UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2023/2024

COURSE NAME   : ENGINEERING ECONOMICS

COURSE CODE   : BFC 44602

PROGRAMME CODE   : BFF

EXAMINATION DATE   : JANUARY/FEBRUARY 2024

DURATION   : 2 HOURS

INSTRUCTION   : 1. ANSWER **ALL** QUESTIONS
                              2. THIS FINAL EXAMINATION IS CONDUCTED VIA
                                ☐ Open book
                                ☒ Closed book
                              3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF **ELEVEN (11)** PAGES

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Q1   (a)   Titan company in Johor is planning to send all its engineers to attend a technical workshop in Kuala Lumpur. The duration of the trip will be 2 days and 1 night. **Table Q1.1** shows the necessary expenses for the trip.

Table Q1.1 Cost of the workshop trip.

Bus rental	RM 250 per day
Accommodation	RM 100 per twin sharing room
Food and beverages	RM 50 per person
Taxi fare (one way)	RM 30 per person

(i)   Establish an equation to estimate the total expenses for the trip. You may provide any logically appropriate assumption (if required).

(5 marks)

(ii)   If the bus capacity is 40 seats and the organizer offers a package of RM 200 per person for the trip. Calculate the maximum profit that the company could gain.

(5 marks)

(iii)   The company decided to cancel the trip if the trip is unprofitable. In this case, calculate the minimum number of packages that need to be sold to ensure the trip can proceed as planned.

(5 marks)

(b)   Titan Sdn. Bhd is a contractor company specialised in bridge construction. The company has been offered two projects to construct a bridge at two different locations. However, based on the company's capability, the company can only accept one project at a time. To make the decision, cost estimation has to be made. **Table Q1.2** shows the cost factors for both projects.

Table Q1.2

Cost Factors	Project A	Project B
Concrete beams and columns needed	6 beams, 12 columns	8 beams, 16 columns
Equipment rental (per month)	RM1000	RM2500
Site investigation	RM40636	RM30848
Labour cost:		
(i) Design engineer	RM 150 per hour	RM 130 per hour
(ii) Field/construction engineer	RM 100 per hour	RM 90 per hour

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Total of 12 months are required for design and construction phase, with 6 working days per week and 8 working hours per day. The volume for each beam and column are 500m^3 and 314m^3, respectively. The cost of concrete is RM65 per unit volume. Evaluate the best project based on total project cost with suitable justification

(10 marks)

Q2 (a) Cost estimation in a construction project is a complex and critical task that requires a various approaches and methods to ensure accuracy and reliability. Discuss the top-down and bottom-up approaches in cost estimation.

(8 marks)

(b) Cost and revenue estimates can be classified according to detail, accuracy, and their intended use. Describe the following:

(i) Rough estimation

(2 marks)

(ii) Detailed estimation

(2 marks)

(c) You are managing a civil engineering construction project that involves assembling pre-fabricated structural components. You have observed that as the construction crew gain experience, the time required to assemble the following unit is reduced. The time it took to assemble the first component was 90 minutes. The learning curve is 90%, meaning that as output is doubles, the time per unit is reduced by 10%. Consider working hours per day is 10 hours (2 hours overtime included).

(i) Calculate the estimated time required to assemble the 5th structural component for the construction project.

(3 marks)

(ii) Based on the cumulative average assembly time for the first 5 components, calculate the number of components that can be assembled in a day.

(6 marks)

(iii) From your result in **Q2(c)(ii)**, calculate the actual amount of overtime (in minutes).

(4 marks)

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Q3 (a) A robot will be purchased for RM18,000. It will cost RM2,500 per year to operate and maintain for 6 years. The robot also requires an overhaul at the end of year 4, costing RM5,000. At the end of year 6, it will be donated to Metro School of Engineering. The donation will save RM2000 in taxes. Draw the cash flow diagram.

(5 marks)

(b) A new engineer plans on depositing RM500 per month in an account that pays 6% annual interest with monthly compounding to buy a car next years.

(i) Calculate the down payment for a car, accumulated after a year by the engineer.

(3 marks)

(ii) If he targeted RM7,000 for the down payment, calculate the monthly deposit.

(2 marks)

(c) Bersih Environmental Services is evaluating two alternative methods for the disposing of municipal waste. The first involves developing a landfill site near the city. Costs of the site include RM1,000,000 start-up costs, RM100,000 closedown costs 30 years from now, and operating costs of RM20,000 per year. Starting in 10 years, it is expected that there will be revenues from user fees of RM30,000 per year. The alternative is to ship the waste out of the region. An area firm will agree to a long-term contract to dispose of the waste for RM130,000 per year.

(i) Which alternative is economically preferred for a MARR of 11% using annual equivalent value.

(13 marks)

(ii) Based on **Q3(c)(i)**, provide appropriate justification to defend your opinion.

(2 marks)

Q4 (a) A toll bridge across the Sungai Pahang is being considered to replace the current bridge linking Maran to Chini. The B-C ratio method must be applied in the evaluation. Investment costs of the structure are estimated to be RM17,500,00. RM325,000 is expected to be spent annually on operations and maintenance. In

4

addition, the bridge must be resurfaced every 5 years of its 30-year projected life at a cost of RM1,250,000 per occurrence. From this construction, the administrators through the surrounding community will get revenue estimated at RM23 Million. Assume there is no market value for the bridge at the end of 30 years and a MARR is 10% per year. Prepare a benefit-cost analysis to determine whether the toll bridge should be constructed.

(9 marks)

(b)   Refer to **Q4(a)**; suppose that the toll bridge can be redesigned for a more one-time life. MARR remains at 10% per year. **Table Q4.1** provides the revised costs and expected revenues.

Table Q4.1

	RM
Capital investment	22,500,000
Annual operating and maintenance costs	250,000
Resurface cost every 10 years	1,000,000
Structural repair cost in the 20th year	1,750,000
Revenue per year (treated as constant – no rate of increase)	3,000,000

(i)   Compute the B-C ratio of the bridge within the specified time.

(8 marks)

(ii)   Calculate and identify whether the new design is better than the initial design in **Q4(a).**

(8 marks)

– END OF QUESTIONS –

APPENDIX A

0.50%		Table 2 Discrete cash flow: compound interest factors					0.50%
Single Payments		Uniform-Series Payments				Uniform Gradient	
Compound Amount	Present Worth	Sinking Fund	Compound Amount	Capital Recovery	Present Worth	Gradient Present	Gradient Annual
F/P	P/F	A/F	F/A	A/P	P/A	Worth P/G	Series A/G
1	1.0050	0.9950	1.00000	1.00000	1.00500	0.9950		
2	1.0100	0.9901	0.49875	2.00500	0.50375	1.9851	0.9901	0.4988
3	1.0151	0.9851	0.33167	3.01502	0.33667	2.9702	2.9604	0.9967
4	1.0202	0.9802	0.24813	4.03010	0.25313	3.9505	5.9011	1.4938
5	1.0253	0.9754	0.19801	5.05025	0.20301	4.9259	9.8026	1.9900
6	1.0304	0.9705	0.16460	6.07550	0.16960	5.8964	14.6552	2.4855
7	1.0355	0.9657	0.14073	7.10588	0.14573	6.8621	20.4493	2.9801
8	1.0407	0.9609	0.12283	8.14141	0.12783	7.8230	27.1755	3.4738
9	1.0459	0.9561	0.10891	9.18212	0.11391	8.7791	34.8244	3.9668
10	1.0511	0.9513	0.09777	10.22803	0.10277	9.7304	43.3865	4.4589
11	1.0564	0.9466	0.08866	11.27917	0.09366	10.6770	52.8526	4.9501
12	1.0617	0.9419	0.08107	12.33556	0.08607	11.6189	63.2136	5.4406
13	1.0670	0.9372	0.07464	13.39724	0.07964	12.5562	74.4602	5.9302
14	1.0723	0.9326	0.06914	14.46423	0.07414	13.4887	86.5835	6.4190
15	1.0777	0.9279	0.06436	15.53655	0.06936	14.4166	99.5743	6.9069
16	1.0831	0.9233	0.06019	16.61423	0.06519	15.3399	113.4238	7.3940
17	1.0885	0.9187	0.05651	17.69730	0.06151	16.2586	128.1231	7.8803
18	1.0939	0.9141	0.05323	18.78579	0.05823	17.1728	143.6634	8.3658
19	1.0994	0.9096	0.05030	19.87972	0.05530	18.0824	160.0360	8.8504
20	1.1049	0.9051	0.04767	20.97912	0.05267	18.9874	177.2322	9.3342
21	1.1104	0.9006	0.04528	22.08401	0.05028	19.8880	195.2434	9.8172
22	1.1160	0.8961	0.04311	23.19443	0.04811	20.7841	214.0611	10.2993
23	1.1216	0.8916	0.04113	24.31040	0.04613	21.6757	233.6768	10.7806
24	1.1272	0.8872	0.03932	25.43196	0.04432	22.5629	254.0820	11.2611
25	1.1328	0.8828	0.03765	26.55912	0.04265	23.4456	275.2686	11.7407
26	1.1385	0.8784	0.03611	27.69191	0.04111	24.3240	297.2281	12.2195
27	1.1442	0.8740	0.03469	28.83037	0.03969	25.1980	319.9523	12.6975
28	1.1499	0.8697	0.03336	29.97452	0.03836	26.0677	343.4332	13.1747
29	1.1556	0.8653	0.03213	31.12439	0.03713	26.9330	367.6625	13.6510
30	1.1614	0.8610	0.03098	32.28002	0.03598	27.7941	392.6324	14.1265
36	1.1967	0.8356	0.02542	39.33610	0.03042	32.8710	557.5598	16.9621
40	1.2208	0.8191	0.02265	44.15885	0.02765	36.1722	681.3347	18.8359
48	1.2705	0.7871	0.01849	54.09783	0.02349	42.5803	959.9188	22.5437
50	1.2832	0.7793	0.01765	56.64516	0.02265	44.1428	1035.6966	23.4624
52	1.2961	0.7716	0.01689	59.21803	0.02189	45.6897	1113.8162	24.3778
55	1.3156	0.7601	0.01584	63.12577	0.02084	47.9814	1235.2686	25.7447
60	1.3489	0.7414	0.01433	69.77003	0.01933	51.7256	1448.6458	28.0064
72	1.4320	0.6983	0.01157	86.40886	0.01657	60.3395	2012.3478	33.3504
75	1.4536	0.6879	0.01102	90.72650	0.01602	62.4136	2163.7525	34.6679
84	1.5204	0.6577	0.00961	104.07393	0.01461	68.4530	2640.6641	38.5763
90	1.5666	0.6383	0.00883	113.31094	0.01383	72.3313	2976.0769	41.1451
96	1.6141	0.6195	0.00814	122.82854	0.01314	76.0952	3324.1846	43.6845
100	1.6467	0.6073	0.00773	129.33370	0.01273	78.5426	3562.7934	45.3613
108	1.7137	0.5835	0.00701	142.73990	0.01201	83.2934	4054.3747	48.6758

6%			Table 11 Discrete cash flow: compound interest factors					6%
	Single Payments		Uniform-Series Payments				Uniform Gradient	
	Compound Amount	Present Worth	Sinking Fund	Compound Amount	Capital Recovery	Present Worth	Gradient Present	Gradient Annual
	F/P	P/F	A/F	F/A	A/P	P/A	Worth P/G	Series A/G
1	1.0600	0.9434	1.00000	1.00000	1.06000	0.9434		
2	1.1236	0.8900	0.48544	2.06000	0.54544	1.8334	0.8900	0.4854
3	1.1910	0.8396	0.31411	3.18360	0.37411	2.6730	2.5692	0.9612
4	1.2625	0.7921	0.22859	4.37462	0.28859	3.4651	4.9455	1.4272
5	1.3382	0.7473	0.17740	5.63709	0.23740	4.2124	7.9345	1.8836
6	1.4185	0.7050	0.14336	6.97532	0.20336	4.9173	11.4594	2.3304
7	1.5036	0.6651	0.11914	8.39384	0.17914	5.5824	15.4497	2.7676
8	1.5938	0.6274	0.10104	9.89747	0.16104	6.2098	19.8416	3.1952
9	1.6895	0.5919	0.08702	11.49132	0.14702	6.8017	24.5768	3.6133
10	1.7908	0.5584	0.07587	13.18079	0.13587	7.3601	29.6023	4.0220
11	1.8983	0.5268	0.06679	14.97164	0.12679	7.8869	34.8702	4.4213
12	2.0122	0.4970	0.05928	16.86994	0.11928	8.3838	40.3369	4.8113
13	2.1329	0.4688	0.05296	18.88214	0.11296	8.8527	45.9629	5.1920
14	2.2609	0.4423	0.04758	21.01507	0.10758	9.2950	51.7128	5.5635
15	2.3966	0.4173	0.04296	23.27597	0.10296	9.7122	57.5546	5.9260
16	2.5404	0.3936	0.03895	25.67253	0.09895	10.1059	63.4592	6.2794
17	2.6928	0.3714	0.03544	28.21288	0.09544	10.4773	69.4011	6.6240
18	2.8543	0.3503	0.03236	30.90565	0.09236	10.8276	75.3569	6.9597
19	3.0256	0.3305	0.02962	33.75999	0.08962	11.1581	81.3062	7.2867
20	3.2071	0.3118	0.02718	36.78559	0.08718	11.4699	87.2304	7.6051
21	3.3996	0.2942	0.02500	39.99273	0.08500	11.7641	93.1136	7.9151
22	3.6035	0.2775	0.02305	43.39229	0.08305	12.0416	98.9412	8.2166
23	3.8197	0.2618	0.02128	46.99583	0.08128	12.3034	104.7007	8.5099
24	4.0489	0.2470	0.01968	50.81558	0.07968	12.5504	110.3812	8.7951
25	4.2919	0.2330	0.01823	54.86451	0.07823	12.7834	115.9732	9.0722
26	4.5494	0.2198	0.01690	59.15638	0.07690	13.0032	121.4684	9.3414
27	4.8223	0.2074	0.01570	63.70577	0.07570	13.2105	126.8600	9.6029
28	5.1117	0.1956	0.01459	68.52811	0.07459	13.4062	132.1420	9.8568
29	5.4184	0.1846	0.01358	73.63980	0.07358	13.5907	137.3096	10.1032
30	5.7435	0.1741	0.01265	79.05819	0.07265	13.7648	142.3588	10.3422
31	6.0881	0.1643	0.01179	84.80168	0.07179	13.9291	147.2864	10.5740
32	6.4534	0.1550	0.01100	90.88978	0.07100	14.0840	152.0901	10.7988
33	6.8406	0.1462	0.01027	97.34316	0.07027	14.2302	156.7681	11.0166
34	7.2510	0.1379	0.00960	104.18375	0.06960	14.3681	161.3192	11.2276
35	7.6861	0.1301	0.00897	111.43478	0.06897	14.4982	165.7427	11.4319
40	10.2857	0.0972	0.00646	154.76197	0.06646	15.0463	185.9568	12.3590
45	13.7646	0.0727	0.00470	212.74351	0.06470	15.4558	203.1096	13.1413
50	18.4202	0.0543	0.00344	290.33590	0.06344	15.7619	217.4574	13.7964
55	24.6503	0.0406	0.00254	394.17203	0.06254	15.9905	229.3222	14.3411
60	32.9877	0.0303	0.00188	533.12818	0.06188	16.1614	239.0428	14.7909
65	44.1450	0.0227	0.00139	719.08286	0.06139	16.2891	246.9450	15.1601
70	59.0759	0.0169	0.00103	967.93217	0.06103	16.3845	253.3271	15.4613
75	79.0569	0.0126	0.00077	1300.94868	0.06077	16.4558	258.4527	15.7058
80	105.7960	0.0095	0.00057	1746.59989	0.06057	16.5091	262.5493	15.9033
85	141.5789	0.0071	0.00043	2342.98174	0.06043	16.5489	265.8096	16.0620
90	189.4645	0.0053	0.00032	3141.07519	0.06032	16.5787	268.3946	16.1891
95	253.5463	0.0039	0.00024	4209.10425	0.06024	16.6009	270.4375	16.2905
96	268.7590	0.0037	0.00022	4462.65050	0.06022	16.6047	270.7909	16.3081
98	301.9776	0.0033	0.00020	5016.29411	0.06020	16.6115	271.4491	16.3411
100	339.3021	0.0029	0.00018	5638.36806	0.06018	16.6175	272.0471	16.3711

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10%		Table 15 Discrete cash flow: compound interest factors					10%
	Single Payments		Uniform-Series Payments				Uniform Gredient
	Compound Amount	Present Worth	Sinking Fund	Compound Amount	Capital Recovery	Present Worth	Gredient Present	Gredient Annual
	F/P	P/F	A/F	F/A	A/P	P/A	Worth P/G	Series A/G
1	1.1000	0.9091	1.00000	1.00000	1.10000	0.9091		
2	1.2100	0.8264	0.47619	2.10000	0.57619	1.7355	0.8264	0.4762
3	1.3310	0.7513	0.30211	3.31000	0.40211	2.4869	2.3291	0.9366
4	1.4641	0.6830	0.21547	4.64100	0.31547	3.1699	4.3781	1.3812
5	1.6105	0.6209	0.16380	6.10510	0.26380	3.7908	6.8618	1.8101
6	1.7716	0.5645	0.12961	7.71561	0.22961	4.3553	9.6842	2.2236
7	1.9487	0.5132	0.10541	9.48717	0.20541	4.8684	12.7631	2.6216
8	2.1436	0.4665	0.08744	11.43589	0.18744	5.3349	16.0287	3.0045
9	2.3579	0.4241	0.07364	13.57948	0.17364	5.7590	19.4215	3.3724
10	2.5937	0.3855	0.06275	15.93742	0.16275	6.1446	22.8913	3.7255
11	2.8531	0.3505	0.05396	18.53117	0.15396	6.4951	26.3963	4.0641
12	3.1384	0.3186	0.04676	21.38428	0.14676	6.8137	29.9012	4.3884
13	3.4523	0.2897	0.04078	24.52271	0.14078	7.1034	33.3772	4.6988
14	3.7975	0.2633	0.03575	27.97498	0.13575	7.3667	36.8005	4.9955
15	4.1772	0.2394	0.03147	31.77248	0.13147	7.6061	40.1520	5.2789
16	4.5950	0.2176	0.02782	35.94973	0.12782	7.8237	43.4164	5.5493
17	5.0545	0.1978	0.02466	40.54470	0.12466	8.0216	46.5819	5.8071
18	5.5599	0.1799	0.02193	45.59917	0.12193	8.2014	49.6395	6.0526
19	6.1159	0.1635	0.01955	51.15909	0.11955	8.3649	52.5827	6.2861
20	6.7275	0.1486	0.01746	57.27500	0.11746	8.5136	55.4069	6.5081
21	7.4002	0.1351	0.01562	64.00250	0.11562	8.6487	58.1095	6.7189
22	8.1403	0.1228	0.01401	71.40275	0.11401	8.7715	60.6893	6.9189
23	8.9543	0.1117	0.01257	79.54302	0.11257	8.8832	63.1462	7.1085
24	9.8497	0.1015	0.01130	88.49733	0.11130	8.9847	65.4813	7.2881
25	10.8347	0.0923	0.01017	98.34706	0.11017	9.0770	67.6964	7.4580
26	11.9182	0.0839	0.00916	109.18177	0.10916	9.1609	69.7940	7.6186
27	13.1100	0.0763	0.00826	121.09994	0.10826	9.2372	71.7773	7.7704
28	14.4210	0.0693	0.00745	134.20994	0.10745	9.3066	73.6495	7.9137
29	15.8631	0.0630	0.00673	146.63093	0.10673	9.3696	75.4146	8.0489
30	17.4494	0.0573	0.00608	164.49402	0.10608	9.4269	77.0766	8.1762
31	19.1943	0.0521	0.00550	181.94342	0.10550	9.4790	78.6395	8.2962
32	21.1138	0.0474	0.00497	201.13777	0.10497	9.5264	80.1078	8.4091
33	23.2252	0.0431	0.00450	222.25154	0.10450	9.5694	81.4856	8.5152
34	25.5477	0.0391	0.00407	245.47670	0.10407	9.6086	82.7773	8.6149
35	28.1024	0.0356	0.00369	271.02437	0.10369	9.6442	83.9872	8.7086
40	45.2593	0.0221	0.00226	442.59256	0.10226	9.7791	88.9525	9.0962
45	72.8905	0.0137	0.00139	718.90484	0.10139	9.8628	92.4544	9.3740
50	117.3909	0.0085	0.00086	1163.90853	0.10086	9.9148	94.8889	9.5704
55	189.0591	0.0053	0.00053	1880.59142	0.10053	9.9471	96.5619	9.7075
60	304.4816	0.0033	0.00033	3034.81640	0.10033	9.9672	97.7010	9.8023
65	490.3707	0.0020	0.00020	4893.70725	0.10020	9.9796	98.4705	9.8672
70	789.7470	0.0013	0.00013	7887.46957	0.10013	9.9873	98.9870	9.9113
75	1271.8954	0.0008	0.00008	12708.95371	0.10008	9.9921	99.3317	9.9410
80	2048.4002	0.0005	0.00005	20474.00215	0.10005	9.9951	99.5606	9.9609
85	3298.9690	0.0003	0.00003	32979.69030	0.10003	9.9970	99.7120	9.9742
90	5313.0226	0.0002	0.00002	53120.22612	0.10002	9.9981	99.8118	9.9831
95	8556.6760	0.0001	0.00001	85556.76047	0.10001	9.9988	99.8773	9.9889
96	9412.3437	0.0001	0.00001	94113.43651	0.10001	9.9989	99.8874	9.9898
98	11388.9358	0.0001	0.00001	113879.35818	0.10001	9.9991	99.9052	9.9914

11%			Table 16 Discrete cash flow: compound interest factors					11%
	Single Payments		Uniform-Series Payments				Uniform Gradient	
	Compound Amount	Present Worth	Sinking Fund	Compound Amount	Capital Recovery	Present Worth	Gradient Present	Gradient Annual
	F/P	P/F	A/F	F/A	A/P	P/A	Worth P/G	Series A/G
1	1.1100	0.9009	1.00000	1.00000	1.11000	0.9009		
2	1.2321	0.8116	0.47393	2.11000	0.58393	1.7125	0.8116	0.4739
3	1.3676	0.7312	0.29921	3.34210	0.40921	2.4437	2.2740	0.9306
4	1.5181	0.6587	0.21233	4.70973	0.32233	3.1024	4.2502	1.3700
5	1.6851	0.5935	0.16057	6.22780	0.27057	3.6959	6.6240	1.7923
6	1.8704	0.5346	0.12638	7.91286	0.23638	4.2305	9.2972	2.1976
7	2.0762	0.4817	0.10222	9.78327	0.21222	4.7122	12.1872	2.5863
8	2.3045	0.4339	0.08432	11.85943	0.19432	5.1461	15.2246	2.9585
9	2.5580	0.3909	0.07060	14.16397	0.18060	5.5370	18.3520	3.3144
10	2.8394	0.3522	0.05980	16.72201	0.16980	5.8892	21.5217	3.6544
11	3.1518	0.3173	0.05112	19.56143	0.16112	6.2065	24.6945	3.9788
12	3.4985	0.2858	0.04403	22.71319	0.15403	6.4924	27.8388	4.2879
13	3.8833	0.2575	0.03815	26.21164	0.14815	6.7499	30.9290	4.5822
14	4.3104	0.2320	0.03323	30.09492	0.14323	6.9819	33.9449	4.8619
15	4.7846	0.2090	0.02907	34.40536	0.13907	7.1909	36.8709	5.1275
16	5.3109	0.1883	0.02552	39.18995	0.13552	7.3792	39.6953	5.3794
17	5.8951	0.1696	0.02247	44.50084	0.13247	7.5488	42.4095	5.6180
18	6.5436	0.1528	0.01984	50.39594	0.12984	7.7016	45.0074	5.8439
19	7.2633	0.1377	0.01756	56.93949	0.12756	7.8393	47.4856	6.0574
20	8.0623	0.1240	0.01558	64.20283	0.12558	7.9633	49.8423	6.2590
21	8.9492	0.1117	0.01384	72.26514	0.12384	8.0751	52.0771	6.4491
22	9.9336	0.1007	0.01231	81.21431	0.12231	8.1757	54.1912	6.6283
23	11.0263	0.0907	0.01097	91.14788	0.12097	8.2664	56.1864	6.7969
24	12.2392	0.0817	0.00979	102.17415	0.11979	8.3481	58.0656	6.9555
25	13.5855	0.0736	0.00874	114.41331	0.11874	8.4217	59.8322	7.1045
26	15.0799	0.0663	0.00781	127.99877	0.11781	8.4881	61.4900	7.2443
27	16.7386	0.0597	0.00699	143.07864	0.11699	8.5478	63.0433	7.3754
28	18.5799	0.0538	0.00626	159.81729	0.11626	8.6016	64.4965	7.4982
29	20.6237	0.0485	0.00561	178.39719	0.11561	8.6501	65.8542	7.6131
30	22.8923	0.0437	0.00502	199.02088	0.11502	8.6938	67.1210	7.7206
31	25.4104	0.0394	0.00451	221.91317	0.11451	8.7331	68.3016	7.8210
32	28.2056	0.0355	0.00404	247.32362	0.11404	8.7686	69.4007	7.9147
33	31.3082	0.0319	0.00363	275.52922	0.11363	8.8005	70.4228	8.0021
34	34.7521	0.0288	0.00326	306.83744	0.11326	8.8293	71.3724	8.0836
35	38.5749	0.0259	0.00293	341.58955	0.11293	8.8552	72.2538	8.1594
40	65.0009	0.0154	0.00172	581.82607	0.11172	8.9511	75.7789	8.4659
45	109.5302	0.0091	0.00101	986.63856	0.11101	9.0079	78.1551	8.6763
50	184.5648	0.0054	0.00060	1668.77115	0.11060	9.0417	79.7341	8.8185
55	311.0025	0.0032	0.00035	2818.20424	0.11035	9.0617	80.7712	8.9135
60	524.0572	0.0019	0.00021	4755.06584	0.11021	9.0736	81.4461	8.9762
65	883.0669	0.0011	0.00012	8018.79027	0.11012	9.0806	81.8819	9.0172
70	1488.0191	0.0007	0.00007	13518.35574	0.11007	9.0848	82.1614	9.0438
75	2507.3988	0.0004	0.00004	22785.44339	0.11004	9.0873	82.3397	9.0610
80	4225.1128	0.0002	0.00003	38401.02500	0.11003	9.0888	82.4529	9.0720
85	7119.5607	0.0001	0.00002	64714.18815	0.11002	9.0896	82.5245	9.0790

12%	Table 17 Discrete cash flow: compound interest factors						12%
	Single Payments		Uniform-Series Payments				Uniform Gradient
	Compound Amount	Present Worth	Sinking Fund	Compound Amount	Capital Recovery	Present Worth	Gradient Present Worth P/G	Gradient Annual Series A/G
	F/P	P/F	A/F	F/A	A/P	P/A	P/G	A/G
1	1.1200	0.8929	1.00000	1.00000	1.12000	0.8929		
2	1.2544	0.7972	0.47170	2.12000	0.59170	1.6901	0.7972	0.4717
3	1.4049	0.7118	0.29635	3.37440	0.41635	2.4018	2.2208	0.9246
4	1.5735	0.6355	0.20923	4.77933	0.32923	3.0373	4.1273	1.3589
5	1.7623	0.5674	0.15741	6.35285	0.27741	3.6048	6.3970	1.7746
6	1.9738	0.5066	0.12323	8.11519	0.24323	4.1114	8.9302	2.1720
7	2.2107	0.4523	0.09912	10.08901	0.21912	4.5638	11.6443	2.5515
8	2.4760	0.4039	0.08130	12.29969	0.20130	4.9676	14.4714	2.9131
9	2.7731	0.3606	0.06768	14.77566	0.18768	5.3282	17.3563	3.2574
10	3.1058	0.3220	0.05698	17.54874	0.17698	5.6502	20.2541	3.5847
11	3.4785	0.2875	0.04842	20.65458	0.16842	5.9377	23.1288	3.8953
12	3.8960	0.2567	0.04144	24.13313	0.16144	6.1944	25.9523	4.1897
13	4.3635	0.2292	0.03568	28.02911	0.15568	6.4235	28.7024	4.4683
14	4.8871	0.2046	0.03087	32.39260	0.15087	6.6282	31.3624	4.7317
15	5.4736	0.1827	0.02682	37.27971	0.14682	6.8109	33.9202	4.9803
16	6.1304	0.1631	0.02339	42.75328	0.14339	6.9740	36.3670	5.2147
17	6.8660	0.1456	0.02046	48.88367	0.14046	7.1196	38.6973	5.4353
18	7.6900	0.1300	0.01794	55.74971	0.13794	7.2497	40.9080	5.6427
19	8.6128	0.1161	0.01576	63.43968	0.13576	7.3658	42.9979	5.8375
20	9.6463	0.1037	0.01388	72.05244	0.13388	7.4694	44.9676	6.0202
21	10.8038	0.0926	0.01224	81.69874	0.13224	7.5620	46.8188	6.1913
22	12.1003	0.0826	0.01081	92.50258	0.13081	7.6446	48.5543	6.3514
23	13.5523	0.0738	0.00956	104.60289	0.12956	7.7184	50.1776	6.5010
24	15.1786	0.0659	0.00846	118.15524	0.12846	7.7843	51.6929	6.6406
25	17.0001	0.0588	0.00750	133.33387	0.12750	7.8431	53.1046	6.7708
26	19.0401	0.0525	0.00665	150.33393	0.12665	7.8957	54.4177	6.8921
27	21.3249	0.0469	0.00590	169.37401	0.12590	7.9426	55.6369	7.0049
28	23.8839	0.0419	0.00524	190.69889	0.12524	7.9844	56.7674	7.1098
29	26.7499	0.0374	0.00466	214.58275	0.12466	8.0218	57.8141	7.2071
30	29.9599	0.0334	0.00414	241.33268	0.12414	8.0552	58.7821	7.2974
31	33.5551	0.0298	0.00369	271.29261	0.12369	8.0850	59.6761	7.3811
32	37.5817	0.0266	0.00328	304.84772	0.12328	8.1116	60.5010	7.4586
33	42.0915	0.0238	0.00292	342.42945	0.12292	8.1354	61.2612	7.5302
34	47.1425	0.0212	0.00260	384.52098	0.12260	8.1566	61.9612	7.5965
35	52.7996	0.0189	0.00232	431.66350	0.12232	8.1755	62.6052	7.6577
40	93.0510	0.0107	0.00130	767.09142	0.12130	8.2438	65.1159	7.8988
45	163.9876	0.0061	0.00074	1358.23003	0.12074	8.2825	66.7342	8.0572
50	289.0022	0.0035	0.00042	2400.01825	0.12042	8.3045	67.7624	8.1597
55	509.3206	0.0020	0.00024	4236.00505	0.12024	8.3170	68.4082	8.2251
60	897.5969	0.0011	0.00013	7471.64111	0.12013	8.3240	68.8100	8.2664
65	1581.8725	0.0006	0.00008	13173.93742	0.12008	8.3281	69.0581	8.2922
70	2787.7998	0.0004	0.00004	23223.33190	0.12004	8.3303	69.2103	8.3082
75	4913.0558	0.0002	0.00002	40933.79867	0.12002	8.3316	69.3031	8.3181
80	8658.4831	0.0001	0.00001	72145.69250	0.12001	8.3324	69.3594	8.3241
85	15259.2057	0.0001	0.00001	127151.71400	0.12001	8.3328	69.3935	8.3278

APPENDIX B

LIST OF FORMULA

1. $p(1+i)^n$

2. $C_n = C_k (I_n/I_k)$

3. $Z_u = K(u^n)$

4. $n = \log s / \log 2$

5. $I_n = \dfrac{W1\,(C_{n1}/C_{k2}) + W2\,(C_{n2}/C_{k2}) + W\ldots(C_{n\ldots}/C_{k\ldots})}{W1 + W2 + W\ldots\ldots} \times I_k$

6. Conventional B-C ratio with PW
   $$B\text{-}C = PW(B) \div [(I - PW(MV)) + PW(O\&M)]$$

7. Modified B-C ratio with PW
   $$B\text{-}C = [PW(B) - PW(O\&M)] \div [I - PW(MV)]$$

8. Conventional B-C ratio with AW
   $$B\text{-}C = AW(B) \div [CR + AW(O\&M)]$$

9. Modified B-C ratio with AW
   $$B\text{-}C = [AW(B) - AW(O\&M)] \div CR$$

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