1. Largest percentage uncertainty is in extension *x*, of 0.0005 m  100% / 0.008 m = ± 6%. Because there are other uncertainties, though smaller, it would be safest to round the overall uncertainty up to ± 10%.

*E = F L* / *A x* = 0.5 N  0.145 m / (4.0  10-6 m2  0.008 m) *=*  2.3 106 Pa ± 10% or *E* = (2.3 ± 0.3) 106 Pa, rounding up the uncertainty.

2. Remember that when squaring a quantity, a small percentage uncertainty in the quantity is approximately doubled in the quantity squared. Here the diameter is squared.

For breaking the largest percentage uncertainty is in the cross-sectional area *A* =  (*d*  / 2 )2, and is 2  (0.01 mm  100% / 0.31 mm) = ± 6.5%. Because there are other uncertainties, though smaller, it would be safest to round the overall uncertainty up to ± 10%.

breaking = *F* / *A* = 11.5 N /  (0.31  10-3 m / 2)2 = 1.52  108 Pa ± 10% or breaking = (1.5 ± 0.2) 108 Pa, rounding up the uncertainty to be on the safe side.

For breaking the largest percentage uncertainty is in *x* = 0.002 m  100% / 0.655 m = ± 0.3%.

The percentage error in *L* is only 0.1%.

breaking = *x* / *L* = 0.655 m / 1.50 m = 0.437 ± 0.3% or breaking = 0.437 ± 0.002, rounding up the uncertainty to be on the safe side.

3. Largest percentage uncertainty is in thickness = 0.01 mm  100% / 1.05 mm = ± 1%. This would be the place to consider how to improve the measurement. However, there are several other uncertainties to think about:

in width = ± 0.01 mm  100% / 5.1 mm = ± 0.2 %

inlength = ± 0.01 mm  100% / 10.20 mm = ± 0.1 %

in *V =* ± 0.01 V  100% / 2.40 V = ± 0.4 %

in *I =* ± 0.1 mA  100% / 40 mA = ± 0.3 %.

In view of these extra uncertainties, it might be wise to (say) double the largest uncertainty to estimate the overall uncertainty, so take ± 2 % as the uncertainty.

= *R A* / *L* = *V A* / *I L* = (2.4 V  5.1  10-3 m  1.05  10-3 m) / (40  10-3 A  10.2  10-3 m) = 3.15 10-2 m

If the uncertainty is ± 2% then  = (3.15 ± 0.06) 10-2 m.

4. Largest percentage uncertainty is in *d* = 0.01 mm  100% / 0.16 mm = ± 6%.

This gives the percentage uncertainty in the cross-sectional area *A* =  (*d* / 2)2 to be 2  (6%) = ± 12%.

All the other uncertainties are much smaller:

in *V* = ± 0.001 V  100% / 0.500 V = ± 0.2 %

in *I* = ± 0.001 A  100% / 0.146 A = ± 0.7 %

in *L* = ± 0.01 m  100% / 4.00 m = ± 0.3 %.

This suggests treating ± 12% as the overall uncertainty.

 = *G L* / *A* = *I L* / *V A* = (0.146 A  4.00 m) / (0.500 V   (0.16  10-3 m / 2)2 ) = 5.8 107 S m-1

If the uncertainty is ± 12% then = (5.8 ± 0.7) 107 S m-1 .

5.  = 1 /  so min = 1 / max. Now max = (104 / 100)  = (104 / 100) /  so min = 100 / 104 = 0.962 , which is low by 3.8%  4%.

Similarly, max= 1 /min and max = 100 / 96 = 1.042 , which is high by 4.2%  4%.

You have effectively shown that small percentage uncertainties for any quantity are sensibly the same as the uncertainties in the reciprocal of the quantity. Many interesting physical concepts have inverses that are also useful to consider. For example:

R = 1 / *G*  = 1 /  Plens = 1 / *f*