

Momentum

Momentum is the unit that has been taught to the archery world what gives us penetration. At this time, there has only ever been one study looking at arrow lethality and what gives us penetration. That is the Ashby studies. (1)

In the studies, there is a paper called "Momentum, Kinetic Energy, and Arrow Penetration (And What They Mean for the Bowhunter)" (2)

In the paper, Ashby talks about momentum. One of the critical points Ashby makes is, "Given two arrows, identical in shaft and broadhead materials and profile, and having EQUAL momentum, but possessing UNEQUAL mass, the arrow deriving the greater portion of its momentum from its mass will penetrate better. The Laws of Physics requires this to be true" (2)

A quick research of equal momentum but unequal mass shows this statement by Ashby to be a false statement. Looking at Newton's Second Law and the Work-Energy Theorem, (3) we can look at an equation looking at two arrows with equal momentum and unequal mass. The equation uses the mass of the two arrows and the velocity. In the equation, you can calculate which arrow will be easier to stop.

Looking at the arrow, that will be easier to stop. (ETS)

The equation is $(m1 < m2) (v1 > v2) ETS = .5*m1*(m2/m1) *v2^2$

Here is some data provided by Joel Maxfield.

Arrow 1

- 400gr
- 313FPS

Arrow 2

- 600gr
- 209FPS

Equal Momentum	kg	m/s	J	р	
Arrow 1 (m1)	0.0259196	95.4024	117.9550	2.4728	
Arrow 2 (m2)	0.0388793	63.7032	78.8881	2.4767	
ETS (J)= .5*m1*(m2/m1)*v2^2			78.8881		
	gr	FPS	KE	slug- ft/s	
Arrow 1 (m1)	400	313	86.9993	0.55591	
Arrow 2 (m2)	600	209	58.185	0.55679	
Data provided by Joel Maxfield					

Here is a look at the calculations of the two arrows.

Looking at the calculation of the ETS, you can see that working the equation shows that the 600gr with equal momentum to the 400gr will be easier to stop.

Next, we need to look at a test to see if the test results show what physics tells us to be true. Joel Maxfield provided a test with equal momentum using a stationary foam target.

The measurements of penetration.

Arrow	pen. (meters)		
.02592kg	0.32639		
.03888kg	0.25273		
	pen. <i>(in)</i>		
400gr	12.85		
600gr	9.95		
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Data provided by Joel Maxfield

Looking at the penetration measurements into a foam target, we see the results based on the equal momentum unequal mass calculation.

The test is a physics test based on the test media of a foam target. The test correlates to what physics tells us to be true. The outcome of the test may or may not be equal to a test on a live animal. The test and the equation based on physics show Ashby's statement in his study to be a false statement.

References

- 1. <u>Ashby Reports Ashby Bowhunting Foundation</u>
- 2. <u>Microsoft Word New PDF copy, Momentum, Kinetic Energy and Arrow Penetration</u> (squarespace.com)
- 3. <u>Work-Energy Theorem: Definition, Equation (w/ Real Life Examples) | Sciencing</u>

Data provided by Joel Maxfield

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