**Question 1**

a) in PDF??????

Inductive Step:

Take is : [Int] and i : Int arbitrary

Inductive Hypothesis: rev (flip is) = flip (rev is)

To show: rev (flip (i:is)) = flip (rev (i:is))

rev(flip (i:is))

= rev ( (-i) : flip is) (by definition of flip)

= rev (flip is) ++ [-i] (by definition of rev)

= flip (rev is) ++ [-i] (by Inductive Hypothesis)

= (flip (rev is)) ++ (flip [i]) (by C)

= flip ((rev is) ++ [-i]) (by B)

= flip (rev (i:is)) (by definition of rev)

[Alternate Solution]

Inductive Step:

rev(flip(i : is)) = rev((-i) : flip(is)) = rev(flip(is)) ++ [-i] = flip(rev(is)) ++ [-i] = flip(rev(is)) ++ (flip ([i])) = flip ((rev(is)) ++ [i]) = flip(rev(i : is))

[Add in justifications along the way, using lemmas B and C and the function definitions]

b) still requires special attention but possibly

Using array slice notation instead:

c) Q is p = acc \*

**Question 2**

Answer worked through in Mark’s 2017 Panopto recording at 1:38:00

1. i) 1

ii) 4

iii) 12

b) M1: a ≈ a0 ^ a[s] <= a0[0..a.length)

(or a[s] = min(a))

M2: a ≈ a0 ^ a[s] <= a0[0..a.length) ^ a[b] >= a0[0..a.length)

(or a[b] = max(a))`

c) Q2 [n |-> a’ , n0 |-> a] ^ P1 ^ s’ = r ^ a ≈ a0 → M1[a |-> a’ , s |-> s’]

Given:

1. a’ ≈ afrom Q2
2. a’[r] <= a’[0 .. a’.length) from Q2
3. a0 != null from P1
4. a0.length > 0 from P1
5. s’ = r from line 5
6. a ≈ a0  implicit from code

To Show:

a) a’ ≈ a0

b) a’[s’] <= a’[0..a’.length)

Proof:

7)

1. Follows from 1) and 6)
2. Follows from 2) and 5)

d)

INV: 1 <= cnt <= a.length

^ a ≈ a0

^ a[s] <= a[0 .. cnt) (a[s] = min(a[0 .. cnt)))

^ a[b] >= a[0 .. cnt) (a[b] = max(a[0 .. cnt)))

VAR: a.length - cnt

e) i) P1 ^ ∀k[0..a.length) a[k] >= 0

ii) negative values would break the altered version of Q1 thus the new precondition doesn’t allow negative values within the array (or something similar to that).