L-2/T-2/IPE   **Date : 08/01/2013**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

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

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

Full Marks : 140   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**.

Compounding tables attached

1. (a) How can alternatives for providing the same or accomplishing the same function be compared when interest is involved over extended periods of time? (5⅓)

   (b) What do you understand by the term 'Economic Equivalence'? Explain with a suitable example that equivalence can be established when total interest paid, divided by dollar-years of borrowing, is a constant ratio among financing plans (i.e., alternatives). (12)

   (c) What are the principles of engineering economy you need to consider when you want to compare mutually exclusive alternatives? Discuss briefly. (6)

2. (a) Refer to the cash flow diagram shown in Figure 1 and solve for the unknown quantity in parts (i) through (iv) that makes the equivalent value of cash outflows equal to the equivalent value of the cash inflow. (13⅓)

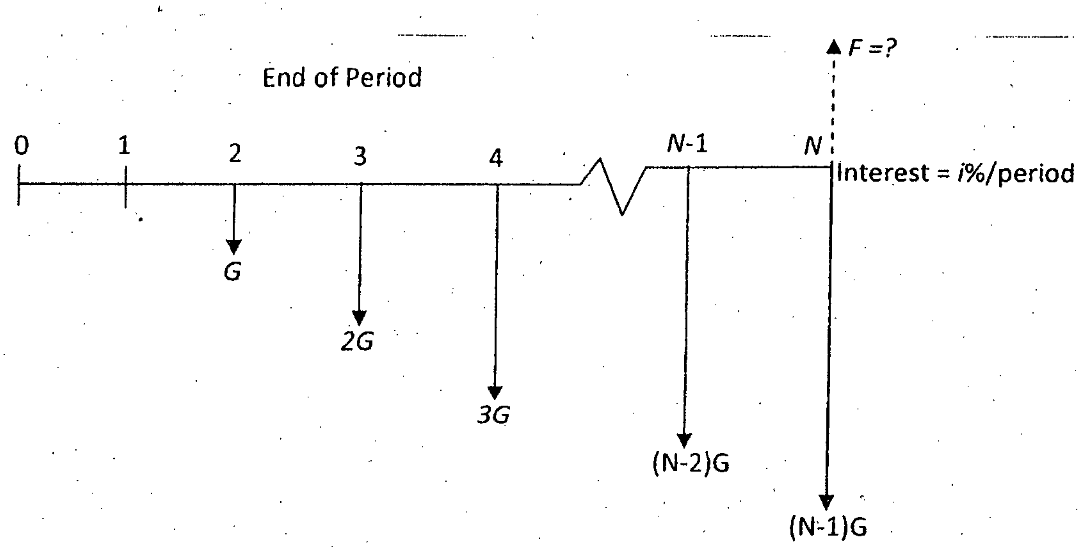

Figure 1: Cash Flow Diagram for Q.2(a)

   (i) If F = \$10,000, G = \$600, and N = 6, then i = ?

   (ii) If F = \$10,000, G = \$600, and i = 5% per period, then N = ?

   (iii) If G = \$1,000, N = 12, and i = 10% per period, then F = ?

   (iv) If F = \$8,000, N = 6, and i = 10% per period, then G = ?

   (b) Set up an expression for the value of Z on the left-hand cash flow diagram that establishes equivalence with the right-hand cash flow diagram. The nominal interest rate is 12% compounded quarterly. (see Figure 2) (10)

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

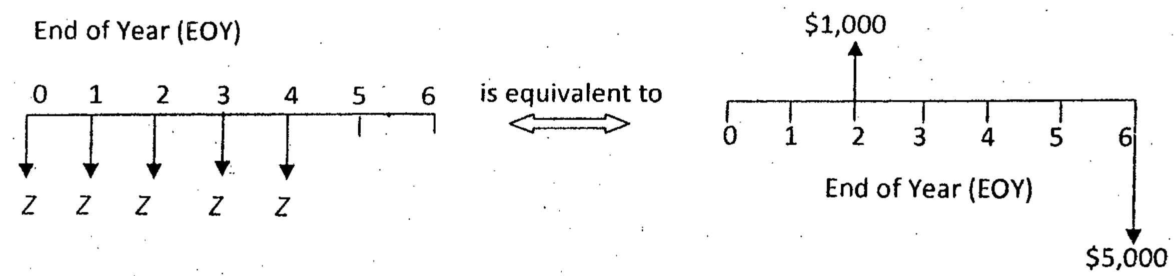

Figure 2: Cash Flow diagrams for Q.2(b)

3. (a) What is Minimum Attractive Rate of Return (MARR)? What are the major considerations in determining MARR? **(6⅓)**

(b) What are the assumptions in equivalent worth method? **(5)**

(c) A small company bought BMI bonds at their face value on January 1, 1991. These bonds pay interest of 7.25% every six months. The face value of the bonds is $100,000, and they mature on December 31, 2006. On January 1, 2001, these bonds were sold for $110,000. What interest rate (per six months) was earned by the company on the BMI bonds? **(12)**

4. (a) A certain project has net receipts equaling $1,000 now, has costs of $5,000 at the end of the first year, and earns $6,000 at the end of the second year. **(11⅓)**

(i) Show that multiple rates of return exist for this problem when using the IRR method.

(ii) If an external reinvestment rate of 10% is available, what is the rate of return for this project using the ERR method?

(b) Select the preferred investment alternative from the mutually exclusive pair shown in the following table based on (i) the repeatability assumption, (ii) the coterminated assumption with a four-year study period and the market value of alternative 2 (at the end of year four) determined using the imputed market value technique, and (iii) the coterminated assumption with an eight-year study period. The MARR is 10% per year. **(12)**

End of Year	Alternative 1	Alternative 2
0	-$40,000	-$50,000
1	12,000	10,000
2	12,000	10,000
3	12,000	10,000
4	36,000	10,000
5		10,000
6		10,000
7		10,000
8		10,000
8 (MV)		40,000

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SECTION – B

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

5. (a) Discuss the general relationship between the Engineering Economic Analysis procedure and the Engineering Design Process. **(5)**

   (b) Describe the two approaches that have found wide acceptance in industry for developing sound investment alternatives by removing some of the barriers to creative thinking. **($13\frac{1}{3}$)**

   (c) State the principles of Engineering Economy. **(5)**

6. (a) What are the purposes of using the results of cost estimation? Describe the two main tasks for cost-driven design optimization. **($8\frac{1}{3}$)**

   (b) A company producer circuit boards used to update outdated computer equipment. The fixed cost is $42,000, per month and the variable cost is $53 per circuit board. The selling price per unit is p = $150 – 0.02 D, Maximum output of the plant is 4000 units per month. **(15)**

   Determine -

   (i) the optimum demand for this product

   (ii) maximum profit per month

   (iii) at what volume does the breakeven occurs

   (iv) what is the company's range of profitable demand.

7. (a) Describe the Matheson formula. What are the basic requirements that must be met for a property to be depreciable? **(10)**

   (b) A secondhand bulldozer acquired at the beginning of the fiscal year at a cost of $58,000 has an estimated salvage value of $8000 and an estimated useful life of 12 years. Determine the following - **($13\frac{1}{3}$)**

   (i) the amount of annual depreciation computed by SL method.

   (ii) the amount of depreciation for the third year computed by the double-declining balance method.

8. (a) What do you mean by Benefit/Cost ratio? Discuss the shortcomings of the Benefit/Cost ratio method. **($8\frac{1}{3}$)**

   (b) A public project being considered by a local government has the following estimated benefit-cost profile - **(15)**

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n	Benefit, b_n	Investment, C_n	A_n
0		$ 10	-$ 10
1		$ 10	-$ 10
2	$ 20	$ 5	$ 15
3	$ 30	$ 5	$ 25
4	$ 30	$ 8	$ 22
5	$ 20	$ 8	$ 12

Assume $i = 10\%$, $N = 5$ and $k = 1$

Compute -

(i) Present worth of benefit

(ii) Present worth of cost

(iii) Capital expenditure

(iv) Annual operating cost.

TABLE C-8 Discrete Compounding; $i = 5\%$

	Single Payment		Uniform Series				Uniform Gradient		
	Compound Amount Factor	Present Worth Factor	Compound Amount Factor	Present Worth Factor	Sinking Fund Factor	Capital Recovery Factor	Gradient Present Worth Factor	Gradient Uniform Series Factor	
	To Find F Given P	To Find P Given F	To Find F Given A	To Find P Given A	To Find A Given F	To Find A Given P	To Find P Given G	To Find A Given G	
N	F/P	P/F	F/A	P/A	A/F	A/P	P/G	A/G	N
1	1.0500	0.9524	1.0000	0.9524	1.0000	1.0500	0.000	0.0000	1
2	1.1025	0.9070	2.0500	1.8594	0.4878	0.5378	0.907	0.4878	2
3	1.1576	0.8638	3.1525	2.7232	0.3172	0.3672	2.635	0.9675	3
4	1.2155	0.8227	4.3101	3.5460	0.2320	0.2820	5.103	1.4391	4
5	1.2763	0.7835	5.5256	4.3295	0.1810	0.2310	8.237	1.9025	5
6	1.3401	0.7462	6.8019	5.0757	0.1470	0.1970	11.968	2.3579	6
7	1.4071	0.7107	8.1420	5.7864	0.1228	0.1728	16.232	2.8052	7
8	1.4775	0.6768	9.5491	6.4632	0.1047	0.1547	20.970	3.2445	8
9	1.5513	0.6446	11.0266	7.1078	0.0907	0.1407	26.127	3.6758	9
10	1.6289	0.6139	12.5779	7.7217	0.0795	0.1295	31.652	4.0991	10
11	1.7103	0.5847	14.2068	8.3064	0.0704	0.1204	37.499	4.5144	11
12	1.7959	0.5568	15.9171	8.8633	0.0628	0.1128	43.624	4.9219	12
13	1.8856	0.5303	17.7130	9.3936	0.0565	0.1065	49.988	5.3215	13
14	1.9799	0.5051	19.5986	9.8986	0.0510	0.1010	56.554	5.7133	14
15	2.0789	0.4810	21.5786	10.3797	0.0463	0.0963	63.288	6.0973	15
16	2.1829	0.4581	23.6575	10.8378	0.0423	0.0923	70.160	6.4736	16
17	2.2920	0.4363	25.8404	11.2741	0.0387	0.0887	77.141	6.8423	17
18	2.4066	0.4155	28.1324	11.6896	0.0355	0.0855	84.204	7.2034	18
19	2.5270	0.3957	30.5390	12.0853	0.0327	0.0827	91.328	7.5569	19
20	2.6533	0.3769	33.0660	12.4622	0.0302	0.0802	98.488	7.9030	20
21	2.7860	0.3589	35.7193	12.8212	0.0280	0.0780	105.667	8.2416	21
22	2.9253	0.3418	38.5052	13.1630	0.0260	0.0760	112.846	8.5730	22
23	3.0715	0.3256	41.4305	13.4886	0.0241	0.0741	120.009	8.8971	23
24	3.2251	0.3101	44.5020	13.7986	0.0225	0.0725	127.140	9.2140	24
25	3.3864	0.2953	47.7271	14.0939	0.0210	0.0710	134.228	9.5238	25
30	4.3219	0.2314	66.4388	15.3725	0.0151	0.0651	168.623	10.9691	30
35	5.5160	0.1813	90.3203	16.3742	0.0111	0.0611	200.581	12.2498	35
40	7.0400	0.1420	120.7998	17.1591	0.0083	0.0583	229.545	13.3775	40
45	8.9850	0.1113	159.7002	17.7741	0.0063	0.0563	255.315	14.3644	45
50	11.4674	0.0872	209.3480	18.2559	0.0048	0.0548	277.915	15.2233	50
60	18.6792	0.0535	353.5837	18.9293	0.0028	0.0528	314.343	16.6062	60
80	49.5614	0.0202	971.2288	19.5965	0.0010	0.0510	359.646	18.3526	80
100	131.5013	0.0076	2610.0252	19.8479	0.0004	0.0504	381.749	19.2337	100
∞				20.0000		0.0500			∞

TABLE C-13 Discrete Compounding; $i = 10\%$

	Single Payment		Uniform Series				Uniform Gradient		
	Compound Amount Factor	Present Worth Factor	Compound Amount Factor	Presen. Worth Factor	Sinking Fund Factor	Capital Recovery Factor	Gradient Present Worth Factor	Gradient Uniform Series Factor	
	To Find F Given P	To Find P Given F	To Find F Given A	To Find P Given A	To Find A Given F	To Find A Given P	To Find P Given G	To Find A Given G	
N	F/P	P/F	F/A	P/A	A/F	A/P	P/G	A/G	N
1	1.1000	0.9091	1.0000	0.9091	1.0000	1.1000	0.000	0.0000	1
2	1.2100	0.8264	2.1000	1.7355	0.4762	0.5762	0.826	0.4762	2
3	1.3310	0.7513	3.3100	2.4869	0.3021	0.4021	2.329	0.9366	3
4	1.4641	0.6830	4.6410	3.1699	0.2155	0.3155	4.378	1.3812	4
5	1.6105	0.6209	6.1051	3.7908	0.1638	0.2638	6.862	1.8101	5
6	1.7716	0.5645	7.7156	4.3553	0.1296	0.2296	9.684	2.2236	6
7	1.9487	0.5132	9.4872	4.8684	0.1054	0.2054	12.763	2.6216	7
8	2.1436	0.4665	11.4359	5.3349	0.0874	0.1874	16.029	3.0045	8
9	2.3579	0.4241	13.5795	5.7590	0.0736	0.1736	19.422	3.3724	9
10	2.5937	0.3855	15.9374	6.1446	0.0627	0.1627	22.891	3.7255	10
11	2.8531	0.3505	18.5312	6.4951	0.0540	0.1540	26.396	4.0641	11
12	3.1384	0.3186	21.3843	6.8137	0.0468	0.1468	29.901	4.3884	12
13	3.4523	0.2897	24.5227	7.1034	0.0408	0.1408	33.377	4.6988	13
14	3.7975	0.2633	27.9750	7.3667	0.0357	0.1357	36.801	4.9955	14
15	4.1772	0.2394	31.7725	7.6061	0.0315	0.1315	40.152	5.2789	15
16	4.5950	0.2176	35.9497	7.8237	0.0278	0.1278	43.416	5.5493	16
17	5.0545	0.1978	40.5447	8.0216	0.0247	0.1247	46.582	5.8071	17
18	5.5599	0.1799	45.5992	8.2014	0.0219	0.1219	49.640	6.0526	18
19	6.1159	0.1635	51.1591	8.3649	0.0195	0.1195	52.583	6.2861	19
20	6.7275	0.1486	57.2750	8.5136	0.0175	0.1175	55.407	6.5081	20
21	7.4002	0.1351	64.0025	8.6487	0.0156	0.1156	58.110	6.7189	21
22	8.1403	0.1228	71.4027	8.7715	0.0140	0.1140	60.689	6.9189	22
23	8.9543	0.1117	79.5430	8.8832	0.0126	0.1126	63.146	7.1085	23
24	9.8497	0.1015	88.4973	8.9847	0.0113	0.1113	65.481	7.2881	24
25	10.8347	0.0923	98.3471	9.0770	0.0102	0.1102	67.696	7.4580	25
30	17.4494	0.0573	164.4940	9.4269	0.0061	0.1061	77.077	8.1762	30
35	28.1024	0.0356	271.0244	9.6442	0.0037	0.1037	83.987	8.7086	35
40	45.2593	0.0221	442.5926	9.7791	0.0023	0.1023	88.953	9.0962	40
45	72.8905	0.0137	718.9048	9.8628	0.0014	0.1014	92.454	9.3740	45
50	117.3909	0.0085	1163.9085	9.9148	0.0009	0.1009	94.889	9.5704	50
60	304.4816	0.0033	3034.8164	9.9672	0.0003	0.1003	97.701	9.8023	60
80	2048.4002	0.0005	20474.0021	9.9951	*	0.1000	99.561	9.9609	80
100	13780.6123	0.0001	137796.1234	9.9993	*	0.1000	99.920	9.9927	100
∞				10.0000		0.1000			∞

* Less than 0.0001.

TABLE C-15 Discrete Compounding; i = 15%

	Single Payment		Uniform Series				Uniform Gradient		
	Compound Amount Factor	Present Worth Factor	Compound Amount Factor	Present Worth Factor	Sinking Fund Factor	Capital Recovery Factor	Gradient Present Worth Factor	Gradient Uniform Series Factor	
N	To Find F Given P F/P	To Find P Given F P/F	To Find F Given A F/A	To Find P Given A P/A	To Find A Given F A/F	To Find A Given P A/P	To Find P Given G P/G	To Find A Given G A/G	N
1	1.1500	0.8696	1.0000	0.8696	1.0000	1.1500	0.000	0.0000	1
2	1.3225	0.7561	2.1500	1.6257	0.4651	0.6151	0.756	0.4651	2
3	1.5209	0.6575	3.4725	2.2832	0.2880	0.4380	2.071	0.9071	3
4	1.7490	0.5718	4.9934	2.8550	0.2003	0.3503	3.786	1.3263	4
5	2.0114	0.4972	6.7424	3.3522	0.1483	0.2983	5.775	1.7228	5
6	2.3131	0.4323	8.7537	3.7845	0.1142	0.2642	7.937	2.0972	6
7	2.6600	0.3759	11.0668	4.1604	0.0904	0.2404	10.192	2.4498	7
8	3.0590	0.3269	13.7268	4.4873	0.0729	0.2229	12.481	2.7813	8
9	3.5179	0.2843	16.7858	4.7716	0.0596	0.2096	14.755	3.0922	9
10	4.0456	0.2472	20.3037	5.0188	0.0493	0.1993	16.980	3.3832	10
11	4.6524	0.2149	24.3493	5.2337	0.0411	0.1911	19.129	3.6549	11
12	5.3503	0.1869	29.0017	5.4206	0.0345	0.1845	21.185	3.9082	12
13	6.1528	0.1625	34.3519	5.5831	0.0291	0.1791	23.135	4.1438	13
14	7.0757	0.1413	40.5047	5.7245	0.0247	0.1747	24.973	4.3624	14
15	8.1371	0.1229	47.5804	5.8474	0.0210	0.1710	26.693	4.5650	15
16	9.3576	0.1069	55.7175	5.9542	0.0179	0.1679	28.296	4.7522	16
17	10.7613	0.0929	65.0751	6.0472	0.0154	0.1654	29.783	4.9251	17
18	12.3755	0.0808	75.8364	6.1280	0.0132	0.1632	31.157	5.0843	18
19	14.2318	0.0703	88.2118	6.1982	0.0113	0.1613	32.421	5.2307	19
20	16.3665	0.0611	102.4436	6.2593	0.0098	0.1598	33.582	5.3651	20
21	18.8215	0.0531	118.8101	6.3125	0.0084	0.1584	34.645	5.4883	21
22	21.6447	0.0462	137.6316	6.3587	0.0073	0.1573	35.615	5.6010	22
23	24.8915	0.0402	159.2764	6.3988	0.0063	0.1563	36.499	5.7040	23
24	28.6252	0.0349	184.1678	6.4338	0.0054	0.1554	37.302	5.7979	24
25	32.9190	0.0304	212.7930	6.4641	0.0047	0.1547	38.031	5.8834	25
30	66.2118	0.0151	434.7451	6.5660	0.0023	0.1523	40.753	6.2066	30
35	133.1755	0.0075	881.1702	6.6166	0.0011	0.1511	42.359	6.4019	35
40	267.8635	0.0037	1779.0903	6.6418	0.0006	0.1506	43.283	6.5168	40
45	538.7693	0.0019	3585.1285	6.6543	0.0003	0.1503	43.805	6.5830	45
50	1083.6574	0.0009	7217.7163	6.6605	0.0001	0.1501	44.096	6.6205	50
60	4383.9987	0.0002	29219.9916	6.6651	*	0.1500	44.343	6.6530	60
80	71750.8794	*	478332.5293	6.6666	*	0.1500	44.436	6.6656	80
100	1174313.4507	*	7828749.6713	6.6667	*	0.1500	44.444	6.6666	100
∞				6.6667		0.1500			∞

* Less than 0.0001.

TABLE C-17 Discrete Compounding; i = 20%

	Single Payment		Uniform Series				Uniform Gradient		
	Compound Amount Factor	Present Worth Factor	Compound Amount Factor	Present Worth Factor	Sinking Fund Factor	Capital Recovery Factor	Gradient Present Worth Factor	Gradient Uniform Series Factor	
N	To Find F Given P F/P	To Find P Given F P/F	To Find F Given A F/A	To Find P Given A P/A	To Find A Given F A/F	To Find A Given P A/P	To Find P Given G P/G	To Find A Given G A/G	N
1	1.2000	0.8333	1.0000	0.8333	1.0000	1.2000	0.000	0.0000	1
2	1.4400	0.6944	2.2000	1.5278	0.4545	0.6545	0.694	0.4545	2
3	1.7280	0.5787	3.6400	2.1065	0.2747	0.4747	1.852	0.8791	3
4	2.0736	0.4823	5.3680	2.5887	0.1863	0.3863	3.299	1.2742	4
5	2.4883	0.4019	7.4416	2.9906	0.1344	0.3344	4.906	1.6405	5
6	2.9860	0.3349	9.9299	3.3255	0.1007	0.3007	6.581	1.9788	6
7	3.5832	0.2791	12.9159	3.6046	0.0774	0.2774	8.255	2.2902	7
8	4.2998	0.2326	16.4991	3.8372	0.0606	0.2606	9.883	2.5756	8
9	5.1598	0.1938	20.7989	4.0310	0.0481	0.2481	11.434	2.8364	9
10	6.1917	0.1615	25.9587	4.1925	0.0385	0.2385	12.887	3.0739	10
11	7.4301	0.1346	32.1504	4.3271	0.0311	0.2311	14.233	3.2893	11
12	8.9161	0.1122	39.5805	4.4392	0.0253	0.2253	15.467	3.4841	12
13	10.6993	0.0935	48.4966	4.5327	0.0206	0.2206	16.588	3.6597	13
14	12.8392	0.0779	59.1959	4.6106	0.0169	0.2169	17.601	3.8175	14
15	15.4070	0.0649	72.0351	4.6755	0.0139	0.2139	18.510	3.9588	15
16	18.4884	0.0541	87.4421	4.7296	0.0114	0.2114	19.321	4.0851	16
17	22.1861	0.0451	105.9306	4.7746	0.0094	0.2094	20.042	4.1976	17
18	26.6233	0.0376	128.1167	4.8122	0.0078	0.2078	20.681	4.2975	18
19	31.9480	0.0313	154.7400	4.8435	0.0065	0.2065	21.244	4.3861	19
20	38.3376	0.0261	186.6880	4.8696	0.0054	0.2054	21.740	4.4643	20
21	46.0051	0.0217	225.0256	4.8913	0.0044	0.2044	22.174	4.5334	21
22	55.2061	0.0181	271.0307	4.9094	0.0037	0.2037	22.555	4.5941	22
23	66.2474	0.0151	326.2369	4.9245	0.0031	0.2031	22.887	4.6475	23
24	79.4968	0.0126	392.4842	4.9371	0.0025	0.2025	23.176	4.6943	24
25	95.3962	0.0105	471.9811	4.9476	0.0021	0.2021	23.428	4.7352	25
30	237.3763	0.0042	1181.8816	4.9789	0.0008	0.2008	24.263	4.8731	30
35	590.6682	0.0017	2948.3411	4.9915	0.0003	0.2003	24.661	4.9406	35
40	1469.7716	0.0007	7343.8578	4.9966	0.0001	0.2001	24.847	4.9728	40
45	3657.2620	0.0003	18281.3099	4.9986	0.0001	0.2001	24.932	4.9877	45
50	9100.4382	0.0001	45497.1908	4.9995	*	0.2000	24.970	4.9945	50
60	56347.5144	*	281732.5718	4.9999	*	0.2000	24.994	4.9989	60
80	2160228.4620	*	10801137.3101	5.0000	*	0.2000	25.000	5.0000	80
∞				5.0000		0.2000			∞

* Less than 0.0001.

L-2/T-2/IPE **Date : 20/11/2012**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

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

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

Full Marks : 280 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**.

Normal distribution table attached.

1. (a) What are the sources of uncertainty in a real-world problem? Discuss with examples. **(6⅔)**

(b) State and prove the theorem of total probability. Does it have any relationship with the Bayes' theorem? Explain. **(20)**

(c) Good performance (obtaining a grade of A+) in IPE 207 depends on your attendance (A) and completion of assignments (C). The probabilities that you will receive a grade of A+ are 100%, 70%, 50%, and 0%, if you regularly attend and complete the assignments, if you regularly attend but do not complete the assignments, if you do not regularly attend but complete the assignments regularly, and if you neither attend nor complete assignments, respectively. Further assume that if you attend the class regularly, there is a 90% probability that you will complete the assignments. The probability that you will attend the class regularly is 0.95, and the probability that you will complete the assignments is 0.90. **(20)**

(i) What is the probability that you will receive an A+ in this class?

(ii) If you received an A+, what is the probability that you regularly attended the class and completed the assignments?

2. (a) What is the relationship between the PDF and CDF of a random variable? Explain with the help of a figure. Also, write down their characteristics. **(10⅔)**

(b) The PDF of the annual rainfall, R, of a city is shown in Figure 1 below. **(24)**

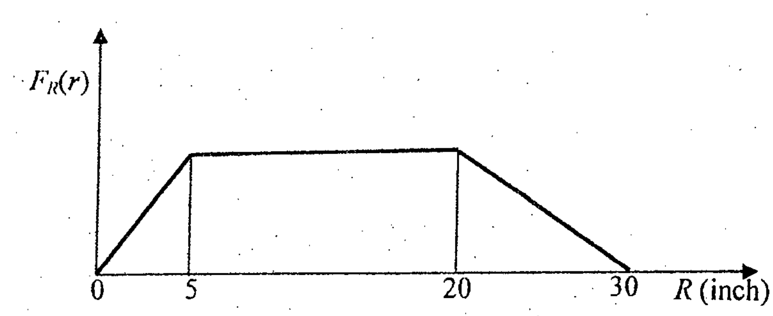


Figure 1: PDF of Annual Rainfall

(i) Define the PDF of R properly. Then determine the following:

(ii) The mean value of R.

(iii) The median of R.

Contd P/2

IPE 207

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

(iv) The mode of R.

(v) The variance, standard deviation, and coefficient of variation of R.

(vi) The skewness of R.

(c) Prove that the covariance of two random variables X and Y with means μ_X and μ_Y respectively, is given by $\sigma_{XY} = E(XY) - \mu_X\mu_Y$. **(12)**

3. (a) What is a Bernoulli process? Write down the properties of the Bernoulli process. **(8⅔)**

(b) Prove that the mean and variance of the uniform distribution are **(12)**

$$\mu = \frac{A+B}{2}, \text{ and } \sigma^2 = \frac{(B-A)^2}{12}$$

(c) For a large construction project, the contractor estimates that the average rate of on-the-job accidents is three times per year. From past experience, the contractor also estimates that the cost incurred for each accident may be modeled as a lognormal random variable with a median of \$6,000 and COV of 20%. The cost of each accident can be assumed to be statistically independent. **(26)**

(i) What is the probability that there will be no accident in the first month of construction?

(ii) What is the probability that only 1 out of the first 3 months of construction is free of accidents?

(iii) What is the probability that an accident will incur a loss exceeding \$4,000?

(iv) What is the probability that none of the accidents in a month will cost more than \$4,000?

4. (a) What is a moment-generating function? Find the moment generating function of the binomial random variable X and then use it to verify that $\mu = np$ and $\sigma^2 = npq$. **(15)**

(b) In earthquake engineering, the PDF for earthquake intensities, for example in Modified Mercalli (MM) scale, is sometimes modeled by an exponential distribution. The parameter υ is determined from local seismicity records. **(21⅔)**

In earthquake-resistant design of nuclear power plants, unserviceability and collapse due to earthquakes are the two most important concerns for engineers. The corresponding earthquake intensities are known in the profession as the operating basis earthquake (OBE) and the safe shutdown earthquake (SSE), respectively. One way to design for these incidents is to choose a design intensity x_i such that the probability that this intensity level is exceeded, that is $P(X > x_i) = p$, is small. Since the collapse of a nuclear power plant presents a great hazard to the public, the chance of its occurrence should be extremely small. Suppose a design intensity x_1 corresponding to a risk level of 10^{-3} is chosen for the OBE, and x_2 corresponding to a risk level of 10^{-6} is chosen for the SSE.

Contd P/3

IPE 207

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

(i) Determine x_2 (SSF intensity) in terms of x_1 (OBE intensity).

(ii) If power plant service is interrupted during an earthquake, what is the probability that the plant will collapse?

(c) The water level in a particular lake depends on two sources, direct rainfall X, and inflow from a stream Y. The rainfall Z around the lake can be considered as a random variable with a mean of μ_z and a standard deviation of σ_z. X and Y are related to Z as

$X = aZ$

$Y = b+cZ$

where a, b, and c are constants. X and Y are functions of random variables and are therefore also random. Calculate the correlation coefficient $\rho_{X,Y}$. **(10)**

SECTION – B

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

t-distribution and chi-square distribution tables attached.

5. (a) Explain the characteristics of the t distribution. **(11)**

(b) Explain the factors that determine the sample size. **(11)**

(c) The Warren Country Telephone Company claims in its annual report that "the typical customer spends \$60 per month on local and long distance service". A sample of 12 subscribers revealed the following amounts spent last month. **($24\frac{2}{3}$)**

\$64, \$66, \$64, \$66, \$59 \$62, \$67, \$61, \$64, \$58, \$54, \$66

(i) What is the point estimate of the population mean?

(ii) Develop a 90 percent confidence interval for the population mean.

(iii) Is the company's claim that the "typical customer" spends \$ 60 per month reasonable? Justify your answer.

6. (a) Define hypothesis. Explain the required steps in conducting a test of hypothesis. **(20)**

(b) A new weight-watching company, Weight Reducers International, advertises that those who join will lose, on the average, 10 pounds the first two weeks. A random sample of 50 people who joined the new weight reduction program revealed the mean loss to be 9 pounds with a standard deviation of 2.8 pounds. At the 0.05 level of significance, can we conclude that those joining Weight Reducers on average will lose less than 10 pounds? **($26\frac{2}{3}$)**

Contd P/4

IPE 207

7. (a) Explain the assumptions of ANOVA. ($6\frac{2}{3}$)

(b) Explain (i) Correlation analysis (ii) Regression analysis (iii) Least Square Principle. (15)

(c) A sample of scores on an examination given in Statistics 201 are: (25)

Men : 72, 69, 98, 66, 85, 76, 79, 80, 77

Women: 81, 67, 90, 78, 81, 80, 76

At the 0.01 significance level, is the mean grade of the women higher than that of the men?

8. (a) Explain coefficient of correlation and coefficient of determination. (12)

(b) Explain the ~~objection~~ objectives of Goodness-of-Fit test. (10)

(c) In a particular market there are three commercial television stations, each with its own evening news program from 6.00 to 6.30 P.M. According to a report in this morning's local newspaper, a random sample of 150 viewers last night revealed 53 watched the news on channel 5, 64 watched on channel 1 and 33 on channel 13. At the 0.05 significance level, is there a difference in the proportion of viewers watching three channels? ($24\frac{2}{3}$)

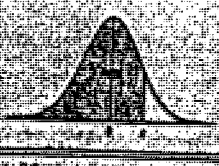
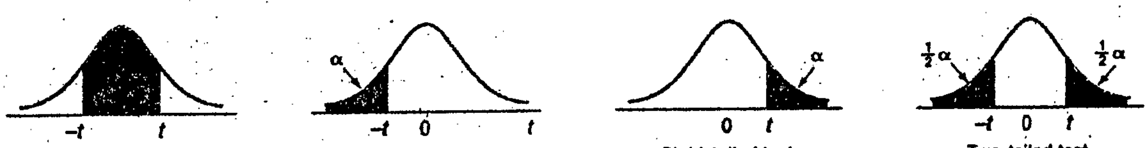


Table A.3 Areas under the Normal Curve

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

Appendix B

B.2 Student's *t* Distribution



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

	Confidence Intervals, *c*					
	80%	90%	95%	98%	99%	99.9%
	Level of Significance for One-Tailed Test, α					
df	0.10	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

	Confidence Intervals, *c*					
	80%	90%	95%	98%	99%	99.9%
	Level of Significance for One-Tailed Test, α					
df	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

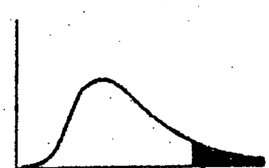
	Confidence Intervals, *c*					
	80%	90%	95%	98%	99%	99.9%
	Level of Significance for One-Tailed Test, α					
df	0.10	0.05	0.025	0.01	0.005	0.0005
	Level of Significance for Two-Tailed Test, α					
	0.20	0.10	0.05	0.02	0.01	0.001
71	1.294	1.667	1.994	2.380	2.647	3.433
72	1.293	1.666	1.993	2.379	2.646	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

	Confidence Intervals, *c*					
	80%	90%	95%	98%	99%	99.9%
	Level of Significance for One-Tailed Test, α					
df	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

Appendix B

B.3 Critical Values of Chi-Square

This table contains the values of χ^2 that correspond to a specific right-tail area and specific number of degrees of freedom.



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

L-2/T-2/IPE Date : 26/12/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

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

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) Briefly describe different types of weld joints. What is the purpose of using flux? **(14)**

(b) Why inadequate joint penetration, slag inclusions and incomplete fusion are occurred in welds and how these defects can be removed or controlled? **(12)**

(c) Describe (with sketches) different types of Spot Welding Methods. **(9)**

2. (a) What is flat rolling? How Roll forces can be reduced in flat rolling? List the defects commonly observed after flat rolling. **(14)**

(b) Write the advantages, disadvantages and applications of 'Projection Welding'. **(10)**

(c) Describe the reactions that take places in oxyacetylene welding. Explain different types of flames used in gas welding. **(11)**

3. (a) With necessary sketches describe briefly the working principle of **(16)**

(i) TIG welding,

(ii) Electron Beam Welding.

(b) What are the similarities and differences between shielded metal arc welding and submerged arc welding process? **(12)**

(c) How different types of seams can be produced in welding? **(7)**

4. (a) Write short notes on **(12)**

(i) Bulging,

(ii) Tube-Hydroforming Process,

(iii) Explosive Forming.

(b) How will you manufacture an aluminium beverage can using metal forming processes? Explain with neat sketches. **(13)**

(c) Compare soldering, brazing and welding. **(10)**

Contd P/2

IPE 205

SECTION – B

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

5. (a) With the help of diagram, describe briefly the following: **(12)**
   (i) Split pattern
   (ii) Loose-piece pattern
   (iii) Sweep pattern and
   (iv) Cope and drag pattern

   (b) What are the different materials used for patterns? Briefly describe the difference types of pattern allowances. **(12)**

   (c) How the molding sands are classified according to their use? Briefly describe the properties required in good molding sand. **(11)**

6. (a) Discuss the considerations that must be taken into account for designing risers in moulds. What is the function of the core in sand molding? How are cores held in place and how are they supported? **(12)**

   (b) With neat sketches, describe briefly the permanent mold casting. Discuss the advantages and limitations of permanent mold casting in comparison with sand mold casting. **(12)**

   (c) What are some of the general defects encountered in casting processes? Discuss the main causes and remedies for the five basic categories of casting defects. **(11)**

7. (a) With the help of necessary sketches, explain the shell-mold casting process. List the advantages and limitations of this process. **(12)**

   (b) Compare Hot Chamber and Cold Chamber die casting process. List the advantages and disadvantages of die casting. **(12)**

   (c) What are the factors that affect the solidification of metals in casting process? Explain the solidification process of an alloy. **(11)**

8. (a) With the help of diagram, discuss the following: **(12)**
   (i) Close die forging
   (ii) Coining
   (iii) Upsetting
   (iv) Roll forging

   (b) With the help of diagram, discuss the following: **(12)**
   (i) Hot extrusion and
   (ii) Hydrostatic extrusion

   (c) What factors are involved in precision forging? Explain the various features of a typical forging die. **(11)**

Sushanta 1/1/2013

L-2/T-2/IPE

Date : 01/01/2013

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

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

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**.

1\. (a) Deduce the expression for torsional deflection of a closely coiled helical spring. **(15)**

(b) A compound shaft is attached to rigid supports as in Fig. 1(b). The limiting shear stresses for the bronze and steel segments are 55 MN/m^2 and 82 MN/m^2. Determine the diameter of each segment so that each material will be simultaneously stressed to its limiting value when a torque 16 kN.m is applied. For bronze G = 42 GN/m^2 and for steel G = 82 GN/m^2. **(20)**

2\. (a) Write the shear force and bending moment equations, and draw their diagrams for the beam in Fig. 2(a). **(18)**

(b) Derive the flexural formula for a beam and list up the assumptions made for the derivation. **(17)**

3\. (a) Obtain the expression for deflection of a simply supported uniformly loaded beam. Hence determine the maximum deflection and its location. **(20)**

(b) In a reinforced concrete beam shown in Fig. 3(b), allowable stresses for the steel and concrete are 100 MPa and 4 MPa, and $E_s/E_c = 15$. Determine the steel area required for the beam to be in balanced reinforcement. **(15)**

4\. (a) What is the use of failure theory? Derive the condition for failure of a body under combined loading by maximum shear distortion theory. **(12)**

(b) The circular link as in Fig. 4(b) has inner diameter of 40 mm. Determine the stresses at A and B for P = 50 kN. Justify that these stresses are the maxima at inner and outer sides of the link. Values of the correction factor K for flexural stress with rectangular cross-section are 0.81 for outside and 1.3 for inside of a curved beam. **(23)**

Contd P/2

SECTION – B

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

Symbols indicate their usual meanings.

5. (a) A cylindrical pressure vessel is fabricated from steel plating that has a thickness of 20 mm. The diameter of the pressure vessel is 450 mm and its length is 2 m. Determine the maximum internal pressure that can be applied if the longitudinal stress is limited to 140 MPa, and the circumferential stress is limited to 60 MPa. **(12)**

   (b) At what angular velocity will the stress in a rotating steel ring equal 150 MPa if its mean radius is 220 mm? The density of steel is 7.85 Mg/m^3. **(8)**

   (c) The rigid platform as shown in Fig. for Q. No. 5(c) has negligible mass and rests on two steel bars, each 250.00 mm long. The center bar is aluminum and 249.90 mm long. Compute the stress in the aluminum bar after the center load P = 400 kN has been applied. For each steel bar, the area is 1200 mm^2 and E = 200 GPa. For the aluminum bar, the area is 2400 mm^2 and E = 70 GPa. **(15)**

6. (a) A bronze bar 3 m long with a cross-sectional area of 320 mm^2 is placed between two rigid walls as shown in Fig. for Q. No. 6(a). At a temperature of –20°C, the gap $\Delta = 2.5$ mm. Find the temperature at which the compressive stress in the bar will be 35 MPa. Use $\alpha = 18.0 \times 10^{-6}$ m/(m.°C) and E = 80 GPa. **(18)**

   (b) A bronze bar is fastened between a steel bar and an aluminum bar as shown in Fig. for Q. No. 6(b). Axial loads are applied at the positions indicated. Find the largest value of P that will not exceed an overall deformation of 3.0 mm, or the following stresses: 140 MPa in the steel, 120 MPa in the bronze, and 80 MPa in the aluminum. Assume that the assembly is suitably braced to prevent buckling. Use E_{st} = 200 GPa, E_{al} = 70 GPa, and E_{br} = 83 GPa. **(17)**

7. (a) Determine the largest load P that can be supported by the circular steel bracket shown in Fig. for Q. No. 7(a) if the normal stress on section A–B is limited to 80 MPa. **(15)**

   (b) If an element is subjected to the state of stress shown in Fig. for Q. No. 7(b), find the principal stresses and the maximum in-plane shearing stresses. Also determine the stress components on planes whose normals are at 45^0 and 135° with the x axis. Show all results on complete sketches of the appropriate elements. Use Mohr's circle. **(20)**

8. (a) How do you interpret the critical load of a column? Briefly describe the limitations of Euler's column formula. Describe different possible end conditions and corresponding effective lengths of columns. **(18)**

   (b) A 50-mm by 100-mm timber is used as a column with fixed ends. Determine the minimum length at which Euler's formula can be used if E = 10 GPa and the proportional limit is 30 MPa. What central load can be carried with a factor of safety of 2 if the length is 2.5 m? **(17)**

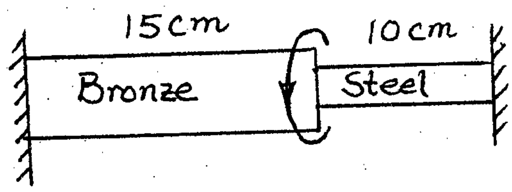


Figure for Q. 1(b)

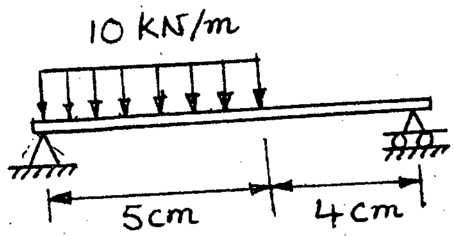


Figure for Q. 2(a)

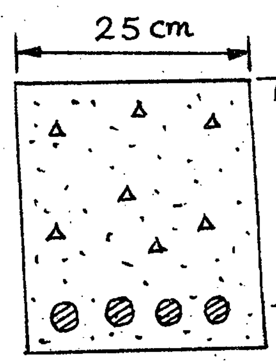


Figure for Q. 3(b)

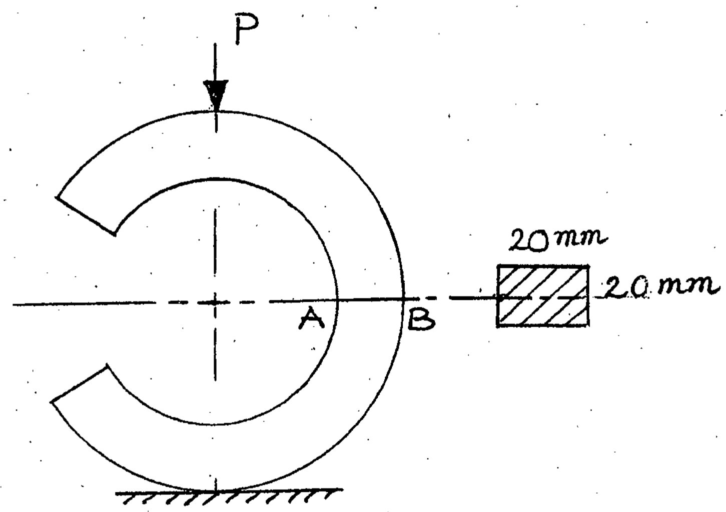


Figure for Q. 4(b)

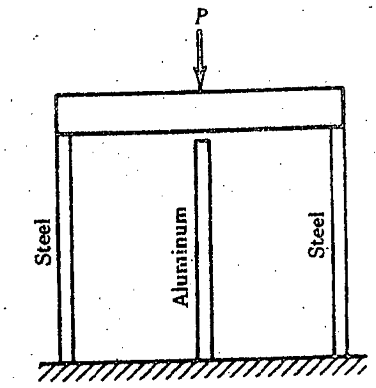


Figure for question No. ~~1~~(c) 5(c)

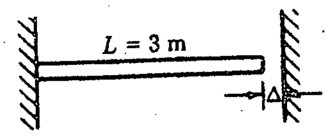


Figure for question No. ~~2~~(a) 6

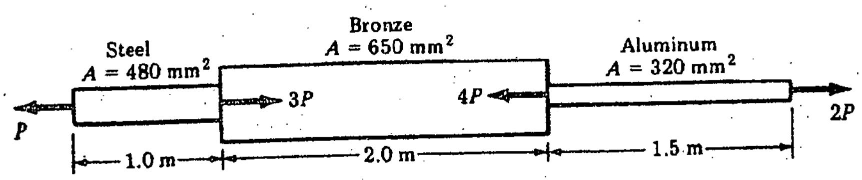


Figure for question No. ~~2~~(b) 6

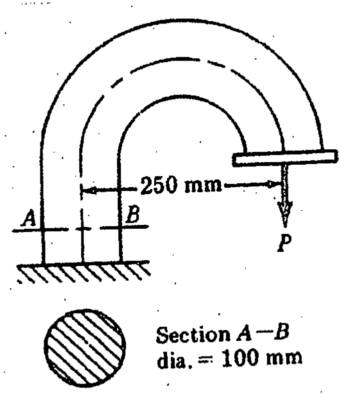


Figure for question No. ~~3~~(a) 7

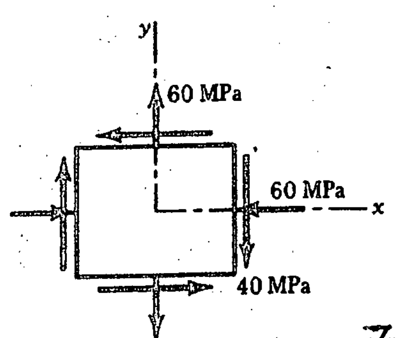


Figure for question No. ~~3~~(b) 7(b)

রবীন্দ্রনাথ ঠাকুর
১১/১২/১২

L-2/T-2/IPE Date : 18/12/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

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

Sub : **ME 265** (Thermodynamics and Head 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**.

Reasonable values can be assumed for any missing data. Symbols have their usual meanings.

1. (a) With a neat sketch, label the different parts of a Babcock and Wilcox boiler. **(12⅔)**

(b) Show graphically the variation of heat transfer rate with the outer radius of an insulation. **(5)**

(c) Consider a 5 m high, 8 m long and 0.22 m thick wall whose representative cross-section is shown in Fig. 1(c). The thermal conductivities of various materials used, in W/m°C, are $K_A = K_F = 2$, $K_B = 8$, $K_C = 20$, $K_D = 15$ and $K_E = 35$. The left and right surfaces of the wall are maintained at uniform temperature of 300°C and 100°C respectively. Assuming heat transfer through the wall to be one-dimensional, determine— **(29)**

(i) the rate of heat transfer through the wall.

(ii) the temperature drop across the section F. Disregard any contact resistance at the interface.

2. (a) What is a regenerative heat exchanger? Differentiate between static type and dynamic type of regenerative heat exchanger. **(15)**

(b) When a long section of a compressed air line passes through the outdoors, it is observed that the moisture in the compressed air freezes in cold weather, disrupting and even completely blocking the air flow in the pipe. To avoid this problem, the outer surface of the pipe is wrapped with electric strip heaters and then insulated. **(31⅓)**

Consider, a compressed air pipe (as shown in Fig. 2(b)) of length L = 6 m, inner radius r_1 = 3.7 cm, outer radius, r_2 = 4.0 cm, and the thermal conductivity k = 14 W/m°C equipped with a 300 W strip heater. Air is flowing through the pipe at an average temperature of –10°C, and the average convection heat transfer coefficient on the inner surface is h = 30 W/m^2.°C. Assuming 15% of the heat generated in the strip heater is lost through the insulation,

(i) express the differential equation and the boundary conditions for steady one dimensional heat conduction through the pipe.

(ii) obtain a relation for the variation of temperature in the pipe material and

(iii) evaluate the inner and outer surface temperatures of the pipe.

Contd P/2

ME 265

3. (a) Derive the energy equation for heat conduction in a solid. (22⅔)

(b) A 2-shell passes and 4-tube passes heat exchanger is used to heat glycerine from 20°C to 50°C by hot water, which enters the thin-walled 2 cm diameter tubes at 80°C and leaves at 40°C as shown in Fig. 3(b)(i). The total length of the tubes in the heat exchanger is 60 m. The convection heat transfer coefficient is 25 W/m^2.°C on the glycerine (shell) side and 160 W/m^2.°C on the water (tube) side. Determine the rate of heat transfer in the heat exchanger, (i) before any fouling and (ii) after fouling with a fouling factor of 0.0006 m^3.°C/W occurs on the outer surfaces of the tubes. (24)

4. (a) What is the physical significance of Biot number? (6)

(b) Consider heat transfer between two identical solid bodies and their environments. The first solid is dropped in a large container filled with water, while the second one is allowed to cool naturally in the air. For which solid is the lumped system analysis more likely to be applicable? Why? (6)

(c) A person puts a few apples into the freezer at –15°C to cool them quickly for quests who are about to arrive. Initially the apples are at a uniform temperature of 20°C, and the heat transfer coefficient on the surfaces is 8 W/m^2.°C. Treating the apples as 9 cm diameter spheres and taking their properties to be ρ = 840 kg/m^3, C_p = 3.81 kJ/kg.°C, k = 0.418 W/m.°C and $\alpha = 1.3 \times 10^{-7}$ m^2/s, determine the center and surface temperature of the apples in 1 hr. Also, determine the amount of heat transfer from each pipe. (34⅔)

SECTION – B

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

All symbols have their usual meaning.

Reasonable values may be assumed for any missing data.

5. (a) Identify whether the following properties are intensive or extensive property: pressure, temperature, mass, total volume, internal energy, total energy, density, specific volume, entropy, specific enthalpy. (10

(b) Draw the Temperature-Volume diagram for 1 kg of water heated in a closed chamber at different constant pressure and show the saturated-liquid line and saturated-vapor line and critical point. (1(

(c) A cylinder fitted with a piston has a volume of 0.2 m^3 and contains 1 kg of steam at 0.5 MPa. Heat is transferred to the steam until the temperature is 400°C, while the pressure remains constant. Determine the heat transfer and the work for this process. (26⅔

Contd P/3

ME 265

6. (a) What are the most desirable properties of refrigerants? What do you understand by ozone depletion? What are the effects of ozone depletion? **(10)**

(b) Why is a cooling tower used for central air conditioning system? What is ADP? Draw a psychrometric chart and show how ADP is calculated on it. **(10)**

(c) In an air conditioning system 4 kg of return air at 20°C and 60% relative humidity is mixed with 1 kg of fresh air at 35°C and 70% relative humidity to form a mixture. By using the supplied psychrometric chart, determine the following of the mixture: **(26⅔)**

(i) the relative humidity
(ii) the absolute humidity
(iii) the specific enthalpy
(iv) the specific volume
(v) the dry bulb and wet bulb temperature
(vi) the dew point temperature.

7. (a) "For the same compression ratio, the efficiency of the Otto-cycle in higher than that of the Diesel cycle but still diesel engines are more efficiency than petrol engines" — write down the equations for the efficiency of both cycles and explain. **(10)**

(b) Why the inlet valves are opened earlier with respect to TDC and sparks are given earlier with respect to TDC in a four stroke SI engine? **(10)**

(c) The compression ratio in an air-standard Otto cycle is 8. At the beginning of the compression stroke the pressure is 0.1 MPa and the temperature is 15°C. The heat transfer to the air per cycle is 1800 kJ/kg. Determine: **(26⅔)**

(i) the pressure and temperature at the end of each process of the cycle,
(ii) the thermal efficiency, and
(iii) the mean effective pressure.

(Assume C_V of air 0.7165 kJ/kg.k)

8. (a) What are the major applications of gas turbine engine? What are the important functions of air in gas turbine engine? **(10)**

(b) What are the different processes involved in an ideal Brayton Cycle, show it on T-S and P-V diagram. Prove that "the optimum pressure ratio for maximum work is comparatively much less compared with the pressure ratio for maximum efficiency. **(16⅔)**

(c) Air enters the compressor of a gas-turbine engine at 300 K and 100 kPa, where it is compressed to 700 kPa and 580 K. Heat is transferred to air in the amount of 950 kJ/kg before it enters the turbine. For a turbine efficiency of 86 percent. Determine (i) the fraction of the turbine work output used to drive the compressor and (ii) the thermal efficiency.

(Assume C_p of air 1.005 kJ/kg.k)

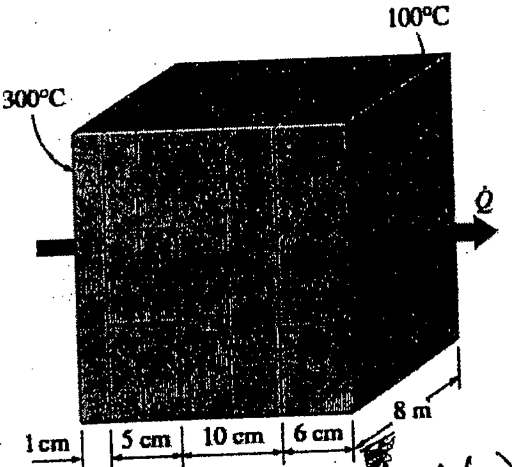


Figure for Que. No. 1(c)

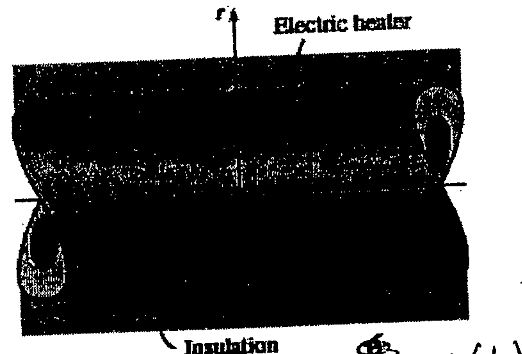
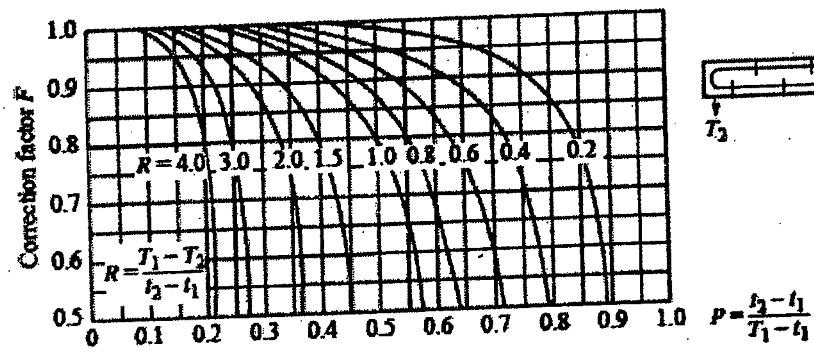


Figure for Que. No. 2(b)



(a) One-shell pass and 2, 4, 6, etc. (any multiple of 2), tube passes

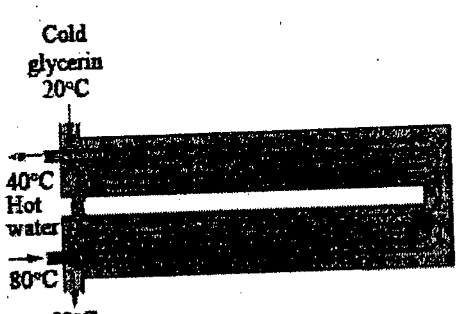
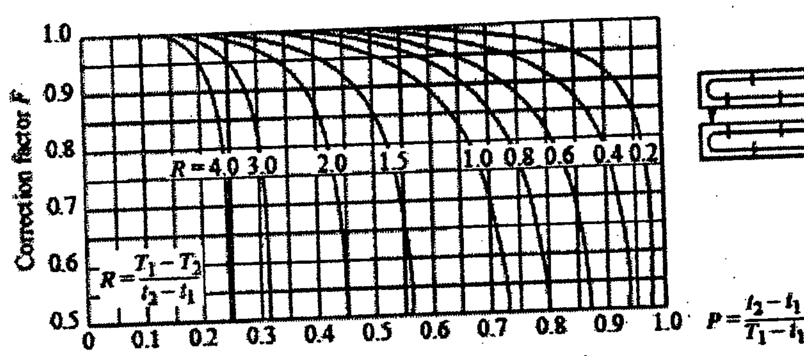


Figure for Que. No. 3(b)(i)



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

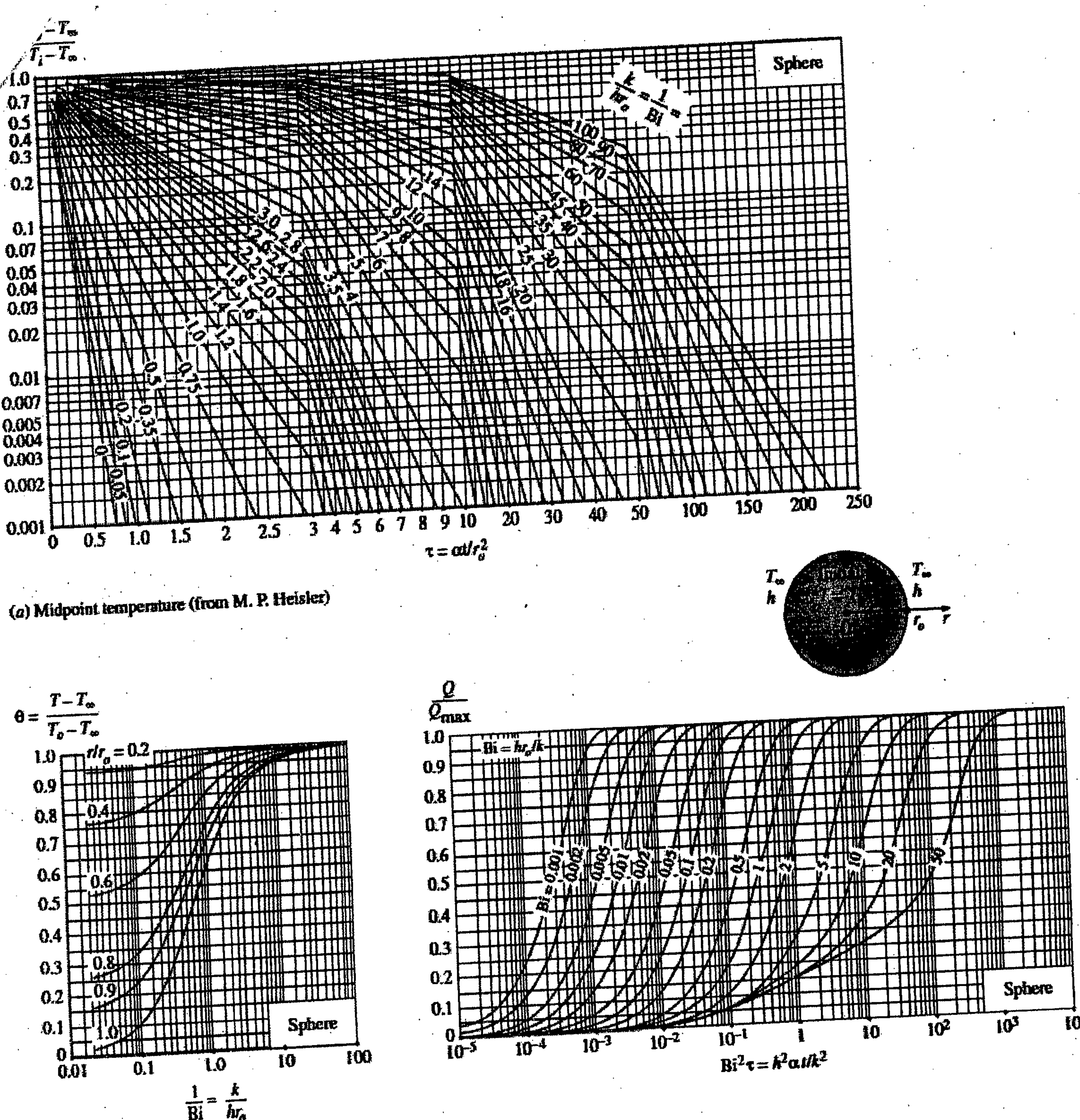
Figure for Que. No. 3(b)(ii) : Correction factor F for common shell-and-tube heat exchangers

Coefficients used in the one-term approximate solution of transient one-dimensional heat conduction in plane walls, cylinders, and spheres (Bi = hL/k for a plane wall of thickness $2L$, and Bi = hr_o/k for a cylinder or sphere of radius r_o)

	Plane Wall		Cylinder		Sphere	
Bi	λ_1	A_1	λ_1	A_1	λ_1	A_1
0.01	0.0998	1.0017	0.1412	1.0025	0.1730	1.0030
0.02	0.1410	1.0033	0.1995	1.0050	0.2445	1.0060
0.04	0.1987	1.0066	0.2814	1.0099	0.3450	1.0120
0.06	0.2425	1.0098	0.3438	1.0148	0.4217	1.0179
0.08	0.2791	1.0130	0.3960	1.0197	0.4860	1.0239
0.1	0.3111	1.0161	0.4417	1.0246	0.5423	1.0298
0.2	0.4328	1.0311	0.6170	1.0483	0.7593	1.0592
0.3	0.5218	1.0450	0.7465	1.0712	0.9208	1.0880
0.4	0.5932	1.0580	0.8516	1.0931	1.0528	1.1164
0.5	0.6533	1.0701	0.9408	1.1143	1.1656	1.1441
0.6	0.7051	1.0814	1.0184	1.1345	1.2644	1.1713
0.7	0.7506	1.0918	1.0873	1.1539	1.3525	1.1978
0.8	0.7910	1.1016	1.1490	1.1724	1.4320	1.2236
0.9	0.8274	1.1107	1.2048	1.1902	1.5044	1.2488
1.0	0.8603	1.1191	1.2558	1.2071	1.5708	1.2732
2.0	1.0769	1.1785	1.5995	1.3384	2.0288	1.4793
3.0	1.1925	1.2102	1.7887	1.4191	2.2889	1.6227
4.0	1.2646	1.2287	1.9081	1.4698	2.4556	1.7202
5.0	1.3138	1.2403	1.9898	1.5029	2.5704	1.7870
6.0	1.3496	1.2479	2.0490	1.5253	2.6537	1.8338
7.0	1.3766	1.2532	2.0937	1.5411	2.7165	1.8673
8.0	1.3978	1.2570	2.1286	1.5526	2.7654	1.8920
9.0	1.4149	1.2598	2.1566	1.5611	2.8044	1.9106
10.0	1.4289	1.2620	2.1795	1.5677	2.8363	1.9249
20.0	1.4961	1.2699	2.2880	1.5919	2.9857	1.9781
30.0	1.5202	1.2717	2.3261	1.5973	3.0372	1.9898
40.0	1.5325	1.2723	2.3455	1.5993	3.0632	1.9942
50.0	1.5400	1.2727	2.3572	1.6002	3.0788	1.9962
100.0	1.5552	1.2731	2.3809	1.6015	3.1102	1.9990
∞	1.5708	1.2732	2.4048	1.6021	3.1416	2.0000

Table for Que. No. 4(c)

(4)



(a) Midpoint temperature (from M. P. Heisler)

(b) Temperature distribution (from M. P. Heisler)

(c) Heat transfer (from H. Gröber et al.)

Figure for Que. No. 4(d): Transient temperature and heat transfer charts for a sphere.

Press., 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
		Specific volume, m³/kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg · K		
0.6113	0.01	0.001000	206.14	0.00	2375.3	2375.3	0.01	2501.3	2501.4	0.0000	9.1562	9.1562
1.0	6.98	0.001000	129.21	29.30	2355.7	2385.0	29.30	2484.9	2514.2	0.1059	8.8697	8.9756
1.5	13.03	0.001001	87.98	54.71	2338.6	2393.3	54.71	2470.6	2525.3	0.1957	8.6322	8.8279
2.0	17.50	0.001001	67.00	73.48	2326.0	2399.5	73.48	2460.0	2533.5	0.2607	8.4629	8.7237
2.5	21.08	0.001002	54.25	88.48	2315.9	2404.4	88.49	2451.6	2540.0	0.3120	8.3311	8.6432
3.0	24.08	0.001003	45.67	101.04	2307.5	2408.5	101.05	2444.5	2545.5	0.3545	8.2231	8.5776
4.0	28.96	0.001004	34.80	121.45	2293.7	2415.2	121.46	2432.9	2554.4	0.4226	8.0520	8.4746
5.0	32.88	0.001005	28.19	137.81	2282.7	2420.5	137.82	2423.7	2561.5	0.4764	7.9187	8.3951
7.5	40.29	0.001008	19.24	168.78	2261.7	2430.5	168.79	2406.0	2574.8	0.5764	7.6750	8.2515
10	45.81	0.001010	14.67	191.82	2246.1	2437.9	191.83	2392.8	2584.7	0.6493	7.5009	8.1502
15	53.97	0.001014	10.02	225.92	2222.8	2448.7	225.94	2373.1	2599.1	0.7549	7.2536	8.0085
20	60.06	0.001017	7.649	251.38	2205.4	2456.7	251.40	2358.3	2609.7	0.8320	7.0766	7.9085
25	64.97	0.001020	6.204	271.90	2191.2	2463.1	271.93	2346.3	2618.2	0.8931	6.9383	7.8314
30	69.10	0.001022	5.229	289.20	2179.2	2468.4	289.23	2336.1	2625.3	0.9439	6.8247	7.7686
40	75.87	0.001027	3.993	317.53	2159.5	2477.0	317.58	2319.2	2636.8	1.0259	6.6441	7.6700
50	81.33	0.001030	3.240	340.44	2143.4	2483.9	340.49	2305.4	2645.9	1.0910	6.5029	7.5939
75	91.78	0.001037	2.217	384.31	2112.4	2496.7	384.39	2278.6	2663.0	1.2130	6.2434	7.4564
Press., MPa												
0.100	99.63	0.001043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1.3026	6.0568	7.3594
0.125	105.99	0.001048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2233
0.175	116.06	0.001057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1717
0.200	120.23	0.001061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1271
0.225	124.00	0.001064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878
0.250	127.44	0.001067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001070	0.6573	548.59	1991.9	2540.5	548.89	2172.4	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001097	0.3427	655.32	1909.2	2564.5	665.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001108	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001121	0.2150	741.83	1838.6	2580.5	742.83	2031.1	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001127	0.19444	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001133	0.17753	780.09	1806.3	2586.4	781.34	2000.4	2871.7	2.1792	4.3744	6.5536
1.20	187.99	0.001139	0.16333	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001144	0.15125	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953

…d water

T	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
	P = 0.01 MPa (45.81°C)*				P = 0.05 MPa (81.33°C)				P = 0.10 MPa (99.63°C)			
Sat	14.674	2437.9	2584.7	8.1502	3.240	2483.9	2645.9	7.5939	1.6940	2506.1	2675.5	7.3594
50	14.869	2443.9	2592.6	8.1749								
100	17.196	2515.5	2687.5	8.4479	3.418	2511.6	2682.5	7.6947	1.6958	2506.7	2676.2	7.3614
150	19.512	2587.9	2783.0	8.6882	3.889	2585.6	2780.1	7.9401	1.9364	2582.8	2776.4	7.6134
200	21.825	2661.3	2879.5	8.9038	4.356	2659.9	2877.7	8.1580	2.172	2658.1	2875.3	7.8343
250	24.136	2736.0	2977.3	9.1002	4.820	2735.0	2976.0	8.3556	2.406	2733.7	2974.3	8.0333
300	26.445	2812.1	3076.5	9.2813	5.284	2811.3	3075.5	8.5373	2.639	2810.4	3074.3	8.2158
400	31.063	2968.9	3279.6	9.6077	6.209	2968.5	3278.9	8.8642	3.103	2967.9	3278.2	8.5435
500	35.679	3132.3	3489.1	9.8978	7.134	3132.0	3488.7	9.1546	3.565	3131.6	3488.1	8.8342
600	40.295	3302.5	3705.4	10.1608	8.057	3302.2	3705.1	9.4178	4.028	3301.9	3704.4	9.0976
700	44.911	3479.6	3928.7	10.4028	8.981	3479.4	3928.5	9.6599	4.490	3479.2	3928.2	9.3398
800	49.526	3663.8	4159.0	10.6281	9.904	3663.6	4158.9	9.8852	4.952	3663.5	4158.6	9.5652
900	54.141	3855.0	4396.4	10.8396	10.828	3854.9	4396.3	10.0967	5.414	3854.8	4396.1	9.7767
1000	58.757	4053.0	4640.6	11.0393	11.751	4052.9	4640.5	10.2964	5.875	4052.8	4640.3	9.9764
1100	63.372	4257.5	4891.2	11.2287	12.674	4257.4	4891.1	10.4859	6.337	4257.3	4891.0	10.1659
1200	67.987	4467.9	5147.8	11.4091	13.597	4467.8	5147.7	10.6662	6.799	4467.7	5147.6	10.3463
1300	72.602	4683.7	5409.7	11.5811	14.521	4683.6	5409.6	10.8382	7.260	4683.5	5409.5	10.5183
	P = 0.20 MPa (120.23°C)				P = 0.30 MPa (133.55°C)				P = 0.40 MPa (143.63°C)			
Sat.	0.8857	2529.5	2706.7	7.1272	0.6058	2543.6	2725.3	6.9919	0.4625	2553.6	2738.6	6.8959
150	0.9596	2576.9	2768.8	7.2795	0.6339	2570.8	2761.0	7.0778	0.4708	2564.5	2752.8	6.9299
200	1.0803	2654.4	2870.5	7.5066	0.7163	2650.7	2865.6	7.3115	0.5342	2646.8	2860.5	7.1706
250	1.1988	2731.2	2971.0	7.7086	0.7964	2728.7	2967.6	7.5166	0.5951	2726.1	2964.2	7.3789
300	1.3162	2808.6	3071.8	7.8926	0.8753	2806.7	3069.3	7.7022	0.6548	2804.8	3066.8	7.5662
400	1.5493	2966.7	3276.6	8.2218	1.0315	2965.6	3275.0	8.0330	0.7726	2964.4	3273.4	7.8985
500	1.7814	3130.8	3487.1	8.5133	1.1867	3130.0	3486.0	8.3251	0.8893	3129.2	3484.9	8.1913
600	2.013	3301.4	3704.0	8.7770	1.3414	3300.8	3703.2	8.5892	1.0055	3300.2	3702.4	8.4558
700	2.244	3478.8	3927.6	9.0194	1.4957	3478.4	3927.1	8.8319	1.1215	3477.9	3926.5	8.6987
800	2.475	3663.1	4158.2	9.2449	1.6499	3662.9	4157.8	9.0576	1.2372	3662.4	4157.3	8.9244
900	2.705	3854.5	4395.8	9.4566	1.8041	3854.2	4395.4	9.2692	1.3529	3853.9	4395.1	9.1362
1000	2.937	4052.5	4640.0	9.6563	1.9581	4052.3	4639.7	9.4690	1.4685	4052.0	4639.4	9.3360
1100	3.168	4257.0	4890.7	9.8458	2.1121	4256.8	4890.4	9.6585	1.5840	4256.5	4890.2	9.5256
1200	3.399	4467.5	5147.5	10.0262	2.2661	4467.2	5147.1	9.8389	1.6996	4467.0	5146.8	9.7060
1300	3.630	4683.2	5409.3	10.1982	2.4201	4683.0	5409.0	10.0110	1.8151	4682.8	5408.8	9.8780
	P = 0.50 MPa (151.86°C)				P = 0.60 MPa (158.85°C)				P = 0.80 MPa (170.43°C)			
Sat.	0.3749	2561.2	2748.7	6.8213	0.3157	2567.4	2756.8	6.7600	0.2404	2576.8	2769.1	6.6628
200	0.4249	2642.9	2855.4	7.0592	0.3520	2638.9	2850.1	6.9665	0.2608	2630.6	2839.3	6.8158
250	0.4744	2723.5	2960.7	7.2709	0.3938	2720.9	2957.2	7.1816	0.2931	2715.5	2950.0	7.0384
300	0.5226	2802.9	3064.2	7.4599	0.4344	2801.0	3061.6	7.3724	0.3241	2797.2	3056.5	7.2328
350	0.5701	2882.6	3167.7	7.6329	0.4742	2881.2	3165.7	7.5464	0.3544	2878.2	3161.7	7.4089
400	0.6173	2963.2	3271.9	7.7938	0.5137	2962.1	3270.3	7.7079	0.3843	2959.7	3267.1	7.5716
500	0.7109	3128.4	3483.9	8.0873	0.5920	3127.6	3482.8	8.0021	0.4433	3126.0	3480.6	7.8673
600	0.8041	3299.6	3701.7	7.3522	0.6697	3299.1	3700.9	8.2674	0.5018	3297.9	3699.4	8.1333
700	0.8969	3477.5	3925.9	8.5952	0.7472	3477.0	3925.3	8.5107	0.5601	3476.2	3924.2	8.3770
800	0.9896	3662.1	4156.9	8.8211	0.8245	3661.8	4156.5	8.7367	0.6181	3661.1	4155.6	8.6033
900	1.0822	3853.6	4394.7	9.0329	0.9017	3853.4	4394.4	8.9486	0.6761	3852.8	4393.7	8.8153
1000	1.1747	4051.8	4639.1	9.2328	0.9788	4051.5	4638.8	9.1485	0.7340	4051.0	4638.2	9.0153
1100	1.2672	4256.3	4889.9	9.4224	1.0559	4256.1	4889.6	9.3381	0.7919	4255.6	4889.1	9.2050
1200	1.3596	4466.8	5146.6	9.6029	1.1330	4466.5	5146.3	9.5185	0.8497	4466.1	5145.9	9.3855
1300	1.4521	4682.5	5408.6	9.7749	1.2101	4682.3	5408.3	9.6906	0.9076	4681.8	5407.9	9.5575

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

Properties of saturated vapor at the specified pressure.

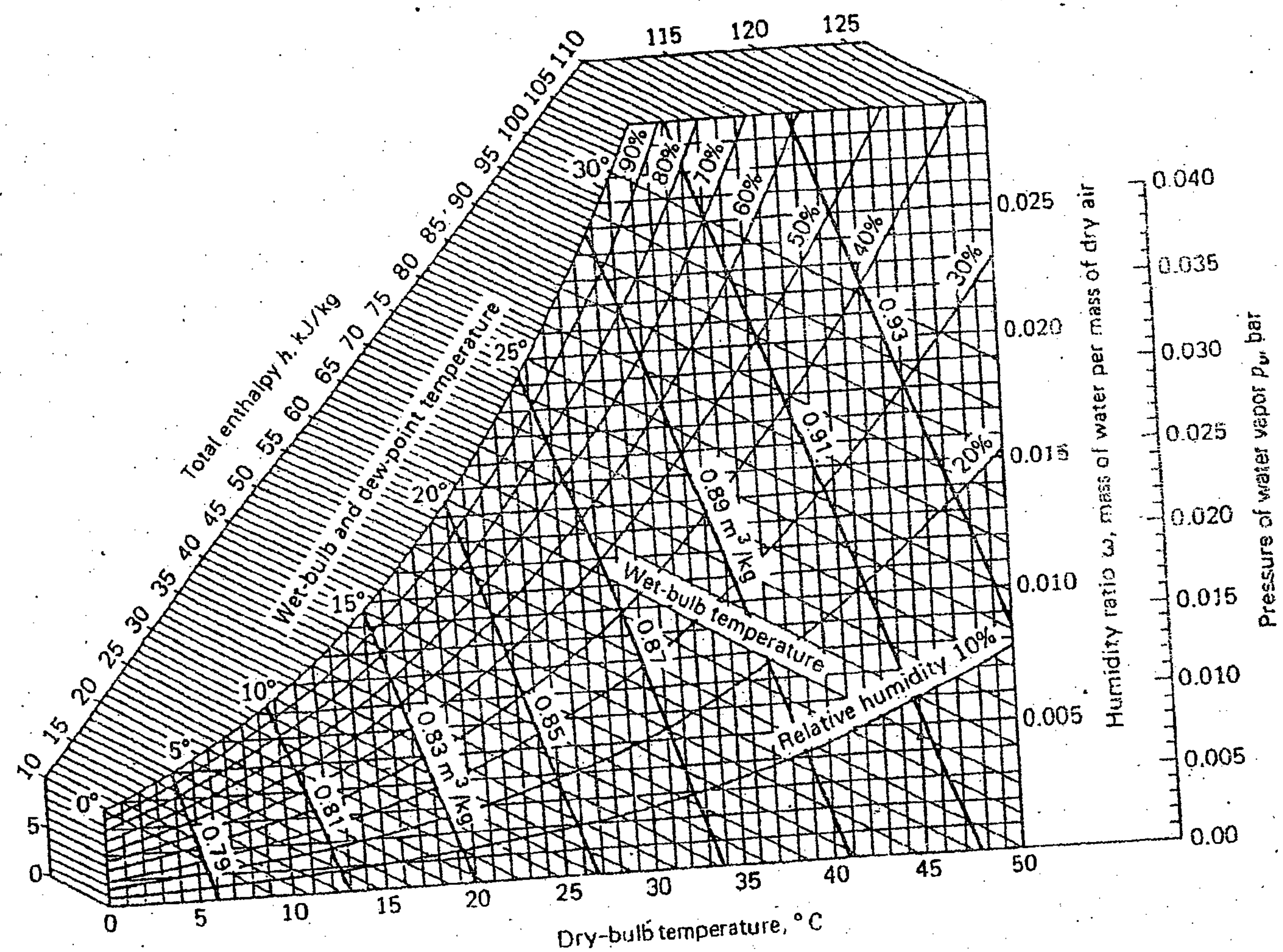


FIGURE A-25M
Psychrometric chart, metric units, barometric pressure 1.01 bars.