Homework 07

For problems that require you to write a script, save your script in a directory named `scripts/` in the top of the homework directory. If the script is supposed to calculate some answer, make a note of of the answer as the Blackboard quiz may ask you for it.

This assignment includes several unit conversion and error propgation problems. Here is a short glossary of terms that are used in the problem set and lectures:

Value A value is just a number, it does not have units.

Unit A unit is a measure for some dimension. For example, foot is a measure for length.

Quantity A physical quantity has a value and a unit. The value of 10 km is 10, the units are km. If you are asked for the value of a quantity, you should not include the unit.

Uncertain Quantity An uncertain quantity is a physical quantity with an uncertainty. For example, (12.0 ± 0.1) cm. An uncertain quantity specifies a range of quantities, in this case 11.9 cm to 12.1 cm that could be the "true" value.

Nominal Quantity The nominal quantity of an uncertain quantity is the center of the uncertain range. In our convention, it is just the quantity without uncertainty. For example, the nominal quantity for (12.0 ± 0.1) cm is 12 cm. The nominal *value* is 12.

Note that the following unit symbols are used in this problem set:

Symbol	Unit
mi	mile
ft	foot
h	hour
min	minute
lbm	pound mass
lbf	pound force
gal	gallon
acre	acre (a unit for area)

1. Write a python script named `unit-convert-length-1.py` to convert 100 km to mi and print the answer to the screen.

2. An acre per meter is a (uncommon) unit for length. For example, $10\,\frac{\text{acre}}{\text{m}}$ would be the length of a 10 acre area that is 10 m wide. Write a python script named `unit-convert-length-2.py` to convert $1\,\frac{\text{acre}}{\text{ft}}$ to km and print the answer to the screen.

3. Write a python script named `unit-convert-speed-1.py` to convert $4.352\,\frac{\text{cm}}{\text{s}}$ to $\frac{\text{mi}}{\text{h}}$ and print the answer to the screen.

4. Write a python script named `unit-convert-density-1.py` to convert $200\,\frac{\text{lbm}}{\text{gal}}$ to $\frac{\text{kg}}{\text{cm}^3}$ and print the answer to the screen.

5. A car travels 729 mi miles in 11 h and 25 min. Write a python script named `speed-calc.py` to compute the car's average speed in $\frac{\text{m}}{\text{s}}$ and print it to the screen.

6. The force required to streatch a spring depends on the "stiffness" of the spring, and how far you stretch it. The force is given by Hook's Law

$$F = k\Delta x,$$

where k is the spring constant, and Δx is how far you stretch the spring. Additionally, a stretched spring stores potential energy, and the amount of energy stored depends on the k and Δx too.

$$U = \frac{1}{2}k\Delta x^2.$$

If you stretch a spring with an unknown spring constant, and find that it takes a 22 mN force to stretch the spring 3.25 in. Write a python script named `spring-calc.py` to calculate both the spring constant for this spring, and the energy stored in the spring when it is stretched, in base SI units. Have your script print these quantities to the screen.

7. Write a python script named `uncertain-unit-convert-length.py` to convert the length measurement $(521 \pm 2)\,\text{mm}$ to in.

8. Recall that the position of an object under constant acceleration is given by the kinematics equation:

$$x(t) = x_0 + v_0 t + \frac{1}{2}at^2.$$

Consider an object who's motion is described by the following, uncertain, quantites:

$$x_0 = (25 \pm 3)\,\text{cm}$$
$$v_0 = (3.0 \pm 0.2)\,\frac{\text{mi}}{\text{h}}$$
$$a = (400 \pm 5)\,\frac{\text{m}}{\text{min}\,\text{s}}$$

Write a python script named `uncertain-position-calc.py` that will compute the position of this object in ft, with uncertainty, at a time $t = (2.00 \pm 0.05)\,\text{min}$.