CONFIDENTIAL

UNIVERSITI KUALA LUMPUR
Malaysian Institute of Marine Engineering Technology

FINAL EXAMINATION
JULY 2025 SEMESTER SESSION (7-WEEK)

SUBJECT CODE	:	**LKB30903**
SUBJECT TITLE	:	**COMPUTATIONAL ANALYSIS FOR OFFSHORE ENGINEERING**
PROGRAMME NAME (FOR MPU: PROGRAMME LEVEL)	:	**BET (OFFSHORE) WITH HONOURS**
TIME / DURATION	:	**09.00AM - 12.00PM (3 HOURS)**
DATE	:	**17 SEPTEMBER 2025**

INSTRUCTIONS TO CANDIDATES

1. Please read **CAREFULLY** the instructions given in the question paper.
2. This question paper has information printed on both sides of the paper.
3. This question paper consists of FIVE (5) questions.
4. Answer **FOUR (4)** questions **ONLY**.
5. Please write your answers on this answer booklet provided.
6. Answer **ALL** questions in English language **ONLY**.
7. Refer to the attached Formula.

THERE ARE 8 PAGES OF QUESTIONS, EXCLUDING THIS COVER PAGE

INSTRUCTION: Answer 4 questions ONLY.
Please use answer booklet provided.

Question 1 (CLO 2)

The development of oil or gas reserves in productive oil or gas fields or the operation for recovering or extracting such reserves fall under production activities. Specific activities include drilling projects, facilities engineering, and other construction projects. Closure activities commence once all reserves have been effectively extracted. These activities include plugging and abandoning fields and project reevaluation. There are different modes of transportation for moving oil and gas products shows in Figure 1. These include pipeline and pipeline networks, rails and trucks for land transportation, and barge and tankers for maritime transportation. Notable examples of midstream players are pipeline transport companies, trucking and hauling companies, shipping companies, and terminal developers and operators, among others. The analysis from this processes can be analysed by using numerical computational analysis.

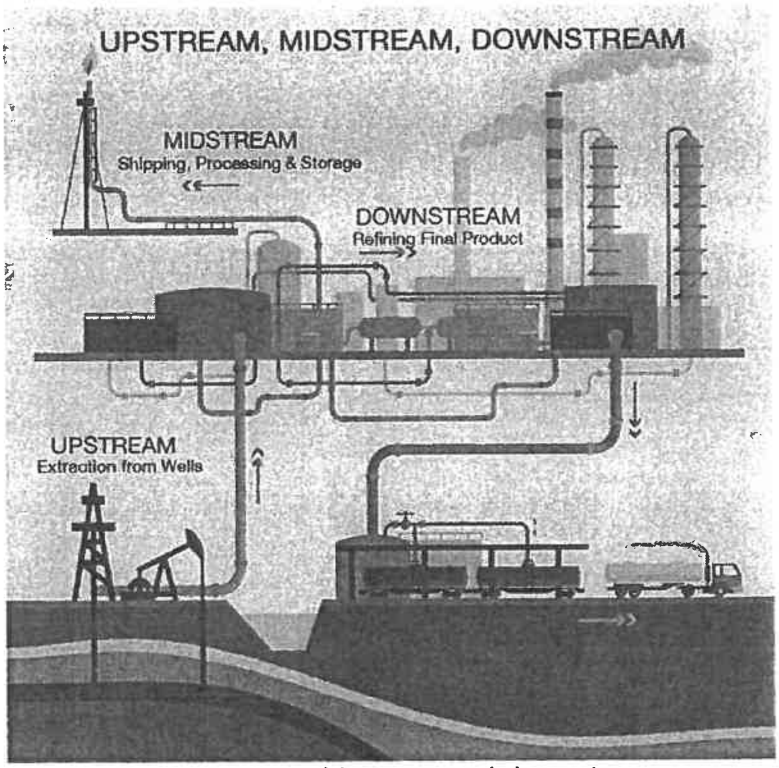


Figure 1: The upstream, midstream and downstream processes

(a) Describe steps involve in solving a non-linear equation using Newton Raphson method (include error approximation).

(5 marks)

(b) Determine the lowest positive roots of equation f(x) $=x^3 - 0.5x^2 + 4x - 2$ by using graphical method (plot in graph paper).

(10 marks)

(c) Then compare your answer by using Newton Raphson method (with initial guesses of $x_i = 0$).

(5 marks)

(d) Another process also need to use Gauss Elimination method. Determine the missing code in M Script file for linear equation below.

$$x_1 + x_2 - x_3 = -3$$

$$6x_1 + 2x_2 + x_3 = 2$$

$$-3x_1 + 4x_2 + x_3 = 1$$

```
function C = ________
A = ___________
B = __________
  i = 1; % loop variable
   X = [ A B ];
  [ nX mX ] = size( X); % determining the size of matrix
  while i <= nX % start of loop
    if X(i,i) == 0 % checking if the diagonal elements are zero or not
       disp('Diagonal element zero') % displaying the result if there exists zero
       return
     end
     X = elimination(X,i,i); % proceeding forward if diagonal elements are non-
zero
     i = i +1;
  end
  ....
```

(5 marks)

Question 2 (CLO 4)

One of the most important issues that offshore structures face is corrosion. Corrosion is a major factor affecting the longevity, protection, and long-term viability of buildings and structures. Corrosion-induced failure can result in severe safety incidents as well as financial losses. The characteristics of materials and structures in the marine environments deteriorate over time as a result of various parameters eroding at the same time, details showed in Figure 2. These parameters such as; dissolved oxygen, temperature, salinity, pH, seawater speed, and other variables. Corrosion progresses more quickly in an offensive setting. Seawater hastens the rate of corrosion due to its high electrolyte levels. The high salt content in this environment contributes additional ions to the water, which in turn increases the charge imbalance discussed above. In order to analyse all these chemical elements, engineer need to apply numerical differentiation methods.

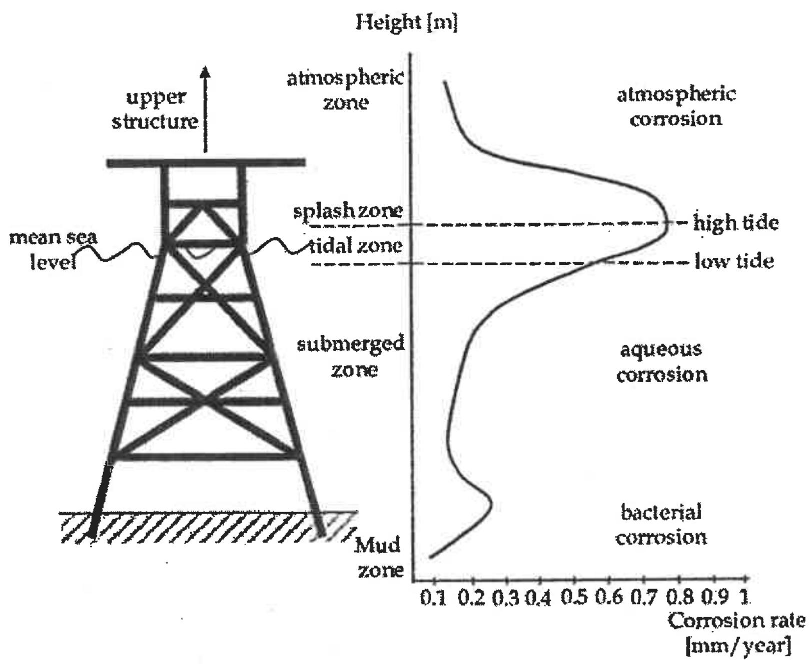


Figure 2: Corrosion Rate for Offshore Platform

(a) From Lagrange polynomial order two formula, derive the constant a_0 , a_1 and a_2.

$$f(x) = a_0(x - x_1)(x - x_2) + a_1(x - x_0)(x - x_2) + a_2(x - x_0)(x - x_1)$$

(8 marks)

(b) The following data come from a Table 1 shows the data corrosion rate (y) versus months (x). Plot the graph for corrosion rate (y) versus moths (x) by using graph paper.

Table 1: Corrosion Rate Versus Month Offshore Platform

x	0	1.8	5	6	8.2	9.2	12
y	26	16.415	5.375	3.5	2.015	2.54	8

(10 marks)

(c) Another process also need to determine y at x = 3.5 month. Note that a polynomial will yield an exact value. Your solution should prove that your result is exact.

(7 marks)

Question 3 (CLO 2)

A permanent mooring must remain secure for long periods while unattended, occasionally under adverse conditions. For peace of mind, it should be the right size for the job. The size of your mooring should depend on the conditions under which the boat is moored, such as the amount of fetch for waves to build up and whether your mooring is for light duty, such as overnight use in fair weather, or designed to ride out a hurricane. The two preferred designs for mooring buoys are a traditional buoy with hardware or a buoy with a tube through the center. Both offer reliable flotation and will last for several seasons, depending upon the salinity of the water. Obviously, freshwater applications will extend the useful life of any mooring system. The mooring buoy chain cable type showed in Figure 2 for details.

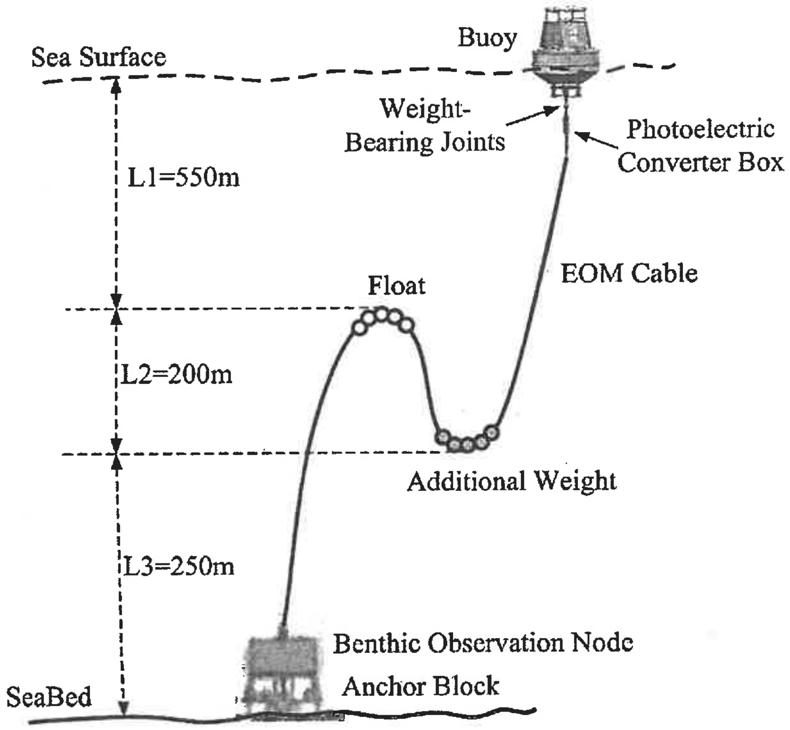


Figure 3: The Mooring Buoy Chain for Anchor

(a) Determine for all the forces (roots) and reaction for the cable in Figure 3 by using graphical method. The forces can be transformed in non-linear equation as roots of equation,

$$f(x) = 5x^3 - 5x^2 + 6x - 2$$

(10 marks)

(b) Solve the linear system below using Gauss-Seidel Iteration method. Calculate up to 3rd iteration.

$$x_1 + x_2 - x_3 = -3$$
$$6x_1 + 2x_2 + 2x_3 = 2$$
$$-3x_1 + 4x_2 + 7x_3 = 1$$

(8 marks)

(c) Determine the missing code in M Script file from (a) Newton Raphson method.

```
%The Newton Raphson Method
clc;
close all;
clear all;
%syms x;
x=__:_____:___;
f(x)=_______________________________________;
g=diff(f); %The Derivative of the Function
n=input('_________________________________:');
epsilon = 1*10^-(n+1)
x0 = input('_________________________________:');
for i=1:100
f0=vpa(subs(f,x,x0)); %Calculating the value of function at x0
 f0_der=vpa(subs(g,x,x0)); %Calculating the value of function derivative at x0
y=x0-f0/f0_der; % The Formula
err=abs(y-x0);
if err<epsilon %checking the amount of error at each iteration
break
end
x0=y;
end
y = y - rem(y,10^-n); %Displaying upto required decimal places
fprintf('The Root is : %f \n',y);
fprintf('No. of Iterations : %d\n',i);
```

(7 marks)

Question 4 (CLO 4)

A jacket is a welded tubular space frame with three or more near vertical tubular chord legs with a bracing system between the legs. The jacket provides support for the foundation piles, conductors, risers, and other appurtenances. A jacket foundation includes leg piles which are inserted through the legs (Figure 4) and connected to the legs either at the top, by welding or mechanical means, or along the length of the legs, by grouting. The data has been taken during installation of the platform.

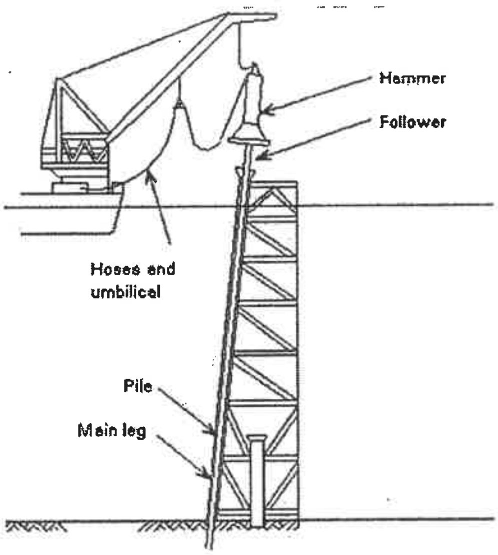


Figure 4: Jacket showing driving of pile through jacket leg

(a) From the given Table 1, showed data taken from a concrete pile composition during seabed auto filling self-pile. Use the best numerical method (for this type of problem) to determine P(x) from the first order Lagrange polynomial until fourth order Lagrange polynomial.

Table 1: Lagrange polynomial Concrete Pile

x	1	2	3	5	7	8
f(x)	3	6	19	99	291	444

Given: First order Equation, $f_1(x)=\frac{(x-x_1)}{(x_0-x_1)}f(x_0)+\frac{(x-x_0)}{(x_1-x_0)}f(x_1)$

(15 marks)

(b) Use the polynomial in (a) to analyse the value of $f_3(4)$.

(10 marks)

Question 5 (CLO 5)

A shear force describes the internal force that acts parallel to a surface trying to slide or deform one part of a surface relative to another. Shear forces appear at any location of the beam (3-meter-long), and it's visualized as an arrow shows in Figure 4. As it appears at any point of the beam, we cut the beam. This is done to calculate the internal forces, such as shear forces at the point of the cut by using numerical integration approach.

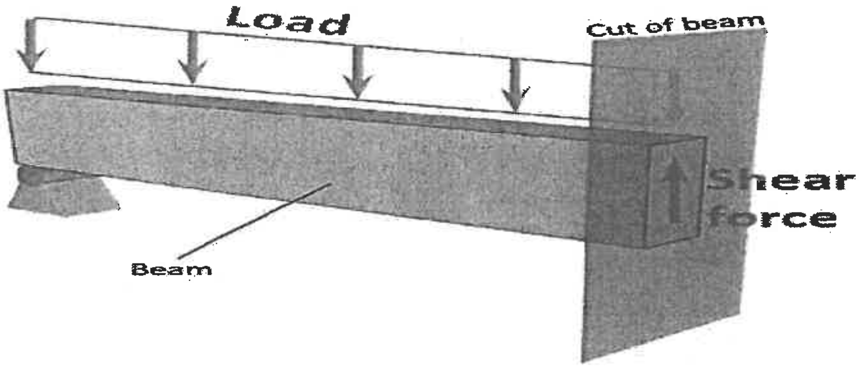


Figure 4: Shear Force Beam Distribution Load

(a) The loads are distributed along the beam and the shear force occurred at the edge of beam accordingly. The shear can be calculated using the equation;

$$f(x)=\int_0^3 (5+3\cos x)dx$$

Integrate the equation by using:

i) Calculus method.

ii) Trapezoidal Rule.

iii) Simpson's 1/3 Rule.

iv) Simpson's 3/8 Rule.

Compute the percentage relative error between calculus and numerical results.

(20 marks)

(b) Multiple of Simpson's application rules, with n=5.

(5 marks)

END OF FINAL EXAMINATION PAPER

FORMULA PROVIDED

Secant Method

$$x_{i+1} = x_i - \frac{f(x_i)(x_i - x_{i-1})}{f(x_i) - f(x_{i-1})}$$

$$|\epsilon_a| = \left|\frac{x_1 - x_0}{x_1}\right| \times 100$$

Newton Raphson Method

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)}$$

Bisection

$$x_m = \frac{x_\ell + x_u}{2}$$

$$|\epsilon_a| = \left|\frac{x_m^{new} - x_m^{old}}{x_m^{new}}\right| \times 100$$

Trapezoidal

$$I = (b - a)\frac{f(a) + f(b)}{2}$$

Multi-application Trapezoidal Rule

$$I = (b - a)\frac{f(x_0) + 2\sum_{i=1}^{n-1} f(x_i) + f(x_n)}{2n}$$, n = no. of segment

Simpson(1/3)

$$I \cong (b - a)\frac{f(x_0) + 4f(x_1) + f(x_2)}{6}$$

Simpson(3/8)

$$I \cong (b - a)\frac{f(x_0) + 3f(x_1) + 3f(x_2) + f(x_3)}{8}$$

Multi-application Simpson's Rule

$$I \cong (b - a)\frac{f(x_0) + 4\sum_{i=1,3,5}^{n-1} f(x_i) + 2\sum_{j=2,4,6}^{n-2} f(x_j) + f(x_n)}{3n}$$ n = no. of segment

LU

$[L][d] = [b]$

$[U][x] = [d]$

Gauss quadrature

$$\int_{-1}^{1} f(x)\,dx = \int_{-1}^{1} W(x)g(x)\,dx \approx \sum_{i=1}^{n} w_i g(x_i).$$

$$x = \frac{b-a}{2}z + \frac{a+b}{2}$$

$$dx = \frac{b-a}{2}dz$$

Table parameter for Gaussian Integration

n	i	w_i	z_i
2	1	1.00000	−0.57735
	2	1.00000	0.57735
3	1	0.55556	−0.77460
	2	0.88889	0.00000
	3	0.55556	0.77460
4	1	0.34785	−0.86114
	2	0.65215	−0.33998
	3	0.65215	+0.33998
	4	0.34785	0.86114
5	1	0.23693	−0.90618
	2	0.47863	−0.53847
	3	0.56889	0.00000
	4	0.47863	0.53847
	5	0.23693	0.90618

(Contd.)

Lagrange Interpolation

i) First-order

$$f_1(x) = \frac{x - x_1}{x_0 - x_1}f(x_0) + \frac{x - x_0}{x_1 - x_0}f(x_1)$$

ii) Second-order

$$f_2(x) = \frac{(x - x_1)(x - x_2)}{(x_0 - x_1)(x_0 - x_2)}f(x_0) + \frac{(x - x_0)(x - x_2)}{(x_1 - x_0)(x_1 - x_2)}f(x_1) + \frac{(x - x_0)(x - x_1)}{(x_2 - x_0)(x_2 - x_1)}f(x_2)$$

iii) Third-order

$$f_3(x) = \frac{(x-x_1)(x-x_2)(x-x_3)}{(x_0-x_1)(x_0-x_2)(x_0-x_3)}f(x_0) + \frac{(x-x_1)(x-x_2)(x-x_3)}{(x_1-x_0)(x_1-x_2)(x_1-x_3)}f(x_1)$$
$$+ \frac{(x-x_0)(x-x_1)(x-x_3)}{(x_2-x_0)(x_2-x_1)(x_2-x_3)}f(x_2) + \frac{(x-x_0)(x-x_1)(x-x_2)}{(x_3-x_0)(x_3-x_1)(x_3-x_2)}f(x_3)$$

Euler

$$y_{n+1} = y_n + f(x_n, y_n)\Delta x$$

Runge-Kutta second order

$$y_{i+1} = y_i + \frac{m_1 + 2m_2}{3}(h)$$

Classical Rungge-Kutta 4th Order

$$m_1 = f(x_i, y_i)$$
$$m_2 = f\left(x_i + \frac{h}{2}, y_i + \frac{m_1 h}{2}\right)$$
$$m_3 = f\left(x_i + \frac{h}{2}, y_i + \frac{m_2 h}{2}\right)$$
$$m_4 = f(x_i + h, y_i + m_3 h)$$
$$y_{i+1} = y_i + \left(\frac{m_1 + 2m_2 + 2m_3 + m_4}{6}\right)h$$

Romberg

$$R(0,0) = \frac{h}{2}[f(a) + f(b)]$$
$$h = b - a$$
$$R(i,0) = \frac{R(i-1,0)}{2} + h_i \sum_{k=1}^{2^{i-1}} f(x_{2k-1})$$
$$h_i = \frac{(b-a)}{2^i}$$
$$x_k = a + kh_i$$
$$R(i,j) = \frac{4^j R(i,j-1) - R(i-1,j-1)}{4^j - 1}$$

Numerical Differentiation

a) Forward Finite- Divided Differences

First Derivative	Error
$f'(x_i) = \dfrac{f(x_{i+1}) - f(x_i)}{h}$	$O(h)$
$f'(x_i) = \dfrac{-f(x_{i+2}) + 4f(x_{i+1}) - 3f(x_i)}{2h}$	$O(h^2)$
Second Derivative	
$f''(x_i) = \dfrac{f(x_{i+2}) - 2f(x_{i+1}) + f(x_i)}{h^2}$	$O(h)$
$f''(x_i) = \dfrac{-f(x_{i+3}) + 4f(x_{i+2}) - 5f(x_{i+1}) + 2f(x_i)}{h^2}$	$O(h^2)$
Third Derivative	
$f'''(x_i) = \dfrac{f(x_{i+3}) - 3f(x_{i+2}) + 3f(x_{i+1}) - f(x_i)}{h^3}$	$O(h)$
$f'''(x_i) = \dfrac{-3f(x_{i+4}) + 14f(x_{i+3}) - 24f(x_{i+2}) + 18f(x_{i+1}) - 5f(x_i)}{2h^3}$	$O(h^2)$
Fourth Derivative	
$f''''(x_i) = \dfrac{f(x_{i+4}) - 4f(x_{i+3}) + 6f(x_{i+2}) - 4f(x_{i+1}) + f(x_i)}{h^4}$	$O(h)$
$f''''(x_i) = \dfrac{-2f(x_{i+5}) + 11f(x_{i+4}) - 24f(x_{i+3}) + 26f(x_{i+2}) - 14f(x_{i+1}) + 3f(x_i)}{h^4}$	$O(h^2)$

b) Backward Finite-Divided Differences

First Derivative	Error
$f'(x_i) = \dfrac{f(x_i) - f(x_{i-1})}{h}$	$O(h)$
$f'(x_i) = \dfrac{3f(x_i) - 4f(x_{i-1}) + f(x_{i-2})}{2h}$	$O(h^2)$
Second Derivative	
$f''(x_i) = \dfrac{f(x_i) - 2f(x_{i-1}) + f(x_{i-2})}{h^2}$	$O(h)$
$f''(x_i) = \dfrac{2f(x_i) - 5f(x_{i-1}) + 4f(x_{i-2}) - f(x_{i-3})}{h^2}$	$O(h^2)$
Third Derivative	
$f'''(x_i) = \dfrac{f(x_i) - 3f(x_{i-1}) + 3f(x_{i-2}) - f(x_{i-3})}{h^3}$	$O(h)$
$f'''(x_i) = \dfrac{5f(x_i) - 18f(x_{i-1}) + 24f(x_{i-2}) - 14f(x_{i-3}) + 3f(x_{i-4})}{2h^3}$	$O(h^2)$
Fourth Derivative	
$f''''(x_i) = \dfrac{f(x_i) - 4f(x_{i-1}) + 6f(x_{i-2}) - 4f(x_{i-3}) + f(x_{i-4})}{h^4}$	$O(h)$
$f''''(x_i) = \dfrac{3f(x_i) - 14f(x_{i-1}) + 26f(x_{i-2}) - 24f(x_{i-3}) + 11f(x_{i-4}) - 2f(x_{i-5})}{h^4}$	$O(h^2)$

c) Centered Finite-Divided Difference

First Derivative — Error

$$f'(x_i) = \frac{f(x_{i+1}) - f(x_{i-1})}{2h} \qquad O(h^2)$$

$$f'(x_i) = \frac{-f(x_{i+2}) + 8f(x_{i+1}) - 8f(x_{i-1}) + f(x_{i-2})}{12h} \qquad O(h^4)$$

Second Derivative

$$f''(x_i) = \frac{f(x_{i+1}) - 2f(x_i) + f(x_{i-1})}{h^2} \qquad O(h^2)$$

$$f''(x_i) = \frac{-f(x_{i+2}) + 16f(x_{i+1}) - 30f(x_i) + 16f(x_{i-1}) - f(x_{i-2})}{12h^2} \qquad O(h^4)$$

Third Derivative

$$f'''(x_i) = \frac{f(x_{i+2}) - 2f(x_{i+1}) + 2f(x_{i-1}) - f(x_{i-2})}{2h^3} \qquad O(h^2)$$

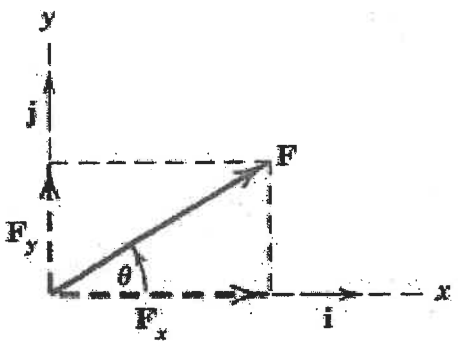
$$f'''(x_i) = \frac{-f(x_{i+3}) + 8f(x_{i+2}) - 13f(x_{i+1}) + 13f(x_{i-1}) - 8f(x_{i-2}) + f(x_{i-3})}{8h^3} \qquad O(h^4)$$

Fourth Derivative

$$f''''(x_i) = \frac{f(x_{i+2}) - 4f(x_{i+1}) + 6f(x_i) - 4f(x_{i-1}) + f(x_{i-2})}{h^4} \qquad O(h^2)$$

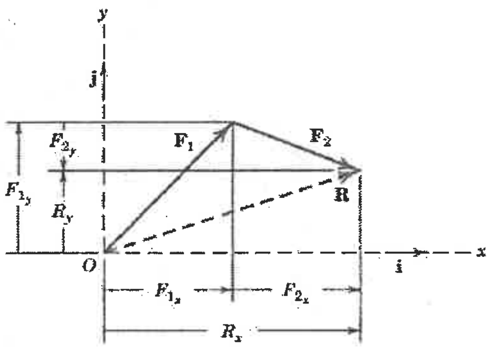
$$f''''(x_i) = \frac{-f(x_{i+3}) + 12f(x_{i+2}) - 39f(x_{i+1}) + 56f(x_i) - 39f(x_{i-1}) + 12f(x_{i-2}) - f(x_{i-3})}{6h^4} \qquad O(h^4)$$

Force & Truss Calculation



$$F_x = F\cos\theta \qquad F = \sqrt{F_x^{\,2} + F_y^{\,2}}$$

$$F_y = F\sin\theta \qquad \theta = \tan^{-1}\frac{F_y}{F_x}$$



$$\mathbf{R} = \mathbf{F}_1 + \mathbf{F}_2 = (F_{1_x}\mathbf{i} + F_{1_y}\mathbf{j}) + (F_{2_x}\mathbf{i} + F_{2_y}\mathbf{j})$$

or

$$R_x\mathbf{i} + R_y\mathbf{j} = (F_{1_x} + F_{2_x})\mathbf{i} + (F_{1_y} + F_{2_y})\mathbf{j}$$

from which we conclude that

$$R_x = F_{1_x} + F_{2_x} = \Sigma F_x$$
$$R_y = F_{1_y} + F_{2_y} = \Sigma F_y$$