>

> #Laboratory work №4
Variant 6
Topic : Numerical methods **for** solving nonlinear equations.
Student of group Tee- 1 :

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> # ***1. One root of the equation, ai=0.02***

> *restart*;

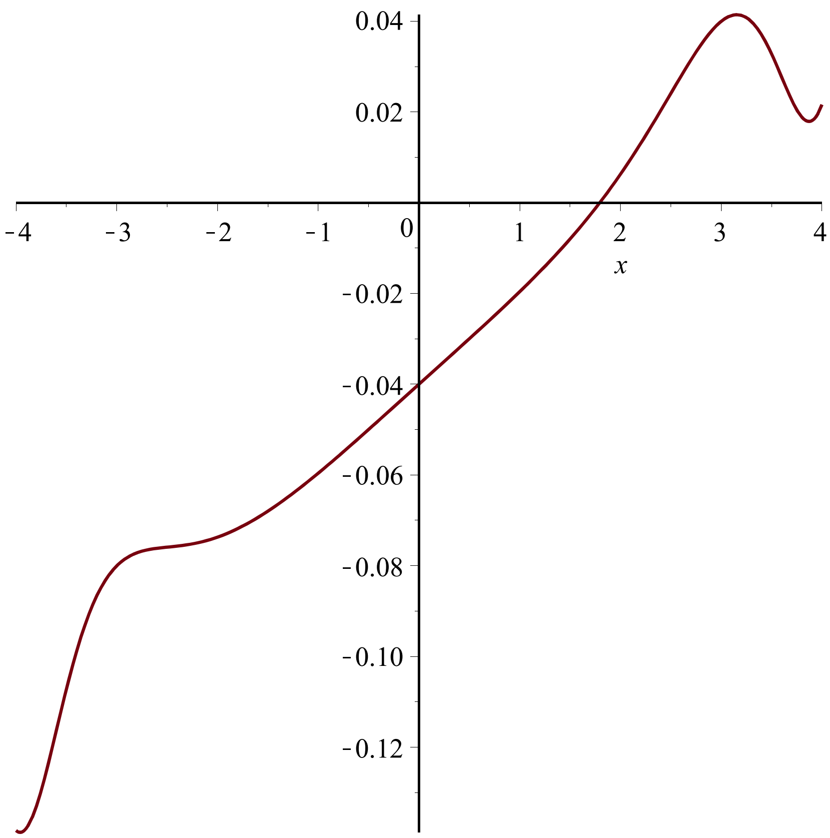
> $f := x \rightarrow ai \cdot \sin(ai \cdot x^4) + ai \cdot (x - 2);$

$$f := x \rightarrow ai \sin(ai\, x^4) + ai\, (x - 2) \quad \textbf{(1)}$$

> $ai := .02;$

$$ai := 0.02 \quad \textbf{(2)}$$

> $plot(f(x), x = -4..4);$



> # ***1. One root of the equation, ai=0.02***

> *restart*;

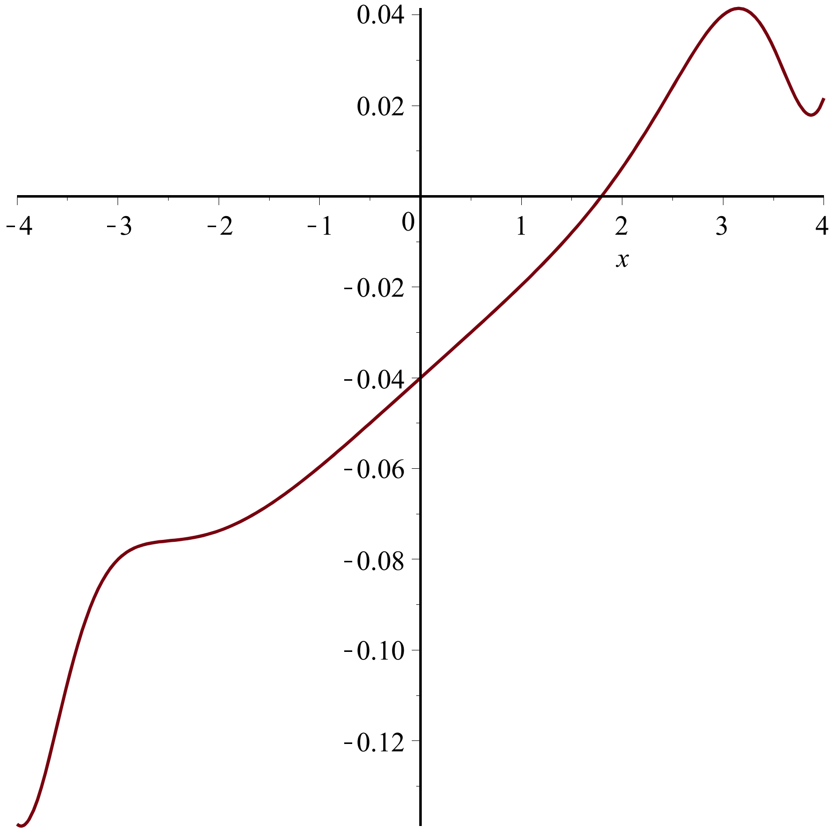
> $f := x \rightarrow ai \cdot \sin\left(ai \cdot x^4\right) + ai \cdot (x - 2);$

$$f := x \rightarrow ai \sin\left(ai\, x^4\right) + ai\, (x - 2) \qquad \textbf{(3)}$$

> $ai := 0.02;$

$$ai := 0.02 \qquad \textbf{(4)}$$

> $plot(f(x), x = -4..4);$



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> $evalf(solve(f(x) = 0));$

$$1.794214915,\ 1.072740544 - 2.912108737\,\mathrm{I},\ -0.6384343767 + 3.534140124\,\mathrm{I},\ -3.311190551 - 0.8768920965\,\mathrm{I},\ -0.6384343767 - 3.534140124\,\mathrm{I},\ 1.072740544 + 2.912108737\,\mathrm{I},\ -3.311190551 + 0.8768920965\,\mathrm{I} \qquad \textbf{(5)}$$

>

> # ***1.1. Bisection method.***
> ***#Select the segment*** **[1.; 2].**

> $a := -1.; b := 2.;$

$$a := -1.$$
$$b := 2. \qquad \textbf{(6)}$$

> sigma := 0.0001; #***Accuracy***

$$\sigma := 0.0001 \quad (7)$$

```
> while b − a > sigma do
   c := (b + a)/2;
   if f(a)·f(c) < 0 then b := c : else a := c : end if
  end do;
```

$$c := 0.5000000000$$
$$c := 1.250000000$$
$$c := 1.625000000$$
$$c := 1.812500000$$
$$c := 1.718750000$$
$$c := 1.765625000$$
$$c := 1.789062500$$
$$c := 1.800781250$$
$$c := 1.794921875$$
$$c := 1.791992188$$
$$c := 1.793457032$$
$$c := 1.794189454$$
$$c := 1.794555664$$
$$c := 1.794372559$$
$$c := 1.794281006 \quad (8)$$

> ***#Root using the bisection method:*1.794281006**

> ***#1.2. Newton's method.***

> $eps := 0.001$;#`#`***Accuracy***

$$eps := 0.001 \quad (9)$$

> $f1 := D(f)$;

$$f1 := x \rightarrow 4\, ai^2 \cos\left(ai\, x^4\right) x^3 + ai \quad (10)$$

> ***#Initial approximation: x0=1.75***

> $x0 := 1.0$;

$$x0 := 1.0 \quad (11)$$

```
> for i to 1000 while abs(evalf(f(x0))) > eps do
   xi := x0 − evalf(f(x0))/evalf(f1(x0));
   x0 := xi end do;
```

$$\xi := 1.907422085$$
$$x0 := 1.907422085$$
$$\xi := 1.797332675$$
$$x0 := 1.797332675 \quad (12)$$

> $print(x0)$;

$$1.797332675 \quad (13)$$

> ***#Root using Newton's method:* 1.797332675**

>

> ***#3. Three roots of the equation, ai=0.1***

> *restart*;

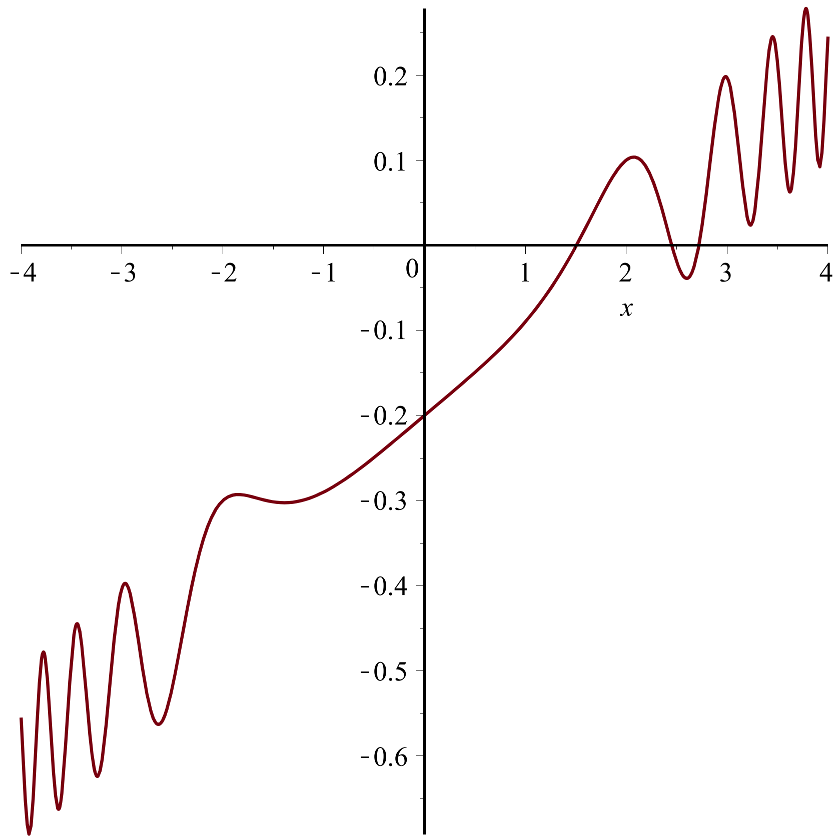
> $f := x \rightarrow ai \cdot \sin(ai \cdot x^4) + ai \cdot (x-2);$

$$f := x \rightarrow ai \sin(ai\, x^4) + ai\, (x-2) \quad (14)$$

> $ai := 0.1;$

$$ai := 0.1 \quad (15)$$

> $plot(f(x), x=-4..4);$



> $evalf(solve(f(x)=0));$

1.506907954, -0.3948442108 + 2.312340925 I, -2.183080653 - 0.5426164243 I, 0.6060732880 - 1.932440761 I, -0.3948442108 - 2.312340925 I, -2.183080653 + 0.5426164243 I, 2.451123996, 0.6060732880 + 1.932440761 I **(16)**

> ***#3.1. Bisection method. First root of the equation.***

> ***#Select the segment [1;2].***

> $a := 1.; b := 2;$

$$a := 1.$$
$$b := 2 \quad (17)$$

> sigma := 0.001; #***Accuracy***

$$\sigma := 0.001 \quad (18)$$

> **while** $b - a >$ sigma **do**
$c := \frac{(b+a)}{2}$;
if $f(a) \cdot f(c) < 0$ **then** $b := c$: **else** $a := c$: **end if**
end do;

$$c := 1.500000000$$
$$c := 1.750000000$$
$$c := 1.625000000$$
$$c := 1.562500000$$
$$c := 1.531250000$$
$$c := 1.515625000$$
$$c := 1.507812500$$
$$c := 1.503906250$$
$$c := 1.505859375$$
$$c := 1.506835938 \quad \textbf{(19)}$$

> ***#1st Root using the bisection method:*****1.506835938**

>

> ***#3.2. Newton's method. First root of the equation.***

> $eps := 0.0001$;#`#`***Accuracy***

$$eps := 0.0001 \quad \textbf{(20)}$$

> $f1 := \mathrm{D}(f)$;

$$f1 := x \rightarrow 4\, ai^2 \cos\left(ai\, x^4\right) x^3 + ai \quad \textbf{(21)}$$

> ***#Initial approximation: x0=1.4***

> $x0 := 2.0$;

$$x0 := 2.0 \quad \textbf{(22)}$$

> **for** i **to** 1000 **while** $\mathrm{abs}(evalf(f(x0))) > eps$ **do**
$\mathrm{xi} := x0 - \frac{evalf(f(x0))}{evalf(f1(x0))}$;
$x0 := \mathrm{xi}$ **end do**;

$$\xi := 0.897401256$$
$$x0 := 0.897401256$$
$$\xi := 1.702841709$$
$$x0 := 1.702841709$$
$$\xi := 1.509485880$$
$$x0 := 1.509485880$$
$$\xi := 1.506910132$$
$$x0 := 1.506910132 \quad \textbf{(23)}$$

> $print(x0)$;

$$1.509485880 \quad \textbf{(24)}$$

> ***#1st Root using Newton's method:*** **1.506910132**

>

> ***#3.3. Bisection method. Second root of the equation.***
#Select the segment **[2; 2.5].**

> $a := 2.; b := 2.7;$

$$a := 2.$$
$$b := 2.7 \tag{25}$$

> sigma := 0.001; #***Accuracy***

$$\sigma := 0.001 \tag{26}$$

> **while** $b - a >$ sigma **do**
> $c := \frac{(b+a)}{2};$
> **if** $f(a) \cdot f(c) < 0$ **then** $b := c$: **else** $a := c$: **end if**
> **end do**;

$$c := 2.350000000$$
$$c := 2.525000000$$
$$c := 2.437500000$$
$$c := 2.481250000$$
$$c := 2.459375000$$
$$c := 2.448437500$$
$$c := 2.453906250$$
$$c := 2.451171875$$
$$c := 2.449804688$$
$$c := 2.450488282 \tag{27}$$

> ***#2nd Root using the bisection method:*****2.450488282**

>

> ***#3.4. Newton's method. Second root of the equation.***

> $eps := 0.0001$;#`#`***Accuracy***

$$eps := 0.0001 \tag{28}$$

> $f1 := \mathrm{D}(f);$

$$f1 := x \rightarrow 4\, ai^2 \cos\left(ai\, x^4\right)\, x^3 + ai \tag{29}$$

> ***#Initial approximation: x0=2.5***

> $x0 := 2.5;$

$$x0 := 2.5 \tag{30}$$

> **for** i **to** 1000 **while** $\mathrm{abs}(evalf(f(x0))) > eps$ **do**
> $\mathrm{xi} := x0 - \frac{evalf(f(x0))}{evalf(f1(x0))};$
> $x0 :=$ xi **end do**;

$$\xi := 2.445218502$$
$$x0 := 2.445218502$$
$$\xi := 2.451090382$$
$$x0 := 2.451090382 \tag{31}$$

> $print(x0);$

$$2.451090382 \tag{32}$$

> ***#2nd Root using Newton's method:*** **2.451090382**

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