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Hunting: Spear Flight Profiles

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Abstract

We build upon our previous work on prehistoric spear velocity and use Excel to calculate the velocity throughout the spear's motion and therefore calculate the maximum range it could achieve with and without a launching aid such as an atlatl.

Introduction

In a previous paper [1] we outlined a set of equations that would allow us to calculate a spear's velocity profile, with respect to time, based on a simplified model of projectile launching technique and appropriate drag forces. To recap:

$$v_x(t) = r\omega - \frac{C_D \rho_{air} A v(t)^2 t}{2m}, \quad \dots eqn 1$$
$$v_y(t) = -gt, \quad \dots eqn 2$$
$$v(t) = \sqrt{v_x(t)^2 + v_y(t)^2}. \quad \dots eqn 3$$

Modelling Using Excel

As noted previously $v_x(t)$ is dependent on the total instantaneous velocity, $v(t)$. Therefore to calculate the spear's velocity profile in Excel we will break down the projectile path into discrete time steps of interval Δt . Therefore the velocity during any given time step n , $v_x(t_n)$, can be calculated based upon the velocity of the previous time step, $v(t_{n-1})$. As $t_n - t_{n-1} = \Delta t \rightarrow 0$ this should provide a good approximation of the real velocity profile.

Using the values outlines in table 1 equations 1 and 2 can simplified to:

$$v_x(t_n) = v_x(t - \Delta t) - 0.00112v(t - \Delta t)^2 \Delta t, \quad \dots eqn 4$$
$$v_y(t_n) = -9.81t, \quad \dots eqn 5$$

Constant	Value
r	0.30 m
ω	50 rad s ⁻¹
C_D [2]	2
ρ_{air}	1.20 kg m ⁻³
A	7.00x10 ⁻⁴ m ²
m	0.75 kg
g	9.81 ms ⁻²
Δt	0.001 s

Table 1) A list of values used to simplify equations 1 and 2.

Thus we can also calculate the distance travelled during each time step and therefore plot the instantaneous x and y position using:

$$x(t_n) = v_x(t_n)\Delta t + \sum_{t:0 \rightarrow (n-1)} x(t), \quad \dots eqn 6$$

$$y(t_n) = v_y(t_n)\Delta t + \sum_{t:0 \rightarrow (n-1)} y(t), \quad \dots eqn 7$$

Results and Conclusions

Assuming an initial launching height of 1.5 m for an unaided spear throw we find that the maximum distance travelled is 8.3 m in 0.55 s. When an atlatl of length 0.45 m is used this distance increases to 20.5 m (see fig 1). This clearly shows that using an atlatl was advantageous for prehistoric hunters.

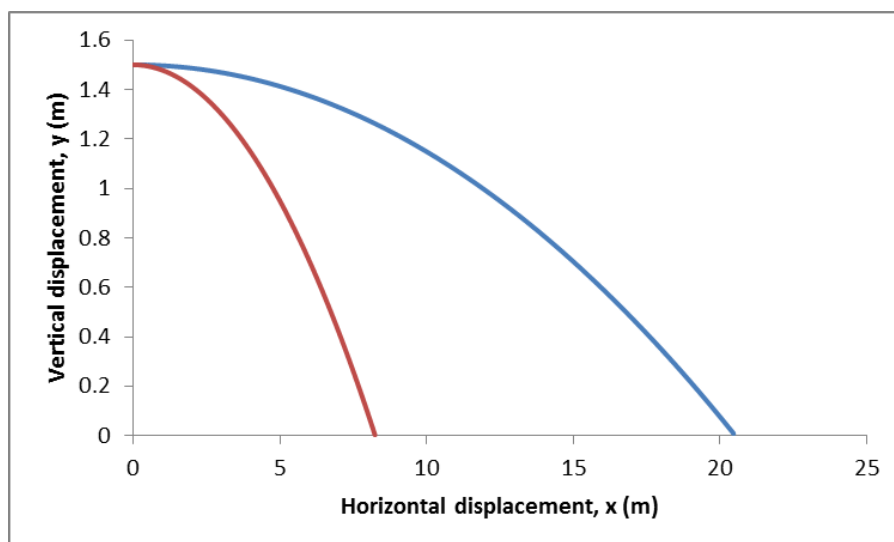


Figure 1) Spear flight profiles: (red) unaided spear and (blue) atlatl assisted spear.

References

- [1] Hurkett, C. P. (2013) Hunting: Prehistoric Spear Velocity. JIST, vol 01.
- [2]<https://sites.google.com/site/technicalarchery/technical-discussions-1/drag-coefficients-of-bullets-arrows-and-spears>