Bows with the Same 300 N Peak Store Energy Differing 1.43 Times by Force Shape, One Held at Full Draw with 60 N

— over a 0.5 m draw, a force proportional to draw stores 75.000000 J while a force that rises and holds flat stores 107.250000 J — the separator is whether a bow's strength is stated as its peak force or as the force integrated over the draw — [Paper 792]

Yuuki YAMAGISHI (山岸 勇輝)
Yamagishi Complexity Torus Lab, Japan
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— *From thinking to syncing.* —

Abstract

A bow's strength is often stated as the peak force needed to draw it. But what passes to the arrow is the energy stored during the draw.With three force shapes sharing the same peak, stored energy, holding force at full draw and arrow speed are counted.No new theorem or law is claimed. First, with the same peak force, stored energy differs ——75.000000, 88.235294 and 107.250000 J (Section 2). **Second, and this is the core. What sets the energy is not the peak force but the shape of the force——shares of peak force times draw are 0.500000, 0.588235 and 0.715000, and the third over the first is 1.430000** (Section 2). **Third, the holding force at full draw can be separated from the peak——the third shape peaks at 300 N yet holds at full draw with 60 N** (Section 2). **Fourth, arrow speed differs as the square root of energy——69.282032, 75.146915 and 82.849261 m/s, a ratio of 1.195826** (Section 3). **Fifth, for the same energy, a smaller peak will do——the third shape stores 75 J with a peak of 209.790210 N** (Section 3). **Sixth, the separator is whether a bow's strength is stated as its peak force or as the force integrated over the draw——"the stronger the bow, the faster the arrow" has no truth value until one says whether strength means peak force or the integral** (Section 4). **Keywords**: bows, springs, work and energy, force-draw curve, compound bow, integration.

Scope of this paper (scope note): **No new theorem or law is claimed——stored energy being the work integrated over the draw, energy changing with force shape at the same peak, and the reduced holding force at full draw of bows with pulleys (let-off) are all known (Klopsteg 1943, Halliday et al. 2013).Force shapes are arrangements——the proportional, 0.7-power and rise-flat-drop shapes are set up for comparison; real bows' force curves are not claimed.Efficiency is held equal——0.8 of stored energy passes to the arrow for all shapes; efficiency differences by shape are not included.Values are representative——peak force 300 N, draw 0.5 m, arrow mass 0.025 kg.Bow design and competition rules are not treated——which bow to choose is not stated.Relation to earlier papers**: **Paper 774 showed that a thermocouple measures not a temperature but an integral between two junctions——its scope note was limited to thermocouple electromotive force. There what looked like a point value was an integral. Here the "peak force" that expresses a bow's strength is counted as not setting the energy passed to the arrow (the integral of force). An integral of temperature, and an integral of force.**What is added is **deriving energy for three shapes with the same peak two ways, by formula and numerical integration**, **tabulating shares of peak force times draw up to 0.715000**, **deriving holding force and arrow speed**, **deriving the 209.790210 N peak needed for the same energy**, and **placing the separator on peak versus integral**.

1. Notation and the Question

Setting: **let $F(x)$ be the force at draw x and d the draw length. Stored energy E, the shape share relative to peak force $F_{\max}$, and the speed of an arrow (mass m, efficiency η) are as follows.**

$$E = \int_0^d F(x)\,dx, \qquad \frac{E}{F_{\max}\,d}, \qquad v = \sqrt{\frac{2\eta E}{m}}$$

Three shapes are compared: proportional (spring) $F = F_{\max}x/d$; 0.7 power $F = F_{\max}(x/d)^{0.7}$; and a third that rises to $F_{\max}$ by 0.25 of the draw, holds flat to 0.70, drops to 60 N by 0.90, then stays at 60 N (the compound shape). Take $F_{\max} = 300$ N, $d = 0.5$ m, $\eta = 0.8$ and $m = 0.025$ kg.

Question: **do bows with the same peak force store the same energy?**

2. Stored Energy

Computation 2.1: **for the three shapes, energy was derived two ways, by piecewise formula and by Simpson integration with kinks aligned to the grid (largest relative difference 3.036×10^{-9}).**

force shape	energy (formula, numerical)	share of peak force times draw	holding force at full draw	arrow speed
proportional (spring)	**75.000000**, **75.000000** J	**0.500000**	**300.0** N	**69.282032** m/s
0.7 power	**88.235294**, **88.235294** J	**0.588235**	**300.0** N	**75.146915** m/s
compound shape	**107.250000**, **107.250000** J	**0.715000**	**60.0** N	**82.849261** m/s

Observation 2.2

with the same peak force, stored energy differs.Every peak is 300 N, yet the energies are 75.000000, 88.235294 and 107.250000 J.

Observation 2.3

this is the core: what sets the energy is not the peak force but the shape of the force.The shares of peak force times draw are 0.500000, 0.588235 and 0.715000, and the energy ratio of the third to the first is 1.430000——a shape that rises early and holds a high force long stores more for the same peak.

Observation 2.4

the holding force at full draw can be separated from the peak.The proportional and 0.7-power shapes hold 300 N at full draw, while the third holds with 60 N——the weight felt at the end, the peak force and the stored energy are each a different number.

3. Arrow Speed and Equal Energy

Computation 3.1: the energy and speed ratios, and the peak force of the third shape storing the same 75 J, were derived.

quantity	value
energy ratio (compound / proportional)	1.430000
arrow speed ratio	1.195826
peak force of compound shape storing 75.0 J	209.790210 N

Observation 3.2

arrow speed differs as the square root of energy.With 1.430000 times the energy, the speed is 1.195826 times.

Observation 3.3

for the same energy, a smaller peak will do.To store the same 75 J as the proportional bow, the third shape needs a peak of only 209.790210 N——a bow with a smaller peak can shoot an arrow as fast as one with a larger peak.

4. The Separator

Observation 4.1

the separator is whether a bow's strength is stated as its peak force or as the force integrated over the draw.By peak force all three are equally strong at 300 N; by the integral they differ 1.430000 times, from 75.000000 to 107.250000 J——"the stronger the bow, the faster the arrow" has no truth value until one says whether strength means peak force or the integral.

Observation 4.2

beside Paper 774.Paper 774 showed that a thermocouple measures not a point temperature but an integral between two junctions——here the peak force expressing a bow's strength is counted as not setting the energy passed to the arrow, which is an integral. The confusion of point value and integral appears on the side of temperature and on the side of force.

Observation 4.3

what is not said.Real force curves, efficiency differences by shape, bow selection and competition rules are not treated——what is shown is that peak force, stored energy and holding force are different numbers.

5. Roll Call and Closing

1. **proportional shape 75.000000 J** (Computation 2.1): **share 0.500000.**
2. **0.7-power shape 88.235294 J** (Computation 2.1): **share 0.588235.**
3. **compound shape 107.250000 J** (Computation 2.1): **share 0.715000.**
4. **energy ratio 1.430000** (Observation 2.3): **the core.**
5. **holding force 60 N** (Observation 2.4): **separate from the peak.**
6. **arrow speeds 69.282032 and 82.849261 m/s** (Computation 2.1): **differing as a square root.**
7. **speed ratio 1.195826** (Observation 3.2): **square root of the energy ratio.**
8. **209.790210 N for the same 75 J** (Observation 3.3): **a smaller peak will do.**
9. **formula and integration differ by 3.036×10^{-9}** (Computation 2.1): **two ways agree.**
10. **peak or integral** (Observation 4.1): **the separator; Paper 774.**

Closing: **Bows with the same 300 N peak store energy differing 1.430000 times with the shape of the force, and one can be held at full draw with 60 N.Over a 0.5 m draw, the proportional shape stores 75.000000 J, the 0.7 power 88.235294 J, and the rise-flat-drop shape 107.250000 J, shares of peak force times draw of 0.500000, 0.588235 and 0.715000——what sets the energy is not the peak force but the integral of the force's shape.Arrow speeds of 69.282032, 75.146915 and 82.849261 m/s differ as the square root of energy, and to store the same 75 J as the proportional bow the third shape needs a peak of only 209.790210 N——peak force, stored energy and holding force are each a different number.The separator is whether a bow's strength is stated as its peak force or as the force integrated over the draw.Placed among the earlier papers——Paper 774 separated point value and integral on the side of temperature; this counts the same confusion on the side of force.To be honest——the force shapes are arrangements, and neither real bow curves nor efficiency differences are treated.**

References

1. Halliday, D., Resnick, R., & Walker, J. (2013). *Fundamentals of Physics* (10th ed.). Wiley.
2. Klopsteg, P. E. (1943). Physics of bows and arrows. *American Journal of Physics*.

3. Yamagishi, Y. (2026). *A Thermocouple Measures Not a Temperature but an Integral Between Two Junctions* [Paper 774]. Zenodo. 10.5281/zenodo.23015271

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Yuuki YAMAGISHI (山岸 勇輝)

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