L-3/T-2/ME Date : 19/11/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2010-2011

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) With neat sketches, describe briefly the investment casting. Discuss the advantages and limitations of investment casting in comparison with sand mold casting. **(16)**

   (b) With the help of diagram, describe briefly the following: **(16)**

   (i) Gated pattern
   (ii) Match plate pattern
   (iii) Cope and drag pattern and
   (iv) Follow board pattern

   (c) How the welding may be classified. Why is shielded metal arc welding a commonly used process? Why it is also called stick welding? **(14⅔)**

2. (a) With the help of neat sketches, describe briefly the principles of operation of MIG welding process. What are the main differences between the EBW and LBW processes? **(16)**

   (b) With the help of neat sketches, describe briefly the principles of operation and give one suitable industrial application of the following welding processes: **(18)**

   (i) Submersed arc welding and
   (ii) Resistance seam welding

   (c) Enumerate common defects encountered with welding products and suggest methods to counter these defects. **(12⅔)**

3. (a) Derive simple equations, using proper diagrams, for conversion of the rake angles of single-point turning tool from **(24)**

   (i) ASA system to ORS (orthogonal rake system) and
   (ii) ORS to ASA system

   (b) Determine the values of side rake (γ_x), back rake (γ_y) and maximum rake (γ_m) angles of the single-point turning tool whose geometry is specified as 0°, 10°, 8°, 6°, 15°, 60°, 0 (mm). **(10)**

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IPE 331

Contd Q. No. 3

(c) Define chip reduction coefficient and explain why the value of chip reduction coefficient is generally greater than 1.0. With the help of a suitable diagram, derive the following expression **(12⅔)**

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

where the notations indicate their usual meanings.

4. (a) Based on the relevant machining condition and type of work material, deduce the following expression **(20)**

$$P_z = \tau_S S_O t \left[\cot\beta + \tan(c - \beta)\right]$$

where the notations indicate their usual meanings.

(b) Show schematically the general pattern (geometry) of wear that develops at the rake surface and the clearance (or flank) surfaces of cutting tool. State the difference among abrasion wear, adhesion wear and diffusion wear in respect of cutting tool wear. **(10)**

(c) During the turning of a steel rod of 150 mm diameter, at a speed of 560 rpm, feed of 0.32 mm/rev. and 4.0 mm depth of cut by a tool of geometry 0°, −12°, 8°, 7°, 30°, 60°, 0 (mm), it was observed that P_z = 1000 N and P_y = 200 N and the chip thickness = 0.80 mm. Determine **(16⅔)**

(i) Frictional force
(ii) Normal force
(iii) Co-efficient of friction
(iv) Shear force
(v) Dynamic yield shear strength.

SECTION – B

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

5. (a) What are the differences between turning and threading operation? How does the turning operation corresponds to threading operation? **(10)**

(b) Discuss the lathe set-up for contour turning and internal threading operations. **(14⅔)**

(c) Discuss the power feed mechanism for turning and threading operations. **(12)**

(d) Discuss the reversing mechanism in lathe operation. Also mention its necessity. **(10)**

Contd P/3

IPE 331

6. (a) Discuss the Side milling and Face milling operations with necessary sketch(es). **(10)**

   (b) Discuss the relative advantages and disadvantages of Up-milling and Down-milling. **(12)**

   (c) Discuss the gear cutting process in milling machine. Also discuss the necessity of dividing head in gear cutting. **(16⅔)**

   (d) What are cutting edges of a double flute twist drill? **(8)**

7. (a) Explain the strain back effect. Why should the clearance angle of the shaper tool be less than 4^{o}? **(12)**

   (b) What are the defects in Rolled plates/sheets? What are the counter measures in order to reduce the rolling defects? **(20)**

   (c) Discuss the upsetting and barreling in Open-die forging. How do you minimize the barreling effect? **(14⅔)**

8. (a) Discuss the difference between Fullering and edging processes. **(10)**

   (b) Calculate the optimum cutting speed to minimize cost. Also explain the effect of Taylor's model of tool life on optimum cutting speed. **(20⅔)**

   (c) Discuss the effect of hot rolling process on material micro structure. Also mention the relative advantages of cold rolling over hot rolling. **(16)**

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18 hrs
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L-3/T-2/ME

Date : 07/01/2013

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2010-2011

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**.

Table-Factors used in 3σ quality control is attached.

1. (a) What is the main idea behind Crosby's 'quality is free' concept? According to him, what are the four 'Absolutes of Quality Management'? **(15)**

   (b) Which tool of TQM is used to show the frequency distribution in a set of data? What are the application differences between histogram and pareto chart? Briefly explain typical histogram shapes and their meanings. **(20)**

2. (a) Why is the following statement true? The further along the process that a failure is discovered, the more expensive it is to correct. **(10)**

   (b) Illustrate how the shape of OC curve changes with different sampling plans. **(10)**

   (c) A company and its customer have agreed to follow a double sampling plan with the following parameters:

   Lot size = 3000, first sample size 40 and the second sample size 80.

   Acceptance number of the first sample is 2 and for the second sample is 4. Find out the probability of accepting the lot for a fraction nonconforming value of 0.05. **(15)**

3. (a) Describe the difference between chance and assignable causes. Why should a manager be aware of assignable and chance causes? **(10)**

   (b) An assembly area has been experiencing serious delays in the construction of the computer printers. As quality assurance manager, you revealed that the shaft which holds the roller in place could be the major cause of assembly problems. To begin to study the situation, measurement of the lengths of the shafts will be sampled. Your team has decided to take a sample of five measurements every 10 minutes from the production. The collected data are shown in table 1. **(25)**

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Table- 1:

Sub group	Time	1	2	3	4	5
1	07:30	11.95	12.00	12.03	11.98	12.01
2	07:40	12.03	12.02	11.96	12.00	11.98
3	07:50	12.01	12.00	11.97	11.98	12.00
4	08:00	11.97	11.98	12.00	12.03	11.99
5	08:10	12.00	12.01	12.02	12.03	12.02
6	08:20	11.98	11.98	12.00	12.01	11.99
7	08:30	12.00	12.01	12.03	12.00	11.98
8	08:40	12.00	12.01	12.04	12.00	12.02
9	08:50	12.00	12.02	11.96	12.00	11.98
10	09:00	12.02	12.00	11.97	12.05	12.00
11	09:10	11.98	11.97	11.96	11.95	12.00
12	09:20	11.92	11.95	11.92	11.94	11.96
13	09:30	11.93	11.95	11.98	11.94	11.96
14	09:40	11.99	11.93	11.94	11.95	11.96
15	09:50	12.00	11.98	11.99	11.95	11.93
16	10:00	12.00	11.98	11.99	11.96	11.97
17	10:10	12.02	11.98	11.97	11.98	11.99
18	10:20	12.00	12.01	12.02	12.01	11.99
19	10:30	11.97	12.03	12.00	12.01	11.99
20	10:40	11.99	12.01	12.02	12.00	12.01
21	10:50	12.00	11.98	11.99	11.99	12.02

(i) Set up an X-bar and R chart on this process.

(ii) Interpret the chart.

(iii) Does the process seem to be in control? If necessary, assume assignable causes and revise the trial control limits.

(iv) If the specification limits are 14 ± 5 inch, calculate process potential and process performance indices.

4. (a) Discuss the basis of accuracies on which a gear can be graded. **(15)**

(b) Why Surface Finish is important in Engineering Applications? In a measurement of surface roughness, heights of 20 successive peaks and troughs were measured from a datum and were (in micron), **(10)**

35	25	40	22	35	18	42	25	35
36	18	42	22	32	21	37	18	35

Contd P/3

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Contd ... Q. No. 4(b)

If these measurements were obtained over a length of 20 mm, determine the C.L.A (Ra) and R.M.S value over rough surface.

(c) State the constructional features of sin bar on which the accuracy of the measurement depends. Explain the limitation of sin bar in angle measurement. **(10)**

SECTION – B

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

Symbols indicate their usual meaning.

Normal distribution table attached.

5. (a) Explain with neat sketch the working principle of the Tomlinson Surface Meter to measure the surface roughness. **(15)**

(b) Explain the basic difference between Differential Statistics and Inferential Statistics? The Quick Change Oil Company has a number of outlets in the metropolitan Seattle area. The daily numbers of oil change at the Oak Street outlet in the past 20 days are: **(15)**

65	98	55	62	79	59	51	90	72	56
70	62	66	80	94	79	63	73	71	85

The data are to be organized in a frequency distribution.

(i) How many classes would you recommend?

(ii) What class interval would you suggest?

(iii) What lower limit would you recommend for the first class?

Organize the number of oil changes into a frequency distribution.

(c) Explain Geometric Distribution with proper example. **(5)**

6. (a) Derive the expression of virtual effective diameter for a screw thread considering Pitch error and Flank angle error. **(15)**

(b) What do you understand by the term 'Conditional Probability' and 'Mutual Exclusive Event'? A study examined national attitudes about antidepressants. The study revealed that approximately 70% believe "antidepressant don't really cure anything, they just cover up the real trouble". According to this study what is the probability that at least 3 of the next 5 people selected at random will have this opinion? **(10)**

(c) State and briefly explain Chebyshev's Theorem and Central Limit Theorem. **(10)**

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7. (a) What do you understand by static and dynamic error in measurement? Explain different type of static errors in measurement. **(15)**

(b) Write the basic properties of Normal Distribution. The mean age at which men in the United States marry for the first time follows the normal distribution with a mean of 24.8 years. The standard deviation of the distribution is 2.5 years. For a random sample of 60 men, what is the probability that, the age at which they were married first time is less than 25.1 years. **(10)**

(c) Differentiate among the gearing operation requirement for 'High Speed Gear', 'High Power Gear' and 'Precision Gear'. **(10)**

8. (a) A hole and shafting system has the 50 mm H7-m6 fit. Given that, $i = 0.45\sqrt[3]{D} + 0.001D\ (\mu m)$. For Tolerance grade IT7 multiplier is 10 and for grade IT6 multiplier is 16. The fundamental deviation (FD) for fit 'm' is given by,

FD = +(IT7 – IT6). Find **(15)**

(i) The class of fit and state its application.

(ii) Sketch the fit and show the actual dimension.

(b) What is the difference between Point Estimate and Confidence Interval? Rutter Nursery Company packages its 'Pine bark mulch' in 50-pound bags. From a long history, the production department reports that the distribution of the bag weights follows the normal distribution and the standard deviation of this process is 3-pounds per bag. At the end of each day, Jeff Rutter, the Production Manager, weights 10 bags and computes the mean weight of the sample. Below are the weights of 10 bags from today's production. **(12)**

45.6	47.7	47.6	46.3	46.2	47.4	49.2	55.8	47.5	48.5

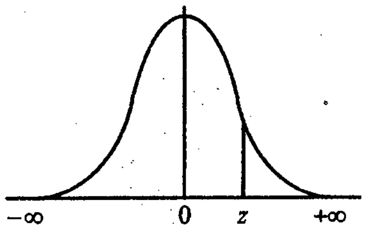
Can Mr. Rutter conclude that the mean weight of the bags is less than 50 pounds? Use the 0.1 significance level.

(c) Explain different types of error in Hypothesis testing. **(8)**

Table B. Factors used in 3σ Quality Control Charts.

Sample size n	$\bar{X}$ charts: Factors for control limits			S charts: Factors for central line	S charts: Factors for control limits				R charts: Factors for central line	R charts: Factors for control limits				
	A	A_2	A_3	c_4	B_3	B_4	B_5	B_6	d_2	d_3	D_1	D_2	D_3	D_4
2	2.121	1.880	2.659	0.7979	0	3.267	0	2.606	1.128	0.853	0	3.686	0	3.267
3	1.732	1.023	1.954	0.8862	0	2.568	0	2.276	1.693	0.888	0	4.358	0	2.574
4	1.500	0.729	1.628	0.9213	0	2.266	0	2.088	2.059	0.880	0	4.698	0	2.282
5	1.342	0.577	1.427	0.9400	0	2.089	0	1.964	2.326	0.864	0	4.918	0	2.114
6	1.225	0.483	1.287	0.9515	0.030	1.970	0.029	1.874	2.534	0.848	0	5.078	0	2.004
7	1.134	0.419	1.182	0.9594	0.118	1.882	0.113	1.806	2.704	0.833	0.204	5.204	0.076	1.924
8	1.061	0.373	1.099	0.9650	0.185	1.815	0.179	1.751	2.847	0.820	0.388	5.306	0.136	1.864
9	1.000	0.337	1.032	0.9693	0.239	1.761	0.232	1.707	2.970	0.808	0.547	5.393	0.184	1.816
10	0.949	0.308	0.975	0.9727	0.284	1.716	0.276	1.669	3.078	0.797	0.687	5.469	0.223	1.777
11	0.905	0.285	0.927	0.9754	0.321	1.679	0.313	1.637	3.173	0.787	0.811	5.535	0.256	1.744
12	0.866	0.266	0.886	0.9776	0.354	1.646	0.346	1.610	3.258	0.778	0.922	5.594	0.283	1.717
13	0.832	0.249	0.850	0.9794	0.382	1.618	0.374	1.585	3.336	0.770	1.025	5.647	0.307	1.693
14	0.802	0.235	0.817	0.9810	0.406	1.594	0.399	1.563	3.407	0.763	1.118	5.696	0.328	1.672
15	0.775	0.223	0.789	0.9823	0.428	1.572	0.421	1.544	3.472	0.756	1.203	5.741	0.347	1.653
16	0.750	0.212	0.763	0.9835	0.448	1.552	0.440	1.526	3.532	0.750	1.282	5.782	0.363	1.637
17	0.728	0.203	0.739	0.9845	0.466	1.534	0.458	1.511	3.588	0.744	1.356	5.820	0.378	1.622
18	0.707	0.194	0.718	0.9854	0.482	1.518	0.475	1.496	3.640	0.739	1.424	5.856	0.391	1.608
19	0.688	0.187	0.698	0.9862	0.497	1.503	0.490	1.483	3.689	0.734	1.487	5.891	0.403	1.597
20	0.671	0.180	0.680	0.9869	0.510	1.490	0.504	1.470	3.735	0.729	1.549	5.921	0.415	1.585
21	0.655	0.173	0.663	0.9876	0.523	1.477	0.516	1.459	3.778	0.724	1.605	5.951	0.425	1.575
22	0.640	0.167	0.647	0.9882	0.534	1.466	0.528	1.448	3.819	0.720	1.659	5.979	0.434	1.566
23	0.626	0.162	0.633	0.9887	0.545	1.455	0.539	1.438	3.858	0.716	1.710	6.006	0.443	1.557
24	0.612	0.157	0.619	0.9892	0.555	1.445	0.549	1.429	3.895	0.712	1.759	6.031	0.451	1.548
25	0.600	0.153	0.606	0.9896	0.565	1.435	0.559	1.420	3.931	0.708	1.806	6.056	0.459	1.541

NORMAL DISTRIBUTION TABLE



	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

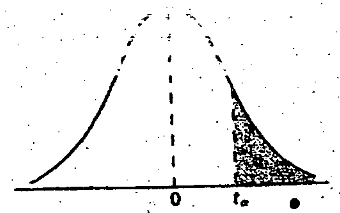


TABLE A.4 Critical Values of the t-Distribution

v	α = 0.40	0.30	0.20	0.15	0.10	0.05	0.025
1	0.325	0.727	1.376	1.963	3.078	6.314	12.706
2	0.289	0.617	1.061	1.386	1.886	2.920	4.303
3	0.277	0.584	0.978	1.250	1.638	2.353	3.182
4	0.271	0.569	0.941	1.190	1.533	2.132	2.776
5	0.267	0.559	0.920	1.156	1.476	2.015	2.571
6	0.265	0.553	0.906	1.134	1.440	1.943	2.447
7	0.263	0.549	0.896	1.119	1.415	1.895	2.365
8	0.262	0.546	0.889	1.108	1.397	1.860	2.306
9	0.261	0.543	0.883	1.100	1.383	1.833	2.262
10	0.260	0.542	0.879	1.093	1.372	1.812	2.228
11	0.260	0.540	0.876	1.088	1.363	1.796	2.201
12	0.259	0.539	0.873	1.083	1.356	1.782	2.179
13	0.259	0.537	0.870	1.079	1.350	1.771	2.160
14	0.258	0.537	0.868	1.076	1.345	1.761	2.145
15	0.258	0.536	0.866	1.074	1.341	1.753	2.131
16	0.258	0.535	0.865	1.071	1.337	1.746	2.120
17	0.257	0.534	0.863	1.069	1.333	1.740	2.110
18	0.257	0.534	0.862	1.067	1.330	1.734	2.101
19	0.257	0.533	0.861	1.066	1.328	1.729	2.093
20	0.257	0.533	0.860	1.064	1.325	1.725	2.086
21	0.257	0.532	0.859	1.063	1.323	1.721	2.080
22	0.256	0.532	0.858	1.061	1.321	1.717	2.074
23	0.256	0.532	0.858	1.060	1.319	1.714	2.069
24	0.256	0.531	0.857	1.059	1.318	1.711	2.064
25	0.256	0.531	0.856	1.058	1.316	1.708	2.060
26	0.256	0.531	0.856	1.058	1.315	1.706	2.056
27	0.256	0.531	0.855	1.057	1.314	1.703	2.052
28	0.256	0.530	0.855	1.056	1.313	1.701	2.048
29	0.256	0.530	0.854	1.055	1.311	1.699	2.045
30	0.256	0.530	0.854	1.055	1.310	1.697	2.042
40	0.255	0.529	0.851	1.050	1.303	1.684	2.021
60	0.254	0.527	0.848	1.045	1.296	1.671	2.000
120	0.254	0.526	0.845	1.041	1.289	1.658	1.980
∞	0.253	0.524	0.842	1.036	1.282	1.645	1.960

TABLE A.4 (continued) Critical Values of the t-Distribution

v	α = 0.02	0.015	0.01	0.0075	0.005	0.0025	0.0005
1	15.895	21.205	31.821	42.434	63.657	127.322	636.590
2	4.849	5.643	6.965	8.073	9.925	14.089	31.598
3	3.482	3.896	4.541	5.047	5.841	7.453	12.924
4	2.999	3.298	3.747	4.088	4.604	5.598	8.610
5	2.757	3.003	3.365	3.634	4.032	4.773	6.869
6	2.612	2.829	3.143	3.372	3.707	4.317	5.959
7	2.517	2.715	2.998	3.203	3.499	4.029	5.408
8	2.449	2.634	2.896	3.085	3.355	3.833	5.041
9	2.398	2.574	2.821	2.998	3.250	3.690	4.781
10	2.359	2.527	2.764	2.932	3.169	3.581	4.587
11	2.328	2.491	2.718	2.879	3.106	3.497	4.437
12	2.303	2.461	2.681	2.836	3.055	3.428	4.318
13	2.282	2.436	2.650	2.801	3.012	3.372	4.221
14	2.264	2.415	2.624	2.771	2.977	3.326	4.140
15	2.249	2.397	2.602	2.746	2.947	3.286	4.073
16	2.235	2.382	2.583	2.724	2.921	3.252	4.015
17	2.224	2.368	2.567	2.706	2.898	3.222	3.965
18	2.214	2.356	2.552	2.689	2.878	3.197	3.922
19	2.205	2.346	2.539	2.674	2.861	3.174	3.883
20	2.197	2.336	2.528	2.661	2.845	3.153	3.849
21	2.189	2.328	2.518	2.649	2.831	3.135	3.819
22	2.183	2.320	2.508	2.639	2.819	3.119	3.792
23	2.177	2.313	2.500	2.629	2.807	3.104	3.768
24	2.172	2.307	2.492	2.620	2.797	3.091	3.745
25	2.167	2.301	2.485	2.612	2.787	3.078	3.725
26	2.162	2.296	2.479	2.605	2.779	3.067	3.707
27	2.158	2.291	2.473	2.598	2.771	3.057	3.690
28	2.154	2.286	2.467	2.592	2.763	3.047	3.674
29	2.150	2.282	2.462	2.586	2.756	3.038	3.659
30	2.147	2.278	2.457	2.581	2.750	3.030	3.646
40	2.125	2.250	2.423	2.542	2.704	2.971	3.551
60	2.099	2.223	2.390	2.504	2.660	2.915	3.460
120	2.076	2.196	2.358	2.468	2.617	2.860	3.373
∞	2.054	2.170	2.326	2.432	2.576	2.807	3.291

L-3/T-2/ME Date : 17/12/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2010-2011

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.

SECTION – A

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

Thermophysical properties of water, heat exchanger curves relevant formulas are supplied.

1\. (a) Define mass transfer coefficient. State and explain Fick's law. **(10)**

(b) To maintain a Pressure Close to 1 atm, an industrial pipe line containing ammonia gas is vented to ambient air. Venting is accomplished by tapping the pipe and inserting a 3-mm diameter tube, which extends for 15 meter in the atmosphere. With the entire system operating at 25°C, calculate the mass rate of ammonia lost to the atmosphere and the mass rate of contamination of the pipe with air. What are the mole and mass fractions of air in the pipe when the ammonia flow rate is 5 kg/hr. Assume $D_{AB} = 0.28 \times 10^{-4}$ m²/s, $R = 8.205 \times 10^{-2} \dfrac{m^3.atm}{kmol.k}$ **(10)**

(c) Derive and discuss the relation $h/h_D = \rho C_p L_e^{2/3}$, where the symbols have their usual meanings. **(15)**

2\. (a) Illustrate with sketches the temperature profiles for hot and cold fluids as a function of the distance along the flow path for (i) parallel-flow heat exchangers, (ii) counter-flow exchangers, (iii) condenser, and (iv) gas-fired boiler. **(10)**

(b) Hot exhaust gases, which enter a finned-tube, cross-flow heat exchanger at 300°C and leave at 110°C, are used to heat pressurized water at a flow rate of 1 kg/s from 35 to 120°C. The exhaust gas specific heat is approximately 1000 J/kg.K and the overall heat transfer coefficient based on the gas-side surface area is 90 W/m².K. Determine the gas-side surface area by (i) LMTD method (ii) ε-NTU method and discuss. Make necessary assumptions. **(25)**

3\. (a) Describe the mechanism of condensation heat transfer on a vertical plate. How does the presence of a noncondensable gas in a vapor influence the condensation heat transfer rate? **(10)**

(b) Consider film-wise condensation on the outer surfaces of a tube whose length is 10 times its diameter. For which orientation of the tube will the heat transfer rate more: horizontal or vertical? Explain. **(10)**

(c) Saturated steam at 1 atmospheric pressure condenses on a 2-m-high and 3-m-wide vertical plate that is maintained at 80°C by circulating cooling water through the other side. Calculate (i) the rate of heat transfer by condensation to the plate (ii) the rate at which the condensate drips off the plate at the bottom. (iii) what would you answer be if the plate were tilted 30° from the vertical. **(15)**

Contd P/2

ME 303

4. (a) What are the differences between (i) pool boiling and flow boiling (ii) saturated boiling and subcooled boiling (iii) nucleate boiling and film boiling. **(12)**

(b) In a gas-fired boiler, water is boiled at 150°C by hot gases flowing through 50-meter-long, 5 cm-outer-diameter mechanically polished stainless-steel pipes submerged in water. If the outer-surface temperature of the pipe is 160°C, calculate (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. Assume Cs-f = 0.0130. **(23)**

SECTION – B

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

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

5. (a) Consider two fluids, one with a large coefficient of volume expansion and the other with a small one. In what fluid will a hot surface initiate stronger natural convection currents? Why? Assume the viscosity of the fluids to be the same. **(5)**

(b) During air cooling of potatoes, the heat transfer coefficient for combined convection, radiation, and evaporation is determined experimentally to be as shown: **(10)**

Air Velocity, m/s	Heat Transfer Coefficient, $W/m^2 . °C$
0.66	14.0
1.00	19.1
1.36	20.2
1.73	24.4

Consider a 10-cm-diameter potato initially at 20°C with a thermal conductivity of 0.49 W/m.°C. Potatoes are cooled by air at 5°C at a velocity of 1 m/s. Determine the initial rate of heat transfer from a potato, and the initial value of the temperature gradient in the potato at the surface.

(c) Oil flow in a journal bearing can be treated as parallel flow between two large isothermal plates with one plate moving at a constant velocity of 12 m/s and the other stationary. Consider such a flow with a uniform spacing of 0.7 mm between the plates. The temperatures of the upper and lower plates are 40°C and 15°C, respectively. By simplifying and solving the continuity, momentum, and energy equations, determine (i) the velocity and temperature distributions in the oil, (ii) the maximum temperature and where it occurs, and (iii) the heat flux from the oil to each plate. **(20)**

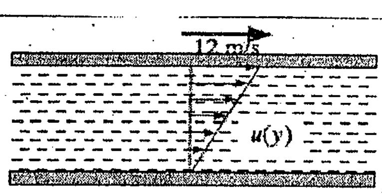


Figure for the Q. No. 5 (c)

6. (a) The forming section of a plastics plant puts out a continuous sheet of plastic that is 1.2 m wide and 2 mm thick at a rate of 15 m/min. The temperature of the plastic sheet is 90°C when it is exposed to the surrounding air, and the sheet is subjected to air flow at 30°C at a velocity of 3 m/s on both sides along its surfaces normal to the direction of motion of the sheet. The width of the air cooling section is such that a fixed point on the plastic sheet passes through that section in 2 s. Determine the rate of heat transfer from the plastic sheet to the air. **(20)**

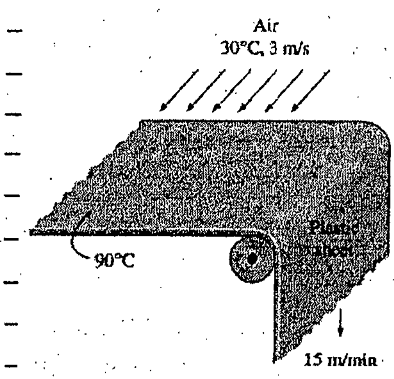


Figure for the Q. No. 6(a)

(b) Consider a 50-cm-diamter and 95-cm-long hot water tank. The tank is placed horizontally on the roof of a house. The water inside the tank is heated to 80°C by a flat-plate solar collector during the day. The tank is then exposed to windy air at 18°C with an average velocity of 40 km/h during the night. Estimate the temperature of the tank after a 45-min period. Assume the tank surface to be at the same temperature as the water inside, and the heat transfer coefficient on the top and bottom surfaces to be the same as that on the side surface. **(15)**

7. (a) Consider the flow of 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 passes through icy waters of a lake at 0°C. Measurements indicate that the surface temperature of the pipe is very nearly 0°C. Disregarding the thermal resistance of the pipe material, determine (i) the temperature of the oil when the pipe leaves the lake, (ii) the rate of heat transfer from the oil, and (ii) the pumping power required to overcome the pressure losses and to maintain the flow oil in the pipe. **(20)**

(b) Air enters a 7-m-long section rectangular duct of cross section 15 cm × 20 cm at 50°C at an average velocity of 7 m/s. If the walls of the duct are maintained at 10°C, determine (i) the outlet temperature of the air, (ii) the rate of heat transfer from the air, and (iii) the fan power needed to overcome the pressure losses in this section of the duct. **(15)**

Contd P/4

ME 303

8. (a) Consider a 15-cm × 20-cm printed circuit board (PCB) that has electronic components on one side. The board is placed in a room at 20°C. The heat loss from the back surface of the board is negligible. If the circuit board is dissipating 8 W of power in steady operation, determine the average temperature of the hot surface of the board, assuming the board is (i) vertical, and (ii) horizontal with hot surface facing up. Take the emissivity of the surface of the board to be 0.8 and assume the surrounding surfaces to be at the same temperature as the air in the room. **(15)**

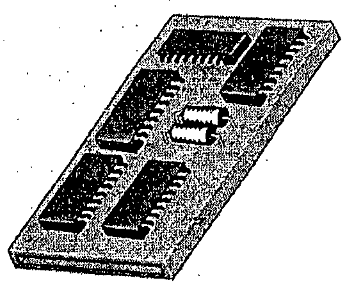


Figure for the Q. No. 8(a)

(b) A solar collector consists of a horizontal aluminum tube of outer diameter 4 cm enclosed in a concentric thin glass tube of 7 cm diameter. Water is heated as it flows through the aluminum tube, and the annular space between the aluminum and glass tubes is filled with air at 1 atm pressure. The pump circulating the water fails during a clear day, and the water temperature in the tube starts rising. The aluminum tube absorbs solar radiation at a rate of 20 W per meter length, and the temperature of the ambient air outside is 30°C. **(20)**

Disregarding any heat loss by radiation, determine the temperature of the aluminum tube when steady operation is established (i.e., when the net heat loss from the tube equals the amount of solar energy absorbed by the tube).

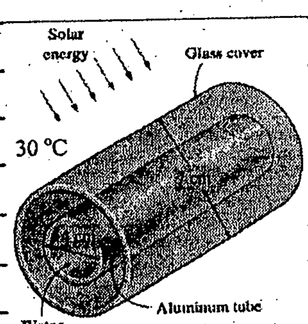


Figure for the Q. No. 8(b)

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6 Thermophysical properties of saturated water

…ERA- …E, T	PRESSURE, P (bars)[a]	SPECIFIC VOLUME (m^3/kg) $v_f \cdot 10^3$	v_g	HEAT OF VAPORIZATION, h_{fg} (kJ/kg)	SPECIFIC HEAT (kJ/kg·K) $c_{p,f}$	$c_{p,g}$	VISCOSITY ($N \cdot s/m^2$) $\mu_f \cdot 10^6$	$\mu_g \cdot 10^6$	THERMAL CONDUCTIVITY (W/m·K) $k_f \cdot 10^3$	$k_g \cdot 10^3$	PRANDTL NUMBER Pr_f	Pr_g	SURFACE TENSION, $\sigma_f \cdot 10^3$ (N/m)	EXPANSION COEFFICIENT, $\beta_f \cdot 10^6$ (K^{-1})	TEMPERATURE, T (K)
3.15	0.00611	1.000	206.3	2502	4.217	1.854	1750	8.02	569	18.2	12.99	0.815	75.5	−68.05	273.15
75	0.00697	1.000	181.7	2497	4.211	1.855	1652	8.09	574	18.3	12.22	0.817	75.3	−32.74	275
280	0.00990	1.000	130.4	2485	4.198	1.858	1422	8.29	582	18.6	10.26	0.825	74.8	46.04	280
285	0.01387	1.000	99.4	2473	4.189	1.861	1225	8.49	590	18.9	8.81	0.833	74.3	114.1	285
290	0.01917	1.001	69.7	2461	4.184	1.864	1080	8.69	598	19.3	7.56	0.841	73.7	174.0	290
295	0.02617	1.002	51.94	2449	4.181	1.868	959	8.89	606	19.5	6.62	0.849	72.7	227.5	295
300	0.03531	1.003	39.13	2438	4.179	1.872	855	9.09	613	19.6	5.83	0.857	71.7	276.1	300
305	0.04712	1.005	27.90	2426	4.178	1.877	769	9.29	620	20.1	5.20	0.865	70.9	320.6	305
310	0.06221	1.007	22.93	2414	4.178	1.882	695	9.49	628	20.4	4.62	0.873	70.0	361.9	310
315	0.08132	1.009	17.82	2402	4.179	1.888	631	9.69	634	20.7	4.16	0.883	69.2	400.4	315
320	0.1053	1.011	13.98	2390	4.180	1.895	577	9.89	640	21.0	5.77	0.894	68.3	436.7	320
325	0.1351	1.013	11.06	2378	4.182	1.903	528	10.09	645	21.3	3.42	0.901	67.5	471.2	325
330	0.1719	1.016	8.82	2366	4.184	1.911	489	10.29	650	21.7	3.15	0.908	66.6	504.0	330
335	0.2167	1.018	7.09	2354	4.186	1.920	453	10.49	656	22.0	2.88	0.916	65.8	535.5	335
340	0.2713	1.021	5.74	2342	4.188	1.930	420	10.69	660	22.3	2.66	0.925	64.9	566.0	340
345	0.3372	1.024	4.683	2329	4.191	1.941	389	10.89	668	22.6	2.45	0.933	64.1	595.4	345
350	0.4163	1.027	3.846	2317	4.195	1.954	365	11.09	668	23.0	2.29	0.942	63.2	624.2	350
355	0.5100	1.030	3.180	2304	4.199	1.968	343	11.29	671	23.3	2.14	0.951	62.3	652.3	355
360	0.6209	1.034	2.645	2291	4.203	1.983	324	11.49	674	23.7	2.02	0.960	61.4	697.9	360
365	0.7514	1.038	2.212	2278	4.209	1.999	306	11.69	677	24.1	1.91	0.969	60.5	707.1	365
370	0.9040	1.041	1.861	2265	4.214	2.017	289	11.89	679	24.5	1.80	0.978	59.5	728.7	370
373.15	1.0133	1.044	1.679	2257	4.217	2.029	279	12.02	680	24.8	1.76	0.984	58.9	750.1	373.15
375	1.0815	1.045	1.574	2252	4.220	2.036	274	12.09	681	24.9	1.70	0.987	58.6	761	375
380	1.2869	1.049	1.337	2239	4.226	2.057	260	12.29	683	25.4	1.61	0.999	57.6	788	380
385	1.5233	1.053	1.142	2225	4.232	2.080	248	12.49	685	25.8	1.53	1.004	56.6	814	385
390	1.794	1.058	0.980	2212	4.239	2.104	237	12.69	686	26.3	1.47	1.013	55.6	841	390
400	2.455	1.067	0.731	2183	4.256	2.158	217	13.05	688	27.2	1.34	1.033	53.6	896	400
410	3.302	1.077	0.553	2153	4.278	2.221	200	13.42	688	28.2	1.24	1.054	51.5	952	410
420	4.370	1.088	0.425	2123	4.302	2.291	185	13.79	688	29.8	1.16	1.075	49.4	1010	420
430	5.699	1.099	0.331	2091	4.331	2.369	173	14.14	685	30.4	1.09	1.10	47.2		430
440	7.333	1.110	0.261	2059	4.36	2.46	162	14.50	682	31.7	1.04	1.12	45.1		440
450	9.319	1.123	0.208	2024	4.40	2.56	152	14.85	678	33.1	0.99	1.14	42.9		450
460	11.71	1.137	0.167	1989	4.44	2.68	143	15.19	673	34.6	0.95	1.17	40.7		460
470	14.55	1.152	0.136	1951	4.48	2.79	136	15.54	667	36.3	0.92	1.20	38.5		470
480	17.90	1.167	0.111	1912	4.53	2.94	129	15.88	660	38.1	0.89	1.23	36.2		480
490	21.83	1.184	0.0922	1870	4.59	3.10	124	16.23	651	40.1	0.87	1.25	33.9	—	490
500	26.40	1.203	0.0766	1825	4.66	3.27	118	16.59	642	42.3	0.86	1.28	31.6	—	500
510	31.66	1.222	0.0631	1779	4.74	3.47	113	16.95	631	44.7	0.85	1.31	29.3	—	510
520	37.70	1.244	0.0525	1730	4.84	3.70	108	17.33	621	47.5	0.84	1.35	26.9	—	520
530	44.58	1.268	0.0445	1679	4.95	3.96	104	17.72	608	50.6	0.85	1.39	24.5	—	530
540	52.38	1.294	0.0375	1622	5.08	4.27	101	18.1	594	54.0	0.86	1.43	22.1	—	540
550	61.19	1.323	0.0317	1564	5.24	4.64	97	18.6	580	58.3	0.87	1.47	19.7	—	550
560	71.08	1.355	0.0269	1499	5.43	5.09	94	19.1	563	63.7	0.90	1.52	17.3	—	560
570	82.16	1.392	0.0228	1429	5.68	5.67	91	19.7	548	76.7	0.94	1.59	15.0	—	570
580	94.51	1.433	0.0193	1353	6.00	6.40	88	20.4	528	76.7	0.99	1.68	12.8	—	580
590	108.3	1.482	0.0163	1274	6.41	7.35	84	21.5	513	84.1	1.05	1.84	10.5	—	590
600	123.5	1.541	0.0137	1176	7.00	8.75	81	22.7	497	92.9	1.14	2.15	8.4	—	600
610	137.3	1.612	0.0115	1068	7.85	11.1	77	24.1	467	103	1.30	2.60	6.3	—	610
620	159.1	1.705	0.0094	941	9.35	15.4	72	25.9	444	114	1.52	3.46	4.5	—	620
625	169.1	1.778	0.0085	858	10.6	18.3	70	27.0	430	121	1.65	4.20	3.5	—	625
630	179.7	1.856	0.0075	781	12.6	22.1	67	28.0	412	130	2.0	4.8	2.6	—	630
635	190.9	1.935	0.0066	683	16.4	27.6	64	30.0	392	141	2.7	6.0	1.5	—	635
640	202.7	2.075	0.0057	560	26	42	59	32.0	367	155	4.2	9.6	0.8	—	640
645	215.2	2.351	0.0045	361	90	—	54	37.0	331	178	12	26	0.1	—	645
647.3[b]	221.2	3.170	0.0032	0	∞	∞	45	45.0	238	238	∞	∞	0.0	—	647.3[b]

[a] 1 bar = 10^5 N/m^2.
[b] Critical temperature.
Adapted from Reference 19.

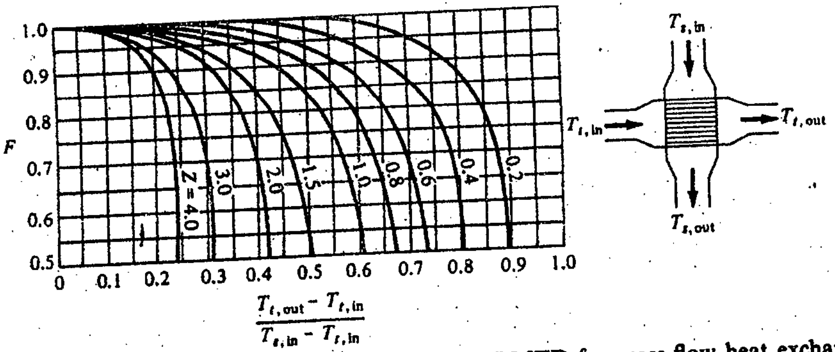

Figure 8.14 Correction factor to counterflow LMTD for cross-flow heat exchangers with the fluid on the shell side mixed, the other fluid unmixed, and one tube pass. [Extracted from R. A. Bowman, A. C. Mueller, and W. M. Nagel (7), with permission of the publishers, the American Society of Mechanical Engineers.]

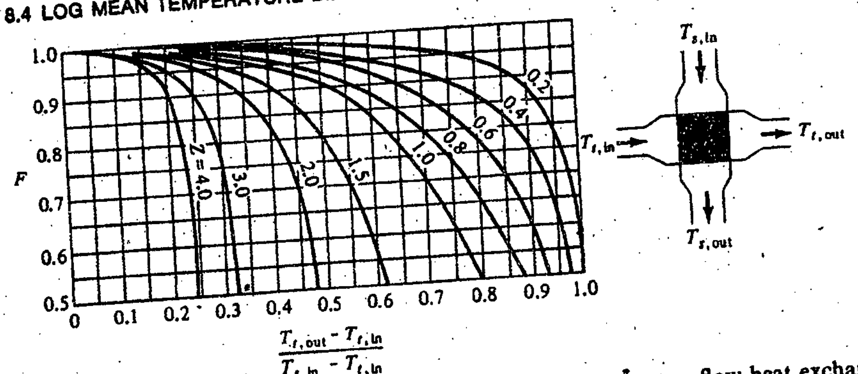

Figure 8.15 Correction factor to counterflow LMTD for a cross-flow heat exchanger with both fluids unmixed and one tube pass. [Extracted from R. A. Bowman, A. C. Mueller, and W. M. Nagel (7); with permission of the publishers, the American Society of Mechanical Engineers.)

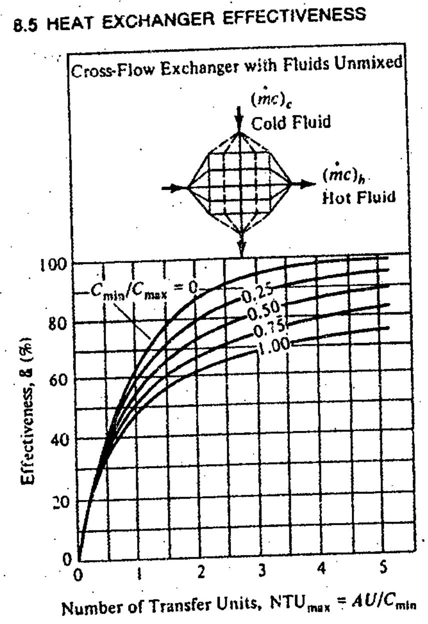

Figure 8.19 Heat exchanger effectiveness for cross-flow with both fluids unmixed. [With permission from W. M. Kays and A. L. London (1).]

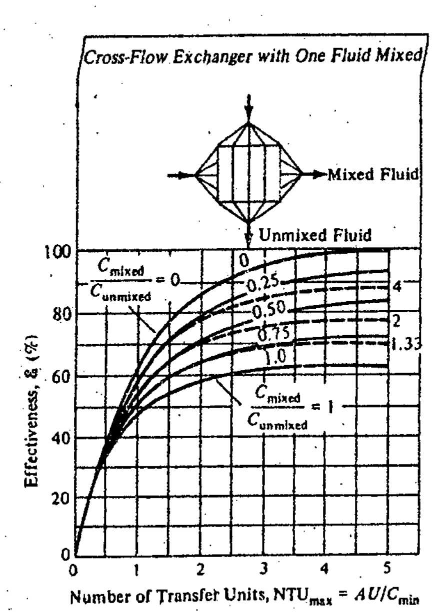

Figure 8.20 Heat exchanger effectiveness for cross-flow with one fluid mixed and the other unmixed. When $C_{mixed}/C_{unmixed} > 1$, NTU_{max} is based on $C_{unmixed}$. [With permission from W. M. Kays and A. L. London (1).]

Nucleate Pool Boiling

$$q''_s = \mu_l h_{fg}\left[\frac{g(\rho_l-\rho_v)}{\sigma}\right]^{1/2}\left(\frac{c_{p,l}\Delta T_e}{C_{s,f}h_{fg}Pr_l^n}\right)^3$$

Critical Heat Flux for Nucleate Pool Boiling

$$q''_{max} = 0.149 h_{fg}\rho_v\left[\frac{\sigma g(\rho_l-\rho_v)}{\rho_v^2}\right]^{1/4}$$

Filmwise Condensation

$$\bar{h}_c = 0.725\left[\frac{\rho_l(\rho_l-\rho_v)gh'_{fg}k^3}{D\mu_l(T_{sv}-T_s)}\right]^{1/4}$$

$$\bar{h}_c = 0.943\left[\frac{\rho_l(\rho_l-\rho_v)gh'_{fg}k^3}{\mu_l L(T_{sv}-T_s)}\right]^{1/4}$$

Table 1:

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
				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

Table 2:

Properties of saturated water

Temp. T, °C	Saturation Pressure P_{sat}, kPa	Density ρ, kg/m³ Liquid	Density ρ, kg/m³ Vapor	Enthalpy of Vaporization h_{fg}, kJ/kg	Specific Heat c_p, J/kg·K Liquid	Specific Heat c_p, J/kg·K Vapor	Thermal Conductivity k, W/m·K Liquid	Thermal Conductivity k, W/m·K Vapor	Dynamic Viscosity μ, kg/m·s Liquid	Dynamic Viscosity μ, kg/m·s Vapor	Prandtl Number Pr Liquid	Prandtl Number Pr 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 3:

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

The continuity, momentum, and energy equations for steady two-dimensional incompressible flow with constant properties are determined from mass, momentum, and energy balances to be

Continuity:
$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

x-momentum:
$$\rho\left(u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\right) = \mu\frac{\partial^2 u}{\partial y^2} - \frac{\partial P}{\partial x}$$

Energy:
$$\rho C_p\left[u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y}\right] = k\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right) + \mu\Phi$$

where the *viscous dissipation function* Φ is

$$\Phi = 2\left[\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial y}\right)^2\right] + \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right)^2$$

The average Nusselt number relations for flow over a flat plate are:

Laminar: $\mathrm{Nu} = \frac{hL}{k} = 0.664\,\mathrm{Re}_L^{0.5}\,\mathrm{Pr}^{1/3}$ $\quad \mathrm{Re}_L < 5 \times 10^5$

Turbulent:

$$\mathrm{Nu} = \frac{hL}{k} = 0.037\,\mathrm{Re}_L^{0.8}\,\mathrm{Pr}^{1/3} \qquad 0.6 \le \mathrm{Pr} \le 60, \quad 5 \times 10^5 \le \mathrm{Re}_L \le 10^7$$

Combined:

$$\mathrm{Nu} = \frac{hL}{k} = (0.037\,\mathrm{Re}_L^{0.8} - 871)\,\mathrm{Pr}^{1/3}, \qquad 0.6 \le \mathrm{Pr} \le 60, \quad 5 \times 10^5 \le \mathrm{Re}_L \le 10^7$$

The average Nusselt numbers for cross flow over a *cylinder* and *sphere* are

$$Nu_{cyl} = \frac{hD}{k} = 0.3 + \frac{0.62\,Re^{1/2}\,Pr^{1/3}}{[1 + (0.4/Pr)^{2/3}]^{1/4}}\left[1 + \left(\frac{Re}{282{,}000}\right)^{5/8}\right]^{4/5}$$

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which is valid for Re Pr > 0.2, and

$$Nu_{sph} = \frac{hD}{k} = 2 + [0.4\,Re^{1/2} + 0.06\,Re^{2/3}]Pr^{0.4}\left(\frac{\mu_\infty}{\mu_s}\right)^{1/4}$$

which is valid for $3.5 \leq Re \leq 80{,}000$ and $0.7 \leq Pr \leq 380$.

The length of the region from the tube inlet to the point at which the boundary layer merges at the centerline is the *hydrodynamic entry length* L_h. The region beyond the entrance region in which the velocity profile is fully developed is the *hydrodynamically fully developed region*. The length of the region of flow over which the thermal boundary layer develops and reaches the tube center is the *thermal entry length* L_t. The region in which the flow is both hydrodynamically and thermally developed is the *fully developed flow region*. The entry lengths are given by

$$L_{h,\,laminar} \approx 0.05\,Re\,D$$
$$L_{t,\,laminar} \approx 0.05\,Re\,Pr\,D = Pr\,L_{h,\,laminar}$$
$$L_{h,\,turbulent} \approx L_{t,\,turbulent} \approx 10D$$

For $\dot{q}_s$ = constant, the rate of heat transfer is expressed as

$$\dot{Q} = \dot{q}_s A_s = \dot{m} C_p (T_e - T_i)$$

For T_s = constant, we have

$$\dot{Q} = hA_s \Delta T_{ln} = \dot{m} C_p (T_e - T_i)$$
$$T_e = T_s - (T_s - T_i)\exp(-hA_s/\dot{m}C_p)$$
$$\Delta T_{ln} = \frac{T_i - T_e}{\ln[(T_s - T_e)/(T_s - T_i)]} = \frac{\Delta T_e - \Delta T_i}{\ln(\Delta T_e/\Delta T_i)}$$

The pressure drop and required pumping power for a volume flow rate of $\dot{V}$ are

$$\Delta P = f\frac{L}{D}\frac{\rho \mathcal{V}_m^2}{2} \quad \text{and} \quad \dot{W}_{pump} = \dot{V}\Delta P$$

For *fully developed laminar flow* in a circular pipe, we have:

$$\mathcal{V}(r) = 2\mathcal{V}_m\left(1 - \frac{r^2}{R^2}\right) = \mathcal{V}_{max}\left(1 - \frac{r^2}{R^2}\right)$$
$$f = \frac{64\mu}{\rho D \mathcal{V}_m} = \frac{64}{Re}$$
$$\dot{V} = \mathcal{V}_{ave} A_c = \frac{\Delta P R^2}{8\mu L}\pi R^2 = \frac{\pi R^4 \Delta P}{8\mu L} = \frac{\pi R^4 \Delta P}{128\mu L}$$

Circular tube, laminar ($\dot{q}_s$ = constant): $Nu = \frac{hD}{k} = 4.36$

Circular tube, laminar (T_s = constant): $Nu = \frac{hD}{k} = 3.66$

For *developing laminar flow* in the entrance region with constant surface temperature, we have

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

Circular tube: $$Nu = 1.86\left(\frac{Re\,Pr\,D}{L}\right)^{1/3}\left(\frac{\mu_b}{\mu_s}\right)^{0.14}$$

Parallel plates: $$Nu = 7.54 + \frac{0.03(D_h/L)\,Re\,Pr}{1 + 0.016[(D_h/L)\,Re\,Pr]^{2/3}}$$

For *fully developed turbulent flow with smooth surfaces,* we have

$$f = (0.790 \ln \mathrm{Re} - 1.64)^{-2} \qquad 10^4 < \mathrm{Re} < 10^6$$

$$\mathrm{Nu} = 0.125 f \,\mathrm{Re}\, \mathrm{Pr}^{1/3}$$

$$\mathrm{Nu} = 0.023\, \mathrm{Re}^{0.8}\, \mathrm{Pr}^{1/3} \quad \begin{pmatrix} 0.7 \le \mathrm{Pr} \le 160 \\ \mathrm{Re} > 10{,}000 \end{pmatrix}$$

$\mathrm{Nu} = 0.023\, \mathrm{Re}^{0.8}\, \mathrm{Pr}^{n}$ with $n = 0.4$ for *heating* and 0.3 for *cooling* of fluid

$$\mathrm{Nu} = \frac{(f/8)(\mathrm{Re} - 1000)\,\mathrm{Pr}}{1 + 12.7(f/8)^{0.5}(\mathrm{Pr}^{2/3} - 1)} \quad \begin{pmatrix} 0.5 \le \mathrm{Pr} \le 2000 \\ 3 \times 10^3 < \mathrm{Re} < 5 \times 10^6 \end{pmatrix}$$

The fluid properties are evaluated at the *bulk mean fluid temperature* $T_b = (T_i + T_e)/2$. For liquid metal flow in the range of $10^4 < \mathrm{Re} < 10^6$ we have:

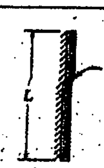
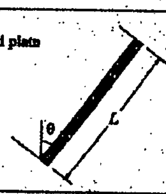
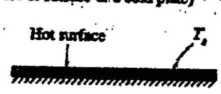
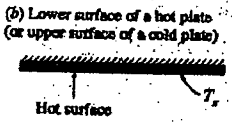
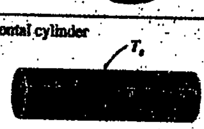
T_s = constant: $\quad \mathrm{Nu} = 4.8 + 0.0156\, \mathrm{Re}^{0.85}\, \mathrm{Pr}_s^{0.93}$

$\dot{q}_s$ = constant: $\quad \mathrm{Nu} = 6.3 + 0.0167\, \mathrm{Re}^{0.85}\, \mathrm{Pr}_s^{0.93}$

The friction factor can be determined for the case of fully developed turbulent flow to be

$$f = 0.184\,\mathrm{Re}^{-0.2}$$

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	$\mathrm{Nu} = 0.59\mathrm{Ra}_L^{1/4}$ $\mathrm{Nu} = 0.1\mathrm{Ra}_L^{1/3}$ $\mathrm{Nu} = \left\{0.825 + \frac{0.387\mathrm{Ra}_L^{1/6}}{[1 + (0.492/\mathrm{Pr})^{9/16}]^{8/27}}\right\}^2$ (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 $\mathrm{Ra} < 10^9$	
Horiontal plate (Surface area A and perimeter p) (a) Upper surface of a hot plate (or lower surface of a cold plate) 	A_s/p	10^4–10^7 10^7–10^{11}	$\mathrm{Nu} = 0.54\mathrm{Ra}_L^{1/4}$ $\mathrm{Nu} = 0.15\mathrm{Ra}_L^{1/3}$	(9-22) (9-23)
(b) Lower surface of a hot plate (or upper surface of a cold plate) 		10^5–10^{11}	$\mathrm{Nu} = 0.27\mathrm{Ra}_L^{1/4}$	(9-24)
Vertical cylinder 	L		A vertical cylinder can be treated as a vertical plate when $D \ge \frac{35L}{\mathrm{Gr}_L^{1/4}}$	
Horizontal cylinder 	D	$\mathrm{Ra}_D \le 10^{12}$	$\mathrm{Nu} = \left\{0.6 + \frac{0.387\mathrm{Ra}_D^{1/6}}{[1 + (0.559/\mathrm{Pr})^{9/16}]^{8/27}}\right\}^2$	(9-25)
Sphere 	D	$\mathrm{Ra}_D \le 10^{11}$ ($\mathrm{Pr} \ge 0.7$)	$\mathrm{Nu} = 2 + \frac{0.589\mathrm{Ra}_D^{1/4}}{[1 + (0.469/\mathrm{Pr})^{9/16}]^{4/9}}$	(9-26)

For *concentric horizontal cylinders,* the rate of heat transfer through the annular space between the cylinders by natural convection per unit length is

$$\dot{Q} = \frac{2\pi k_{\mathrm{eff}}}{\ln(D_o/D_i)}(T_i - T_o)$$

where

$$\frac{k_{\mathrm{eff}}}{k} = 0.386\left(\frac{\mathrm{Pr}}{0.861 + \mathrm{Pr}}\right)^{1/4}(F_{\mathrm{cyl}}\mathrm{Ra}_L)^{1/4}$$

and

$$F_{\mathrm{cyl}} = \frac{[\ln(D_o/D_i)]^4}{L_c^3(D_i^{-3/5} + D_o^{-3/5})^5}$$

L-3/T-2/ME **Date : 31/12/2012**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2010-2011

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

Full Marks : 210 Time : 3 Hours

The questions are of equal value.

'Machine Design Handbook II' may be used.

All symbols have their usual meanings.

Assume any suitable data if needed.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. Design a worm gear set to transmit 7.5 kW at 1200 rpm of the worm with speed ratios m_W = 25. The worm is made of hardened steel and the gear is made of chilled bronze. Consider normal pressure angle, ϕ_n = 20° and the number of start, N_W = 4. Choose suitable factor of safety for your design. Consider limiting endurance strength of chilled bronze as 168 MPa.

2. A pair of spur gears, delivering 75 kW to a reciprocating pump at a pinion speed of 600 rpm, is to serve continuously with indefinite life; minimum number of 20° full depth teeth is 18; m_g = 2.5. Determine suitable values for the module, face width and diameters, if the material is BS 640 M40 alloy steel, hardened and tempered (S_y = 585 MPa, BHN = 250).

3. A 6 × 19 IWRC, IPS wire rope is used for a vertical mine hoist to lift a load of 3.0 tons from a depth of 300 m. The maximum speed of 6 m/s is attained in 5s.
   (a) Determine the size of the wire rope and sheave diameter based on fatigue condition for indefinite life. Choose factor of safety of 1.3 for your design.
   (b) What is the factor of safety for the wire rope in (a) on the static basis?
   (c) Find also the size of the wire rope based on fatigue condition if the life is not to exceed 0.15 million cycles.

4. A pulley of diameter 250 mm is fastened to a machine finished shaft by a key as shown in Fig. for Q. No. 4. The shaft transmits 15 kW of power at 1500 rpm. The shaft material is AISI 1045 QT 316°C. Contact angle of the pulley is 120° and coefficient of friction is 0.30. Stress concentration factor for the profile keyway is 2.0. Determine the shaft diameter based on

Contd P/2

ME 343

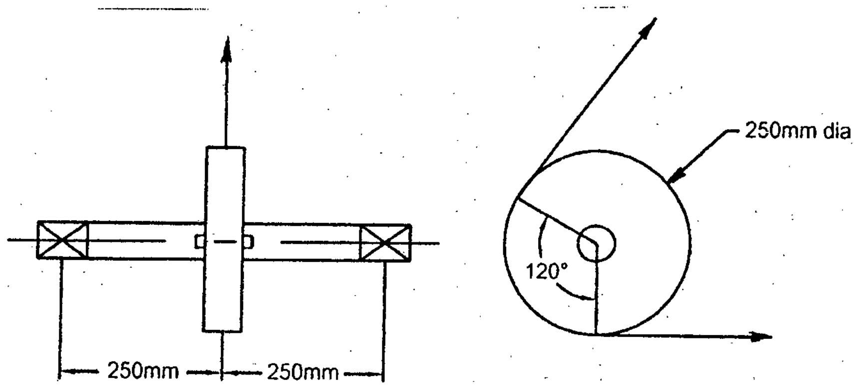
Contd ... Q. No. 4

(a) steady state approach using distortion energy theory

(b) modified Goodman equation

(c)DE-elliptic model

Use factor of safety of 3.0 for steady state approach and 1.3 for modified Goodman equation and DE-elliptic model.



(Fig. for Qs. No. 4)

SECTION – B

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

5. A carbon-steel spring is to be made to carry a ~~vertical~~ variable load of 2 kN to 6 kN. This compression spring is to be filled in a 100 mm cylinder. The spring index is to be between 6 to 10 and spring rate 90 N/mm. Calculate its active coils, free length and solid height.

6. A ball bearing is to carry a radial load of 2 kN and thrust load of 1.3 kN. The bearing operates 8 hr/day for 6 years with light shock at 2500 rpm. With 10% probability of failure, considering outer ring stationary calculate (i) rated 95% life of the bearing (b) its approximate median life (c) If the radial and thrust loads were changed to 1.8 kN and 1.1 kN respectively, determine the probability of the bearing surviving the specified life.

7. The load on a 100 mm full bearing is 8 kN. n = 320 rpm, $l/d = 1.0$, C = 50 μm, inlet oil temperature 40 °C, h_0 = 0.022 mm, (a) Select an oil that will closely accord with the stated conditions. For the selected oil, determine (b) the frictional loss (c) the hydrodynamic oil flow through the bearing (d) the amount of end leakage (e) the maximum pressure.

8. A 50 kW compensator started motor running at 900 rpm is used to drive a reciprocating compressor when D_1 = 400mm and D_2 = 1350 mm. Cemented joint, c = 5 m. Choice a leather flat belt for this drive. If the initial tension is such that $F_1/F_2 = 2$ what is the stress in that tight side of the belt?

L-3/T-2/ME Date : 31/12/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2010-2011

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

Full Marks : 210 Time : 3 Hours

The questions are of equal value.

'Machine Design Handbook II' may be used.

All symbols have their usual meanings.

Assume any suitable data if needed.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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Contd P/2

ME 343

Contd ... Q. No. 4

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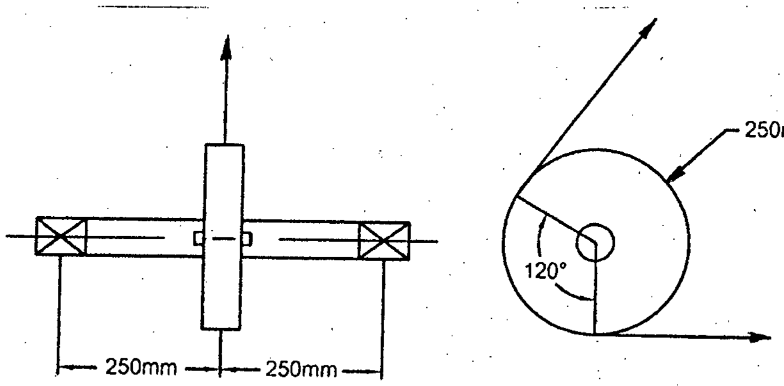
(c)DE-elliptic model

Use factor of safety of 3.0 for steady state approach and 1.3 for modified Goodman equation and DE-elliptic model.



(Fig. for Qs. No. 4)

SECTION – B

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Shorpa 24/12/12

L-3/T-2/ME Date : 24/12/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2010-2011

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

Full Marks : 210 Time : 3 Hours

Assume reasonable data if necessary.

Moody diagram is supplied.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

The questions are of equal value.

1. (a) Explain the term Mach cone. Show that the maximum discharge of compressed air from a large vessel through a converging nozzle takes place when the temperature ratio is about 0.833.

   (b) An airplane is flying at a speed of 1200 km/hr through still air having a pressure of 9×10^4 N/m^2 and temperature – 6 °C. Calculate the pressure, density and temperature of air at stagnation point on the nose of the plane. What is the Mach number? Take k = 1.4 and R = 287 J/kgK.

2. (a) What is shock wave with reference to compressible flow? Deduce an equation in terms of pressure and Mach number considering the upstream and downstream of a normal shock wave.

   (b) In a normal shock wave taking place in an air flow, the upstream pressure, velocity and temperature are 95 kPa absolute, 650 m/s and –21 °C respectively. Find the pressure velocity and temperature just downstream of the shock wave. Take k = 1.4 and R = 287 J/kgK.

3. (a) discuss the different types of similarities which may exist between a model and its prototype.

   (b) A pipe of diameter 1.25 m is required to transport oil of specific gravity 0.85 and viscosity 3 Ns/m^2 at the rate of 2900 l/s. In order to model this flow, water is allowed to flow through a 150 mm diameter pipe having viscosity 1.1 Ns/m^2. Find the velocity and rate of flow in the model pipe.

4. (a) Distinguish between Raleigh's method and Buckingham pi theorem for dimensional analysis with examples.

   (b) Discuss boundary layer with diagrams. Deduce an equation of displacement thickness.

Contd P/2

SECTION – B

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

The figures in the margin indicate full marks.

5. Prove that for a steady laminar flow through a circular pipe, the velocity distribution across the section is parabolic and the average velocity is half of the maximum local velocity. Mention the assumptions considered for this proof. Also mention three practical cases where laminar flow occurs. **(35)**

6. (a) A certain oil is flowing through a 300 m long and 150 mm diameter pipe. The specific gravity of oil is 0.85 and its kinetic viscosity is 7.5×10^{-6} m^2/s. If 20 KW is required to drive the pump whose overall efficiency is 70%, find the flow rate of oil. Consider that the flow is laminar. **(15)**

(b) Find the flow rate of water through a 110 mm diameter and 150 m long commercial steel pipe as shown in Fig. for Q. No. 6(b). In the pipeline there are two elbows (k = 0.9) and a globe valve (k = 10). The coefficient of viscosity of water is 1.02×10^{-3} N s/m^2. **(20)**

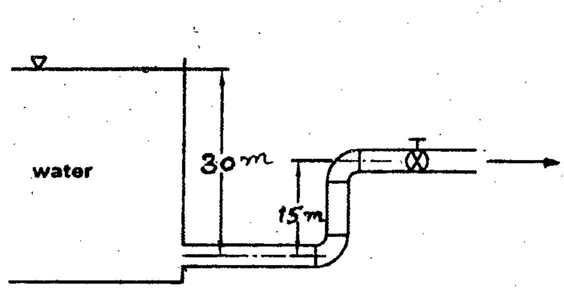

Fig. for Q. No. 6(b)

7. (a) What is meant by the most economical section of a circular open channel? Deduce an expression for the depth of the most economical circular open channel with the condition of maximum discharge. **(17)**

(b) A trapezoidal channel is to be excavated with minimum cost. The flow rate of water is 18 m^3/s and the bed slope is 1 : 2400. Find the dimension of the channel. Take Manning's constant, N = 0.019. **(18)**

8. (a) What is head loss in pipe flow and what is the usefulness of estimating the head losses in pipe flow? **(10)**

(b) Differentiate between the head losses in laminar and turbulent flows. **(5)**

(c) What is Froude number? Explain its physical significance in open channel flow. **(10)**

(d) What is hydraulic jump? State the conditions under which it may ioccur. **(10)**

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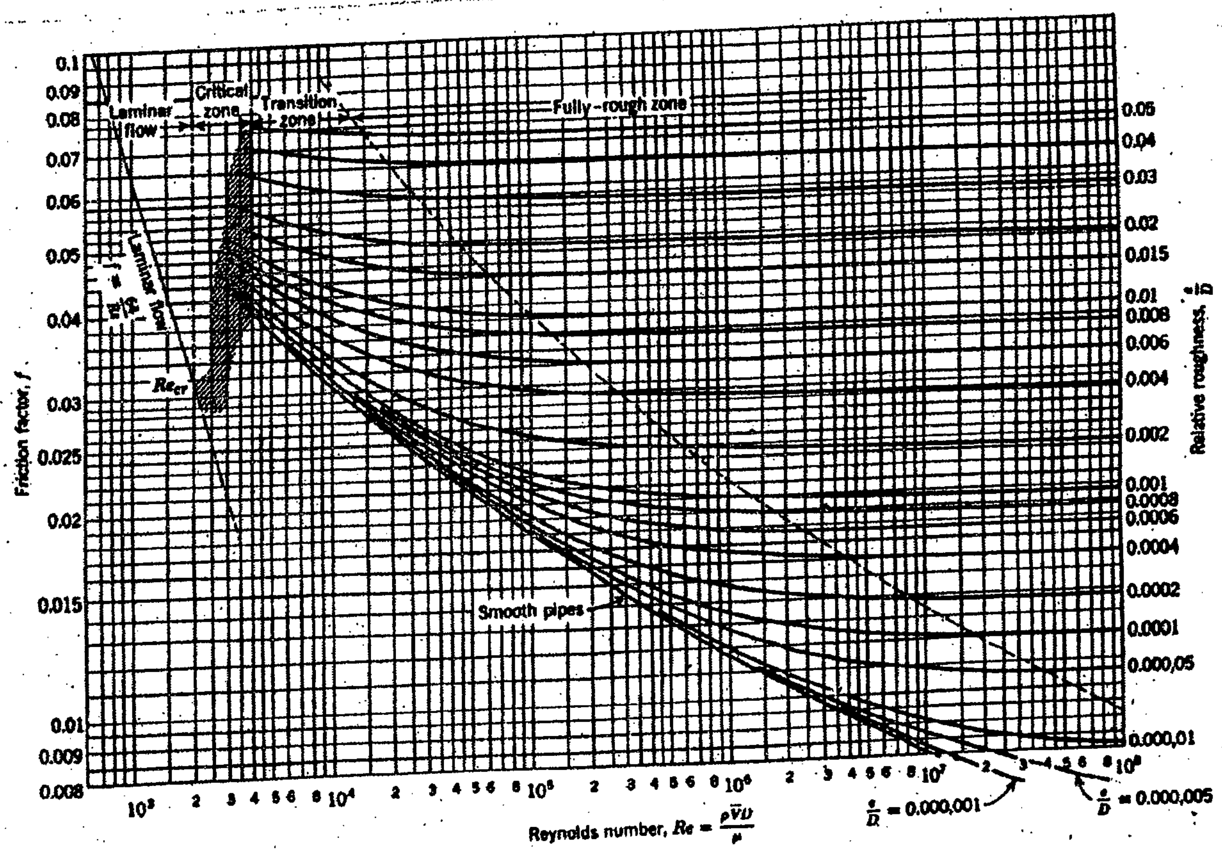

Fig. Moody diagram

	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