L-2/T-2/IPE Date : 22/07/2013

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2011-2012

Sub : **IPE 209** (Engineering Economy)

Full Marks: 140 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) What is "Equal payment series, sinking fund factor"? **($10\frac{1}{3}$)**

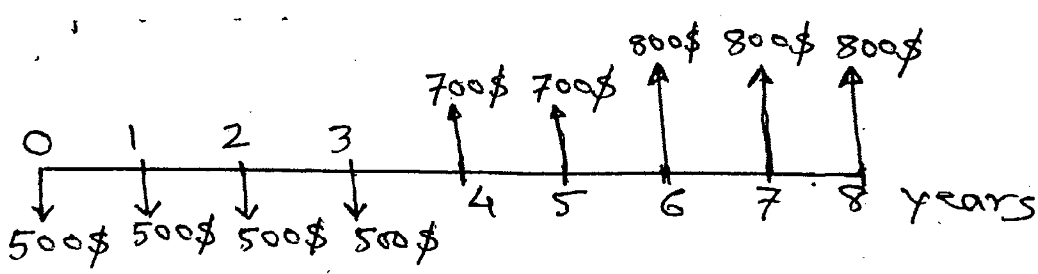
   (b) A company stated that they will pay the production manager \$60,000 as salary in the first year. However, the salary will increase by 15% every year, over a period of 8 years. If the interest rate is 12%, what is the annual equivalent of earnings of the production manager? **(13)**

2. (a) If nominal interest rate is 18%, what is the effective annual interest rate if compounding takes place weekly? If compounding takes place continuously? **(10)**

   (b) A city corporation is considering a profitable project to construct a reservoir in the EPZ. The reservoir will be used to supply treated drinking water to the industries on–payment. The initial construction cost is \$1·00,000. Quarterly operational cost is \$10,000. The city corporation is expecting to earn \$35,000 per quarter, by selling water to the industries. The reservoir is expected to last indefinitely. The city corporation uses an interest rate of 15% per quarter, compounded quarterly. **($13\frac{1}{3}$)**

   Is the project profitable?

3. (a) A financial analyst computes the cash flow of a project, as follows: **(10)**



   The company policy states that MARR is 12% for them. Is the project profitable?

   (b) The FM Electronic Inc. wants to buy an electronic assembly machine at an initial cost of 10,000\$. The machine is expected to generate yearly profit of 2000\$. The machine can be sold at a salvage value of 3500\$ after any year. **($13\frac{1}{3}$)**

   What is the payback period of this machine?

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4. (a) What is Price Index? What is the equation that relates inflation rate and consumer Price Index (CPI)? **(3+7)**

(b) Prove that **(13⅓)**

$$\left(1+\bar{f}\right)^n = \frac{1}{\left(1-\bar{k}\right)^n}$$

where, $\bar{f}$ = Average inflation rate

$\bar{k}$ = Average rate of loss in purchasing power.

SECTION – B

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

5. (a) A small aerospace company is evaluating two alternatives: the purchase of an automatic–feed machine and a manual–feed machine for a product's finishing process. The auto–feed machine has an initial cost of \$23,000, an estimated salvage value of \$4000 and a predicted life of 10 years. One person will operate the machine at a cost of \$12 an hour. The expected output is 8 tons per hour. Annual maintenance and operating cost is expected to be \$3500. **(15⅓)**

The alternative manual–feed machine has a first cost of \$8000, no expected salvage value, a 5–year life, and an output of 6 tons per hour. However, three workers will be required at \$8 an hour each. The machine will have an annual maintenance and operation cost of \$1500. All invested capital is expected to generate a market return of 15% per year before taxes.

(i) How many tons per year must be finished in order to justify the higher purchase cost of the auto–feed machine?

(ii) If a requirement to finish 2000 tons per year is anticipated, which machine should be purchased?

(b) A company which sells reverse osmosis water purifiers has the following fixed and variable cost components for its product over a 1–year period. **(8)**

Fixed costs, \$		Variable costs, \$ per unit	
Administrative	10000	Materials	5
Lease cost	20000	Labor	3
Insurance	7000	Indirect labor	5
Utilities	3000	Other overhead	20
Taxes	10000		
Other operations	50000		

(i) Determine the revenue per unit required to break even if the domestic sales volume is estimated to be 5000 units.

(ii) If foreign sales of 3000 units can be added to the 5000 unit domestic sales, determine the total profit provided the revenue per unit determined in part (a) is realized.

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6. (a) While comparing alternatives with unequal lives, what do you understand by Study Period? **(5)**

(b) Briefly describe different types of investment proposals. **(6)**

(c) A small telephone company is considering two mutually exclusive proposals for the installation of automatic switching equipment. Alternative A1 includes a future expansion, will cost \$360,000 now, will have a 12 year service life and will entail annual operating cost of \$95,000. At the end of year 5 the system will be expanded at a cost of \$300,000. This additional equipment will have a service life of 10 years and will increase operating cost by \$60,000 per year. Alternative A2 is to install a system with full capacity. This system will require an initial investment of \$580,000, will have a 12–year service life, and will entail annual operating costs of \$110,000 the first 5 years and \$170,000 thereafter. If the service will be required for at least the next 10 years, determine which alternative should be implemented, using the following methods. The interest rate is 15%. **($12\frac{1}{3}$)**

(i) Method 1 (Assume that the salvage values of all the proposals are zero through–out their lives). Use a 10–year study period.

(ii) Method 2 (Assume that the salvage values for the proposals are zero at the end of the life of each place of equipment. Use a 10–year study period and indicate the implied salvage values.

7. (a) Consider following two expressions of Benefit–Cost Ratio **(10)**

(i) $B(i) = \dfrac{B}{I+C}$

(ii) $BC'(i) = \dfrac{B-C}{I}$

What is the difference between the above two expressions?

(b) As part of the rehabilitation of the downtown area of a southern U.S. city, the Parks and Recreation Department is planning to develop the space below several overpasses into basketball, handball, miniature golf and tennis courts. The initial cost is expected to be \$150,000 for improvements which are expected to have a 20–year life. Annual maintenance costs are projected to be \$12,000. The department expects 20,000 people per year to use the facilities an average of 2 hours each. The value of the recreation has been conservatively set at \$0.50 per hour. At an interest rate of 12% per year, what is the B/C ratio for the project? **($13\frac{1}{3}$)**

8. (a) Discuss the difference between physical and functional depreciation. **(7)**

(b) What do you understand by double–declining balance method of depreciation?

(c) A machine acquired at cost of \$32,000 had an estimated life of 6 years. Residual salvage value was estimated to be \$3,500. **($11\frac{1}{3}$)**

(i) Determine the annual depreciation charges during the useful life of the machine using basic straight–line depreciation.

(ii) What depreciation rate makes the book value at the end of 6 years equal to the estimated salvage value if the basic declining–balance method of depreciation is used?

TABLE A.16.
12% INTEREST FACTORS FOR DISCRETE COMPOUNDING

	Single Payment		Equal Payment Series				Uniform
n	Compound-amount factor	Present-worth factor	Compound-amount factor	Sinking-fund factor	Present-worth factor	Capital-recovery factor	gradient-series factor
	To find F Given P F/P, i, n	To find P Given F P/F, i, n	To find F Given A F/A, i, n	To find A Given F A/F, i, n	To find P Given A P/A, i, n	To find A Given P A/P, i, n	To find A Given G A/G, i, n
1	1.120	0.8929	1.000	1.0000	0.8929	1.1200	0.0000
2	1.254	0.7972	2.120	0.4717	1.6901	0.5917	0.4717
3	1.405	0.7118	3.374	0.2964	2.4018	0.4164	0.9246
4	1.574	0.6355	4.779	0.2092	3.0374	0.3292	1.3589
5	1.762	0.5674	6.353	0.1574	3.6048	0.2774	1.7746
6	1.974	0.5066	8.115	0.1232	4.1114	0.2432	2.1721
7	2.211	0.4524	10.089	0.0991	4.5638	0.2191	2.5515
8	2.476	0.4039	12.300	0.0813	4.9676	0.2013	2.9132
9	2.773	0.3606	14.776	0.0677	5.3283	0.1877	3.2574
10	3.106	0.3220	17.549	0.0570	5.6502	0.1770	3.5847
11	3.479	0.2875	20.655	0.0484	5.9377	0.1684	3.8953
12	3.896	0.2567	24.133	0.0414	6.1944	0.1614	4.1897
13	4.364	0.2292	28.029	0.0357	6.4236	0.1557	4.4683
14	4.887	0.2046	32.393	0.0309	6.6292	0.1509	4.7317
15	5.474	0.1827	37.280	0.0268	6.8109	0.1468	4.9803
16	6.130	0.1631	42.753	0.0234	6.9740	0.1434	5.2147
17	6.866	0.1457	48.884	0.0205	7.1196	0.1405	5.4353
18	7.690	0.1300	55.750	0.0179	7.2497	0.1379	5.6427
19	8.613	0.1161	63.440	0.0158	7.3658	0.1358	5.8375
20	9.646	0.1037	72.052	0.0139	7.4695	0.1339	6.0202
21	10.804	0.0926	81.699	0.0123	7.5620	0.1323	6.1913
22	12.100	0.0827	92.503	0.0108	7.6447	0.1308	6.3514
23	13.552	0.0738	104.603	0.0096	7.7184	0.1296	6.5010
24	15.179	0.0659	118.155	0.0085	7.7843	0.1285	6.6407
25	17.000	0.0588	133.334	0.0075	7.8431	0.1275	6.7708
26	19.040	0.0525	150.334	0.0067	7.8957	0.1267	6.8921
27	21.325	0.0469	169.374	0.0059	7.9426	0.1259	7.0049
28	23.884	0.0419	190.699	0.0053	7.9844	0.1253	7.1098
29	26.750	0.0374	214.583	0.0047	8.0218	0.1247	7.2071
30	29.960	0.0334	241.333	0.0042	8.0552	0.1242	7.2974
31	33.555	0.0298	271.293	0.0037	8.0850	0.1237	7.3811
32	37.582	0.0266	304.848	0.0033	8.1116	0.1233	7.4586
33	42.092	0.0238	342.429	0.0029	8.1354	0.1229	7.5303
34	47.143	0.0212	384.521	0.0026	8.1566	0.1226	7.5965
35	52.800	0.0189	431.664	0.0023	8.1755	0.1223	7.6577
40	93.051	0.0108	767.091	0.0013	8.2438	0.1213	7.8988
45	163.988	0.0061	1358.230	0.0007	8.2825	0.1207	8.0572
50	289.002	0.0035	2400.018	0.0004	8.3045	0.1204	8.1597

TABLE A.19.
15% INTEREST FACTORS FOR DISCRETE COMPOUNDING

	Single Payment		Equal Payment Series				Uniform
n	Compound-amount factor	Present-worth factor	Compound-amount factor	Sinking-fund factor	Present-worth factor	Capital-recovery factor	gradient-series factor
	To find F Given P F/P, i, n	To find P Given F P/F, i, n	To find F Given A F/A, i, n	To find A Given F A/F, i, n	To find P Given A P/A, i, n	To find A Given P A/P, i, n	To find A Given G A/G, i, n
1	1.150	0.8696	1.000	1.0000	0.8696	1.1500	0.0000
2	1.323	0.7562	2.150	0.4651	1.6257	0.6151	0.4651
3	1.521	0.6575	3.473	0.2880	2.2832	0.4380	0.9071
4	1.749	0.5718	4.993	0.2003	2.8550	0.3503	1.3263
5	2.011	0.4972	6.742	0.1483	3.3522	0.2983	1.7228
6	2.313	0.4323	8.754	0.1142	3.7845	0.2642	2.0972
7	2.660	0.3759	11.067	0.0904	4.1604	0.2404	2.4499
8	3.059	0.3269	13.727	0.0729	4.4873	0.2229	2.7813
9	3.518	0.2843	16.786	0.0596	4.7716	0.2096	3.0922
10	4.046	0.2472	20.304	0.0493	5.0188	0.1993	3.3832
11	4.652	0.2150	24.349	0.0411	5.2337	0.1911	3.6550
12	5.350	0.1869	29.002	0.0345	5.4206	0.1845	3.9082
13	6.153	0.1625	34.352	0.0291	5.5832	0.1791	4.1438
14	7.076	0.1413	40.505	0.0247	5.7245	0.1747	4.3624
15	8.137	0.1229	47.580	0.0210	5.8474	0.1710	4.5650
16	9.358	0.1069	55.717	0.0180	5.9542	0.1680	4.7523
17	10.761	0.0929	65.075	0.0154	6.0472	0.1654	4.9251
18	12.375	0.0808	75.836	0.0132	6.1280	0.1632	5.0843
19	14.232	0.0703	88.212	0.0113	6.1982	0.1613	5.2307
20	16.367	0.0611	102.444	0.0098	6.2593	0.1598	5.3651
21	18.822	0.0531	118.810	0.0084	6.3125	0.1584	5.4883
22	21.645	0.0462	137.632	0.0073	6.3587	0.1573	5.6010
23	24.891	0.0402	159.276	0.0063	6.3988	0.1563	5.7040
24	28.625	0.0349	184.168	0.0054	6.4338	0.1554	5.7979
25	32.919	0.0304	212.793	0.0047	6.4642	0.1547	5.8834
26	37.857	0.0264	245.712	0.0041	6.4906	0.1541	5.9612
27	43.535	0.0230	283.569	0.0035	6.5135	0.1535	6.0319
28	50.066	0.0200	327.104	0.0031	6.5335	0.1531	6.0960
29	57.575	0.0174	377.170	0.0027	6.5509	0.1527	6.1541
30	66.212	0.0151	434.745	0.0023	6.5660	0.1523	6.2066
31	76.144	0.0131	500.957	0.0020	6.5791	0.1520	6.2541
32	87.565	0.0114	577.100	0.0017	6.5905	0.1517	6.2970
33	100.700	0.0099	664.666	0.0015	6.6005	0.1515	6.3357
34	115.805	0.0086	765.365	0.0013	6.6091	0.1513	6.3705
35	133.176	0.0075	881.170	0.0011	6.6166	0.1511	6.4019
40	267.864	0.0037	1779.090	0.0006	6.6418	0.1506	6.5168
45	538.769	0.0019	3585.128	0.0003	6.6543	0.1503	6.5830
50	1083.657	0.0009	7217.716	0.0002	6.6605	0.1501	6.6205

TABLE A.22.
18% INTEREST FACTORS FOR DISCRETE COMPOUNDING

	Single Payment		Equal Payment Series				Uniform
n	Compound-amount factor	Present-worth factor	Compound-amount factor	Sinking-fund factor	Present-worth factor	Capital-recovery factor	gradient-series factor
	To find F Given P F/P, i, n	To find P Given F P/F, i, n	To find F Given A F/A, i, n	To find A Given F A/F, i, n	To find P Given A P/A, i, n	To find A Given P A/P, i, n	To find A Given G A/G, i, n
1	1.180	0.8475	1.000	1.0000	0.8475	1.1800	0.0000
2	1.392	0.7182	2.180	0.4587	1.5656	0.6387	0.4587
3	1.643	0.6086	3.572	0.2799	2.1743	0.4599	0.8902
4	1.939	0.5158	5.215	0.1917	2.6901	0.3717	1.2947
5	2.288	0.4371	7.154	0.1398	3.1272	0.3198	1.6728
6	2.700	0.3704	9.442	0.1059	3.4976	0.2859	2.0252
7	3.185	0.3139	12.142	0.0824	3.8115	0.2624	2.3526
8	3.759	0.2660	15.327	0.0652	4.0776	0.2452	2.6558
9	4.435	0.2255	19.086	0.0524	4.3030	0.2324	2.9358
10	5.234	0.1911	23.521	0.0425	4.4941	0.2225	3.1936
11	6.176	0.1619	28.755	0.0348	4.6560	0.2148	3.4303
12	7.288	0.1372	34.931	0.0286	4.7932	0.2086	3.6470
13	8.599	0.1163	42.219	0.0237	4.9095	0.2037	3.8449
14	10.147	0.0985	50.818	0.0197	5.0081	0.1997	4.0250
15	11.974	0.0835	60.965	0.0164	5.0916	0.1964	4.1887
16	14.129	0.0708	72.939	0.0137	5.1624	0.1937	4.3369
17	16.672	0.0600	87.068	0.0115	5.2223	0.1915	4.4708
18	19.673	0.0508	103.740	0.0096	5.2732	0.1896	4.5916
19	23.214	0.0431	123.414	0.0081	5.3162	0.1881	4.7003
20	27.393	0.0365	146.628	0.0068	5.3527	0.1868	4.7978
21	32.324	0.0309	174.021	0.0057	5.3837	0.1857	4.8851
22	38.142	0.0262	206.345	0.0048	5.4099	0.1848	4.9632
23	45.008	0.0222	244.487	0.0041	5.4321	0.1841	5.0329
24	53.109	0.0188	289.494	0.0035	5.4509	0.1835	5.0950
25	62.669	0.0160	342.603	0.0029	5.4669	0.1829	5.1502
26	73.949	0.0135	405.272	0.0025	5.4804	0.1825	5.1991
27	87.260	0.0115	479.221	0.0021	5.4919	0.1821	5.2425
28	102.967	0.0097	566.481	0.0018	5.5016	0.1818	5.2810
29	121.501	0.0082	669.447	0.0015	5.5098	0.1815	5.3149
30	143.371	0.0070	790.948	0.0013	5.5168	0.1813	5.3448
31	169.177	0.0059	934.319	0.0011	5.5227	0.1811	5.3712
32	199.629	0.0050	1103.496	0.0009	5.5277	0.1809	5.3945
33	235.563	0.0042	1303.125	0.0008	5.5320	0.1808	5.4149
34	277.964	0.0036	1538.688	0.0006	5.5356	0.1806	5.4328
35	327.997	0.0030	1816.642	0.0006	5.5386	0.1806	5.4485
40	750.378	0.0013	4163.213	0.0002	5.5482	0.1802	5.5022
45	1716.684	0.0006	9531.577	0.0001	5.5523	0.1801	5.5293
50	3927.357	0.0003	21813.094	0.0001	5.5541	0.1801	5.5428

L-2/T-2/IPE Date : 21/09/2013

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2011-2012

Sub : **IPE 207** (Probability and Statistics)

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) Define Central Limit Theorem. **(6⅔)**

(b) Explain stratified random sampling and cluster sampling. **(20)**

(c) A new weight-watching company, Weight-Reducers International, advertises that those who join will lose, on the average, 10 pound the first two weeks with a standard deviation of 2.8 pounds. A random sample of 50 people who joined the new weight reduction program revealed the mean loss to be 9 pounds. At the 0.05 level of significance, can we conclude that those joining Weight Reducers on average will lose less than 10 pounds? Determine the p-value. **(20)**

2. (a) Explain the factors on which the sample size depends. **(12)**

(b) Explain the major characteristics of 'F' distribution. **(9⅔)**

(c) Ms. Lisa Monnin is the budget director for Nexus Media, Inc. She would like to compare the daily travel expenses for the sales staff and the audit staff. She collected the following sample information. **(25)**

Sales ($)	131	135	146	165	136	142	
Audit (S)	130	102	129	143	149	120	139

At the 0.10 significance level, can she conclude that the mean daily expenses are greater for the sales staff than the audit staff? What is the p-value?

3. (a) Explain co-efficient of correlation and co-efficient of determination. **(10)**

(b) Mention the characteristics of Least Square regression line. **(6⅔)**

(c) A consumer organization wants to know whether there is a difference in the price of a particular toy at three different types of stores. The price of the toy was checked in a sample of five discount stores, five variety stores, and five department stores. The results are shown below. Use the 0.05 significance level. **(30)**

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Discount	Variety	Department
$ 12	$ 15	$19
13	17	17
14	14	16
12	18	20
15	17	19

4. (a) Explain nonparametric methods. **(6⅔)**

(b) What are the limitations of Chi-Square distribution. **(15)**

(c) A six-sided die is rolled 30 times and the numbers 1 through 6 appears as shown in the following frequency distribution. At the 0.10 significance level, can we conclude that the die is fair? **(25)**

Out come	Frequency
1	3
2	6
3	2
4	3
5	9
6	7

SECTION – B

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

1 chart (Normal probability table)

5. (a) Explain ordinary level data and ratio level data. **(12)**

(b) What do you understand by skewness of data. **(6)**

(c) Records show that, among the parts coming to the local auto parts store, 10% has casting defects, 25% has machining defects and 70% are totally defect free. If an item is randomly chosen, what are the probability that **(16)**

(i) The item has only one type of defect?

(ii) The item has only machining defect?

(d) A sample of ball bearings has a mean dia of of 10 mm and has a standard deviation of 0.75 mm. Using Emperical rule, find out the ranges of diameter with in which **(12⅔)**

(i) 95% of the observations lie.

(ii) 99.7% of the observations lie.

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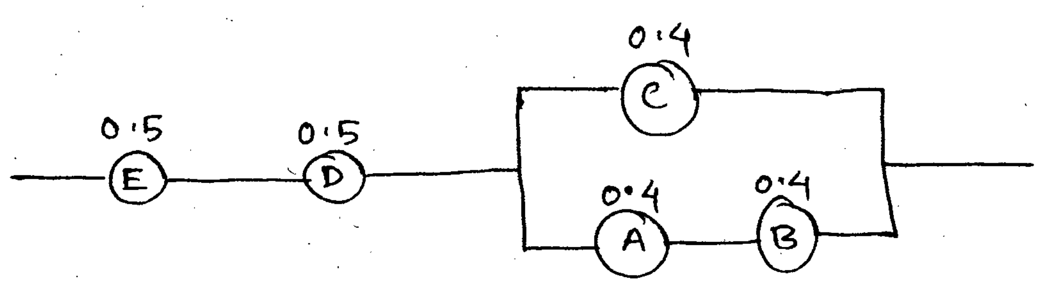
6. (a) In a certain paint store, the probability that a customer will purchase latex paint is 0.75. Of those who purchase latex paint, 60% also purchase rollers. But only 30% of semi-gloss paint buyers purchase rollers. If we randomly select a buyer who has purchased both roller and paint, what is the probability that the paint is latex? **($10\frac{2}{3}$)**

(b) BSTI took a sample of 16 juices from the market. The level of preservatives in those juices (in micro-gram) are as follow. **(22)**

1.08	1.65	2.45
1.21	1.89	3.42
1.30	2.23	
1.5	2.15	
1.43	3.33	
1.21	3.19	
1.49	2.34	

Find out the mean, median and standard deviation of the sample. Also draw the cumulative frequency diagram for the given data.

(c) **(14)**



The figure shows an electrical system of 5 components A, B, C, D and E. What is the probability that

(i) The entire system works?

(ii) Component 'A' doesn't work, given that the system does?

Assume that all 5 components fail independently.

7. (a) Explain memoryless property. What are the other characteristics of the distribution that has memoryless property? **(8)**

(b) Call comes to a certain call-center according to Poisson process. If an average of 2.7 calls come in per minute, then find the probability that **(21)**

(i) No more than 4 calls come in any minute.

(ii) Fewer than 2 calls come in any minute.

(iii) More than 5 calls come in a 5 minute period.

Contd P/4

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Contd... Q. No. 7

(c) The probability that a patient recovers from a heart operation is 0.8. What is the probability that **(17⅔)**

(i) Exactly 2 of the next 3 patients who have this operation will survive?

(ii) Exactly 1 of the next 3 patients will survive?

(iii) At least 2 of the next 3 patients will survive?

8. (a) Describe the characteristics of Normal distribution. **(10)**

(b) An auto-company has a specification for their bearing, which is 3 ± 0.02 cm. If bearing doesn't meet this specification, then it is rejected. If the process follows normal distribution, with a mean = 3.0 cm and $\sigma = 0.008$ cm, then find out the percentage of balls that will be accepted. **(20)**

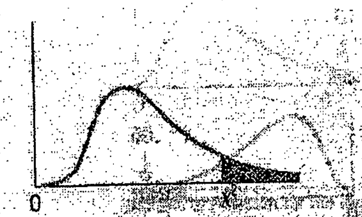
(c) The estimation of a telecom company in a certain bid is 'b'. The density function of the winning bid is, **(16⅔)**

$$f(y) = \begin{cases} \frac{7}{8b} \; , & \frac{4b}{7} \le y \le 2b \\ 0 \; , & \text{elsewhere} \end{cases}$$

Using the given data, find out the cumulative distribution function F(y) and use it to determine the probability that the winning bid is less than the primary estimate 'b'.

B.3 Critical Values of Chi-Square

values of χ^2 that correspond to a specific right-tail area and specific number



Example: With 17 *df* and a .02 area in the upper tail, $\chi^2 = 30.995$

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

B.2 Student's t Distribution

Confidence interval | Left-tailed test | Right-tailed test | Two-tailed test

df	Confidence Intervals, c					
	80%	90%	95%	98%	99%	99.9%
	Level of Significance for One-Tailed Test, α					
	0.10	0.05	0.025	0.01	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
31	1.309	1.696	2.040	2.453	2.744	3.633
32	1.309	1.694	2.037	2.449	2.738	3.622
33	1.308	1.692	2.035	2.445	2.733	3.611
34	1.307	1.691	2.032	2.441	2.728	3.601
35	1.306	1.690	2.030	2.438	2.724	3.591

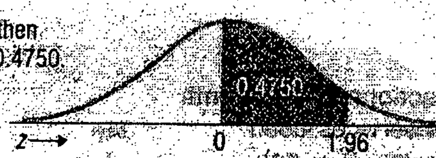
df	Confidence Intervals, c					
	80%	90%	95%	98%	99%	99.9%
	Level of Significance for One-Tailed Test, α					
	0.10	0.05	0.025	0.01	0.005	0.0005
	Level of Significance for Two-Tailed Test, α					
	0.20	0.10	0.05	0.02	0.01	0.001
36	1.306	1.688	2.028	2.434	2.719	3.582
37	1.305	1.687	2.026	2.431	2.715	3.574
38	1.304	1.686	2.024	2.429	2.712	3.566
39	1.304	1.685	2.023	2.426	2.708	3.558
40	1.303	1.684	2.021	2.423	2.704	3.551
41	1.303	1.683	2.020	2.421	2.701	3.544
42	1.302	1.682	2.018	2.418	2.698	3.538
43	1.302	1.681	2.017	2.416	2.695	3.532
44	1.301	1.680	2.015	2.414	2.692	3.526
45	1.301	1.679	2.014	2.412	2.690	3.520
46	1.300	1.679	2.013	2.410	2.687	3.515
47	1.300	1.678	2.012	2.408	2.685	3.510
48	1.299	1.677	2.011	2.407	2.682	3.505
49	1.299	1.677	2.010	2.405	2.680	3.500
50	1.299	1.676	2.009	2.403	2.678	3.496
51	1.298	1.675	2.008	2.402	2.676	3.492
52	1.298	1.675	2.007	2.400	2.674	3.488
53	1.298	1.674	2.006	2.399	2.672	3.484
54	1.297	1.674	2.005	2.397	2.670	3.480
55	1.297	1.673	2.004	2.396	2.668	3.476
56	1.297	1.673	2.003	2.395	2.667	3.473
57	1.297	1.672	2.002	2.394	2.665	3.470
58	1.296	1.672	2.002	2.392	2.663	3.466
59	1.296	1.671	2.001	2.391	2.662	3.463
60	1.296	1.671	2.000	2.390	2.660	3.460
61	1.296	1.670	2.000	2.389	2.659	3.457
62	1.295	1.670	1.999	2.388	2.657	3.454
63	1.295	1.669	1.998	2.387	2.656	3.452
64	1.295	1.669	1.998	2.386	2.655	3.449
65	1.295	1.669	1.997	2.385	2.654	3.447
66	1.295	1.668	1.997	2.384	2.652	3.444
67	1.294	1.668	1.996	2.383	2.651	3.442
68	1.294	1.668	1.995	2.382	2.650	3.439
69	1.294	1.667	1.995	2.382	2.649	3.437
70	1.294	1.667	1.994	2.381	2.648	3.435

df	Confidence Intervals, c					
	80%	90%	95%	98%	99%	99.9%
	Level of Significance for One-Tailed Test, α					
	0.10	0.05	0.025	0.01	0.005	0.0005
	Level of Significance for Two-Tailed Test, α					
	0.20	0.10	0.05	0.02	0.01	0.001
71	1.294	1.667	1.994	2.380	2.647	3.433
72	1.293	1.666	1.993	2.379	2.646	3.431
73	1.293	1.666	1.993	2.379	2.645	3.429
74	1.293	1.666	1.993	2.378	2.644	3.427
75	1.293	1.665	1.992	2.377	2.643	3.425
76	1.293	1.665	1.992	2.376	2.642	3.423
77	1.293	1.665	1.991	2.376	2.641	3.421
78	1.292	1.665	1.991	2.375	2.640	3.420
79	1.292	1.664	1.990	2.374	2.640	3.418
80	1.292	1.664	1.990	2.374	2.639	3.416
81	1.292	1.664	1.990	2.373	2.638	3.415
82	1.292	1.664	1.989	2.373	2.637	3.413
83	1.292	1.663	1.989	2.372	2.636	3.412
84	1.292	1.663	1.989	2.372	2.636	3.410
85	1.292	1.663	1.988	2.371	2.635	3.409
86	1.291	1.663	1.988	2.370	2.634	3.407
87	1.291	1.663	1.988	2.370	2.634	3.406
88	1.291	1.662	1.987	2.369	2.633	3.405

df	Confidence Intervals, c					
	80%	90%	95%	98%	99%	99.9%
	Level of Significance for One-Tailed Test, α					
	0.10	0.05	0.025	0.01	0.005	0.0005
	Level of Significance for Two-Tailed Test, α					
	0.20	0.10	0.05	0.02	0.01	0.001
89	1.291	1.662	1.987	2.369	2.632	3.403
90	1.291	1.662	1.987	2.368	2.632	3.402
91	1.291	1.662	1.986	2.368	2.631	3.401
92	1.291	1.662	1.986	2.368	2.630	3.399
93	1.291	1.661	1.986	2.367	2.630	3.398
94	1.291	1.661	1.986	2.367	2.629	3.397
95	1.291	1.661	1.985	2.366	2.629	3.396
96	1.290	1.661	1.985	2.366	2.628	3.395
97	1.290	1.661	1.985	2.365	2.627	3.394
98	1.290	1.661	1.984	2.365	2.627	3.393
99	1.290	1.660	1.984	2.365	2.626	3.392
100	1.290	1.660	1.984	2.364	2.626	3.390
120	1.289	1.658	1.980	2.358	2.617	3.373
140	1.288	1.656	1.977	2.353	2.611	3.361
160	1.287	1.654	1.975	2.350	2.607	3.352
180	1.286	1.653	1.973	2.347	2.603	3.345
200	1.286	1.653	1.972	2.345	2.601	3.340
∞	1.282	1.645	1.960	2.326	2.576	3.291

B.1 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
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990

B.4 Critical Values of the F Distribution at a 5 Percent Level of Significance

Degrees of Freedom for the Denominator	Degrees of Freedom for the Numerator: 1	2	3	4	5	6	7	8	9	10	12	15	20	24
1	161	200	216	225	230	234	237	239	241	242	244	246	248	249
2	18.5	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.5
3	10.1	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70
120	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52

Mainul 28.9.13

L-2/T-2/IPE Date : 28/09/2013

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2011-2012

Sub : **IPE 205** (Manufacturing Process I)

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) Describe the working principle of TIG welding with necessary sketches. List the advantages and disadvantages of MIG welding. **(14)**

   (b) Explain shielded metal arc welding process. What are the functions of shielding gas in MIG welding? **(13)**

   (c) Explain the steps of friction welding with necessary schematic diagram. **(8)**

2. (a) Describe the mechanism of laser beam welding and electron beam welding process with schematic diagram. **(16)**

   (b) A welding operation will take place on carbon steel. The desired welding speed is 1 in./s. If an arc welding power supply is used with a voltage of 10 V what current is needed if the weld width is to be 0.25 in.? **(7)**

   (c) What are the base material requirements for arc welding? Describe the difference between oxy-fuel gas cutting of ferrous and of non-ferrous alloys. **(12)**

3. (a) Describe the principle behind resistance welding and thermit welding process. **(14)**

   (b) Describe the advantages and limitations of explosion welding. **(10)**

   (c) Two flat copper sheets, each 1.0 mm thick, are being spot-welded by the use of a current of 5000 A and a current flow time of 0.25 s. The electrodes are 5 mm in diameter. Estimate the heat generated in the weld zone. Assume that the resistance is 100 $\mu\Omega$. **(11)**

4. (a) Write short notes on **(12)**
   (i) Thread roling
   (ii) Tube drawing
   (iii) Hydrostatic extrusion

   (b) Compare open die and closed die forging. How important is a close fit for two parts that are to be brazed? **(13)**

   (c) Describe different types of spot welding methods with sketches. **(10)**

Contd P/2

IPE 205

SECTION – B

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

5. (a) Describe the factors that affect the fluidity of the molten metal. **(8)**

   (b) What is molding sand? Describe the composition of molding sand. **(8)**

   (c) Discuss the effects of the following foundry variables on different properties of molding sand. **(12)**

   (i) Grain Fineness
   (ii) Grain Shape
   (iii) Clay Content
   (iv) Moisture Content

   (d) Briefly describe different steps of permanent mold casting process. **(7)**

6. (a) With the help of necessary sketches, explain centrifugal casting process. **(9)**

   (b) Briefly explain the reasons of casting defects. What are the usual casting defects and how to rectify them? **(14)**

   (c) Write down the factors affecting shrinkage, machining and draft allowance of pattern. **(12)**

7. (a) Describe some design rules of casting with necessary sketches. **(15)**

   (b) With the help of diagram discuss the investment casting method. What are the advantages and limitations of this casting method? **(12)**

   (c) What is the function of the core in sand molding? Briefly describe the main objectives of the core design. **(8)**

8. (a) With the help of diagram, discuss the following: **(12)**

   (i) Flashless forging
   (ii) Coining
   (iii) Upsetting
   (iv) Roll forging

   (b) With the help of suitable sketches, describe the following: **(13)**

   (i) Explosive forming
   (ii) Rubber forming and
   (iii) Bulging

   (c) How will you manufacture an aluminum beverage can using metal forming processes? Explain with neat sketches. **(10)**

L-2/T-2/IPE Date : 05/10/2013

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2011-2012

Sub : **ME 243** (Mechanics of Solids)

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**.

Notations have their usual meanings.

1. (a) Deduce the relations among load, shear force and bending moment in a beam. **(12)**

(b) Write the shear force and bending moment equations and draw their diagrams for the beam in Fig. 1(b). **(23)**

2. (a) Transverse load on a hollow circular bar with outside diameter twice the inside diameter produces a bending moment of 40 kNm. If the allowable bending stress is limited to 100 MPa, find the inside diameter of the bar. **(17)**

(b) Show that on the neutral axis of a rectangular section, flexural stress is zero and horizontal shear stress is maximum. **(18)**

3. (a) A cantilever beam has a point load P = 1 kN and a constant EI = 1.2×10^5 Nm^2 throughout as shown in Fig. 3(a). Determine its maximum deflection both by the integration method and the energy method. **(22)**

(b) A reinforced concrete beam as in Fig. 3(b) has steel area equals 10 cm^2 and n = 15. If the allowable stresses are $f_c \leq 4$ MPa and $f_s \leq 100$ MPa, determine whether the beam is in balanced reinforcement. **(13)**

4. (a) The circular link shown in Fig. 4(a) has a rectangular section of width AB = 100 mm and thickness equals 50 mm. Calculate the stresses at A and B. **(20)**

(b) What is the purpose of the theories of failure? Obtain the conditions to cause failure by maximum strain theory. **(15)**

SECTION – B

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

Assume any reasonable value for missing data.

5. (a) With suitable examples and applications, distinguish the following types of material **(18)**

(i) ductile material

(ii) brittle material

Draw typical stress-strain diagrams for the above materials and label them properly.

Contd P/2

ME 243

Contd... Q. No. 5

(b) A hollow steel cylinder surrounds a solid copper cylinder and the assembly is subject to an axial loading of 200 kN, as shown in Fig. for Q5(b). The cross-section area of steel cylinder is 2000 mm^2, while that of copper is 5000 mm^2 Both cylinders have the same length before the load is applied. **(17)**

Determine the temperature rise of the entire system required to place all of the load on the copper cylinder. Assume the cover plate at the top of the assembly as rigid.

For copper	For steel
$E = 120$ GN/m^2	$E = 200$ GN/m^2
$\alpha = 20 \times 10^{-6}$ k^{-1}	$\alpha = 12 \times 10^{-6}$ k^{-1}

6. (a) With necessary assumptions and illustrations, derive the torsion formula for a circular shaft. **(18)**

Schematically show the distribution of torsional stress along the radius of the shaft.

(b) A helical spring B is placed inside the coils of a second helical spring A, having the same number of coils and free axial length and of same material. The two springs are compressed by an axial load of 210 N which is shared between them. The mean coil diameters of A and B are 90 mm and 60 mm and the wire diameters are 12 mm and 7 mm, respectively. Calculate the load taken and the maximum stress in each spring. **(17)**

7. (a) Give the distinguishing characteristics of the following columns: **(18)**
   (i) short column
   (ii) medium size column
   (iii) long column

Define 'critical load' of a column. In a tabular form, give the respective equivalent lengths and critical loads for different end conditions of a column.

(b) Derive an expression for critical stress in a pinned-pinned ideal column. Give the graphical interpretation of the functional relationship between critical stress and slenderness ratio. With a suitable example, describe how the limiting value of slenderness ratio of a column can be obtained. **(17)**

8. (a) How do you differentiate between a thin and thick shell? With neat sketches, show different components of stress involved in their analysis. **(18)**

Derive the expressions of radial and circumferential stresses in a thick-walled cylinder subjected to uniform internal and external pressures.

(b) A plane element is subject to the stresses shown in Fig. for Q8(b). Using Mohr's circle determine: **(17)**
   (i) the principal stress and their directions
   (ii) the maximum shearing stresses and the directions of the planes on which they occur.

L-2/T-2/IPE **Date : 06/07/2013**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2011-2012

Sub : **ME 265** (Thermal Engineering and Heat Transfer)

Full Marks: 280 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

1. (a) Briefly explain the mechanism of heat conduction in solid. **(10)**

(b) A 2-mm diameter and 10-m long electric wire is insulated with a 1-mm thick plastic cover (thermal conductivity k = 0.15 W/m.°C). 80 W heat is generated within the wire due to electrical conduction. Determine the temperature at the interface of the wire and the plastic insulation under steady condition, if the wire with insulation is exposed to air at 30 °C with heat transfer coefficient h = 24 W/m^2.°C. Also find whether doubling the thickness of the plastic layer will increase the rate of heat loss. **(20⅔)**

(c) A 30-m-long, 10-cm-diameter hot water pipe of a heating system as shown in figure for Q. 1(c), is buried in the soil z = 50 cm below the ground surface. The outer surface temperature of the pipe is 80°C. Taking the surface of the earth to be 10°C and the thermal conductivity of the soil to be 0.9 W/m.°C, determine the rate of heat loss from the pipe. The shape factor for this configuration is given as $S = \frac{2\pi L}{\ln(4z/D)}$. **(16)**

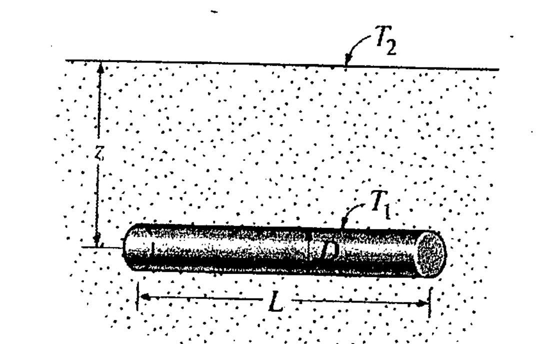


Figure for question : 1(c)

2. (a) Define the velocity boundary layer and the thermal boundary layer. Explain the relevance of these layers in estimating the convection heat transfer from a surface. **(10)**

(b) What is lumped system analysis? When is it applicable? **(10)**

(c) A steel ball [c = 0.46 kJ/kg.°C, k = 35 W/m.°C], 5 cm in diameter and initially at a uniform temperature of 450°C is suddenly placed in a controlled environment in which the temperature is maintained at 100°C. The convection heat transfer coefficient is 10 W/m^2.°C. Calculate the time required for the ball to attain a temperature of 150°C. Confirm the validity of the lumped system analysis. **(26⅔)**

Contd P/2

ME 265

3. (a) Briefly explain the shape factor rules in radiation heat transfer. **(6)**

(b) Derive the expression for the net radiation heat transfer between any two surfaces in terms of surface and space resistances. **($20\frac{2}{3}$)**

(c) Determine the view factors from the base of the pyramid shown in figure 3(c) to each of its four sides. The base of the pyramid is a square and the lengths of the side surfaces are equal. **(20)**

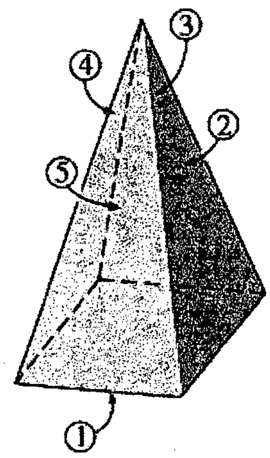


Figure for question : 3(c)

4. (a) Write a short note on compact heat exchangers. Explain why fins are attached to the air side of the heat exchanger surface. **(16)**

(b) A cross-flow air-to-water heat exchanger with an effectiveness of 0.65 is used to heat water (Cp = 4180 J/kg.°C) with hot air (Cp = 1010 J/kg.°C). Water enters the heat exchanger at 20°C at a rate of 4 kg/s, while air enters at 100°C at a rate of 9 kg/s. If the overall heat transfer coefficient based on the water side is 260 W/m^2.°C, determine the heat transfer surface area of the heat exchanger on the water side. Assume both fluids are unmixed. **($30\frac{2}{3}$)**

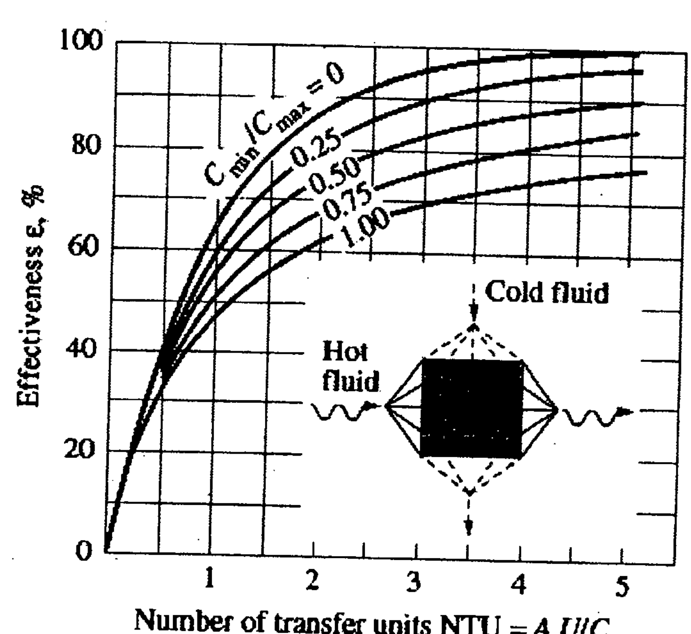


Chart for effectiveness of cross flow heat exchangers with both fluids unmixed.

SECTION – B

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

5. (a) Write down the steady flow energy equation for the following devices with necessary assumptions: (i) Turbine (ii) Nozzle (iii) Boiler. **(9)**

   (b) Briefly explain perpetual-motion machine with necessary examples. **(10)**

   (c) What is renewable energy? Briefly explain the sources of renewable energy. **(6)**

   (d) A cylinder fitted with a piston has a volume of 0.1 m^3 and contains 0.5 kg of Steam at 0.4 MPa. Heat is transferred to the steam until the temperature is 400°C while the pressure remains constant. Determine the heat transfer and Work for this process. **($21\frac{2}{3}$)**

6. (a) Briefly explain a regenerative gas turbine with intercooling and reheat. **(14)**

   (b) How does regeneration affect the efficiency of a Brayton cycle? **(6)**

   (c) Air enters the compressor of a regenerative gas-turbine engine at 300 K and 100 kPa, where it is compressed to 580 K and 800 kPa. The regenerator has an effectivenss of 72%, and the air enters the turbine at 1200 K. For a turbine efficiency of 86%, determine (i) the amount of heat transfer to the regenerator and (ii) the thermal efficiency. **($26\frac{2}{3}$)**

7. (a) Write down the air standard assumptions. **(4)**

   (b) Classify different types of I.C engines. **(8)**

   (c) Draw an actual indicator and valve timing diagram of a 4-stroke S.I engine. **(10)**

   (d) The compression ratio in an air standard Otto cycle is 9. At the beginning of the compression stroke the pressure is 0.1 MPa and the temperature is 25°C. The heat transfer to the air per cycle is 2000 kJ/kg air. Determine: (i) the pressure and temperature at the end of the each process of the cycle and (ii) thermal efficiency. **($24\frac{2}{3}$)**

8. (a) Write down some desirable properties of a refrigerant. **(10)**

   (b) Write short notes on the followings: **(12)**

   (i) Ton of refrigeration (ii) COP of refrigeration cycle (iii) Ozone depletion.

   (c) Saturated air leaving the cooling section of an air-conditioning system at 14°C at a rate of 50 m^3/min is mixed adiabatically with the outside air at 32°C and 60 percent relative humidity at a rate of 20 m^3/min. Assuming that the mixing process occurs at a pressure of 1 atm, determine the specific (i) humidity, (ii) the relative humidity, (iii) the dry-bulb temperature, and (iv) the volume flow rate of the mixture. **($24\frac{2}{3}$)**

TABLE A-5

Saturated water—Pressure table

		Specific volume, m^3/kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg·K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
1.0	6.97	0.001000	129.19	29.302	2355.2	2384.5	29.303	2484.4	2513.7	0.1059	8.8690	8.9749
1.5	13.02	0.001001	87.964	54.686	2338.1	2392.8	54.688	2470.1	2524.7	0.1956	8.6314	8.8270
2.0	17.50	0.001001	66.990	73.431	2325.5	2398.9	73.433	2459.5	2532.9	0.2606	8.4621	8.7227
2.5	21.08	0.001002	54.242	88.422	2315.4	2403.8	88.424	2451.0	2539.4	0.3118	8.3302	8.6421
3.0	24.08	0.001003	45.654	100.98	2306.9	2407.9	100.98	2443.9	2544.8	0.3543	8.2222	8.5765
4.0	28.96	0.001004	34.791	121.39	2293.1	2414.5	121.39	2432.3	2553.7	0.4224	8.0510	8.4734
5.0	32.87	0.001005	28.185	137.75	2282.1	2419.8	137.75	2423.0	2560.7	0.4762	7.9176	8.3938
7.5	40.29	0.001008	19.233	168.74	2261.1	2429.8	168.75	2405.3	2574.0	0.5763	7.6738	8.2501
10	45.81	0.001010	14.670	191.79	2245.4	2437.2	191.81	2392.1	2583.9	0.6492	7.4996	8.1488
15	53.97	0.001014	10.020	225.93	2222.1	2448.0	225.94	2372.3	2598.3	0.7549	7.2522	8.0071
20	60.06	0.001017	7.6481	251.40	2204.6	2456.0	251.42	2357.5	2608.9	0.8320	7.0752	7.9073
25	64.96	0.001020	6.2034	271.93	2190.4	2462.4	271.96	2345.5	2617.5	0.8932	6.9370	7.8302
30	69.09	0.001022	5.2287	289.24	2178.5	2467.7	289.27	2335.3	2624.6	0.9441	6.8234	7.7675
40	75.86	0.001026	3.9933	317.58	2158.8	2476.3	317.62	2318.4	2636.1	1.0261	6.6430	7.6691
50	81.32	0.001030	3.2403	340.49	2142.7	2483.2	340.54	2304.7	2645.2	1.0912	6.5019	7.5931
75	91.76	0.001037	2.2172	384.36	2111.8	2496.1	384.44	2278.0	2662.4	1.2132	6.2426	7.4558
100	99.61	0.001043	1.6941	417.40	2088.2	2505.6	417.51	2257.5	2675.0	1.3028	6.0562	7.3589
101.325	99.97	0.001043	1.6734	418.95	2087.0	2506.0	419.06	2256.5	2675.6	1.3069	6.0476	7.3545
125	105.97	0.001048	1.3750	444.23	2068.8	2513.0	444.36	2240.6	2684.9	1.3741	5.9100	7.2841
150	111.35	0.001053	1.1594	466.97	2052.3	2519.2	467.13	2226.0	2693.1	1.4337	5.7894	7.2231
175	116.04	0.001057	1.0037	486.82	2037.7	2524.5	487.01	2213.1	2700.2	1.4850	5.6865	7.1716
200	120.21	0.001061	0.88578	504.50	2024.6	2529.1	504.71	2201.6	2706.3	1.5302	5.5968	7.1270
225	123.97	0.001064	0.79329	520.47	2012.7	2533.2	520.71	2191.0	2711.7	1.5706	5.5171	7.0877
250	127.41	0.001067	0.71873	535.08	2001.8	2536.8	535.35	2181.2	2716.5	1.6072	5.4453	7.0525
275	130.58	0.001070	0.65732	548.57	1991.6	2540.1	548.86	2172.0	2720.9	1.6408	5.3800	7.0207
300	133.52	0.001073	0.60582	561.11	1982.1	2543.2	561.43	2163.5	2724.9	1.6717	5.3200	6.9917
325	136.27	0.001076	0.56199	572.84	1973.1	2545.9	573.19	2155.4	2728.6	1.7005	5.2645	6.9650
350	138.86	0.001079	0.52422	583.89	1964.6	2548.5	584.26	2147.7	2732.0	1.7274	5.2128	6.9402
375	141.30	0.001081	0.49133	594.32	1956.6	2550.9	594.73	2140.4	2735.1	1.7526	5.1645	6.9171
400	143.61	0.001084	0.46242	604.22	1948.9	2553.1	604.66	2133.4	2738.1	1.7765	5.1191	6.8955
450	147.90	0.001088	0.41392	622.65	1934.5	2557.1	623.14	2120.3	2743.4	1.8205	5.0356	6.8561
500	151.83	0.001093	0.37483	639.54	1921.2	2560.7	640.09	2108.0	2748.1	1.8604	4.9603	6.8207
550	155.46	0.001097	0.34261	655.16	1908.8	2563.9	655.77	2096.6	2752.4	1.8970	4.8916	6.7886
600	158.83	0.001101	0.31560	669.72	1897.1	2566.8	670.38	2085.8	2756.2	1.9308	4.8285	6.7593
650	161.98	0.001104	0.29260	683.37	1886.1	2569.4	684.08	2075.5	2759.6	1.9623	4.7699	6.7322
700	164.95	0.001108	0.27278	696.23	1875.6	2571.8	697.00	2065.8	2762.8	1.9918	4.7153	6.7071
750	167.75	0.001111	0.25552	708.40	1865.6	2574.0	709.24	2056.4	2765.7	2.0195	4.6642	6.6837

TABLE A-6

Superheated water

T °C	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 0.01 MPa (45.81°C)*				P = 0.05 MPa (81.32°C)				P = 0.10 MPa (99.61°C)			
Sat.†	14.670	2437.2	2583.9	8.1488	3.2403	2483.2	2645.2	7.5931	1.6941	2505.6	2675.0	7.3589
50	14.867	2443.3	2592.0	8.1741								
100	17.196	2515.5	2687.5	8.4489	3.4187	2511.5	2682.4	7.6953	1.6959	2506.2	2675.8	7.3611
150	19.513	2587.9	2783.0	8.6893	3.8897	2585.7	2780.2	7.9413	1.9367	2582.9	2776.6	7.6148
200	21.826	2661.4	2879.6	8.9049	4.3562	2660.0	2877.8	8.1592	2.1724	2658.2	2875.5	7.8356
250	24.136	2736.1	2977.5	9.1015	4.8206	2735.1	2976.2	8.3568	2.4062	2733.9	2974.5	8.0346
300	26.446	2812.3	3076.7	9.2827	5.2841	2811.6	3075.8	8.5387	2.6389	2810.7	3074.5	8.2172
400	31.063	2969.3	3280.0	9.6094	6.2094	2968.9	3279.3	8.8659	3.1027	2968.3	3278.6	8.5452
500	35.680	3132.9	3489.7	9.8998	7.1338	3132.6	3489.3	9.1566	3.5655	3132.2	3488.7	8.8362
600	40.296	3303.3	3706.3	10.1631	8.0577	3303.1	3706.0	9.4201	4.0279	3302.8	3705.6	9.0999
700	44.911	3480.8	3929.9	10.4056	8.9813	3480.6	3929.7	9.6626	4.4900	3480.4	3929.4	9.3424
800	49.527	3665.4	4160.6	10.6312	9.9047	3665.2	4160.4	9.8883	4.9519	3665.0	4160.2	9.5682
900	54.143	3856.9	4398.3	10.8429	10.8280	3856.8	4398.2	10.1000	5.4137	3856.7	4398.0	9.7800
1000	58.758	4055.3	4642.8	11.0429	11.7513	4055.2	4642.7	10.3000	5.8755	4055.0	4642.6	9.9800
1100	63.373	4260.0	4893.8	11.2326	12.6745	4259.9	4893.7	10.4897	6.3372	4259.8	4893.6	10.1698
1200	67.989	4470.9	5150.8	11.4132	13.5977	4470.8	5150.7	10.6704	6.7988	4470.7	5150.6	10.3504
1300	72.604	4687.4	5413.4	11.5857	14.5209	4687.3	5413.3	10.8429	7.2605	4687.2	5413.3	10.5229
	P = 0.20 MPa (120.21°C)				P = 0.30 MPa (133.52°C)				P = 0.40 MPa (143.61°C)			
Sat.	0.88578	2529.1	2706.3	7.1270	0.60582	2543.2	2724.9	6.9917	0.46242	2553.1	2738.1	6.8955
150	0.95986	2577.1	2769.1	7.2810	0.63402	2571.0	2761.2	7.0792	0.47088	2564.4	2752.8	6.9306
200	1.08049	2654.6	2870.7	7.5081	0.71643	2651.0	2865.9	7.3132	0.53434	2647.2	2860.9	7.1723
250	1.19890	2731.4	2971.2	7.7100	0.79645	2728.9	2967.9	7.5180	0.59520	2726.4	2964.5	7.3804
300	1.31623	2808.8	3072.1	7.8941	0.87535	2807.0	3069.6	7.7037	0.65489	2805.1	3067.1	7.5677
400	1.54934	2967.2	3277.0	8.2236	1.03155	2966.0	3275.5	8.0347	0.77265	2964.9	3273.9	7.9003
500	1.78142	3131.4	3487.7	8.5153	1.18672	3130.6	3486.6	8.3271	0.88936	3129.8	3485.5	8.1933
600	2.01302	3302.2	3704.8	8.7793	1.34139	3301.6	3704.0	8.5915	1.00558	3301.0	3703.3	8.4580
700	2.24434	3479.9	3928.8	9.0221	1.49580	3479.5	3928.2	8.8345	1.12152	3479.0	3927.6	8.7012
800	2.47550	3664.7	4159.8	9.2479	1.65004	3664.3	4159.3	9.0605	1.23730	3663.9	4158.9	8.9274
900	2.70656	3856.3	4397.7	9.4598	1.80417	3856.0	4397.3	9.2725	1.35298	3855.7	4396.9	9.1394
1000	2.93755	4054.8	4642.3	9.6599	1.95824	4054.5	4642.0	9.4726	1.46859	4054.3	4641.7	9.3396
1100	3.16848	4259.6	4893.3	9.8497	2.11226	4259.4	4893.1	9.6624	1.58414	4259.2	4892.9	9.5295
1200	3.39938	4470.5	5150.4	10.0304	2.26624	4470.3	5150.2	9.8431	1.69966	4470.2	5150.0	9.7102
1300	3.63026	4687.1	5413.1	10.2029	2.42019	4686.9	5413.0	10.0157	1.81516	4686.7	5412.8	9.8828
	P = 0.50 MPa (151.83°C)				P = 0.60 MPa (158.83°C)				P = 0.80 MPa (170.41°C)			
Sat.	0.37483	2560.7	2748.1	6.8207	0.31560	2566.8	2756.2	6.7593	0.24035	2576.0	2768.3	6.6616
200	0.42503	2643.3	2855.8	7.0610	0.35212	2639.4	2850.6	6.9683	0.26088	2631.1	2839.8	6.8177
250	0.47443	2723.8	2961.0	7.2725	0.39390	2721.2	2957.6	7.1833	0.29321	2715.9	2950.4	7.0402
300	0.52261	2803.3	3064.6	7.4614	0.43442	2801.4	3062.0	7.3740	0.32416	2797.5	3056.9	7.2345
350	0.57015	2883.0	3168.1	7.6346	0.47428	2881.6	3166.1	7.5481	0.35442	2878.6	3162.2	7.4107
400	0.61731	2963.7	3272.4	7.7956	0.51374	2962.5	3270.8	7.7097	0.38429	2960.2	3267.7	7.5735
500	0.71095	3129.0	3484.5	8.0893	0.59200	3128.2	3483.4	8.0041	0.44332	3126.6	3481.3	7.8692
600	0.80409	3300.4	3702.5	8.3544	0.66976	3299.8	3701.7	8.2695	0.50186	3298.7	3700.1	8.1354
700	0.89696	3478.6	3927.0	8.5978	0.74725	3478.1	3926.4	8.5132	0.56011	3477.2	3925.3	8.3794
800	0.98966	3663.6	4158.4	8.8240	0.82457	3663.2	4157.9	8.7395	0.61820	3662.5	4157.0	8.6061
900	1.08227	3855.4	4396.6	9.0362	0.90179	3855.1	4396.2	8.9518	0.67619	3854.5	4395.5	8.8185
1000	1.17480	4054.0	4641.4	9.2364	0.97893	4053.8	4641.1	9.1521	0.73411	4053.3	4640.5	9.0189
1100	1.26728	4259.0	4892.6	9.4263	1.05603	4258.8	4892.4	9.3420	0.79197	4258.3	4891.9	9.2090
1200	1.35972	4470.0	5149.8	9.6071	1.13309	4469.8	5149.6	9.5229	0.84980	4469.4	5149.3	9.3898
1300	1.45214	4686.6	5412.6	9.7797	1.21012	4686.4	5412.5	9.6955	0.90761	4686.1	5412.2	9.5625

*The temperature in parentheses is the saturation temperature at the specified pressure.

† Properties of saturated vapor at the specified pressure.

TABLE A–17

Ideal-gas properties of air

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

TABLE A–17

Ideal-gas properties of air (*Concluded*)

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

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

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

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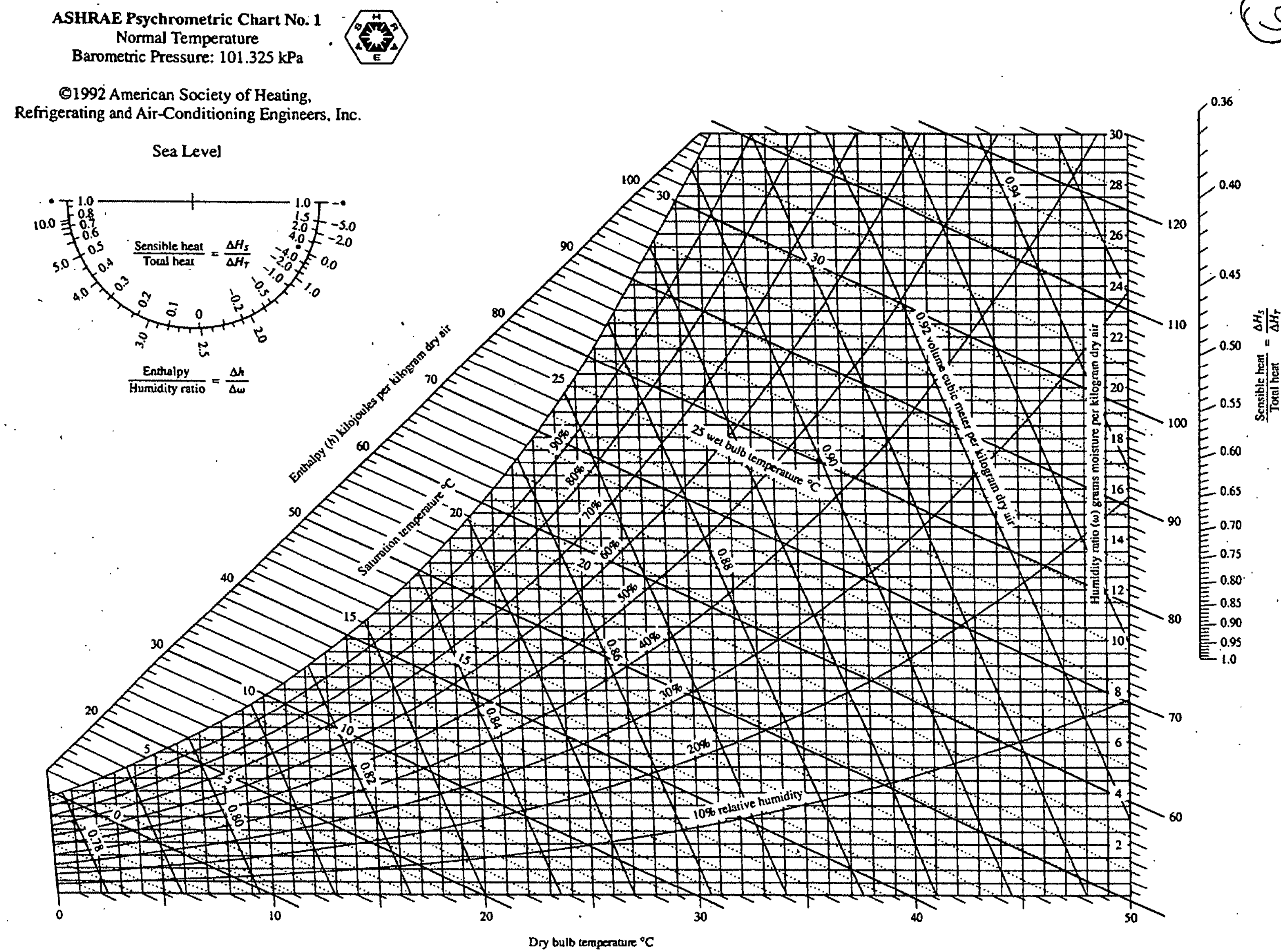

Prepared by Center for Applied Thermodynamic Studies, University of Idaho.

FIGURE A–31

Psychrometric chart at 1 atm total pressure.

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