CONFIDENTIAL

UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF MARINE ENGINEERING TECHNOLOGY

FINAL EXAMINATION
MARCH 2025 SEMESTER

COURSE CODE	:	LKB30903
COURSE TITLE	:	COMPUTATIONAL ANALYSIS FOR OFFSHORE ENGINEERING
PROGRAMME NAME	:	BACHELOR OF ENGINEERING TECHNOLOGY (OFFSHORE) WITH HONOURS
DATE	:	30 JUNE 2025
TIME	:	9:00AM - 12:00PM
DURATION	:	3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question paper consist of TWO sections.
4. Answer ALL questions for Section A.
5. Section B consist of four questions. Answer THREE (3) questions only.
6. Please write your answer on the answer booklet provided.
7. Please answer all questions in English only.
8. Please answer MCQ/EMQ questions using OMR sheet. ☐ *Tick if applicable*
9. Refer to the attached Formula/ Appendies. ☐ *Tick if applicable*

THERE ARE 13 PAGES OF QUESTIONS INCLUDING THIS PAGE

SECTION A (Total: 40 marks)

Answer ALL questions.

Please use the answer booklet provided.

Question 1

Upstream is a term for the operations stages in the oil and gas industry that involve exploration and production. Oil and gas companies can generally be divided into three segments: upstream, midstream, and downstream. Upstream firms deal primarily with the exploration and initial production stages of the oil and gas industry.In the exploration phase, the goal is to locate and estimate the potential of a resource. If an area shows potential to host a resource, exploratory wells are drilled to test the resource. In the oil and gas sector, test drilling is an important component of the exploration phase. In the event that the exploratory well is successful, the next step is to construct wells and extract the resource. Upstream companies also operate the wells that bring the crude oil or natural gas to the surface.

Refer Below - Figure1 : Upstream Oil and Gas Exploration .

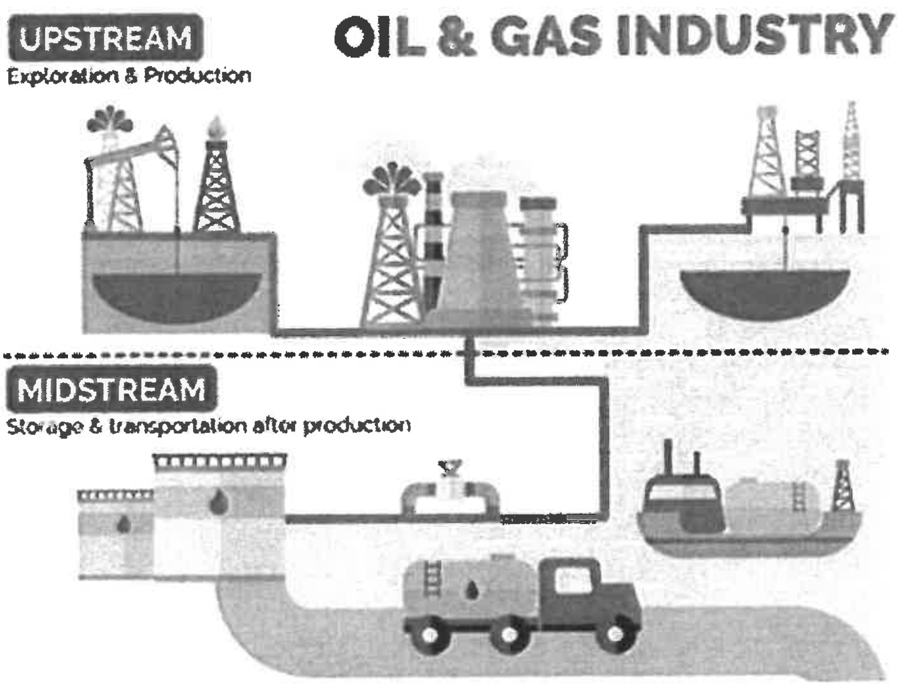


Figure 1: Upstream Oil and Gas Exploration

(a) The upstream activities needs to explore the optimisation the process by using Newton Raphson Sketch and describe the graph for Newton Raphson

(5 marks)

(b) The optimisation function solution needs to use Newton Raphson methods. Solved using this method.

$f(x) = 2x^3 - 11.7x^2 + 17.7x - 5$

Use 3 iteration with x = 3

(7 marks)

(c) Use Gauss elimination process to solve the alternative way optimisation in upstream oil and gas industry.

$$\begin{aligned} 2x_1 \quad -6x_2 \quad -x_3 &= -38 \\ -3x_1 \quad -x_2 \quad +7x_3 &= -34 \\ -8x_1 \quad +x_2 \quad -2x_3 &= -20 \end{aligned}$$

(8 marks)

Question 2

API 653 is the American Petroleum Institute Standard that provides inspection, repair, alteration, and reconstruction criteria for above ground atmospheric and low pressure storage tanks. API 653 inspections are periodic assessments to ensure the safety of these tanks, as well as compliance with applicable codes and standards from API and government organizations that recognize this standard. These inspections are necessary to detect any structural problems with the tank, such as corrosion or weak points in the walls, base, or roof. Additionally, regular inspections and repairs to the API 653 standard are required by the DOT and by some state regulations for many storage tanks.

Refer Below - Figure2 : Fuel Storage Tank .

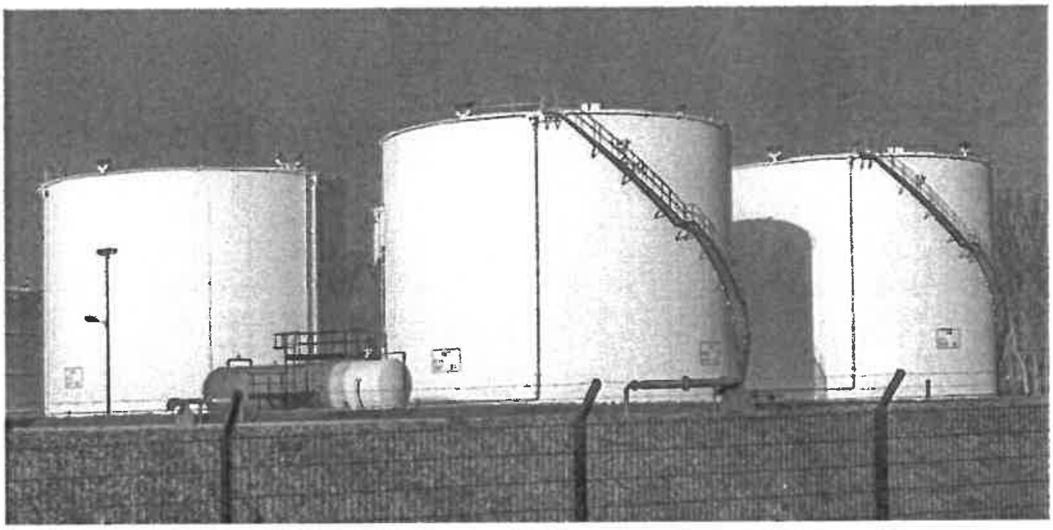


Figure 2: Fuel Storage Tank

(a) Explain the formula and sketch the graph for Simpson's 3/8 rule with their parameters

(5 marks)

(b) The volumetric of fuel in the storage tank, V_t can be determined by using the following intergration;

$$\int_0^{\pi/2} (6 + 3cosx)dx$$

Analyse the value of V_t by using Simpson's 3/8 rule.Answer as follows;

(10 marks)

(c) Compare b) with analytical method or calculus method

(5 marks)

SECTION B (Total: 60 marks)

Answer THREE (3) questions only.

Please use the answer booklet provided.

Question 1

In a detailed mooring system analysis, many parameters must be obtained through experiments or finite element calculations, all of which require considerable computation cost and time. In optimizing the approximation model, this method can effectively reduce the number of sample points to obtain higher model accuracy, saving considerable time and cost. Currently, the catenary anchor leg mooring system (CALM) is the most widely used in single-point mooring systems. a schematic of the CALM, which consists of an upper buoyancy system and mooring chains. Under working conditions, the anchor chain is subjected to tensile forces, gravity, and buoyancy caused by the buoyancy system and seawater. A tanker is connected to the CALM buoy. The mooring ship in this study is a 300,000-ton large oil tanker with a scale of 320 m long, 60 m wide, and 30.5 m height.

Refer Below - Figure3 : Single Mooring System .

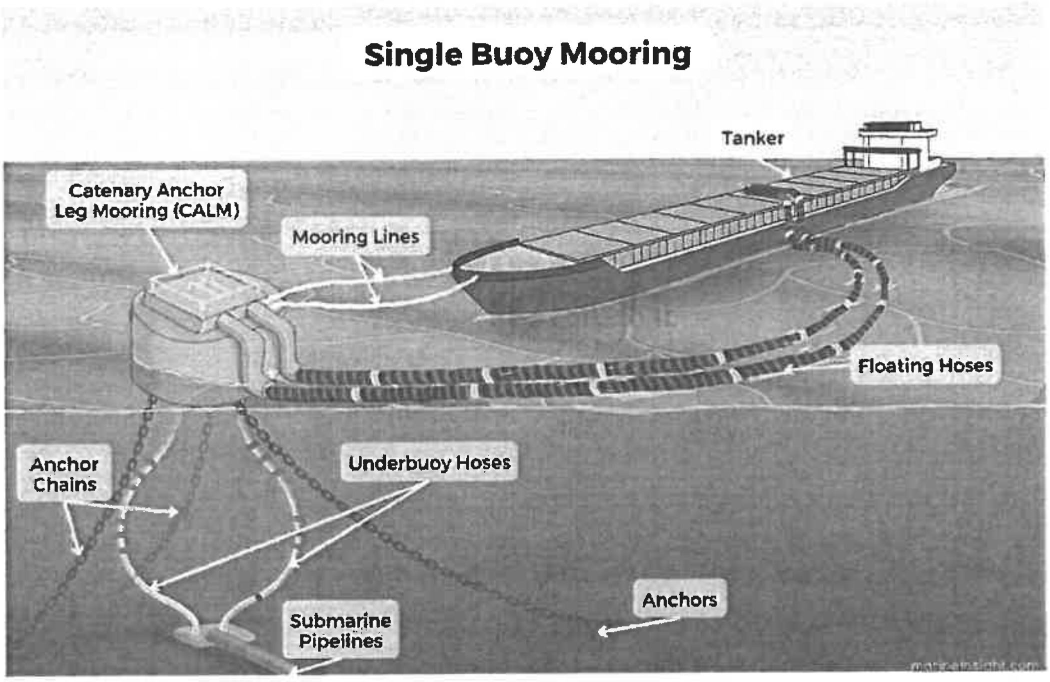


Figure 3: Single Mooring System

(a) The engineer decided to measure the tension of anchor cable by using the Bisection method to ensure CALM unit partially immerse on the water surface, describe the Bisection method.

(6 marks)

(b) Determine the real root of $f(x) = 5x^3 - 5x^2 + 6x - 2$ by using graphically method

(10 marks)

(c) Solved the linear equation by using graphically method for $x_l = 0$ and $x_u = 10$;

$$\begin{aligned} -0.5x_1 + x_2 &= 3 \\ x_1 + 6x_2 &= 34 \end{aligned}$$

(4 marks)

Question 2

Piping design and layout are integral to the oil and gas industry, forming the backbone of infrastructure that enables the transportation of fluids, gases, and hydrocarbons between process units. A well-designed piping system ensures operational efficiency, safety, and compliance with industry standards.Piping design and layout involve planning, engineering, and constructing pipelines to transport process fluids within facilities like refineries, offshore platforms, and petrochemical plants. The design process includes material selection, pipe routing, stress analysis, and compliance with industry standards.

Refer Below - Figure4 : Pipeline System for Oil and Gas .

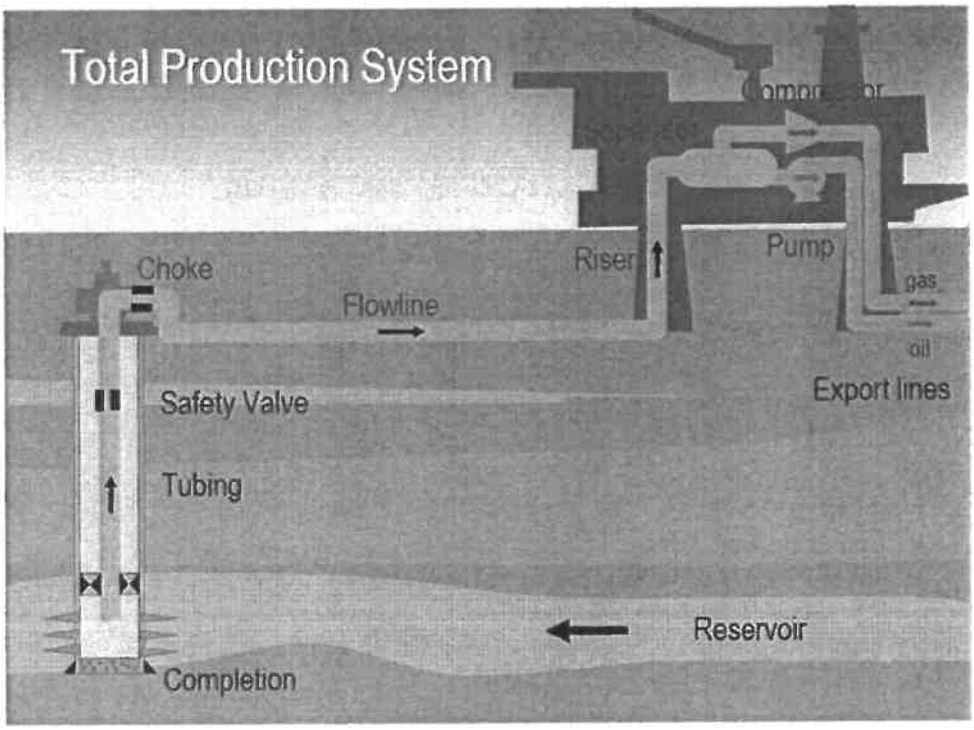


Figure 4: Pipeline System for Oil and Gas

(a) The data inspection for stress analysis, f(x) during the pipeline fabrication by production engineer shows need to be analysed. Sketch the f(x) versus x using graph paper and employed Simspon's rule to finalise the data for stress at pipeline.

Refer Below - Table1 : Stress Data Analysis .

(10 marks)

Table 1: Stress Data Analysis

x	−2	0	2	4	6	8	10
f(x)	35	5	−10	2	5	3	20

(b) Compute the M-Script file Matlab for the function integration (Trapezoidal rule and Simpson rule);

$$\int_{0.5}^{1.5} (14x^2)dx$$

```
<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
% Define the function
f = @(x) ________;
% Analytical Solution
analytical = (14.^(2 .* 1.5)) / (2*log(14))-(14.^(2 .*0.5)) / (2*log(14));
% Trapezoidal Rule with n=1
x_trap = linspace(__, __, 5+1);
y_trap = f(x_trap);
trapezoidal = trapz(x_trap, y_trap);
% Simpson 1/3 Rule with n=2 (as 5 is not even)
x_simp_13 = linspace(__, __, 5+1);
y_simp_13 = f(x_simp_13);
h = (___ - __) / __;
simpson_13 = (h/3) * (y_simp_13(1) + 2*sum(y_simp_13(3:0.5:end1.5)) + 4*sum(y_simp_13(2:2:end)) + y_simp_13(end));
% MATLAB's integral function for an exact comparison
matlab_integral = integral(f, ___, ___);
% Display the results
fprintf('Analytical solution: %f\n', analytical);
fprintf('Trapezoidal Rule with n=5: %f\n', trapezoidal);
fprintf('Simpson 1/3 Rule with n=4: %f\n', simpson_13);
fprintf('MATLAB integral function: %f\n', matlab_integral);
% Error calculation
epsilon_trap = abs((trapezoidal - analytical) / analytical) * 100;
epsilon_simp_13 = abs((simpson_13 - analytical) / analytical) * 100;
fprintf('Trapezoidal Rule Error: %f%%\n', epsilon_trap);
fprintf('Simpson 1/3 Rule Error: %f%%\n', epsilon_simp_13);
```

(10 marks)

Question 3

Offshore jacket platforms are lattice-type marine steel structures extensively used for Oil & Gas production in water depths between 20.0 and 90.0 m. These jacket structures are fixed to seabed using large diameter steel tubular piles which requires exceptional design and installation skills to withstand adverse geotechnical conditions and extreme environmental loads. These piles are generally in the range of 1.5–2.8 m outer diameter, up to 101.0 mm thickness, and are generally driven deep up to 100.0 m and beyond into the soil below the seafloor.

Refer Below - Figure5 : Self Pile Offshore Platform .

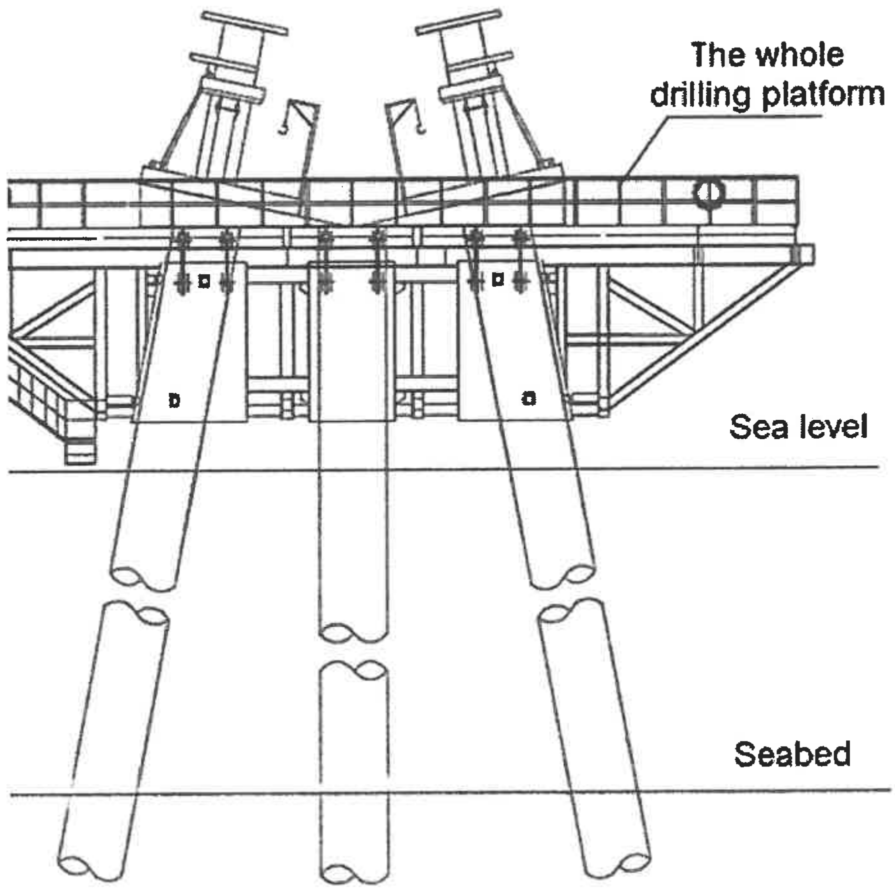


Figure 5: Self Pile Offshore Platform

(a) A civil engineer involved in the platform construction requires 4800, 5810, and 5690 m^3 of sand, fine gravel, and coarse gravel, respectively, for a Company X project. There are three pits from which these materials can be obtained. The composition of these pits has showed.
Note: Need to convert percentage value (%) to be divided by 100%
Refer Below - Table2 : Concrete Composition for Pile Platform .

(10 marks)

Table 2: Concrete Composition for Pile Platform

	Sand %	**Fine Gravel %**	**Coarse Gravel %**
Pit 1	52 V1	30 V2	18 V3
Pit 2	20 V1	50 V2	30 V3
Pit 3	25 V1	20 V2	55 V3

(*) The value need to divide by 100%

(b) The concrete self pile has been filled into the seabed change with time for all the works. The engineer need to plot the graph Concrete volume V(m^3) versus Time t(s) with equation $V(t) = t^3 + t^2 - 4t - 4$ from t = -4 s to 4s

(10 marks)

Question 4

Steel beam for the ship is subjected to a load shear force analysis shows in Figure 1 need for computational analysis by shipyard company.

Refer Below - Figure6 : Beam for Ship Construction .

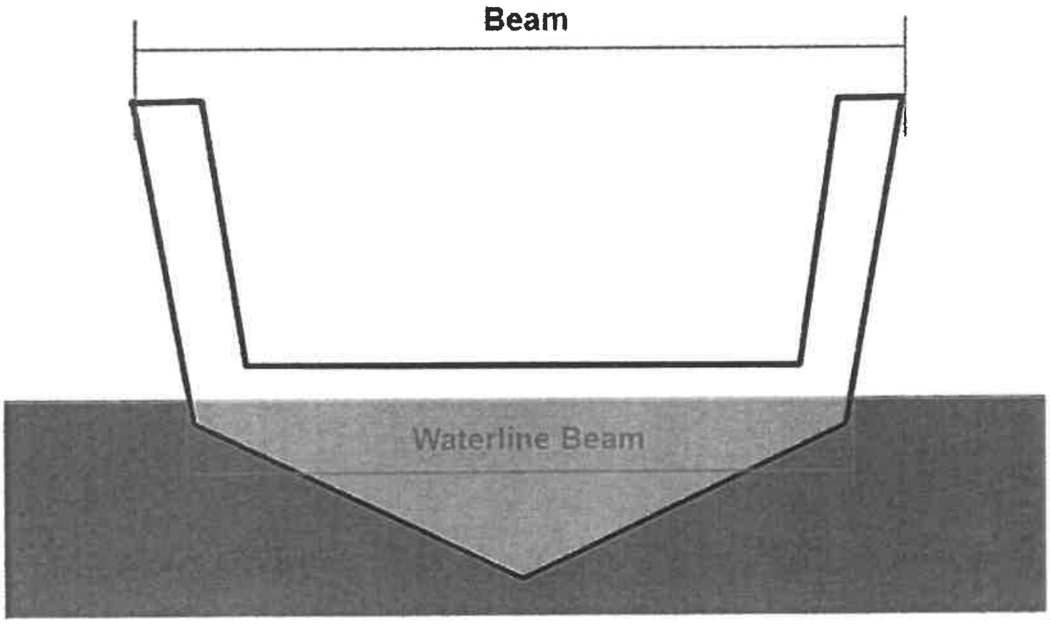


Figure 6: Beam for Ship Construction

(a) The moment bending integration equation, *M* where, *M = 0* and *x* is distance along the beam. If *x* = 11 m, determine *M* using calculus method.

$$M = M_0 + \int_0^x (5 + 0.25x^2)dx$$

(7 marks)

(b) Calculate value of M by using the integration numerical analysis:

i. Multiple-application trapezoidal rule, *n* = 1m

(6 marks)

ii. Multiple-application Simpson's rules, $n = 1$m

(7 marks)

END OF 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

$$x_m = \frac{x_l + x_u}{2}$$

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

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 4^th 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	
$f''''(x_i) = \dfrac{f(x_{i+4}) - 4f(x_{i+3}) + 6f(x_{i+2}) - 4f(x_{i+1}) + f(x_i)}{h^4}$	$O(h)$
$f''''(x_i) = \dfrac{-2f(x_{i+5}) + 11f(x_{i+4}) - 24f(x_{i+3}) + 26f(x_{i+2}) - 14f(x_{i+1}) + 3f(x_i)}{h^4}$	$O(h^2)$

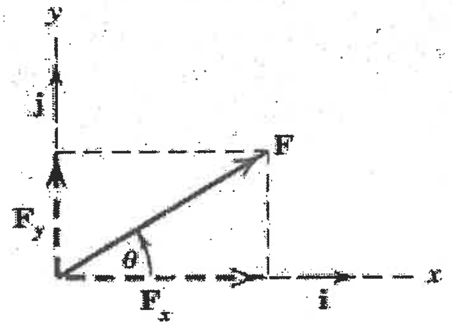
b) Backward Finite-Divided Differences

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

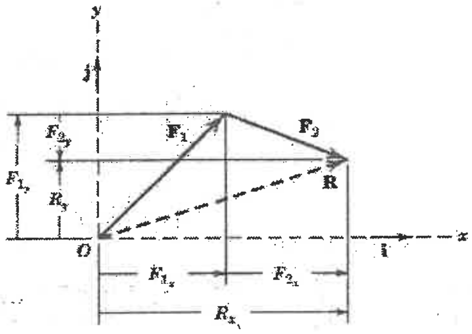
	Error
First Derivative	
$f'(x_i) = \dfrac{f(x_{i+1}) - f(x_{i-1})}{2h}$	$O(h^2)$
$f'(x_i) = \dfrac{-f(x_{i+2}) + 8f(x_{i+1}) - 8f(x_{i-1}) + f(x_{i-2})}{12h}$	$O(h^4)$
Second Derivative	
$f''(x_i) = \dfrac{f(x_{i+1}) - 2f(x_i) + f(x_{i-1})}{h^2}$	$O(h^2)$
$f''(x_i) = \dfrac{-f(x_{i+2}) + 16f(x_{i+1}) - 30f(x_i) + 16f(x_{i-1}) - f(x_{i-2})}{12h^2}$	$O(h^4)$
Third Derivative	
$f'''(x_i) = \dfrac{f(x_{i+2}) - 2f(x_{i+1}) + 2f(x_{i-1}) - f(x_{i-2})}{2h^3}$	$O(h^2)$
$f'''(x_i) = \dfrac{-f(x_{i+3}) + 8f(x_{i+2}) - 13f(x_{i+1}) + 13f(x_{i-1}) - 8f(x_{i-2}) + f(x_{i-3})}{8h^3}$	$O(h^4)$
Fourth Derivative	
$f''''(x_i) = \dfrac{f(x_{i+2}) - 4f(x_{i+1}) + 6f(x_i) - 4f(x_{i-1}) + f(x_{i-2})}{h^4}$	$O(h^2)$
$f''''(x_i) = \dfrac{-f(x_{i+3}) + 12f(x_{i+2}) - 39f(x_{i+1}) + 56f(x_i) - 39f(x_{i-1}) + 12f(x_{i-2}) - f(x_{i-3})}{6h^4}$	$O(h^4)$

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

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