Carleton University
Department of Civil and Environmental Engineering
Engineering Economics (ECOR 3800 B)
Term Test, Feb. 25, 2016

One side information sheet is allowed
Scientific calculator only (no programmable calculator)

Always support your answer with C.F.D

This question paper has 11 pages.
Test time is 3 hours

Notes:

1. All questions carry the same mark.
2. If doubt exists as to the interpretation of any question, the student is urged to make a clear statement of assumption made.
3. Use these pages for all your work. No extra paper will be provided, allowed or marked.
4. **Do not Unstapled or separate any of these pages only the last page (tables) could be unstapled.**

	ECOR 3800 B Midterm Exam 25 Feb. 2016
Name	
ID	

Question	**Marks**
1	
2	
3	
4	
5	
6	
Total	

Question 1

(1)

Some of the following problems would be suitable for solution by engineering economic analysis. Which ones are they?

A Would it be better to buy a car with a diesel engine or a gasoline engine?
B Should an automatic machine be purchased to replace three workers now doing a task by hand?
C Would it be wise to enrol for an early morning class so you could avoid travelling during the morning rush hour?
D Would you be better off if you changed your major?
E One of the people you might marry has a job that pays very little money, while

(2)

A company must install one of two production machines that have identical costs. What criterion should be used to determine which machine to install if annual cash flow analysis is to be used?

A Choose machine with the lower EUAB (Equivalent Uniform Annual Benefit)
B Choose machine with the lower EUAC (Equivalent Uniform Annual Cost)
C Choose machine with the lower MARR (Minimum Attractive Rate of Return)
D Choose machine with the higher EUAB

(3)

A contractor must purchase one of three trucks for his business. The trucks vary in both costs and benefits. What criterion should be used to determine which truck to purchase if annual cash flow analysis is to be used?

A Choose truck with the lowest NPW
B Choose truck with the highest PW of Benefit – PW of Cost
C Choose truck with the highest inflow cash PW
D Choose truck with the lowest capital costs

(4)

Which equation below gives at 10% interest the equivalent uniform annual cost of owning an asset with an initial cost of $30,000 and an estimated salvage value of $12,000 after its 7-year service life? In this question we are interested in capital costs only, excluding O&M costs

A EAC of capital costs = (30,000)(A/P,10%,7) - (12,000)(A/F,10%,7)
B EUAC of capital costs = (30,000 - 12,000)(A/P,10%,7) - (12,000)(0.10)
C EUAC of capital costs = (30,000 - 12,000)(A/P,10%,7) + (12,000)(0.10)
D EUAC of capital costs = (30,000 - 12,000)(A/P,10%,7) + (12,000)(10)

(5)
At 10% interest, what is the equivalent uniform annual cost of owning an asset with an initial cost of $30,000 and an estimated salvage value of $30,000 after its 2-year service life? Calculate capital costs only, excluding O&M costs for now.

A $3,000
B $6,000
C $9,000
D $12,000

Question 2

For the following transactions, draw the C.F.D and find the value of G that makes the deposit series equivalent to the withdrawal series at interest rate of **10%**, compounded annually.

End of period	Deposit	Withdrawal
0	$800	
1	800	
2	600	
3	400	
4	200	
5	200	
6		G
7		2G
8		3G
9		4G
10		5G

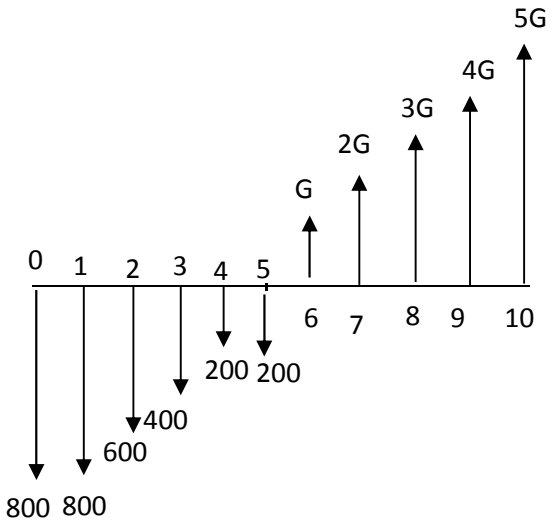
Solution:

G(A/G,10%,6)(P/A,10%,6) = [800(F/A,10%,4)-200(A/G,10%,4)* (F/A,10%,4)]

+800(F/P,10%,4)+200*(P/F,10%,1)

G={ 800*4.641-200*1.3812*4.641*1.5735}+800*1.4641+200*0.9091/2.2236*4.3553

G=$ 390.7302



Question 3

John Montgomery is considering buying a **$125,000** home with a **$25,000** down payment. He can get a conventional mortgage in the amount of **$100,000** with a three-year term at **10%** per annum from TD Canada Trust. He has selected an amortization period of **25** years. The mortgage is a closed mortgage with the following prepayment privileges:

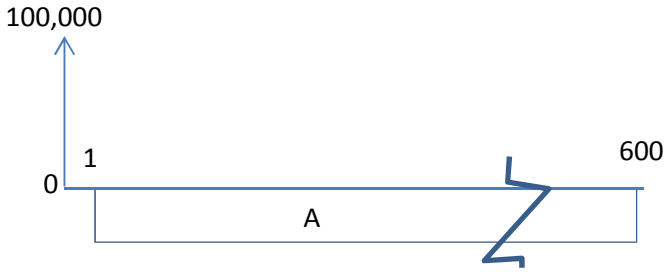
- Once each calendar year, on any regular payment date, Jhon can repay on account of principal a sum not more than **10%** of the original borrowed amount, without notice or charge. If this privilege is not exercised in a certain year, it cannot be carried forward to the following years.
- Once each calendar year, on any regular payment date, on written notice, John, without charge, can increase the amount of the regular installment of principal and interest. The total of such increases cannot exceed **100%** of the installment of principal and interest set out in the mortgage document. If the regular installment has been increased, the mortgage may decrease the installments to an amount not less than the installment of principal and interest set out in the mortgage document, on written notice, without charge.

Answer the following questions regarding the mortgage in consideration:

(a) What is the amount of his regular payment if he chooses to pay semimonthly, or monthly?
(b) What would the balance be at the end of the term for each of the two payment frequencies if the calculated regular payment amount is followed exactly?
(c) Assume that John has selected the option of monthly payment because he receives only one salary payment per month. In year **2**, he increases his monthly payment by **50%**. In year **3**, he doubles his calculated monthly payment in (a). What is the balance of the mortgage at the time of renewal?
(d) In addition to (c), if he makes lump sum payments of **$8000** and **$10,000** at the first and second anniversaries, respectively, what is the balance of the mortgage at the time of renewal?

Solution:

(a)



Semi Monthly

r = 10% (nominal interest)

N=24 *25=600 half –month

For mortgage always M=2(semi-annually compounding)

M=C x K

K= number of payment per year = 24

➔ C=M/K = 2/24 =1/12

$i_{\frac{1}{2}\,month}=(1+r/M)^{c}-1=(1+0.1/2)^{1/12}-1=0.407\%$

$A_{\frac{1}{2}\,month}=100{,}000(A/p, 0.407\%, 600)=\$445.98$

Snice the 600 period is not in the table therefore you have to use the formulas to find the interest factors

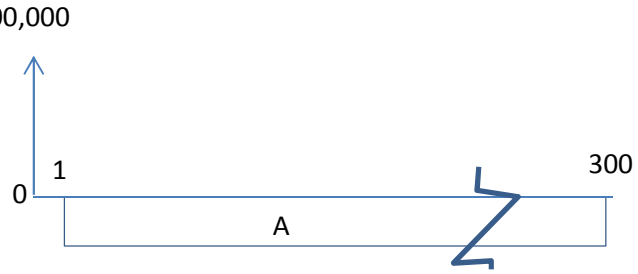
$$A=P(1+i)^{N}\left[\frac{i}{(1+i)^{N}-1}\right]$$

$$A=100000(1+0.00407)^{600}\left[\frac{0.00407}{(1+0.00407)^{600}-1}\right]$$

$$=\$445.98$$

The same procedures will be used for the monthly payment except the calculation of the monthly effective interest

Monthly



N=12 *25=300 month

$i_{month}=(1+r/M)^{c}-1=(1+0.1/2)^{1/6}-1=0.816\%$

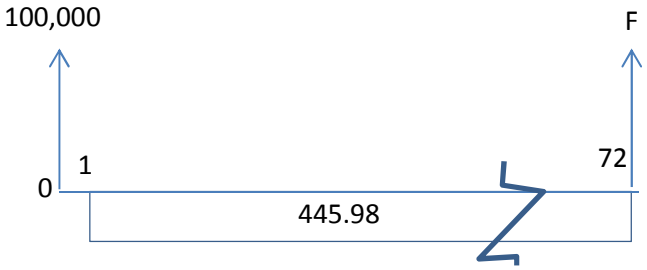
$A_{month}=100{,}000(A/p, 0.00816\%, 300)=\$894.0796$

$$A=P(1+i)^{N}\left[\frac{i}{(1+i)^{N}-1}\right]$$

$$A=100000(1+0.00816)^{300}\left[\frac{0.00816}{(1+0.00816)^{300}-1}\right]$$

$$=\$894.0796$$

(b)



Semi Monthly Payments

From Part (a)

$i_{\frac{1}{2}\text{ month}} = 0.407\%$

n=3*24 =72

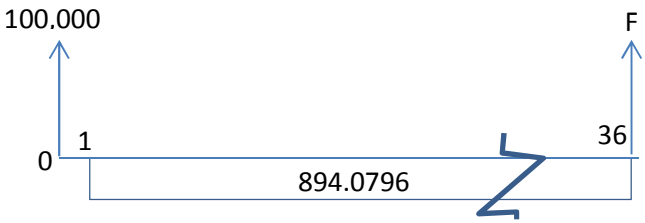
$$(F/A, i, n)=[((1+i)^{N}-1)/i]$$

$$(F/P, i, n)=(1+i)^{N}$$

Balance at the end of 3 years

$B_{\frac{1}{2}\text{ month}}$=100000(F/P, 0.407%, 72)-445.98(F/A, 0.407%, 72)

=100,000x 1.3397 -445.98x 83.4642 = $96746.56



Monthly Payments

*n=3*12 =36*

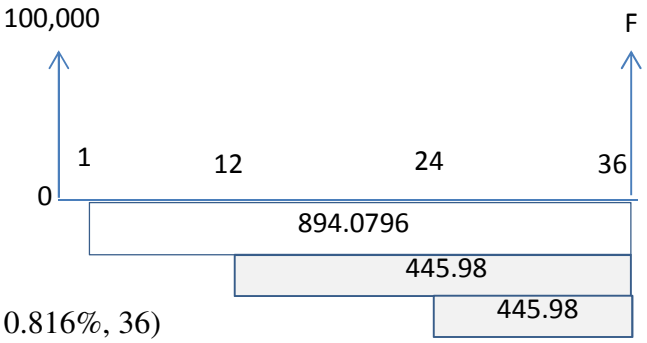
$i_{month}=(1+r/M)^{c}-1=(1+0.1/2)^{1/6}-1= 0.816\%$

Balance at the end of 3 years

B_{month}=100000(F/P, 0.816%, 36)-894.0796(F/A, 0.816%, 36)

=100,000x 1.3399 -894.0796x 41.6500 = $ 96747.99

(c)

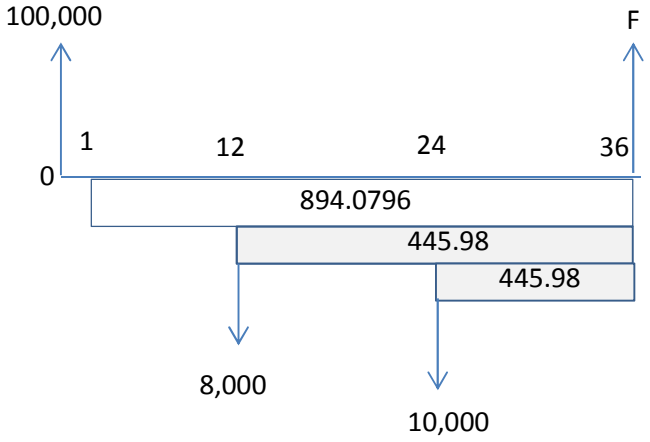


B $_{\text{at the renewal}}$=100000(F/P, 0.816%, 36)-894.0796(F/A, 0.816%, 36)

-447.0398(F/A, 0.816%, 24) - 447.0398(F/A, 0.816%, 12)

B $_{\text{at the renewal}}$=100000 x1.3399-894.0796x 41.6500

-447.0398x 26.3929- 447.0398x 12.5535= $79337.40611



(d)

B(d)= 79337.40611-8000*(F/P, 0.816%, 24)-10,000(F/P, 0.816%, 12)

B(d)= 79337.40611-8000* 1.2154-10,000 x1.1024

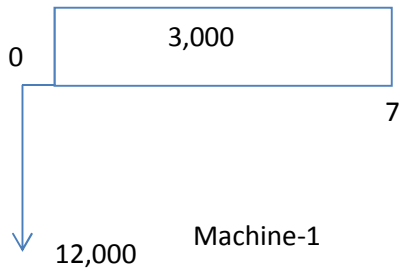
= $58590.11377

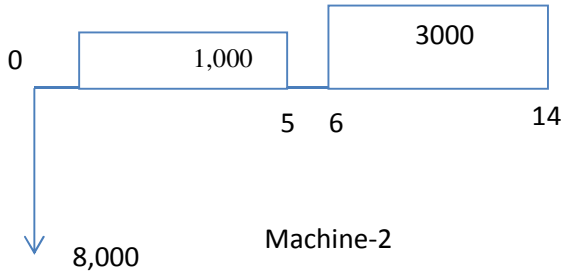
Question 4

Two equivalent pieces of quality inspection equipment are being considered for purchase by Square D Electric. Machine 2 expected to be versatile and technologically advanced enough to provide net income longer than machine 1. *Assume i*= 10%. Select the best machine based on the discounted pay back method.

	Machine 1	Machine 2
First cost($)	12,000	8,000
Annual NCF($)	3,000	1,000(years 1-5) 3,000(years 6-14)
Maximum life (years)	7	14

Solution:





Machine 1
0=-12,000+3000(P/A,10 %,np)
np==5.37 years

Machine 2
0=-8,000+1000(P/A,10%,5)+3000(P/A,10%,np-5)(P/F,10%,5)=
Np= 7.7years

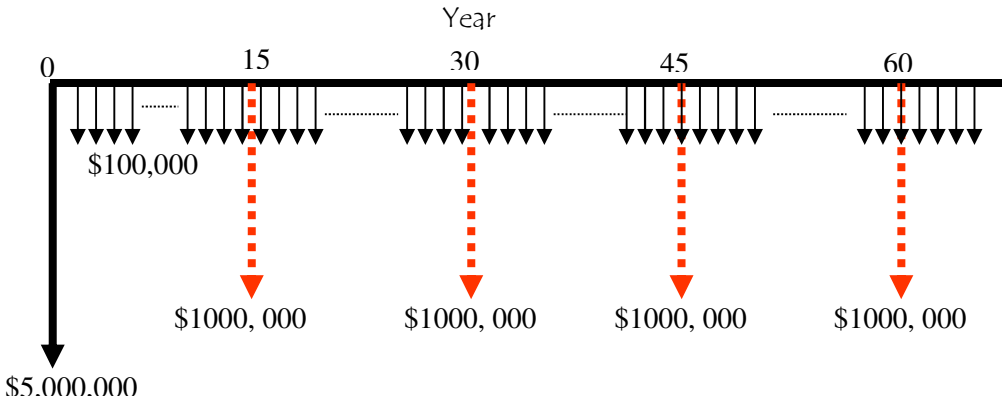
Then choose machine 1

Question 5

A newly constructed bridge costs **$5,000,000**. The same bridge is estimated to need renovation every **15** years at a cost of **$1,000,000**. Annual repairs and maintenance are estimated to be **$100,000** per year.

(a) If the interest rate is **10%**, determine the capitalized cost of the bridge.

(b) Suppose that, in (a), the bridge must be renovated every **20** years, not every **15** years. What is the capitalized cost of the bridge?



Solution:

(a)

Construction Cost

$P_1 = \$5,000,000$

Maintenance Costs

$P_2 = \$100,000/0.1 = \$1,000,000$

Renovation Costs

$P_3 = \{\$1000, 000(A/F, 10\%, 15)\}/0.1$

$=1000, 000x\ 0.0315/0.1$

$=\$315,000$

Total Present Worth

$P = P_1 + P_2 + P_3 = 5,000,000+1,000,000+315,000=\$6,315,000$

(b) **Construction Cost**

$P_1 = \$5,000,000$ **Maintenance Costs** $P_2 = \$100,000/0.1 = \$1,000,000$

Renovation Costs

$P_3 = \{\$1000, 000(A/F, 10\%, 20)\}/0.1$

$=1000, 000x\ 0.0175/0.1 = \$175,000$

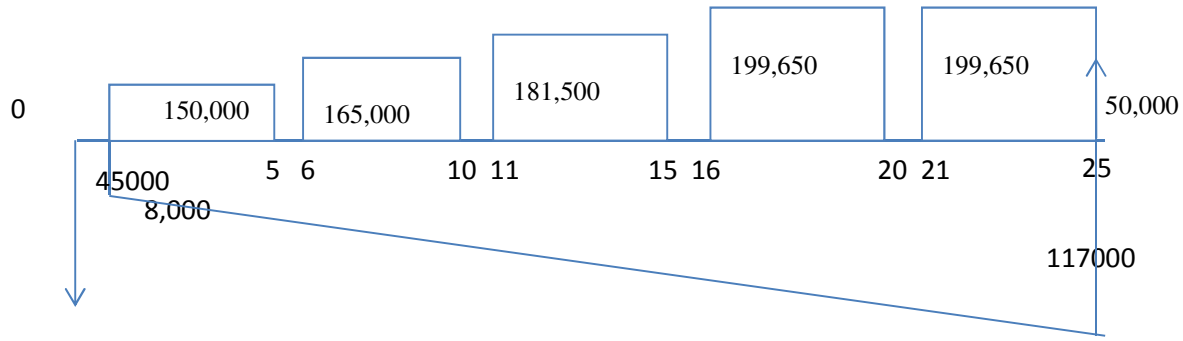
Total Present Worth $P = P_1 + P_2 + P_3 =$

$5,000,000+1,000,000+175,000=\$6,175,000$

Question 6

Your firm is considering purchasing an old office building with an estimated remaining service life of **25** years. Recently, the tenants signed a long-term lease, which leads you to believe that the current rental income of **$150,000** per year will remain constant for the first **5** years. Then the rental income will increase by **10%** for every **5**- year's interval over the remaining life of the asset. For example, the annual rental income would be **$165,000** for years **6** through **10**, **$181,500** for years **11** through **15, $199,650** for years 16 through **20**, and **$219,615** for years **21** through **25**. You estimate that operating expenses, including income taxes, will be **$45,000** for the first year and that they will increase by **$3000** each year thereafter. You also estimate that razing the building and selling the lot on which it stands will realize a net amount of **$50,000** at the end of the **25**- year period. If you had the opportunity to invest your money elsewhere and thereby earn interest at the rate of **10%** per annum, what would be the maximum amount you would be willing to pay for the building and lot at the present time?

Solution:



Given: Estimated remaining service life = 25 years,
current rental income = $150,000 per year,
O&M costs = $45,000 for the first year increasing by $3,000 thereafter,
salvage value = $50,000 , and. Interest = 10%
Let A_0 be the maximum investment required to break even.

PW(10%) = -A_o +[150,000(F/A,10%,25)+15,000(F/A,10%,20) +16,500 (F/A,10%,15)+18,150(F/A,10%,10)+19,965(F/A,10%,5)+50,000](P/F,10%,25)-45,000(P/A,10%,25)-3,000(P/G,10%,25)=0

$\therefore$ Solving for A_0 = yields

A_o =$920,309

This Page is left Blank Intentionally

10% Compound Interest Factors 10%

	Single Payment		Uniform Payment Series				Arithmetic Gradient		
	Compound Amount Factor	Present Worth Factor	Sinking Fund Factor	Capital Recovery Factor	Compound Amount Factor	Present Worth Factor	Gradient Uniform Series	Gradient Present Worth	
	Find *F* Given *P*	Find *P* Given *F*	Find *A* Given *F*	Find *A* Given *P*	Find *F* Given *A*	Find *P* Given *A*	Find *A* Given *G*	Find *P* Given *G*	
n	*F/P*	*P/F*	*A/F*	*A/P*	*F/A*	*P/A*	*A/G*	*P/G*	*n*
1	1.100	.9091	1.0000	1.1000	1.000	0.909	0	0	1
2	1.210	.8264	.4762	.5762	2.100	1.736	0.476	0.826	2
3	1.331	.7513	.3021	.4021	3.310	2.487	0.937	2.329	3
4	1.464	.6830	.2155	.3155	4.641	3.170	1.381	4.378	4
5	1.611	.6209	.1638	.2638	6.105	3.791	1.810	6.862	5
6	1.772	.5645	.1296	.2296	7.716	4.355	2.224	9.684	6
7	1.949	.5132	.1054	.2054	9.487	4.868	2.622	12.763	7
8	2.144	.4665	.0874	.1874	11.436	5.335	3.004	16.029	8
9	2.358	.4241	.0736	.1736	13.579	5.759	3.372	19.421	9
10	2.594	.3855	.0627	.1627	15.937	6.145	3.725	22.891	10
11	2.853	.3505	.0540	.1540	18.531	6.495	4.064	26.396	11
12	3.138	.3186	.0468	.1468	21.384	6.814	4.388	29.901	12
13	3.452	.2897	.0408	.1408	24.523	7.103	4.699	33.377	13
14	3.797	.2633	.0357	.1357	27.975	7.367	4.996	36.801	14
15	4.177	.2394	.0315	.1315	31.772	7.606	5.279	40.152	15
16	4.595	.2176	.0278	.1278	35.950	7.824	5.549	43.416	16
17	5.054	.1978	.0247	.1247	40.545	8.022	5.807	46.582	17
18	5.560	.1799	.0219	.1219	45.599	8.201	6.053	49.640	18
19	6.116	.1635	.0195	.1195	51.159	8.365	6.286	52.583	19
20	6.728	.1486	.0175	.1175	57.275	8.514	6.508	55.407	20
21	7.400	.1351	.0156	.1156	64.003	8.649	6.719	58.110	21
22	8.140	.1228	.0140	.1140	71.403	8.772	6.919	60.689	22
23	8.954	.1117	.0126	.1126	79.543	8.883	7.108	63.146	23
24	9.850	.1015	.0113	.1113	88.497	8.985	7.288	65.481	24
25	10.835	.0923	.0102	.1102	98.347	9.077	7.458	67.696	25
26	11.918	.0839	.00916	.1092	109.182	9.161	7.619	69.794	26
27	13.110	.0763	.00826	.1083	121.100	9.237	7.770	71.777	27
28	14.421	.0693	.00745	.1075	134.210	9.307	7.914	73.650	28
29	15.863	.0630	.00673	.1067	148.631	9.370	8.049	75.415	29
30	17.449	.0573	.00608	.1061	164.494	9.427	8.176	77.077	30
31	19.194	.0521	.00550	.1055	181.944	9.479	8.296	78.640	31
32	21.114	.0474	.00497	.1050	201.138	9.526	8.409	80.108	32
33	23.225	.0431	.00450	.1045	222.252	9.569	8.515	81.486	33
34	25.548	.0391	.00407	.1041	245.477	9.609	8.615	82.777	34
35	28.102	.0356	.00369	.1037	271.025	9.644	8.709	83.987	35
40	45.259	.0221	.00226	.1023	442.593	9.779	9.096	88.953	40
45	72.891	.0137	.00139	.1014	718.905	9.863	9.374	92.454	45
50	117.391	.00852	.00086	.1009	1 163.9	9.915	9.570	94.889	50
55	189.059	.00529	.00053	.1005	1 880.6	9.947	9.708	96.562	55
60	304.482	.00328	.00033	.1003	3 034.8	9.967	9.802	97.701	60
65	490.371	.00204	.00020	.1002	4 893.7	9.980	9.867	98.471	65
70	789.748	.00127	.00013	.1001	7 887.5	9.987	9.911	98.987	70
75	1 271.9	.00079	.00008	.1001	12 709.0	9.992	9.941	99.332	75
80	2 048.4	.00049	.00005	.1000	20 474.0	9.995	9.961	99.561	80
85	3 299.0	.00030	.00003	.1000	32 979.7	9.997	9.974	99.712	85
90	5 313.0	.00019	.00002	.1000	53 120.3	9.998	9.983	99.812	90
95	8 556.7	.00012	.00001	.1000	85 556.9	9.999	9.989	99.877	95
100	13 780.6	.00007	.00001	.1000	137 796.3	9.999	9.993	99.920	100