* 1. A certain rock on the moon weighs 1.75 pound. The scale used to weigh it there has a precision of ± 0.05 pound, or perhaps a little better. With a balance we can measure its mass with a precision of ± 0.1 gram. One student concludes that the balance is less precise (more uncertain) than the scale, because 0.1 is greater than 0.05. Another student insists that the mass uncertainty should be expressed as 0.0001 *kilogram*. Since 0.05 is much greater than 0.0001, she argues that the weight measurement has a greater uncertainty than the mass, so that the balance is *more* precise than the scale. Can you settle this controversy? Please explain your idea and show how you get your answer. If you need a hint, read the title of this page and review page 10R. Also use #12 on RS I.

2. The cost of filling a tank with gasoline is the product of the price "P" (in dollars per gallon) and the tank's volume "V", in gallons. Suppose a new gas tank is two percent larger than the old one:
   a. Your new fill-up cost is equal to the old cost multiplied by ____, so the cost has increased by ___%.
   b. Now suppose that the price of gasoline increases by three percent on the same day: That second change multiplies the cost by ____. The overall result of both changes is a ___-percent ___crease.

3. If "A" is increased by x% and "B" is increased by y%, the product "AB" increases by approximately _____ percent. Does this conclusion contradict #2? ___

4. Suppose “A” and “B” are the MLV’s of two measured quantites. Their uncertaintes are “a” and “b”.
   a. To calculate the MLV of their product we must multiply the __LV of the first factor by the __LV of the second factor. Using the given letters, the result is ____.
   b. To calculate the GLV of their product we must multiply the __LV of the first factor by the __LV of the second factor. (See #7 on page 14) Using the “FOIL” method from Algebra I, you get:
   (A + a)(B + b) = AB + ____ + ____ + ____
   c. To calculate the SLV of their product you would multiply the __LV of A by the __LV of B:
   (A - a)(B - b) = AB - ____ - ____ + ____
   d. To get the absolute uncertainty of the product you must ________ the SLV from the _____ and then divide the result by __, as in #16 on RS I: **abs. unc. =** ________ Does 17e on RS I agree? __
   e. To convert that uncertainty into ***relative*** form (using 18 & 19 on RS I) you must divide it by ____ . (Use only the given symbols.) After simplifying, you get: **Rel. Unc. of Product = ___ + ___.**
   f. Using #19 on RS I, the ***relative*** uncertainty of "A" was ____. (formula involving A and a) Similarly, the relative uncertainty of "B" was ____. -Can a relative uncertainty ever have units? __
   g. Conclusion: The relative uncertainty of a product can be estimated by _____ing the relative uncertainties of its factors. Do #2, 3, & 4e agree with this conclusion? ___

5. To convert a relative uncertainty from decimal form into percentage form you simply move the decimal point __ jumps to the _____, as explained on page 10R. In #4 we proved that if the relative uncertainty of "A" is X% and the relative uncertainty of "B" is Y%, then the uncertainty of the product "AB" is _____% This discovery is recorded in #__ on RSII.

6. Practice examples: *Use scientific notation, round off properly, and be careful with units.*
   a. (50 mph ± 3%)(3 hour ± 1%) = _____ miles ± ___%
   b. (9.803 ± 0.20 m/s^2)(0.749 sec ± 1.5%) = _____ ____ ± ___%
   c. (2.54×10^{-3} m ± 0.65%)^2 = __________ _____ ± ____%

7. “Squaring” a number involves multiplication. When you square a number (as in 6c) its relative uncertainty is _______ed. If you *cube* a number its relative uncertainty will be _______ed. (verbs)

8. Calculating a “square root” is the *inverse* (opposite) of squaring. When you calculate the square root of a number you must _______ its percentage uncertainty by ____. This important discovery is being saved in # ___ on RS ___.

9. For example, suppose two pendulums on Mars have the following length ratio: L_2/L_1 = 4.0 ± 2%
   a. The ratio of their periods must then be P_2/P_1 = ____ ± ___%, because pendulum period is proportional to the _______ _____ of length. (See #18 on RS II. Also use #8 above.)
   b. If the period of the shorter pendulum is 1.35 sec., then the longer period must be ____ ± ___ sec.

1. Suppose I increase the width of a rectangle by a factor of 2, and I increase its height by a factor of 3: The area of the rectangle will ___crease by a factor of _____.

2. Suppose I increase the width of a rectangle by a factor of 1.01, and I increase its height by a factor of 1.02: The area of the rectangle will ___crease by a factor of _____.

3. The easiest way to increase a quantity by 1% is to multiply it by _____.
   a. In #2 the width was multiplied by _____, causing it to increase by ___%.
   b. In #2 the length was multiplied by _____, causing it to __crease by ___%.
   c. The product of the length and width was increased by a factor of _____, which means it was increased by ____ percent.

4. If I increase the price of gasoline by 2% and the volume of my tank by 3% then the cost of filling my tank must ___crease by ___%.

5. If I increase one factor in a product by x% and another factor in that product by y%, then the product itself is ___creased by roughly ______%. *Do 3c and 4 agree with this fact?* ____
   This trick works best if x and y are ________ percentages. (large, small)

6. To *reduce* a quantity by one percent you can *divide* it by _____ or you can multiply it by ____. (Please insert numbers in *decimal form*.)

7. Reducing a quantity by x% causes the reciprocal of that quantity to ___crease by ___%. For example, decreasing the frequency of a ticker by 0.75% causes its period to ___crease by ____%.

8. If we increase the numerator (top part) of a fraction by x% and we *decrease* the denominator (bottom) by y% then the value of the fraction (quotient) ___creases by roughly _______%.
   Again, this trick works best if the percentages are _______. (large, small)

9. If the uncertainty of A is 2% and the uncertainty of B is 3% then:
   a. The GLV of AB is roughly ______% greater than the MLV of AB.
   b. The GLV of A/B is roughly ______% greater than the MLV of A/B.
   c. The uncertainty of the product is roughly ___%. The uncertainty of the quotient is roughly ___%.
   d. If the uncertainty of A is x% and the uncertainty of B is y% then the uncertainty of the product is _____ % and the uncertainty of the quotient is _____ %. -Does 9d contradict #8? ____

* 10. Suppose two quantities have identical relative uncertainties:
   For example, 250 dots ± 5%, and 5.0 seconds ± 5%.
   a. Does that mean their quotient can be calculated with perfect precision? __
   b. If you *multiply* the two quantities, you must ______ the relative uncertainties.
   c. Some people believe that you should do the opposite when you divide the two numbers. Does #10a agree with that opinion? ____
   d. If so, explain why. If not, explain what *should* be done. (See in #9, above.)
   e. A copy of this discovery (10d) is being saved in # __ on RS ___

* 11. Suppose "B" is a **counted** quantity, i.e. one with ***no*** uncertainty: How can the relative uncertainties of AB, A/B, and B/A be estimated from the relative uncertainty of A in that special situation?

* 12. Bonus Problem: Use logic similar to #4 on page 20 to prove the quotient rule stated in 10d.
   a. Begin by using #8 to create formulas for the GLV and the SLV of the quotient.
   b. Then use the definition, which is still recorded in # ___ on RS I:
   "Abs. Unc. of quotient = [GLV of quotient - SLV of quotient]÷2".
   c. Show how the common denominator can be used to simplify the formula..
   d. Simplify further by dropping the insignificant term.
   e. Remember to convert the resulting uncertainty into *relative* form, as you did in 4f on page 20.