Determining the Mass of the Ninja from N

First I calculated the height (H) of the character after being launched with a force (F). Below is an explanation of the symbols used:

- m is the mass of the character
- v is the velocity of the character as he leaves the launch pad
- g is the acceleration due to gravity
- H is the maximum height the character reaches after being launched
- F is the force the launch pad applies
- t_i is the time interval over which the force of the launch pad is applied

$$\frac{1}{2}mv^2 = mgh$$

$$v = \sqrt{2gh}$$

$$mv = Ft_i$$

$$m\sqrt{2gh} = Ft_i$$

$$m^2(2gh) = F^2t_i^2$$

$$H = \frac{F^2t_i^2}{2gm^2}$$

Then the acceleration due to gravity (g) was calculated. Below are the additional symbols used:

- t_s is the time it takes to fall from the top of the screen to the bottom
- D is the distance that the character falls when dropped from the top of the screen

$$D = \frac{1}{2}gt_f^2$$

$$g = \frac{2D}{t_f^2}$$

Then the expression for the acceleration due to gravity was substituted for g in the equation for H and the equation was simplified.

$$H = \frac{F^2t_i^2}{2\left(\frac{2D}{t_f^2}\right)m^2}$$

$$H = \frac{F^2t_s^2t_f^2}{4Dm^2}$$

The formula was rearranged.

$$H = \frac{t_s^2t_f^2}{4Dm^2}F^2$$

Data Tables

D (m)	22.0
Ti (s)	0.008
Tp (s)	0.776

F (Code N)	H (± 0.5m)	F^2 (Code N)^2	H (± 0.5m)
0.3	0.5	0.09	0.5
0.4	0.9	0.16	0.9
0.5	1.5	0.25	1.5
0.6	3.0	0.36	3.0
0.7	4.0	0.49	4.0
0.8	5.6	0.64	5.6
0.9	7.6	0.81	7.6
1.0	10.2	1.00	10.2
1.1	13.0	1.21	13.0
1.2	16.1	1.44	16.1
1.3	20.0	1.69	20.0

**The grey values are the values used for analysis.*

Using the values and uncertainties values for the slope and the minimum and maximum slopes were calculated.

Slope		
Actual	Min	Max
12.2	11.6	12.8

Using the formula below where *S* is the slope the mass of the character and the minimum and maximum masses were calculated.

$$Slope(S) = \frac{t_s^2 t_f^2}{4Dm^2}$$

$$m = \frac{t_s^2 t_f^2}{2}(DS)^{-\left(\frac{1}{2}\right)}$$

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$(0.190 \pm 0.005\ g) * K$

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