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DECUS NO.	FOCAL8-109a
TITLE	Program To Find Real Roots of a Polynomial Equation of Degree N (an integer) With Real Coefficients
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SOURCE LANGUAGE	

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A Program To Find Real Roots of a Polynomial Equation of Degree N
(an integer) With Real Coefficients

DECUS Program Library Write-up

DECUS NO. FOCAL8-109a

This program uses the NEWTON-RAPHSON method to find the real roots of a polynomial equation of degree N with real coefficients. It has the usual limitations of the above method, but has worked well for a large number of problems found in Calculus and Elementary Functions textbooks.

Given the appropriate interval $[LL, UL]$, the program searches for possible zeros of the $P(x)$. Using synthetic division, it checks for any remainders = 0. If it finds any, it outputs the value of x as a root. Where the remainders are not zeros, the program looks for changes in sign of the $P(x)$. Then it makes its own approximation and uses the Newton-Raphson Method to arrive at a good approximation of root. Any failure to output all the real roots may be due to an inappropriate interval, or simply the fact that the Newton-Raphson Method does not work for every polynomial equation.

For student use, synthetic division can be output by modifying line 2.10 as follows:

```
2.10 T %4.02,!"X ="X;S P=0;F I=0,DE;S P=P*X+C(I);T P
```

A sample run using this modification appears on p. 2. It illustrates some of the concepts used in discussing a polynomial equation, such as, a lower bound, and upper bound, etc.

*C-FDCAL,1969

```
*
*01.01 C TO FIND REAL ROOTS OF A P(X)=0.
*01.02 C NEWTON-RAPHSON METHOD.
*01.10 A !!?DEGREE?;!, "COEFF.;" S K=0; F I=0, DE; A C(I)
*01.20 A !?LL UL?; F X=LL, UL; D 2
*01.30 T !!, %2, K, " REAL ROOT(S) IN ["LL, ", "UL, "]; G 1.1
*
*02.10 S P=0; F I=0, DE; S P=P*X+C(I)
*02.20 D 3
*
*03.05 S Y=X-1; S Q=0; F I=0, DE; S Q=Q*Y+C(I)
*03.10 I [P*Q]3.2, 3.3; R
*03.20 D 4
*03.25 R
*03.30 I [P]3.4, 3.5
*03.40 R
*03.50 T %2, ! "ROOT ="Y+1; S K=K+1; R
*
*04.10 S AP=(2*Y+1)/2
*04.20 S P=0; F I=0, DE; S P=P*AP+C(I)
*04.30 F J=0, DE; S B(J)=C(J)*(DE-J)
*04.40 S P'=0; F J=0, DE-1; S P'=P'*AP+B(J)
*04.50 S RJ=AP-P/P'; I (RJ-AP)4.6, 4.7
*04.60 S AP=RJ; G 4.2
*04.70 T %6.03, ! "ROOT ="RJ; S K=K+1; R
**
*C
```

```
DEGREE:4
COEFF.:3 :-8 :-40 :48 :45
LL :-4 UL:5
ROOT =- 3
ROOT =- 0.646
ROOT = 1.667
ROOT = 4.646
```

$$3X^4 - 8X^3 - 40X^2 + 48X + 45 = 0$$

4 REAL ROOT(S) IN [- 4, 5]

DEGREE:3
COEFF.:3 :-5 :-8 :2
LL :-3 UL:3
ROOT = - 1.152
ROOT = 0.223
ROOT = 2.595

$$3X^3 - 5X^2 - 8X + 2 = 0$$

3 REAL ROOT(S) IN [- 3, 3]

DEGREE:6
COEFF.:1 :0 :0 :0 :0 :-70
LL :0 UL:3
ROOT = 2.030

$$X^6 - 70 = 0$$

1 REAL ROOT(S) IN [0, 3]

DEGREE:6
COEFF.:1 :0 :0 :0 :0 :-70
LL :-3 UL:3
ROOT = - 2.030
ROOT = 2.030

$$X^6 - 70 = 0$$

2 REAL ROOT(S) IN [- 3, 3]

DEGREE:2 @ 01.10

C-FOCAL,1969

```
01.01 C TO FIND REAL ROOTS OF A P(X)=0.
01.02 C NEWTON-RAPHSON METHOD.
01.10 A !!?DEGREE?;!,"COEFF.":S K=0;F I=0,DE;A C(I)
01.20 A !?LL UL?;F X=LL,UL;D 2
01.30 T !!,%2,K," REAL ROOT(S) IN ["LL,","UL,"]";G 1.1
```

```
02.10 T %3.01,! "X ="X;S P=0;F I=0,DE;S P=P*X+C(I);T P
02.20 D 3
```

```
03.05 S Y=X-1;S Q=0;F I=0,DE;S Q=Q*Y+C(I)
03.10 I [P*Q]3.2,3.3;R
03.20 D 4
03.25 R
03.30 I [P]3.4,3.5
03.40 R
03.50 T %2,! "ROOT ="Y+1;S K=K+1;R
```

```
04.10 S AP=(2*Y+1)/2
04.20 S P=0;F I=0,DE;S P=P*AP+C(I)
04.30 F J=0,DE;S B(J)=C(J)*(DE-J)
04.40 S P'=0;F J=0,DE-1;S P'=P'*AP+B(J)
04.50 S RO=AP-P/P';I (RO-AP)4.6,4.7
04.60 S AP=RO;G 4.2
04.70 T %6.03,! "ROOT ="RO;S K=K+1;R
*G
```

```
DEGREE:4
COEFF.:3 :-8 :-40 :48 :45
LL :-4 UL:6
X = - 4.0 3.0-20.0 40.0-112 493
X = - 3.0 3.0-17.0 11.0 15.0 0.0
ROOT = - 3
X = - 2.0 3.0-14.0-12.0 72.0-99.0
X = - 1.0 3.0-11.0-29.0 77.0-32.0
X = 0.0 3.0- 8.0-40.0 48.0 45.0
ROOT = - 0.646
X = 1.0 3.0- 5.0-45.0 3.0 48.0
X = 2.0 3.0- 2.0-44.0-40.0-35.0
ROOT = 1.667
X = 3.0 3.0 1.0-37.0-63.0-144
X = 4.0 3.0 4.0-24.0-48.0-147
X = 5.0 3.0 7.0- 5.0 23.0 160
ROOT = 4.646
X = 6.0 3.0 10.0 20.0 168 0.105E+04
```

4 REAL ROOT(S) IN [- 4, 6]

DEGREE: ?01.00 @ 01.10

*