Question 1 (Exponential series using Taylor Series)

Exponential Series is a series which is used to find the value of ex.The formula used to express the ex as Exponential Series is

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!}$$

Expanding the above notation, the formula of Exponential Series is

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots$$

Further this is expanded to the below line

e^x = 1 + (x/1) (1 + (x/2) (1 + (x/3) (.....)))

For example,

Let the value of **x** be **3**.

$$e^3 = 1 + 3 + \frac{3^2}{2!} + \frac{3^3}{3!} + \cdots$$

This logic expression has been implemented in Kiel
The following table has been obtained from the code

Sl no	x	exp(x) obtained in cortex M4	exp(x) actual from calculator
1	0	1	1
2	1	2.7182817	2.71828
3	5	148.40292	148.413
4	10	20952.885	22026.46
5	15	1857094.6	3269017.372
6	30	5.86E+12	1.06865E+13
7	35	8.64E+14	1.58601E+15
8	45	2.59E+18	3.49343E+19
9	50	4.46E+20	5.18471E+21
10	60	4.46E+20	1.14201E+26
11	70	1.88E+28	2.51544E+30
12	80	6.61E+32	5.54062E+34
13	90	6.13E+35	1.2204E+39
14	95	1.44E+37	1.81124E+41
15	100	2.91E+38	2.68812E+43

Table 1:The different value of x the exponential values

No of iteration	Kiel	C	From Calculator	Error with C	Error with value from calculator
5	9128.5	9128.5	3269017.372	0	3259888.872
10	387262.22	387262.2188	3269017.372	0.0012	2881755.152
15	1857094.6	1857094.75	3269017.372	0.15	1411922.772
25	3248798.8	3248798.75	3269017.372	0.05	20218.57247
30	3268371.8	3268372.5	3269017.372	0.7	645.5724721

Table 2:For different iteration the value is calculated for kiel ,C and from calculator

Fig 1: Exponential series graph obtained from Kiel

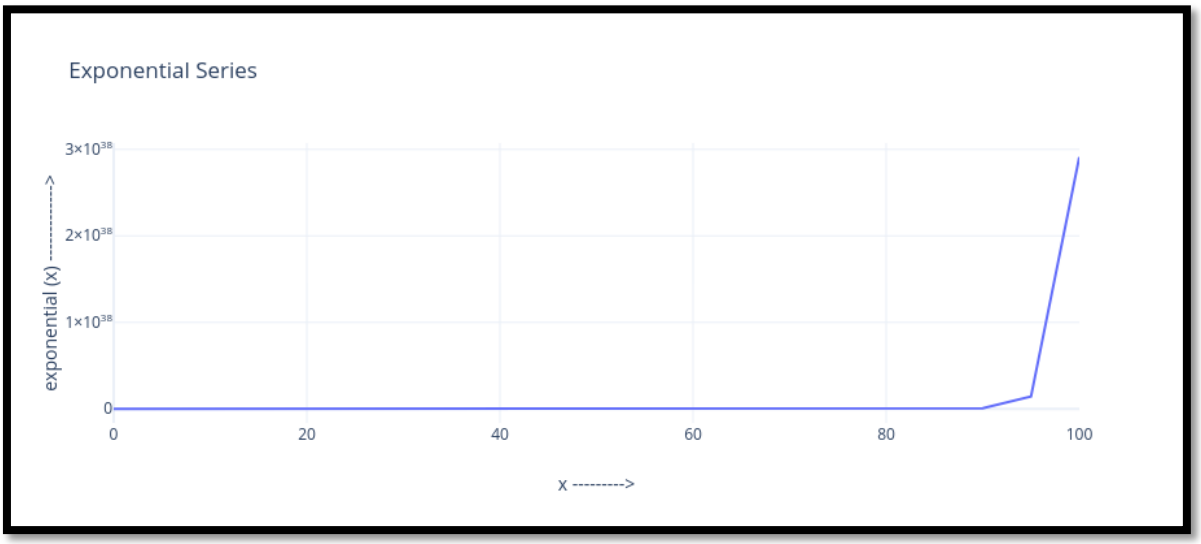


Fig2: Error in value of exponential(x) between calculator and keil

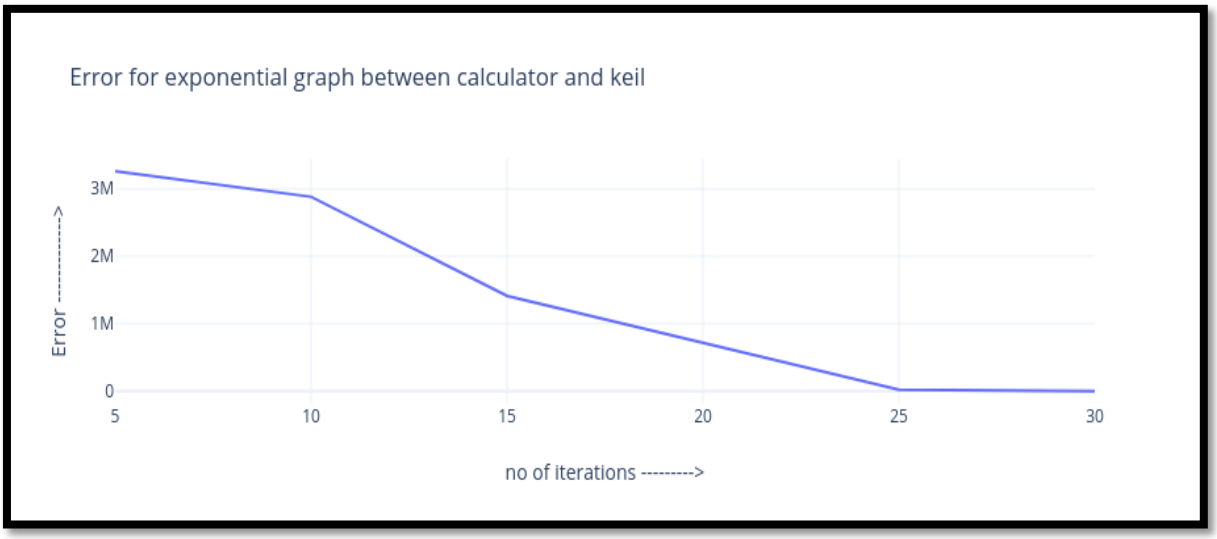
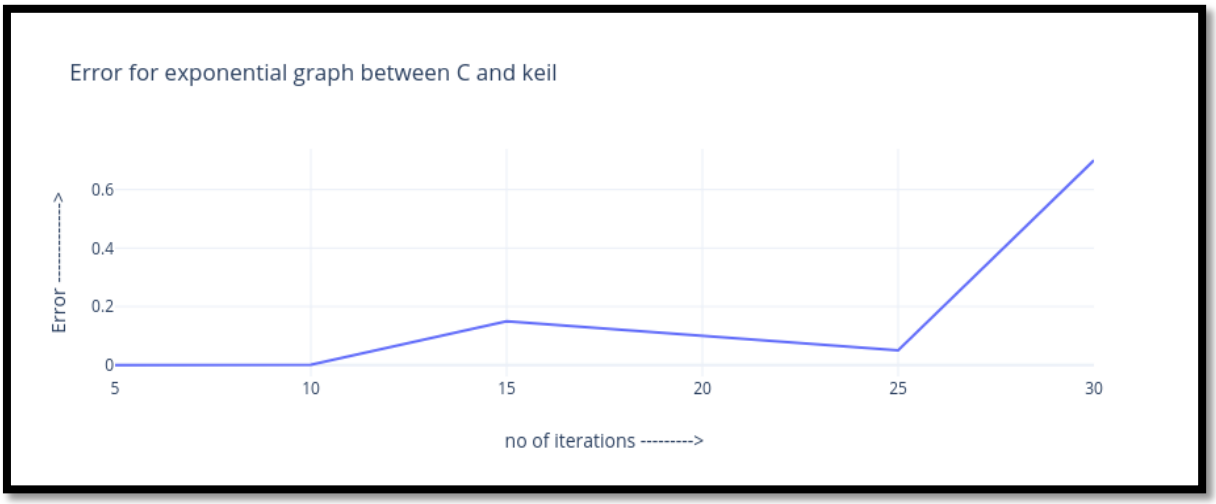


Fig3: Error in value of exponential(x) between C and keil



Question 2 : Implementing tan(x) as a infinite series using the Tan series

- Here the tan series is obtained by finding the taylor series for sine and cosine series and then dividing them.

- **Sine Series:**
  Sine Series is a series which is used to find the value of Sin(x).where, x is the angle in degree which is converted to Radian.The formula used to express the Sin(x) as Sine Series is

$$\sin x = \sum_{x=0}^{\infty} (-1)^n \frac{x^{2n+1}}{(2n+1)!}$$

Expanding the above notation, the formula of Sine Series is

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \dots$$

For example,

Let the value of x be 30.

$$x = 30 * \frac{\pi}{180} = 30 * \frac{3.14159}{180} = 0.52359$$

So, Radian value for 30 degree is 0.52359

$$\text{Sin}(0.52359) = 0.52359 - \frac{0.52359^3}{3!} + \frac{0.52359^5}{5!} - \frac{0.52359^7}{7!} + \dots\dots\dots$$

Cosine Series:
Cosine Series is a series which is used to find the value of Cos(x).where, **x** is the angle in **degree** which is converted to **Radian**.The formula used to express the Cos(x) as Cosine Series is

$$\cos x = \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n}}{(2n)!}$$

Expanding the above notation, the formula of Cosine Series is

$$\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \ldots$$

$$\text{Cos}(0.52359) = 1 - \frac{0.52359^2}{2!} + \frac{0.52359^4}{4!} - \frac{0.52359^6}{6!} + \ldots\ldots\ldots$$

- The tangent is calculated using sine/cosine in Cortex M4
- The C code and .s file is enclosed in the link

Sl no	x(in degrees)	tanx obtained in cortex M4	Actual tan x values(From calcultor)	Actual tan x values(From C)	Error between C and Kiel	Error between Kiel and calculator
1	0	0	0	0	0	0
2	10	0.17725718	0.176326	0.1763	0.00095718	0.00093118
3	20	0.36589354	0.36397	0.364	0.00189354	0.00192354
4	30	0.57987195	0.57735	0.5773	0.00257195	0.00252195
5	45	0.9968389	1	1	0.0031611	0.0031611
6	50	1.1806085	1.191753	1.1918	0.0111915	0.0111445
7	60	1.6733124	1.732	1.732	0.0586876	0.0586876
8	75	3.8360896	3.732	3.732	0.1040896	0.1040896
9	90	NaN	infinity	infinity	infinity	infinity
10	120	-1.6893802	-1.732	-1.7321	0.0427198	0.0426198
11	135	-0.975841	-1	-1	0.024159	0.024159
12	150	-0.5593768	-0.5773	-0.5774	0.0180232	0.0179232
13	180	0.016303653	0	0	0.016303653	0.016303653
14	220	0.8736361	0.83909	0.8391	0.0345361	0.0345461
15	260	6.572747	5.67	5.6711	0.901647	0.902747
16	270	nan	infinity	infinity	infinity	infinity
17	300	-1.6282328	-1.732	-1.7321	0.1038672	0.1037672
18	360	0.03261497	0	0	0.03261497	0.03261497

Table 4 :Shows the calculation of Tanx in kiel,c and calculator

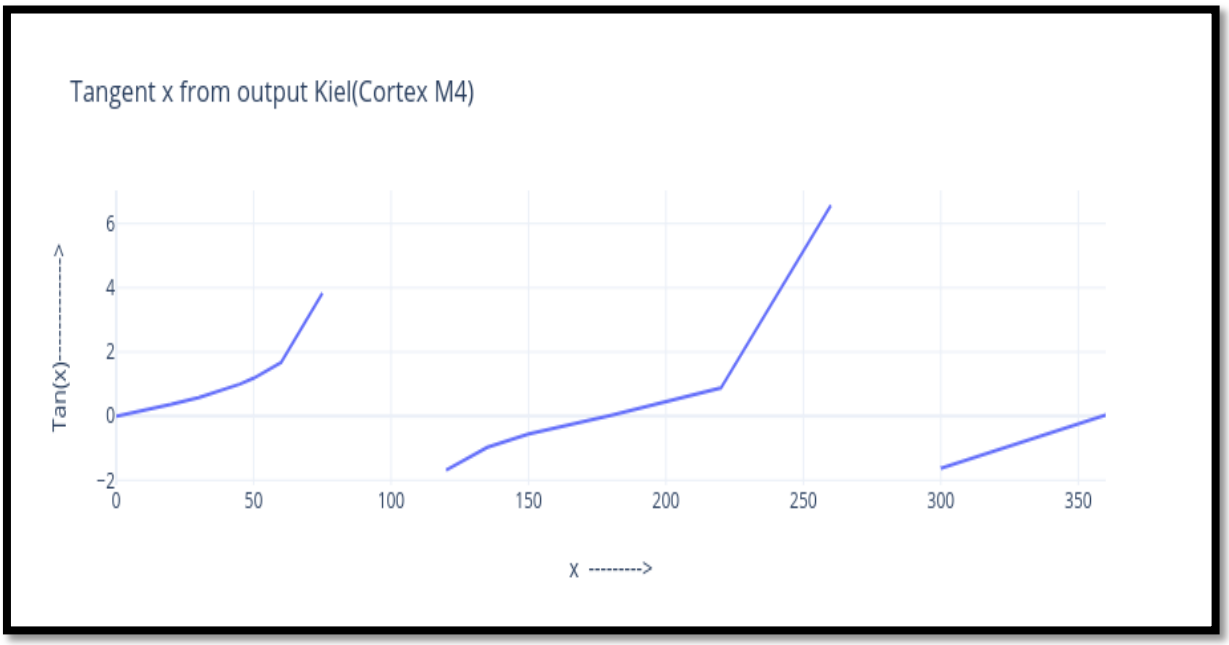


Fig 4: Tangent(x) obtained from Kiel

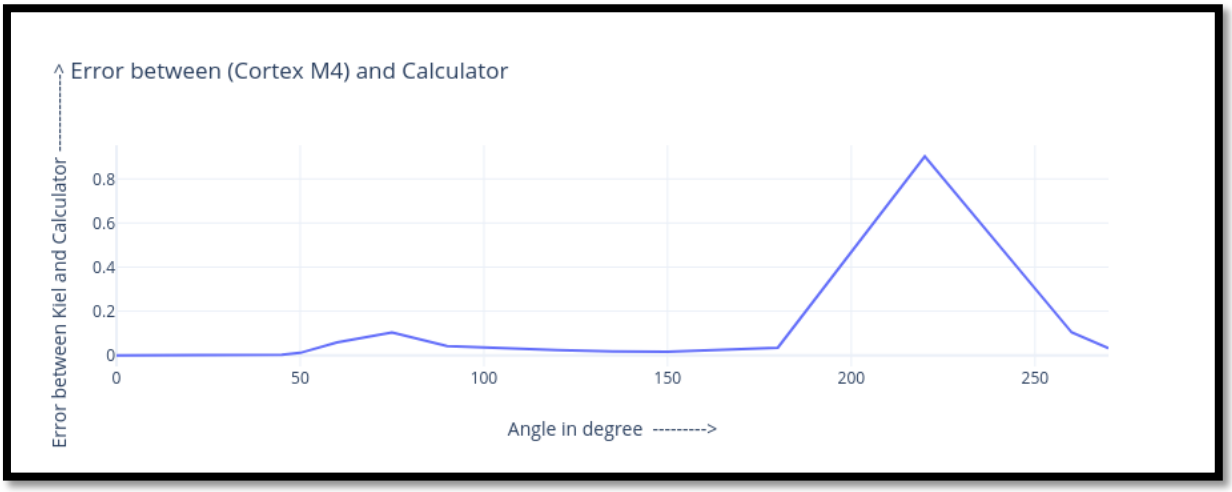


Fig 5: Error in value ofTangent(x) obtained from Kiel and calculator

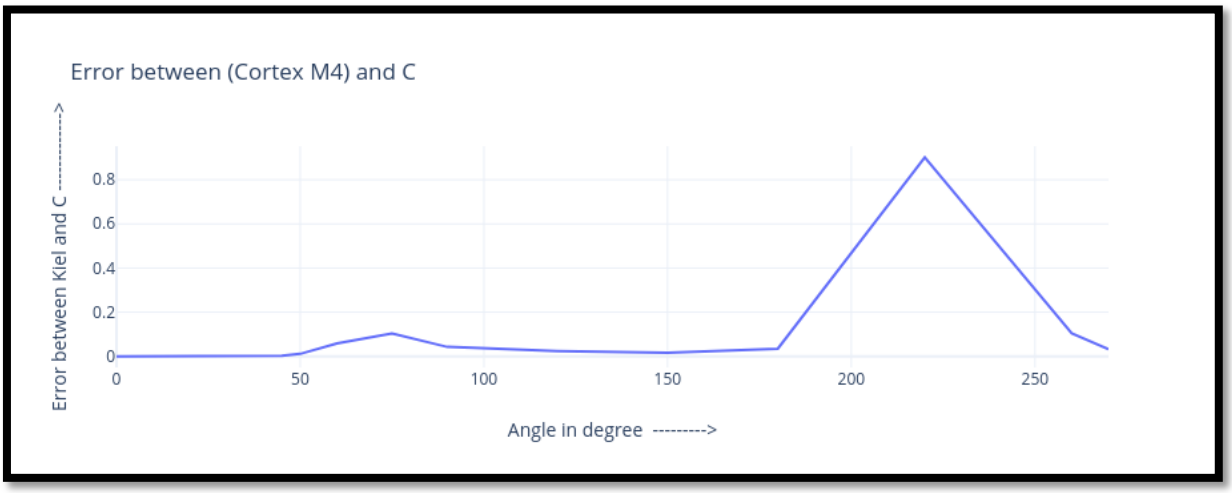


Fig 6: Error in value ofTangent(x) obtained from Kiel and C

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