L-3/T-2/ME **Date : 20/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

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

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**.

1. (a) Explain nominal-level data and interval-level data. **(12)**

(b) Three salesmen A, B and C have been given a target of selling 10,000 units of a particular product, the probabilities of their achieving targets being respectively 0.25, 0.30 and 0.50. If these three salesmen try to sell the product, find the probabilities of success of only one salesman and failure of the other two. **(12)**

(c) Assume that a factory has two machines. Past records show that machine 1 produces 30% of the items of output and machine 2 produces 70% of the items. Further, 5% of the items produced by machine 1 are defective and only 1% produced by machine 2 are defective. If a deflective item is drawn at random, what is the probability that it was produced by (i) machine 1 or (ii) machine 2? **(11)**

2. (a) Explain the characteristics of Poisson distribution. **(10)**

(b) Prove that the mean of the Hyper geometric distribution, $E(x) = \frac{nk}{N}$. **(10)**

(c) The incidence of a certain disease is such that, on the average, 20% of the workers suffer from it. If 10 workers are selected at random, find the probability that **(15)**

(i) Exactly 2 workers suffer from the disease,

(ii) Not more than 2 workers suffer from the disease.

3. (a) One overnight case contains 2 bottles of aspirin and 3 bottles of thyroid tablets. A second tote bag contains 3 bottles of aspirin, 2 bottles of thyroid tablets, and 1 bottle of laxative tablets. If one bottle of tablets is taken at random from each piece of luggage, find the probability that **(12)**

(i) Both bottles contain thyroid tablets,

(ii) Neither bottles contain thyroid tablets,

(iii) The 2 bottles contain different tablets.

(b) The proportion of people who respond to a certain mail-order solicitation is a continuous random variable x that has the density function **(10)**

$$f(x) = \begin{cases} \frac{2(x+2)}{5}, & 0 < x < 1 \\ 0, & \text{elsewhere} \end{cases}$$

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Contd... Q. No. 3 (b)

(i) Show that P $(0 < x < 1) = 1$

(ii) Find the probability that more than $\frac{1}{4}$ but fewer than $\frac{1}{2}$ of the people contracted will respond to this type of solicitation.

(c) You have been asked to determine the sample size for a proposed survey of households in a town. One of the main objectives of the proposed survey is to estimate the annual mean income of households. You have been told that the standard deviation of the household is RS 150. **(13)**

(i) It is desired that the estimate should be ± RS 20 of the population value. If 95 percent confidence level is desired, what should be the sample size?

(ii) If you were to double the precision and at the same time to have 99 percent confidence, what size of the sample would you take?

4. (a) Explain Type I error and Type II error. **(6)**

(b) The Crossett Trucking company claims that the mean weight of their delivery trucks when they are fully loaded is 6,000 pounds and the standard deviation is 150 pounds. Assume that the population follows the normal distribution. Forty trucks are randomly selected and weighted within what limits will 95 percent of the sample mean occur? **(13)**

(c) A spark plug manufacturer claimed that its plugs have a mean life in excess of 22,100 miles. Assume the life of the spark plug follows the normal distribution. A fleet owner purchased a large number of sets. A sample of 18 sets revealed that the mean life was 23,400 miles and the standard deviation was 1,500 miles. Is there enough evidence to substantiate the manufacture's claim at the 0.05 significance level? **(16)**

SECTION-B

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

5. (a) Briefly state the importance of metrology. Explain the difference between random errors and systematic errors arise during measurement. **(12)**

(b) Determine the actual dimensions and type of fit for a shaft and a hole 90 mm size for H_8/e_9. Size 90 mm falls in the diameter step of 80-120 mm and tolerance factor i (in microns) = $0.45\sqrt[3]{D} + 0.001D$. Also design the GO and NOT GO gauges for checking the hole and shaft limits considering gauge maker's tolerance to be 10% (Unilateral system) and wear allowance to be 5% of the work tolerance when applicable. **(23)**

Contd P/3

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6. (a) Describe the working principle of 'Autocollimator' used for angular measurement. **(12)**

   (b) Describe a method to measure the effective pitch diameter of a screw plug gauge. Also explain how the errors in pitch and angle affect the virtual effective diameter? **(13)**

   (c) Explain the 'constant chord method' of measuring tooth thickness. **(10)**

7. (a) The Perfect Circle Company manufactures bushings. Once each hour a sample of 125 finished bushings is drawn from the output; each bushing is examined by a technician. Those which fail are classified as defective; the rest are satisfactory. Here are data on ten consecutive samples taken in one week: **(23)**

Sample no.	1	2	3	4	5	6	7	8	9	10
Defective	15	13	16	11	13	14	20	25	30	45

   Draw the p-chart. Is this system under control? What should the quality control engineer do?

   (b) What is an operating characteristic (OC) curve, and how is it useful in acceptance sampling? Briefly explain each of the following terms: AQL, LTPD, Producer's risk, Consumer's risk. **(12)**

8. (a) When non-destructive testing of a product can be used? Explain different radiographic inspection methods with neat sketch. **(18)**

   (b) What is meant by roughness and waviness of machined surfaced? How the 'Tomlinson surface recorder' work? Explain with necessary sketch. **(17)**

[redacted]

Table 1: Formulae for Fundamental Deviations for Shafts for sizes upto 500 mm

Upper Deviation (es)

Shaft Designation	*In microns (for D in mm)*
a	$= -(265+1.3D)$ for $D \leq 120$ and $= -3.5D$ for $D > 120$
b	$= -(140 + 0.85D)$ for $D \leq 160$ $= -1.8D$ for $D > 160$
c	$= -52D^{0.2}$ for $D \leq 40$ $= -(95 + 0.8D)$ for $D > 40$
d	$= -16D^{0.44}$
e	$= -11D^{0.41}$
f	$= -5.5D^{0.41}$
g	$= -2.5D^{0.34}$
h	$= 0$

Lower Deviation (ei)

Shaft Designation	*In microns (for D in mm)*
$j5$ to $j8$	No formula
$k4$ to $k8$	$= +0.6\sqrt[3]{D}$
k for grade ≤ 3 and ≥ 4	$= 0$
m	$= +(IT7 - IT6)$
n	$= +5D^{0.34}$
p	$= +IT7 + 0$ to 5
r	= geometric mean of values ei for p and s
s	$= IT8 + 1$ to 4 for $D \leq 50$ $= +IT7$ to $+0.4D$ for $D > 50$
t	$= IT7 + 0.63D$
u	$= +IT7 + D$
v	$= +IT7 + 1.25D$
x	$= +IT7 + 1.6D$
y	$= +IT7 + 2d$
z	$= +IT7 + 2.5D$
za	$= IT8 + 3 + 3.15D$
zb	$= +IT9 + 4D$
zc	$= +IT10 + 5D$

For js : The deviation are equal to $\pm IT/2$

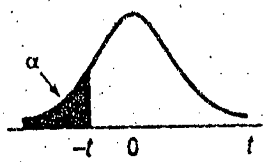
Table 2: Standard Tolerances

IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16
10i	16i	25i	40i	64i	100i	160i	250i	400i	640i	1000i

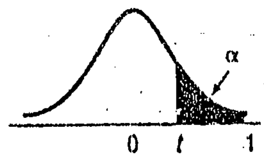
Appendix F

Student's *t* Distribution

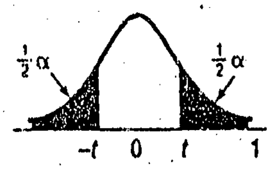
c Confidence Interval



Left-tailed test



Right-tailed test



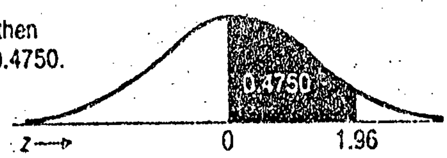
Two-tailed test

	Confidence Intervals, *c*					
	80%	90%	95%	98%	99%	99.9%
	Level of Significance for One-Tailed Test, α					
df	0.100	0.050	0.025	0.010	0.005	0.0005
	Level of Significance for Two-Tailed Test, α					
	0.20	0.10	0.05	0.02	0.01	0.001
1	3.078	6.314	12.706	31.821	63.657	636.619
2	1.886	2.920	4.303	6.965	9.925	31.599
3	1.638	2.353	3.182	4.541	5.841	12.924
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.869
6	1.440	1.943	2.447	3.143	3.707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.408
8	1.397	1.860	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.250	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.140
15	1.341	1.753	2.131	2.602	2.947	4.073
16	1.337	1.746	2.120	2.583	2.921	4.015
17	1.333	1.740	2.110	2.567	2.898	3.965
18	1.330	1.734	2.101	2.552	2.878	3.922
19	1.328	1.729	2.093	2.539	2.861	3.883
20	1.325	1.725	2.086	2.528	2.845	3.850
21	1.323	1.721	2.080	2.518	2.831	3.819
22	1.321	1.717	2.074	2.508	2.819	3.792
23	1.319	1.714	2.069	2.500	2.807	3.768
24	1.318	1.711	2.064	2.492	2.797	3.745
25	1.316	1.708	2.060	2.485	2.787	3.725
26	1.315	1.706	2.056	2.479	2.779	3.707
27	1.314	1.703	2.052	2.473	2.771	3.690
28	1.313	1.701	2.048	2.467	2.763	3.674
29	1.311	1.699	2.045	2.462	2.756	3.659
30	1.310	1.697	2.042	2.457	2.750	3.646
40	1.303	1.684	2.021	2.423	2.704	3.551
60	1.296	1.671	2.000	2.390	2.660	3.460
120	1.289	1.658	1.980	2.358	2.617	3.373
∞	1.282	1.645	1.960	2.326	2.576	3.291

Appendix D

Areas under the Normal Curve

Example:
If $z = 1.96$, then
$P(0 \text{ to } z) = 0.4750$.



z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	[illegible]	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990

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L-3/T-2/ME **Date : 16/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

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) Why do we provide "taper sprue" and "choke" in gating system of a sand mold? Explain. **(10)**

   (b) In which case Match-Plate Psatterns are suitable? Explain the pattern with necessary sketches. **(10)**

   (c) What are the advantages and disadvantages of wooden pattern in sand casting? **(8)**

   (d) What are the purposes of chaplet and core print? Explain with necessary sketches. **($10\frac{2}{3}$)**

   (e) How do you control the thickness of the shell in Dump-Box Technique? Explain briefly. **(8)**

2. (a) Why does the mold is heated before pouring of molten metal in permanent mold casting? **(7)**

   (b) What are the causes of casting defects, "Incomplete Casting" and "Inclusion"? **($16\frac{2}{3}$)**

   (c) What are the measures those you can consider to eliminate Hot tear and shrinkage porosity? Explain briefly. **(15)**

   (d) How do you set metal padding or chills into the sand of sand mold? Explain. **(8)**

3. (a) Discuss the necessities of change gears in a lathe machine. **($10\frac{2}{3}$)**

   (b) Discuss the following machining processes with necessary sketches and show the direction of movement. **(20)**

   (i) Taper boring (ii) Knurling (iii) Internal threading (iv) Face Milling.

   (c) What do you mean by 20 grit size? **(5)**

   (d) What are the purposes of purposes of body diameter clearance in drill tool? **(6)**

   (e) How do you sharpen the drill tool? **(5)**

4. (a) Explain details of a hole broach with necessary sketches. **(12)**

   (b) Explain the Honing and Super finishing Process in detail. **(18)**

   (c) What are the purposes of adjustable sector in indexing process in Milling machine. **(6)**

   (d) How does the clapper box mechanism save the cutting tool from the consequence of the strain back effect? Explain. **($10\frac{2}{3}$)**

Contd P/2

IPE 331

SECTION-B

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

5. (a) With the help of a suitable diagram, derive the following expression **($10\frac{2}{3}$)**

$$\xi = e^{\mu\left(\frac{\pi}{2}-\gamma_0\right)}$$

where the notations indicate their usual meanings.

(b) During a steel rod of diameter 160 mm at a speed of 560 rpm and depth of cut are 0.32 mm/rev. and 4.0 mm, respectively. The cutting tool used is carbide insert which has the following geometry: **(12)**

$$0^0, -10^0, 6^0, 15^0, 75^0, 0\ (\text{mm})$$

it is found by the dynamometer that the main cutting force = 1600 N and feed force = 800 N. If chip thickness is 1 mm, determine the followings:

(i) Coefficient of friction

(ii) Chip velocity

(iii) Dynamic yield shear strength

(iv) Required cutting power

(c) Prove the followings by master line method for a single point cutting tool. **(24)**

(i) $\tan\lambda = -\tan\gamma_x \cos\varphi + \tan\gamma_y \sin\varphi$

(ii) $\tan\gamma_m = \sqrt{\tan^2\gamma_0 + \tan^2\lambda}$

6. (a) Suppose two long thin sheets of stainless steel are to be joined by resistance spot welding. Number of weld nuggets to be formed is 11. Time required for transferring the electrode from one spot to the next is 1.5 seconds. Time between the initial application of the electrode pressure on one spot of the work and the initial application of current to make the weld is 1.2 seconds. The welding current flows through the circuit in total for 30 seconds. Time during which force acts on a spot of welding after the last impulse of welding current ceases is 1.5 seconds. Calculate the total time required for joining the stainless steel sheets if the machine setup time is 2 minutes. **($6\frac{2}{3}$)**

(b) With neat sketches, explain the following welding process. Also list three advantages, three disadvantages and two applications for each of them. **(20)**

(i) Friction welding

(ii) Laser beam welding

(c) Discuss the following welding defects with neat sketches. Also mention their remedies: **(20)**

Contd P/3

IPE 331

Contd... Q. No. 6 (c)

(i) Crakes

(ii) Incomplete penetration

(iii) Porosity and blow holes

(iv) Spatter

7. (a) A solid cylindrical slug made of 304 stainless steel is 150 mm in diameter and 100 mm high. It is reduced in height by 50% at room temperature by open-die forging with flat dies. Calculate the final diameter of the part after being forged. **($6\frac{2}{3}$)**

(b) "Coining is an impression-die forging process"- do you agree with this statement? Justify your answer. Explain coining process with neat sketches. Why are lubricants not used in this process? **(12)**

(c) With the help of suitable diagrams, show that during flat rolling with two rolls, **(12)**

$$\text{The total power required} = \frac{2\pi FLN}{60{,}000}\text{ Kilowatts.}$$

where F = roll force in newtons, L = roll gap in meters, and N = revolutions per minute for each roll.

(d) With neat sketches, describe various thread-rolling process. "Rolled threads have higher strength than machined threads" – explain. **(16)**

8. (a) Explain the significance of positive rake angle, negative rake angle and zero rake angle. Differentiate between straight oil cutting fluids and soluble oil cutting fluids. **($10\frac{2}{3}$)**

(b) With neat sketches, discuss the stages in forging a connecting rod for an internal combustion engine. **(12)**

(c) With neat sketches, visualize the features of wear of turning tool. **(12)**

(d) With suitable diagrams, explain the following processes: **(12)**

(i) Direct extrusion

(ii) Indirect extrusion

L-3/T-2/ME **Date : 16/07/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

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

Full Marks: 210 Time : 3 Hours

The figures in the margin indicate full marks.

Assume reasonable value of any missing data. 'Shigley's Mechanical Engineering Design' text book will be supplied.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) A squared and ground compression spring is to meet the following design requirements: Spring index = 10, mean coil dia = 60 mm, number of active turns = 10, material is 302 stainless steel (unpeened), loads: $F_m = 350$ N, $F_a = 250$ N, $\gamma = 82 \times 10^{-6}$ N/mm^3. **(20)**

Calculate: (i) Solid height, (ii) free length for which buckling is imminent, (iii) chance of yielding if, $S_{sy} = 0.45\ S_{ut}$, (iv) fatigue safety factor using Zimmerli's data and Sine's criterion, (v) spring's safe operating frequency.

(b) An automobile leaf spring carries a total vertical load of P kN, so that half of this load acts on each tip (eye). The spring has 10 leaves and each leaf is 80 mm wide; thickness of each leaf is 10 mm. Total span of main leaf is 500 mm. Take, E = 200 GPa. Given, the maximum bending stress in the main leaf is 62.5 MPa, find: (i) Magnitude of P, (ii) Energy absorbed, (iii) the maximum bending stress in the bottom most leaf. Ignore effect of stress-concentration. **(15)**

2. A pair of helical gears have the following design data: $\psi = 30^0, \phi_n = 20^0$ FD, normal module = 10 mm, driver pinion ($N_p = 18$, $n_p = 1120$ rpm) transmits 75 kW to a 72-teeth gear, face width is thrice the circular pitch, tooth is uncrowned, pinion life = 10^7 cycle with 50% reliability, material: ASTM A-48 Gray C.I. class 40 for both gears, gears are straddle mounted with bearings immediately adjacent, take $Q_v = 6$, m_B (backup ratio) = 1.1, both gears have moderate shock. Find (a) virtual no. of teeth of gears, (b) fatigue safety factor using suitable AGMA equation. **(35)**

3. An electric motor (nominal power 1.5 hp at 1450 rpm) is directly coupled to a single threaded worm (High-test CI). The worm drives a 40 teeth bronze gear that is centrifugally cast. Given: 1 hp = 33000 ft-lb/min, $\phi_n = 25^0$, $m_t = 1/6$ inch, $d_w = 2$ inch, $F_e = 1$ inch, lateral area of the gear case is TWICE the minimum lateral area recommended by AGMA. To take care of unfavorable working conditions, load application factor is 1.12 and design factor is 1.25. Based on the fact that the driver worm receives input power from the motor, find: **(35)**

Contd P/2

ME 343

Contd... Q. No. 3

(a) gear rpm, (b) efficiency of the drive, (c) safety factors by AGMA equation and Buckingham wear load equation. (d) Is a cooling fan necessary if sump oil temperature must not increase by more than 40° F?

4. (a) Explain with necessary sketches, why there is thrust in a bevel gear but not in a herringbone gear. **(10)**

   (b) A pair of outboard mounted straight bevel gears have the following design data: **(25)**
   Material: Steel (Grade 1, through hardened to $H_B = 200$), driver pinion ($N_P = 40$, 250 rpm) transmits 10 kW to the gear ($N_g = 80$), m = 12 mm at larger end, b = 75 mm, $\phi_n = 25°$, $Q_v = 5$, R = 95%, n_L (pinion) = 8000 cycles, temperature = 70° C, crowned teeth, both gears experience light shock. Find safety factor using suitable AGMA equation.

SECTION-B

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

5. (a) An angular contact, inner ring rotating, 02- series ball bearing is required for an application in which the life requirement is 50 kh at 480 rpm. The design radial load is 2900 N. The application factor is 1.5. The reliability goal is 0.90. Find the catalog rating C_{10} for this bearing. Choose the bearing and estimate the existing reliability in service. **(18)**

   (b) A deep groove ball bearing is to carry a radial load of 40 kN at a speed of 20 rpm for 20% of the time, then a radial load of 30 kN at a speed of 80 rpm for 60% of the time, finally a radial load of 20 kN at 120 rpm for the remaining 20% of the time. The expected life of the bearing is 3500 hour. Select the deep groove ball bearing and give the significant dimensions. **(17)**

6. (a) A countershaft is supported by two tapered roller bearings. The radial bearing loads are 2240 N for the left bearing and 4000 N for the right hand bearing. Also, an axial load of 900 N is carried by the left bearing. The shaft rotates at 400 rpm. If the desired life is 40 kh, application factor is 1.4, the reliability goal is 0.9, find the required radial rating for each bearing. Use an initial value of K as 1.5. **(18)**

   (b) A 150 × 150 mm full bearing is to support 18 kN load with a minimum film thickness of 0.05 mm and a radial clearance of 0.30 mm. If the shaft rotates at 3000 rpm, determine the followings- **(17)**

Contd P/3

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Contd... Q. No. 6(b)

(i) the viscosity of the oil,

(ii) the frictional power loss,

(iii) the eccentricity ratio,

(iv) the oil flow needed,

(v) the end leakage,

(vi) the temperature rise of oil,

(vii) the maximum pressure developed in the oil.

7. A natural circulation pillow-block bearing has a journal diameter d of 62.5 mm with a unilateral tolerance of –0.025 mm. The bushing bore diameter is 62.6 mm with a unilateral tolerance of 0.1 mm. The shaft runs at an angular speed of 1120 rpm. The bearing uses SAE grade 20 oil and carries a steady load of 1350 N in shaft stirred air at 21° C. The lateral area of the pillow-block housing is 38700 mm^2. Using Trumpler's criteria, perform a design assessment using minimum radial clearance for a load of 2700 N. Assume that the l/d ratio of the bearing is unity and the value of α is also unity. **(35)**

8. (a) A 20° full depth steel spur pinion rotates at 1145 rpm. It has a module of 6 mm, a face width of 75 mm, and 16 milled teeth. The ultimate tensile strength at involute is 900 MPa with a BHN of 260. The gear is of steel material with 30 teeth and has identical to pinion material strengths. Find the power rating of the gear set based on Lewis bending equation. Use a factor of safety of 1.3. **(18)**

(b) List relative merits and demerits of gear drive over flexible power transmission elements. **(9)**

(c) What are the advantages of journal bearings over rolling contact bearings? Identify the major problem of a journal bearing. **(8)**

L-3/T-2/ME Date : 09/08/2017

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

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

Full Marks: 210 Time : 3 Hours

The figures in the margin indicate full marks.

Assume reasonable value for any missing data. All symbols have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) What are the differences between evaporation, boiling and condensation? Give two examples of each of the above mentioned heat transfer processes. Sketch and name the different boiling regimes in the order they occur in a vertical tube during flow boiling. **(15)**

(b) Water is boiled at sea level in a coffee maker equipped with a 20-cm long 0.4-cm-diameter immersion-type electric heating element made of mechanically polished stainless steel. The coffee maker initially contains 1 L of water at 18°C. Once boiling starts, it is observed that half of the water in the coffee maker evaporates in 25 min. Determine the power rating of the electric heating element immersed in water and the surface temperature of the heating element. Also determine how long it will take for this heater to raise the temperature of 1 L of cold water from 18°C to the boiling temperature. **(20)**

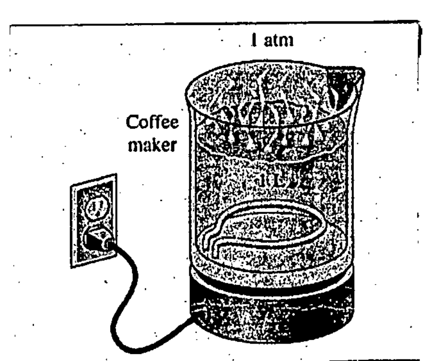

Fig. for Q. No. 1(b)

2. (a) What is the modified latent heat of vaporization? How does it differ from the ordinary latent of vaporization? Consider film condensation on a vertical plate. Will the heat flux be higher at the top or at the bottom of the plate? Why? **(10)**

(b) The condenser of a steam power plant operates at a pressure of 4.25 kPa. The condenser consists of 100 horizontal tubes arranged in a 10 x 10 square array. The tubes are 8 m long and have an outer diameter of 3 cm. If the tube surfaces are at 20°C, determine (i) the rate of heat transfer from the steam to the cooling water and (ii) the rate of condensation of steam in the condenser. **(25)**

Contd P/2

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Contd... Q. No. 2 (b)

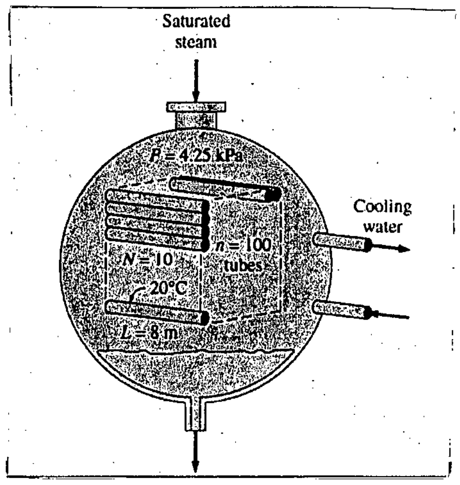

Fig. for Q. No. 2(b)

3. (a) Physically, what does the Grashof number represent? How does the Grashof number differ from the Reynolds number? What do you mean by Boussinesq approximation? **(10)**

(b) A 40-cm-diameter, 110-cm-high vertical cylindrical hot water tank is located in the bathroom of a house maintained at 30°C. The surface temperature of the tank is measured to be 50°C. Taking the surrounding surface temperature to be also 30°C, determine the rate of heat loss from all the surfaces (top, bottom and side) of the tank by natural convection. **(25)**

4. (a) What are the common causes of fouling in a heat exchanger? How does fouling affect heat transfer and pressure drop? **(10)**

(b) Cold water (C_p = 4180 J/kg.°C) enters the tubes of a heat exchanger with 2-shell-passes and 20-tube-passes at 20°C at a rate of 3 kg/s, while hot oil (C_p = 2200 J/kg.°C) enters the shell at 130°C at the same mass flow rate. The overall heat transfer coefficient based on the outer surface of the tube is 300 W/m^2.°C and the heat transfer surface area on that side is 20 m^2. Determine the rate of heat transfer using (i) the LMTD method and (ii) the ε –NTU method. **(25)**

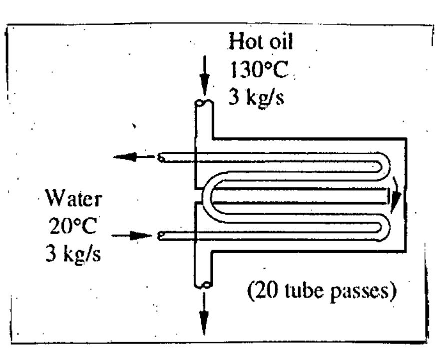

Fig. for Q. No. 4(b)

Contd P/3

SECTION-B

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

5. (a) Explain the mechanism and the classification of convection heat transfer. **(7)**

   (b) Show the analogy between two-dimensional, steady-state momentum and energy equations in non-dimensional forms for forced convection over a flat plate. Explain the physical significance of non-dimensional governing parameters involved in those equations. **(8)**

   (c) Consider the flow of fluid between two large parallel isothermal plates separated by a distance *L*. The upper plate is moving at a constant velocity of *V* and maintained at temperature T_0 while the lower plate is stationary and insulated. By simplifying and solving the continuity, momentum and energy equations, obtain the relation for the maximum temperature of fluid. **(20)**

6. (a) Air at 27°C and 1 atm flows over a 20-cm square flat plate at a free-stream speed of 20 m/s. The last half of the plate is heated to a constant temperature of 350 K. Calculate the heat lost by the plate. **(18)**

   (b) Air flows across a 4 cm square cylinder at a velocity of 10 m/s. The surface temperature is maintained at 85°C. Free-stream air conditions are 20°C and 0.6 bar. Calculate the heat loss from the cylinder per meter of length. Use the following correlation: $\mathrm{Nu} = 0.094\mathrm{Re}_D^{0.675}\mathrm{Pr}^{0.33}$; $3900 \le \mathrm{Re}_D \le 79{,}000$. **(17)**

7. (a) Water is to be heated from 15°C to 65°C as it flows through a 3-cm-internal-diameter 5-m-long tube. The tube is equipped with an electric resistance heater that provides uniform isoflux heating throughout the surface of the tube. The outer surface of the heater is well insulated, so that in steady operation all the heat generated in the heater is transferred to the water in the tube. If the system is to provide hot water at a rate of 10 L/min, determine the power rating of the resistance heater. Also, estimate the inner surface temperature of the pipe at the exit. **(20)**

   Use Colburn correlation: $\mathrm{Nu} = 0.023\mathrm{Re}^{0.8}\,\mathrm{Pr}^{1/3}$ for $0.7 \le \mathrm{Pr} \le 160$ and $\mathrm{Re} > 10{,}000$.

   (b) 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 Dittus-Boelter equation: $\mathrm{Nu} = 0.023\mathrm{Re}^{0.8}\,\mathrm{Pr}^{n}$ for $\mathrm{Re} > 10{,}000$ and $0.7 \le \mathrm{Pr} \le 160$; n = 0.4 heating and n = 0.3 cooling. **(15)**

8. (a) Using dimensional analysis, show that for forced convection mass transfer over a flat plate, $\mathrm{Sh} = f(\mathrm{Re}, \mathrm{Sc})$. **(10)**

Contd P/4

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Contd... Q. No. 8

(b) Air at atmospheric pressure and 25°C containing small quantities of iodine flows with a velocity of 5.18 m/s inside a tube with an ID of 30.48 mm. Determine the mass transfer coefficient for iodine transfer from the gas stream to the wall surface. Mass diffusivity for the air-iodine system at atmospheric pressure and 25°C is 0.0834 cm^2/s. Use the following correlation: $Sh = 0.023 Re_D^{0.83} Sc^{0.44}$ for $2000 \leq Re_D \leq 35000$ and $0.6 \leq Sc \leq 2.5$. **(15)**

(c) What do you mean by equimolar counter diffusion? Describe with proper sketches and examples. "In equimolar counter diffusion of two gases, the partial pressure gradients must be equal in magnitude but opposite in direction", explain. **(10)**

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.

Condensation:

The average heat transfer coefficient for film condensation on the outer surfaces of a *horizontal tube* is determined to be

$$h_{\text{horiz}} = 0.729\left[\frac{g\rho_l(\rho_l - \rho_v)\, h^*_{fg} k_l^3}{\mu_l (T_s - T_{\text{sat}})D}\right]^{1/4} \qquad (\text{W/m}^2 \cdot {}^\circ\text{C})$$

$$h_{\text{horiz, } N \text{ tubes}} = 0.729\left[\frac{g\rho_l(\rho_l - \rho_v)\, h^*_{fg} k_l^3}{\mu_l (T_{\text{sat}} - T_s)\, ND}\right]^{1/4} = \frac{1}{N^{1/4}} h_{\text{horiz, 1 tube}}$$

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

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

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

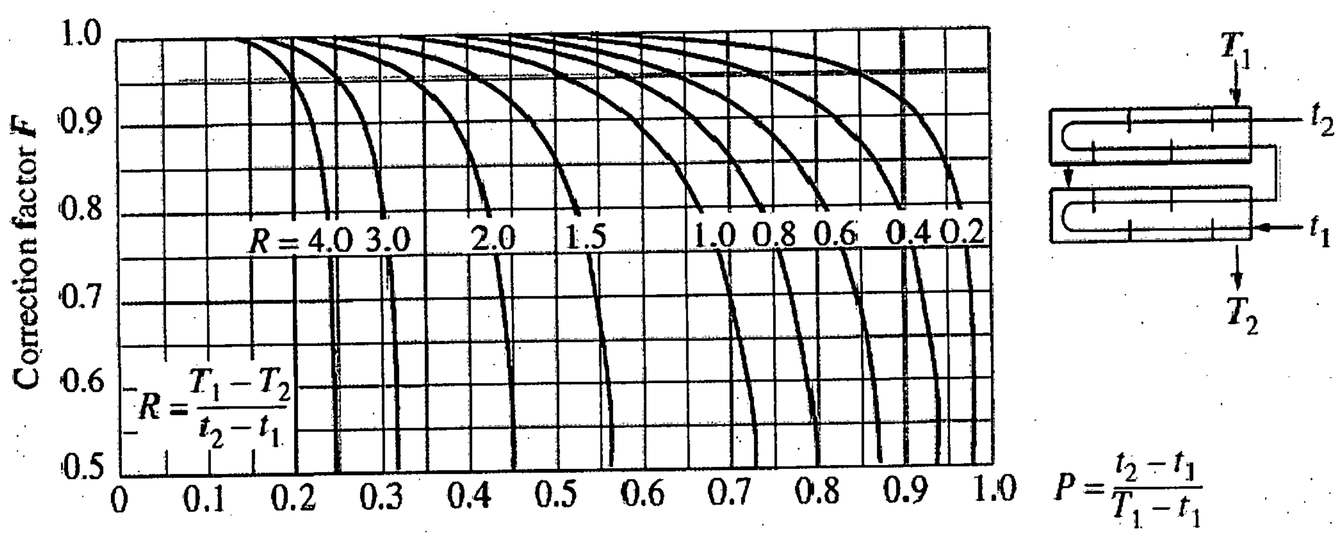
T, °C	σ, N/m*
0	0.0757
20	0.0727
40	0.0696
60	0.0662
80	0.0627
100	0.0589
120	0.0550
140	0.0509
160	0.0466
180	0.0422
200	0,0377
220	0.0331
240	0.0284
260	0.0237
280	0.0190
300	0.0144
320	0.0099
340	0.0056
360	0.0019
374	0.0

Table: 3

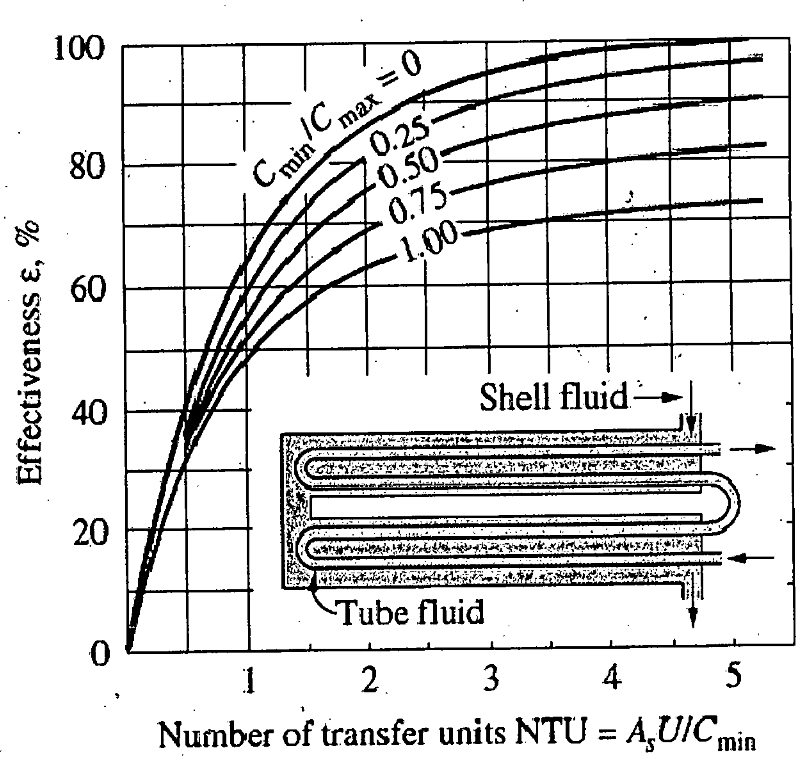
Values of the coefficient C_{sf} and n for various fluid–surface combinations

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

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 fer

Isoflux (q_w = constant)

$Nu_x = 0.453 Re_x^{1/2} Pr^{1/3}$

$Nu_L = 0.680 Re_L^{1/2} Pr^{1/3}$

$Nu_x = 0.0308 Re_x^{4/5} Pr^{1/3}$

$Nu_L = 0.037 Re_L^{4/5} Pr^{1/3}$

$Nu_L = \frac{0.037 Re_L^{4/5} Pr^{1/3}}{1+12.35\times 10^6 Re_L^{-6/5}}$

$Nu_x = \frac{0.4637 Re_x^{1/2} Pr^{1/3}}{\left[1+\left(\frac{0.0207}{Pr}\right)^{2/3}\right]^{1/4}}$

$\left[\left(\frac{\xi}{x}\right)^{3/4}\right]^{-1/3}$

$\left[\left(\frac{\xi}{x}\right)^{9/10}\right]^{-1/9}$

$\left[1-\left(\frac{\xi}{L}\right)^{\frac{p+1}{p+2}}\right]^{\frac{p}{p+1}}$

Natural Convection:

Table 4:

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

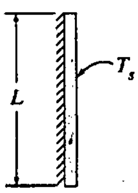
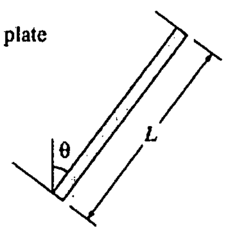
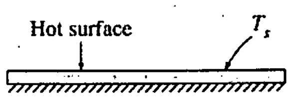
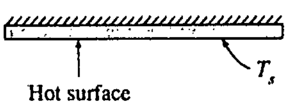
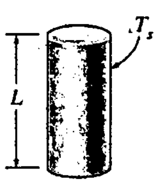
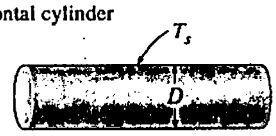
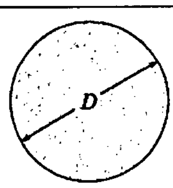
Geometry	Characteristic length L_c	Range of Ra	Nu	
Vertical plate 	L	10^4–10^9 10^9–10^{13} Entire range	$Nu = 0.59Ra_L^{1/4}$ $Nu = 0.1Ra_L^{1/3}$ $Nu = \left\{0.825 + \frac{0.387Ra}{[1 + (0.492/Pr}\right.$ (complex but more accurate)	(9-19) (9-20) (9-21)
Inclined plate 	L		Use vertical plate equations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

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Table A-5 | Properties of air at atmospheric pressure.†

The values of μ, k, c_p, and Pr are not strongly pressure-dependent and may be used over a fairly wide range of pressures

T, K	ρ kg/m^3	c_p kJ/kg · °C	$\mu \times 10^5$ kg/m · s	$\nu \times 10^6$ m^2/s	k W/m · °C	$\alpha \times 10^4$ m^2/s	Pr
100	3.6010	1.0266	0.6924	1.923	0.009246	0.02501	0.770
150	2.3675	1.0099	1.0283	4.343	0.013735	0.05745	0.753
200	1.7684	1.0061	1.3289	7.490	0.01809	0.10165	0.739
250	1.4128	1.0053	1.5990	11.31	0.02227	0.15675	0.722
300	1.1774	1.0057	1.8462	15.69	0.02624	0.22160	0.708
350	0.9980	1.0090	2.075	20.76	0.03003	0.2983	0.697
400	0.8826	1.0140	2.286	25.90	0.03365	0.3760	0.689
450	0.7833	1.0207	2.484	31.71	0.03707	0.4222	0.683
500	0.7048	1.0295	2.671	37.90	0.04038	0.5564	0.680
550	0.6423	1.0392	2.848	44.34	0.04360	0.6532	0.680
600	0.5879	1.0551	3.018	51.34	0.04659	0.7512	0.680
650	0.5430	1.0635	3.177	58.51	0.04953	0.8578	0.682
700	0.5030	1.0752	3.332	66.25	0.05230	0.9672	0.684
750	0.4709	1.0856	3.481	73.91	0.05509	1.0774	0.686
800	0.4405	1.0978	3.625	82.29	0.05779	1.1951	0.689
850	0.4149	1.1095	3.765	90.75	0.06028	1.3097	0.692
900	0.3925	1.1212	3.899	99.3	0.06279	1.4271	0.696
950	0.3716	1.1321	4.023	108.2	0.06525	1.5510	0.699
1000	0.3524	1.1417	4.152	117.8	0.06752	1.6779	0.702
1100	0.3204	1.160	4.44	138.6	0.0732	1.969	0.704
1200	0.2947	1.179	4.69	159.1	0.0782	2.251	0.707
1300	0.2707	1.197	4.93	182.1	0.0837	2.583	0.705
1400	0.2515	1.214	5.17	205.5	0.0891	2.920	0.705
1500	0.2355	1.230	5.40	229.1	0.0946	3.262	0.705
1600	0.2211	1.248	5.63	254.5	0.100	3.609	0.705
1700	0.2082	1.267	5.85	280.5	0.105	3.977	0.705
1800	0.1970	1.287	6.07	308.1	0.111	4.379	0.704
1900	0.1858	1.309	6.29	338.5	0.117	4.811	0.704
2000	0.1762	1.338	6.50	369.0	0.124	5.260	0.702
2100	0.1682	1.372	6.72	399.6	0.131	5.715	0.700
2200	0.1602	1.419	6.93	432.6	0.139	6.120	0.707
2300	0.1538	1.482	7.14	464.0	0.149	6.540	0.710
2400	0.1458	1.574	7.35	504.0	0.161	7.020	0.718
2500	0.1394	1.688	7.57	543.5	0.175	7.441	0.730

†From *Natl. Bur. Stand. (U.S.) Circ.* 564, 1955.

L-3/T-2/ME **Date : 05/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

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

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**.

Moody diagram is attached.

1. (a) From the fundamental concept of fluid flow, derive an expression of average velocity in steady laminar flow through annulus. **(17)**

(b) A certain oil of specific gravity 0.85 and viscosity 0.15 N-s/m^2 is pumped at the rate of 25 litre/s through a pipe. The diameter of the pipe is 220 mm and its length is 1200 m. It is laid at a slope up of 1.0 in 200. Find the head loss due to friction and power required for driving the pump, if the pump efficiency is 70%. **(18)**

2. (a) Discuss the "laws of fluid friction" in pipe flow. **(5)**

(b) Obtain an expression of head loss due to sudden expansion in a pipe line. **(10)**

(c) Water is flowing from one reservoir to another through a 250 m long commercial steel pipe of 150 mm diameter as shown in Fig. for Q. No. 2(c). For elbows in pipe line K = 0.9. Find the flow rate of water. The kinematic viscosity of water is 1.02×10^{-6} m^2/s. **(20)**

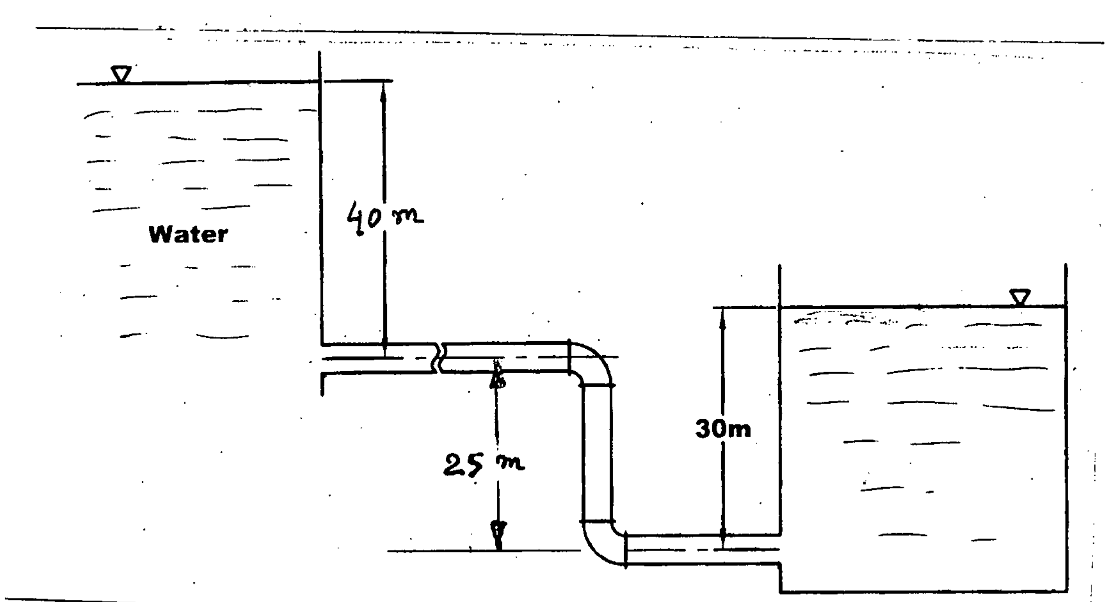

Fig. for Q. No. 2(c)

Contd P/2

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3. (a) What is meant by the most economical section of open channel? Deduce the conditions for the most economical section of circular open channel. **(18)**

(b) A trapezoidal channel is to be excavated with minimum cost. The flow rate of water is 20 m^3/s and the bed slope is 1: 2500. Find the dimensions of the channel. Take Manning's constant, N = 0.019. **(17)**

4. (a) What is critical depth in open channel flow? Show that the critical depth of flow in open channel occurs when the Froude number is unity. **(15)**

(b) Write short notes on the followings (any **two**): **(20)**

(i) Energy loss in hydraulic jump.

(ii) Energy thickness in boundary layer.

(iii) Lift and Drag forces of an airfoil.

SECTION-B

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

5. (a) Compressed air is stored in a large tank of volume, V where the pressure is initially kept at $p_0|_{t=0}$ as shown in Fig. for Q. 5(a). After a while, air is allowed to blowdown (through a converging nozzle with throat area, A^*) to the atmosphere where the pressure is constant at p_b $(p_b << p_0|_{t=0})$. Accordingly, the pressure inside the tank will decrease with time, t. Theoretically model this unsteady blowdown process and derive the expression of time dependent pressure inside the tank, $p_0|_{t=t}$ until $p_0|_{t=t} \geq 1.893 p_b$. **(15)**
Assume that the thermal condition is remained constant during this blowdown process.

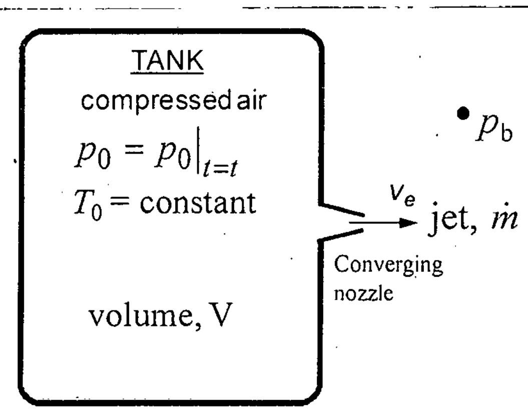

Fig. for Q. 5(a)

(b) An air tank of volume 1500 liter is at 800 kPa and 20°C (as shown in Fig. for Q. 5(a)) when it begins exhausting through a converging nozzle to sea-level condition, $p_b = 100\,\text{kPa}$. The throat area is 0.75 cm^2. Estimate: **(15)**

(i) Initial mass flow rate at t = 0.

(ii) Time, t to blowdown to 400 kPa and mass flow rate at this condition.

(iii) Time, t when the nozzle ceases being choked and the corresponding mass flow rate.

Contd P/3

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Contd... Q. No. 5

(c) Sketch the basic flow structure of underexpanded nozzle flows. **(5)**

6. (a) What do you mean by "stagnation state" in context of compressible fluid flow? Show that- the value of pressure coefficient (c_p) at a stagnation point in compressible flow could be expressed by the following relation **(12)**

$$\left(c_{p,\text{stag.}}\right)_{\text{compressible}} = 1.0 + \frac{M^2}{4} + \ldots\ldots\ldots$$

(b) Two geometric configurations are shown in Fig. for Q. 6(b)

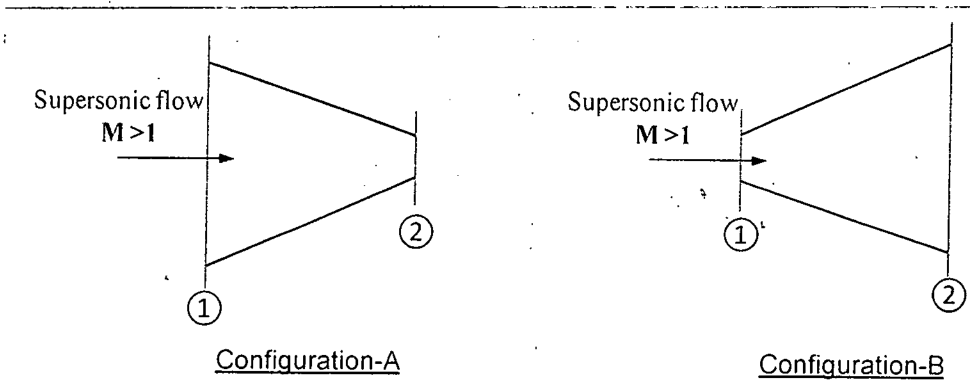

Fig. for Q.6 (b)

For the given flow condition, identify which one will act as a diffuser? **(15)**
Derive the generalized fundamental equation for the change of flow area which results the change of velocity inside a 1-D variable area duct to support your above identification.
(c) Consider a converging-diverging nozzle with an exit-to-throat area ratio of 4.2. Calculate the design Mach number and design NPR. **(8)**

7. (a) How can you differentiate between normal and oblique shock waves? Show that the strength of a normal shock can be expressed by the following relation, **(20)**

$$\frac{2k}{k+1}\left(M_1^2 - 1\right)$$

where the symbols have their usual meaning.
(b) For simplicity, the combustion product feeding from the combustion chamber (CC) can be approximately modeled as air (k = 1.4) as shown in Fig. for Q. 7(b). This air is passing through a converging-diverging nozzle. At a particular off-design operation, a normal shock wave appears inside the nozzle with M_1 = 2.5. If the throat area is 300 mm^2, then determine- **(15)**
(i) Sectional area of the nozzle where this shock wave appears.
(ii) Mach number and static pressure downstream of the shock.
(iii) Available total pressure at the nozzle exit.

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Contd... Q. No. 7 (b)

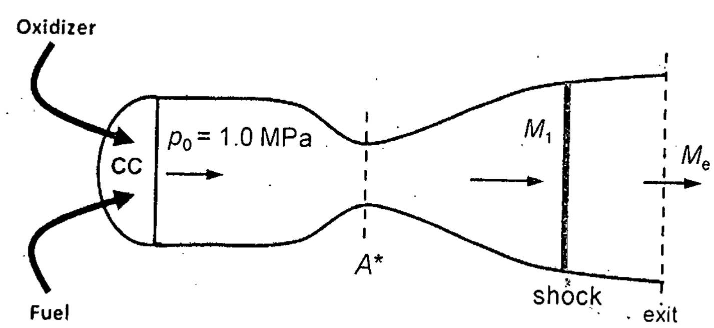


Fig. for Q. 7(b)

8. (a) Experiments show that a ball placed in a jet can remain suspended in a stable equilibrium position as shown in Fig. for Q. 8(a). The equilibrium height, h of the ball in the jet is found to depend on ball diameter (D), jet diameter (d), jet velocity (V), fluid density (ρ), fluid viscosity (μ), and weight of the ball (W). Dimensional analysis is suggested to correlate experimental data. Find the Π parameters that characterize this phenomenon. **(25)**

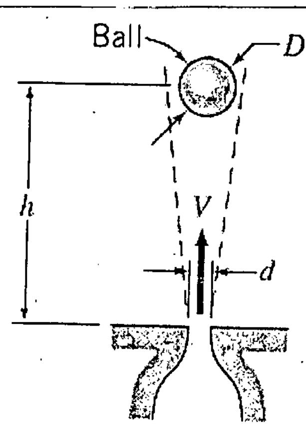
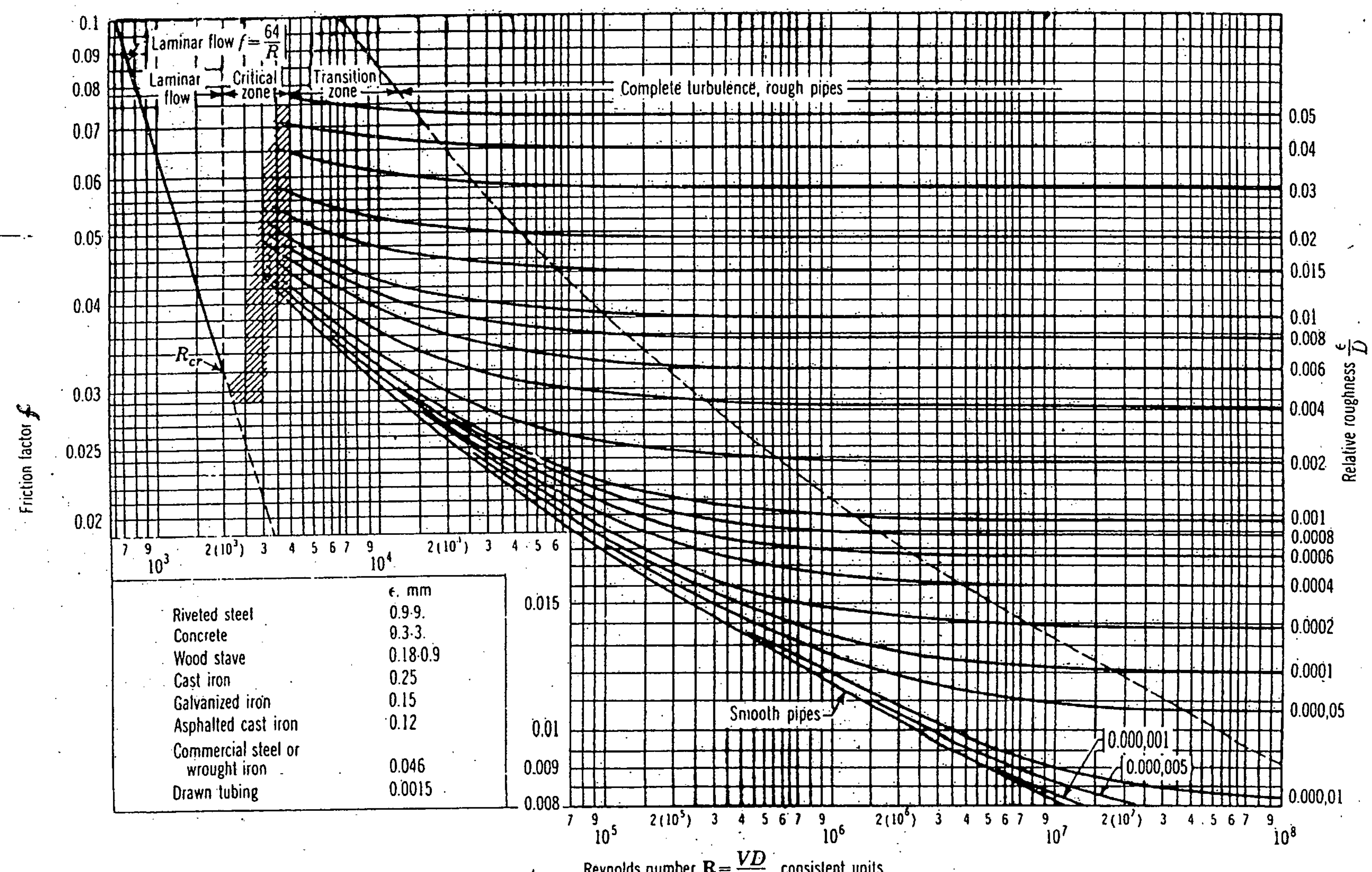


Fig. for Q. 8(a)

(b) A test is to be performed on a proposed design for a large pump that is to deliver 1.5 m^3/s of water from a 40-cm-diameter impeller with a pressure rise of 400 kPa. A model with an 8-cm-diameter impeller is to be used. What flow rate should be used and what pressure rise is to be expected? The model fluid is water at the same temperature as the water in the prototype. **(10)**



	ϵ, mm
Riveted steel	0.9-9.
Concrete	0.3-3.
Wood stave	0.18-0.9
Cast iron	0.25
Galvanized iron	0.15
Asphalted cast iron	0.12
Commercial steel or wrought iron	0.046
Drawn tubing	0.0015

Figure Moody diagram.

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