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AS-2259
Model Answer
M.Sc.(CS) (First Semester) EXAMINATION,2013
Programming Based Numerical Analysis
(M.Sc. (CS) -102)

Time: Three Hours] **[Maximum Marks: 60**

Note: Question Number 1 is Compulsory. Answer any four from the remaining. Scientific calculators are allowed.

Q.1 **(10X2=20 Marks)**

(a) Differentiate between algebraic equation and Transdental Equation with suitable examples?

Solution-

S.No.	Algebraic equation	Transcendental equation
1.	If f(x) is any polynomial, then the equation f(x)=0 is called an algebraic equation in x. For example- $3x^7 - 8x^6 + 2x^5 - 5x^4 + 3x^3 + 7x^2 + 9x - 8 = 0\ and\ x^4 - x + 9 = 0.$	If an expression f(x) also contains some other functions such as logarithmic, exponential and trigonometrical functions etc. then the equation f(x)=0 is called transcendental equation. For example- $x^2 + 4\sin x = 0$

(b) Add the following floating-point numbers 0.6434e99 and 0.4845e99.
Subtract the floating-point number 0.36132346 x10^7 from 0.36143447 x 10^7.

Solution-

This problem has an equal exponent but on adding we get 1.1279e99, that is, mantissa has 5 digits and is greater than 1, that's why it is shifted right one place. Hence we get the resultant value 0.1127e100.

Subtract the floating-point number 0.36132346 × 10^7 from 0.36143447 × 10^7.

Solution- The number 0.36132346 × 107 after subtracting from 0.36143447 × 10^7 gives 0.00011101 × 10^7. On shifting the fractional part three places to the left we have 0.11101 × 10^4 which is obviously a floating-point number. Also 0.00011101 × 10^7 is a floating-point number but not in the normalized form.

(c) Round off the following numbers to four significant figures:

i. 38.46235
ii. 0.70029
iii. 0.0022218
iv. 19.235101

Solution—

38.46, 0.7003, 0.002222, 19.24

(d) Give the name of Methods for Finding the Root of an Equation?

Solution-

Bisection method, Regula falsi method, Newton Raphson method.

(e) For solving a linear system, compare Gauss elimination method and Gauss Jordan method.

Solution-

S.No.	Gauss elimination method	Gauss Jordan method
1.	Direct method	Direct method
2.	Coefficient matrix is transformed into upper triangular matrix.	Coefficient matrix is transformed into diagonal matrix
3.	We obtain the solution by back substitution method	No need for substitution method

(f) Distinguish between direct and iterative method of solving simultaneous equation.

Solution-

S.No.	Direct method	Iterative method.
1.	We get exact solution	Approximjate solution
2.	Simple take less time	Time consuming laborious

(g) Obtain a divided difference table for the following data:

x	5	7	11	13	17
y	150	392	1452	2366	5202

Solution-

X	Y	$\Delta f(x)$	$\Delta^2 f(x)$	$\Delta^2 f(x)$
5	150	$\frac{392-150}{7-5}=121$		
			$\frac{265-121}{11-5}=24$	
7	392			
		$\frac{1452-392}{11-7}=265$		$\frac{32-24}{13-5}=1$
11	1452		$\frac{457-265}{13-7}=32$	
		$\frac{2366-1452}{13-11}=457$		
13	2366		$\frac{709-457}{17-11}=42$	$\frac{42-32}{17-7}=1$
		$\frac{5202-2366}{17-13}=709$		
17	5202			

(h) Find the polynomial for the following data by Newton's backward difference formula.

x	0	1	2	3
y	3	2	9	18

Solution-

x	y	∇y_0	∇y_0^2	∇y_0^3
0	3			
		2-3=-1		
1	2		7+1=8	
		9-2=7		2-8=-6
2	9		9-7=2	
		18-9=9		
3	18			

Then the Newton's forward difference interpolation formula is given by

$$y_n = y_0 + \frac{u}{1!}\nabla y_0 + \frac{u(u+1)}{2!}\nabla^2 y_0 + \frac{u(u+1)(u+2)}{3!}\Delta^3 y_0 + \cdots \ldots \ldots$$

$$where\ u = \frac{x - x_0}{h} = \frac{x-3}{1} = x - 3, y_0 = 18, \nabla y_0 = 9, \nabla y_0^2 = 2, \nabla y_0^3 = -6$$

$$y_n = 18 + \frac{(x-3)}{1!} \times 9 + \frac{(x-3)(x-3+1)}{2} \times 2 + \frac{(x-3)(x-3+1)(x-3+2)}{-6} \times -6$$

(i) Say true or false:
Newton's interpolation formulae are not suited to estimate the value of a function near the middle of a table.

Solution-

TRUE

(j) State the formula of Trapezoidal rule.

Solution-

The Trapezoidal rule is given by

$$\int_{x_0}^{x_0+nh} f(x)dx = \frac{h}{2}\{y_0 + 2(y_1 + y_2 + y_3 + \cdots \ldots . y_{n-1}\} + y_n\}$$

(4X10=40 Marks)

Q.2 Using Bisection Method determines a real root of the equation $\mathbf{f(x) = 8x^3 - 2x - 1 = 0}$.

Solution- it is given that $f(x) = 8x^3 - 2x - 1$

Then $f(0) = 8(0)^3 - 2(0) - 1 = -1$ and $f(1) = 8(1)^3 - 2(1) - 1 = 5$

Therefore, f(0) is negative and f(1) is positive so that the root lies between 0 and 1.

First Approximation: First approximation to the root is given by

$$x_1 = \frac{0+1}{2} = 0.5$$

$$f(0.5) = 8(0.5)^3 - 2(0.5) - 1 = -1, \textit{which is negative}.$$

$thus$ $f(0.5)$ is negative and f(1) is positive. Then the root lies between 0.5 and 1.

Second Approximation: the second approximation to the root is given by

$$x_2 = \frac{0.5+1}{2} = 0.75$$

$$f(0.75) = 8(0.75)^3 - 2(0.75) - 1 = 2.265 - 2.5 = 0.875, \textit{which is Positive}.$$

$thus$ $f(0.5)$ is negative and f(0.75) is positive. Then the root lies between 0.5 and 0.75.

Third Approximation: the Third approximation to the root is given by

$$x_3 = \frac{0.5+0.75}{2} = 0.625$$

$$f(0.625) = 8(0.625)^3 - 2(0.625) - 1 = 1.935 - 2.25 = -0.297, \textit{which is Negative}.$$

$thus$ $f(0.625)$ is negative and f(0.75) is positive. Then the root lies between 0.625 and 0.75.

Fourth Approximation: the Fourth approximation to the root is given by

$$x_4 = \frac{0.625+0.75}{2} = 0.688$$

$$f(0.688) = 8(0.688)^3 - 2(0.688) - 1 = 2.605 - 2.376 = 0.229, \textit{which is Positive}.$$

$thus$ $f(0.688)$ is obtained positive and f(0.625) is negative. Then the root lies between 0.625 and 0.688.

Fifth Approximation: the Fifth approximation to the root is given by

$$x_5 = \frac{0.625+0.688}{2} = 0.657$$

$$f(0.657) = 8(0.657)^3 - 2(0.657) - 1 = 2.269 - 2.314 = -0.045, \textit{which is Negative}.$$

$thus$ $f(0.657)$ is obtained negative and f(0.688) is Positive. Then the root lies between 0.657 and 0.688.

Sixth Approximation: the Sixth approximation to the root is given by

$$x_6 = \frac{0.657+0.688}{2} = 0.673$$

$$f(0.673) = 8(0.673)^3 - 2(0.673) - 1 = 2.439 - 2.346 = 1.093, \textit{which is Positive}.$$

$thus$ $f(0.673)$ is obtained Positive and f(0.657) is Negative. Then the root lies between 0.657 and 0.673.

Seventh Approximation: The Seventh approximation to the root is given by

$$x_7 = \frac{0.657 + 0.673}{2} = 0.665$$

$$f(0.665) = 8(0.665)^3 - 2(0.665) - 1 = 2.353 - 2.33 = 0.023, \textit{which is Positive}.$$

$thus$ $f(0.665)$ is obtained Positive and f(0.657) is Negative. Then the root lies between 0.657 and 0.665.

Eighth Approximation: The Seventh approximation to the root is given by

$$x_8 = \frac{0.657 + 0.665}{2} = 0.661$$

$$f(0.661) = 8(0.661)^3 - 2(0.661) - 1.$$

From the last two approximations i.e. $x_7 = 0.665$ and $x_8 = 0.661$ it is observed that the approximate value of the root of $F(x) = 0$ up to two decimal places is 0.66.

Q.3 Find a real root of the equation $\mathbf{f(x) = x^3 - x^2 - 2 = 0}$ by Regula-Falsi method.

Solution- let $f(x) = x^3 - x^2 - 2 = 0$

Then $f(0) = 0^3 - 0^2 - 2 = -2$, $f(1) = 1^3 - 1^2 - 2 = -2$ and $f(2) = 2^3 - 2^2 - 2 = 2$

Then the root lies between 1 and 2.

First approximation: taking $x_0 = 1, x_1 = 2, f(x_0) = -2$ *and* $f(x_1) = 2$ *then by Regula Falsi method an approximation to the root is given by*

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

$$= 1 - \frac{2-1}{2+2}(-2) = 1 + \frac{1}{2} = 1.5$$

$$f(x_2) = f(1.5)$$

$$, \quad f(1.5) = (1.5)^3 - (1.5)^2 - 2 = 3.375 - 4.25 = -0.875$$

then the root lies between 1.5 and 2.

Second Approximation: taking

$x_0 = 1.5, x_1 = 2, f(x_0) = -0.875$ *and* $f(x_1) = 2$ *then by Regula Falsi method an approximation to the root is given by*

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

$$= 1.5 - \frac{2 - 1.5}{2 + 0.875}(-0.875) = 1.5 + 0.1522 = 1.6522$$

$$f(x_2) = f(1.6522)$$

$$, \quad f(1.6522) = (1.6522)^3 - (1.6522)^2 - 2 = 4.5101 - 4.7298 = -0.2197$$

then the root lies between 1.6522 and 2.

Third Approximation: taking

$x_0 = 1.6522, x_1 = 2, f(x_0) = -0.2197$ *and* $f(x_1) = 2$ *then by Regula Falsi* *method an approximation to the root is given by*

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

$$= 1.6522 - \frac{2 - 1.6522}{2 + 0.2197}(-0.2197) = 1.6522 + 0.0344 = 1.6866$$

$$f(x_2) = f(1.6866)$$

$$,\quad \mathrm{f}(1.6866) = (1.6866)^3 - (1.6866)^2 - 2 = 4.7977 - 4.8446 = -0.0469$$

then the root lies between 1.6866 and 2.

Fourth Approximation: taking

$x_0 = 1.6866, x_1 = 2, f(x_0) = -0.046 \text{ and } f(x_1) = 2 \text{ then by Regula Falsi}$

method an approximation to the root is given by

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

$$= 1.6866 - \frac{2 - 1.6866}{2 + 0.0469}(-0.0469) = 1.6866 + 0.0072 = 1.6938$$

$$f(x_2) = f(1.6938)$$

$$,\quad \mathrm{f}(1.6938) = (1.6938)^3 - (1.6938)^2 - 2 = 4.8594 - 4.8690 = -0.096$$

then the root lies between 1.6938 and 2.

Fifth Approximation: taking

$x_0 = 1.6938, x_1 = 2, f(x_0) = -0.0096 \text{ and } f(x_1) = 2 \text{ then by Regula Falsi}$

method an approximation to the root is given by

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

$$= 1.6938 - \frac{2 - 1.6938}{2 + 0.0096}(-0.0096) = 1.6938 + 0.0015 = 1.6953$$

$$f(x_2) = f(1.6953)$$

$$,\quad \mathrm{f}(1.6953) = (1.6953)^3 - (1.6953)^2 - 2 = 4.8724 - 4.8740 = -0.0016$$

then the root lies between 1.6953 and 2.

Sixth Approximation: taking

$x_0 = 1.6953, x_1 = 2, f(x_0) = -0.0016 \text{ and } f(x_1) = 2 \text{ then by Regula Falsi}$

method an approximation to the root is given by

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

$$= 1.6953 - \frac{2 - 1.6953}{2 + 0.0016}(-0.0016) = 1.6953 + 0.0002 = 1.6955$$

From the last two approximations i.e. $x_5 = 1.6953$ and $x_6 = 1.6955$ it is observed that the approximate value of the root of $F(x) = 0$ up to two decimal places is 1.695, Hence the root is 1.695 correct to three places of decimal.

Q.4 Solve the system of equation by Gauss-Elimination method.

$$\mathbf{2x + 3y - z = 5, \quad 4x + 4y - 3z = 3, \quad 2x - 3y - 2z = 2}$$

Solution- Let

$$2x + 3y - z = 5 \qquad (1)$$

$$4x + 4y - 3z = 3 \qquad (2)$$

$$2x - 3y - 2z = 2 \qquad (3)$$

To eliminate x from the second equation of the system (1), we multiply the first equation by 2 and subtract it from the second equation and obtain

$$4y + 2z = 14$$

Similarly to eliminate x from the third equation of the system (1), we subtract first equation from the third equation and obtain

$$6y + z = 3$$

Now the system of equation (1) becomes

$$2x + 3y - z = 5 \qquad (1)$$

$$4y + 2z = 14 \qquad (4)$$

$$6y + z = 3 \qquad (5)$$

Now to eliminate y from the above equation we multiply the equation no. fourth by 6 and equation no. fifth by 4 then add equation no. fourth and fifth.

$$8z = 72,$$

$$z = 9$$

Now put these value of z in equation no. 5.

$$6y + z = 3$$

$$6y + 9 = 3$$

$$6y = 3 - 9$$

$$y = \frac{3 - 9}{6}$$

$$y = \frac{-6}{6}$$

$$y = -1$$

Now put the value of z and y in equation (1)

$$2x + 3y - z = 5$$

$$2x + 3(-1) - (9) = 5$$

$$x = \frac{17}{2} = 8.5$$

Now put the value of x, y and z in equation (1)

$$2x + 3y - z = 5$$

$$2(8.5) + 3(-1) - 9 = 5$$

$$5 = 5$$

So the equation satisfied the value of x, y and z.

$$x = 8.5, \quad y = -1, \quad z = 9 \qquad Ans.$$

Q.5 Ordinates f(x) of a normal curve in terms of standard deviation x are given as:

x	1.00	1.02	1.04	1.06	1.08
$f(x)$	0.2420	0.2371	0.2323	0.2275	0.2227

Use Newton's formula, Find the ordinate for standard deviation $x = 1.025$.

Solution-

Let us first form the difference table:

x	y	Δ	Δ^2	Δ^3	Δ^4
1.00	0.2420				
		-0.0049			
1.02	0.2371		0.0001		
		-0.0048		-0.0001	
1.04	0.2323		0		0.001
		-0.0048		0	
1.06	0.2275		0		
		-0.0048			
1.08	0.2227				

Here, $h = 0.02, a = 1.00, x = 1.025$

$$\therefore u = \frac{1.025 - 1.00}{0.02} = 1.25$$

$\therefore f(1.025)$

$$= f(a) + u\Delta f(a) + \frac{u(u-1)}{2!}\Delta^2 f(a) + \frac{u(u-1)(u-2)}{3!}\Delta^3 f(a) + \frac{u(u-1)(u-2)(u-3)}{4!}\Delta^4 f(a)$$

Now on putting values of various fumctions, we get

$$= 0.2420 + 1.25 \times (-0.0049) + \frac{1.25(0.25)}{2} \times (0.0001) + \frac{1.25(0.25)(-0.75)}{6} \times (0.0001) + \frac{1.25(0.25)(-0.75)(-1.75)}{24} \times (0.0001)$$

$$= 0.2424 - 0.006125 + 0.000015625 + 0.000003906 + 0.000001708$$

$$= 0.242021239 - 0.006125 = 0.235896239(Approx.)$$

Q.6 Find $f(5)$ by Lagrange's interpolation formula for the following data:

x	1	3	4	6	10
$f(x)$	0	18	48	180	900

Solution-

$Let\ f(x)\ be\ a\ function\ which\ takes\ the\ values\ y_0, y_1, y_2, y_3, \ldots \ldots . y_n\ corresponding\ to$
$x = x_0, x_1, x_1, x_3, \ldots \ldots ., x_{n.}$
$the\ lagrange's interpolation\ fromula\ is$

$$y = f(x) = \frac{(x-x_1)(x-x_2)\ldots\ldots(x-x_n)}{(x_0-x_1)(x_0-x_2)\ldots\ldots(x_0-x_n)} y_0 + \frac{(x-x_0)(x-x_2)\ldots\ldots(x-x_n)}{(x_1-x_1)(x_1-x_2)\ldots\ldots(x_1-x_n)} y_1 + \cdots \ldots \ldots + \frac{(x-x_0)(x-x_1)\ldots\ldots(x-x_{n-1})}{(x_n-x_1)(x_n-x_2)\ldots\ldots(x_n-x_n)} y_n.$$

$$x = 5, \qquad so,$$

$$y_n = \frac{(5-3)(5-4)(5-6)(5-10)}{(1-3)(1-4)(1-6)(1-10)} \times 0 + \frac{(5-1)(5-4)(5-6)(5-10)}{(3-1)(3-4)(3-6)(3-10)} \times 18 + \frac{(5-1)(5-3)(5-6)(5-10)}{(4-1)(4-3)(4-6)(4-10)} \times 48 + \frac{(5-1)(5-3)(5-4)(5-10)}{(6-1)(6-3)(6-4)(6-10)} \times 180 + \frac{(5-1)(5-3)(5-4)(5-6)}{(10-1)(10-3)(10-4)(10-6)} \times 900 = 99.99491\ Ans.$$

Q.7 Compute the value of the definite integral

$$\int_0^1 \left(\frac{x^2}{1+x^3}\right) dx$$

using (i) Trapezoidal rule(ii) Simpson's 1/3 Rule (iii) Simpson's 3/8 Rule, by dividing the range into four equal parts.

Solution: –

X_h	Y_k	Simpson's 1/3 rule
X_0=0	Y_0=0	Y_0=0
$X_1=x_0$+h=0.25	Y_1=0.06154	$4y_1$=0.24616
X_2=x0+2h=0.50	Y_2=0.22222	$2y_2$=0.44444
$X_3=x_0$+3h=0.75	Y_3=0.39560	$4y_3$=1.5824
$X_4=x^0$+4h=1.00	Y_4=0.50000	Y_4=0.50000
	Total	2.773

Therefore Simpson's 1/3 rule,

$$\int_a^b f(x)dx \approx \frac{1}{3}h\left[y_1 + 4y_2 + 2y_3 + 4y_4 + 2y_5 + \ldots + 4y_{2n} + y_{2n+1}\right]$$

$$\int_0^1 \frac{x^2}{1+x^3}\,\mathrm{dx} = \frac{0.25}{0.3}[2.773]$$

$$=0.23108$$

Similarly solve for Trapezoidal rule and Simpson's 3/ 8 rule.

Trapezoidal rule

$$\int_{x_0}^{x_0+nh} f(x)dx = \frac{h}{2}\{y_0 + 2(y_1 + y_2 + y_3 + \cdots \ldots . y_{n-1}\} + y_n\}$$

$$\int_0^1 \frac{x^2}{1+x^3}\,\mathrm{dx} = 0.2678$$

Simpson's 3/ 8 rule

$$\int_0^1 \frac{x^2}{1+x^3}\,\mathrm{dx} = 0.22743$$

Q.8 Solve the equation $\mathbf{y' = (x+y)}$ with $\mathbf{y_0 = 1}$ by Runge-Kutta rule from x = 0 to x = 0.4 with h = 0.1

Solution-

Here $f(x,y) = x + y, h = 0.1\ given\ y_0 = 1\ when\ x_0 = 0$

We have

$$k_1 = hf(x_0, y_0)$$
$$k_1 = 0.1(0+1) = 0.1$$
$$k_2 = hf\left(x_0 + \frac{h}{2}, y_0 + \frac{k_1}{2}\right)$$
$$k_2 = 0.1(0.05 + 1.05) = 0.11$$
$$k_3 = hf\left(x_0 + \frac{h}{2}, y_0 + \frac{k_2}{2}\right)$$
$$k_3 = 01(0.05 + 1.055) = 0.1105$$
$$k_4 = hf(x_0 + h, y_0 + k_3)$$
$$k_4 = 0.1(0.1 + 1.1105) = 0.12105$$
$$y_1 = y_0 + \tfrac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)$$
$$y_1 = 1 + \frac{1}{6}(0.1 + 0.22 + 0.2210 + 0.12105) = 1.11034$$

Similarly for finding $\boldsymbol{y_2 = y(x = 0.2)}$, *we get*

$$k_1 = hf(x_0, y_0)$$
$$k_1 = 0.1(0.1 + 1.11034) = 0.121034$$
$$k_2 = hf\left(x_0 + \frac{h}{2}, y_0 + \frac{k_1}{2}\right)$$
$$k_2 = 0.1(0.15 + 1.11034 + 0.660517) = 0.13208$$
$$k_3 = hf\left(x_0 + \frac{h}{2}, y_0 + \frac{k_2}{2}\right)$$
$$k_3 = 0.1(0.15 + 1.11034 + 0.06604) = 0.13263$$
$$k_4 = hf(x_0 + h, y_0 + k_3)$$
$$k_4 = 0.1(0.20 + 1.11034 + 0.13263) = 0.14263$$
$$y_2 = y_1 + \tfrac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)$$

$$y_2 = (1.11034 + \frac{1}{6}[0.121034 + 2(0.13208) + 2(0.13263) + 0.14429]) = 1.2428$$

Similarly for finding $y_3 = y(x = 0.3)$, *we get*

$$k_1 = hf(x_0, y_0)$$
$$k_1 = 0.1(0.3 + 1.2428) = 0.14428$$
$$k_2 = hf\left(x_0 + \frac{h}{2}, y_0 + \frac{k_1}{2}\right)$$
$$k_2 = 0.1(0.25 + 13248 + 0.0.07214) = 0.15649$$
$$k_3 = hf\left(x_0 + \frac{h}{2}, y_0 + \frac{k_2}{2}\right)$$
$$k_3 = 0.1(0.25 + 1.2428 + 0.07824) = 0.15710$$
$$k_4 = hf(x_0 + h, y_0 + k_3)$$
$$k_4 = 0.1(0.30 + 1.2428 + 0.15710) = 0.16999$$
$$y_3 = y_2 + \tfrac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)$$

$$y_3 = 1.2428 + \frac{1}{6}[0.14428 + 2(0.15649) + 2(0.15710) + 0.14429)] = 0.13997$$

Similarly for finding $y_3 = y(x = 0.4)$, *we get*

$$k_1 = hf(x_0, y_0)$$
$$k_1 = 0.1[0.3 + 1.3997] = 0.16997$$
$$k_2 = hf\left(x_0 + \frac{h}{2}, y_0 + \frac{k_1}{2}\right)$$
$$k_2 = 0.1[0.35 + 1.3997 + 0.08949] = 0.18347$$
$$k_3 = hf\left(x_0 + \frac{h}{2}, y_0 + \frac{k_2}{2}\right)$$
$$k_3 = 0.1[0.35 + 1.3997 + 0.9170] = 0.18414$$
$$k_4 = hf(x_0 + h, y_0 + k_3)$$
$$k_4 = 0.1[0.4 + 1.3997 + 0.18414] = 0.19838$$
$$y_4 = y_3 + \tfrac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)$$

$$y_4 = 1.3997 + \frac{1}{6}[1.6997 + 2(0.18347) + 2(0.18414) + 0.19838] = 1.5836 \quad Ans.$$

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Sushma Jaiswal
Assistant Professor,
Department of Computer Science & Information Technology
Guru Ghasidas Vishwavidyalaya,Bilaspur(C.G.)
(A Central University established by the Central Universities Act, 2009)

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