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import random, math, pylab

def direct_pi(N):
    n_hits = 0
    for i in range(N):
        x, y = random.uniform(-1.0, 1.0), random.uniform(-1.0, 1.0)
        if x ** 2 + y ** 2 < 1.0:
            n_hits += 1
    return n_hits

n_runs = 500
n_trials_list = []
sigmasqs = []
newf=[]

for poweroftwo in range(4, 13):
    n_trials = 2 ** poweroftwo
    sigmasq = 0.0
    for run in range(n_runs):
        pi_est = 4.0 * direct_pi(n_trials) / float(n_trials)
        sigmasq += (pi_est - math.pi) ** 2
    sigmasqs.append(math.sqrt(sigmasq/(n_runs)))
    newf.append(1.642/math.sqrt(n_trials))
    n_trials_list.append(n_trials)

pylab.plot(n_trials_list, sigmasqs, 'o')
pylab.plot(n_trials_list, newf, '-')
pylab.xscale('log')
pylab.yscale('log')
pylab.xlabel('number of trials')
pylab.ylabel('root mean square deviation')
pylab.title('Direct sampling of pi: root mean square deviation vs. n_trials')
pylab.savefig('direct_sampling_rms_deviation.png')
pylab.show()

print(n_trials)
print(n_trials_list)
print(sigmasq)

```