Exercise 4.2.21

```
A=gallery('kahan',90,1.2,0);
sig = svd(A);
format long e;
disp([sig(1),sig(89),sig(90)])
```

```
  Columns 1 through 2

     8.789335328546841e+00     2.384232536378107e-03

  Column 3

     3.960650377185735e-15
```

The numerical rank of A is seen to be 89 - based on the discussion around theorem 4.2.15.

```
A=gallery('kahan',90,1.2,25);
sig = svd(A);
disp([sig(1),sig(89),sig(90)])
```

```
  Columns 1 through 2

     8.789335328546738e+00     2.384232536386803e-03

  Column 3

     3.960639908759231e-15
```

We see the peturbed A is stil rank deficient.

```
[Q,R,E] = qr(A);
dif = norm(eye(90)-E)
```

```
dif =
     0
```

We see that $E = I$ and there was no pivoting (permuting) done in the QR decomposition.

```
R(90,90)
```

```
ans =
     1.903869390467939e-03
```

```
min(abs(diag(R))) %Double check - R_{i,i} should be decreasing due to column pivoting
```

```
ans =
     1.903869390467939e-03
```

And we see that the QR implementation fails to detect the near rank deficiency of A in this case.