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Program DEMO1; {keskmise ja standardhälbe hindamine}
{$M 65000, 0, 655360} {pinu maht suurte massiivide jaoks}
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Const nmax = 10000; {suurim lubatud lugemite arv seerias}
Var   n : integer; {tegelik lugemite arv seerias}
      out : text;   {väljund, kas ekraan või fail}
```

```
Function Lugem : single;
{Gaussi jaotus, keskväärtus = 6, standardhälve = 1}
Var x : single; i : integer;
Begin x := random;
      for i := 2 to 12 do x := x + random;
      lugem := x;
End;
```

```
Procedure Esimene (var kesk, sigma : single);
Var i : integer;
    s : single;
    x : array [1..nmax] of single;
Begin
  if n > nmax then begin {alternatiivne meetod oleks $R+}
    writeln ('Lugemite arv ei tohi olla suurem kui ', nmax);
    writeln ('Vajuta ENTER!'); readln; halt;
  end;
  for i := 1 to n do x [i] := lugem;
  s := 0;
  for i := 1 to n do s := s + x [i];
  kesk := s / n;
  s := 0;
  for i := 1 to n do s := s + sqr (x [i] - kesk);
  sigma := sqrt (s / (n - 1));
End;
```

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{Võrdlusvariante:
  s := x [1]; for i := 2 to n do s := s + x [i];
  sigma := sqrt (s / n);
  sigma := sqrt (s / (n * (n - 1)));
  sigma := sqrt (abs ((s / (n - 1))));}
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```
Procedure Teine (var kesk, sigma : single);
Var i : integer;
    x, s, ss : single;
Begin
  s := 0; ss := 0;
  for i := 1 to n do begin
    x := lugem;
    s := s + x;
    ss := ss + x * x;
  end;
  kesk := s / n;
  sigma := sqrt ((ss - s * kesk) / (n - 1));
End;
```

```

Procedure Kolmas (var kesk, sigma : single);
  Var i : integer;
      x, ss : single;
Begin
  ss := 0;
  for i := 1 to n do begin
    x := lugem;
    kesk := ((i - 1) * kesk + x) / i;
    ss := ss + x * x;
  end;
  sigma := sqrt ((ss - n * kesk * kesk) / (n - 1));
End;

Var m, s : single; {keskväärtuse ja standardhälbe hinnangud}
    i, k : integer;
    nimi : string;

BEGIN
writeln;
write ('Väljundfaili nimi (vahetu ENTER = ekraan) : ');
readln (nimi); assign (out, nimi); rewrite (out);
writeln (out, 'Fail: ', nimi); writeln (out);
repeat
  writeln ('Arvutamise lõpetab lugemite arv = 0');
  write ('Lugemite arv = '); readln (n);
  if n > 0 then begin
    write ('Korduste arv = '); readln (k);
    writeln (out, n, ' lugemit, ', k, ' kordust');
    for i := 1 to k do begin
      Esimene (m, s); writeln (out, '1) m =', m:6:3, ' s =', s:6:3);
      Teine (m, s); writeln (out, '2) m =', m:6:3, ' s =', s:6:3);
      Kolmas (m, s); writeln (out, '3) m =', m:6:3, ' s =', s:6:3);
    end;
    writeln (out);
  end;
until n = 0;
close (out);
END.

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Program DEMO2; {standardhälbe hindamise katseline analüüs}
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```
Const k = 100000; {Monte Carlo statistika maht}
Var out : text;
```

```
Function Lugen : single;
  {Gaussi jaotus, keskvaartus = 6, standardhälve = 1}
  Var x : single; i : integer;
  Begin x := random;
    for i := 2 to 12 do x := x + random;
    lugem := x;
  End;
```

```
Procedure Sigmad (n : longint; var sigmal, sigma2 : double);
  Var i : longint;
    x, s, ss : double;
  Begin
    s := 0; ss := 0;
    for i := 1 to n do begin
      x := lugem;
      s := s + x; ss := ss + x * x;
    end;
    sigmal := sqrt ((ss - s * s / n) / n);
    sigma2 := sqrt ((ss - s * s / n) / (n - 1));
  End;
```

```
Var s1, s2, sum1, sum2, ssum1, ssum2,
    skesk1, skesk2, ssigmal, ssigma2 : double;
    n, i, j : longint;
    nimi : string;
```

```
BEGIN
randomize;
write ('Väljundfaili nimi (vahetu ENTER = ekraan) : ');
readln (nimi); assign (out, nimi); rewrite (out);
writeln (out, 'Fail: ', nimi);
writeln (out, 'Monte Carlo statistika maht = ', k);
writeln (out);
writeln (out, '
                Keskmine      Sigma');
writeln (out, 'Lugemeid      n    n-1      n    n-1');
n := 4;
for j := 1 to 3 do begin
  sum1 := 0; sum2 := 0; ssum1 := 0; ssum2 := 0;
  for i := 1 to k do begin
    sigmad (n, s1, s2); {s1 := s1 * s1; s2 := s2 * s2;} {s/d}
    sum1 := sum1 + s1; ssum1 := ssum1 + s1 * s1;
    sum2 := sum2 + s2; ssum2 := ssum2 + s2 * s2;
  end;
  skesk1 := sum1 / k;
  ssigmal := sqrt ((ssum1 - sum1 * skesk1) / (k - 1));
  skesk2 := sum2 / k;
  ssigma2 := sqrt ((ssum2 - sum2 * skesk2) / (k - 1));
  writeln (out, n:8, skesk1:6:3, skesk2:6:3, ssigmal:6:3, ssigma2:6:3);
  n := 5 * n;
end;
close (out); if nimi = '' then readln;
END.
```

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Program DEMO3; {keskmistamine rikub täpsuse}
{NB: nulliga jagamise risk ei ole välistatud!}

Const k = 100000; {Monte Carlo statistika maht}
Var out : text;

Function Lugem : single;
{tangensruutkärbestega jaotus, keskpunkt = 0}
Var x, s : double;
Begin
  x := pi * (random - 0.5); s := x / abs (x);
  if random < 0.01 then x := x + s * sqr (sin (x) / cos(x));
  lugem := x / 10;
End;

Function Keskmine (n : longint) : double;
Var i : longint;
  s : double;
Begin
  s := 0;
  for i := 1 to n do begin
    s := s + lugem;
  end;
  keskmine := s / n;
End;

Var x, s, ss, kesk, sigma : double;
  n, i, j : longint;
  nimi : string;

BEGIN
randomize;
writeln;
write ('Väljundfaili nimi (vahetu ENTER = ekraan) : ');
readln (nimi); assign (out, nimi); rewrite (out);
writeln (out, 'Fail: ', nimi);
writeln (out, 'Monte Carlo statistika maht = ', k);
writeln (out);
writeln (out, 'Lugemeid   Keskmine   Sigma');
n := 1;
for j := 1 to 4 do begin
  s := 0; ss := 0;
  for i := 1 to k do begin
    x := keskmine (n);
    s := s + x; ss := ss + x * x;
  end;
  kesk := s / k;
  sigma := sqrt ((ss - s * kesk) / (k - 1));
  writeln (out, n:8, kesk:9:3, sigma:9:3);
  n := 5 * n;
end;
close (out); if nimi = '' then readln;
END.

```

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Program DEMO4; {kahe kerge keha kaalumine}

Const k = 100; {Monte Carlo statistika maht}
      m01 = 10; {esimese keha mass, mg}
      m02 = 20; { teise keha mass, mg}
Var out : text;

Function Viga : single;
{Normaaljaotusega juhuslik viga, sigma = 1 mg}
Var x : single; i : integer;
Begin x := random;
      for i := 2 to 12 do x := x + random;
      viga := x - 6;
End;

Var x1, x2, y1, y2, s1, s2, ss1, ss2,
    m1, m2, sigma1, sigma2 : double;
    i : longint;
    nimi : string;

BEGIN
randomize;
write ('Väljundfaili nimi (vahetu ENTER = ekraan) : ');
readln (nimi); assign (out, nimi); rewrite (out);
writeln (out, 'Fail: ', nimi);
writeln (out, 'Monte Carlo statistika maht = ', k);
writeln (out);
{Lihtkaalumine}
  s1 := 0; ss1 := 0; s2 := 0; ss2 := 0;
  for i := 1 to k do begin
    x1 := m01 + viga;
    x2 := m02 + viga;
    s1 := s1 + x1; ss1 := ss1 + x1 * x1;
    s2 := s2 + x2; ss2 := ss2 + x2 * x2;
  end;
  m1 := s1 / k; sigma1 := sqrt ((ss1 - s1 * m1) / (k * (k - 1))); {NB!}
  m2 := s2 / k; sigma2 := sqrt ((ss2 - s2 * m2) / (k * (k - 1)));
  writeln (out, 'Lihtkaalumine:');
  writeln (out, '    m1 =', m1:7:3, ' +-', sigma1:6:3, ' mg',
    '    m2 =', m2:7:3, ' +-', sigma2:6:3, ' mg');
{Multiplekskaalumine}
  s1 := 0; ss1 := 0; s2 := 0; ss2 := 0;
  for i := 1 to k do begin
    y1 := m02 + m01 + viga;
    y2 := m02 - m01 + viga;
    x1 := (y1 - y2) / 2;
    x2 := (y1 + y2) / 2;
    s1 := s1 + x1; ss1 := ss1 + x1 * x1;
    s2 := s2 + x2; ss2 := ss2 + x2 * x2;
  end;
  m1 := s1 / k; sigma1 := sqrt ((ss1 - s1 * m1) / (k * (k - 1)));
  m2 := s2 / k; sigma2 := sqrt ((ss2 - s2 * m2) / (k * (k - 1)));
  writeln (out, 'Multiplekskaalumine:');
  writeln (out, '    m1 =', m1:7:3, ' +-', sigma1:6:3, ' mg',
    '    m2 =', m2:7:3, ' +-', sigma2:6:3, ' mg');
close (out); if nimi = '' then readln;
END.

```

Fail: D:\edu\mootmine\demo1.txt

10 lugemit, 3 kordust

1) m = 6.066 s = 1.285
 2) m = 5.993 s = 1.218
 3) m = 6.069 s = 0.804
 1) m = 6.242 s = 0.804
 2) m = 6.136 s = 0.830
 3) m = 6.365 s = 1.546
 1) m = 6.189 s = 0.952
 2) m = 5.919 s = 0.624
 3) m = 5.880 s = 0.935

1000 lugemit, 3 kordust

1) m = 6.034 s = 1.015
 2) m = 5.970 s = 1.010
 3) m = 5.940 s = 0.987
 1) m = 5.961 s = 0.985
 2) m = 6.064 s = 1.015
 3) m = 6.041 s = 0.982
 1) m = 5.940 s = 0.959
 2) m = 6.005 s = 0.996
 3) m = 5.970 s = 0.966

100 lugemit, 3 kordust

1) m = 5.997 s = 0.965
 2) m = 5.769 s = 0.973
 3) m = 6.118 s = 1.036
 1) m = 6.000 s = 1.027
 2) m = 6.031 s = 0.963
 3) m = 6.015 s = 0.986
 1) m = 6.005 s = 0.981
 2) m = 5.804 s = 0.818
 3) m = 6.103 s = 0.983

10000 lugemit, 3 kordust

1) m = 5.996 s = 1.003
 2) m = 5.997 s = 0.999
 3) m = 5.997 s = 1.006
 1) m = 6.002 s = 0.995
 2) m = 5.988 s = 1.003
 3) m = 6.003 s = 1.000
 1) m = 6.002 s = 1.002
 2) m = 5.981 s = 0.991
 3) m = 6.004 s = 1.008

Fail: d:\edu\mootmine\demo2s.txt
 Monte Carlo statistika maht = 100000

Lugemeid	Keskmine		Sigma	
	n	n-1	n	n-1
4	0.798	0.921	0.332	0.383
20	0.962	0.987	0.154	0.158
100	0.992	0.997	0.069	0.069

Fail: d:\edu\mootmine\demo2d.txt
 Monte Carlo statistika maht = 100000

Lugemeid	Keskmine		Sigma	
	n	n-1	n	n-1
4	0.750	1.000	0.598	0.798
20	0.950	1.001	0.301	0.316
100	0.991	1.001	0.138	0.139

Fail: d:\edu\mootmine\demo3.txt
 Monte Carlo statistika maht = 100000

Lugemeid	Keskmine	Sigma
1	0.247	95.009
5	-0.807	195.875
25	-1.586	922.418
125	32.963	7519.063

Fail: d:\edu\mootmine\demo4.txt
 Monte Carlo statistika maht = 100

Lihtkaalumine:

m1 = 10.153 +- 0.090 mg m2 = 20.104 +- 0.089 mg

Multiplekskaalumine:

m1 = 9.931 +- 0.070 mg m2 = 20.033 +- 0.063 mg