Quant. Comp. HW - 2

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1 Simon's Problem

(a) There are 128 possible outputs
(b) See attached source code:
0011001100001110100110000011111110111101100000010000001001110011010100001
1100010010000011101110001010010010110010100100100100001

$$\boxed{340282366920938463463374607431768211455}$$

(c) I reported an average of 15 trials
(d)

2 Modular Exponentiation

Here was my python code:

```
#Modular Exponentiation
import math

def modular_exponentiation(base, exponent, modulus):
         c = 1
         for e_prime in range(1, exponent+1):
                    c = (c * base) % modulus
        return c

print modular_exponentiation(1234, 1234*1234, math.pow(10, 10))
```

And the output was:

$$\boxed{3102217216.0}$$

3 RSA Misuse

I first tried to solve this as strictly a math problem, but had little success, in large part because I thought that the gcd(e1, e2) was somehow irrelevant to the problem. However, I noticed that normally the exponents are the same value when performing RSA, so I scoured google to see if there was some well known attack where you have a common modulus with different attacks. Turns out that it is fairly well documented, and Simmons wrote a paper on it a while back.

The basic idea is: Since

$$gcd(e_1, e_2) = 1$$

, then

$$\exists u, v \ s.t. \ e_1 * u + e_2 * v = 1$$

To solve for u and v, I used the extended Euclidean algorithm. I then raise each side to u and v

$$c1^u = (M^{e1})^u mod\ n$$

$$c2^v = (M^{e2})^v mod\ n$$

$$c1^u * c2^v = (M^{e1})^u * (M^{e2})^v mod\ n = M^{e1*u+e2*v} mod\ n = M mod\ n$$

From this I can multiply $c1^d$ and $(c2^f)^{-1}$:

$$c1^d * (c2^f)^{-1} = M^{bd}M^{-ce} = M^{bd-ce} = M mod\ n$$

Because my modular exponentiation code can't handle negatives, note that $c2^{-v}\ mod\ n = c2^{n-f} mod\ n$

4 Prime factorization

Problem: Consider n=1219326321033379414645633286435005l9

(a) How many bits is n?

```
print len(str(121932632103337941464563328643500519))
```

Output:

$$\boxed{36}$$

(b) Find if n is prime with program that runs in less than one second.

```
def miller_rabin_pass(a, s, d, n):
         a_to_power = pow(a, d, n)
         if a_to_power == 1:
                   return True
         for i in xrange(s-1):
                if a_to_power == n - 1:
                          return True
                a_to_power = (a_to_power * a_to_power) % n
        return a_to_power == n - 1

def miller_rabin(n):
        #compute s and d
         d = n - 1
         s = 0
        while d % 2 == 0:
                  d >>= 1
                  s += 1

         #Run several miller_rabin passes
         for repeat in xrange(20):
                   a = randint(2, n-1)
                   if not miller_rabin_pass(a, s, d, n):
                            return False
         return True

print miller_rabin(n)
```

$$\boxed{False}$$

(c) Simple trial divisions only need to try up to $sqrtn$ in the worst case. So

$$\boxed{O(2^{n/2})}$$

(d)

(e) See attached code