L-3/T-2/ME **Date : 17/01/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2013-2014

Sub : **IPE 331** (Production Processes)

Full Marks: 280 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Briefly describe the different types of pattern allowances. Why are allowances provided for making patterns? **(10)**

   (b) With the help of suitable diagrams, describe the following: **(16)**

   (i) Pressure die casting

   (ii) Lost-wax casting

   (c) Write short notes on the following: **(12)**

   (i) Dry sand molding

   (ii) Loose piece pattern

   (iii) Sweep pattern

   (d) With the help of suitable diagram, describe the surface and internal defects encountered in sand casting processes. How do you rectify them? **(8⅔)**

2. (a) Derive the expression for chip reduction coefficient in orthogonal cutting in terms of rake angle and coefficient of friction. **(12)**

   (b) Drive, with the help of MCD, simple expression for: **(12)**

   (i) P_s and P_n as functions of P_x, P_z, γ and β

   (ii) F and N as functions of P_y, P_z and γ

   (c) During the orthogonal turning of a rod it was observed that **(12)**

   $P_z = P_{xy} = P_x = F = N$ and $P_n = 2P_s$, where the notations indicate their usual meaning. Draw the MCD and determine the possible values of the rake angle (γ), principal cutting edge angle (φ) and shear angle (β) for the above condition.

   (d) Discuss the various types of cutting fluids and state their methods of application. List the essential characteristics of cutting fluid. **(10⅔)**

3. (a) With the help of neat sketch, describe briefly the principles of operation of MIG welding process. LBM has certain advantages over EBM. What are they? **(12)**

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Contd... Q. No. 3

(b) With the help of suitable diagrams, describe the following: **(24)**

(i) Flash welding

(ii) Thermit welding

(iii) Electron beam welding

(c) Enumerate common defects encountered with welding products and suggest methods to counter these defects. Identify the factors that affect weldability. **(10⅔)**

4. (a) Explain why squeeze casting produces parts with better mechanical properties, dimensional accuracy and surface finish than that of parts produced by centrifugal casting processes. Why are steels more difficult to cast than cast irons? **(12)**

(b) In an orthogonal cutting tool what are the important angles that are to be maintained? For each of the angle, explain its influence on the machining performance. **(12)**

(c) What are the desirable properties of a metal that would provide good weldability for resistance welding? With the help of suitable diagram describe the sequence of steps in the cycle of a resistance spot-welding operation. **(12)**

(d) What is meant by orthogonal cutting and oblique cutting? State the causes why the direction of chip flow deviates from orthogonal plane. **(10⅔)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Briefly describe the application of any two work holding devices used in a lathe machine. **(12)**

(b) With the help of suitable diagram, describe different peripheral milling operations. **(14)**

(c) With the help of neat sketches, describe briefly the following: **(12)**

(i) Boring

(ii) Reaming

(iii) Countersinking

(d) Describe honing operation with necessary sketches. **(8⅔)**

6. (a) Describe a taper turning method in which a cutting tool can be moved in angular way. **(9⅔)**

(b) Classify grinding operation based on the type of surface produced and describe each type with necessary sketches. **(15)**

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(c) With the help of neat sketches, describe different cutting tools used for milling operation. **(10)**

(d) Describe the kinematics of Shaping and Planning operation with appropriate figures. Briefly describe shaper size and shaper width. **(8+4=12)**

7. (a) With the help of suitable diagram, describe impression die forging and roll forging. **(8+8=16)**

(b) Describe the defects commonly observed in extruded product. **(12)**

(c) Describe Mannesmann process with necessary sketches. **(10⅔)**

(d) Discuss the effect of hot rolling process on material micro structure. **(8)**

8. (a) With the help of suitable sketches, describe the following forming operation: **(20)**

(i) Dimpling
(ii) Beading
(iii) Hydro forming
(iv) Redrawing

(b) Discuss the upsetting and barreling in Open-die forging. How do you minimize the barreling effect? **(14)**

(c) Explain the effect of cutting speed on production cost with suitable graph. Calculate the optimum cutting speed to minimize cost. **(12⅔)**

L-3/T-2/ME **Date : 23/01/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2013-2014

Sub : **ME 303** (Convection, Boiling, Condensation and Mass Transfer)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

Assume reasonable values for missing data. All symbols have their usual meaning.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Draw the typical boiling curve for water at 1 atm pressure and identify the different boiling regimes. **(10)**

   (b) In a gas-fired boiler, water is boiled at 150°C by hot gases flowing through 50-m-long, 5-cm-outer-diamter mechanically polished stainless steel pipes submerged in water. If the outer surface temperature of the pipes is 165°C, determine (i) the rate of heat transfer from the hot gases to water, (ii) the rate of evaporation, (iii) the ratio of the critical heat flux to the present heat flux, and (iv) the surface temperature of the pipe at which critical heat flux occurs. **(25)**

2. (a) What is the difference between film and drop-wise condensation? Which is a more effective mechanism of heat transfer? **(10)**

   (b) Saturated steam at 1 atm condenses on a 3-m-high and 5-m-wide vertical plate that is maintained at 90°C by circulating cooling water through the other side. Determine (i) the rate of heat transfer by condensation to the plate, and (ii) the rate at which the condensate drips off the plate at the bottom. **(25)**

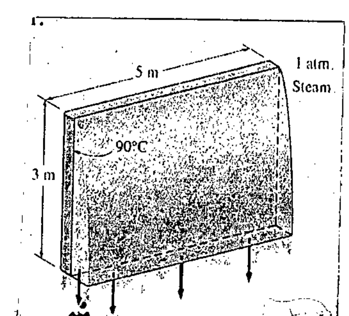

Figure for the Q. No. 2(b)

3. (a) Briefly describe the working principle of shell and tube heat exchanger with schematic diagram. **(10)**

   (b) A shell-and-tube heat exchanger with 2-shell passes and 8-tube passes is used to heat ethyl alcohol $C_p = 2670\ J/kg\cdot{}^{o}C$) in the tubes from 25°C to 70°C at a rate of 2.1 kg/s. The heating is to be done by water ($C_p = 4190\ J/kg\cdot{}^{o}C$) that enters the shell at 95°C and leaves at 60°C. If the overall heat transfer coefficient is 800 W/m^2.°C, determine the heat transfer surface area of the heat exchanger using (i) the LMTD method and (ii) the ε-NTU method. **(25)**

Contd P/2

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4. (a) The vertical 0.8-m-high, 2-m-wide double-pane window shown in Figure consists of two sheets of glass separated by a 2-cm air gap at atmospheric pressure. If the glass surface temperatures across the air gap are measured to be 12°C and 2°C, determine the rate of heat transfer through the window. **(15)**

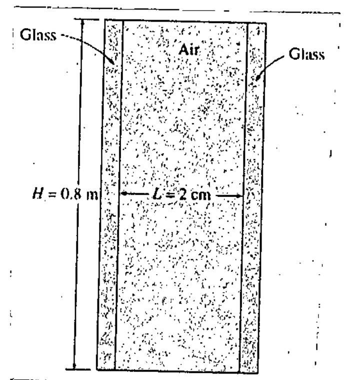

Figure for the Q. No. 4(a)

(b) A 400-W cylindrical resistance heater is 1 m long and 0.5 cm in diameter. The resistance wire is placed horizontally in a fluid at 20°C. Determine the outer surface temperature of the resistance wire in steady operation if the fluid is air. Ignore any heat transfer by radiation. Use properties at 500°C for air. **(20)**

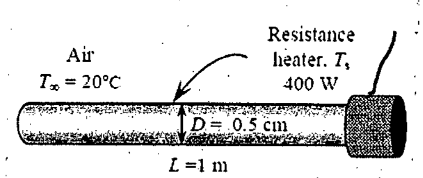

Figure for the Q. No. 4(b)

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Write down two dimensional, steady-state governing equations for simultaneous convection heat and mass transfer in Cartesian coordinate system. **(10)**

(b) Define Prandtl number, Schmidt number and Lewis number. Explain their physical significance. **(9)**

(c) Using dimensional analysis, show that for forced convection heat transfer over a flat plate, $Nu = f(\text{Re}, \text{Pr})$. **(16)**

6. (a) With a neat sketch show the hydrodynamic and the thermal boundary layers for forced air flow over a cold flat plate and indicate different flow regimes, velocity and temperature profiles, and boundary layer thickness. **(15)**

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Contd... Q. No. 6

(b) Consider a rectangular fin that is used to cool a motorcycle engine. The fin is 0.15 m long and at a temperature of 250°C, while the motorcycle is moving at 80 km/hr in air at 27°C. The air is in parallel flow over both surfaces of the fin, and turbulent flow conditions may be assumed to exist throughout. What is the rate of heat removal per unit width of the fin? **(20)**

7. (a) In a long annulus (35 mm ID and 50 mm OD), water is heated by maintaining the outer surface of inner tube at 60°C. Water enters at 20°C and leaves at 34°C, while its flow velocity is 2 m/s. Estimate the heat transfer coefficient. Use relation: **(15)**

$$Nu = 0.023\,\mathrm{Re}^{0.8}\,\mathrm{Pr}^{0.4}$$

(b) Consider the flow of engine oil at 10°C in a 40-cm diameter pipeline at an average velocity of 0.5 m/s. A 300-m long section of the pipeline pass through icy waters of a lake at 0°C. Disregarding the thermal resistance of the pipe material, determine (i) the temperature of the oil when the pipe leaves the lake, and (ii) the rate of heat transfer from the oil. Correlation for the thermal entrance region: **(20)**

$$Nu = 3.66 + \frac{0.065(D/L)\mathrm{Re}_D\,\mathrm{Pr}}{1 + 0.04[(D/L)\mathrm{Re}_D\,\mathrm{Pr}]^{2/3}}$$

Correlation for fully developed turbulent flow:

$$Nu = \frac{(\mathrm{Re}_D - 1000)\mathrm{Pr}(f/8)}{1.07 + 12.7(\mathrm{Pr}^{2/3} - 1)(f/8)^{1/2}} \qquad 0.5 < \mathrm{Pr} < 2000,\ 2300 < \mathrm{Re}_D < 5\times10^6$$

$$f = (0.790 \ln \mathrm{Re}_D - 1.64)^{-2}$$

8. (a) What is Fick's law of diffusion? Explain with neat sketch. **(10)**

(b) Write down the Reynolds analogy for pipe flow to mass transfer problems and hence show the interrelation in between heat and mass transfer when both occurs simultaneously. **(10)**

(c) Dry air at atmospheric pressure blows across a thermometer which is enclosed in a dampened cover. The thermometer reads a temperature of T_w. Using the relation between heat and mass transfer derive an expression for determination of the temperature of the dry air. **(15)**

Boiling:

The most widely used correlation for the rate of heat transfer in the nucleate boiling regime was proposed in 1952 by Rohsenow, and expressed as

$$\dot{q}_{\text{nucleate}} = \mu_l h_{fg}\left[\frac{g(\rho_l - \rho_v)}{\sigma}\right]^{1/2}\left[\frac{C_{pl}(T_s - T_{\text{sat}})}{C_{sf} h_{fg} \Pr_l^n}\right]^3$$

The maximum (or critical) heat flux in nucleate pool boiling is determined from

$$\dot{q}_{\max} = C_{cr}\, h_{fg}[\sigma g \rho_v^2 (\rho_l - \rho_v)]^{1/4}$$

where C_{cr} is a constant whose value depends on the heater geometry.

Table 1:

Properties of saturated water

Temp. T, °C	Saturation Pressure P_{sat}, kPa	Density ρ, kg/m³ Liquid	Density Vapor	Enthalpy of Vaporization h_{fg}, kJ/kg	Specific Heat c_p, J/kg·K Liquid	Specific Heat Vapor	Thermal Conductivity k, W/m·K Liquid	Thermal Conductivity Vapor	Dynamic Viscosity μ, kg/m·s Liquid	Dynamic Viscosity Vapor	Prandtl Number Pr Liquid	Prandtl Number Vapor	Volume Expansion Coefficient β, 1/K Liquid
0.01	0.6113	999.8	0.0048	2501	4217	1854	0.561	0.0171	1.792×10^{-3}	0.922×10^{-5}	13.5	1.00	-0.068×10^{-3}
5	0.8721	999.9	0.0068	2490	4205	1857	0.571	0.0173	1.519×10^{-3}	0.934×10^{-5}	11.2	1.00	0.015×10^{-3}
10	1.2276	999.7	0.0094	2478	4194	1862	0.580	0.0176	1.307×10^{-3}	0.946×10^{-5}	9.45	1.00	0.733×10^{-3}
15	1.7051	999.1	0.0128	2466	4185	1863	0.589	0.0179	1.138×10^{-3}	0.959×10^{-5}	8.09	1.00	0.138×10^{-3}
20	2.339	998.0	0.0173	2454	4182	1867	0.598	0.0182	1.002×10^{-3}	0.973×10^{-5}	7.01	1.00	0.195×10^{-3}
25	3.169	997.0	0.0231	2442	4180	1870	0.607	0.0186	0.891×10^{-3}	0.987×10^{-5}	6.14	1.00	0.247×10^{-3}
30	4.246	996.0	0.0304	2431	4178	1875	0.615	0.0189	0.798×10^{-3}	1.001×10^{-5}	5.42	1.00	0.294×10^{-3}
35	5.628	994.0	0.0397	2419	4178	1880	0.623	0.0192	0.720×10^{-3}	1.016×10^{-5}	4.83	1.00	0.337×10^{-3}
40	7.384	992.1	0.0512	2407	4179	1885	0.631	0.0196	0.653×10^{-3}	1.031×10^{-5}	4.32	1.00	0.377×10^{-3}
45	9.593	990.1	0.0655	2395	4180	1892	0.637	0.0200	0.596×10^{-3}	1.046×10^{-5}	3.91	1.00	0.415×10^{-3}
50	12.35	988.1	0.0831	2383	4181	1900	0.644	0.0204	0.547×10^{-3}	1.062×10^{-5}	3.55	1.00	0.451×10^{-3}
55	15.76	985.2	0.1045	2371	4183	1908	0.649	0.0208	0.504×10^{-3}	1.077×10^{-5}	3.25	1.00	0.484×10^{-3}
60	19.94	983.3	0.1304	2359	4185	1916	0.654	0.0212	0.467×10^{-3}	1.093×10^{-5}	2.99	1.00	0.517×10^{-3}
65	25.03	980.4	0.1614	2346	4187	1926	0.659	0.0216	0.433×10^{-3}	1.110×10^{-5}	2.75	1.00	0.548×10^{-3}
70	31.19	977.5	0.1983	2334	4190	1936	0.663	0.0221	0.404×10^{-3}	1.126×10^{-5}	2.55	1.00	0.578×10^{-3}
75	38.58	974.7	0.2421	2321	4193	1948	0.667	0.0225	0.378×10^{-3}	1.142×10^{-5}	2.38	1.00	0.607×10^{-3}
80	47.39	971.8	0.2935	2309	4197	1962	0.670	0.0230	0.355×10^{-3}	1.159×10^{-5}	2.22	1.00	0.653×10^{-3}
85	57.83	968.1	0.3536	2296	4201	1977	0.673	0.0235	0.333×10^{-3}	1.176×10^{-5}	2.08	1.00	0.670×10^{-3}
90	70.14	965.3	0.4235	2283	4206	1993	0.675	0.0240	0.315×10^{-3}	1.193×10^{-5}	1.96	1.00	0.702×10^{-3}
95	84.55	961.5	0.5045	2270	4212	2010	0.677	0.0246	0.297×10^{-3}	1.210×10^{-5}	1.85	1.00	0.716×10^{-3}
100	101.33	957.9	0.5978	2257	4217	2029	0.679	0.0251	0.282×10^{-3}	1.227×10^{-5}	1.75	1.00	0.750×10^{-3}
110	143.27	950.6	0.8263	2230	4229	2071	0.682	0.0262	0.255×10^{-3}	1.261×10^{-5}	1.58	1.00	0.798×10^{-3}
120	198.53	943.4	1.121	2203	4244	2120	0.683	0.0275	0.232×10^{-3}	1.296×10^{-5}	1.44	1.00	0.858×10^{-3}
130	270.1	934.6	1.496	2174	4263	2177	0.684	0.0288	0.213×10^{-3}	1.330×10^{-5}	1.33	1.01	0.913×10^{-3}
140	361.3	921.7	1.965	2145	4286	2244	0.683	0.0301	0.197×10^{-3}	1.365×10^{-5}	1.24	1.02	0.970×10^{-3}
150	475.8	916.6	2.546	2114	4311	2314	0.682	0.0316	0.183×10^{-3}	1.399×10^{-5}	1.16	1.02	1.025×10^{-3}

Table: 2

Surface tension of liquid–vapor interface for water

T, °C	σ, N/m*
0	0.0757
20	0.0727
40	0.0696
60	0.0662
80	0.0627
100	0.0589
120	0.0550
140	0.0509
160	0.0466
180	0.0422
200	0,0377
220	0.0331
240	0.0284
260	0.0237
280	0.0190
300	0.0144
320	0.0099
340	0.0056
360	0.0019
374	0.0

Table: 3

Values of the coefficient C_{sf} and n for various fluid–surface combinations

Fluid-Heating Surface Combination	C_{sf}	n
Water–copper (polished)	0.0130	1.0
Water–copper (scored)	0.0068	1.0
Water–stainless steel (mechanically polished)	0.0130	1.0
Water–stainless steel (ground and polished)	0.0060	1.0
Water–stainless steel (teflon pitted)	0.0058	1.0
Water–stainless steel (chemically etched)	0.0130	1.0
Water–brass	0.0060	1.0
Water–nickel	0.0060	1.0
Water–platinum	0.0130	1.0
n-Pentane–copper (polished)	0.0154	1.7
n-Pentane–chromium	0.0150	1.7
Benzene–chromium	0.1010	1.7
Ethyl alcohol–chromium	0.0027	1.7
Carbon tetrachloride–copper	0.0130	1.7
Isopropanol–copper	0.0025	1.7

Table:4

Values of the coefficient C_{cr} for use in Eq. for maximum heat flux (dimensionless parameter $L^* = L[g(\rho_l - \rho_v)/\sigma]^{1/2}$)

Heater Geometry	C_{cr}	Charac. Dimension of Heater, L	Range of L^*
Large horizontal flat heater	0.149	Width or diameter	$L^* > 27$
Small horizontal flat heater[1]	$18.9 K_1$	Width or diameter	$9 < L^* < 20$
Large horizontal cylinder	0.12	Radius	$L^* > 1.2$
Small horizontal cylinder	$0.12 L^{*-0.25}$	Radius	$0.15 < L^* < 1.2$
Large sphere	0.11	Radius	$L^* > 4.26$
Small sphere	$0.227 L^{*-0.5}$	Radius	$0.15 < L^* < 4.26$

[1] $K_1 = \sigma/[g(\rho_l - \rho_v)A_{heater}]$

condensation:

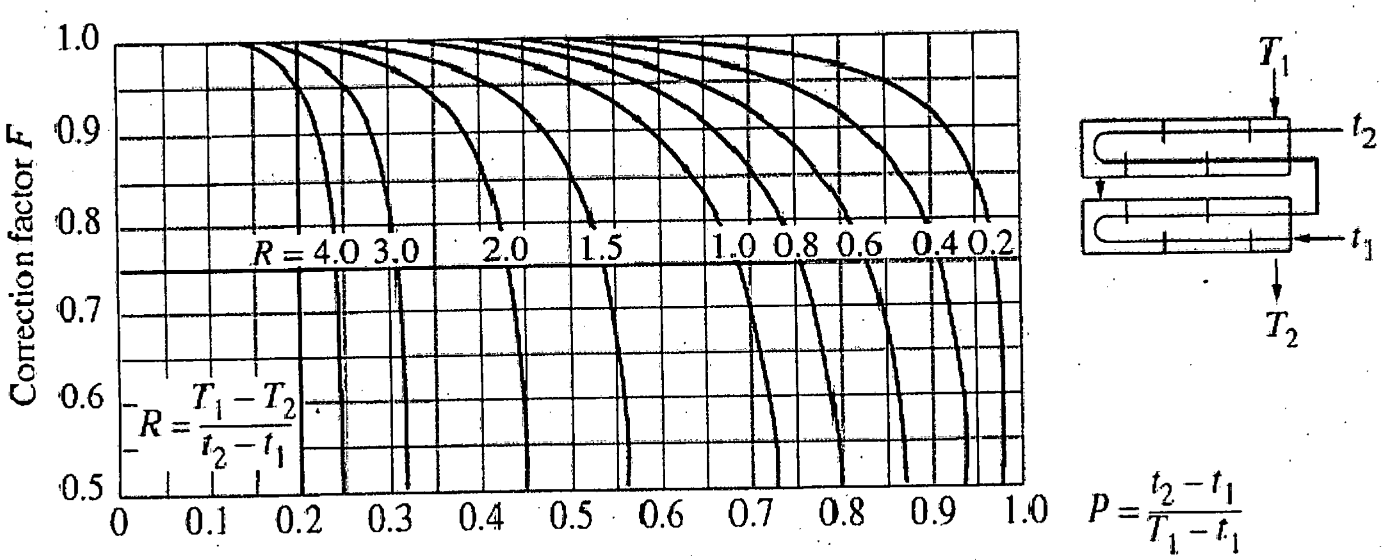
$$\mathrm{Re}_{\text{vert, wavy}} = \left[4.81 + \frac{3.70\, L k_l (T_{sat} - T_s)}{\mu_l\, h^*_{fg}}\left(\frac{g}{\nu_l^2}\right)^{1/3}\right]^{0.820}, \quad \rho_v \ll \rho_l$$

h^*_{fg} is the *modified latent heat of vaporization*, defined as

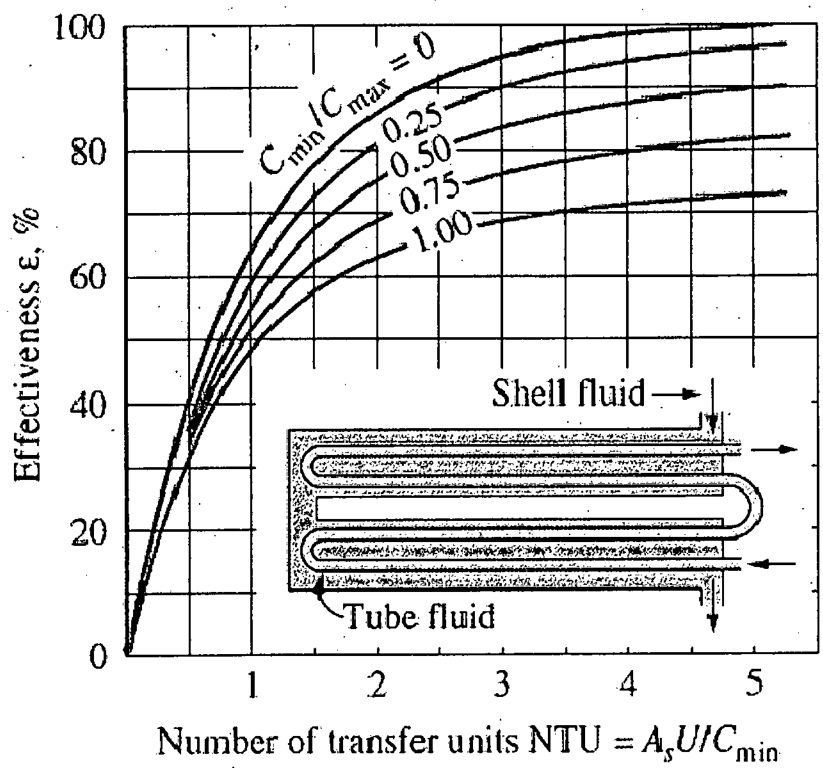
$$h^*_{fg} = h_{fg} + 0.68 C_{pl} (T_{sat} - T_s)$$

$$h_{\text{vert, wavy}} = \frac{\mathrm{Re}\, k_l}{1.08\, \mathrm{Re}^{1.22} - 5.2}\left(\frac{g}{\nu_l^2}\right)^{1/3}, \qquad 30 < \mathrm{Re} < 1800, \quad \rho_v \ll \rho_l$$

Heat Exchanger:



(*b*) Two-shell passes and 4, 8, 12, etc. (any multiple of 4), tube passes



(*d*) Two-shell passes and 4, 8, 12, ... tube passes

Natural Convection:

For vertical enclosures with larger aspect ratios, the following correlations can be used [MacGregor and Emery (1969), Ref. 26]

$$\text{Nu} = 0.42\,\text{Ra}_L^{1/4}\,\text{Pr}^{0.012}\left(\frac{H}{L}\right)^{-0.3} \qquad \begin{array}{c} 10 < H/L < 40 \\ 1 < \text{Pr} < 2 \times 10^4 \\ 10^4 < \text{Ra}_L < 10^7 \end{array}$$

$$\text{Nu} = 0.46\,\text{Ra}_L^{1/3} \qquad \begin{array}{c} 1 < H/L < 40 \\ 1 < \text{Pr} < 20 \\ 10^6 < \text{Ra}_L < 10^9 \end{array}$$

Again all fluid properties are to be evaluated at the average temperature $(T_1 + T_2)/2$.

Table-5:

Empirical correlations for the average Nusselt number for natural convection over surfaces

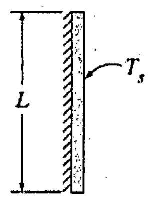
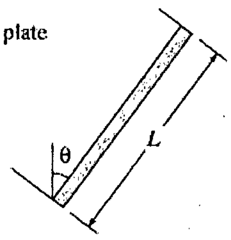
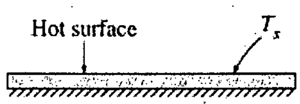
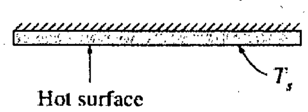
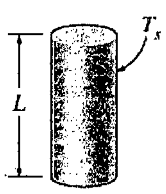
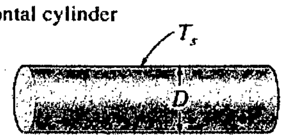
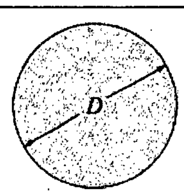
Geometry	Characteristic length L_c	Range of Ra	Nu
Vertical plate 	L	10^4–10^9 10^9–10^{13} Entire range	$\text{Nu} = 0.59\text{Ra}_L^{1/4}$ (9-19) $\text{Nu} = 0.1\text{Ra}_L^{1/3}$ (9-20) $\text{Nu} = \left\{0.825 + \dfrac{0.387\text{Ra}_L^{1/6}}{[1 + (0.492/\text{Pr})^{9/16}]^{8/27}}\right\}^2$ (9-21) (complex but more accurate)
Inclined plate 	L		Use vertical plate equations for the upper surface of a cold plate and the lower surface of a hot plate Replace g by $g\cos\theta$ for $\text{Ra} < 10^9$
Horiontal plate (Surface area A and perimeter p) (*a*) Upper surface of a hot plate (or lower surface of a cold plate)  (*b*) Lower surface of a hot plate (or upper surface of a cold plate) 	A_s/p	10^4–10^7 10^7–10^{11} 10^5–10^{11}	$\text{Nu} = 0.54\text{Ra}_L^{1/4}$ (9-22) $\text{Nu} = 0.15\text{Ra}_L^{1/3}$ (9-23) $\text{Nu} = 0.27\text{Ra}_L^{1/4}$ (9-24)
Vertical cylinder 	L		A vertical cylinder can be treated as a vertical plate when $D \geq \dfrac{35L}{\text{Gr}_L^{1/4}}$
Horizontal cylinder 	D	$\text{Ra}_D \leq 10^{12}$	$\text{Nu} = \left\{0.6 + \dfrac{0.387\text{Ra}_D^{1/6}}{[1 + (0.559/\text{Pr})^{9/16}]^{8/27}}\right\}^2$ (9-25)
Sphere 	D	$\text{Ra}_D \leq 10^{11}$ ($\text{Pr} \geq 0.7$)	$\text{Nu} = 2 + \dfrac{0.589\text{Ra}_D^{1/4}}{[1 + (0.469/\text{Pr})^{9/16}]^{4/9}}$ (9-26)

Table-6:

Properties of air at 1 atm pressure

Temp. T, °C	Density ρ, kg/m³	Specific Heat c_p, J/kg·K	Thermal Conductivity k, W/m·K	Thermal Diffusivity α, m²/s	Dynamic Viscosity μ, kg/m·s	Kinematic Viscosity ν, m²/s	Prandtl Number Pr
−150	2.866	983	0.01171	4.158×10^{-6}	8.636×10^{-6}	3.013×10^{-6}	0.7246
−100	2.038	966	0.01582	8.036×10^{-6}	1.189×10^{-5}	5.837×10^{-6}	0.7263
−50	1.582	999	0.01979	1.252×10^{-5}	1.474×10^{-5}	9.319×10^{-6}	0.7440
−40	1.514	1002	0.02057	1.356×10^{-5}	1.527×10^{-5}	1.008×10^{-5}	0.7436
−30	1.451	1004	0.02134	1.465×10^{-5}	1.579×10^{-5}	1.087×10^{-5}	0.7425
−20	1.394	1005	0.02211	1.578×10^{-5}	1.630×10^{-5}	1.169×10^{-5}	0.7408
−10	1.341	1006	0.02288	1.696×10^{-5}	1.680×10^{-5}	1.252×10^{-5}	0.7387
0	1.292	1006	0.02364	1.818×10^{-5}	1.729×10^{-5}	1.338×10^{-5}	0.7362
5	1.269	1006	0.02401	1.880×10^{-5}	1.754×10^{-5}	1.382×10^{-5}	0.7350
10	1.246	1006	0.02439	1.944×10^{-5}	1.778×10^{-5}	1.426×10^{-5}	0.7336
15	1.225	1007	0.02476	2.009×10^{-5}	1.802×10^{-5}	1.470×10^{-5}	0.7323
20	1.204	1007	0.02514	2.074×10^{-5}	1.825×10^{-5}	1.516×10^{-5}	0.7309
25	1.184	1007	0.02551	2.141×10^{-5}	1.849×10^{-5}	1.562×10^{-5}	0.7296
30	1.164	1007	0.02588	2.208×10^{-5}	1.872×10^{-5}	1.608×10^{-5}	0.7282
35	1.145	1007	0.02625	2.277×10^{-5}	1.895×10^{-5}	1.655×10^{-5}	0.7268
40	1.127	1007	0.02662	2.346×10^{-5}	1.918×10^{-5}	1.702×10^{-5}	0.7255
45	1.109	1007	0.02699	2.416×10^{-5}	1.941×10^{-5}	1.750×10^{-5}	0.7241
50	1.092	1007	0.02735	2.487×10^{-5}	1.963×10^{-5}	1.798×10^{-5}	0.7228
60	1.059	1007	0.02808	2.632×10^{-5}	2.008×10^{-5}	1.896×10^{-5}	0.7202
70	1.028	1007	0.02881	2.780×10^{-5}	2.052×10^{-5}	1.995×10^{-5}	0.7177
80	0.9994	1008	0.02953	2.931×10^{-5}	2.096×10^{-5}	2.097×10^{-5}	0.7154
90	0.9718	1008	0.03024	3.086×10^{-5}	2.139×10^{-5}	2.201×10^{-5}	0.7132
100	0.9458	1009	0.03095	3.243×10^{-5}	2.181×10^{-5}	2.306×10^{-5}	0.7111
120	0.8977	1011	0.03235	3.565×10^{-5}	2.264×10^{-5}	2.522×10^{-5}	0.7073
140	0.8542	1013	0.03374	3.898×10^{-5}	2.345×10^{-5}	2.745×10^{-5}	0.7041
160	0.8148	1016	0.03511	4.241×10^{-5}	2.420×10^{-5}	2.975×10^{-5}	0.7014
180	0.7788	1019	0.03646	4.593×10^{-5}	2.504×10^{-5}	3.212×10^{-5}	0.6992
200	0.7459	1023	0.03779	4.954×10^{-5}	2.577×10^{-5}	3.455×10^{-5}	0.6974
250	0.6746	1033	0.04104	5.890×10^{-5}	2.760×10^{-5}	4.091×10^{-5}	0.6946
300	0.6158	1044	0.04418	6.871×10^{-5}	2.934×10^{-5}	4.765×10^{-5}	0.6935
350	0.5664	1056	0.04721	7.892×10^{-5}	3.101×10^{-5}	5.475×10^{-5}	0.6937
400	0.5243	1069	0.05015	8.951×10^{-5}	3.261×10^{-5}	6.219×10^{-5}	0.6948
450	0.4880	1081	0.05298	1.004×10^{-4}	3.415×10^{-5}	6.997×10^{-5}	0.6965
500	0.4565	1093	0.05572	1.117×10^{-4}	3.563×10^{-5}	7.806×10^{-5}	0.6986
600	0.4042	1115	0.06093	1.352×10^{-4}	3.846×10^{-5}	9.515×10^{-5}	0.7037
700	0.3627	1135	0.06581	1.598×10^{-4}	4.111×10^{-5}	1.133×10^{-4}	0.7092
800	0.3289	1153	0.07037	1.855×10^{-4}	4.362×10^{-5}	1.326×10^{-4}	0.7149
900	0.3008	1169	0.07465	2.122×10^{-4}	4.600×10^{-5}	1.529×10^{-4}	0.7206
1000	0.2772	1184	0.07868	2.398×10^{-4}	4.826×10^{-5}	1.741×10^{-4}	0.7260
1500	0.1990	1234	0.09599	3.908×10^{-4}	5.817×10^{-5}	2.922×10^{-4}	0.7478
2000	0.1553	1264	0.11113	5.664×10^{-4}	6.630×10^{-5}	4.270×10^{-4}	0.7539

Summary of Correlation for Forced Convection Flow over Flat Plates

Properties evaluated at Film temperature

Type	Restrictions	Fluid Flow	Heat Transfer: Isothermal (T_w = constant)	Heat Transfer: Isoflux (q_w = constant)
Local	Laminar: $Re_x < 5 \times 10^5$; $0.6 < Pr < 50$	$C_{f,x} = 0.664 Re_x^{-1/2}$	$Nu_x = 0.332 Re_x^{1/2} Pr^{1/3}$	$Nu_x = 0.453 Re_x^{1/2} Pr^{1/3}$
Average	Laminar: $Re_L < 5 \times 10^5$; $0.6 < Pr < 50$	$C_f = 1.328 Re_L^{-1/2}$	$Nu_L = 0.664 Re_L^{1/2} Pr^{1/3}$	$Nu_L = 0.680 Re_L^{1/2} Pr^{1/3}$
Local	Turbulent: $5 \times 10^5 \le Re_x \le 10^7$; $0.6 \le Pr \le 60$	$C_{f,x} = 0.059 Re_x^{-1/5}$	$Nu_x = 0.0296 Re_x^{4/5} Pr^{1/3}$	$Nu_x = 0.0308 Re_x^{4/5} Pr^{1/3}$
Average	Turbulent: $5 \times 10^5 \le Re_L \le 10^7$; $0.6 \le Pr \le 60$	$C_f = 0.074 Re_L^{-1/5}$	$Nu_L = 0.037 Re_L^{4/5} Pr^{1/3}$	$Nu_L = 0.037 Re_L^{4/5} Pr^{1/3}$
Average	Partly Laminar, Partly Turbulent: $5 \times 10^5 \le Re_L \le 10^7$; $0.6 \le Pr \le 60$; $Re_{cr} = 5 \times 10^5$	$C_f = 0.074 Re_L^{-1/5} - 1742 Re_L$	$Nu_L = \left(0.037 Re_L^{4/5} - 871\right) Pr^{1/3}$	$Nu_L = \dfrac{0.037 Re_L^{4/5} Pr^{1/3}}{1 + 12.35 \times 10^6 Re_L^{-6/5}}$
Local	All Prandtl number (Churchill and Ozoe): $Pe_x \ge 100$		$Nu_x = \dfrac{0.3387 Re_x^{1/2} Pr^{1/3}}{\left[1 + \left(\dfrac{0.0468}{Pr}\right)^{2/3}\right]^{1/4}}$	$Nu_x = \dfrac{0.4637 Re_x^{1/2} Pr^{1/3}}{\left[1 + \left(\dfrac{0.0207}{Pr}\right)^{2/3}\right]^{1/4}}$
Local	ξ = unheated starting length; Laminar: $Re_x < 5 \times 10^5$; $0.6 < Pr < 50$	$C_{f,x} = 0.664 Re_x^{-1/2}$	$Nu_x = Nu_{x(\text{for } \xi=0)} \left[1 - \left(\dfrac{\xi}{x}\right)^{3/4}\right]^{-1/3}$	
Local	ξ = unheated starting length; Turbulent: $5 \times 10^5 \le Re_x \le 10^7$; $0.6 \le Pr \le 60$	$C_{f,x} = 0.059 Re_x^{-1/5}$	$Nu_x = Nu_{x(\text{for } \xi=0)} \left[1 - \left(\dfrac{\xi}{x}\right)^{9/10}\right]^{-1/9}$	
Average	ξ = unheated starting length; Laminar: $Re_L < 5 \times 10^5$; p = 2; Turbulent: $5 \times 10^5 \le Re_L \le 10^7$; p = 8		$Nu_L = Nu_{L(\text{for } \xi=0)} \left(\dfrac{L}{L-\xi}\right) \left[1 - \left(\dfrac{\xi}{L}\right)^{\frac{p+1}{p+2}}\right]^{\frac{p}{p+1}}$	

TABLE A-13

Properties of liquids

Temp. T, °C	Density ρ, kg/m³	Specific Heat c_p, J/kg·K	Thermal Conductivity k, W/m·K	Thermal Diffusivity α, m²/s	Dynamic Viscosity μ, kg/m·s	Kinematic Viscosity ν, m²/s	Prandtl Number Pr	Volume Expansion Coeff. β, 1/K
				Methane [CH_4]				
−160	420.2	3492	0.1863	1.270×10^{-7}	1.133×10^{-4}	2.699×10^{-7}	2.126	0.00352
−150	405.0	3580	0.1703	1.174×10^{-7}	9.169×10^{-5}	2.264×10^{-7}	1.927	0.00391
−140	388.8	3700	0.1550	1.077×10^{-7}	7.551×10^{-5}	1.942×10^{-7}	1.803	0.00444
−130	371.1	3875	0.1402	9.749×10^{-8}	6.288×10^{-5}	1.694×10^{-7}	1.738	0.00520
−120	351.4	4146	0.1258	8.634×10^{-8}	5.257×10^{-5}	1.496×10^{-7}	1.732	0.00637
−110	328.8	4611	0.1115	7.356×10^{-8}	4.377×10^{-5}	1.331×10^{-7}	1.810	0.00841
−100	301.0	5578	0.0967	5.761×10^{-8}	3.577×10^{-5}	1.188×10^{-7}	2.063	0.01282
−90	261.7	8902	0.0797	3.423×10^{-8}	2.761×10^{-5}	1.055×10^{-7}	3.082	0.02922
				Methanol [$CH_3(OH)$]				
20	788.4	2515	0.1987	1.002×10^{-7}	5.857×10^{-4}	7.429×10^{-7}	7.414	0.00118
30	779.1	2577	0.1980	9.862×10^{-8}	5.088×10^{-4}	6.531×10^{-7}	6.622	0.00120
40	769.6	2644	0.1972	9.690×10^{-8}	4.460×10^{-4}	5.795×10^{-7}	5.980	0.00123
50	760.1	2718	0.1965	9.509×10^{-8}	3.942×10^{-4}	5.185×10^{-7}	5.453	0.00127
60	750.4	2798	0.1957	9.320×10^{-8}	3.510×10^{-4}	4.677×10^{-7}	5.018	0.00132
70	740.4	2885	0.1950	9.128×10^{-8}	3.146×10^{-4}	4.250×10^{-7}	4.655	0.00137
				Isobutane (R600a)				
−100	683.8	1881	0.1383	1.075×10^{-7}	9.305×10^{-4}	1.360×10^{-6}	12.65	0.00142
−75	659.3	1970	0.1357	1.044×10^{-7}	5.624×10^{-4}	8.531×10^{-7}	8.167	0.00150
−50	634.3	2069	0.1283	9.773×10^{-8}	3.769×10^{-4}	5.942×10^{-7}	6.079	0.00161
−25	608.2	2180	0.1181	8.906×10^{-8}	2.688×10^{-4}	4.420×10^{-7}	4.963	0.00177
0	580.6	2306	0.1068	7.974×10^{-8}	1.993×10^{-4}	3.432×10^{-7}	4.304	0.00199
25	550.7	2455	0.0956	7.069×10^{-8}	1.510×10^{-4}	2.743×10^{-7}	3.880	0.00232
50	517.3	2640	0.0851	6.233×10^{-8}	1.155×10^{-4}	2.233×10^{-7}	3.582	0.00286
75	478.5	2896	0.0757	5.460×10^{-8}	8.785×10^{-5}	1.836×10^{-7}	3.363	0.00385
100	429.6	3361	0.0669	4.634×10^{-8}	6.483×10^{-5}	1.509×10^{-7}	3.256	0.00628
				Glycerin				
0	1276	2262	0.2820	9.773×10^{-8}	10.49	8.219×10^{-3}	84,101	
5	1273	2288	0.2835	9.732×10^{-8}	6.730	5.287×10^{-3}	54,327	
10	1270	2320	0.2846	9.662×10^{-8}	4.241	3.339×10^{-3}	34,561	
15	1267	2354	0.2856	9.576×10^{-8}	2.496	1.970×10^{-3}	20,570	
20	1264	2386	0.2860	9.484×10^{-8}	1.519	1.201×10^{-3}	12,671	
25	1261	2416	0.2860	9.388×10^{-8}	0.9934	7.878×10^{-4}	8,392	
30	1258	2447	0.2860	9.291×10^{-8}	0.6582	5.232×10^{-4}	5,631	
35	1255	2478	0.2860	9.195×10^{-8}	0.4347	3.464×10^{-4}	3,767	
40	1252	2513	0.2863	9.101×10^{-8}	0.3073	2.455×10^{-4}	2,697	
				Engine Oil (unused)				
0	899.0	1797	0.1469	9.097×10^{-8}	3.814	4.242×10^{-3}	46,636	0.00070
20	888.1	1881	0.1450	8.680×10^{-8}	0.8374	9.429×10^{-4}	10,863	0.00070
40	876.0	1964	0.1444	8.391×10^{-8}	0.2177	2.485×10^{-4}	2,962	0.00070
60	863.9	2048	0.1404	7.934×10^{-8}	0.07399	8.565×10^{-5}	1,080	0.00070
80	852.0	2132	0.1380	7.599×10^{-8}	0.03232	3.794×10^{-5}	499.3	0.00070
100	840.0	2220	0.1367	7.330×10^{-8}	0.01718	2.046×10^{-5}	279.1	0.00070
120	828.9	2308	0.1347	7.042×10^{-8}	0.01029	1.241×10^{-5}	176.3	0.00070
140	816.8	2395	0.1330	6.798×10^{-8}	0.006558	8.029×10^{-6}	118.1	0.00070
150	810.3	2441	0.1327	6.708×10^{-8}	0.005344	6.595×10^{-6}	98.31	0.00070

Source: Data generated from the EES software developed by S. A. Klein and F. L. Alvarado. Originally based on various sources.

L-3/T-2/ME **Date : 27/01/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2013-2014

Sub : **ME 323** (Fluid Mechanics II)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Assume reasonable data if necessary. Symbols carry their usual meaning.

1. (a) Prove that for steady laminar flow through a circular pipe, the velocity distribution across the section is parabolic. What are the assumptions for this proof? **(15)**

(b) Petroleum oil is flowing through an inclined galvanized pipe at the rate of 0.3 m^3/s as shown in Fig. for Q. No. 1(b). At point 1, pressure is 2500 kPa and at point 2 pressure is atmospheric. Neglecting minor losses, find the diameter of the pipe. Specific gr. of oil is 0.72 and its absolute viscosity is 2.9×10^{-4} Ns/m^2. **(20)**

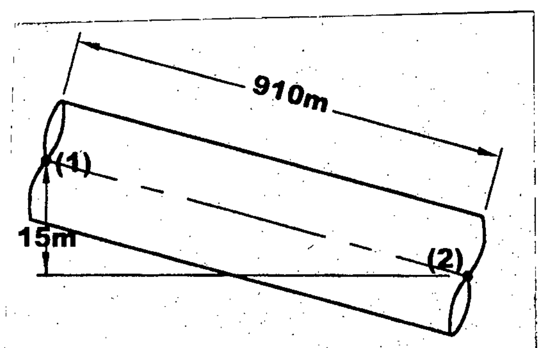


Fig. for Q. No. 1(b)

2. (a) What is meant by the most economical section of an open channel? Derive an expression for the condition of the most economical section of a trapezoidal channel. **(20)**

(b) A circular sewer of 60 cm inside diameter has a slope of 1 in 450. Find the depth when the discharge is 0.3 cumec, taking C in chezy formula as 50. **(15)**

3. (a) What is boundary layer? Deduce an equation of energy thickness for boundary layer. **(10)**

(b) For a laminar boundary layer the velocity distribution is given by: **(25)**

$$\frac{u}{U} = \frac{3}{2}(y/\delta) - \frac{1}{2}(y/\delta)^3$$

Find δ, $\delta, \delta^*, \theta, \tau_w$ and C_D in terms of Re.

Contd P/2

4. (a) A thin plate is moving in still atmospheric air at velocity of 4.5 m/s. The length of the plate is 0.6 m and width 0.5 m. Calculate (i) the thickness of the boundary layer at the end of the plate, and (ii) the drag force on the plate. The density of air is 1.25 kg/m^3 and Kinematic viscosity is 0.15 stokes. **(11)**

(b) Write the short notes on the following: **(24)**

(i) Conjugate depths in hydraulic jump

(ii) Profile and induced drags on airfoil

(iii) Minor losses.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) How can you differentiate between 'static' and 'stagnation' properties in context of compressible flow? Derive an expression of stagnation pressure for isentropic compressible flow. **(15)**

(b) A wing of a supersonic aircraft is being tested in a wind tunnel at Mach number of 1.8. Air is the working fluid (ideal gas). The stagnation pressure and temperature for the wind tunnel are 1300 kPa and 260°C, respectively. The model wing area, S is 0.07 m^2. The measured lift force, L is 50,000 N. Find the lift coefficient of the wing. **(20)**

Hint: Lift coefficient, $C_L = \dfrac{L}{\frac{1}{2}\rho V^2 S}$

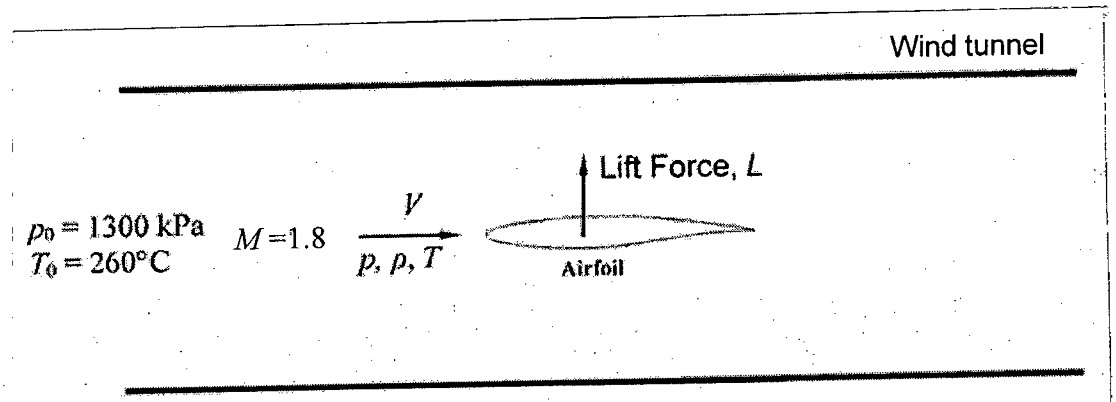


Fig. for Q. 5(b)

6. (a) Derive an expression of local Mach number, $M(x)$ with respect to the ratio of local area to critical area, $\dfrac{A(x)}{A*}$ for 1D isentropic flow of compressible fluid through a variable area duct. **(15)**

Simplify this expression for the case of air flow $(k = 1.40)$.

Contd P/3

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Contd... Q. No. 6

(b) A planar (x, y) convergent-divergent (C-D) nozzle is being used to expand the air to supersonic speed from a large reservoir as shown in Fig. for Q. 6(b). The reservoir pressure is kept at 500 kPa. Determine the Mach number and static pressure at the points shown in the figure. Present your result graphically. **(20)**

Consider 1D isentropic flow in your calculation.

The locations of the points are given in the following table:

Point	1	2*	3	4	5	6
height, y (mm)	25	20	22	25	28	31

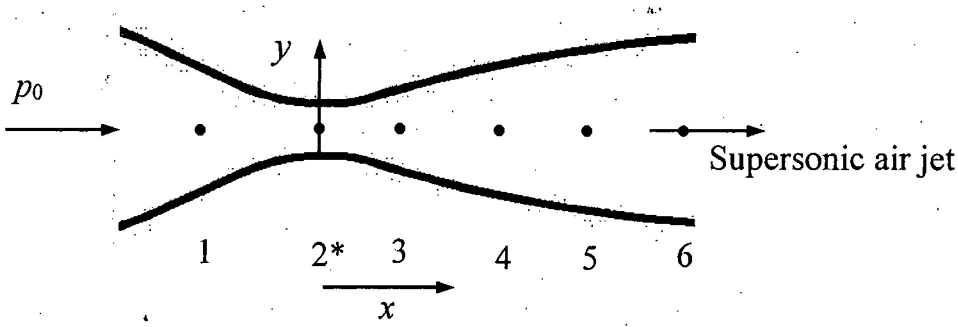

Fig. for Q. 6(b)

7. (a) A convergent nozzle of throat area 3 cm^2 is attached to the exhaust of an aircraft engine as shown in Fig. for Q. 7(a). The exhaust gas is supplied from a combustion chamber in which the pressure is 150 kPa and the temperature is 1400 K. Calculate the mass flow rate through the exhaust nozzle and available thrust for back pressures of **(20)**

   (i) 120 kPa

   (ii) 60 kPa

Assume isentropic flow through the exhaust nozzle and

$k_{\text{exhaust gas}} = 1.4$

$R_{\text{exhaust gas}} = 415.7$ J/(kg K)

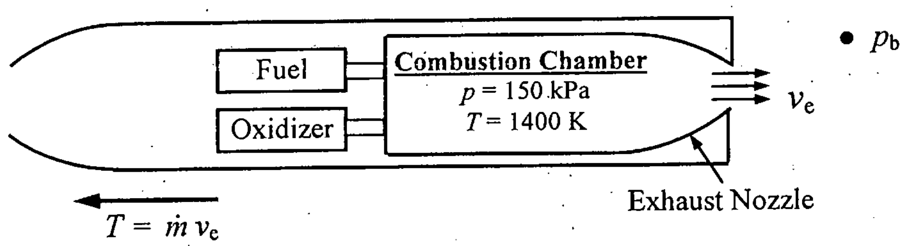

Fig. for Q. 7(a)

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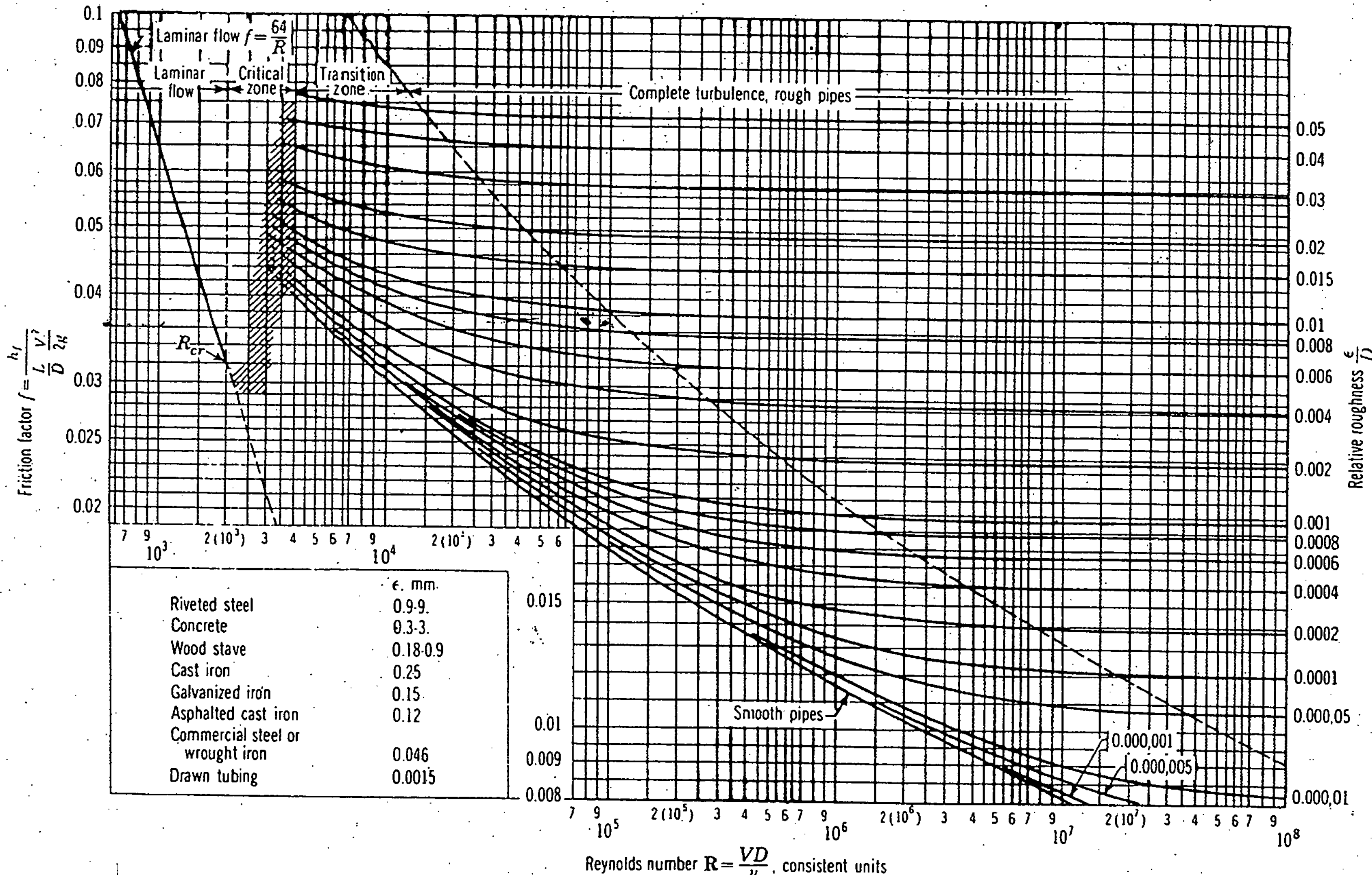
Contd... Q. No. 7

(b) What is a shock wave? Deduce an expression of downstream Mach number in terms of upstream Mach number (only) in case of a normal shock wave. State the assumption used in the derivation. **(15)**

8. (a) What do you mean by similitude in context of fluid mechanics? Discuss different types of similarities which must exist between a model and its prototype. **(10)**

(b) The pressure drop, Δp for steady, incompressible viscous flow through a straight horizontal pipe depends on the pipe length (L), the average velocity (V), the fluid viscosity (μ), the pipe diameter (D), the fluid density (ρ), and the average "roughness" height (e). **(25)**

Determine a set of dimensionless groups that can be used to correlate data using Buckingham π-theorem.



Moody diagram.

L-3/T-2/ME **Date : 31/01/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2013-2014

Sub : **ME 343** (Machine Design II)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

'Shigley's Mechanical Engineering Design' textbook may be used.

1. (a) A journal bearing has a shaft diameter of 75.00 mm with a unilateral tolerance of -0.02 mm. The bushing bore has a diameter of 75.10 mm with a unilateral tolerance of 0.06 mm. The bushing is 36 mm long and supports a load of 2 kN. The journal speed is 720 rev/min. For the minimum clearance assembly find the minimum film thickness, the heat loss rate, and the maximum lubricant pressure for SAE 40 lubricant operating at an average film temperature of 60°C. **(15)**

   (b) An 02-series single-row deep-groove ball bearing with a 65-mm bore is loaded with a 3-kN axial load and a 7-kN radial load. The outer ring rotates at 500 rev/min. **(20)**

   (i) Determine the equipment radial load that will be experienced by this particular bearing.

   (ii) Determine whether this bearing should be expected to carry this load with a 95 percent reliability for 10 kh.

2. A shaft is supported by two rolling contact bearings at the ends. A static force analysis shows the forces acting on the shaft AB in Figure for Q. 2. The shaft transmits 1007 W at 500 rev/min. Bearing *A* is to be an angular-contact ball bearing mounted to take the 2470-N thrust load. The bearing at *B* is to take only the radial load, so a straight roller bearing will be employed. Use an application factor of 1.2, a desired life of 30 kh. As the thrust load is considerably larger than other radial loads, bearing at B is likely to require a reliability of 100%. Design goal is to achieve overall reliability of 99%. Specify each bearing. **(35)**

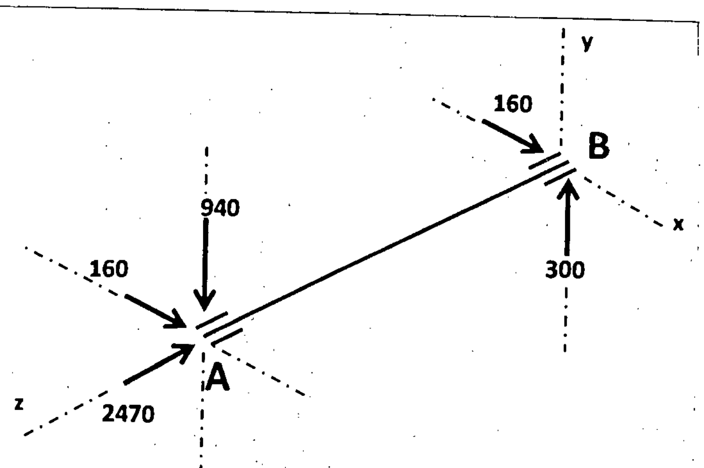


Figure for Q2

Contd P/2

ME 343

3. (a) A steel spur pinion has a module of 1 mm and 16 teeth cut on the 20° full-depth system and is to carry 0.15 kW at 400 rev/min. Determine a suitable face width based on an allowable Lewis bending stress of 150 MPa. **(15)**

(b) Find the contact stress in a 20-tooth cast-iron spur pinion having a module of 4 mm and 20° pressure angle. The pinion rotating at 1000 rpm drives a 60-tooth cast-iron gear. The face width is 50 mm, and 10 kW of power is transmitted. Use elastic coefficient data from table 14-8. **(20)**

4. A hydraulic speed-reducer machine is to be designed with a spur gear mesh with 20° full-depth uncrowned teeth. The commercial grade casing enclosed gearset has 22 and 60 teeth. The module is 5 mm and the face width is 82 mm. The pinion shaft is to transmit 30 kW at 1145 rev/min. The service life goal is about 3×10^9 pinion revolutions. The absolute value of the pitch variation is such that the transmission accuracy level number is 6. the materials are 4340 through-hardened grade 1 steels, heat-treated to 250 Brinell, core and case for both the gears. The load is moderate shock and the power is smooth and temperature is steady at 70° C. For the reliability of 0.99, estimate the stresses of pinion bending, gear bending, pinion wear, and gear wear and the attendant AGMA factors of safety $(S_F)_P$, $(S_F)_G$, $(S_H)_P$ and $(S_H)_G$. What mode of failure is the most threatening? **(35)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

'Machine Design Book' is supplied.

Assume reasonable value for any missing data. Symbols carry their usual meaning.

5. (a) A helical compression spring has to meet following design requirements: solid height = 50 mm, number of active turns = 8, ends: squared and ground, mean coil dia = 50 mm, material is 302 stainless steel wire (peened), $\gamma = 82 \times 10^{-6} \frac{N}{mm^3}$. **(18)**

Loads: $F_m = 400$ N, $F_a = 300$ N

Calculate: (i) wire dia (ii) free length for which buckling is imminent (iii) fundamental natural frequency (iv) fatigue safety factor according to modified Goodman criterion. Use Zimmerli's data (v) predict the response of the spring if the frequency of F_a is 80.9 Hz.

(b) An automobile leaf spring supports a total vertical load of 6 kN, so that half of this load acts on each tip (eye). The spring has 8 leaves each of width 90 mm and thickness of 10 mm. Total span of the main leaf is 500 mm. Take, E = 200 GPa and find- **(17)**

(i) the maximum stress and its location,

(ii) spring constant, and

(iii) energy absorbed.

Contd P/3

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6. An electric motor (nominal power: 1.5 hp, 1450 rpm) is directly coupled to a single threaded worm (steel, 250 BHN (minimum)). The worm is in mesh with a 40 teeth bronze (centrifugally cast) gear. **(35)**

Given: $\phi_n = 25°$, $m_t = \frac{1}{6}$ inch, $d_w = 2$ inch, Fe = 1 inch, load application factor = 1.4, lateral area of gear case is thrice the minimum lateral area recommended by AGMA. 1 hp = 33000 $\frac{\text{ft-lb}}{\text{min}}$.

Calculate: (i) f (ii) gear rpm (iii) separating force between work and gear (iv) efficiency of the drive (vi) safety factors by AGMA equation and Buckingham wear load equation (vi) temperature rise of sump oil, if gear case is naturally cooled.

7. (a)(i) Mention a typical use of bevel gear. 'Unlike spur gears straight bevel gears experience axial force' — why? **(7)**

(ii) A pair of straight bevel gears (material: steel, through hardened BHN = 200) have following data: driver pinion (N_p = 50) runs at 400 rpm and transmits 8 kW to the gear (N_g = 100), m = 15 mm at larger end. b = 80 mm, $\phi_n = 20°$, reliability = 95%, n_L (pinion) = 8000 cycles, temperature = 65°C, motion is smooth and uniform. **(10)**

(b) With reference to FIG. for Q. 7(b), a single ply, flat belt made of leather is to be used for transmitting power between two shafts parallel and 2 m apart. Given: D = d = 150 mm, t = 5 mm, b = 200 mm, driver pulley's rpm = 400, service factor = 1.2, design factor = 1.1. Design requires that the average bearing stress on each pulley must be exactly 0.036 MPa during power transmission. Find- **(18)**

(i) the largest allowable tension for this belt,
(ii) resultant force F on the shaft and initial tension on the belt,
(iii) the maximum power rating and the nominal power rating for this belt drive,
(iv) required coefficient of friction to avoid slippage.

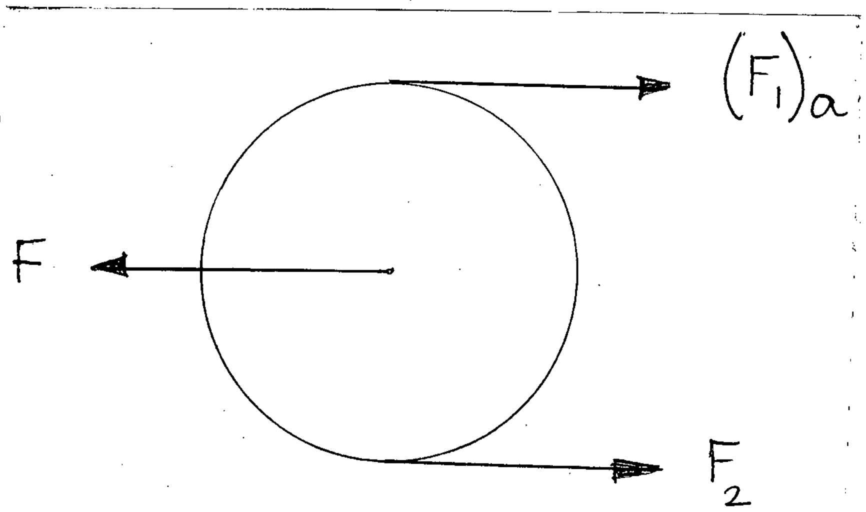

FIG. for Q.7(b)

8. (a) 2 ropes of size d = 12 mm (6 × 19 IPS, regular lay) are in use for a skip to lift a load of 1000 kg from a depth of 100 m. The skip itself weighs 1000 kg. Given: D = 68 d, E_r = 83 GPa, rope's life = 2 × 10^5 cycles, required fatigue safety factor =

$$n_{fs} = \frac{F_f - F_b}{Dynamic\ F_t} = 1.5.$$ **(15)**

Find-

(i) the maximum acceleration that is allowed.

(ii) static safety factor

(iii) the maximum elongation of the rope.

(b) Specify the pitch of a single strand roller chain drive where the driver sprocket has 17 teeth running at 100 rpm and chain line velocity is 0.72 m/s. Also calculate the chordal speed variation for the same drive. **(10)**

(c) An internally expanding single primary brake shoe has following data: **(10)**

friction material: Cermet (refer to Table 16-3), P_a = 1MPa, b = 80 mm, r = 250 mm, θ_1 = 5°, θ_2 = 75°.

Calculate the maximum braking torque (T) possible for this shoe.

What is the advantage of Cermet over other friction materials?

L-3/T-2/ME **Date : 06/02/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2013-2014

Sub : **IPE 381** (Measurement and Quality Control)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Explain ordinal-level data and ratio-level data. **(12)**

(b) Explain measures of dispersion, mutually exclusive events and independent events. **(9)**

(c) Five out of 100 items produced in machine A and one out of 100 items produced in machine B are found to be defective. An item drawn at random from the items produced by A and B is found to be defective. What is the probability that this item has been made in machine A, assuming that both machines produced equal number of items. **(14)**

2. (a) Define frequency distribution. What are the differences between frequency distribution and cumulative frequency distribution? **(7)**

(b) If on an average 8 ships out of 10 arrive safely at ports, obtain mean and standard deviation of number of ships returning safely out of 150 ships. **(13)**

(c) Suppose, on an average, one house in 1000, in a certain town, has a fire during the year. If there are 2000 houses, what is the probability that (a) exactly 3 houses (b) more than two houses will have fire during the year? **(15)**

3. (a) Explain the factors that determine the sample size. **(6)**

(b) Five men, in a company of 20, are graduates. If three men are picked, out of 20, at random, what is the probability that they all graduates? What is the probability that none is a graduate? What is the probability that at least one is a graduate? **(15)**

(c) Two computers A and B are to be marketed. A salesman who is assigned a job of finding customers for them has 60% and 40% chances respectively of succeeding in case of computers A and B. The computers can be sold independently. Given that he was able to sell at least one computer, what is the probability that the computer A has been sold? **(14)**

4. (a) Explain the limitations of Chi-square distribution. **(6)**

(b) An urn contains an unknown proportion of red and white marbles. A random sample of 60 marbles, selected with replacement from the urn, showed that 70% were red. How large a sample of marbles should be taken in order to be (a) 95%, (b) 99% confident that the true proportion does not differ from the sample proportion by more than 5%? **(12)**

Contd P/2

Contd ... Q. No. 4

(c) A company manufacturing automobile tyres finds that tyre-life is normally distributed with a mean of 40,000 km and a standard deviation of 3,000 km. It is believed that a change in the production process will result in a better product and the company has developed a new tyre. A sample of 100 new tyres has been selected. The company has found that the mean life of these new tyres is 40,900 km. can it be concluded that the new tyre is significantly better than the old one, using the significance level of 0.01? **(17)**

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) Prove that both mean and variance of Poisson distribution are λt. **(10)**

   (b) Explain the characteristics of Poisson distribution. **(8)**

   (c) What are the features that determine the accuracy of sine bar? Describe the working principle of autocollimator as an angular measuring instrument with necessary figures. **(5+12)**

6. (a) What is measurement error? Briefly describe different types of measurement error. **(13)**

   (b) What is effective diameter of screw thread? Explain the Two Wire method. **(12)**

   (c) Briefly describe the working principle of radiography as a non destructive testing method. **(10)**

7. (a) Explain Taylor's principle with necessary figures. **(12)**

   (b) In the measurement of surface roughness, heights of 20 successive peaks and troughs were measured from a datum and were 35, 25, 40 22, 35, 18, 42, 25, 35, 22, 36, 18, 42, 22, 32, 21, 37, 18, 35, 20 microns. If these measurements were obtained over a length of 20 mm, determine the CLA and RMS value of the rough surface. **(8)**

   (c) Explain the procedure of measuring tooth thickness of gear by gear tooth vernier calipers with necessary equations and sketch. **(15)**

8. (a) Why hole based system is preferred to shaft based system? Explain briefly. **(7)**

   (b) Briefly describe type I and type II error. **(8)**

   (c) "In order to detect out of control signal of a process precisely, we have to use both X-bar chart and R-chart" – justify this statement with necessary figures. **(12)**

   (d) Mention the characteristics of TQM. **(8)**

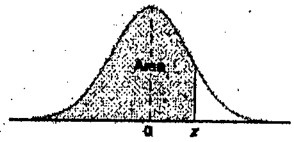

Table A.3 Areas under the Normal Curve

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