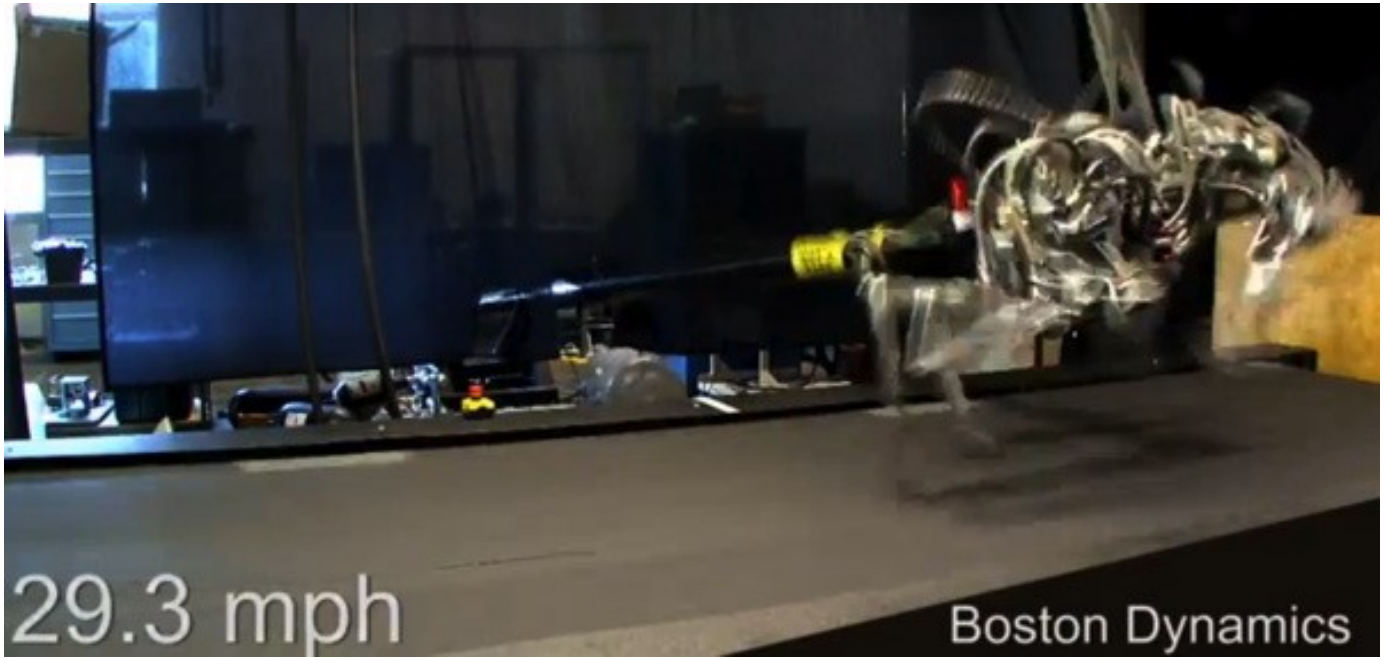
Boston Dynamics' sprinting robot, Cheetah, has now broken the land-speed record for humans, clocking speeds of 29.3 miles per hour, meaning not even the 27.79mph Usain Bolt can escape. Fortunately for us, it's got a fatal flaw; a balance problem that means it can only remain upright with a boom keeping it steady. Unfortunately, that's not going to be a problem for long, since field-testing on an independently upright version begins early next year.



http://news.cnet.com/8301-17938_105-57506996-1/all-hope-lost-as-cheetah-robot-outruns-usain-bolt/
http://news.cnet.com/8301-17938_105-57373477-1/darpa-takes-bigger-bigdog-out-for-walkies/

Open Questions

- Using dlc

  `./dlc -e bits.c`

  comment explicitly on every problem

```
[taylorm@jazz710:datalab-handout> ./dlc bits.c
dlc:bits.c:142:bitNor: Illegal operator (/)
dlc:bits.c:142:bitNor: Illegal operator (+)
dlc:bits.c:142:bitNor: Illegal operator (<<)
```

- T*U = T or U? (integer mult)
  - Just conventions for talking about math
  - Really just bit patterns

- Other questions about the lab?

1. 3
2. 3
3. 5
4. 3
5. 4
6. 2
7. 1

21 min

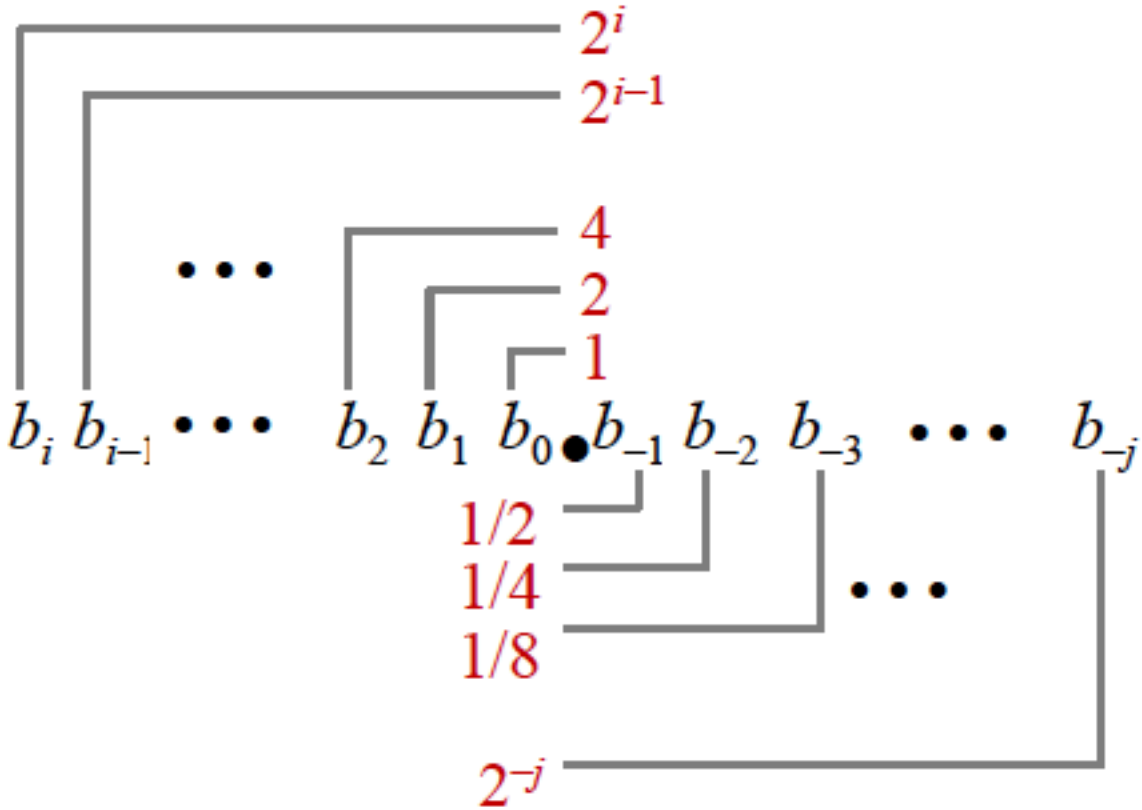
Problems considered for Quiz

- 2.17 (p. 61)
- What is -5 in two's compliment with 4 bits?
  - 5 bits?
  - 6 bits?
  - See the pattern?
- 2+5, 4 bit answer in two's compliment
- 5+5, 4 bit answer in two's compliment
- 2.31
- 3*3, 3 bit answer, in unsigned and two's compliment
- 5*3, 3 bit answer, in unsigned and two's compliment
- 2.40
- 2.44

Aside

- Precision in Python

Fractional Binary Numbers



- **Representation**
  - Bits to right of "binary point" represent fractional powers of 2
  - Represents rational number: $\sum_{k=-j}^{i} b_k \cdot 2^k$

Floating Point Representation

- **Numerical Form:**

$$(-1)^s \, M \;\; 2^E$$

  - **Sign bit** ***s*** determines whether number is negative or positive
  - **Significand** ***M*** normally a fractional value in range [1.0,2.0).
  - **Exponent** ***E*** weights value by power of two

- **Encoding**
  - MSB **s** is sign bit ***s***
  - **`exp`** field encodes ***E*** (but is not equal to E)
  - **`frac`** field encodes ***M*** (but is not equal to M)

s	exp	frac

Normalized Values

Condition 1

- **Condition: `exp` ≠ `000…0` and `exp` ≠ `111…1`**

- **Exponent coded as *biased* value: *E* = *Exp* – *Bias***
  - *Exp*: unsigned value **`exp`**
  - *Bias* = 2^{e-1} - 1, where e is number of exponent bits
    - Single precision: 127 (*Exp*: 1…254, *E*: -126…127)
    - Double precision: 1023 (*Exp*: 1…2046, *E*: -1022…1023)

- **Significand coded with implied leading 1: *M* = `1.xxx…x`$_2$**
  - **`xxx…x`**: bits of **`frac`**
  - Minimum when **`000…0`** (*M* = 1.0)
  - Maximum when **`111…1`** (*M* = 2.0 – ε)
  - Get extra leading bit for "free"

Normalized Encoding Example

- **Value:** `Float F = 15213.0;`
  - $15213_{10} = 11101101101101_2$
    $=$ [redacted]

- **Significand**
  M =
  `frac=`

- **Exponent**
  E =
  Bias =
  Exp =

- **Result:**

0		
s	exp	frac

Examples: 8 bit representation

- k = 4 (exponent)
- n =3 (fraction bits)
- (bias = 7)

0 0001 000

0 0001 001

0 0111 000

0 1110 111