	4.378	4
5	1.611	.6209	.1638	.2638	6.105	3.791	1.810	6.862	5
6	1.772	.5645	.1296	.2296	7.716	4.355	2.224	9.684	6
7	1.949	.5132	.1054	.2054	9.487	4.868	2.622	12.763	7
8	2.144	.4665	.0874	.1874	11.436	5.335	3.004	16.029	8
9	2.358	.4241	.0736	.1736	13.579	5.759	3.372	19.421	9
10	2.594	.3855	.0627	.1627	15.937	6.145	3.725	22.891	10
11	2.853	.3505	.0540	.1540	18.531	6.495	4.064	26.396	11
12	3.138	.3186	.0468	.1468	21.384	6.814	4.388	29.901	12
13	3.452	.2897	.0408	.1408	24.523	7.103	4.699	33.377	13
14	3.797	.2633	.0357	.1357	27.975	7.367	4.996	36.801	14
15	4.177	.2394	.0315	.1315	31.772	7.606	5.279	40.152	15
16	4.595	.2176	.0278	.1278	35.950	7.824	5.549	43.416	16
17	5.054	.1978	.0247	.1247	40.545	8.022	5.807	46.582	17
18	5.560	.1799	.0219	.1219	45.599	8.201	6.053	49.640	18
19	6.116	.1635	.0195	.1195	51.159	8.365	6.286	52.583	19
20	6.728	.1486	.0175	.1175	57.275	8.514	6.508	55.407	20
21	7.400	.1351	.0156	.1156	64.003	8.649	6.719	58.110	21
22	8.140	.1228	.0140	.1140	71.403	8.772	6.919	60.689	22
23	8.954	.1117	.0126	.1126	79.543	8.883	7.108	63.146	23
24	9.850	.1015	.0113	.1113	88.497	8.985	7.288	65.481	24
25	10.835	.0923	.0102	.1102	98.347	9.077	7.458	67.696	25
26	11.918	.0839	.00916	.1092	109.182	9.161	7.619	69.794	26
27	13.110	.0763	.00826	.1083	121.100	9.237	7.770	71.777	27
28	14.421	.0693	.00745	.1075	134.210	9.307	7.914	73.650	28
29	15.863	.0630	.00673	.1067	148.631	9.370	8.049	75.415	29
30	17.449	.0573	.00608	.1061	164.494	9.427	8.176	77.077	30
31	19.194	.0521	.00550	.1055	181.944	9.479	8.296	78.640	31
32	21.114	.0474	.00497	.1050	201.138	9.526	8.409	80.108	32
33	23.225	.0431	.00450	.1045	222.252	9.569	8.515	81.486	33
34	25.548	.0391	.00407	.1041	245.477	9.609	8.615	82.777	34
35	28.102	.0356	.00369	.1037	271.025	9.644	8.709	83.987	35
40	45.259	.0221	.00226	.1023	442.593	9.779	9.096	88.953	40
45	72.891	.0137	.00139	.1014	718.905	9.863	9.374	92.454	45
50	117.391	.00852	.00086	.1009	1 163.9	9.915	9.570	94.889	50
55	189.059	.00529	.00053	.1005	1 880.6	9.947	9.708	96.562	55
60	304.482	.00328	.00033	.1003	3 034.8	9.967	9.802	97.701	60
65	490.371	.00204	.00020	.1002	4 893.7	9.980	9.867	98.471	65
70	789.748	.00127	.00013	.1001	7 887.5	9.987	9.911	98.987	70
75	1 271.9	.00079	.00008	.1001	12 709.0	9.992	9.941	99.332	75
80	2 048.4	.00049	.00005	.1000	20 474.0	9.995	9.961	99.561	80
85	3 299.0	.00030	.00003	.1000	32 979.7	9.997	9.974	99.712	85
90	5 313.0	.00019	.00002	.1000	53 120.3	9.998	9.983	99.812	90
95	8 556.7	.00012	.00001	.1000	85 556.9	9.999	9.989	99.877	95
100	13 780.6	.00007	.00001	.1000	137 796.3	9.999	9.993	99.920	100

12% Compound Interest Factors 12%

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

15% Compound Interest Factors 15%

	Single Payment		Uniform Payment Series				Arithmetic Gradient		
n	Compound Amount Factor Find *F* Given *P* *F/P*	Present Worth Factor Find *P* Given *F* *P/F*	Sinking Fund Factor Find *A* Given *F* *A/F*	Capital Recovery Factor Find *A* Given *P* *A/P*	Compound Amount Factor Find *F* Given *A* *F/A*	Present Worth Factor Find *P* Given *A* *P/A*	Gradient Uniform Series Find *A* Given *G* *A/G*	Gradient Present Worth Find *P* Given *G* *P/G*	n
1	1.150	.8696	1.0000	1.1500	1.000	0.870	0	0	1
2	1.322	.7561	.4651	.6151	2.150	1.626	0.465	0.756	2
3	1.521	.6575	.2880	.4380	3.472	2.283	0.907	2.071	3
4	1.749	.5718	.2003	.3503	4.993	2.855	1.326	3.786	4
5	2.011	.4972	.1483	.2983	6.742	3.352	1.723	5.775	5
6	2.313	.4323	.1142	.2642	8.754	3.784	2.097	7.937	6
7	2.660	.3759	.0904	.2404	11.067	4.160	2.450	10.192	7
8	3.059	.3269	.0729	.2229	13.727	4.487	2.781	12.481	8
9	3.518	.2843	.0596	.2096	16.786	4.772	3.092	14.755	9
10	4.046	.2472	.0493	.1993	20.304	5.019	3.383	16.979	10
11	4.652	.2149	.0411	.1911	24.349	5.234	3.655	19.129	11
12	5.350	.1869	.0345	.1845	29.002	5.421	3.908	21.185	12
13	6.153	.1625	.0291	.1791	34.352	5.583	4.144	23.135	13
14	7.076	.1413	.0247	.1747	40.505	5.724	4.362	24.972	14
15	8.137	.1229	.0210	.1710	47.580	5.847	4.565	26.693	15
16	9.358	.1069	.0179	.1679	55.717	5.954	4.752	28.296	16
17	10.761	.0929	.0154	.1654	65.075	6.047	4.925	29.783	17
18	12.375	.0808	.0132	.1632	75.836	6.128	5.084	31.156	18
19	14.232	.0703	.0113	.1613	88.212	6.198	5.231	32.421	19
20	16.367	.0611	.00976	.1598	102.444	6.259	5.365	33.582	20
21	18.822	.0531	.00842	.1584	118.810	6.312	5.488	34.645	21
22	21.645	.0462	.00727	.1573	137.632	6.359	5.601	35.615	22
23	24.891	.0402	.00628	.1563	159.276	6.399	5.704	36.499	23
24	28.625	.0349	.00543	.1554	184.168	6.434	5.798	37.302	24
25	32.919	.0304	.00470	.1547	212.793	6.464	5.883	38.031	25
26	37.857	.0264	.00407	.1541	245.712	6.491	5.961	38.692	26
27	43.535	.0230	.00353	.1535	283.569	6.514	6.032	39.289	27
28	50.066	.0200	.00306	.1531	327.104	6.534	6.096	39.828	28
29	57.575	.0174	.00265	.1527	377.170	6.551	6.154	40.315	29
30	66.212	.0151	.00230	.1523	434.745	6.566	6.207	40.753	30
31	76.144	.0131	.00200	.1520	500.957	6.579	6.254	41.147	31
32	87.565	.0114	.00173	.1517	577.100	6.591	6.297	41.501	32
33	100.700	.00993	.00150	.1515	664.666	6.600	6.336	41.818	33
34	115.805	.00864	.00131	.1513	765.365	6.609	6.371	42.103	34
35	133.176	.00751	.00113	.1511	881.170	6.617	6.402	42.359	35
40	267.864	.00373	.00056	.1506	1779.1	6.642	6.517	43.283	40
45	538.769	.00186	.00028	.1503	3585.1	6.654	6.583	43.805	45
50	1083.7	.00092	.00014	.1501	7217.7	6.661	6.620	44.096	50
55	2179.6	.00046	.00007	.1501	14524.1	6.664	6.641	44.256	55
60	4384.0	.00023	.00003	.1500	29220.0	6.665	6.653	44.343	60
65	8817.8	.00011	.00002	.1500	58778.6	6.666	6.659	44.390	65
70	17735.7	.00006	.00001	.1500	118231.5	6.666	6.663	44.416	70
75	35672.9	.00003		.1500	237812.5	6.666	6.665	44.429	75
80	71750.9	.00001		.1500	478332.6	6.667	6.666	44.436	80
85	144316.7	.00001		.1500	962104.4	6.667	6.666	44.440	85

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

SEMESTER FINAL EXAMINATION — WINTER SEMESTER 2017-18
COURSE NO : **MCE 4725** — TIME : 3 hours
COURSE TITLE : **Machine Maintenance Engineering** — TOTAL MARKS: 150

There are **EIGHT (8)** questions. Answer any **SIX** (6) of them.
Figures in the right margin indicate full marks. Some Formulas are provided at the end of the question/separately. Assume reasonable values if required. Programmable Calculators are not allowed. Don't write on this question paper.

1. (a) Define failure rate and describe the failure rate at different stages of the life cycle of a product using bath-tub curve. [10]
   (b) A voltage regulator may be obtained from two vendors. Vendor A's regulator costs \$150 and Vendor B's regulator costs \$200. Vendor A's regulator is less reliable with a MTTF of 1,800 days while Vendor B's MTTF is 2,600 days. Vendor A's regulator has a modular design and is therefore easier to replace with a MTTR of 4 hr while Vendor B's regulator takes 6 hrs to replace. If a failed regulator must be replaced at its unit cost, which product should be used? The labor rate is \$45 per hour and the design life of the regulator is considered to be 10 year. [10]
   (c) A component can be repaired at the constant rate of 10 per 8 hour day. What is the probability of a single repair exceeding 1 hour? [5]

2. (a) Describe seven steps of Jishu Hozen(Autonomous Maintenance). [8]
   (b) A machine has failure pattern under Weibull distribution with a shape parameter of 1/2 and scale parameter of 15,000 hours . [9]
   i)Find the Reliability function, MTTF, median and mode.
   ii)What would be its design life if 80 percent reliability is desired?
   iii) If the machine runs for 11,000 hours, what would be the reliability?
   (c) Write the main difference between parallel network and series network for reliability analysis. A jet engine consists of five modules in a series network where each of which was found to have a Weibull failure distribution with a shape parameter of 1.5. Their scale parameters in operating cycles are as follows: 3600, 7100, 5950, 4680, 512o and 9260. Find MTTF and median time to failure of the engine. [2+6]

3. (a) What do you understand by maintenance ? Describe different types of maintenance with features, advantages and disadvantages. [18]
   (b) Describe VED and FSN analysis for spare parts maintenance? [7]

4. (a) Describe design for maintainability guidelines for components consideration, handling and access. [15]
   (b) Describe SFMEA method for maintenance management including its major benefits and limitations. [10]

5. (a) Describe the procedure to judge Weibull distribution using the plotting paper through ranking and then to find out shape parameter and characteristics life. [14]
   (b) Describe troubleshooting guideline of any one type of compressors. [11]

6. (a) Describe any two predictive maintenance techniques. [10]
   (b) Write short notes on the following: i) Common problems of Boilers ii) Wear, iii) Lubricant maintenance using processing and refortification techniques. [15]

7. (a) What is CMMS? Describe the general features provided by CMMS. [5]
   (b) Describe general troubleshooting guidelines for centrifugal pumps. [12]
   (c) Describe any one step in the systematic approach of maintenance strategy. [8]

8. (a) Derive the following equation. Notations have their usual meanings. [8]
   $R(t)=e^{-\lambda t}$
   (b) Describe guideline for preventive maintenance of generators. [10]
   (c) Describe 5S method. [7]

Formulas MCE 4725 WINTER SEMESTER FINAL EXAMINATION

$R(t) = e^{-(\frac{t}{\theta})^{\beta}}$

$MTTF = \theta\Gamma\left(1+\frac{1}{\beta}\right)$

$\sigma^2 = \theta^2\left\{\Gamma\left(1+\frac{2}{\beta}\right) - \left[\Gamma\left(1+\frac{1}{\beta}\right)\right]^2\right\}$

$t_R = \theta\ (-lnR)^{1/\beta}$

$t_{med} = \theta\ (-ln0.5)^{1/\beta}$

$t_{mode} = \theta\ (1-\frac{1}{\beta})^{1/\beta}$ when $\beta > 1$

$= 0$ when $\beta <= 1$

$\Theta_s = \left[\sum_{i=1}^{n} (\frac{1}{\theta_i})^{\beta}\right]^{-1/\beta}$

$R(t) = \exp\left[-n(\frac{t}{\theta})^{\beta}\right]$

$R(t) = \exp\left[-n(\frac{t-t_0}{\theta})^{\beta}\right]$ when $t >= t_0$

$\lambda(t) = \frac{\beta}{\theta}(\frac{t-t_0}{\theta})^{\beta-1}$ when $t >= t_0$

$MTTF = t_0 + \theta\,\Gamma\left(1+\frac{1}{\beta}\right)$

$t_{med} = t_0 + \theta\ (0.69315)^{1/\beta}$

$t_d = t_0 + \theta\ (-lnR)^{1/\beta}$

$R_s(t) = 1 - \left[1 - e^{-(\frac{t}{\theta})^{\beta}}\right]^2$

$MTTF = \theta\,\Gamma\left(1+\frac{1}{\beta}\right)(2 - 2^{-\frac{1}{\beta}})$

$\mu = \lambda + 1/ts$

$H(t) = 1 - e^{-t/MTTR}$

$Cost = C_a + (t_d / MTBF)(C_f + C_v\, MTTR)$

$$P(A|B) = \frac{P(B|A)\cdot P(A)}{\sum_i P(B|A_i)\cdot P(A_i)}$$

TABLE A.9
Gamma function

x	$\Gamma(x)$	x	$\Gamma(x)$	x	$\Gamma(x)$	x	$\Gamma(x)$
1.01	.99433	1.51	.88659	2.01	1.00427	2.51	1.33875
1.02	.98884	1.52	.88704	2.02	1.00862	2.52	1.34830
1.03	.98355	1.53	.88757	2.03	1.01306	2.53	1.35798
1.04	.97844	1.54	.88818	2.04	1.01758	2.54	1.36779
1.05	.97350	1.55	.88887	2.05	1.02218	2.55	1.37775
1.06	.96874	1.56	.88964	2.06	1.02687	2.56	1.38784
1.07	.96415	1.57	.89049	2.07	1.03164	2.57	1.39807
1.08	.95973	1.58	.89142	2.08	1.03650	2.58	1.40844
1.09	.95546	1.59	.89243	2.09	1.04145	2.59	1.41896
1.10	.95135	1.60	.89352	2.10	1.04649	2.60	1.42962
1.11	.94740	1.61	.89468	2.11	1.05161	2.61	1.44044
1.12	.94359	1.62	.89592	2.12	1.05682	2.62	1.45140
1.13	.93993	1.63	.89724	2.13	1.06212	2.63	1.46251
1.14	.93642	1.64	.89864	2.14	1.06751	2.64	1.47377
1.15	.93304	1.65	.90012	2.15	1.07300	2.65	1.48519
1.16	.92980	1.66	.90167	2.16	1.07857	2.66	1.49677
1.17	.92670	1.67	.90330	2.17	1.08424	2.67	1.50851
1.18	.92373	1.68	.90500	2.18	1.09000	2.68	1.52040
1.19	.92089	1.69	.90678	2.19	1.09585	2.69	1.53246
1.20	.91817	1.70	.90864	2.20	1.10180	2.70	1.54469
1.21	.91558	1.71	.91057	2.21	1.10785	2.71	1.55708
1.22	.91311	1.72	.91258	2.22	1.11399	2.72	1.56964
1.23	.91075	1.73	.91467	2.23	1.12023	2.73	1.58237
1.24	.90852	1.74	.91683	2.24	1.12657	2.74	1.59528
1.25	.90640	1.75	.91906	2.25	1.13300	2.75	1.60836
1.26	.90440	1.76	.92137	2.26	1.13954	2.76	1.62162
1.27	.90250	1.77	.92376	2.27	1.14618	2.77	1.63506
1.28	.90072	1.78	.92623	2.28	1.15292	2.78	1.64868
1.29	.89904	1.79	.92877	2.29	1.15976	2.79	1.66249
1.30	.89747	1.80	.93138	2.30	1.16671	2.80	1.67649
1.31	.89600	1.81	.93408	2.31	1.17377	2.81	1.69068
1.32	.89464	1.82	.93685	2.32	1.18093	2.82	1.70506
1.33	.89338	1.83	.93969	2.33	1.18819	2.83	1.71963
1.34	.89222	1.84	.94261	2.34	1.19557	2.84	1.73441
1.35	.89115	1.85	.94561	2.35	1.20305	2.85	1.74938
1.36	.89018	1.86	.94869	2.36	1.21065	2.86	1.76456
1.37	.88931	1.87	.95184	2.37	1.21836	2.87	1.77994
1.38	.88854	1.88	.95507	2.38	1.22618	2.88	1.79553
1.39	.88785	1.89	.95838	2.39	1.23412	2.89	1.81134
1.40	.88726	1.90	.96177	2.40	1.24217	2.90	1.82736
1.41	.88676	1.91	.96523	2.41	1.25034	2.91	1.84359
1.42	.88636	1.92	.96877	2.42	1.25863	2.92	1.86005
1.43	.88604	1.93	.97240	2.43	1.26703	2.93	1.87673
1.44	.88581	1.94	.97610	2.44	1.27556	2.94	1.89363
1.45	.88566	1.95	.97988	2.45	1.28421	2.95	1.91077
1.46	.88560	1.96	.98374	2.46	1.29298	2.96	1.92814
1.47	.88563	1.97	.98769	2.47	1.30188	2.97	1.94574
1.48	.88575	1.98	.99171	2.48	1.31091	2.98	1.96358
1.49	.88595	1.99	.99581	2.49	1.32006	2.99	1.98167
1.50	.88623	2.00	1	2.50	1.32934	3.00	2

B.Sc.Engg. (M)7th Sem./B.Sc. TE(1 Yr. Prog.),1st Sem./
B.Sc. TE (2 Yr. Prog), 3rd Sem. 24 May, 2018 (Aft.)

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

Semester Final Examination — Winter Semester, A.Y. 2017-2018
Course No. MCE 4739/MCE 4797 — TIME : 3 Hours
Course Title: Machine Design - II — Full Marks : 150

There are 7 (Seven) Questions. Answer any 2(Two) Questions from SECTION-A and any 3(Three) Questions from SECTION - B.

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

SECTION- A

1. a) A 75 kW induction motor runs at 740 rpm in clock wise direction as shown in Fig.1. A 19 tooth helical pinion with 20^{o} normal pressure angle, 10 mm normal module and a helix angle of 23^{o} is keyed to the motor shaft. Draw a 3-dimensional sketch of the motor shaft and the pinion. Show the forces acting on the pinion and the bearing at A and B. The thrust should be taken out at A. (30)

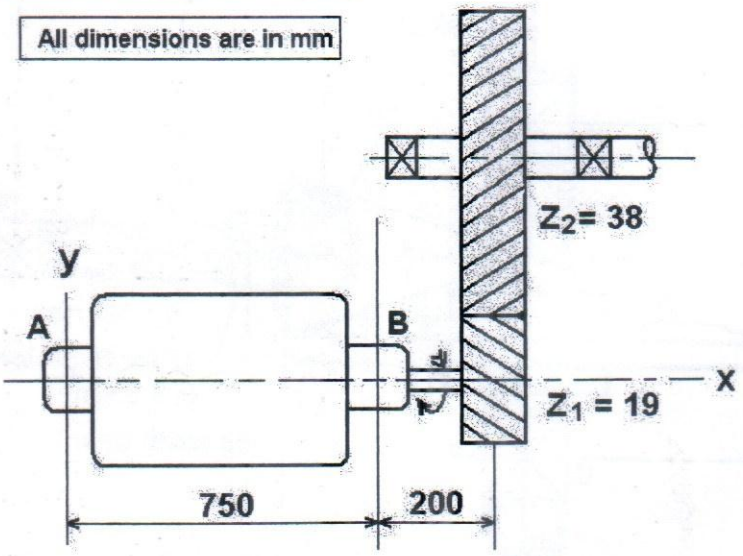

Fig. 1

2. In a conveyor system a step-down gear drive is used. The input pinion is made of 18 teeth, 2.5 mm module, 20^{o} full depth teeth of hardness 330 Bhn and runs at 1720 rpm. The driven gear is of hardness 280 Bhn and runs with moderate shock at 860 rpm. Face width of wheels is 35 mm. The gears are supported on less rigid mountings, less accurate gears and contact across full face may be assumed. The ultimate tensile strength of pinion and gear materials is 420 and 385 MPa respectively. The gears are made by hobbing process. Find the tooth bending strength of both wheels and the maximum power that can be transmitted by the drive with a factor of safety 1.5. The layout diagram is shown in the Fig 2. (30)

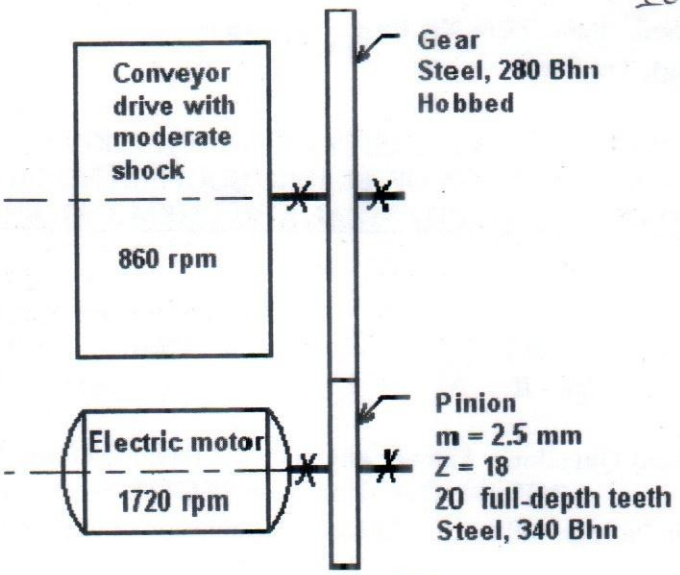

Fig.2

3 The bevel pinion shown in Fig.3 rotates at 960 rev/min in the clockwise direction, viewing from the right side and transmits 5 kW to the gear. The mounting distances, the location of all bearings, and the radii of the pitch circles of the pinion and gear are shown in pitch cones in the figure. Bearings A and C should take the thrust loads. Find the bearing forces on the gear shaft.. 30

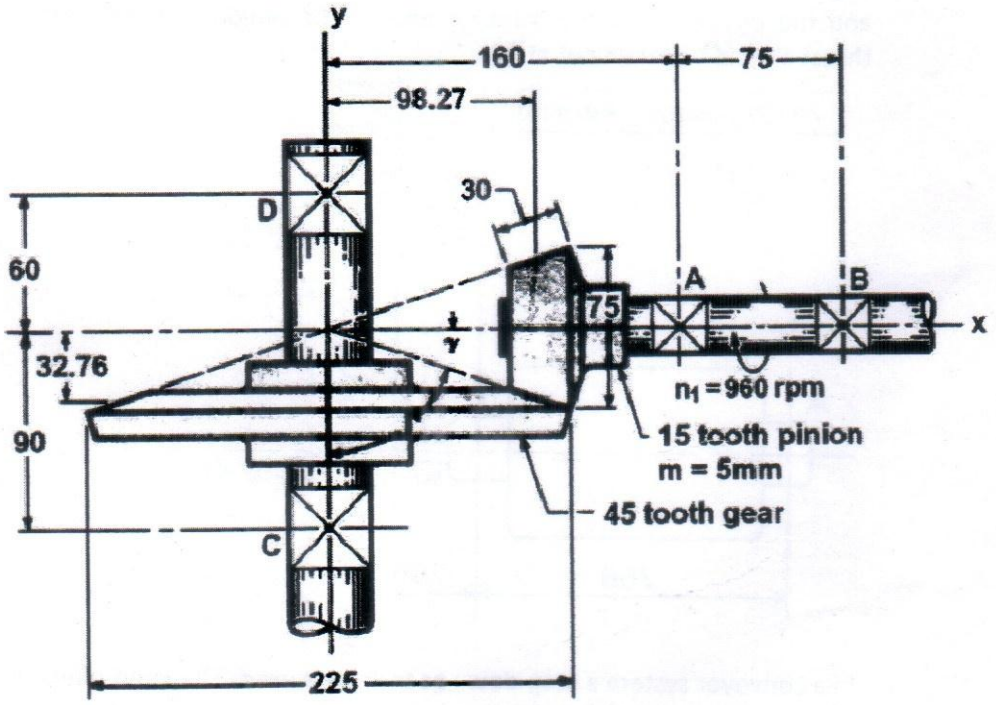

Fig. 3

SECTION - B

4. a) What do you mean by brake? What are the general procedure of analysis of a brake? Deduce the formula for calculating the actuation force and reaction forces for a drum type internal expanding brake. (18)

b) The brake shown in Fig. 4 is 300 mm in diameter and is actuated by a mechanism that exerts the same force F on each shoe. The shoes are identical and have a face width of 32 mm. The lining is a molded asbestos having a coefficient of friction of 0.32 and a pressure limitation of 1000 kPa. Estimate the maximum (12)

(a) Actuating force F.
(b) Braking capacity.
(c) Hinge-pin reactions.

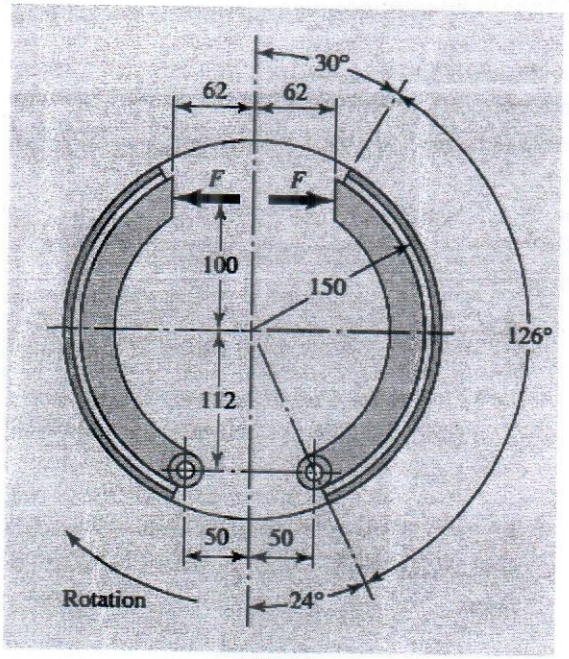

Fig. 4

5. a) Two annular pads with internal dia r_i, external dia r_o, subtend an angle of θ have a coefficient of friction of f and are actuated by a pair of hydraulic cylinder Fig 5. For uniform wear deduce the formula for the largest normal pressure p_a, the actuating force F., the equivalent radius r_e and force location r. (18)

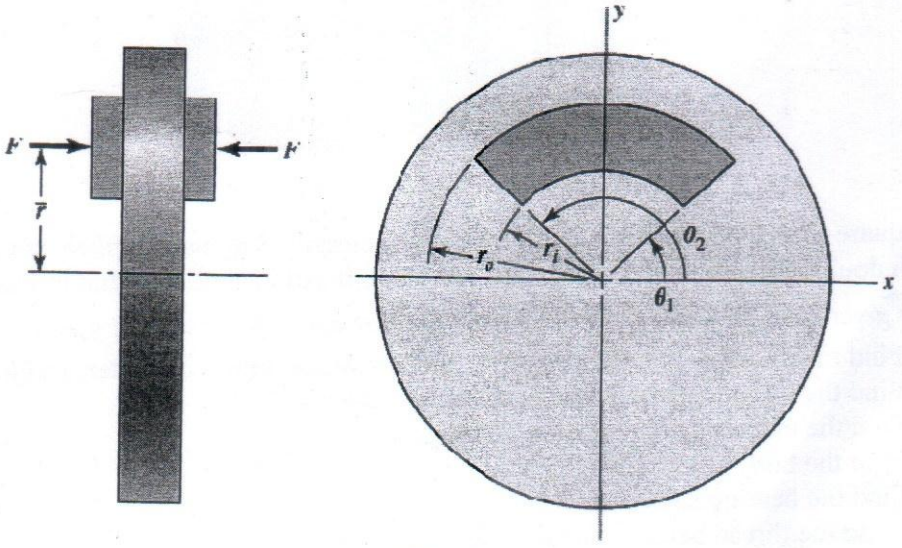

Fig. 5

b) Two annular pads, r_i = 3.875 in, r_o = 5.50 in, subtend an angle of 108° have a coefficient of friction of 0.37, and are actuated by a pair of hydraulic cylinders 1.5 in in diameter. The torque requirement is 13 000 lbf · in. For uniform wear (12)

(*a*) Find the largest normal pressure p_a.
(*b*) Estimate the actuating force F.
(*c*) Find the equivalent radius r_e and force location r.
(*d*) Estimate the required hydraulic pressure.

6. a) Using the theory of mechanics of power screw deduce the formulae for the followings if it is to be used in an application similar to that in Fig. 6. (18)

(*a*) Torque required to raise and lower the load.
(*b*) Efficiency during lifting the load.
(*c*) Body stresses, torsional and compressive.
(*d*) Bearing stress.
(*e*) Thread bending stress at the root of the thread.
(*f*) Von Mises stress at the root of the thread.
(g) Maximum shear stress at the root of the thread.

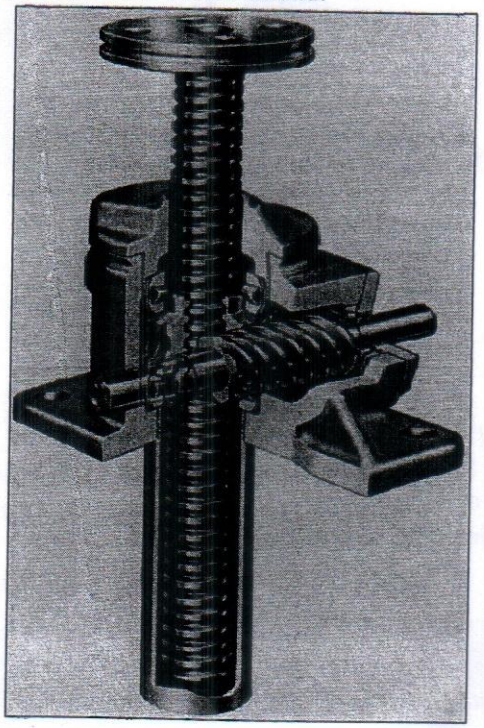

Fig. 6

b) A square-thread power screw has a major diameter of 32 mm and a pitch of 4 mm with double threads, and it is to be used in an application similar to that in Fig. 6 (12)

The given data include $f = f_c$ = 0.08, d_c = 40 mm, and F = 6.4 kN per screw.

(*a*) Find the thread depth, thread width, pitch diameter, minor diameter, and lead.
(*b*) Find the torque required to raise and lower the load.
(*c*) Find the efficiency during lifting the load.
(*d*) Find the body stresses, torsional and compressive.
(*e*) Find the bearing stress.
(*f*) Find the thread bending stress at the root of the thread.
(*g*) Determine the von Mises stress at the root of the thread.
(*h*) Determine the maximum shear stress at the root of the thread.

7. As shown in Fig. 7, two plates are clamped by washer-faced 1/2 in-20 UNF × 1-1/2 in SAE grade 5 bolts each with a standard 1/2 N steel plain washer. (30)

(a) Determine the member spring rate k_m if the top plate is steel and the bottom plate is gray cast iron.

(b) Using the method of conical frusta, determine the member spring rate k_m if both plates are steel.

(c) Using Experimental equation determine the member spring rate k_m if both plates are steel. Compare the results of (c) with (b).

(d) Determine the bolt spring rate k_b.

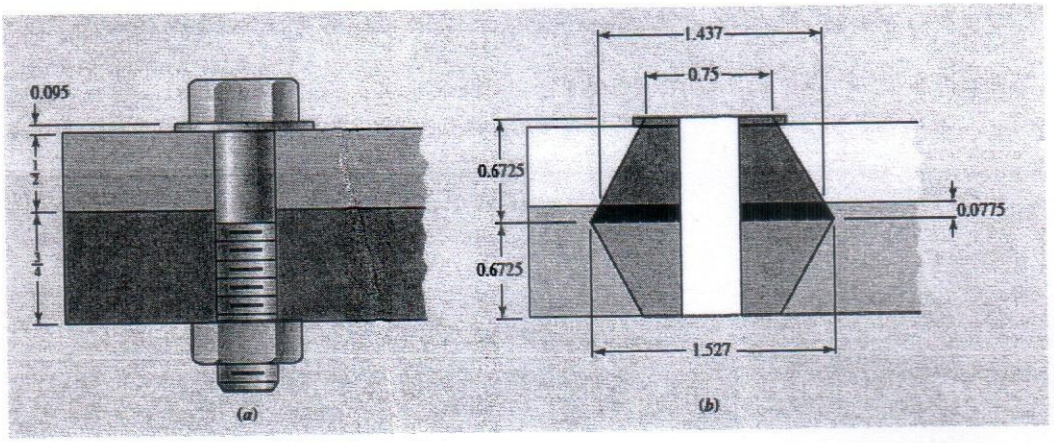

Fig. 7

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B.Sc. Engg. (M)/7th Sem 110 June 05, 2018

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

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination — Winter Semester, A. Y. 2017-2018
Course No.: MCE 4787 — Time: 3 Hours 00 Min(s)
Course Title: Automobile Engineering — Full Marks: 150

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

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

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1. a) What is an automobile chassis? Briefly explain the different components of an automobile chassis. 15
   b) Draw and explain the valve timing diagram of a four stroke diesel engine. 10

2. a) What is an engine electronic control unit (ECU)? Briefly discuss the different types of input and output parameters of engine ECU. 15
   b) What is engine idle adjustment? How can achieve different types of idle adjustment in an automobile engine? 10

3. a) How does an engine cooling system work? Explain with necessary schematic diagram. 15
   b) How a VVT-i system works in a Toyota manufactured engine? 10

4. a) What is the purpose of using a clutch in a manual transmission system? Write down the functions of the following components in an engine clutch: 15
      i. Dampener spring plate and spring
      ii. Pressure plate
      iii. Clutch spring
      iv. Clutch fork and throw out bearing
   b) Is it possible to replace manual shifting with pneumatic shifting in automobile manual transmission to move the shift lever? Justify your statement. 10

5. a) 15

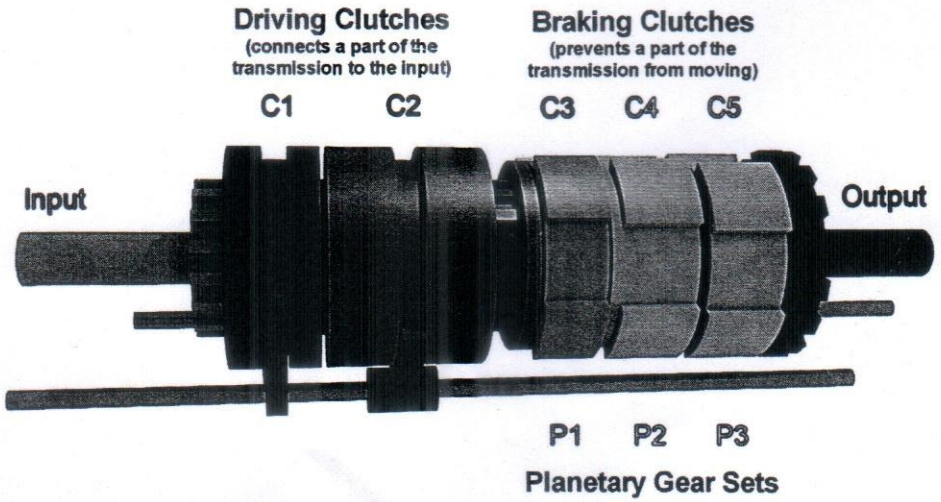

Figure 1: Allison 1000 Automatic Transmission system

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

b) What is a torque converter clutch (TCC)? Write down the function and advantages of using TCC. 10

6. a) Explain the working principle of a Torsen Differential with necessary diagram. 15
   b) What are the advantages of using Thompson Coupling over standard U joint and Rzeppa joint? 10

7. a) Draw and explain the construction of a Macpherson Strut. 15
   b) What are the different types of springs used in a suspension system? Why in a leaf spring two ends joint by a hanger and a shackle rather both ends joint by hangers? 10

8. a) Explain the Ackerman steering mechanism and its necessity. 15
   b) Explain the self-adjusting mechanism of a drum brake system. 10

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B.Sc.Engg(EEE)/7th Semester *1June 2018*

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

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

SEMESTER FINAL EXAMINATION — WINTER SEMESTER 2017-2018
COURSE NO. : **MCE 4791** — TIME : 3 hours
COURSE TITLE : **Engineering Economics** — TOTAL MARKS: 100

There are **EIGHT(8)** questions. Answer any **SIX**(6) of them.
Assume reasonable value if required. Marks in the Margin indicate the full marks.
Programmable Calculators are not allowed. Don't write on this question paper.

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1. (a) Derive the following equation where symbols have their usual meanings [4]
   $P = F \,/\, (1+i)^n$
   (b) Briefly describe Peer to Peer(P2P) loan system with an example. [6.6]
   (c) Write two main difference between conventional and Islamic Insurance(Takaful)? Describe any one method of Islamic Insurance(Takaful). [2+4]

2. (a) KTL enterprises constructed an addition to its building at a cost of $70,000. Extra annual expenses are expected to be $1850, but extra income will be $14,000 per year. There is a one time registration fee of $300 to be paid at year 2. Find out the pay back period for this addition at an interest rate of 12% per year. [7]
   (b) Compare the alternatives shown below on the basis of their capitalized costs, using an interest rate 12% per year and select one of them. [9.6]

	Project X	Project Y
Initial Cost, $	250,000	300,000
Annual operating cost, $/year	130,000	Not Applicable
Maintenance Cost,$	Not Applicable	$ 36000, at year 3,then increases by 5% every year
Annual Revenue, $/year	400,000	370,000
Painting cost in every 3rd year,$	2000	1500
Salvage value, $	Not applicable	100,000
Life, years	infinity	6

3. (a) A company that manufactures magnetic membrane switches is investigating three production options that have the estimated cash flows below. Determine the which option is preferable at an interest rate of 12% per year using Annual Worth(AW) method. All values are in millions. [8.6]

	In house	License	Contract
Initial Cost, $	30	2	0
Annual cost, $/year	5	0.2	2
Annual income, $/year	14	1.5	2.5
Salvage value, $	7	0	0
Life, years	10	infinity	5

(b) A company that manufactures amplified pressure transducers is trying to decide between the machines shown below. Compare them on the basis of their present worth(PW) values, using an interest rate of 12% per year. [8]

	Automatic Machine	Manual Machine
First cost, $	250000	224000
Annual Operating Cost,$/year	231000	235000
Onetime overhauling cost in year 3, $	Not Applicable	26000
Onetime overhauling cost in year 4, $	140000	Not Applicable
Servicing cost, $	$ 500 at year 2 and then increases by $50 every year	$ 300 at year 3 and then increases by 2% every year
Salvage value	49000	10000
Life, years	6	12

4. (a) A grateful alumna of a university wants to establish a permanent scholarship endowment in his name. He wants the endowment to provide the scholarship of $20,000 per year for an infinite time, with the first scholarship to be given at year 6. He plans to make his first deposit at year 1 and increase each succeeding annual deposit by $5000 upto year 4. So he would make total four deposits. If the fund earns interest at a rate of 12% per year, what is the amount of his first deposit at year 1? [8.6]

(b) Two routes are under construction for a new interstate highway. Long route is 25km long, initial cost $21 mil, maintenance cost $40000 per year and short route is 10 km, initial cost $45mil, maintenance cost $15000 per year. Volume of traffic is 400000 vehicles per year regardless of the route. Vehicle operating cost is $0.27 per km per vehicle. Find beneficial route using B/C ratio. Assume the roads are permanent and i=12% per year. [8]

5. (a) Manama Mining Company has purchased a computer controlled gold ornaments manufacturing unit for $80,000. The unit has an anticipated life of 5 years and a salvage value of $10000. Use the Double Declining balance Method to find out schedule of depreciation and book value for each year and present in a table [10]

(b) Select appropriate bundle of proposals, if any, using capital budgeting method. Here MARR is 12% per year and available capital budget is $16100. [6.6]

		Net Cash Flow(NCF), $				
Proposal	Initial Investment, $	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
P1	6000	1000	1700	2400	3100	3800
P2	10000	500	600	700	800	10500
P3	8000	5000	5000	2000		
P4	9000	0	0	0	15000	

6. (a) Geo Health, a bio device systems leasing company, is considering a new equipment purchase to replace a currently owned asset that was purchased 2 years ago for $250,000. It is appraised at a current market value of only $50,000. An upgrade is possible for $200,000 now that would be adequate for another 3 years of lease rights, after which the entire system could be sold on the international circuit for an estimated $40,000. The challenger can be purchased at a cost of $300,000, has an expected life of 10 years, and has a $50,000 salvage value. Determine whether the company should upgrade or replace at a MARR of 12% per year. Assume the AOC estimates are the same for both alternatives. [7]

(b) A 3 year old asset is being considered for early replacement. Its current market value is $13000. Estimated future market values and annual operating costs for the next 5 years are given in the following table. What is the Economic service life of this asset if a 12% per year return is required? [9.6]

Year	Salvage Value,$	Annual Operating cost,$
1	9000	2500
2	8000	2700
3	6000	3000
4	2000	3500
5	0	4500

7. (a) What do you understand by nominal and effective interest rate? How much money would be in the account of a person who deposited $1000 now and $100 every month and withdrew $100 every 2 months for 3 years? Use an interest rate of 11.66% per year compounded half yearly with no interperiod interest paid. Use the closest interest rate provided in the factor table after getting effective rate. [8]

(b) State Nostrom's law. From the cash series below calculate the composite rate of return using a reinvestment rate of 20% per year? [8.6]

Year	Cash flow, $
0	2000
1	-500
2	-8100
3	6800

8. (a) A gold mine was purchased for $10 million. It has an anticipated gross income of $5.0 million per year for years 1 to 5 and $3.0 million per year after year 5. Assume that depletion charges do not exceed 50% of taxable income. Compute annual depletion amounts for the mine. How long will it take to recover the initial investment at i = 0% (zero)per year? Annual percentage depletion for gold is 15%. [4]

(b) Derive the equation for pay back quantity. BIGS Corporation assembles 30 trucks per year. Find out the current break even quantity from the following information is available: [6.6]
Fixed cost : $ 800,000
Variable cost per unit: $35000
Revenue per unit: $75000

(c) KRC Ltd, leases generators. The net profit(i.e. net cash flow) from the equipment for each of the last 4 years has been decreasing, as shown below in the table. Also shown are the annual rates of return on invested capital. Determine the equivalent present worth(PW) and equivalent uniform series (A) of the net profit series. [6]

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

Formulas:

Effective interest rate, $i = (1+\frac{r}{m})^{m} - 1$

In Geometric Gradient Series :

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

12% Compound Interest Factors 12%

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

15% Compound Interest Factors 15%

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

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PhD/M Sc. Eng.(M) 01 June 2018

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

Final Semester Examination — Winter Semester, A.Y. 2017-2018
Course Code: Math 6103 — Time : 3 hours
Course Title: Advanced Mathematics — Full Marks: 150

There are **7 (Seven)** Questions. Answer any **5 (Five)** of them. All Questions carry equal Marks. Programmable calculators are not allowed. Do not write on this question paper.The Symbols have their usual meaning.

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

   In each part, describe the graph of the function in *xyz*-coordinate system.

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

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

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

   b) If $T(x, y)$ is the temperature at a point (x, y) on a thin metal plate in the *xy*-plane, then the level curves of T are called ***isothermal curves***. All points on such a curve are at the same temperature. Suppose that a plate occupies the first quadrant and $T(x, y) = xy$.
   (i) Sketch the isothermal curves on which $T = 1$, $T = 2$, and $T = 3$.
   (ii) An ant, initially at $(1, 4)$, wants to walk on the plate so that the temperature along its path remains constant. What path should the ant take and what is the temperature along that path?

2. a) Locate all relative extrema and saddle points of $f(x, y) = 4xy - x^4 - y^4$.

   b) Find the absolute minimum and absolute maximum of $f(x,y)=192x^3+y^2-4xy^2$ on the triangle with vertices (0, 0), (4, 2) and (-2, 2).

3. a) Use Lagrange multipliers to determine the dimensions of a rectangular box, open at the top, having a volume of 32 ft^3, and requiring the least amount of material for its construction.

   b) Find the maximum and minimum values of $f(x,y,z)=xyz$ subjected to the constrained $x+y+z=1$. Assume that $x,y,z\geq 0$.

4. a) Use triple integration in cylindrical coordinates to find the volume of the solid G that is bounded above by the hemisphere $z=\sqrt{25-x^2-y^2}$, below by the *xy*-plane, and laterally by the cylinder $x^2+y^2=9$.

   b) Find the mass and the center of gravity of a cylindrical solid of height hand radius a (Shown in Fig.: 01), assuming that the density at each point is proportional to thedistance between the point and the base of the solid.

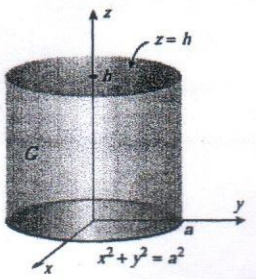

Fig.: 01

5. a) You are working for a start-up computer assembly company and have been asked to determine the minimum number of computers that the shop will have to sell to make a profit. The equation that gives the minimum number of computers n to be sold after considering the total costs and the total sales is

$$f(n) = 40n^{1.5} - 875n + 35000 = 0$$

Use the Newton-Raphson method of finding roots of equations to find the minimum number of computers that need to be sold to make a profit. Conduct three iterations to estimate the root of the above equations. Find the absolute relative approximate error at the end of each iteration and the number of significant digits at least correct at the end of each iteration.

b) A trunnion has to be cooled before it is shrinking fitted into a steel hub.

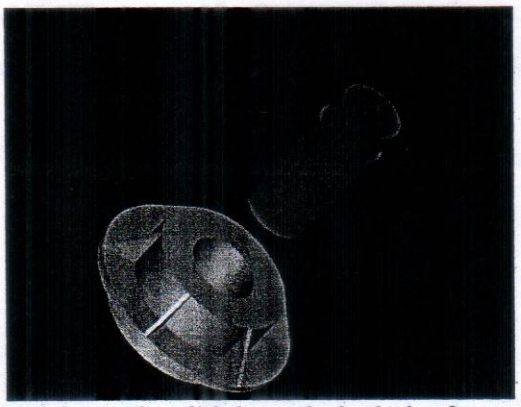

Fig. 02: Trunnion to be slid through the hub after contracting.

The equation that gives the temperature T_f to which the trunnion has to be cooled to obtain the desired contraction is given by

$$f(T_f) = -0.50598 \times 10^{-10} T_f^3 + 0.38292 \times 10^{-7} T_f^2 + 0.74363 \times 10^{-4} T_f + 0.88318 \times 10^{-2} = 0$$

Use the bisection method of finding roots of equations to find the temperature T_f to which the trunnion has to be cooled. Conduct three iterations to estimate the root of the above equation. Find the absolute relative approximate error at the end of each iteration and the number of significant digits at least correct at the end of each iteration.

6. Consider a steel rod that is subjected to a temperature of 100^0C on the left end and 25^0Con the right end. If the rod is of length 0.05m, use the explicit method to find the temperature distribution in the rod from $t = 0$ and $t = 6$ seconds.
Use $\Delta x = 0.01m$, $\Delta t = 3s$.

7. Consider a plate $2.4m \times 3.0m$ that is subjected to the boundary conditions shown below. Find the temperature at the interior nodes using a square grid with a length of 0.6m using the Gauss-Siedel method. Assume the initial temperature at all interior nodes to be 0^0C.

M.Sc. Engg 120 24 May' 2018 (Group-B)

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

Semester Final Examination — Winter Semester, A.Y. 2017-2018
Course Code: MCE 6121 — Time : 3 hours
Course Title: Advanced Topics in Manufacturing — Full Marks : 150

There are 8 (Eight) Questions. Answer any 6 (six) of them.

Marks in the Margin indicate the full marks.

1. a) Explain in details the different types of manufacturing processes used in different industries? 13

b) Define the term production system, production facilities and product quantities and hence explain the manufacturing support system algorithm in advanced manufacturing. 12

2. Five machines will constitute a GT cell. The from-to data for the machines are shown in the table below. (i) Determine the most logical sequence of machines for this data, according to Hollier's method 1, and construct the flow diagram for the data, showing where and how many parts enter and exit the system. (ii) Repeat step (i) only using Hollier's method 2. (iii) Compute the percentage of in-sequence moves and the percentage of back-tracking moves in the solution for the two methods. Which method is better, according to these measures? (iv) Develop a feasible layout plan for the cell based on the better of the two Hollier methods. 25

	To:				
From:	1	2	3	4	5
1	0	10	80	0	0
2	0	0	0	85	0
3	0	0	0	0	0
4	70	0	20	0	0
5	0	75	0	20	0

3. a) Explain the mechanism of using Electro-Discharge Machining and write down the differences in between Electro-Chemical Machining (ECM) and Electro-Discharge Machining. 15

b) Explain with neat sketches Ultrasonic Machining and Laser beam machining (LBM) processes. 10

4. A company is seeking proposals for an automated storage/retrieval system that will have a throughput rate of 300 storage/retrieval transactions/hour during the one 8-hour shift per day. The request for proposal indicates that the number of single command cycles is expected to be four times the number of dual command cycles. The first proposal received is from a vendor who specifies the following: ten aisles, each aisle 150 ft long and 50 ft high; horizontal and vertical speeds of the S/R machine = 200 ft/min and 66.67 ft/min, respectively; and pick and deposit time = 0.3 min. As the responsible engineer for the project, you must analyze the proposal and make recommendations accordingly. One of the difficulties identified in the proposed AS/RS is the large number of S/R machines that would be required - one for each of the 10 aisles. This makes the proposed system very expensive. Recommendation is to reduce the number of aisles from 10 to 6 and to select a S/R machine with horizontal and vertical speeds of 300 ft/min and 100 ft/min, respectively. Although each high speed S/R machine is slightly more expensive than the slower model, reducing the number of machines from 10 to 6 will significantly reduce total cost. Also, fewer aisles will reduce the cost of the rack structure even though each aisle will be somewhat larger since total storage capacity must remain the same. The problem is that throughput rate will be adversely affected. 25

(i) Determine the throughput rate of the proposed 10-aisle AS/RS and calculate its utilization relative to the specified 300 transactions/hour.

(ii) Determine the length and height of a six-aisle AS/RS whose storage capacity would be the same as the proposed 10-aisle system.

(iii) Determine the throughput rate of the 6-aisle AS/RS and calculate its utilization relative to the

specified 300 transactions/hour. 121

(iv) Given the dilemma now confronting you, what other alternatives would you analyze and recommendations would you make to improve the design of the system?

5 a) What is advanced manufacturing planning? Explain with necessary diagram the different activities in advanced manufacturing planning cycle. 15

b) Write down the general principles and guidelines in design for manufacturing and assembles. 10

6 a) What is the meaning of Statistical process control? List the different SPC tool and hence define the term defect concentration diagram. 10

b) A plastic extrusion process is in statistical control and the output is normally distributed. Extrudate is produced with a critical cross-section dimension = 28.6 mm and standard deviation = 0.53 mm. (i) Determine the process capability. The design specification on the part is that the critical cross-sectional dimension = 28.0 ± 2.0 mm. (ii) What proportion of parts fall outside the tolerance limits? (iii) If the process were adjusted so that its mean diameter = 28.0 mm and the standard deviation remained the same, what proportion of parts would fall outside the tolerance limits? (iv) With the adjusted mean at 28.0 mm, determine the value of the process capability index. 15

7 a) A dial indexing machine has six stations that perform assembly operations on a base part. The operations, element times, q and m values for components added are given in the table below (NA means q and m are not applicable to the operation). The indexing time for the dial table is 2 seconds. When a jam occurs, it requires 1.5 minutes to release the jam and put the machine back in operation. Determine: (i) production rate for the assembly machine, (ii) yield of good product (final assemblies containing no defective components), and (iii) proportion uptime of the system. 18

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

b) Write down the recommendations and principles that can be applied in product design to facilitate automated assembly? 07

8 a) What do you mean by Computer Aided process planning? Write down the different CAPP approaches and hence explain the general procedure for using retrieval CAPP systems. 15

b) Explain the features of parts classification and coding systems and hence explain the optiz classification system with example. 10

M Sc.Engg. (MCE) 122 08 June 2018

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

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

Winter Semester: **A.Y. 2017-2018**
Time : **3.0 Hours**
Full Marks : **150**

OPEN BOOK

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

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1. a) What is pool boiling system? Discuss the principle boiling regime in pool boiling of water at atmospheric pressure and saturation temperature. **(10)**

   b) Saturated water at $T_{sat} = 210°C$ flows with a mass flow rates of $M = 0.17kg/s$ through a 2.0 cm internal diameter. Subjected to a uniform wall heat flux of $q_w = 139\frac{W}{m^2}$. Calculate the tube wall temperature T_w and the two phase heat transfer coefficient h_{TP}, at the location where the vapor mass is *0.37*. **(15)**

2. a) What is film-wise and drop-wise condensation? Differentiate the characteristics between Condensation on Inclined surfaces and Horizontal tubes. **(09)**

   b) Air-free saturated steam at *50°C* and *12.35kPa* condenses on the outside surface of a *2.5cm* outer diameter, *2 m* long vertical tube maintained at a uniform temperature *30°C* by the flow of cooling water through the tube. Assuming film condensation, calculate (a) Average condensation heat transfer coefficient over the entire length of the tube, (b) the rate of condensate flow at the bottom of the tube, and (c) the condensate thickness at the bottom of the tube. **(16)**

3. a) Write down the physical significance of *Reynolds number* and *Grashof number*. **(08)**

   b) A square plate $\frac{1}{2}\ m$ by $\frac{1}{2}\ m$ is thermally insulated on one side and subjected to a solar radiation flux $q = 600\ Wm^{-2}$ on the other side which is considered a black surface. The plate makes an angle $\theta = -50°$ with the vertical, so that hot surface is facing upward. The heated surface dissipates heat by free convection into atmospheric air at $T_\infty = 333K$. Calculate the equilibrium temperature of the plate. **(17)**

4. a) Discuss the mechanism of free convection in enclosed spaces for a) Horizontal layer with Benard cells, b) Vertical layer, c) Inclined layer. **(09)**

   b) A spherical storage tank of diameter D=1.5 m contains a cold liquid at $T_1 = 15°C$. To reduce the heat losses, this storage tank is enclosed inside another spherical shell, and the gap spacing is 3 cm. The temperature of the outer sphere is $T_2 = 25°C$. Determine the rate of heat loss by free convection across the gap filled with air at (a) $\frac{1}{20}$, (b) $\frac{1}{10}$ and (c) 1 atm. **(16)**

5. a) Discuss the basic principle of *von Karman integral method* for the determination of the velocity boundary layer thickness. **(10)**

   b) Atmospheric air at $T_\infty = 275\ K$ and a free stream velocity $u_\infty = 20\ m/s$ flows over a flat plate L=1.5 m long that is maintained at a uniform temperature $T_w = 325\ K$. **(15)**
   (a). Calculate the average heat transfer coefficient h_m over the regions where the boundary layer is turbulent.
   (b). Find the average heat transfer coefficient over the entire length L=1.5 m of the plate.
   (c). Calculate the total heat transfer rate Q from the plate to the air over the length L=1.5 m and width w=1 m.

6. a) How the heat transfer and pressure drop are affected by the variation of longitudinal pitch, transverse pitch and diagonal pitch in heat exchanger? **08**

   b) Air at a pressure of $P = \frac{1}{20}$ atm, temperature $T_\infty = 273K$ and velocity $u_\infty = 450\ m/s$ flows over a flat plate L=1.0 m long and w=0.5 m wide. Calculate the amount of cooling needed to maintain the plate surface at a uniform temperature $T_w = 350K$ **17**

7. a) Discuss the different heat transfer augmentation techniques **05**

   b) Air flows with a mean velocity of 2.7 m/s inside a circular pipe of inside diameter of 5 cm. The pipe is of Aluminium and its wall is maintained at a uniform temperature of 69°C by condensing steam on its outer surface. At a location where the fluid is hydrodynamically and thermally developed, the bulk mean temperature of water is 40°C. Calculate the heat transfer coefficient h for a smooth pipe by using the following correlations: **20**
   (a). The Notter and Sleicher equation.
   (b). The Dittus and Boelter equation.

8. a) Discuss the physical significance of Nu, St, E, Re. **12**

   b) The exact expression for the local Nusselt number for laminar flow along a flat plate is given by $Nu_x = \frac{h(x)x}{k} = 0.332\ Pr^{\frac{1}{3}}\ Re^{\frac{1}{2}}$. **13**
   Develop a relation for the average heat transfer coefficient h(x) from x=0 to x=L. Atmospheric air at $T_\infty = 400K$ with a velocity $u_\infty = 2.5\ m/s$ flows over a flat plate L=2m long maintained at a uniform temperature $T_w = 333K$.
   Calculate the *average heat transfer coefficient* h_m from x=0 to x=L=2 m.
   Calculate the *heat transfer rate* from airstream to the plate from x=0 to x=L=2 m for w=0.5 m.

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M. Sc. TE /1th Sem (2 Yr.) 07 June 2018

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

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination
Course No.: MCE 6197
Course Title: Advanced Machine Tools

Winter Semester, A. Y. 2017-2018
Time: 3 Hours
Full Marks: 150

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

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

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1. a) What is the machine tool shown in figure 1? Write down the names of different components (according to the number shown in figure 1)? Write down the kinematic system and working principle of this machine tool. 18

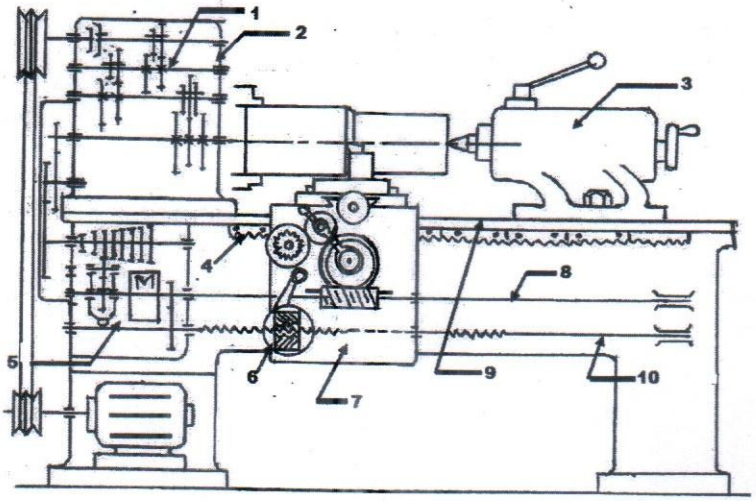

Figure 1

b) Classify machine tools according to purpose, feed mechanism, types of motions and method of actuation. 7

2. What are the different methods of mounting cutting tool and job in milling machine? 25

3. a) Using differential indexing method, calculate the indexing and change gear required for 51 divisions. The available index plate hole circles are as follows: 18

Plate A : 15, 16, 17, 18, 19, 20
Plate B : 21, 23, 27, 29, 31, 33
Plate C : 37, 39, 41, 43, 47, 49

The change gears supplied with the dividing head are as follows:
22, 28, 30, 40, 44, 48, 56, 65, 72, 80, 86, 104.

b) Write down the steps to mill a square with direct indexing. 7

4. Describe taper turning and spherical turning attachment (with and without template) used in a center lathe. 25

5. a) Explain the working principle of Norton gearbox with necessary diagram. 13
   b) Describe frictional drives of single disc, double disc and using cones. 12

6. a) Write down the working principle of a gear pump with figures. What is the main drawback of this pump and how it will be recovered? 13
   b) Explain the working principle of axial piston pump. Write down its advantages. 12

7. Draw structural diagrams for a speed gear box of $z = 12\ (3 \times 2 \times 2)$ and $u = 3$. Explain, in order to design a speed gear box of $\varphi = 1.41$, which one of you will select. 25

8. Explain the setup for Electro-Discharge Machining and Laser Beam Machining with the help of sketches and describe the working principle. 25