Seeing Force

A Newtonian Phenomenology of Perceived Motion in the Psycho-Vector Series

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Abstract

Why do we perceive movement in a static painting, and why do some images seem to move faster than others? Beginning in the early 1980s, and inspired by the pictorial dynamism of Wassily Kandinsky, I set out to answer these questions by mapping the perception of visual motion, term for term, onto the quantities of Newtonian mechanics. The Psycho-Vector series is the result: a sequence of paintings that leads a viewer through that mapping in stages, from the perception of shape to the perception of velocity, mass, momentum, force, and energy, and finally to the summation of these quantities across whole fields of form. This paper presents the theoretical account of the series. It begins not with paint but with the body, using a simple demonstration in water to show how felt force and seen motion are fused into a single perceptual meaning that vision alone can later recover. It then shows how a single triangular form yields, to the trained eye, a measurable velocity (its slope), a mass (its area), and their products, and it follows the construction through to the vector summation of a field. The argument throughout is that this multisensory fusion is what allows configured light to be experienced as carrying force, and that it therefore supplies the perceptual foundation on which the entire mapping rests.

Keywords: *visual perception; multisensory integration; Newtonian mechanics; momentum; force; vector summation; visual poetics; Kandinsky; psycho-vector*

1. Introduction

Two questions motivate the work described here. The first is why we are able to perceive movement at all in a static piece of artwork — why a fixed arrangement of marks on a flat surface should seem to surge, rise, or rush. The second is why some images are perceived to imply a greater velocity than others, so that one form reads as swift and another as ponderous though neither in fact moves. These questions are not merely psychological curiosities; they point to something fundamental about how vision carries meaning.

The paintings of Wassily Kandinsky taught a generation of viewers to see a canvas not as an inert arrangement of colored areas but as a field in motion. Lines advance and recede; a point presses on the plane that contains it; forms travel across the surface in different directions and, unmistakably, at different velocities (Kandinsky 1977 [1911]; 1979 [1926]). Kandinsky described these effects in a vocabulary of tension and inner life. Studying Newtonian mechanics at the same time that I was looking at such pictures, I was struck by a correspondence that seemed to me more than metaphor. If a painting can present motion that has both direction and magnitude, then it presents something formally identical to a vector; and if the eye can read differences of velocity across a surface, then it is already performing, intuitively, an operation that physics performs explicitly. The question that organizes the present work is whether the perceptual content

of pictorial movement can be mapped, term for term, onto the kinematic and dynamic quantities of classical mechanics — position, velocity, mass, momentum, force, and energy.

The Psycho-Vector series was conceived as the demonstration of that mapping. Rather than merely asserting the correspondence, the paintings are arranged to lead a viewer through it in stages, and this paper follows the same staged path. I use the term psycho-vector to name the object of that perception — the felt-and-seen vector, a quantity of perceived motion or force that is at once a fact of the picture and a fact of the body that reads it. Before any claim can be made about paint, however, the perceptual phenomenon on which the whole series depends must be exhibited plainly. That is the purpose of the demonstration with which we begin.

2. The Merging of the Senses: A Demonstration in Water

Consider an experience available to anyone with access to a swimming pool. Seated at the edge, one lowers a hand into the water and sweeps it back and forth. The character of the experience depends sharply on the orientation of the hand. When the broad face of the palm is held parallel to the direction of travel, so that the hand enters the water edge-on (Figure 1), the hand slices through with little resistance. When the palm is turned so that its broad face is normal — perpendicular — to the direction of travel (Figure 2), the same sweep meets pronounced resistance, and the hand drags a visible mass of churning water behind it.

Figure 1. ***The sweeping hand held edge-on, its palm parallel to the direction of travel. The streamlined orientation presents minimal area to the water and meets little resistance.***

Figure 2. ***The sweeping hand held broadside, its palm normal to the direction of travel. The orientation presents maximal area and meets pronounced resistance, dragging a turbulent wake.***

This contrast is not incidental; it is lawful, and Newton himself analyzed it. In Book II of the Principia, devoted to the motion of bodies through resisting media, Newton established that the resistance offered by a fluid increases with the cross-sectional area the body presents to the flow and with the square of the body's speed (Newton 1999 [1687]). Modern fluid dynamics records the same relation in the drag equation,

$$F_d = \tfrac{1}{2} \rho v^2 C_d A,$$

in which ρ is the density of the fluid, v the speed of the hand relative to the water, A the frontal area presented to the flow, and C_d a dimensionless coefficient that encodes the influence of shape. Held edge-on, the palm presents a small frontal area and a low drag coefficient, and the resistance is slight; held broadside, it presents a large area and a high coefficient, and the resistance is large. For a fixed muscular effort, then, the edge-on hand attains a markedly greater velocity, while the broadside hand moves slowly and spends its effort stirring a broad, turbulent wake. We register this difference twice over: we feel it as a difference in the load borne by the arm, and we see it as a difference in the water itself. The same event is delivered to two senses at once — and, crucially, it is delivered as one event.

That the two deliverances are experienced as one is the point on which everything that follows depends. They are not two parallel reports to be compared and reconciled after the fact; they form a single happening with a single meaning. Merleau-Ponty argued that this unity is constitutive of perception rather than a synthesis added to it: the senses communicate within the lived body, and a perceived thing is grasped whole, across the modalities, before it is ever decomposed into the separate data of sight or touch (Merleau-Ponty 1962 [1945]). The hand in the water is not a visual flow plus a tactile load; it is the resistance of the water, perceived.

That force itself can be an object of vision — not merely inferred from sight but seen — has direct experimental support. Michotte showed that observers viewing wholly abstract displays, in which one shape approaches and "launches" another, spontaneously and irresistibly perceive a transmitted force and a causal relation, with no appeal to reasoning (Michotte 1963 [1946]). In a kindred spirit, Arnheim held that pictorial compositions are experienced as fields of directed tension, so that the "visual forces" a viewer feels in a composition are not a figure of speech but a description of what the eye is actually given (Arnheim 1974; 1982). Gibson, for his part, showed that the optic flow generated by motion lawfully specifies that motion to an observer (Gibson 1979). On these accounts the perception of motion and force is not a late intellectual achievement but part of the primary furnishing of sight.

Two consequences follow. First, because the felt resistance and the seen flow are fused into one meaning at the moment of experience, that meaning becomes available to either sense alone on later occasions. Having many times both felt and watched the water resist a broadside hand, one needs thereafter only to see such a motion — or even a still record of it, as in Figure 2 — to recover implicitly the force it involved. Second, this is exactly the capacity a painting exploits. A canvas offers nothing to the hand; it offers only configured light. Yet because the eye has been schooled by a lifetime of episodes like the one in the pool, configured light suffices to deliver velocity and force to the viewer. The static image is read dynamically because perception was dynamic to begin with.

3. Reading Velocity from a Form

With that foundation in place we can turn to form alone. Consider the pair of triangular figures that constitute the 1981 painting Equal Momentum Study of Isosceles Images with Seven Times Difference in Velocity (Figure 3): a narrow, spire-like triangle at the left and a broad triangle at the right, each rising from a common base toward the top of the picture. Let us deliberately restrict the viewing context to a single direction — upward, toward the top of the field — and regard the image as a flat, two-dimensional plane. The restriction is methodological: by collapsing the reading to one axis we obtain a scalar magnitude of motion, the visual counterpart of speed rather than of velocity in its full vectorial sense. (We lift this restriction in Section 7.)

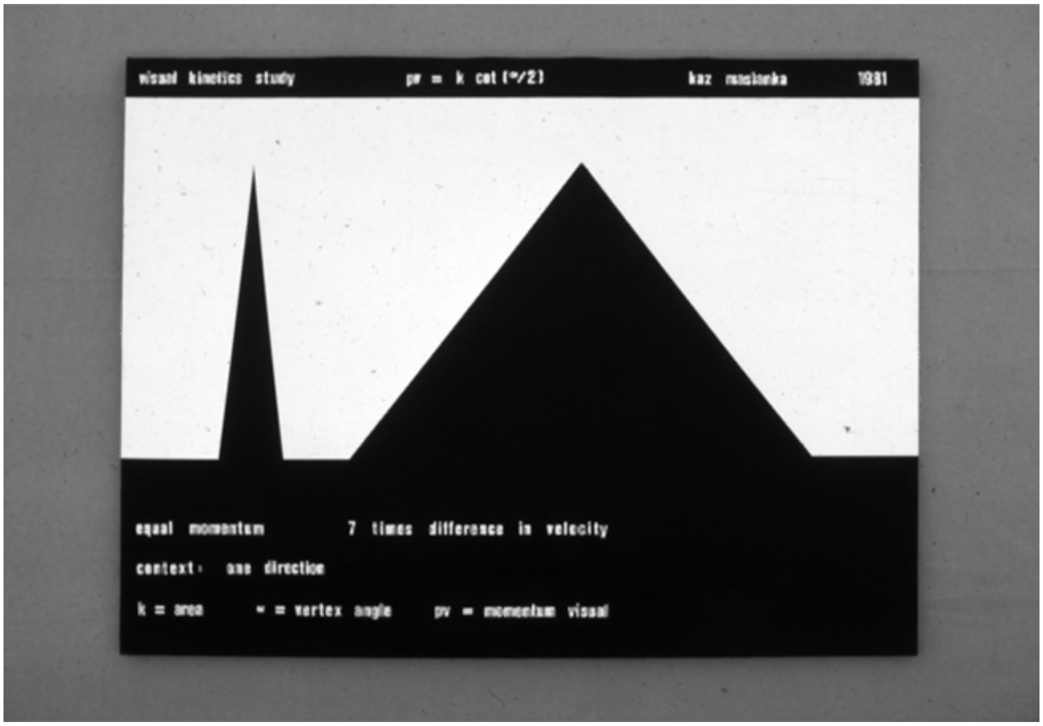

Figure 3. *Equal Momentum Study of Isosceles Images with Seven Times Difference in Velocity (1981; oil on canvas, 36" × 48"). Inscribed $p_v = K \cot(\alpha/2)$; the narrow figure reads as seven times faster than the broad one, yet the two carry equal visual momentum.*

Asked which figure implies the greater velocity, almost every viewer chooses the narrow triangle at the left; it looks faster. The reason lies in the inclination of the sides that rise from the vertex. Those sides ascend toward the top of the picture more steeply than they spread toward its edges — they gain more height per unit of width — and the steeper that ascent, the greater the impression of speed. This is a quantity we can measure. Counting the units a side rises and dividing by the units it runs yields the slope,

slope = rise ÷ run.

For the narrow figure the side rises seven units while running one (Figure 4), giving a slope of 7/1 = 7. For the broad figure the side rises one unit while running one (Figure 5), giving a slope of 1/1 = 1. We may therefore say, within the chosen context, that the left figure carries seven times the velocity of the right: it reads as travelling seven times faster. Visual velocity, on this construction, is the slope of the form's bounding edge relative to the base of the picture.

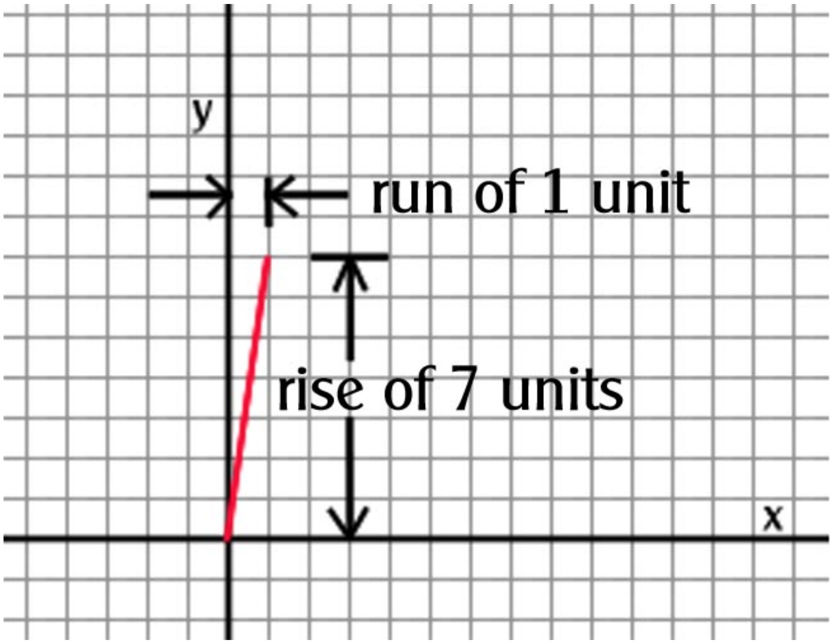

Figure 4. ***Measuring the slope of the narrow figure's edge: a rise of seven units against a run of one, giving a slope of 7.***

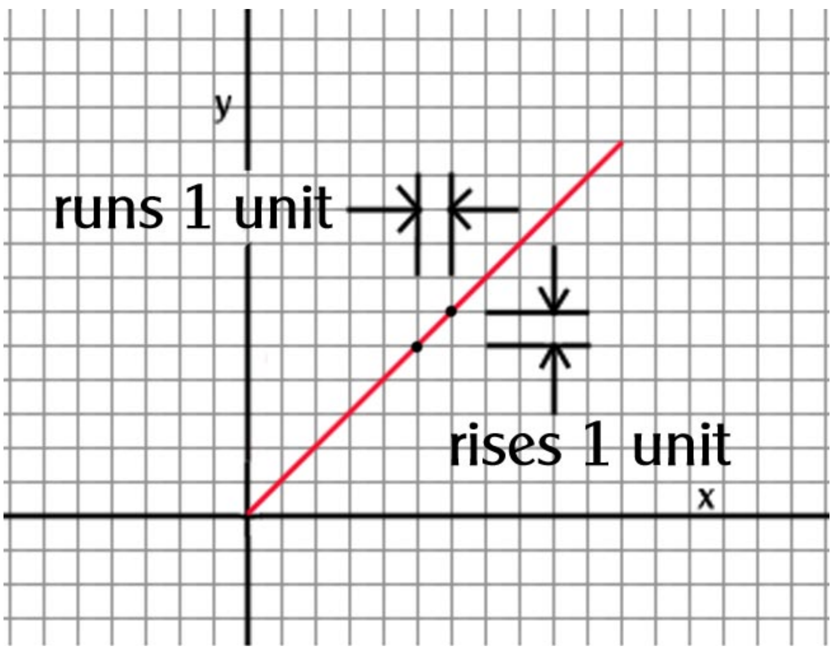

Figure 5. ***Measuring the slope of the broad figure's edge: a rise of one unit against a run of one, giving a slope of 1.***

4. Reading Mass from a Form

A second question may be put to the same pair: which figure is the more massive? Here the verdict reverses. The broad triangle at the right,

covering by far the greater area, appears the weightier of the two. The judgment is as immediate as the judgment of speed, and it suggests a second correspondence: that the eye reads the area a form occupies as its mass. Visual mass, on this construction, is the area of the form. We now possess two readings drawn from a single shape — the triangle's slope gives its velocity, its area gives its mass — and it remains to combine them.

5. Visual Momentum

In mechanics, momentum (p) is the product of mass and velocity, $p = mv$. The quantity is easily felt. Imagine two marbles of equal size, one of wood and one of steel, thrown at the chest with the same speed (Figure 6). The steel marble hurts more. Their velocities are identical; what distinguishes them is mass, and the greater mass of the steel marble gives it the greater momentum. At equal velocity, more mass means more momentum — and the body registers the difference directly, just as it registered the difference of resistance in the pool.

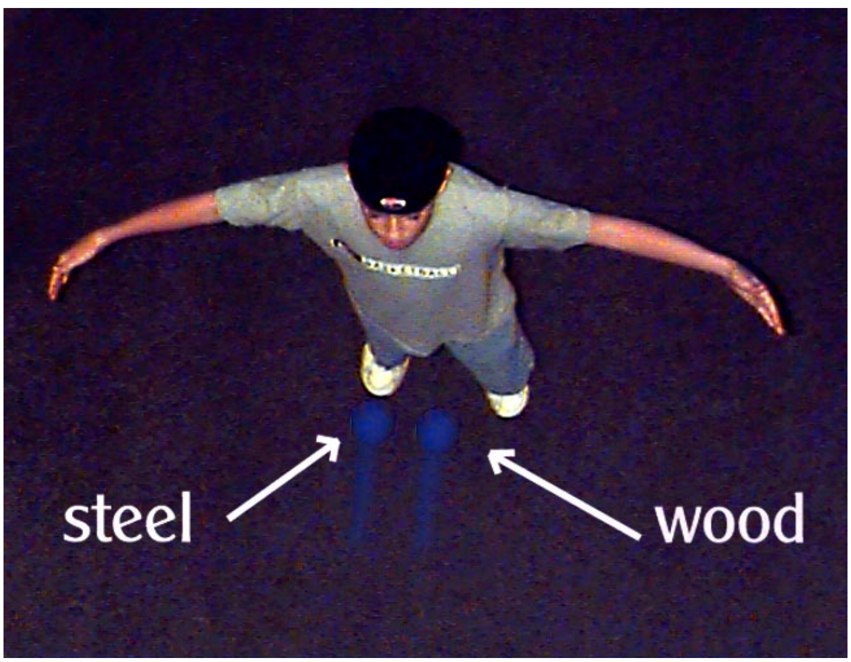

Figure 6. *The marble demonstration. Two marbles of equal size but different material — one wood, one steel — thrown with the same velocity. The steel marble, having the greater mass, strikes with the greater momentum.*

By analogy, and within the one-directional context already established, we may define a visual momentum, p_v, as the product of visual mass and visual velocity — that is, of area and slope:

$$p_v = slope \times area.$$

It is worth replacing slope with an equivalent trigonometric expression, because doing so binds the quantity directly to the geometry of the form. A side rising from the apex makes an angle of half the vertex angle with the figure's vertical axis; its slope relative to the horizontal base is therefore the cotangent of that half-angle (Figure 7). Writing α for the vertex angle, slope = $\cot(\alpha/2)$. Letting K denote the area, visual momentum takes the form inscribed on the paintings themselves:

$$p_v = K \cot(\alpha/2).$$

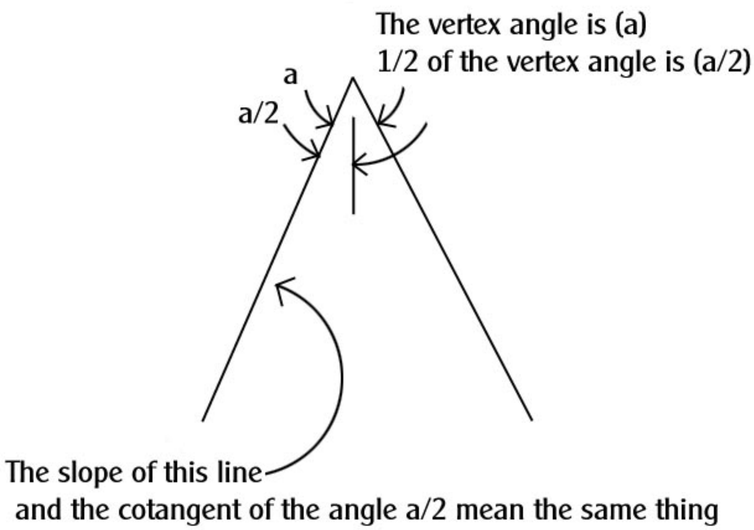

Figure 7. *Why slope equals $\cot(\alpha/2)$. For a vertex angle α, each side makes the angle $\alpha/2$ with the vertical axis; the slope of that side relative to the horizontal base is the cotangent of $\alpha/2$. The two descriptions are identical.*

A quick check fixes the intuition: a vertex angle of 90° gives sides at 45° and a slope of cot 45° = 1 (the broad figure), while a slope of 7 corresponds to a vertex angle of roughly 16° (the narrow spire). The formula is not merely descriptive; in Figure 3 it is constructive. The two triangles are proportioned so that their visual momenta are equal even as their velocities differ by a factor of seven. The narrow figure, with a slope of seven, is given one-seventh the area of the broad figure, whose slope is one; the products $7 \times \frac{1}{9}$ and 1×1 coincide. The eye is thus presented with two forms that read as sharing a single momentum while one appears to move seven times faster than the other — a visible demonstration that velocity and mass trade off in perception exactly as they do in mechanics. More generally, any two isosceles images of the same height carry the same visual momentum: the greater area of the wider one exactly compensates the greater slope of the narrower one, and the bargain always balances.

The construction need not be confined to isosceles forms. Figure 8, Equal Momentum Study of Isosceles and Scalene Images with Three Times Difference in Velocity (1981), pairs an isosceles figure carrying three times the velocity of a scalene figure of unequal sides; once again the two are proportioned to share a single visual momentum. The principle is general: whatever the shape, the product of slope and area fixes the momentum the form conveys.

Figure 8. *Equal Momentum Study of Isosceles and Scalene Images with Three Times Difference in Velocity (1981; oil on canvas, 36" × 48"). The isosceles figure at left carries three times the velocity of the scalene figure at right; the two carry equal visual momentum.*

6. Visual Force and Visual Energy

Physics defines force (F) as the change in momentum per unit time. The meaning is vivid in the children's game of egg toss, in which two players throw a raw egg back and forth, stepping apart after each catch; the team that throws and catches it over the greatest distance without breaking it wins (Figure 9). The whole art of the game is to bring the egg's momentum from its maximum, in flight, down to zero, at rest in the hand, over the longest possible time. A player who lets the hand travel backward with the egg, slowing it gradually, spreads that change over a long interval and exerts little force; a player who stops it abruptly spreads the same change over a short interval and exerts a large force — and the egg breaks. To

change a momentum over a long time is to apply a small force; to change it over a short time is to apply a large one.

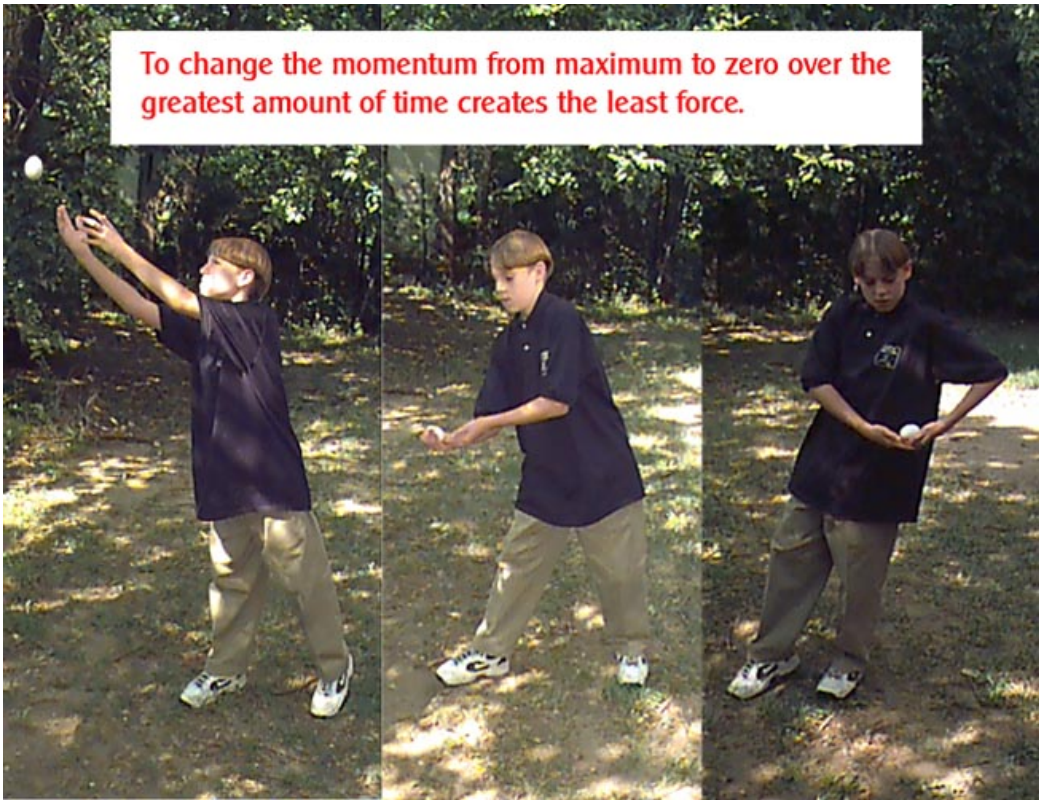

Figure 9. ***Bringing a moving mass to rest. Spreading the change of momentum over a longer time yields a smaller force; the same change over a shorter time yields a larger force.***

To carry this into the picture we need a visual time. The change in visual momentum is easy to identify — it runs from zero, where the form begins at its base, to a maximum, where it culminates — but the painting does not tell us directly how much time has elapsed. It does, however, imply a distance of travel, namely the height the form rises (Figure 10). Physics relates these by d = vt: distance equals velocity multiplied by time. We already know the distance (the rise) and the velocity (the slope), so we may solve for the time. Because slope is rise divided by run, and the run for a single side is half the base, the time this yields is exactly half the base of the triangular image. This is the temporal midpoint of the motion — the average of the initial and final times — so the full elapsed time, the final time, is twice that value, which we write as 2t. The result is consistent in both languages at once: velocity is distance over time in physics, and rise over run in visual kinematics, and the two readings agree.

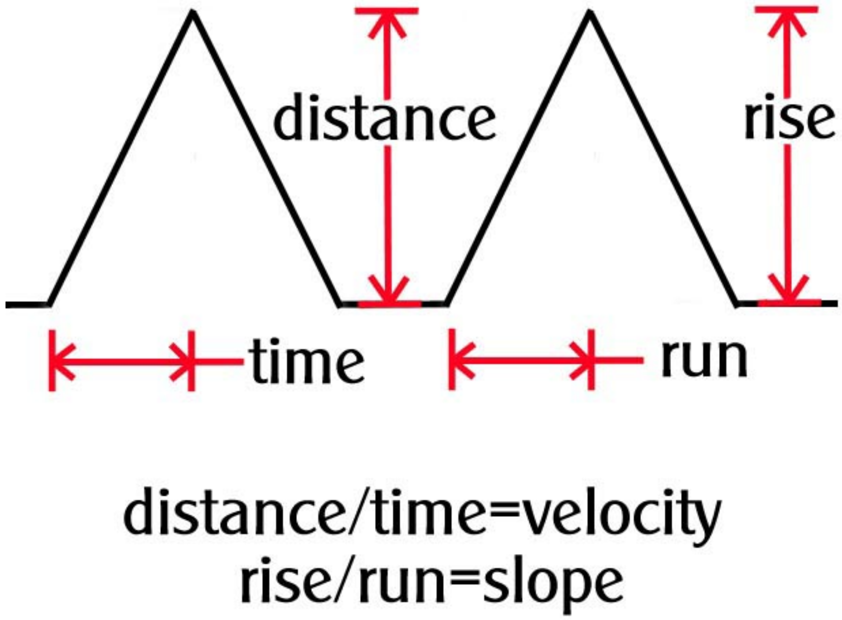

Figure 10. *Reading time from the form. The rise of the triangle stands for distance, its run for time; their ratio (rise over run) is the velocity. Solving d = vt for the time yields half the base, the midpoint of the motion, so the full elapsed time is 2t.*

With a visual time in hand, visual force is simply the maximum visual momentum divided by the time over which it is acquired:

$F_v = K \cot(\alpha/2) \div 2t.$

And since physics defines energy as force times distance, E = Fd, the corresponding visual energy is

$E_v = d \cdot K \cot(\alpha/2) \div 2t.$

Just as a painting can be built to equalize momentum, it can be built to equalize force. Figure 11, Equal Force Study of Isosceles Images with Four Times Difference in Momentum (1984), pairs two figures in which the left carries four times the visual momentum of the right while the two share a single visual force — the larger momentum of the left being acquired over a correspondingly longer implied time, so that momentum-per-time comes out the same. The inscription records the relation as $F_v = (K \cot(\alpha/2)) / 2t$.

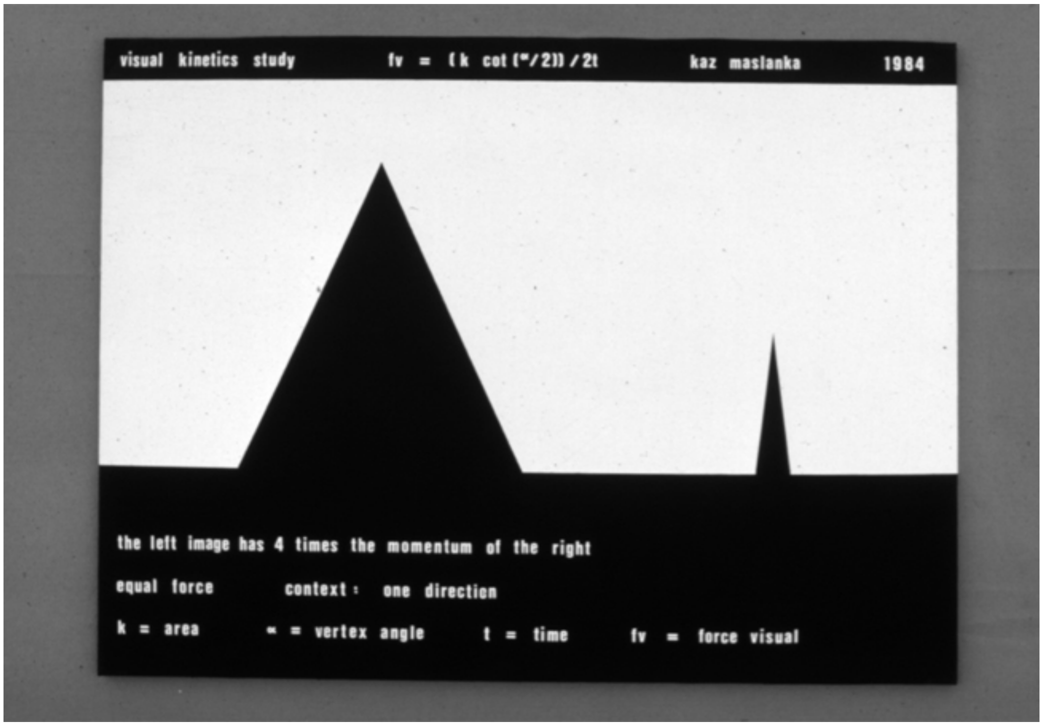

Figure 11. ***Equal Force Study of Isosceles Images with Four Times Difference in Momentum (1984; oil on canvas, 36" × 48"). The left figure carries four times the visual momentum of the right; the two carry equal visual force.***

7. Pandirectional Movement and Vector Sums

So far we have confined ourselves to movement in a single direction. A triangle, however, points three ways at once: each of its three vertices implies a motion outward along its own line, so the form in fact carries three movements rather than one (Figure 12). To combine them we need the idea of a vector.

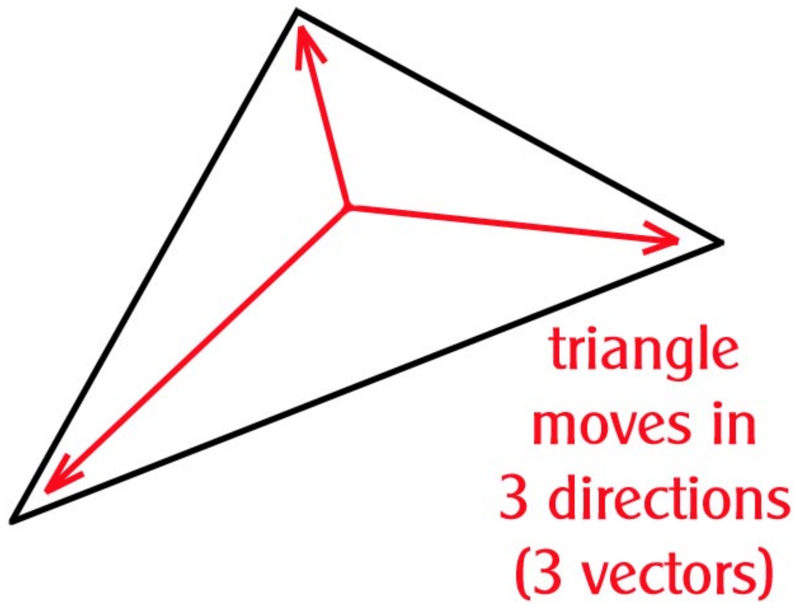

Figure 12. *A triangle implies movement in three directions at once — one outward through each vertex — so it carries three vectors, not one.*

A vector is anything that has both a magnitude and a direction. A baseball thrown north at thirty miles per hour is a vector: thirty miles per hour is the magnitude, north the direction. A weight of two hundred and thirty pounds is a vector whose magnitude is the weight and whose direction is down. Each of a triangle's three implied movements is likewise a vector, carrying a visual momentum (or, equally, a visual force) of a certain magnitude in a certain direction.

When several vectors act at once, their combined effect is found by adding them, and the sum is itself a vector. The addition is easy to feel. Imagine three people holding ropes tied to a single ring on the floor between them, each pulling outward toward themselves (Figure 13). Each pull is a force vector. If the two people in blue pull harder than the one in red, the ring does not move toward either of the two who pull hardest; it moves in a direction between them, settling where the three pulls balance. This combined magnitude and direction is the vector sum, and the single arrow that represents it is called the resultant.

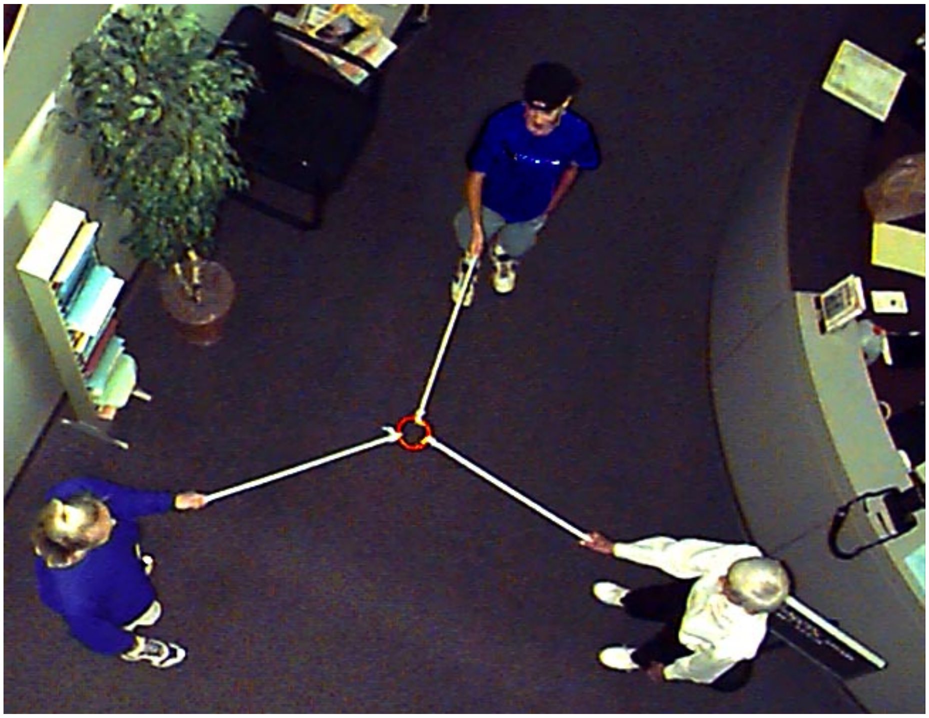

Figure 13. ***Three people pull ropes tied to a central ring. The ring moves not toward any single puller but in the direction of the vector sum — the resultant of the three forces.***

Returning to the triangle, its three visual momentum vectors (or visual force vectors) may be added in just this way to find the resultant — the single direction and magnitude in which the form visually moves. Figure 14, Equal Momentum Vector Sums (1984), makes the reading deliberately tricky. The dart-like figure at the left invites the eye to read it as moving down and to the right, toward its sharp point; but if we attend to the movement as issuing from the center of the form, the vector sum points up and to the left instead (Figure 15). The broad figure at the right is easier to read. In fact both figures move in the same direction, at 135° to the northwest as the inscription records, and with the same visual momentum magnitude.

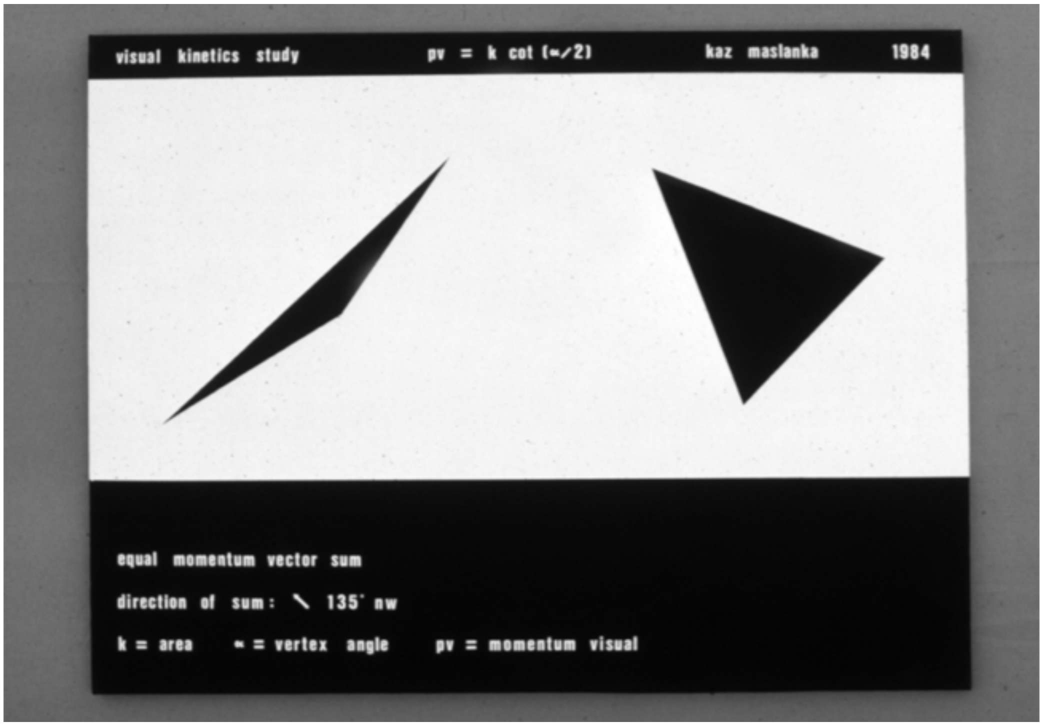

Figure 14. ***Equal Momentum Vector Sums (1984; oil on canvas, 36" × 48"). Both figures resolve to the same visual-momentum resultant, directed 135° to the northwest, despite their contrary appearances.***

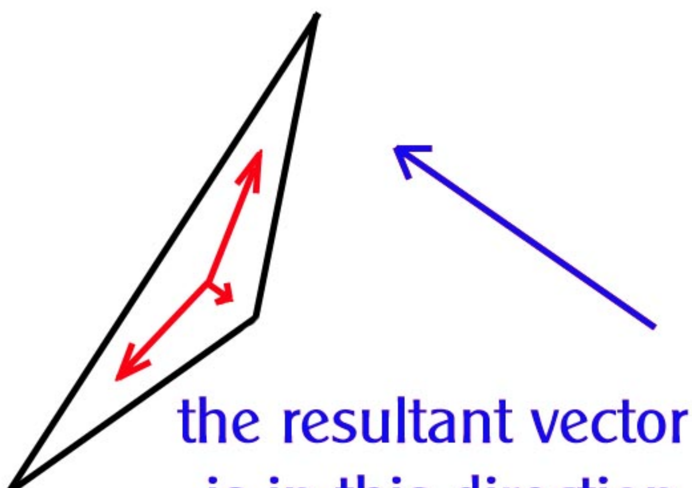

Figure 15. ***Resolving the dart. Read from its center, the three internal vectors of the left figure sum to a resultant directed up and to the left — the opposite of the naive reading toward its point.***

Figure 16, Equal Force Vector Sums (1984), is the same study seen through the lens of force rather than momentum, its resultant again directed 135° to the northwest. Together the two works show that the whole apparatus of vector addition — magnitude, direction, resultant — applies to perceived motion exactly as it does to physical motion.

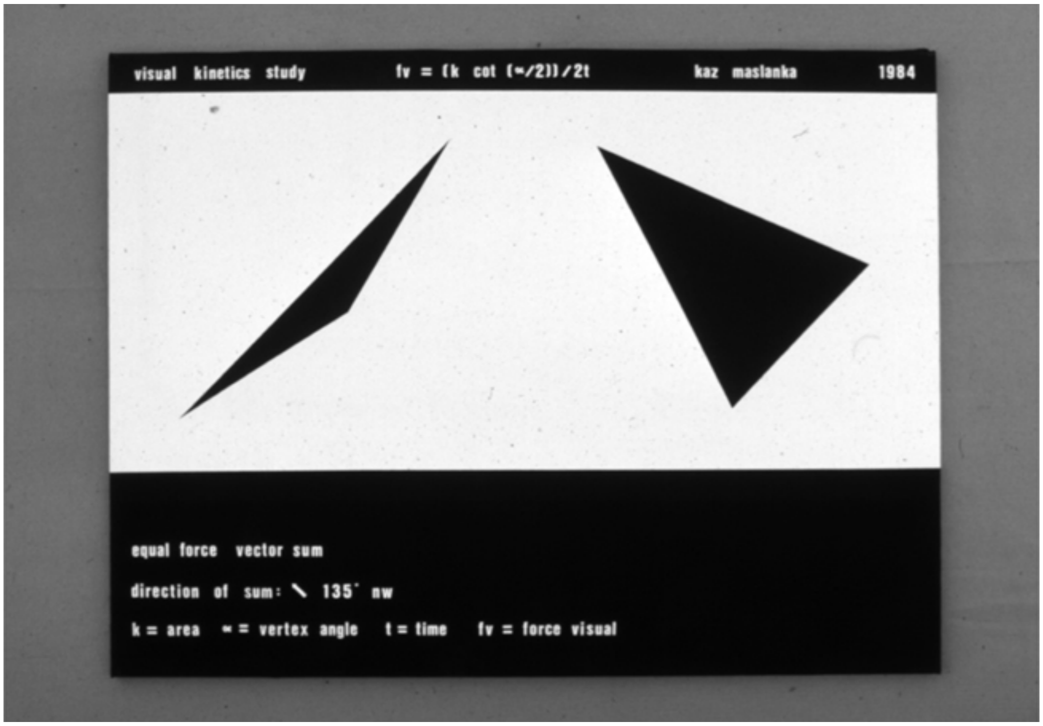

Figure 16. *Equal Force Vector Sums (1984; oil on canvas, 36" × 48"). The companion to Figure 14, focusing attention on visual force; the resultant is again directed 135° to the northwest.*

8. Fields of Force: The Psycho-Vector Paintings

The final three works of the series extend the summation from a single pair of forms to an entire field of triangles, adding their visual momentum and visual force vectors and summing their visual energies across the whole composition. Because there are no established units for quantities of this kind, I assigned them honorary ones, drawn from artists and poets whose work bears on the project: the chron for visual time, the Kandinsky for visual force, the Apollinaire per meter-chron for visual momentum, and the Matta for visual energy. The choices are not idle — Kandinsky for the painter of pictorial force, Apollinaire for the poet whose Calligrammes made writing into a visual field, and Matta for the painter of cosmic energies. Beneath each field the resultant momentum, force, and energy are inscribed as magnitudes and directions.

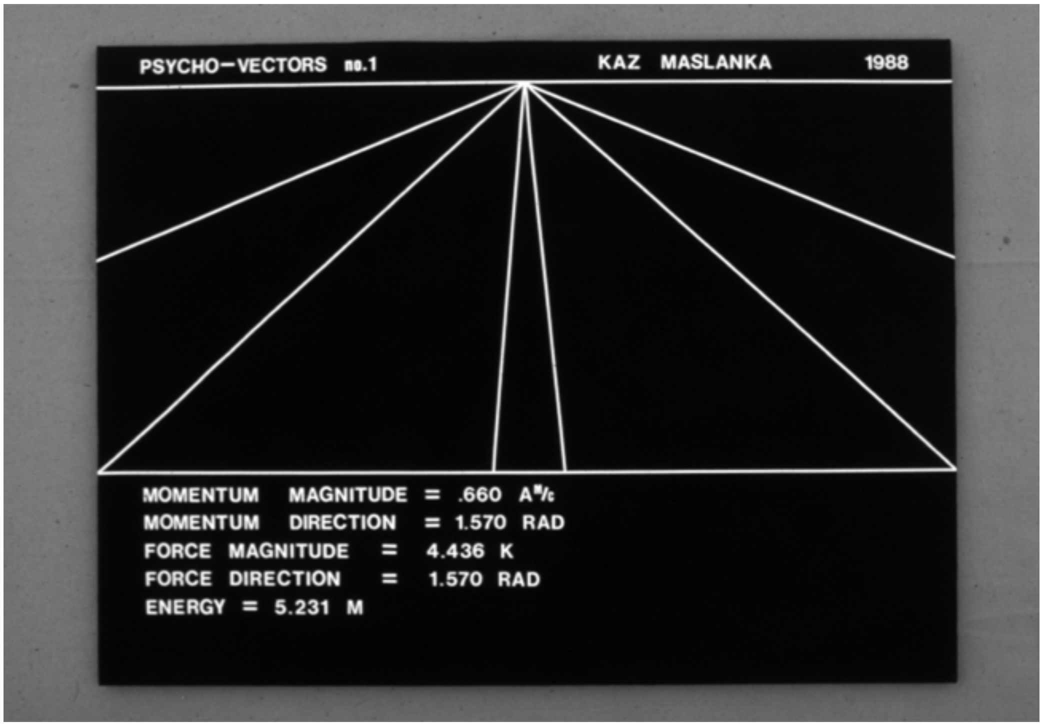

Figure 17. ***Psycho-Vectors no. 1 (1988; oil on canvas, 36″ × 48″). A symmetric fan of forms; the resultant momentum and force are directed at 1.570 radians — essentially π/2, straight upward — as the inscribed values confirm.***

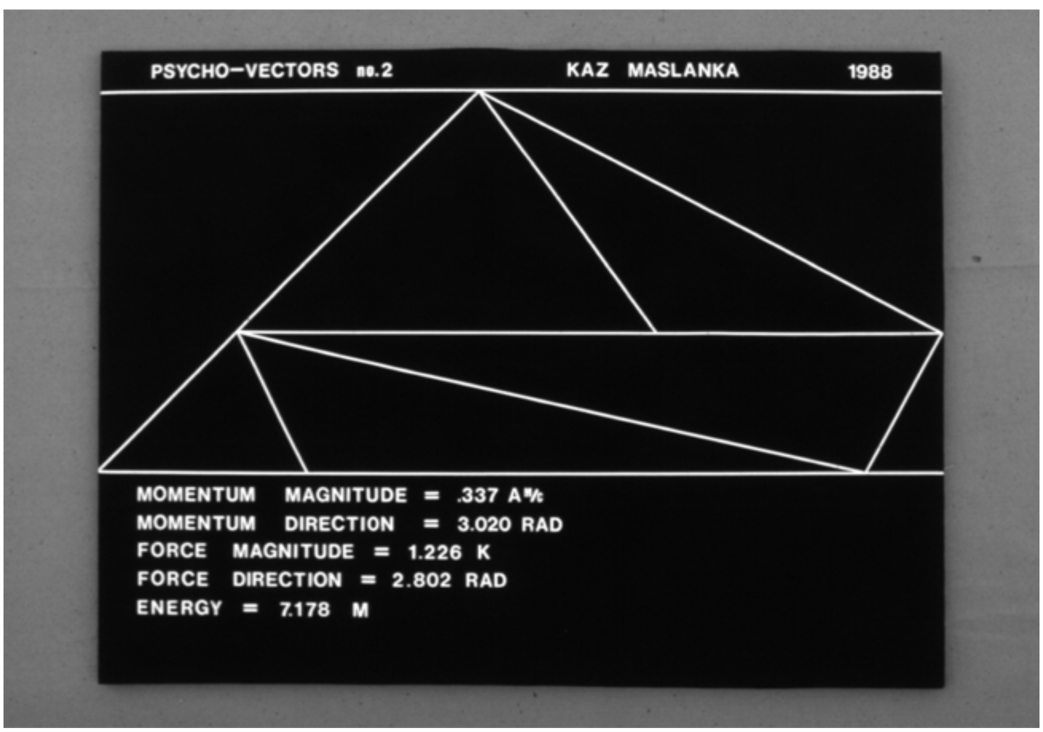

Figure 18. ***Psycho-Vectors no. 2 (1988; oil on canvas, 36″ × 48″). An asymmetric field whose summed momentum and force point up and to the left, with the resultant magnitudes and directions inscribed below.***

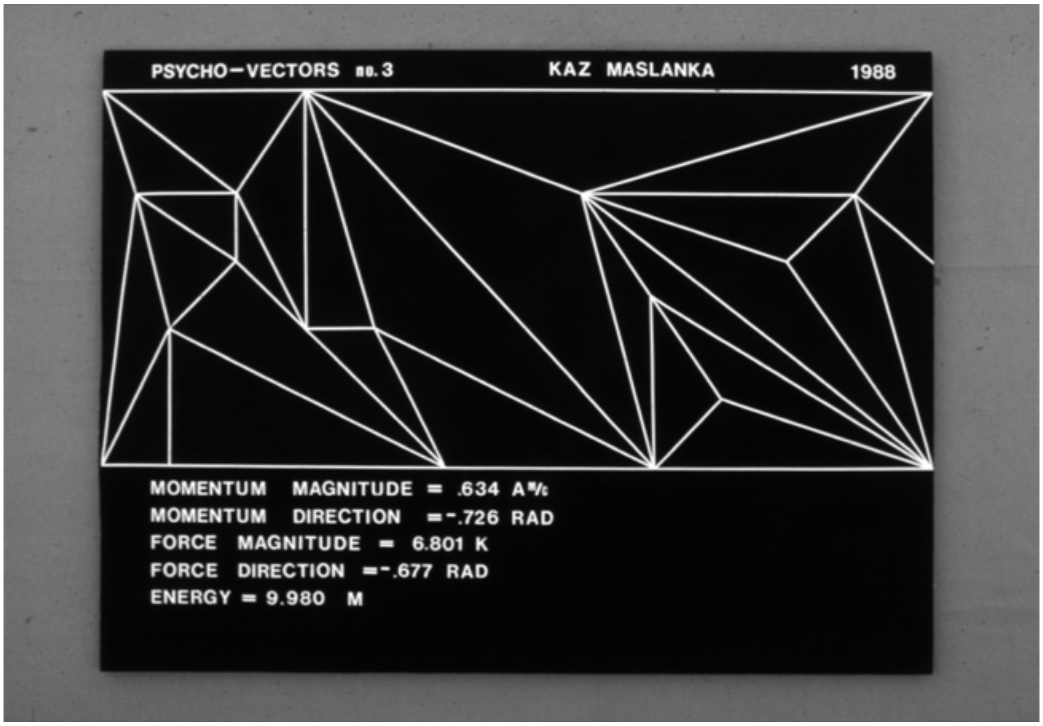

Figure 19. *Psycho-Vectors no. 3 (1988; oil on canvas, 36" × 48"). A dense field of triangles; its inscribed resultants record the greatest visual force and energy of the three works.*

In these field paintings the program reaches its widest expression. A single triangle gave us velocity, mass, momentum, force, and energy; a pair let us equalize one quantity while varying another, and then introduced direction; a field lets us sum all of these at once into a single resultant that the composition as a whole conveys. What began as the felt resistance of water against a hand has become a calculable field of forces presented to the eye alone.

9. Conclusion

The series set out to answer why we perceive movement in a static image and why some images imply greater velocity than others. The answer it offers is that perception is multisensory at its root: because felt force and seen motion are fused into one meaning in lived experience, vision alone can afterward recover the whole, and a configured form can therefore deliver velocity, mass, momentum, force, and energy to a viewer who never touches it. The Psycho-Vector paintings make that delivery exact. They assign visual velocity to the slope of an edge (equivalently, the cotangent of half the vertex angle), visual mass to the area enclosed, and then build from these the visual momentum K cot(α/2), the visual force K cot(α/2) / 2t,

and the visual energy $d \cdot K \cot(\alpha/2) / 2t$ — finally summing these as vectors across whole fields of form.

The aim has not been to reduce painting to physics but to show that the eye, schooled by the body, already reads pictures in something very close to the language of mechanics, and that a painter can compose in that language deliberately. Kandinsky intuited as much when he wrote of the tensions and movements of points and lines. The Psycho-Vector series attempts to give that intuition a measure.

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