

## SKILLS NEEDED FOR THE FIRST SEPTEMBER TEST (L-H)

1. Read and follow instructions. Write an answer *in* a given answer space.
2. Given a measurement in “range” form, estimate its MLV and uncertainty as we did on page 4R.  
For example, if some quantity is “probably between 9 and 11” then it could also be written as “ $10 \pm 1$ ”.  
Also convert an uncertainty from absolute to percentage form.
3. Do routine arithmetic with scientific notation, units, and uncertainties as on Quiz 1.
4. Use the definition of “ratio”. Calculate a ratio in decimal form.
5. Determine the MLV, SLV, GLV and uncertainty of a product or quotient, as on pages 4 & 4R.
6. Use routine algebraic procedures to simplify an expression.  
Also use the rules of algebra to simplify the units of a product or quotient as on Quiz 1.
7. Use 5e on RSI to solve simple proportion problems similar to #5 on page 5. For example, given the mass of a certain object, determine the mass that will remain if a given fraction of the material is removed.
8. Given the size and shape of a familiar geometric figure, calculate its area.
9. Estimate the volume of any familiar object in standard SI units. (Choose a SLV which is about one-third as great and a GLV about three times as great so that the final estimate is in the form of a very generous range.)
10. If the opposite ends of a spring are pulled in opposite directions and the strength of the pull on one end is given, determine how hard the other end is being pulled by using the discoveries on page 7.
11. Determine the tension of a spring by either of the methods on page 7. Given a spring's graph of tension vs. length, and given a tension value, determine the spring's length by using Hooke's equation.
12. Use the relation between mass and weight that you discovered on page 6.
13. Use the fact that the moon's gravity is about one sixth as strong as the earth's, as on page 6.
14. Use the definitions of “frequency” and “period” on RS I:  
Given the frequency of a periodic motion, calculate its period.  
Given the period, calculate the frequency.
15. Convert a given uncertainty into percentage form, as in #19 on RS I.  
Also convert from percentage back to absolute form. For example,  $3.45 \pm 0.07 \text{ cm.} = \mathbf{3.45 \text{ cm.} \pm 2\%}$ .
16. Use the definition of "average speed" on RS I.
17. Given a ticker-tape record of an object's motion, label the first and last dots and indicate the direction of the tape's motion, as we did on page 8.
18. Use a ticker-tape recording to decide if an object moved with increasing speed, decreasing speed, or constant speed as you did on page 8.
19. Use similar triangles to make an equation and solve it for an unknown, as on pages 0 and 7R.

**First September Test (honors level)**

name \_\_\_\_\_

**ANSWER SPACES**

Write your answers *in* the answer boxes. *No* credit will be given for anything outside of the boxes. Credit *will* be given for units wherever they are necessary, even if the numerical answer is wrong. If an answer needs units and you omit them then your answer is wrong.

1. Imagine a box with a volume of one cubic meter. Also imagine a one-gallon paint can or a half-gallon milk carton. By comparing their sizes, estimate the number of cubic meter in a gallon. To make this a reliable estimate, you must express it in the form of a *range*. To be very safe, make your SLV about one third of the correct value and give a GLV that is about three times the correct value. You will get full credit if the correct answer is within your estimated range and if the upper and lower ends of that range differ by no more than a factor of ten. There will be a penalty if either number is off by more than a factor of 100. Include no more than one fictional digit in each number.
2. To calculate a car's "gas mileage" you divide the distance driven by the amount of gasoline consumed. As you know, the SI unit of distance is "meters" (not miles) so the SI unit of volume must be the "cubic meters", rather than gallons. What SI *units* must your gas mileage have after routine simplification? (Use standard abbreviations.)
3. Suppose you can measure a time interval with an uncertainty of  $\pm 0.05$  seconds. You have a pendulum with a period of roughly 1.5 sec/sw. How many consecutive swings must you time in order to determine its period with a precision of  $\pm 0.5\%$ ?
4. A "ticker" is a device that makes dots on a paper tape at a steady tempo. We find that 254 dots are produced in  $4.2 \pm 0.03$  seconds.
  - a. Determine the period of the ticker, with absolute uncertainty.
  - b. Determine the frequency of the ticker in *range* form.
5. A certain helical spring lying on a table is 12 cm. long. When we tie one end to a doorknob and pull on the other end with a 5.0-pound force it stretches to a new length of 40 cm. Sketch the spring's tension vs length graph on the back of this paper. Put dots on the sketched graph to represent the two given data points.
  - a. How much force did the doorknob exert on the spring when it was stretched to 40 cm?
  - b. Calculate the slope of the spring's tension vs length graph. Don't forget the units.
  - c. Now one student pulls on one end with a force of 2.0 pounds while another student pulls the other end in the opposite direction with the same amount of force. Place a third dot on the graph to indicate the new tension and length. Make a small circle around that third dot, so I'll recognize it.
  - d. How long is the spring in 5c if the tension vs length graph is linear?
6. The mass of a certain solid object in this room is 12.0 kilograms.
  - a. Calculate its weight (in SI units) by using #10 on Review Sheet I.
  - b. How heavy would it be on the moon? (Again, please use SI units.)
  - c. If we measured its mass with a balance on the moon, what result would we get?
  - d. A similar object is made from the same material but is exactly three-fifths as tall, three-fifths as long, and three-fifths as wide. Predict the result that would be obtained if we measured its mass here in this room.
7. The width of a triangle is  $0.647 \pm 0.01$  meter. Its altitude is  $0.365$  meter  $\pm 1.5\%$ .
  - a. Calculate the MLV of its area. (Don't forget the units!)
  - b. Calculate the uncertainty of that area, with units.
  - c. Convert that uncertainty to percentage form.

1) \_\_\_\_\_

2) \_\_\_\_\_

3) \_\_\_\_\_

4a) \_\_\_\_\_

4b) \_\_\_\_\_

5a) \_\_\_\_\_

5b) \_\_\_\_\_

6a) \_\_\_\_\_

6b) \_\_\_\_\_

6c) \_\_\_\_\_

6d) \_\_\_\_\_

7a) \_\_\_\_\_

7b) \_\_\_\_\_

7c) \_\_\_\_\_

8) \_\_\_\_\_

## Solutions to First September Test (honors level)

1. Imagine a box with a volume of one cubic meter. Also imagine a one-gallon paint can or a half-gallon milk carton. By comparing their sizes, estimate the number of cubic meters in a gallon.

*A paint can is less than a foot high, or roughly 0.3 m high. If it were a box instead of a cylinder its width would be somewhat less than 20 cm, or 0.2 m. Its volume is then somewhat less than the product  $(0.2\text{ m})(0.2\text{ m})(0.3\text{ m}) = 0.01\text{ m}^3$ . To be very safe, make your SLV about one third of the correct value and give a GLV that is about three times the correct value:*

*One gallon is probably between **0.003 and 0.03 cubic meters**.*

2. To calculate a car's "gas mileage" you divide the distance driven by the amount of gasoline consumed. As you know, the SI unit of distance is "meters" (not miles) so the SI unit of volume must be the "cubic meters", rather than gallons. What SI units must your gas mileage have?

$$\text{Distance unit/Volume unit} = \text{m/m}^3 = \text{m}^{-2}$$

3. Suppose you can measure a time interval with an uncertainty of  $\pm 0.05$  seconds. You have a pendulum with a period of roughly 1.5 sec/sw. How many consecutive swings must you time in order to determine its period with a precision of  $\pm 0.5\%$ ? *Timing a single swing gives a percentage uncertainty of  $0.05\text{s}/1.5\text{s} = 0.033 = 3.3\%$ . Reducing that to 1% would require 3.3 times as many swings; reducing it to half a percent would require 6.6 times as many swings, or **at least 7 swings**.*

4. A ticker makes 254 dots on a paper tape in  $4.2 \pm 0.03$  seconds.

- a. Determine the period of the ticker, with absolute uncertainty.

$$P = (4.2 \pm 0.03 \text{ sec})/254 \text{ dots} = \mathbf{0.0165 \pm 0.00001 \text{ sec/dot}} = \mathbf{(1.65 \pm 0.01) \times 10^{-2} \text{ sec/dot}}$$

- b. Frequency of the ticker in range form: *SLV of freq. =  $254 \text{ dots}/4.23 \text{ sec} = 60.0 \text{ dot/sec}$*

$$\text{GLV of freq.} = 254 \text{ dots}/4.17 \text{ sec} = 60.9 \text{ dot/sec.} \quad \mathbf{\text{Frequency is between 60 and 61 dots per sec}}$$

5. A certain helical spring lying on a table is 12 cm. long. When we tie one end to a doorknob and pull on the other end with a 5.0-pound force it stretches to a new length of 40 cm. Sketch the spring's tension vs length graph with dots to represent the two given data points.

- a. How much force did the doorknob exert on the spring when stretched to 40 cm? **5.0**

**pounds**

- b. Calculate the slope of the spring's tension vs length graph.

$$\text{Slope} = \text{height of triangle/width} = 5.0 \text{ pd}/(40 - 12 \text{ cm}) = \mathbf{0.178 \text{ pd/cm}}$$

- c. Now one student pulls on one end with a force of 2.0 pounds while another student pulls the other end in the opposite direction with the same amount of force. Place a third dot on the graph to indicate the new tension and length. Make a small circle around that third dot.

- d. How long is the spring in 5c if the tension vs length graph is linear?

$$\text{width/height for smaller triangle} = \text{Width/Height for big triangle, so } w = (h)(\text{Width/Height})$$

$$w = (2.0 \text{ pd})(28 \text{ cm}/5.0 \text{ pd}) = 11.2 \text{ cm. Adding the original length, } L = 11.2 + 12 \text{ cm} = \mathbf{23.2 \text{ cm}}$$

6. The mass of a certain solid object in this room is 12.0 kilograms.

- a. Calculate its weight (in SI units) by using #10 on Review Sheet I.  $(12.0 \text{ kg})(9.8 \text{ N/kg}) = \mathbf{118 \text{ N}}$

- b. How heavy would it be on the moon? (Again, please use SI units.)  $118 \text{ N}/6 = \mathbf{19.6 \text{ N}}$

- c. If we measured its mass with a balance on the moon, what would we get? **12.0 Kg**

- d. A similar object is made from the same material but is exactly three-fifths as tall, three-fifths as long, and three-fifths as wide. *New mass =  $(12 \text{ kg})(3/5)^3 = \mathbf{2.59 \text{ kg}}$*

7. The width of a triangle is  $0.647 \pm 0.01$  meter. Its altitude is 0.365 meter  $\pm 1.5\%$ .

- a. Calculate the MLV of its area:  $(0.647 \text{ m})(0.365 \text{ m})/2 = \mathbf{0.118 \text{ m}^2}$

- b. Calculate the uncertainty of that area: *GLV of area =  $(0.657 \text{ m})(1.015 \times 0.365 \text{ m})/2 = 0.1217 \text{ m}^2$*

$$\text{SLV} = (0.637 \text{ m})(0.985 \times 0.365 \text{ m})/2 = 0.1145 \text{ m}^2. \quad \text{Unc} = (\text{GLV} - \text{SLV})/2 = \pm \mathbf{0.0036 \text{ m}^2}$$

- c. Convert that uncertainty to percentage form:  $\pm 0.0036 \text{ m}^2/0.118 \text{ m}^2 = \pm 0.0305 = \pm \mathbf{3\%}$