

# Random Algorithm HW 9.12

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**a**

First it is clear that the extracted bits are independent since  $x_{2i-1}, x_{2i}$  are independent on different  $i$ .

So we only need to show the  $i$ th bit has equal probability to be 1 or 0. This is actually also quite obvious since the probability for the original bias coin to generate a (heads,tails) is the same as to generate a (tails, heads) since they are independent trials.

**b**

There are  $\lfloor \frac{n}{2} \rfloor$  pairs. One pair will only generate a bit if it is a (heads,tails) or (tails,head). The expected number of bits one single pair will generate is  $p(1-p) + (1-p)p = 2p(1-p)$  by the linearity of expectation. The expected total number of bits will be  $\lfloor \frac{n}{2} \rfloor 2p(1-p)$

**c**

Y is a sequence of independent trials with head probability  $\frac{p^2}{p^2+(1-p)^2}$ . So from the result of (a), running A on Y would produce bits that are independent and unbiased. Furthermore, since the original trials are independent and the sequence X and Y will generate bits on are mutually exclusive. So the bits generated from Y are independent from the bits generated from X.

**d**

Z is a sequence of independent trials with head probability  $p^2 + (1-p)^2$ . So the bits extracted from Z using A is independent and unbiased. It is also independent from X and Y, since giving X and Y will not affect Z.

**e**

From the result of (b),(c) and (d), the total number of bits generated is the sum of those generated from X, Y, Z

So,  $A(p) = Prob(X \text{ will generate a bit}) * A(X) + Prob(Y \text{ will generate a bit}) * A(Y) + Prob(Z \text{ will generate a bit}) * A(Z)$   
 $A(Z) = p(1-p) + \frac{1}{2} * (p^2 + q^2) A(\frac{p^2}{p^2+q^2}) + \frac{1}{2} * A(p^2 + q^2)$

**f**

Substitute the function A with the entropy function H. The recursive function holds.