Numerical Analysis Homework

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A homework dedicated to

Doctor of Mathematics

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1 The Errors.

1. Most numerical calculations are inexact because of ... .

   a) Inaccuracies in given data

   b) Inaccuracies introduced in the subsequent analysis of the given data

   c) Both a and b

   d) Neither a nor b

   Answer: **c**

2. Which of the following statements is false?

   a) An exact number may be regarded as an approximate number with error zero

   b) An approximate number x_0 is a number that differs but slightly from an exact number x and it is used in place of the later in calculations

   c) If x_0 is an approximate value of the number x, we write $x_0 \approx x$

   d) By the error ϵ of an approximate number x_0 we ordinarily mean the difference between the exact number x and the given approximate number, that is $\epsilon = x_0 + x$

   Answer: **d**, By the error ϵ of an approximate number x_0 we ordinarily mean the difference between the exact number x and the given approximate number, that is $\epsilon = x - x_0$

3. What is the absolute error of the approximate number x_0?

   a) $E_{abs} = |\epsilon|$

   b) $E_{abs} = |x - x_0|$

   c) Both a and b

   d) Neither a nor b

   Answer: **c**, $\epsilon = x - x_0$

4. Which of the following statements is false?

   a) The absolute error E_{abs} of an approximate number x_0 is the absolute value of the difference between the corresponding exact number x and the approximate number x_0

   b) The absolute error suffices to describe the accuracy of a measurement or a computation

   c) An essential point in the accuracy of measurements is the absolute error related to the unit length

   d) An essential point in the accuracy of measurements is the relative error

   Answer: **b**, relative error: the absolute error related to the unit length, The absolute error does not suffice to describe the accuracy of a measurement or a computation

5. Which of the following statements is false?

   a) $E_r = \frac{E_{abs}}{|x|}, x \neq 0$

   b) The relative error E_r of an approximate number x_0 is the ratio of the absolute error E_{abs} of the number to the modulus (absolute value) of the corresponding exact number x $(x \neq 0)$

   c) $E_r = \frac{E_{abs}}{|x|}$, x can be 0

   d) The relative error is the absolute error related to the unit length

   Answer: **c**, x must not be 0

6. Errors that influence numerical results can be … .

   a) Difficult to influence
   b) Reduced
   c) Eliminated
   d) All of the previous

   Answer: **d**

7. Which of the following not a basic source of errors?

   a) Errors in given input data
   b) Round-off errors during the computations
   c) Truncation error
   d) Simplifications in the mathematical model
   e) Human errors
   f) Machine errors
   g) Lollipop errros

   Answer: **g**

8. Round-off errors occur whenever … .

   a) An irrational number is shortened to a fixed number of decimals
   b) An irrational number is rounded off to a fixed number of decimals
   c) A decimal fraction is converted to the form used in computer
   d) All of the previous

   Answer: **d**

9. Truncation errors occur whenever … .

   a) A limited process is truncated(broken off) before one has come to the limiting value
   b) An infinite series is broken off after a finite number of terms
   c) A derivative is approximated with a difference quotient
   d) A nonlinear function is approximated with a linear function
   e) All the previous

   Answer: **e**

10. Discretization error occur whenever … .

    a) A limited process is truncated(broken off) before one has come to the limiting value
    b) An infinite series is broken off after a finite number of terms
    c) A derivative is approximated with a difference quotient
    d) A nonlinear function is approximated with a linear function
    e) All the previous

    Answer: **c**

11. Which of the following is not considered a significant digit of a number in its decimal representation?

a) Any nonzero digit
b) Any zero lying between significant digits
c) Any zero used as a placeholder, to indicate a retained place
d) Any zero that serve only to fix the position of the decimal point

Answer: **d**

12. How many significant digits in the this number 0.002080

a) 2
b) 4
c) 6
d) 7

Answer: **b**

13. Which of the following statements is false?

a) The absolute error of an algebraic sum of several approximate numbers does not exceed the sum of the absolute errors of the numbers
b) The absolute error of an algebraic difference of several approximate numbers does not exceed the sum of the absolute errors of the numbers
c) The relative error of a product of several approximate nonzero numbers does not exceed the sum of the relative errors of the numbers
d) The relative error of a quotient exceeds the sum of the relative errors of the divided and divisor

Answer: **d**, The relative error of a quotient does not exceed the sum of the relative errors of the divided and divisor

2 Difference operators and their simplest properties points

14. Given a function $f(x)$ defined for discrete values of x, which statement is true about the function?

a) The function is continuous
b) The function is differentiable
c) The function has distinct and separate values for each x
d) The function is defined for all real numbers

Answer: **c**, A discrete function has distinct and separate values for each x.

15. Which of the following is not one of the operators in numerical analysis?

a) The forward difference operator
b) The backward difference operator
c) The central difference operator
d) The average operator
e) The distance(shift) operator
f) The differentiable operator
g) The lollipop operator

Answer: **g**

16. What is the general formula of the forward difference operator Δ?

a) $\Delta^n y_i = \Delta^{n-1} y_{i+1} + \Delta^{n-1} y_i$
b) $\Delta^n y_i = \Delta^{n-1} y_{i+1} - \Delta^{n-1} y_i$
c) $\Delta^n y_i = \Delta^{n+1} y_{i+1} - \Delta^{n+1} y_i$
d) Otherwise

Answer: **b**

17. Which of the following is not a property of Δ?

a) $\Delta[f(x) \pm g(x)] = \Delta f(x) \pm \Delta g(x)$
b) $\Delta[\alpha f(x)] = \alpha \Delta f(x), \alpha$ is constant
c) $\Delta^m \Delta^n f(x) = \Delta^{m+n} f(x) = \Delta^n \Delta^m f(x)$
d) $\Delta[f(x).g(x)] = f(x).\Delta g(x)$

Answer: **d**, $\Delta[f(x).g(x)] \neq f(x).\Delta g(x)$

18. $\Delta cos(x) = \dots$

a) $cos(x+h) - cos(x)$
b) $-2sin(x + \frac{h}{2})sin(\frac{h}{2})$
c) Both a and b
d) neither a nor b

Answer: **c**

19. $\Delta log(f(x)) = \dots$

a) $log\frac{f(x)+\Delta f(x)}{f(x)}$
b) $log\frac{f(x+h)}{f(x)}$
c) Both a and b
d) neither a nor b

Answer: **c**

20. What is the general formula of the backward difference operator ∇?

a) $\nabla^n y_i = \nabla^{n-1} y_{i+1} + \nabla^{n-1} y_i$
b) $\nabla^n y_i = \nabla^{n-1} y_{i+1} - \nabla^{n-1} y_i$
c) $\nabla^n y_i = \nabla^{n+1} y_{i+1} - \nabla^{n+1} y_i$
d) Otherwise

Answer: **d**, $\nabla^n y_i = \nabla^{n-1} y_i - \nabla^{n-1} y_{i-1}$

21. What is the general formula of the backward difference operator ∇?

a) $\nabla^n y_{i+1} = \nabla^{n-1} y_{i+1} + \nabla^{n-1} y_i$
b) $\nabla^n y_{i+1} = \nabla^{n-1} y_{i+1} - \nabla^{n-1} y_i$
c) $\nabla^n y_{i+1} = \nabla^{n+1} y_{i+1} - \nabla^{n+1} y_i$
d) Otherwise

Answer: **b**

22. Which of the following is not a property of ∇?

a) $\nabla[f(x) \pm g(x)] = \nabla f(x) \pm \nabla g(x)$
b) $\nabla[\alpha f(x)] = \alpha \nabla f(x), \alpha$ is variable
c) $\nabla^m \nabla^n f(x) = \nabla^{m+n} f(x) = \nabla^n \nabla^m f(x)$
d) $\nabla[f(x) \cdot g(x)] \neq [\nabla f(x)] \cdot g(x)$

Answer: **b**, $\nabla[\alpha f(x)] = \alpha \nabla f(x), \alpha$ is constant

23. What is the general formula of the central difference operator?

a) $\delta^n y_k = \delta^{n+1} y_{k+\frac{1}{2}} - \delta^{n-1} y_{k-\frac{1}{2}}$
b) $\delta^n y_k = \delta^{n-1} y_{k+\frac{1}{2}} + \delta^{n-1} y_{k-\frac{1}{2}}$
c) $\delta^n y_k = \delta^{n-1} y_{k+\frac{1}{2}} - \delta^{n-1} y_{k-\frac{1}{2}}$
d) Otherwise

Answer: **c**

24. What is the formula of the distance operator?

a) $E^p y_k = y_{k+p}$

b) $E^p y_k = y_{k-p}$

c) $E^p y_k = y_{p+k}$

d) $E^p y_k = y_{p-k}$

Answer: **a**

25. What is the formula of the average operator?

a) $\mu = \frac{1}{2}(E^{\frac{1}{2}} - E^{-\frac{1}{2}})$

b) $\mu = \frac{1}{2}(E^{-\frac{1}{2}} - E^{\frac{1}{2}})$

c) $\mu = \frac{1}{2}(E^{-\frac{1}{2}} + E^{\frac{1}{2}})$

d) Otherwise

Answer: **c**

26. What is the general formula of the differetial operator?

a) $Df(x) = \frac{d}{dx}f(x)$

b) $D^n f(x) = \frac{d^n}{dx^n}f(x)$

c) Both a and b

d) Otherwise

Answer: **b**

27. $\Delta^0 y = \dots .$

a) y

b) 0

c) 1

d) Otherwise

Answer: **a**

28. What is the relation between E and Δ?

a) $\Delta = E - 1$

b) $\Delta = E + 1$

c) $\Delta = 1 - E$

d) Otherwise

Answer: **a**

29. What is the relation between E and ∇?

a) $\nabla E^{-\frac{1}{2}} = \delta$

b) $E = (1 - \nabla)^{-1}$

c) $\nabla = 1 - E^{-1}$

d) All of them

Answer: **d**

30. Which of the following relations of the central difference operator δ is false?

a) $\delta = E^{\frac{1}{2}} - E^{-\frac{1}{2}}$

b) $\delta^n y_k = \delta^{n-1} y_{k+\frac{1}{2}} - \delta^{n-1} y_{k-\frac{1}{2}}$

c) $\delta = E^{\frac{1}{2}}\nabla$

d) $\delta = E^{-\frac{1}{2}}\Delta$

e) $\delta = E^{\frac{1}{2}}(1 - E^{-1})$

f) $\delta = E^{-\frac{1}{2}}(E - 1)$

g) $\delta = (\nabla\Delta)^{\frac{1}{2}}$

h) $\delta = (\Delta\nabla)^{\frac{1}{2}}$

i) $\delta = (\Delta - \nabla)^{\frac{1}{2}}$

j) None of them

Answer: **j**

31. What is the relation between E and D?

a) $E = e^{-hD}$

b) $hD = log(1 + \Delta)$

c) $hD = log(\nabla - 1)$

d) Otherwise

Answer: **b**

32. When does the generalized power coincide with the ordinary power s.t. $x^{[n]} = x^n$?

 a) if $h = 0$ b) if $n > 5$

 c) h is constatnt d) Otherwise

 Answer: **a**

33. What is the formula of the generalized power?

 a) $x^{[n]} = x(x-h)(x-2h)...[x-(n-1)h]$ b) $x^n = x(x-h)(x-2h)...[x-(n-1)h]$

 c) $x^{[n]} = x(x-h)(x-2h)...[x-(n+1)h]$ d) Otherwise

 Answer: **a**

34. What is the formula of the first difference of the generalized power?

 a) $\Delta x^{[n]} = nhx^{[n+1]}$ b) $\Delta x^n = nhx^{[n-1]}$

 c) $\Delta x^{[n]} = nhx^{n-1}$ d) Otherwise

 Answer: **b**

35. What is the formula of the second difference of the generalized power?

 a) $\Delta^2 x^{[n]} = n(n+1)h^2 x^{n-2}$ b) $\Delta^2 x^{[n]} = n(n-1)h^2 x^{n+2}$

 c) $\Delta^2 x^{[n]} = n(n-1)h^2 x^{n-2}$ d) Otherwise

 Answer: **d**, $\Delta^2 x^{[n]} = n(n-1)h^2 x^{[n-2]}$

36. What is the general formula of the differences of the generalized power?

 a) $\Delta^k x^{[n]} = n(n-1)...[n-(k-1)]hx^{[n-k]}$ b) $\Delta^k x^{[n]} = n(n-1)...[-k+(n+1)]h^k x^{[n-k]}$

 c) $\Delta^k x^{[n]} = n(n-1)...[n-(k+1)]h^k x^{[n-k]}$ d) Otherwise

 Answer: **b**, $\Delta^k x^{[n]} = n(n-1)...[n-(k-1)]h^k x^{[n-k]} \equiv \Delta^k x^{[n]} = n(n-1)...[-k+(n+1)]h^k x^{[n-k]}$

37. $\Delta^k x^{[n]} = 0$ iff ...

 a) $n < k$ b) $k \geq n$

 c) $k = n$ d) Otherwise

 Answer: **a**

3 Interpolation for the case of equally spaced points

38. The problem can have ... solution(s).

 a) infinity b) no

 c) Both a and b d) Otherwise

 Answer: **c**

39. What is the newton's first interpolation formula?

a) $p_n(x) = y_0 + q\Delta y_0 + \frac{q(q-1)}{2!}\Delta^2 y_0 + \cdots + \frac{q(q-1)\ldots(q-n+1)}{n!}\Delta^n y_n$
b) $p_n(x) = y_0 + \frac{\Delta y_0}{h}(x-x_0)^{[1]} + \frac{\Delta^2 y_0}{2!h^2}(x-x_0)^{[2]} + \cdots + \frac{\Delta^n y_0}{n!h^n}(x-x_0)^{[n]}$
c) $p_n(x) = y_0 + q\Delta y_0 + \frac{q(q-1)}{2!}\Delta^2 y_0 + \cdots + \frac{q(q-1)\ldots(q+n-1)}{n!}\Delta^n y_0$
d) Otherwise

Answer: **b**

40. What is q in the newton's first interpolation formula?

a) $\frac{-x_0+x}{h}$, the number of steps needed to reach a point x proceeding from x_0
b) $\frac{x-x_n}{h}$, the number of steps needed to reach a point x proceeding from x_n
c) $\frac{x-x_0}{h}$, the number of steps needed to reach a point x_0 proceeding from x
d) Otherwise

Answer: **a**

41. What is the formula of the coefficients in newton's first interpolation formula?

a) $a_i = \frac{\Delta^i y_i}{i!h^i}$, $(i = 0, 1, \ldots, n-1)$
b) $a_i = \frac{\Delta^i y_i}{i!h^i}$, $(i = 0, 1, \ldots, n+1)$
c) $a_i = \frac{\Delta^i y_i}{i!h^i}$, $(i = 0, 1, \ldots, n)$
d) Otherwise

Answer: **c**, $a_i = \frac{\Delta^i y_0}{i!h^i}$, $(i = 0, 1, \ldots, n)$

42. What is the newton's second interpolation formula?

a) $p_n(x) = y_n + q\Delta y_{n-1} + \frac{q(q+1)}{2!}\Delta^2 y_{n-2} + \cdots + \frac{q(q+1)\ldots(q+n-1)}{n!}\Delta^n y_0$
b) $p_n(x) = y_n + \frac{\Delta y_{n-1}}{h}(x-x_n)^{[1]} + \frac{\Delta^2 y_{n-2}}{2!h^2}(x-x_{n-1})^{[2]} + \cdots + \frac{\Delta^n y_0}{n!h^n}(x-x_1)^{[n]}$
c) Both a and b
d) Otherwise

Answer: **c**

43. What is q in the newton's second interpolation formula?

a) $\frac{-x_0+x}{h}$, the number of steps needed to reach a point x proceeding from x_0
b) $\frac{-x_n+x}{h}$, the number of steps needed to reach a point x_n proceeding from x
c) $\frac{x-x_n}{h}$, the number of steps needed to reach a point x proceeding from x_n
d) Otherwise

Answer: **c**

44. What is the formula of the coefficients in newton's second interpolation formula?

a) $a_i = \frac{\Delta^i y_{n-i}}{i!h^i}$, $(i = 0, 1, \ldots, n)$
b) $a_i = \frac{\Delta^i y_{n+i}}{i!h^i}$, $(i = 0, 1, \ldots, n)$
c) $a_i = \frac{\Delta^i y_n}{i!h^i}$, $(i = 0, 1, \ldots, n)$
d) Otherwise

Answer: **a**

4 Interpolation for the case of unequally spaced points

45. What is Lagrange's interpolation formula used for?

    a) Curve fitting
    b) Numerical integration
    c) Root finding
    d) Optimization

    Answer: **a**

46. Which of the following formulas is used for arbitrary specified points?

    a) Gauss first interpolation formula
    b) Newten's first interpolation formula
    c) Newten's second interpolation formula
    d) Lagrange's interpolation formula

    Answer: **d**

47. Which of the following is false?

    a) The Lagrange polynomial is unique
    b) The Lagrange interpolation polynomial can coincides with the Newton interpolation polynomial
    c) The Lagrange interpolation polynomial cannot coincides with the Newton interpolation polynomial
    d) Lagrange's interpolation formula is used for arbitrary specified points

    Answer: **c**, if the points are equally spaced, then the Lagrange interpolation polynomial coincides with the Newton interpolation polynomial

48. What does it mean that the arguments of the function are equally spaced?

    a) They have a constant interval
    b) They have a variable interval
    c) They have a 0 interval
    d) Otherwise

    Answer: **a**

49. What does it mean that the arguments of the function are unequally spaced?

    a) They have a constant interval
    b) They have a variable interval
    c) They have a 0 interval
    d) Otherwise

    Answer: **b**

50. For functions with unequally spaced arguments, the concept of finite differences is generalized to $\dots$.

    a) Divided differences
    b) Infinite differences
    c) Both a and b
    d) Otherwise

    Answer: **a**

51. Which of the following is false about divided differences?

a) They remain unchanged under a permutation of the elements
b) They are symmetric functions of their arguments
c) For functions with equally spaced arguments, the concept of finite differences is generalized to divided differences
d) Generally, $(n+1)$th order divided differences are obtained from nth order divided differences by means of the recurrence relation
e) Otherwise

Answer: **c**

5 Numerical differentiation

52. What is numerical differentiation primarily used for?

a) Solving nonlinear equations
b) Approximating derivatives of functions
c) Interpolating data points
d) Integrating functions numerically

Answer: **b**, Numerical differentiation is primarily used for approximating derivatives of functions.

6 Numerical integration

53. What is the purpose of numerical integration?

a) Approximating definite integrals of functions
b) Finding roots of equations
c) Solving linear systems of equations
d) Interpolating data points

Answer: **a**, Numerical integration is primarily used for approximating definite integrals of functions.

54. What is the trapezoidal rule used for in numerical integration?

a) Approximating definite integrals using linear interpolation
b) Solving systems of linear equations
c) Finding roots of nonlinear equations
d) Computing eigenvalues of matrices

Answer: **a**

55. What is the purpose of Simpson's rule in numerical integration?

a) Approximating derivatives of functions
b) Estimating the area under a curve
c) Solving linear systems of equations
d) Interpolating data points

Answer: **b**, Simpson's rule is primarily used for estimating the area under a curve in numerical integration.

56. Which statement accurately describes the relationship between the degree of the Newton-Cotes formula and the number of function evaluations?

    a) The degree increases with the number of function evaluations

    b) The degree is independent of the number of function evaluations

    c) The degree decreases with the number of function evaluations

    d) The degree is unrelated to the accuracy of the quadrature

    Answer: **a**

7 Numerical solution for systems of linear equations

57. Which of the following is false about gaussian elimination?

    a) It is unusual

    b) It is direct

    c) A solution is obtained after a single application of gaussian elimination

    d) It offers a method of refinement once a solution has been obtained

    e) It is sensitive to rounding error

    Answer: **d**, Once a solution has been obtained, Gaussian elimination offers no method of refinement.

58. Which of the following is not an iterative method?

    a) The Jacobi method

    b) The Gauss-Seidel method

    c) Carl's iterative method

    d) Newton's iterative method

    Answer: **c**

59. Which of the following is an iterative method for approximating the solution of a system of n linear equations in n variables?

    a) The Jacobi method

    b) The Gauss-Seidel method

    c) Both a and b

    d) Otherwise

    Answer: **c**

60. Which of the following is an iterative method for approximating the zeros of a differentiable function?

    a) The Jacobi method

    b) Newton's iterative method

    c) Both a and b

    d) Otherwise

    Answer: **b**

61. Determine whether the matrix

$$A = \begin{bmatrix} 5 & -1 & 0 \\ 2 & 8 & -3 \\ 1 & -1 & 4 \end{bmatrix}$$

is strictly diagonal dominant.

a) Yes, the matrix is strictly diagonal dominant.

b) No, the matrix is not strictly diagonal dominant.

c) It cannot be determined from the given information.

d) The matrix is not square, so the concept does not apply.

Answer: **a**, Yes, the matrix is strictly diagonal dominant.

62. Which of the following statements is false?

a) Strict diagonal dominance is a necessary condition for convergence of the Jacobi or Gauss-Seidel methods

b) If A is strictly diagonally dominant, then the system of linear equations given by $AX = b$ has a unique solution to which the Jacobi method and the Gauss-Seidel method will converge for any initial approximation

c) An $n \times n$ matrix A is strictly diagonally dominant if the absolute value of each entry on the main diagonal is greater than the sum of the absolute values of the other entries Diagonally Dominant in the same row.

d) Strict diagonal dominance is not a necessary condition for convergence of the Jacobi or Gauss-Seidel methods

Answer: **d**,

63. Which of the following systems of linear equations has a strictly diagonally dominant coefficient matrix?

a) $3x_1 - x_2 = -4$
$2x_1 + 5x_2 = 2$

b) $4x_1 + 2x_2 - x_3 = -1$
$x_1 + 2x_3 = -4$
$3x_1 - 5x_2 + x_3 = 3$

c) Both a and b

d) Otherwise

Answer: **a**

64. Which of the following systems of linear equations doesn't have a strictly diagonally dominant coefficient matrix?

a) $\begin{cases} 2x + y = 5 \\ 3x - 2y = 4 \end{cases}$ b) $\begin{cases} 4x - y = 7 \\ 2x + 3y = 5 \end{cases}$ c) $\begin{cases} 3x - 2y = 6 \\ x + 4y = 9 \end{cases}$ d) $\begin{cases} 5x + 2y = 8 \\ -3x + 6y = 1 \end{cases}$

Answer: **a**

8 Numerical solution of nonlinear algebraic equations

65. Which numerical method is commonly used for solving a single nonlinear algebraic equation $f(x) = 0$?

a) Newton-Raphson method

b) Gaussian elimination

c) Euler's method

d) Simpson's rule

Answer: **a**, The Newton-Raphson method is commonly used for solving a single nonlinear algebraic equation.

66. In the context of numerical solutions for systems of nonlinear algebraic equations, which method requires the computation of partial derivatives?

    a) Bisection method
    b) Secant method
    c) Newton-Raphson method
    d) Gaussian elimination

    Answer: **c**, The Newton-Raphson method requires the computation of partial derivatives in the context of systems of nonlinear algebraic equations.

67. Which statement accurately describes the Bisection Method for root finding?

    a) It involves dividing the interval and selecting the subinterval where the function changes sign.
    b) It uses the derivative of the function to iteratively approach the root.
    c) It approximates the root by linear interpolation between function values.
    d) It is specifically designed for solving linear equations.

    Answer: **a**

9 Essay

68. What is numerical analysis?

    branch in mathematics that focuses on studying and developing numerical methods

69. What is the ultimate aim of the field of numerical analysis?

    to provide convenient methods for obtaining useful solutions to mathematical problems and for extracting useful information from available solutions which are not expressed in tractable forms.

70. What is the strictly diagonally dominant matrix?

    An nxn matrix A is strictly diagonally dominant if the absolute value of each entry on the main diagonal is greater than the sum of the absolute values of the other entries Diagonally Dominant in the same row.

71. What is a significant digit?

    A significant digit of an approximate number is any nonzero digit, in its decimal representation, or any zero lying between significant digits or used as a placeholder, to indicate a retained place. All other zeros of the approximate number that serve only to fix the position of the decimal point are not to be considered significant digits.

72. What is a discretization error?

    the error that occurs when a derivative is approximated with a difference quotient

10 Notes

• Gaussian elimination is sensitive to rounding error

• For example, in calculus you probably studied Newton's iterative method for approximating the zeros of a differentiable function. In this chapter we look at two iterative methods for approximating the solution of a system of n linear equations in n variables.

• For tables with unequally spaced values of the argument (variable interval), the concept of finite differences is generalized to

11 About

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