Practice 3.1

Practice sheets are not assessed. The intention is to use material from lectures in preparation for Competence tests and Assignments. You are encouraged to use `thing.[TAB]` and `thing?` in IPython.

Generators and differential equations

Here's a trivial **generator** which makes the squared numbers up to some specified maximum:

```
def gen(N):
    for n in range(N):
        yield n**2

a = gen(10)
next(a), next(a), next(a), next(a), next(a)
```

```
(0, 1, 4, 9, 16)
```

A generator is like a function, except `yield` instead of `return`, and a generator **picks up where it left off** when you ask it for another value using `next`.

You can have infinite generators:

```
isprime = lambda N: all([N % n != 0 for n in range(2,N)]) if N > 1 else False
def primes(n=1):
    """Generate prime numbers, starting at n"""
    while True:
        if isprime(n):
            yield n
        n += 1 ## short-hand for n = n + 1 (but careful with mutables, such as numpy.array)
```

It can be used in a for loop, but don't forget to `break` or it could run forever:

```
stuff = list()
for p in primes(n=50):
    stuff.append(p)
    if len(stuff) >= 100:
        break
```

Try the above bits of code!

Generators are a convenient structure for solving differential equations of the form $\dot{x} = f(x)$. The simplest numerical method for this form of equation is **Euler's method**. (Do **not** use Euler's method for real problems; it's often unstable and it's not very accurate.)

Here's Euler's method as a generator:

```
def euler(f, x0, dt):
    xn = x0
    while True:
        yield xn
        xn = xn + f(xn)*dt
```

Use it to solve the differential equation $\dot{x} = -\sin x$ with $x(0) = 3$ with time-step $\delta t = 0.1$, for $0 \leq t \leq 10$.

Gaussian random numbers

The velocity distribution of gas molecules at thermal equilibrium is independent Gaussians for v_x, v_y, and v_z.

Using `randn` and `hist`, plot the **speed** distribution for gas molecules whose Gaussian width is $300\,\mathrm{m/s}$ in each direction. i.e. use `randn` and multiply values from this standard Gaussian by 300.

What is the average **speed**? i.e. compute $v = \sqrt{v_x^2 + v_y^2 + v_z^2}$ and then find the mean of v.