UNIVERSITY OF JOHANNESBURG
DEPARTMENT OF CIVIL ENGINEERING SCIENCE

EXAMINATION – JUNE 2016

SECTION A: 30 MINUTES 20 marks
SECTION B: 150 MINUTES 130 marks

COURSE: ENGINEERING **TIME:** 180 min

PAPER: PROJECT MANAGEMENT 4A **FULL MARKS:** 150

EXAMINERS: 1. Mr D Kruger UJ
2. Dr J Pretorius LSL Consulting

(THIS PAPER CONSISTS OF 8 PAGES INCLUDING ANNEXURES)

NOTES: 1. **SECTION A:** The original copy of the SAICE General Conditions of Contract 2010 or 2015 may be consulted during the first 30 minutes of the exam after which these books must be closed and place on the floor below the candidate's chair prior to starting on section B of this exam in a new answer sheet.

2. **SECTION B**: CLOSED BOOK EXAM

3. NO MOBILE PHONES ARE ALLOWED ON OR NEAR ANY CANDIDATE WRITING THIS PAPER.

4. USE OF CALCULATORS AND ATTACHED DATA SHEET ARE ALLOWED

SECTION A: GENERAL CONDITIONS OF CONTRACT (20 marks)

Question 1 (10 marks)

Using the GCC as basis, briefly explain the appointment, the role and duties of the engineer (or employer's agent) on a construction site. Also explain what process should the engineer follow should s/he exercises discretion or makes or issues any ruling, contract interpretation or price determination which is not clearly described in the Contract data.

Question 2 (10 marks)

Using the GCC as basis, define the concept "Retention Money" and explain the purpose, deduction and payment of this money. Is there a relationship between "Retention Money" and "Performance Guarantee"?

SECTION B: CONSTRUCTION MANAGEMENT

Question 1 (10 marks)

It is essential for construction managers to understand and fully appreciate the relevance and importance of engineering economics as background to the investment decision-making process and cost control. Explain the term "break-even point" with reference to the above statement. Discuss the importance of the break-even point and give an example to enhance your explanation.

Question 2 (20 marks)

A medium sized housing development company has acquired land suitable for the construction of 100 small residential dwellings. They allow a contract period of 24 months and will be selling the houses at R800 000 each. Assume a year has 290 working days. Both marginal and selling price remain the same over the 24 months. The marginal cost per house is R300 000 and the fixed overhead costs associated with this development is R4 500 000 per annum escalating by 10% per year. It is assumed that the tempo of construction remains linear from start to finish. Answer the following questions:

1. Using the full 24 month contract period in your analysis, after how many working days will the company start to break even?
2. After what percentage level of activity will the company break even?

Question 3 (20 marks)

In diverting river water for an irrigation project, two alternative options are proposed. Income from this irrigation project is contractually fixed at R33 095 per month over the life of the scheme. Details of each option are as follows:

Option A: An open ditch and tunnel system with a capital cost of R2 500 000 and an annual maintenance cost of R40 000 per year. This scheme has no salvage value at the end of the life cycle.

Option B: Pipework and open flume with a capital cost of R1 750 000 and a maintenance cost of R 80 000 per year and a major replacement cost of R120 000 every 10 years. This option has a salvage value of R200 000 at the end of its life cycle when the pipes may be sold as scrap.

Assume an operational life span of 30 years is possible for both options. Calculate the Internal Rate of Return for both options and make a recommendation as to which option should be selected.

Question 4 (20 marks)

On a concreting job, your team of operators need to place formwork to eight (8) above-ground square bases having dimensions of 6m by 6m by 2 meters high. The labour rate for placing of the formwork in the BoQ is R580/m2 and the actual labour cost per day for your formwork erection team is R7900. Under ideal conditions, your team could erect optimally $15m^2$ of formwork per day. You own adequate form-working material to erect all eight basis simultaneously. If the main construction program allows 30 working days for the erecting of the formwork for all these basis, at what rate should your team be erecting this formwork to meet this schedule. Would you be making a profit at this rate? If not, what are the maximum number of days you should use for this formwork erection? Calculate the maximum profit you could make on the labour cost if your team performs at optimal performance levels.

Question 5 (10 marks)

The concept of "Life-Cycle Costing" is of importance when planning and managing your construction fleet. List and briefly describe the main cost components making up this life-cycle costing and explain the intention of employing life-cycle costing.

Question 6 (10 marks)

Implementing a recognised systematic approach to quality in construction is necessary to attainment of a sustainable competitive advantage. Briefly discuss the ISO 9001 quality management system with regards to this statement. Highlight the scope, implementation, significance and benefits of this QMS.

Question 7 (10 marks)

During site establishment, the adequacy of the contractors preliminary and general cost allowances in the BoQ are crucial. List and briefly describe the items normally covered by these P&G's.

Question 8 (30 marks)

The client for which you are doing a project with activities (DURATION IN WEEKS) as per the table below, indicates a latest finish for the final activity at 28 weeks after commencement of the project.

8.1. Draw the network diagram using the activity-in-the-box format and indicate the ES, LS, EF, LF and slack for each activity. (10)

8.2. Clearly indicate the most critical path on your sketch. (5)

8.3. If activity G is delayed by three weeks, what effect will it have on the critical path? How will you go about to rectify this variation? (5)

8.4. What is the probability of finishing this project within the time specified by the client? (10)

Activity	T_o	T_m	T_p	Predecessor
A	2	4	6	-
B	2	2	2	A
C	2	3	10	A
D	1	5	9	B
E	3	3	3	C
F	2	4	6	D
G	5	6	7	E
H	2	3	10	C,F
I	4	7	10	H
J	1	5	9	C
K	2	2	2	F
L	2	3	10	I,J
M	1	5	9	K
N	1	1	1	G,L,M

Table 2.1 Discrete compound interest factors

Factor	*Expressions*		*Find*	*Given*
A. Single payment				
1. Compound amount	$F=P[1+i]^n$	$(F\|P, i\%, n)$	F	P
2. Present worth	$P=F\left[\frac{1}{(1+i)^n}\right]$	$(P\|F, i\%, n)$	P	F
B. Uniform series				
3. Compound amount	$F=A\left[\frac{(1+i)^n-1}{i}\right]$	$(F\|A, i\%, n)$	F	A
4. Sinking fund	$A=F\left[\frac{i}{(1+i)^n-1}\right]$	$(A\|F, i\%, n)$	A	F
5. Present worth	$P=A\left[\frac{(1+i)^n-1}{i(1+i)^n}\right]$	$(P\|A, i\%, n)$	P	A
6. Capital recovery	$A=P\left[\frac{i(1+i)^n}{(1+i)^n-1}\right]$	$(A\|P, i\%, n)$	A	P
C. Arithmetic gradient				
7. Uniform series equivalent	$A=G\left\{\frac{1}{i}-\frac{n}{i}\left[\frac{i}{(1+i)^n-1}\right]\right\}$	$(A\|G, i\%, n)$	A	G

14% **End-of-Period Compound Interest Factors** 14%

	Single Payment		Uniform Payment Series				Arithmetic Gradient		
N	Compound Amount Factor F/P	Present Worth Factor P/F	Capital Recovery Factor A/P	Present Worth Factor P/A	Sinking Fund Factor A/F	Compound Amount Factor F/A	Present Worth Factor P/G	Uniform Payment Factor A/G	N
1	1.140	.8772	1.1400	.877	1.0000	1.000	0	0	1
2	1.300	.7695	.6073	1.647	.4673	2.140	.769	.467	2
3	1.482	.6750	.4307	2.322	.2907	3.440	2.119	.913	3
4	1.689	.5921	.3432	2.914	.2032	4.921	3.896	1.337	4
5	1.925	.5194	.2913	3.433	.1513	6.610	5.973	1.740	5
6	2.195	.4556	.2572	3.889	.1172	8.536	8.251	2.122	6
7	2.502	.3996	.2332	4.288	.0932	10.730	10.649	2.483	7
8	2.853	.3506	.2156	4.639	.0756	13.233	13.103	2.825	8
9	3.252	.3075	.2022	4.946	.0622	16.085	15.563	3.146	9
10	3.707	.2697	.1917	5.216	.0517	19.337	17.991	3.449	10
11	4.226	.2366	.1834	5.453	.0434	23.045	20.357	3.733	11
12	4.818	.2076	.1767	5.660	.0367	27.271	22.640	4.000	12
13	5.492	.1821	.1712	5.842	.0312	32.089	24.825	4.249	13
14	6.261	.1597	.1666	6.002	.0266	37.581	26.901	4.482	14
15	7.138	.1401	.1628	6.142	.0228	43.842	28.862	4.699	15
16	8.137	.1229	.1596	6.265	.0196	50.980	30.706	4.901	16
17	9.276	.1078	.1569	6.373	.0169	59.118	32.430	5.089	17
18	10.575	.0946	.1546	6.467	.0146	68.394	34.038	5.263	18
19	12.056	.0829	.1527	6.550	.0127	78.969	35.531	5.424	19
20	13.743	.0728	.1510	6.623	.0110	91.025	36.914	5.573	20
21	15.668	.0638	.1495	6.687	.00954	104.8	38.190	5.711	21
22	17.861	.0560	.1483	6.743	.00830	120.4	39.366	5.838	22
23	20.362	.0491	.1472	6.792	.00723	138.3	40.446	5.955	23
24	23.212	.0431	.1463	6.835	.00630	158.7	41.437	6.062	24
25	26.462	.0378	.1455	6.873	.00550	181.9	42.344	6.161	25
26	30.167	.0331	.1448	6.906	.00480	208.3	43.173	6.251	26
27	34.390	.0291	.1442	6.935	.00419	238.5	43.929	6.334	27
28	39.204	.0255	.1437	6.961	.00366	272.9	44.618	6.410	28
29	44.693	.0224	.1432	6.983	.00320	312.1	45.244	6.479	29
30	50.950	.0196	.1428	7.003	.00280	356.8	45.813	6.542	30
31	58.083	.0172	.1425	7.020	.00245	407.7	46.330	6.600	31
32	66.215	.0151	.1421	7.035	.00215	465.8	46.798	6.652	32
33	75.485	.0132	.1419	7.048	.00188	532.0	47.222	6.700	33
34	86.053	.0116	.1416	7.060	.00165	607.5	47.605	6.743	34
35	98.100	.0102	.1414	7.070	.00144	693.6	47.952	6.782	35
40	188.9	.00529	.1407	7.105	.000745	1342	49.238	6.930	40
45	363.7	.00275	.1404	7.123	.000386	2591	49.996	7.019	45
50	700.2	.00143	.1402	7.133	.000200	4995	50.438	7.071	50
55	1348	.00074	.1401	7.138	.000104	9623	50.691	7.102	55
60	2596	.00039	.1401	7.140	.000054	18535	50.836	7.120	60
∞	∞	0	.14	7.143	0	∞	51.020	7.143	∞

	Single Payment		Uniform Payment Series				Arithmetic Gradient		
N	Compound Amount Factor F/P	Present Worth Factor P/F	Capital Recovery Factor A/P	Present Worth Factor P/A	Sinking Fund Factor A/F	Compound Amount Factor F/A	Present Worth Factor P/G	Uniform Payment Factor A/G	N
1	1.160	.8621	1.1600	.862	1.0000	1.000	0	0	1
2	1.346	.7432	.6230	1.605	.4630	2.160	.743	.463	2
3	1.561	.6407	.4453	2.246	.2853	3.506	2.024	.901	3
4	1.811	.5523	.3574	2.798	.1974	5.066	3.681	1.316	4
5	2.100	.4761	.3054	3.274	.1454	6.877	5.586	1.706	5
6	2.436	.4104	.2714	3.685	.1114	8.977	7.638	2.073	6
7	2.826	.3538	.2476	4.039	.0876	11.414	9.761	2.417	7
8	3.278	.3050	.2302	4.344	.0702	14.240	11.896	2.739	8
9	3.803	.2630	.2171	4.607	.0571	17.519	14.000	3.039	9
10	4.411	.2267	.2069	4.833	.0469	21.321	16.040	3.319	10
11	5.117	.1954	.1989	5.029	.0389	25.733	17.994	3.578	11
12	5.936	.1685	.1924	5.197	.0324	30.850	19.847	3.819	12
13	6.886	.1452	.1872	5.342	.0272	36.786	21.590	4.041	13
14	7.988	.1252	.1829	5.468	.0229	43.672	23.217	4.246	14
15	9.266	.1079	.1794	5.575	.0194	51.660	24.728	4.435	15
16	10.748	.0930	.1764	5.668	.0164	60.925	26.124	4.609	16
17	12.468	.0802	.1740	5.749	.0140	71.673	27.407	4.768	17
18	14.463	.0691	.1719	5.818	.0119	84.141	28.583	4.913	18
19	16.777	.0596	.1701	5.877	.0101	98.603	29.656	5.046	19
20	19.461	.0514	.1687	5.929	.00867	115.4	30.632	5.167	20
21	22.574	.0443	.1674	5.973	.00742	134.8	31.518	5.277	21
22	26.186	.0382	.1664	6.011	.00635	157.4	32.320	5.377	22
23	30.376	.0329	.1654	6.044	.00545	183.6	33.044	5.467	23
24	35.236	.0284	.1647	6.073	.00467	214.0	33.697	5.549	24
25	40.874	.0245	.1640	6.097	.00401	249.2	34.284	5.623	25
26	47.414	.0211	.1634	6.118	.00345	290.1	34.811	5.690	26
27	55.000	.0182	.1630	6.136	.00296	337.5	35.284	5.750	27
28	63.800	.0157	.1625	6.152	.00255	392.5	35.707	5.804	28
29	74.009	.0135	.1622	6.166	.00219	456.3	36.086	5.853	29
30	85.850	.0116	.1619	6.177	.00189	530.3	36.423	5.896	30
31	99.586	.0100	.1616	6.187	.00162	616.2	36.725	5.936	31
32	115.5	.00866	.1614	6.196	.00140	715.7	36.993	5.971	32
33	134.0	.00746	.1612	6.203	.00120	831.3	37.232	6.002	33
34	155.4	.00643	.1610	6.210	.00104	965.3	37.444	6.030	34
35	180.3	.00555	.1609	6.215	.000892	1121	37.633	6.055	35
40	378.7	.00264	.1604	6.233	.000424	2361	38.299	6.144	40
45	795.4	.00126	.1602	6.242	.000201	4965	38.660	6.193	45
50	1671	.00060	.1601	6.246	.000096	10436	38.852	6.220	50
55	3509	.00028	.1600	6.248	.000046	21925	38.953	6.234	55
60	7370	.00014	.1600	6.249	.000022	46058	39.006	6.242	60
∞	∞	0	.16	6.250	0	∞	39.063	6.250	∞

End-of-Period Compound Interest Factors

	Single Payment		Uniform Payment Series				Arithmetic Gradient		
N	Compound Amount Factor F/P	Present Worth Factor P/F	Capital Recovery Factor A/P	Present Worth Factor P/A	Sinking Fund Factor A/F	Compound Amount Factor F/A	Present Worth Factor P/G	Uniform Payment Factor A/G	N
1	1.180	.8475	1.1800	.847	1.0000	1.000	0	0	1
2	1.392	.7182	.6387	1.566	.4587	2.180	.718	.459	2
3	1.643	.6086	.4599	2.174	.2799	3.572	1.935	.890	3
4	1.939	.5158	.3717	2.690	.1917	5.215	3.483	1.295	4
5	2.288	.4371	.3198	3.127	.1398	7.154	5.231	1.673	5
6	2.700	.3704	.2859	3.498	.1059	9.442	7.083	2.025	6
7	3.185	.3139	.2624	3.812	.0824	12.142	8.967	2.353	7
8	3.759	.2660	.2452	4.078	.0652	15.327	10.829	2.656	8
9	4.435	.2255	.2324	4.303	.0524	19.086	12.633	2.936	9
10	5.234	.1911	.2225	4.494	.0425	23.521	14.352	3.194	10
11	6.176	.1619	.2148	4.656	.0348	28.755	15.972	3.430	11
12	7.288	.1372	.2086	4.793	.0286	34.931	17.481	3.647	12
13	8.599	.1163	.2037	4.910	.0237	42.219	18.877	3.845	13
14	10.147	.0985	.1997	5.008	.0197	50.818	20.158	4.025	14
15	11.974	.0835	.1964	5.092	.0164	60.965	21.327	4.189	15
16	14.129	.0708	.1937	5.162	.0137	72.939	22.389	4.337	16
17	16.672	.0600	.1915	5.222	.0115	87.068	23.348	4.471	17
18	19.673	.0508	.1896	5.273	.00964	103.7	24.212	4.592	18
19	23.214	.0431	.1881	5.316	.00810	123.4	24.988	4.700	19
20	27.393	.0365	.1868	5.353	.00682	146.6	25.681	4.798	20
21	32.324	.0309	.1857	5.384	.00575	174.0	26.300	4.885	21
22	38.142	.0262	.1848	5.410	.00485	206.3	26.851	4.963	22
23	45.008	.0222	.1841	5.432	.00409	244.5	27.339	5.033	23
24	53.109	.0188	.1835	5.451	.00345	289.5	27.772	5.095	24
25	62.669	.0160	.1829	5.467	.00292	342.6	28.155	5.150	25
26	73.949	.0135	.1825	5.480	.00247	405.3	28.494	5.199	26
27	87.260	.0115	.1821	5.492	.00209	479.2	28.791	5.243	27
28	103.0	.00971	.1818	5.502	.00177	566.5	29.054	5.281	28
29	121.5	.00823	.1815	5.510	.00149	669.4	29.284	5.315	29
30	143.4	.00697	.1813	5.517	.00126	790.9	29.486	5.345	30
31	169.2	.00591	.1811	5.523	.00107	934.3	29.664	5.371	31
32	199.6	.00501	.1809	5.528	.000906	1103	29.819	5.394	32
33	235.6	.00425	.1808	5.532	.000767	1303	29.955	5.415	33
34	278.0	.00360	.1806	5.536	.000650	1539	30.074	5.433	34
35	328.0	.00305	.1806	5.539	.000550	1817	30.177	5.449	35
40	750.4	.00133	.1802	5.548	.000240	4163	30.527	5.502	40
45	1717	.000583	.1801	5.552	.000105	9532	30.701	5.529	45
50	3927	.000255	.1800	5.554	.0000458	21813	30.786	5.543	50
55	8985	.000111	.1800	5.555	.0000200	49910	30.827	5.549	55
60	20555	.000049	.1800	5.555	.0000088	114190	30.846	5.553	60
∞	∞	0	.18	5.556	0	∞	30.864	5.556	∞

Table of Areas of the Normal Curve between the Maximum Ordinate and Values of Z

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3304	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993	0.4993	0.4994	0.4994	0.4994	0.4994	0.4994	0.4995	0.4995	0.4995
3.3	0.4995	0.4995	0.4995	0.4996	0.4996	0.4996	0.4996	0.4996	0.4996	0.4997
3.4	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4998
3.5	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998
3.6	0.4998	0.4998	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999

UNIVERSITY OF JOHANNESBURG
DEPARTMENT OF CIVIL ENGINEERING SCIENCE

EXAMINATION SUPPLEMENTARY EXAM 2016

SECTION A: 30 MINUTES 20 marks
SECTION B: 150 MINUTES 130 marks

COURSE: ENGINEERING **TIME:** 180 min

PAPER: PROJECT MANAGEMENT 4A **FULL MARKS:** 150

EXAMINERS: 1. Mr D Kruger UJ
2. Dr J Pretorius LSL Consulting

(THIS PAPER CONSISTS OF 8 PAGES INCLUDING ANNEXURES)

NOTES: 1.**SECTION A**: The original copy of the SAICE General Conditions of Contract 2010 or 2015 may be consulted during the first 30 minutes of the exam after which these books must be closed and place on the floor below the candidate's chair prior to starting on section B of this exam in a new answer sheet.
2. **SECTION B** : CLOSED BOOK EXAM
3. NO MOBILE PHONES ARE ALLOWED ON OR NEAR ANY CANDIDATE WRITING THIS PAPER.
4. USE OF CALCULATORS AND ATTACHED DATA SHEET ARE ALLOWED

SECTION A: GENERAL CONDITIONS OF CONTRACT (20 marks)

Question 1 (10 marks)

Explain the concept "Extension of Time"? In your explanation you need to refer to the due completion date, penalties, causes and reasons for delays, additional payments. End your discussion by explaining how a contractor should claim for an extension of time.

Question 2 (10 marks)

What is the "defects liability period"? In your discussion, highlight the purpose of this period, when this period starts and when does it end?

SECTION B: CONSTRUCTION MANAGEMENT

Question 1 (10 marks)

It is essential for construction managers to understand and fully appreciate the relevance and importance of engineering economics as background to investment decision-making processes and cost control. Explain the term "Marginal Cost" with reference to the above statement. Give an example to enhance your explanation.

Question 2 (20 marks)

A company purchases a small compactor for R15 000. For 5 years the machine is rented out to clients to generate an income. The gross annual receipts from clients and the expenditure on operational costs are as per the table below. After the 5 years, the machine is reconditioned at a cost of R500 and sold for R2000. Calculate the IRR for this investment.

Year	Receipts (R)	Expenditures (R)
0	0	-15000
1	6000	-2000
2	7500	-3500
3	6500	-2500
4	8000	-3500
5	5000	-2500
6	2000	-500

Question 3 (20 marks)

Your company has just purchased a concrete batching plant for R2 500 000 which needs major upgrades at the end of each of 6 years, 8 years and 12 years at respective costs of R100 000, R180 000 and R225 000. You plan to invest 50% of the amount required for these upgrades now and the other 50% of this amount at the end of the second year of operation. These two investments will allow you to have these funds available for the upgrades when they are due. Calculate these two investment amounts if the interest rate is assumed as 5%?

Question 4 (20 marks)

You are programming for a task of excavating a 700mm wide, 2m deep pipe trench over a distance of 10km of soil with an excavator capable of performing at 25m^3 per hour at ideal conditions. Your geotechnical report indicates that the material to be excavated is of a higher density that what is considered ideal conditions for the excavator and the machine's performance manual recommends a production reduction factor of 90%. In addition, the operator is not as experienced as required and a further reduction of 70% is recommended.

Material is stockpiled directly next to the trench and no tipper trucks are involved in this excavation.

Your site operates on an eight hour shift for 5 days a week with a 30min lunch break and two 15 tea-breaks per shift. The excavator is serviced once a week during normal operating hours resulting in a loss of two working hours per week.

How many weeks should you allow for this excavation?

Question 5 (10 marks)

Health and safety on site is a primary responsibility of any construction manager. To ensure compliance to OSHAct and other legislation, a project Health and Safety plan is required which forms the basis for safe working practices on site. List the key elements that should be included in such a construction phase health and safety plan.

Question 6 (10 marks)

Some of the more innovative construction companies are implementing Business Process-Engineering to their organisations. Explain this BPR concept in terms of its use, advantages and interrelationships with TQM and JIT.

Question 7 (10 marks)

Construction site management is a highly specialized field of management in a highly competitive market with a great deal of uncertainly and variability. For site managers to survive in this industry and to be effective and efficient, they must have certain characteristics and skills. Briefly discuss these characteristic, skills as well as leadership styles successful site managers should have.

Question 8 (30 marks)

Your construction project is scheduled to be completed in exactly 50 weeks from now. Your client is very strict about this deadline. The project includes the following main tasks to be done and you estimate the optimistic, pessimistic and most likely durations and dependencies for each activity as per the table below. The project can start at time 0.

8.1. Calculate the expected time and slack for each activity. (10)

8.2. Calculate the earliest finishing time for this project and list the most critical activities. (5)

8.3. If activity C is delayed by one week, what effect will it have on the critical path? How will you go about to rectify this variation? (5)

8.4. Determine the latest date by which this project must be completed if a 67% probability of completion is required. (10)

Activity	Optimistic Time (weeks)	Most Likely Time (weeks)	Pessimistic Time (weeks)	Predecessor
A	3	6	9	-
B	2	8	14	A
C	4	6	8	A
D	4	4	4	B
D1	3	7	11	G
E	2	4	6	C
F	11	13	15	A
G	12	15	18	D
H	3	3	3	E,G
I	5	8	11	F,H
J	1	1	1	I
K	6	8	10	D1, J

Table 2.1 Discrete compound interest factors

Factor	*Expressions*		*Find*	*Given*
A. Single payment				
1. Compound amount	$F = P[1+i]^n$	$(F\|P, i\%, n)$	F	P
2. Present worth	$P = F\left[\frac{1}{(1+i)^n}\right]$	$(P\|F, i\%, n)$	P	F
B. Uniform series				
3. Compound amount	$F = A\left[\frac{(1+i)^n - 1}{i}\right]$	$(F\|A, i\%, n)$	F	A
4. Sinking fund	$A = F\left[\frac{i}{(1+i)^n - 1}\right]$	$(A\|F, i\%, n)$	A	F
5. Present worth	$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$	$(P\|A, i\%, n)$	P	A
6. Capital recovery	$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$	$(A\|P, i\%, n)$	A	P
C. Arithmetic gradient				
7. Uniform series equivalent	$A = G\left\{\frac{1}{i} - \frac{n}{i}\left[\frac{i}{(1+i)^n - 1}\right]\right\}$	$(A\|G, i\%, n)$	A	G

End-of-Period Compound Interest Factors

	Single Payment		Uniform Payment Series				Arithmetic Gradient		
N	Compound Amount Factor F/P	Present Worth Factor P/F	Capital Recovery Factor A/P	Present Worth Factor P/A	Sinking Fund Factor A/F	Compound Amount Factor F/A	Present Worth Factor P/G	Uniform Payment Factor A/G	N
1	1.050	.9524	1.0500	.952	1.0000	1.000	0	0	1
2	1.103	.9070	.5378	1.859	.4878	2.050	.907	.488	2
3	1.158	.8638	.3672	2.723	.3172	3.153	2.635	.967	3
4	1.216	.8227	.2820	3.546	.2320	4.310	5.103	1.439	4
5	1.276	.7835	.2310	4.329	.1810	5.526	8.237	1.903	5
6	1.340	.7462	.1970	5.076	.1470	6.802	11.968	2.358	6
7	1.407	.7107	.1728	5.786	.1228	8.142	16.232	2.805	7
8	1.477	.6768	.1547	6.463	.1047	9.549	20.970	3.245	8
9	1.551	.6446	.1407	7.108	.0907	11.027	26.127	3.676	9
10	1.629	.6139	.1295	7.722	.0795	12.578	31.652	4.099	10
11	1.710	.5847	.1204	8.306	.0704	14.207	37.499	4.514	11
12	1.796	.5568	.1128	8.863	.0628	15.917	43.624	4.922	12
13	1.886	.5303	.1065	9.394	.0565	17.713	49.988	5.322	13
14	1.980	.5051	.1010	9.899	.0510	19.599	56.554	5.713	14
15	2.079	.4810	.0963	10.380	.0463	21.579	63.288	6.097	15
16	2.183	.4581	.0923	10.838	.0423	23.657	70.160	6.474	16
17	2.292	.4363	.0887	11.274	.0387	25.840	77.140	6.842	17
18	2.407	.4155	.0855	11.690	.0355	28.132	84.204	7.203	18
19	2.527	.3957	.0827	12.085	.0327	30.539	91.328	7.557	19
20	2.653	.3769	.0802	12.462	.0302	33.066	98.488	7.903	20
21	2.786	.3589	.0780	12.821	.0280	35.719	105.667	8.242	21
22	2.925	.3418	.0760	13.163	.0260	38.505	112.846	8.573	22
23	3.072	.3256	.0741	13.489	.0241	41.430	120.009	8.897	23
24	3.225	.3101	.0725	13.799	.0225	44.502	127.140	9.214	24
25	3.386	.2953	.0710	14.094	.0210	47.727	134.228	9.524	25
26	3.556	.2812	.0696	14.375	.0196	51.113	141.259	9.827	26
27	3.733	.2678	.0683	14.643	.0183	54.669	148.223	10.122	27
28	3.920	.2551	.0671	14.898	.0171	58.403	155.110	10.411	28
29	4.116	.2429	.0660	15.141	.0160	62.323	161.913	10.694	29
30	4.322	.2314	.0651	15.372	.0151	66.439	168.623	10.969	30
31	4.538	.2204	.0641	15.593	.0141	70.761	175.233	11.238	31
32	4.765	.2099	.0633	15.803	.0133	75.299	181.739	11.501	32
33	5.003	.1999	.0625	16.003	.0125	80.064	188.135	11.757	33
34	5.253	.1904	.0618	16.193	.0118	85.067	194.417	12.006	34
35	5.516	.1813	.0611	16.374	.0111	90.320	200.581	12.250	35
40	7.040	.1420	.0583	17.159	.00828	120.8	229.545	13.377	40
45	8.985	.1113	.0563	17.774	.00626	159.7	255.315	14.364	45
50	11.467	.0872	.0548	18.256	.00478	209.3	277.915	15.223	50
55	14.636	.0683	.0537	18.633	.00367	272.7	297.510	15.966	55
60	18.679	.0535	.0528	18.929	.00283	353.6	314.343	16.606	60
65	23.840	.0419	.0522	19.161	.00219	456.8	328.691	17.154	65
70	30.426	.0329	.0517	19.343	.00170	588.5	340.841	17.621	70
75	38.833	.0258	.0513	19.485	.00132	756.7	351.072	18.018	75
80	49.561	.0202	.0510	19.596	.00103	971.2	359.646	18.353	80
85	63.254	.0158	.0508	19.684	.000803	1245	366.801	18.635	85
90	80.730	.0124	.0506	19.752	.000627	1595	372.749	18.871	90
95	103.0	.00971	.0505	19.806	.000490	2041	377.677	19.069	95
100	131.5	.00760	.0504	19.848	.000383	2610	381.749	19.234	100
∞	∞	0	.05	20	0	∞	400	20	∞

End-of-Period Compound Interest Factors

	Single Payment		Uniform Payment Series				Arithmetic Gradient		
N	Compound Amount Factor F/P	Present Worth Factor P/F	Capital Recovery Factor A/P	Present Worth Factor P/A	Sinking Fund Factor A/F	Compound Amount Factor F/A	Present Worth Factor P/G	Uniform Payment Factor A/G	N
1	1.110	.9009	1.1100	.901	1.0000	1.000	0	0	1
2	1.232	.8116	.5839	1.713	.4739	2.110	.812	.474	2
3	1.368	.7312	.4092	2.444	.2992	3.342	2.274	.931	3
4	1.518	.6587	.3223	3.102	.2123	4.710	4.250	1.370	4
5	1.685	.5935	.2706	3.696	.1606	6.228	6.624	1.792	5
6	1.870	.5346	.2364	4.231	.1264	7.913	9.297	2.198	6
7	2.076	.4817	.2122	4.712	.1022	9.783	12.187	2.586	7
8	2.305	.4339	.1943	5.146	.0843	11.859	15.225	2.958	8
9	2.558	.3909	.1806	5.537	.0706	14.164	18.352	3.314	9
10	2.839	.3522	.1698	5.889	.0598	16.722	21.522	3.654	10
11	3.152	.3173	.1611	6.207	.0511	19.561	24.695	3.979	11
12	3.498	.2858	.1540	6.492	.0440	22.713	27.839	4.288	12
13	3.883	.2575	.1482	6.750	.0382	26.212	30.929	4.582	13
14	4.310	.2320	.1432	6.982	.0332	30.095	33.945	4.862	14
15	4.785	.2090	.1391	7.191	.0291	34.405	36.871	5.127	15
16	5.311	.1883	.1355	7.379	.0255	39.190	39.695	5.379	16
17	5.895	.1696	.1325	7.549	.0225	44.501	42.409	5.618	17
18	6.544	.1528	.1298	7.702	.0198	50.396	45.007	5.844	18
19	7.263	.1377	.1276	7.839	.0176	56.939	47.486	6.057	19
20	8.062	.1240	.1256	7.963	.0156	64.203	49.842	6.259	20
21	8.949	.1117	.1238	8.075	.0138	72.265	52.077	6.449	21
22	9.934	.1007	.1223	8.176	.0123	81.214	54.191	6.628	22
23	11.026	.0907	.1210	8.266	.0110	91.148	56.186	6.797	23
24	12.239	.0817	.1198	8.348	.00979	102.2	58.066	6.956	24
25	13.585	.0736	.1187	8.422	.00874	114.4	59.832	7.104	25
26	15.080	.0663	.1178	8.488	.00781	128.0	61.490	7.244	26
27	16.739	.0597	.1170	8.548	.00699	143.1	63.043	7.375	27
28	18.580	.0538	.1163	8.602	.00626	159.8	64.497	7.498	28
29	20.624	.0485	.1156	8.650	.00561	178.4	65.854	7.613	29
30	22.892	.0437	.1150	8.694	.00502	199.0	67.121	7.721	30
31	25.410	.0394	.1145	8.733	.00451	221.9	68.302	7.821	31
32	28.206	.0355	.1140	8.769	.00404	247.3	69.401	7.915	32
33	31.308	.0319	.1136	8.801	.00363	275.5	70.423	8.002	33
34	34.752	.0288	.1133	8.829	.00326	306.8	71.372	8.084	34
35	38.575	.0259	.1129	8.855	.00293	341.6	72.254	8.159	35
40	65.001	.0154	.1117	8.951	.00172	581.8	75.779	8.466	40
45	109.5	.00913	.1110	9.008	.00101	986.6	78.155	8.676	45
50	184.6	.00542	.1106	9.042	.000599	1669	79.734	8.819	50
55	311.0	.00322	.1104	9.062	.000355	2818	80.771	8.913	55
60	524.1	.00191	.1102	9.074	.000210	4755	81.446	8.976	60
65	883.1	.00113	.1101	9.081	.000125	8019	81.882	9.017	65
70	1488	.000672	.1101	9.085	.0000740	13518	82.161	9.044	70
75	2507	.000399	.1100	9.087	.0000439	22785	82.340	9.061	75
80	4225	.000237	.1100	9.089	.0000260	38401	82.453	9.072	80
85	7120	.000140	.1100	9.090	.0000155	64714	82.524	9.079	85
90	11997	.000083	.1100	9.090	.0000092	109053	82.570	9.083	90
95	20215	.000049	.1100	9.090	.0000054	183768	82.598	9.086	95
100	34064	.000029	.1100	9.091	.0000032	309665	82.616	9.088	100
∞	∞	0	.11	9.091	0	∞	82.645	9.091	∞

End-of-Period Compound Interest Factors

	Single Payment		Uniform Payment Series				Arithmetic Gradient		
N	Compound Amount Factor F/P	Present Worth Factor P/F	Capital Recovery Factor A/P	Present Worth Factor P/A	Sinking Fund Factor A/F	Compound Amount Factor F/A	Present Worth Factor P/G	Uniform Payment Factor A/G	N
1	1.130	.8850	1.1300	.885	1.0000	1.000	0	0	1
2	1.277	.7831	.5995	1.668	.4695	2.130	.783	.469	2
3	1.443	.6931	.4235	2.361	.2935	3.407	2.169	.919	3
4	1.630	.6133	.3362	2.974	.2062	4.850	4.009	1.348	4
5	1.842	.5428	.2843	3.517	.1543	6.480	6.180	1.757	5
6	2.082	.4803	.2502	3.998	.1202	8.323	8.582	2.147	6
7	2.353	.4251	.2261	4.423	.0961	10.405	11.132	2.517	7
8	2.658	.3762	.2084	4.799	.0784	12.757	13.765	2.869	8
9	3.004	.3329	.1949	5.132	.0649	15.416	16.428	3.201	9
10	3.395	.2946	.1843	5.426	.0543	18.420	19.080	3.516	10
11	3.836	.2607	.1758	5.687	.0458	21.814	21.687	3.813	11
12	4.335	.2307	.1690	5.918	.0390	25.650	24.224	4.094	12
13	4.898	.2042	.1634	6.122	.0334	29.985	26.674	4.357	13
14	5.535	.1807	.1587	6.302	.0287	34.883	29.023	4.605	14
15	6.254	.1599	.1547	6.462	.0247	40.417	31.262	4.837	15
16	7.067	.1415	.1514	6.604	.0214	46.672	33.384	5.055	16
17	7.986	.1252	.1486	6.729	.0186	53.739	35.388	5.259	17
18	9.024	.1108	.1462	6.840	.0162	61.725	37.271	5.449	18
19	10.197	.0981	.1441	6.938	.0141	70.749	39.037	5.627	19
20	11.523	.0868	.1424	7.025	.0124	80.947	40.685	5.792	20
21	13.021	.0768	.1408	7.102	.0108	92.470	42.221	5.945	21
22	14.714	.0680	.1395	7.170	.00948	105.5	43.649	6.088	22
23	16.627	.0601	.1383	7.230	.00832	120.2	44.972	6.220	23
24	18.788	.0532	.1373	7.283	.00731	136.8	46.196	6.343	24
25	21.231	.0471	.1364	7.330	.00643	155.6	47.326	6.457	25
26	23.991	.0417	.1357	7.372	.00565	176.9	48.369	6.561	26
27	27.109	.0369	.1350	7.409	.00498	200.8	49.328	6.658	27
28	30.633	.0326	.1344	7.441	.00439	227.9	50.209	6.747	28
29	34.616	.0289	.1339	7.470	.00387	258.6	51.018	6.830	29
30	39.116	.0256	.1334	7.496	.00341	293.2	51.759	6.905	30
31	44.201	.0226	.1330	7.518	.00301	332.3	52.438	6.975	31
32	49.947	.0200	.1327	7.538	.00266	376.5	53.059	7.039	32
33	56.440	.0177	.1323	7.556	.00234	426.5	53.626	7.097	33
34	63.777	.0157	.1321	7.572	.00207	482.9	54.143	7.151	34
35	72.069	.0139	.1318	7.586	.00183	546.7	54.615	7.200	35
40	132.8	.00753	.1310	7.634	.000986	1014	56.409	7.389	40
45	244.6	.00409	.1305	7.661	.000534	1874	57.515	7.508	45
50	450.7	.00222	.1303	7.675	.000289	3460	58.187	7.581	50
55	830.5	.00120	.1302	7.683	.000157	6380	58.591	7.626	55
60	1530	.00065	.1301	7.687	.000085	11762	58.831	7.653	60
∞	∞	0	.13	7.692	0	∞	59.172	7.692	∞

Table of Areas of the Normal Curve between the Maximum Ordinate and Values of Z

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3304	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993	0.4993	0.4994	0.4994	0.4994	0.4994	0.4994	0.4995	0.4995	0.4995
3.3	0.4995	0.4995	0.4995	0.4996	0.4996	0.4996	0.4996	0.4996	0.4996	0.4997
3.4	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4998
3.5	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998
3.6	0.4998	0.4998	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999