Bungee Jump

$$v(t) = \sqrt{\frac{g \cdot m}{Cd}} \cdot \tanh\left(\sqrt{\frac{g \cdot Cd}{m}} \cdot t\right)$$

$$= \sqrt{\frac{9.81\,(68.1)}{0.25}} \cdot \tanh\left(\sqrt{\frac{9.81\,(0.25)}{68.1}} \cdot t\right) \qquad // \; 51.6938 \tanh(0.18977\,t)$$

Matlab

```
>>  t = [0 : 2 : 20]'          // create column vector of time values
```

step size

```
t =    0
       2
       4
       :
      20
```

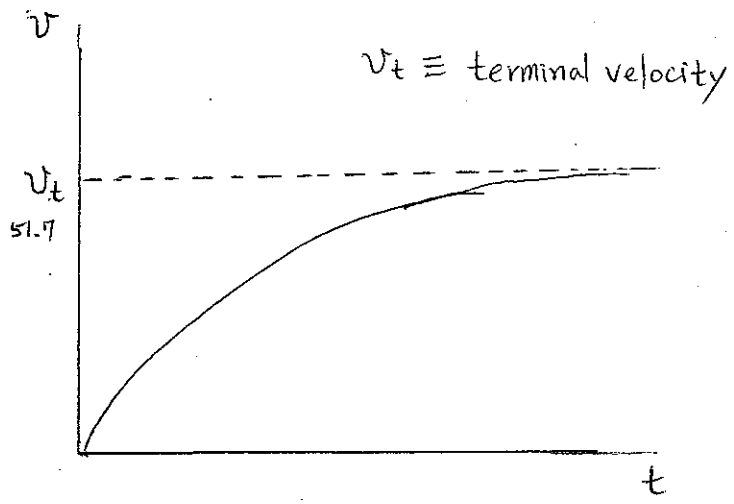
```
>> length (t)

ans =  11
```

```
>> g = 9.81;  m = 68.1;  cd = 0.25;
```

```
>> v = sqrt (g*m/cd) * tanh ( sqrt (g * cd / m) * t)

v =         0
       18.7292
       33.1118
          :
       51.6416
```



Terminal velocity, v_t

$$F = m \cdot a$$
$$= m \frac{dv}{dt}$$

$$\therefore \frac{dv}{dt} = \frac{F}{m}$$

For the bungee jumper's case,

$$F = F_d + F_u$$
$$= m g - c_d v^2$$

$$\therefore \frac{dv}{dt} = g - \frac{C_d \cdot v^2}{m}$$

Eventually, the force of gravity will be balanced with the air resistance.

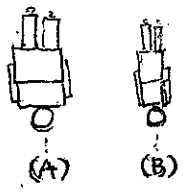
Acceleration = 0 ➔ constant velocity ➔ terminal velocity

Drag Coefficient

$$v_t = \sqrt{\frac{g \cdot m}{Cd}}$$

$$Cd = \frac{g \cdot m}{v_t^2}$$

Note.



m	83.6	60.2	72.1	91.1	92.9	65.3	80.9
v_t	53.4	48.5	50.9	55.7	54	47.7	51.1

```
>> m = [83.6  60.2  72.1  91.1  92.9  65.3  80.9]
>> vt = [53.4  48.5  50.9  55.7  54    47.7  51.1]
>> g  = 9.81
>> cd = g * m ./ vt .^2
```

cd = 0.2876 0.2511 (min) 0.2730 0.2881 0.3125 (max) 0.2815 0.3039

```
>> cdavg = mean(cd)
```

cdavg = 0.2854

```
>> cdlow = min(cd)
```

cdlow = 0.2511

```
>> cdhigh = max(cd)
```

cdhigh = 0.3125

Terminal velocity of each person using mean drag coefficient

```
>> vt = sqrt (g * m / cdavg)
```

v = 53.6065 45.4897 … 52.7338

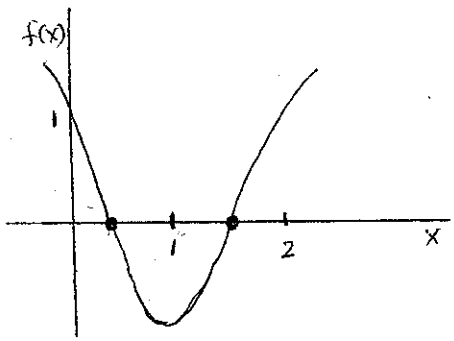
Matlab for finding roots

syntax:

fzero (function, x) // x : initial guess

or fzero (function, [x x]) // bracket that sign change occurs

Example $f(x) = x^3 - 3x + 1$




```
>> x = fzero (@(x) x^3 - 3 * x + 1, 0)
```

x = 0.3473

```
>> x = fzero (@(x) x^3 – 3 * x + 1, 1)
```

x = 1.5321

```
>> x = fzero (@(x) x^3 – 3 * x + 1, [0 1])
```

x = 0.3473

```
>> x = fzero (@(x) x^3 – 3 * x + 1, [0 2])
```

??? Error using => fzero at 293

The function value at the interval endpoints must differ in sign.