Paper2Program

Name:

Date:

Physics/maths review for (Python) programming

Today we review Newtonian physics of simple motion (assume SI units for all quantities). For this task, some standard, basic maths are required as well as some specialized formulas, which we kindly provide here.

The formula for the change in height of a freely-falling object initially at rest as a function of time is

$$\Delta h(t) = -0.5 g t^2 \,. \tag{1}$$

For this test, it's fine to assume an approximate value of gravity near Earth's surface of $g \approx 10\,\mathrm{m/s^2}$.

Additionally, the horizontal displacement of an object moving at constant velocity, v, is

$$D(t) = vt \,. \tag{2}$$

Main part of test: questions to answer.

1) What is the change in height of an apple falling from rest for $t = 4\,\mathrm{s}$?

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$$\mathbf{D} = \mathbf{vt} \,, \tag{3}$$

where $\mathbf{v} = (\mathbf{v_x}, \mathbf{v_y}, \mathbf{v_z})$ and similarly for $\mathbf{D}$. What is the displacement of an object in this case moving at $\mathbf{v} = (\mathbf{3}, \mathbf{4}, \mathbf{5})$ for $2.5\,\mathrm{s}$? What is its total distance traveled?

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Program

To be made by directly translating many of the known maths:

- notations,
- structures,
- organization

(from top to bottom)

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```
# AIMS class
# October, 2012
# Programming review for maths/physics
```

Comment from beginning (might need to refer back to later, or submit as part of a project or form part of group work, etc.)

2. Will need to refer to common, *general*, known maths to do work below.

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# October, 2012
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import numpy as np
```

Import known functions from existing **libraries** such as numpy. Many commonly-used **functions** (e.g., sqrt, sin, cos, exp, etc.) from a wide number of fields have been written and can make life easier. Import these at the beginning for use anywhere later.

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Can think of a **function** as a rule for taking in some input (variables and parameters) and producing an output quantity. (To use in a program, you **call** it by name with values for its inputs, and then it can give you (**return**) the value of an output).

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NB: we also remembered to put a comment, called a **docstring**, for what the function does. This format allows the writing to be seen with the **help()** function in Python.

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Also note that the 'workings' of the function start with the colon (':') in the **def** line, and the **indentation** (tabbed spacing) at the beginning of subsequent lines shows which operations belong to it (next lines in the program after line 12 *won't* be indented). A common error in early days of programming is to get indentation wrong and to confuse the compiler/programmer/user…

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Question: anyone notice a difference between this function and the one on the left?

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where $\mathbf{v} = (\mathbf{v_x}, \mathbf{v_y}, \mathbf{v_z})$ and similarly for $\mathbf{D}$. What is the displacement of an object in this case moving at $\mathbf{v} = (\mathbf{3}, \mathbf{4}, \mathbf{5})$ for 2.5 s? What is its total distance traveled?

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# October, 2012
# Programming review for maths/physics

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def delta_h(t):
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```

Once a '**global constant**' is defined at the top, it can be controlled more easily, changing its value everywhere at once, such as gravity going from the approximation of 10 m/s^2 to having more exactness with 9.8 m/s^2. (NB: function still self-contained once input is given, because constants at top are 'seen' everywhere.) G*ood practice to define global (or program-wide) constants at top!* *[even though technically it's not a constant in Python and it's value could be changed]*

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Physics/maths review for (Python) programming

4. Can have several functions. Define the function's input.

rest as a function of time is

$$\Delta h(t) = -0.5gt^2\,. \tag{1}$$

For this test, it's fine to assume an approximate value of gravity near Earth's surface of $g \approx 10\,\mathrm{m/s^2}$.

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Physics/maths review for (Python) programming

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ts

as

at

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Similar definition of function: first define name and what input(s) are needed-- note that here, velocity is also needed as an 'input', similar to role as a parameter as if the function had been written mathematically as: *D(t ; v)*.

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Important sidenote: *are we going to run into confusion with the way 't' has now been used twice? Will their be ambiguity or overwriting of values?*

To answer, let's look at the math: here we have 't' used in several places. Is anybody confused by what it meant by 't' at any point?

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This is an example of what is called the '**scope of variables**'. The **scope** is the section of the program in which a variable can be used as itself. As one might think from the math case, the scope of each 't' is just limited to its own function definition. The same is true in the program; to the computer, the 't' is line 9 is totally distinct from that in the other function in line 14.

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# main ================================================
if __name__ == "__main__":
    '''Answer questions from class'''
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This line should be in each program, showing the end of the **def**s (functions and constants which *can* be used) and the start of the **main** operations of the program. Here, variables get assigned specific values and functions get **called** into use. Again, all variables in main are self-contained (+ global constants), so that **main** kind of behaves like a big function itself…

```

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if __name__ == "__main__":
    '''Answer questions from class'''

    # Q1
    height1 = delta_h(4)
    print height1
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    # Q1
    height1 = delta_h(4)
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```

Call function ‘delta_h’ with specific input ‘4’; the function **returns** a value, which is stored in the variable ‘height1’

NB: the '=' is the **assignment** operator. It's not a passive description of equality, but instead an *active* role of evaluating the expression on the RHS and assigning that value to a location on the computer, referenced by the variable name.

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Note that this could have been written in several ways, including even as:

t=4

height1 = delta_h(t)

Would there have been confusion with 't' values in a given function?

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Not for the computer, because of the **scope of variables**-- the other 't's were in separate functions, and this one is in **main.** However, it might get confusing to the programmer/human to keep seeing 't' everywhere, so it probably makes sense to not use 't' again here.

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where $\mathbf{v} = (\mathbf{v_x}, \mathbf{v_y}, \mathbf{v_z})$ and similarly for $\mathbf{D}$. What is the displacement of an object in this case moving at $\mathbf{v} = (\mathbf{3}, \mathbf{4}, \mathbf{5})$ for $2.5\,\mathrm{s}$? What is its total distance traveled?

```python
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# October, 2012
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import numpy as np

g = 9.8     # gravity const (m/s^2), all units SI!

def delta_h(t):
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def D(t, v):
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    return v*t







# main ===============================================
if __name__ == "__main__":
    '''Answer questions from class'''

    # Q1
    height1 = delta_h(4)
    print height1
```

Print provides a useful interface for the human to see: how the program is progressing, what value a variable has (e.g., is it to be expected, or is it a cause for worry?). Nice to use when writing and testing, as well as **ipython**.

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7. Now start calculating things, using *specific values* (that is, assigning values to variables and tracking values through operations and functions using them).

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1) What is the change in height of an apple falling from rest for $t = 4\,\mathrm{s}$?

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```

Call same function 'D' twice, use different inputs (that's why functions are efficient… don't need to keep writing same relations; ***in genera***l,if you keep typing the same lines/patterns of code over and over, there is a better way to do it, such as with a function (or perhaps with loops, discussed later).

```

    # Q2
    carA = D(2.25, 10.35)
    carB = D(2.75, 9.85)
```

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if __name__ == "__main__"
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    height1 = delta_h(4)
    print height1

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    carA = D(2.25, 10.35)
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```

'D' was defined with two inputs, so we use two inputs; it gives single output, so returned value is caught with single output.

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    # compare dists
```

Can do simple comparison with '**if/else**' to test condition and print relevant output

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    # compare dists
    if( carA > carB ):
        print '\ncar A went further, since',carA ,'>',carB
    else:
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```

Pretty simple structure: test condition, if true, start one or more operations (again, start with ':' and go until indentation stops); else, do one or more (other) operations, etc.

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# main ==============================================
if __name__ == "__main__":
```

Looks quite similar to the **def** of D. Does that make sense?

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    # Q2
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# main ===========================================
if __name__ == "__main__":
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Looks quite similar to the **def** of D. Does that make sense?

We just have to make sure when *using* this function that we input a 3D vector if we want a 3D vector output.

```
rB
    else:
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Looks quite similar to the **def** of D. Does that make sense?

We just have to make sure when *using* this function that we input a 3D vector if we want a 3D vector output.

(Actually, we could just keep using 'D', since if we input a vector v, a 3D vector will be output, in either case.)

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8b. Looking ahead, though, we see that both the vector displacement and scalar distance are asked for-- multiple outputs!

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Not a problem; can do multiple outputs, just calculate another quantity and then output it.

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```

And this will mean that it will be useful to have a separate function from 'D', since this one has different outputs and requires 3D input (since call d[0], d[1], …). Note that all quantities in 'D_vec3' are still self-contained.

```
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```

In using 'D_vec3', we can define a vector/array 'v' with specific values (again: note that due to **scope of variables**, this 'v' is different than those in function **def**s)…

```

    # Q3
    v = np.array([3.,4.,5.])
```

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… and input this with a time value to have the appropriate inputs for the function, and we make sure to have 2 outputs for the function! *Q: what **types** of variables are 'disp' and 'totdist'?*

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    # Q3
    v = np.array([3.,4.,5.])
    disp,totdist = D_vec3(2.5, v)
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array (~vector)

float (~scalar)

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For this test, it's fine to assume an approximate value of gravity near Earth's surface of $g \approx 10\,\mathrm{m/s^2}$.

Additionally, the horizontal displacement of an object moving at constant velocity, v, is

$$D(t) = vt\,. \tag{2}$$

Main part of test: questions to answer.

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    print '\ndone!\n'      # ending.
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** ***benefit of planning on paper before coding → clarity, understanding!*** **

Keywords/terms/symbols:

function, definition, call, return,
if/else(/elif),
indentation, ':',
variable, assignment, '=', scope, ' global constant',
import, library,
comment, docstring, print,
help.

Think about:

1) What is a function, and what does it do?

2) How does a computer know where a function's steps start and end?

3) What does the '=' do?

4) What is modularity, and how does it apply to program design?