



- [6] 1 Use the Nelson-Oppen procedure to determine satisfiability of the following formulas:
- (a) The following formula combines uninterpreted functions and linear real arithmetic:
- $$z = 0 \wedge y \leq x \wedge x \leq y + z \wedge f(y) = f(z) \wedge f(y) = 1 \wedge f(z) = 2$$
- (b) The following formula combines uninterpreted functions and linear real arithmetic:
- $$x = y + 1 \wedge y \leq z \wedge x \geq z + 1 \wedge f(y) = a \wedge f(z) = b$$
- (c) The following formula combines uninterpreted functions and linear *integer* arithmetic:
- $$1 \leq x \wedge x \leq 2 \wedge f(1) = a \wedge f(x) = b \wedge a = b + 2 \wedge f(2) = f(1) + 3$$

- [2] 2 Is the theory of bit vectors convex? Give a proof or a counterexample.

- 3 Consider the following hash functions and try to find hash collisions.

- [2] (a) For the following Bernstein hash, is there a hash collision for strings of length 8?

```
unsigned bernstein(char *s, int len){
    unsigned h = 0;
    for (int i = 0; i < len; i++)
        h = (h * 33) + s[i];
    return h;
}
```

- [2] * (b) For the following FNV hash, is there a hash collision for strings of length 3?

```
unsigned fnv(char *s, int len){
    unsigned h = 14695981039346656037;
    for (int i = 0; i < len; i++)
        h = (h * 1099511628211) ^ s[i];
    return h;
}
```