Final Exam (AMIE20102, Fall 2014)
December 19, 2014. 2:00 pm – **3:30 pm**
Prof. Youngmin You

1. Obtain the numerical solutions for the following equations. Employ the indicated method that appears after each equation. You should show the final line of the iteration table; see below as an example (*10 points*).

(1) $e^{2x}-1=\dfrac{2x}{x-1}$ → the method of bisection (구간이등분법) Note: Obtain a negative solution (*3 point*)

Let $f(x)=e^{2x}-1-\dfrac{2x}{x-1}$,

Solution: No solution in the negative region.

(2) $2x=\dfrac{1-x^3}{3}$ → the method of fixed points (고정점방법) (*3 points*)

Let

$$x=\frac{1-x^3}{6}$$

$$g(x)=\frac{1-x^3}{6}$$

n	Xn	g(Xn)
0	-2	1.5
1	1.5	-0.39583
2	-0.39583	0.177003
3	0.177003	0.165742
4	0.165742	0.165908
5	0.165908	0.165906
6	0.165906	0.165906
7	0.165906	0.165906
8	0.165906	0.165906
9	0.165906	0.165906

Solution: $x = 0.17$

(3) $x+x^2\sin x-1=0$ → the Newton's method (*4 point*)

$$f(x)=x+x^2\sin x-1$$
$$f'(x)=1+2x\sin x+x^2\cos x$$

n	Xn	f(Xn)	f'(Xn)
0	1	0.841471	3.223244
1	0.738937	0.106687	2.398966
2	0.694464	0.003112	2.259461
3	0.693087	2.94E-06	2.255186
4	0.693086	2.65E-12	2.255182
5	0.693086	0	2.255182
6	0.693086	0	2.255182
7	0.693086	0	2.255182
8	0.693086	0	2.255182
9	0.693086	0	2.255182
10	0.693086	0	2.255182

Solution: $x = 0.69$

2. Perform the following integration. Employ the indicated method that appears after each equation. You should show the *full* iteration table (*10 points*).

(1) $\int_1^3 \frac{\sin x}{x^2} dx$ → the rectangular method (직사각형 공식) with $n = 10$ (*5 points*)

The length of the range = 2, $n = 10 \rightarrow h = 0.2$

m	Xm	f(Xm)
1	1.1	0.736535
2	1.3	0.570153
3	1.5	0.443331
4	1.7	0.343137
5	1.9	0.262133
6	2.1	0.195739
7	2.3	0.140965
8	2.5	0.095756
9	2.7	0.058625
10	2.9	0.028448
sum of f(Xm) =		2.874822
h =		0.2
h*sum of f(Xm) =		0.574964

Solution: 0.57

(2) $\int_1^2 \left(e^x - 1\right) dx$ → the trapezoidal method (사다리꼴 공식) with $n = 10$ (*5 points*)

The length of the range = 1, $n = 10 \rightarrow h = 0.1$

m	Xm	f(Xm)	f(Xm-1)+f(Xm)
0	1	1.718282	
1	1.1	2.004166	3.722447852
2	1.2	2.320117	4.324282947
3	1.3	2.669297	4.98941359
4	1.4	3.0552	5.724496634
5	1.5	3.481689	6.536889037
6	1.6	3.953032	7.434721495
7	1.7	4.473947	8.426979816
8	1.8	5.049647	9.523594856
9	1.9	5.685894	10.73554191
10	2	6.389056	12.07495054
sum of f(Xm-1)+f(Xm) =			73.49331868
h =			0.1
(h/2)*(sum of f(Xm-1)+f(Xm)) =			3.674665934

Solution: 3.67

3. Obtain the numerical solution for $y' = 2x - y$ and $y(0) = 1$. Employ the improved Euler–Cauchy method with $h = 0.1$. You should show the iteration table (*7 points*).

The improved Euler–Cauchy method:

$$y^*_{n+1} = y_n + hf(x_n, y_n)$$

$$y_{n+1} = y_n + \frac{h}{2}[f(x_{n+1}, y_{n+1}) + f(x_n, y_n)]$$

$$y^*_{n+1} = 0.2x_n + 0.9y_n$$

Thus, $y_{n+1} = 0.1x_{n+1} + 0.09x_n + 0.905y_n$

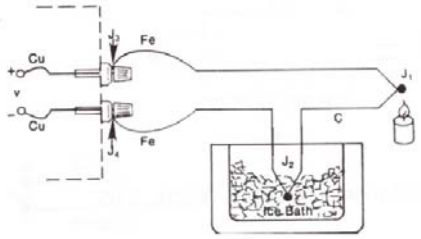
$(y_{n+1} = 0.19x_n + 0.905y_n + 0.01)$

n	Xn	Yn	Yn+1 = 0.1Xn+1 + 0.09Xn -0.905Yn
0	0	1	0.915
1	0.1	0.915	0.857075
2	0.2	0.857075	0.823652875
3	0.3	0.823653	0.812405852
4	0.4	0.812406	0.821227296
5	0.5	0.821227	0.848210703
6	0.6	0.848211	0.891630686
7	0.7	0.891631	0.949925771
8	0.8	0.949926	1.021682823
9	0.9	1.021683	1.105622955
10	1	1.105623	1.200588774
11	1.1	1.200589	1.30553284
12	1.2	1.305533	1.41950722
13	1.3	1.419507	1.541654035
14	1.4	1.541654	1.671196901
15	1.5	1.671197	1.807433196
16	1.6	1.807433	1.949727042
17	1.7	1.949727	2.097502973
18	1.8	2.097503	2.250240191
19	1.9	2.25024	2.407467373
20	2	2.407467	2.568757972
21	2.1	2.568758	2.733725965
22	2.2	2.733726	2.902021998
23	2.3	2.902022	3.073329908
24	2.4	3.07333	3.247363567
25	2.5	3.247364	3.423864028
26	2.6	3.423864	3.602596945
27	2.7	3.602597	3.783350236
28	2.8	3.78335	3.965931963
29	2.9	3.965932	4.150168427
30	3	4.150168	4.025902426

Solution at $x = 3$ is 4.15

4. Explain the principle of a *J*-type thermocouple (*4 points*).

J-type thermocouple is a sensor that reads temperature by means of a difference in potentials at two bimetallic junctions. It comprises iron and Constantan (Cu/Ni alloy). What differs from T–type thermocouple is that 1) potentials due to two junctions to a voltameter are canceled out, and 2) a reference junction (Fe/Constantan) is immersed into an ice bath. These enable accurate determination of temperature.



5. Shown below is the chemical structure of *fac*–Ir(ppy)$_3$, a phosphorescent dopant for electroluminescence devices. Open ChemDraw and answer following questions (*9 points*).

   (1) What is the molecular weight of *fac*–Ir(ppy)$_3$ (*3 points*)?

   654.78

   (2) What is the chemical formula for *fac*–Ir(ppy)$_3$ (*3 points*)?

   $C_{33}H_{24}IrN_3$

   (3) What is the elemental composition of *fac*–Ir(ppy)$_3$ (*3 points*)?

   C, 60.53; H, 3.69; Ir, 29.36; N, 6.42

6. Take-home exam: You are supposed to submit a LabVIEW program for temperature conversion from Celsius to Fahrenheit (*5 points*).