The Three Equations in *Gravity's Rainbow*

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Pynchon's references to mathematics and science attracted early notice among the first critics confronting the unsettling complexities of *Gravity's Rainbow*. Lance Ozier explicated the mathematical concepts underlying the Pointsman/Mexico dualism (AA) and the transformations of Slothrop and others (CT). Joseph Slade, in his pioneering book-length study, provided the template for much later discussion of Pynchon's interest in and thematic use of mathematics and science. Other critics writing soon after the publication of *Gravity's Rainbow* also remarked on Pynchon's heterodox preferences in both content and narrative structure. Pynchon's marshalling of film, music, history and religion as well as science, technology and mathematics contributes to the apparent pastiche of *Gravity's Rainbow*, which—diverse as its contents and methods are—critics increasingly argued was structured with uncommon artfulness.

The purpose of this essay is not to add to the general discussion of how Pynchon uses mathematical concepts, but to focus specifically on the narrative function of the three equations actually inscribed in the novel. Drawing on our professional backgrounds in literature (Schachterle) and physics (Aravind), we aim to show how Pynchon turns mathematical expressions into rhetorical tropes which complicate the text by playing upon the authority the equations convey. Each of the three equations is a different kind—genre, if you like—of mathematical expression, each with a different role in the narrative. Each equation plays upon the expectations readers bring to the text—expectations about how both words and equations normally communicate and with what authority.

In our view, Pynchon inscribes these equations into *Gravity's Rainbow* to challenge readers with yet another form of authority within the text. For readers whose conceptual and working knowledge of mathematics does not extend beyond trying to balance a checkbook, mathematics may embody a form of authority beyond human control. (Even the Pope, in scene 11 of Brecht's *Galileo*, acknowledges that the authority of the "multiplication tables" exceeds his own.) Mathematics, to the layperson, by enabling technological practitioners to predict and control outcomes (like making a V-2 land on London), makes things happen in ways both potent and mysterious.

In contrast, we do not usually expect novels to make things happen. Nor do we expect equations to turn up in fiction. The kinds of experience mathematical and verbal symbol systems embody seem entirely different. (The only other novel we know containing an equation explicated at length is David Foster Wallace's *Infinite Jest*.[1]) But precisely because mathematics furnishes such powerful tools for manipulating nature, the equations in *Gravity's Rainbow* provide Pynchon with yet another way of presenting and ultimately challenging authority.

Without the scientific analysis and mathematical prediction Pynchon describes at length in the novel, German scientists and engineers could not have controlled the motion of the V-2. The equation of motion discussed below, first developed in the eighteenth century, provided the predictive power for twentieth-century military technicians to direct V-2s to Antwerp and London. *Gravity's Rainbow*, by contrast, can warn of the horror of a rocket-born nuclear holocaust but not predict or prevent it.

The three equations appear on pages 140, 239 and 450 of the Viking/Penguin edition of the novel. We contextualize the equations within the narrative section (as demarcated by the rows of hollow squares) in which each appears: part 1, episode 17, pages 136–44; 2.5, 236–44; and 3.13, 448–56. Using Pynchon's own descriptors, we have called these equations 1) the "power series" (140), 2) "motion under the aspect of yaw control" (239) and 3) "hilarious graffito of visiting mathematicians" (450).

We will discuss the last of these equations first because its use of mathematics is less problematic than that in the other two. Episode 13 of part 3 begins with the bizarrely comic description of the overspecialization of the German military resulting in the Toiletship *Rücksichtslos*. The episode is Pynchonesque comedy at its most distinctive: bathroom humor in a hyperbolic narrative capped with a Teutonic pun ("Rücksichtslos" translates roughly as "don't look back.") But the same German penchant for finely demarcating natural boundaries and pressing specialization to extremes led to the V-2 as well as the Toiletship. Pynchon points to this correspondence by gliding in this section from Toiletship comedy to the interrogation of engineer Horst Achtfaden, who tells the Hereros that he cannot answer their questions about the specially designed V-2, the 00000, because "'it wasn't my *job*'" (456).

The Achtfaden interrogation connects with Pynchon's descriptions elsewhere of the involved and interlocking technologies required to create the V-2. The Toiletship is a simpler technology, designed to afford German enlisted men and officers (their accommodations are sharply distinguished) some R&R along with their easing of nature. Steve and Charles, industrial spies working for GE to secure German technologies of the Second World War for use in the next war, find little of interest in the *Rücksichtslos*. In passing through the ship, they note the following "among the hilarious graffiti of visiting mathematicians":

$$\int \frac{1}{(cabin)} d(\text{cabin}) = \text{log cabin} + \text{c} = \text{houseboat}$$

This mathematical pun is based on a standard formula in integral calculus that all first-year science and engineering students learn:

$$\int \frac{1}{x} d(x) = \log x + c$$

It states that the indefinite integral of the function $1/x$ is the logarithm of x plus a constant of integration, usually denoted by the symbol c. The pun, revealed in the last part of the equation, follows if the quantity x in the formula is replaced by the word cabin and the symbol c by the word sea—leading to the solution "log cabin" plus "sea" equals "houseboat." It works for the reader in the know about mathematics the way, say, the pun "'For De Mille, young fur-henchmen can't be rowing'" (559) works for the reader in the know about popular culture of the 1930s. The mathematical pun would appeal especially to a first-year student who has just taken calculus. It was probably invented by such a student—perhaps even by Pynchon himself. (For Pynchon's first year of study in mathematics and the sciences in Cornell's Engineering Physics program in 1953–1954, see Schachterle.) The pun seems to have no grander purpose than to provide some passing amusement—amusement enhanced precisely to the degree to which the reader appreciates the underlying mathematics.

The second equation in the text is more chilling in its import. The equation "describ[ing] motion under the aspect of yaw control" appears in an episode (2.5) saturated with descriptions of how people try to control the motion (and lives) of others. The section's opening set piece (236–37) describing the rebirth of nature in spring 1945—complete with references to Orff's libidinous *Carmina Burana*—begins by suggesting the possibilities of new life at the end of the war. But the spring rebirth is soon cut off. The movement toward life turns deathwards as the East/West Cold War rivalry arises from each side's striving to capture German V-2 experts in preparation for the next war. Through this section flits the ghost of "the late Roland Feldspath [. . .] long–co-opted expert on control systems, guidance equations, feedback situations for this Aeronautical Establishment and that" (238). From beyond, Feldspath knows what Slothrop can only glimpse paranoiacally: "the deep conservatism of Feedback and the kinds of lives they were coming to lead *in the very process* of embracing it" (239).

The historical impetus that led to formulating feedback as a powerful mathematical tool during the Second World War was the need to improve antiaircraft gunnery, as seen in the work of Norbert Wiener (Wiener; Hayles 106–12). Controlling movement through feedback takes many forms in this section: pushing post–First-World-War Germany toward another war by manipulating the economy (238); discovering Shell Oil's involvement in the British liquid-fuel research program (240); using that company's headquarters building in the Hague for a guidance-transmitter tower to aim V-2s at London (241). Pynchon hints at these control plots in a series of "Proverbs for Paranoids" (this section contains the first two), which further heighten Slothrop's and the reader's uneasiness about being subject to invisible control. Slothrop appears quite rightly to fear the dark forest: "Edges were hardly ever glimpsed, much less flirted at or with. Destruction, oh, and demons—yes, including Maxwell's—were there, deep in the woods, with other beasts vaulting among the earthworks of your safety" (239).

The equation of motion in this section is the most problematic of the three equations in *Gravity's Rainbow*. The sentence immediately preceding the equation implies that it has something (or perhaps a lot) to do with yaw control, and the nonscientific reader might well want to see this connection spelt out simply and clearly by someone in the know. But indeed, the equation should not be taken too literally. Inspection of the mathematics discloses that it describes the physical realities of rocket flight in only the loosest terms. The equation works in the text more as a metaphor than as a precise simile; it is most clearly seen for what it is when viewed through a lens of intermediate magnification rather than one that is too powerful or too weak.

The equation of motion is presented as follows:

> So was the Rocket's terrible passage reduced, literally, to bourgeois terms, terms of an equation such as that elegant blend of philosophy and hardware, abstract change and hinged pivots of real metals which describes motion under the aspect of yaw control:

$$\Theta\frac{d^2\phi}{dt^2}+\delta^*\frac{d\phi}{dt}+\frac{\partial L}{\partial \alpha}(s_1-s_2)\alpha=-\frac{\partial R}{\partial \beta}s_3\beta,$$

> preserving, possessing, steering between Scylla and Charybdis the whole way to Brennschluss. (239)

Pynchon's language here is at its most charged. The equation mediates between the abstract laws of physics and the practical engineering of metal parts, enabling engineers to direct the rocket's ascent to the point at which the motor shuts off—Brennschluss—and the rocket becomes an unguided ballistic missile. The equation also effects a Weberian routinization of charisma, making of the mysteries of flight a commonplace bourgeois weapons system.

This equation, a differential equation, exemplifies one of the more advanced constructs of the calculus with widespread application. Broadly speaking, the purpose of a differential equation is to provide a dynamic graphic of how the state of some entity—say, a rocket or the economy—changes in response to the influences governing it. These influences could be thrust and gravity in the case of a rocket or interest rates in the case of the economy. A differential equation expresses, in highly compact symbolic form, how various influences or driving forces combine (or conspire) to cause the state of the primary entity to change (usually) over time. The adjective differential denotes the fact that such an equation has derivatives in it. A derivative is an expression like dx/dt or d^2x/dt^2 symbolizing the rate at which one quantity (here x) changes with respect to another (here t); it constitutes the elemental stuff of which all differential equations are made. Solving a differential equation predicts how the position of the rocket will change or the health of the economy will fare over time. Because the influences that govern the evolution of a system can be numerous and quite complex, solving a differential equation may turn out to be a complicated mathematical task that frustrates one's efforts to eke out all the meaning compressed in it.

In the case of a rocket, again, a differential equation predicts how some property of the rocket—say, its position or orientation—will change over time as a result of the forces acting on it. Those forces include gravity, thrust and air resistance, all of which are themselves constantly changing during flight. The equation incorporates the effect of each of the influences into one of its terms and combines the terms to predict how the state of the rocket will change over time. The equation has to be solved, based on a knowledge of the rocket's position and velocity at some initial time, to predict its position, orientation and velocity at all later times—including the moment of impact.

The orientation of a rigid body, such as a rocket, is described by three angles, usually termed pitch, roll and yaw, that quantify the ways the object can rotate in space. In the case of an aircraft, for ease of illustration, pitch refers to the motion by which the nose bobs up or down, roll to the motion by which the wings tilt from the horizontal, and yaw to the motion by which the aircraft turns to port or starboard without the wings' being tilted. The differential equations describing how these angles change during the rocket's flight are known as Euler's equations, after the eighteenth-century Swiss mathematician who first formulated them. Euler's equations are usually very difficult to solve because the forces acting on the rocket are all individually very complex. A practical solution of Euler's equations usually proceeds by modeling the forces or torques acting on the rocket to the desired degree of accuracy and then solving the resulting equations on a powerful computer.

Is Pynchon's equation of motion a standard differential equation used by specialists to calculate the path of a rocket's flight or to control its yaw? No: Pynchon's equation does not resemble anything one might reasonably expect. We compared it with those in two texts on rocketry: Prussing and Conway, a modern text dealing with the motion of rockets and artificial satellites; and Kooy and Uytenbogaart, the vintage text usually taken to be Pynchon's source for the equation of motion. Not only are most of the symbols in Pynchon's equation obscure, but the general structure of the terms in the equation also makes it impossible to identify with one or other of the equations describing the position and orientation of a rocket in flight. This equation, then, is not a genuine mathematical expression in this context. It may appear authoritative to the layperson, but it is unlikely to fool a rocket scientist.[2]

Nonetheless, the equation is not entirely implausible as a description of a rocket in flight. It has the form of a second-order differential equation, which is generally what is required in these circumstances. A reader familiar with differential equations but lacking knowledge of rocket dynamics might think the equation was applicable to rocket motion, just as a museum-goer looking at unfamiliar works is sometimes unable to tell an imitation from a genuine objet d'art.

One clue is the sentence "You could not pump the swings of these playgrounds higher than a certain angle from the vertical" (238), in the paragraph before the one in which the equation appears. The motion of a playground swing—a damped driven oscillator that mimics some of the simpler aspects of rocket flight—is described by a differential equation not much unlike Pynchon's. This merging of images—playground swings and rockets, toys and terror weapons—adds yet another ambiguity to the equation.

So what might Pynchon's literary purpose have been in using this equation? Perhaps to convey the power and control the young German engineers had over the V-2. A differential equation on the page conveys this point to a mathematically literate reader in a way mere words cannot. The equation also contributes a metaphor to the themes of feedback and control that dominate this episode. Thus the control equation not only suggests the formalized dynamics of how the German engineers sought to stabilize the trajectory of the V-2, but also generalizes beyond the physics of flight to the far more shadowy attempts at control adumbrated in the two Proverbs for Paranoids in this section.

Our third equation is, in fact, the first one in the novel. The power-series equation appears in an episode (1.17) that narrates Edward Pointsman's conscious and unconscious struggles to understand how Tyrone Slothrop's sexual adventures, plotted on a map of London, reliably predate by several days V-2 hits in the same locations. Pointsman, a disciple of Pavlov, longs to reduce all phenomena—including this curious relation—to cause and effect. He yearns to extend his laboratory experiments on stimulus and response in dogs to Slothrop himself, to get at what he believes must be the causal relation between Slothrop's amorous hits and the V-2's fatal ones. Discovering how Slothrop appears to anticipate V-2 hits will satisfy the one great fantasy desire in the highly repressed scientist's life—to visit Stockholm to accept the Nobel Prize.

Frustrating Pointsman are not only the difficulties of experimenting on the novel's principal character, but also statistician Roger Mexico's frequent reminders of a central irony in the physics and mathematics of *Gravity's Rainbow*. The equation of motion discussed above commands authority because of its enormous predictive power. Using the right terms (not the bogus ones Pynchon apparently devised) enabled the German military to create the reign of terror of silent (because supersonic) and thus unanticipated V-2s striking at random within and around London—a terror Slothrop bluntly describes as "Them fucking rockets. You couldn't adjust to the bastards. No way" (21). Pointsman seeks from Mexico certitude about the pattern of hits; Roger assures him that all mathematics can do is calculate in aggregate the probability of certain numbers of hits in given sections of the city. The authority of mathematics can go no further to specify where the next rocket will fall. From the German point of view, mathematics has the predictive power inscribed in the equation of motion to guide the rockets toward

London (although the technology of the middle of the last century could not target specific sites precisely); but from the point of view of the targeted humans, mathematics does not have the power to warn potential victims precisely of each fatal destination.

Mexico's advocacy of probabilistic rather than deterministic science affronts Pointsman's most treasured beliefs about science being grounded on mechanistic cause and effect. The power-series equation Pointsman recalls thus haunts him, like other ghosts in this section, because it articulates the purely random "Poisson dispensation ruling not only these annihilations no man can run from [his colleague Kevin Spectro has just been killed by a V-2], but also cavalry accidents, blood counts, radioactive decay, number of wars per year" (140). The power-series equation has the form

$$Ne^{-m}\left(1+m+\frac{m^2}{2!}+\frac{m^3}{3!}+\ldots+\frac{m^{n-1}}{(n-1)!}\right).$$

Before commenting on this equation, let us note that the modifier "power" in the descriptor "power series" has nothing to do with any of the everyday senses of the word, such as the ability to control, or the commodity one is charged for in the monthly utility bill. Instead, "power" here refers to the exponents of the quantity m in the power-series equation. In the mathematical expression x^2, shorthand for x multiplied by x, the number 2 is the power (or exponent) of x. A power series in x is simply a sum of terms involving regularly increasing powers of x; for example, $3x + 4x^2 + 5x^3$ is a power series in x involving just three terms. Pynchon's power-series equation is a power series in the variable m, in which the power ranges all the way from 1 to the number "n - 1."

This equation actually embodies a well-known statistical law—the Poisson distribution—that describes the occurrence of certain types of random events. Each term of the power series specifies the probability of a certain number of occurrences of a random event whose average number of occurrences is m. Suppose one gathers 500 people, chosen at random from a large population, and wants to know the probability that exactly k among them will have their birthdays on New Year's Day. The probabilities can be calculated with the power-series equation by taking $N = 1$, $m = 500/365 = 1.369$, and using the first term for no birthdays on New Year's Day, the second term for one birthday, the third for two birthdays, and so on. The reader with a scientific calculator can readily verify that the probabilities of zero, one and two birthdays falling on New Year's Day are 0.2541, 0.3481 and 0.2385, respectively. The probabilities of larger numbers of birthdays drop off quite rapidly, and the sum of all the probabilities, of course, equals one.

The power series—or the Poisson distribution—does indeed describe the pattern of random events such as cavalry accidents and radioactive decay, and perhaps even the locations of Slothrop's sexual conquests (assuming—a risky step—that Slothrop accurately records his hits on the famous map; see Duyfhuizen). But to infer that one set of random events (Slothrop's sexual adventures) is closely correlated with another (V-2 hits) is to dangle Lady Luck over a precipice by the slimmest of threads. Linking this succession of events—Slothrop's sexual exploits, his mapping of them, and the V-2 strikes—each of which has its own underlying uncertainties, sets the stage for the undermining of Pointsman's nineteenth-century determinism and all it entails. The point is that the future of individual V-2 hits or of love (Slothrop's, Mexico's, Tchitcherine's) cannot be determined or precisely predicted, a fact which offers the promise of an escape from those lusting to control rockets and human emotions.[3]

The law of the lawless—the ability to predict random events only in the aggregate—enshrined in the Poisson distribution has fascinated great and ordinary minds alike from the earliest days of probability theory (see Tölölyan for an early appreciation of Pynchon's use of Poisson's work). The topic ties in with many other ideas in Pynchon's fiction, such as Maxwell's Demon, entropy and Claude Shannon's information theory, all of which grew out of the transition from nineteenth-century classical thermodynamics to twentieth-century statistical physics.

Rhetorically, these three equations mirror the diversity of register that characterizes Pynchon's other modes of portraying and challenging authority. Each equation can be read on several levels. To the reader fairly ignorant of mathematics—incapable of distinguishing a differential equation from a simple linear equation with one unknown—all three equations bear down with the might and authority of mathematics to enhance the narrator's credibility. The effect might be expressed as "Boy, this Pynchon sure knows his stuff, with all these allusions. He can even do the math!" But a closer inspection—or what we call being in the know—discloses a more complex picture. The cabin/sea logarithmic equation elaborates a mathematical pun, the purpose of which—if any beyond momentary frisson—perhaps is to show that mathematics and mathematicians have their own inside humor and way of sticking it to authority.

The equation of motion is far more sinister, for as we have explained, equations of this general type were crucial to engineering the V-2 as a vengeance weapon. The differential equation that controls motion powerfully exemplifies authority—the capacity to direct and predict where a lethal explosion will likely occur. But, curiously, on closer inspection, as we have seen, the equation does not stand up to physical/mathematical analysis. Will the reader in the know about the equation recognize its inner hollowness, its inability as presented to do what it purports to control motion? Previous critics have assumed that Pynchon took this equation from an authoritative source, Kooy and Uytenbogaart's *Ballistics of the Future with Special Reference to the Dynamical and Physical Theory of the Rocket Weapons*. But the equation cited on page 239 of *Gravity's Rainbow* does not appear in *Ballistics of the Future*. We assume Pynchon invented it—and knew that, as given, it does not describe the motion of the V-2 as suggested by the context.

As a final irony, the Poisson power-series equation yields only the probabilities that, over time, certain numbers of locations will receive certain numbers of V-2 hits. It cannot predict exactly where the next rocket launched using the equation of motion will explode, not even—maddeningly—when it is known where the last one, five or *n* rockets have fallen. But to one in the know like Roger Mexico, the power series implies, with the authority of mathematics, an escape from the deterministic mechanics embodied in Pointsman. The implication offers a small but real promise of escape from those like Pointsman who are part of the Firm seeking control over us all.

These three equations, then, function—along with the third of a million words and various other graphics—as "not a disentanglement from, but a progressive *knotting into*" (3), in a narrative which uses both verbal and mathematical symbols to complicate and challenge the idea of authority. The logarithmic pun laughs at mathematical authority, here reduced to a labored in-joke. The equation of motion, lacking the specific terms that would render it a precise formulation of how German technologists coopted gravity in a futile attempt to stave off military defeat, derides those engineers' effort to control the war. The only equation presented in all mathematical seriousness, the Poisson distribution, mocks the power of the Firm by reminding us that, just as we cannot hope as readers to connect everything to everything in *Gravity's Rainbow*, even the authority of mathematics cannot always predict or control.

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Notes

[1]*Infinite Jest* uses the "Extreme Value Theorem" in an elaborate mock-discussion of a nuclear-bomb air-burst (1023–25). We thank our WPI colleague

Mike Ciaraldi for calling our attention to Italo Calvino's *Cosmicomics*, in which several characters are based on mathematical functions.

[2]Steven Weisenburger's assertion that "the formula Pynchon quotes is from Kooy and Uytenbogaart (247)" (126) is incorrect. No equation remotely like Pynchon's appears on that page of *Ballistics of the Future* or anywhere else in the section dealing with control of a V-2 before Brennschluss. In fact, nowhere in the section "Motion of a Rocket Controlled by a Gyro Pilot" (246–56) do any differential equations as formidable looking as Pynchon's appear; most of the mathematics there is high school trigonometry. We assume Pynchon made up the equation to look like an appropriate differential equation of motion.

Kooy and Uytenbogaart's book on "the dynamical and physical theory of the rocket weapons" was written contemporaneously with the German firings from the Hague against London mentioned in *Gravity's Rainbow* (GR 241). "During the second World War," the Publisher's Preface notes, "Ir [Engineer] Dr. J. M. J. Kooy of the Aeronautical School, the Hague, decided to elaborate a theoretical-mathematical thesis on the dynamics of the projectile and the rocket under the influence of the field of gravity of the earth and the atmosphere, as well as beyond, in world space." But before the book was completed, the reality of the war intruded: the combination of German misfirings from the Hague and Allied bombing of the rocket sites there "delayed the publication of this work" (BF 7). Kooy and Uytenbogaart (Professor of Mechanical Technology at Delft), who "had made a special and intensive study of the operation and construction of these V-weapons, in support of the great task of the Allies," were well aware of the place in history their study occupied as the first detailed study of "the technical data and scientific laws" of rockets (7, 9). Indeed, they conclude their own brief introduction with the hope that "a more widespread knowledge of the technical data and scientific laws governing the subject of this book will contribute to the banning of the rocket weapons for war purposes" (9).

Of the twelve chapters of *Ballistics of the Future*, the first nine deal with mathematical and physical formulations of the dynamics of ballistic flight. Chapter 10 covers the V-1, chapter 11 the V-2, and chapter 12 "Extra-Terrestrial Dynamics of the Rocket" (including discussion of trips to and around the moon). Much of Pynchon's description of the V-2 could have come from chapter 11 (280–400, about a quarter of the book), with its ten-page history of the rocket, detailed descriptions of its motor, propulsion chemicals, launch and steering, and conclusion, "Future Prospects of the V2 Rocket" (398).

[3]Pynchon reinforces—for the mathematically-literate reader—the uncertainty of individual V-2 strikes in episode 4.8 (706–17), "the Gross Suckling Conference," with a formula expressed discursively rather than in mathematical notation. The formula is particularly poignant in the dramatic context. Jessica has just desolated Roger by telling him of her impending

marriage to Jeremy and of their efforts to have a baby, and then called security on him. The cocksure Jeremy rescues Roger, and the two of them discuss Jeremy's next military assignment, to learn to control the V-2s:

> "Why?" Roger keeps asking, trying to piss Jeremy off. "Why do you want to put them together and fire them?"
>
> "We've captured them, haven't we? What does one *do* with a rocket?"
>
> "But why?"
>
> "Why? Damn it, to *see*, obviously. Jessica tells me you're—ah—a *math chap?"*
>
> "Little sigma, times P of s-over-little-sigma, equals one over the square root of two pi, times e to the minus s squared over two little-sigma squared."
>
> "Good Lord." Laughing, hastily checking out the room.
>
> "It is an old saying among my people." (709)

This old saying among Roger's people is one of the central formulations of probability theory, the definition of the Gaussian distribution. The symbolic rendering, with the σ from the left-hand side in the verbal version transposed to the right to present the equation in standard form, is

$$P\left(\frac{s}{\sigma}\right) = \frac{1}{\sqrt{2\pi}\,\sigma}\exp\left(-\frac{s^2}{2\sigma^2}\right).$$

The symbol σ in the equation is the standard deviation. A plot of the Gaussian function (*P* on the ordinate vs. *s* on the abscissa) yields the well-known bell curve. The width of the curve is determined by σ.

The Gaussian distribution can be used to describe the scatter of rocket strikes about an intended target. In this application, the symbol *s* represents the distance of the rocket from the target, and σ is a measure of the accuracy of the targeter: a small value for sigma would indicate a good targeter and a large sigma a poor one. For any given value of sigma, the formula can be used to calculate the probability of the rocket's landing at a given distance *s* from the target. The probability would be appreciable only for *s* less than sigma, while it would tail off quite rapidly as *s* increased well beyond sigma.

Jeremy fails to understand the formula or its import: he looks nervously around the room, as if for a quick exit. Roger's old saying among statisticians challenges the determinism of the Firm just as his and Seaman Bodine's gross menu suggestions upset Their banquet at the end of the episode. The exact hits of V-2s and of love's arrows are hard to predict. Not only does Roger's reference to probabilities remind us how difficult it will prove, in the Cold War now starting, to gain precise control over the new rocket-guidance technology; it may also suggest that Jeremy's firm confidence that he has wrested Jessica away from Roger is misplaced, given the magic uncertainties of love.

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