

the determination of quantity involved in these objects, and as we have seen, ignores time itself, and concentrates only upon the figurations and combinations of the unit. In the theory of motion, time will certainly also be treated by this science, but applied mathematics, precisely because it is the application of pure mathematics to a given material, and the determinations of this material are taken from experience, is in no respect an immanent science. 5

C

Place and motion

(*The union of space and time*)

§ 260

Space in itself is the contradiction of indifferent juxtaposition and of continuity devoid of difference; it is the pure negativity of itself, and the **initial transition into time**. 10  
 Time is similar, for as its opposed moments, held together in unity, immediately sublata themselves, it constitutes an immediate *collapse* into undifferentiation, into the undifferentiated extrinsicality of *space*. **Consequently, the negative determination here, which is the exclusive point, is no longer merely implicit in its conformity to the Notion, but is posited, and is in itself concrete on account of the total negativity of time.** 15  
**This concrete point is place** (§ 255 and § 256).

*Addition.* If we refer back to the exposition of the Notion of duration, we see that this immediate unity of space and time is already the ground of their being. 20  
 The negative of space is time, and the positive, or the being of the differences of time, is space. In this analysis however, they are posited as of unequal import, or their unity is merely presented as the movement of the transition from one into the other. Consequently the beginning, and the realization, the result, fall apart. The result is the precise expression of their ground and truth however. 25  
 The durable element is the self-equality into which time has returned; this is space, the determinability of which is indifferent existence in general. Here the point is that which it is in its truth as a universal; it is in fact the whole of space, as a totality of all dimensions. This here is to the same extent time, and is now +  
 an immediately self-sublating present, or a now which has been. As it is the 30

point of duration, the here is at the same time a now. This unity of here and now is place.

§ 261

Initially, the place which is thus the posited identity of space and time is also the posited contradiction set up by the mutual  
 5 exclusiveness of space and time. Place is spatial and therefore indifferent singularity, and is this only as the spatial now, or time. As this place, it is therefore in a condition of immediate indifference to itself; it is external to itself, the negation of itself, and constitutes another place. This *passing away* and self-  
 10 *regeneration* of space in time and time in space, in which time posits itself spatially as place, while this indifferent spatiality is likewise posited immediately in a temporal manner, constitutes motion. To an equal extent however, this becoming is itself the internal collapse of its contradiction, it is therefore the  
 15 *immediately identical* and *existent* unity of place and motion, i.e. *matter*.

*Remark*

The transition from ideality to reality, from abstraction to concrete existence, in this case from space and time to the reality which makes its appearance as *matter*, is incom-  
 20 prehensible to the understanding, for which it therefore always remains as something externally presented. Space and time are usually imagined as **being empty and indifferent to that which fills them, and yet as always to be regarded as full.** They are thought to be *empty* until they have been *filled* with  
 25 matter from *without*. On the one hand material things are therefore taken to be indifferent to space and time, and yet at the same time they are accepted as essentially spatial and temporal.

It is said of matter that: (a) it is *composite*, which is a  
 30 property it derives from its abstract extrinsicality, space. In so far as an abstraction is made of time and all form, matter is said to be eternal and immutable, which is in fact the immediate result of this; but matter in such a state is merely an untrue abstraction. (b) It is *impenetrable* and offers

*resistance*, it can be felt, seen etc. These predicates merely indicate that matter has two determinations, according to which it exists partly for determinate perception, or more generally *for another*, and partly and equally, *for itself*. It has these two determinations as the *identity* of space and time, and of immediate *extrinsicality* and *negativity*, or as **the being-for-self of singularity**.

The *transition of ideality into reality* also expresses itself in the familiar mechanical phenomenon of reality being replaceable by ideality and vice versa, and it is only the thoughtlessness of popular conception and of the understanding which prevents the identity of both from being recognized in this interchangeability. In the case of the *lever* for example, the mass may be replaced by the *distance* and vice versa, and a certain quantum of moments of an ideal nature produces the same effect as the corresponding moments of a real nature. Similarly, in the *magnitude of motion, velocity*, which is a quantitative relationship, simply between space and time, replaces *mass*; and conversely, the real nature of the same effect is obtained by augmenting the mass and correspondingly diminishing space and time. A tile does not strike a man dead by itself, it only has this effect by virtue of the velocity it has acquired, i.e. the man is struck dead by *space* and *time*. Here the understanding gets no further than the reflectional determination of *force*, which it regards as fundamental, and is not therefore tempted to look further into the relationship of its determinations. Even this thought implies vaguely that the *effect* of force is a sensuous event of a real nature however, that there is no difference between the *content* and expression of force, and that precisely *this force* has the *real nature* of its *expression* in the relationship between the ideal nature of the moments of space and time.

This sort of notionless reflection also thinks of what it calls forces, as being *implanted* in matter, and therefore originally *external* to it. The very identity of time and space which hovers vaguely before this reflectional determination of *force*, and which constitutes the true essence of matter, is consequently posited as something *alien* and *contingent* to it, and as **brought into it from without**.

*Addition.* One place does not merely imply another, it sublates itself into  
 + becoming another; the difference is also a sublatedness however. Each place  
 is for itself only this place, so that all places are the same, and place is the simply  
 + mediated here. Something occupies one place, and then changes its place, passing  
 5 thereby into another place; but both before and after this, it does not leave, but  
 occupies its place. *Zeno* enunciated this dialectic within place, when he demon-  
 + strated immobility by saying that to move was to change place, but that the  
 arrow never leaves its place. This dialectic is precisely the infinite Notion, or  
 the here, for time is posited as being implicit. There are three different  
 10 places, the present, that which is to be occupied, and the vacated. The  
 disappearance of the dimensions of time is paralysed, but at the same time  
 there is only one place which is common to these places, and invariable  
 throughout all change, and this is the duration which is in immediate  
 accordance with its Notion, i.e. motion. This demonstration of motion is  
 15 self-evident, for the intuition of it coincides with its Notion. Its essence  
 is its being as the immediate unity of space and time; it is time realizing  
 itself and subsisting in space, or space first truly differentiated through time.  
 We know therefore that space and time belong to motion. Velocity,  
 which is quantum of motion, is space in relationship to a specific time  
 20 elapsed. Motion is also said to be a relation of space and time; it was  
 necessary however to grasp the more exact definition of this relation.  
 Space and time first attain actuality in motion.

+ Just as time is the simply formal soul of nature, and according to  
 Newton, space is the sensorium of God, so motion is the Notion  
 + of the true soul of the world. We habitually regard it as a predicate  
 or state, but it is in fact the self, the subject as subject, and the per-  
 sistence, even of disappearance. It is precisely because of its immediate necessity  
 to dissolve itself that it appears as predicate. Rectilinear motion is not motion  
 in and for itself, but motion subordinated to another term, of which, in that it  
 30 has become a predicate, or sublated, it is a moment. The re-establishment of the  
 duration of the point in opposition to its motion, is the re-establishment of the  
 immobility of place. This re-established place is not immediate, but the return  
 from alteration, and is the result and ground of motion. In that it is dimen-  
 sion, and so opposed to the other moments, it is the centre. This return as line is  
 + the circular line; it is the now, before, and after, joining itself with itself; it is the  
 indifference of these dimensions, in which the before is just as much an after as  
 the after is a before. This is the first necessary paralysis of these dimensions  
 posited in space. Circular motion is the spatial or subsistent unity of the  
 dimensions of time. The point tends towards a place which is its future, and  
 40 vacates one which is the past; but that which it has behind it, is at

the same time that at which it will arrive; and it has already been at the after towards which it tends. Its goal is the point which is its past. The truth of time is that its goal is the past and not the future. The motion which relates itself to the centre is itself the *plane*, that is to say the motion which, in that it forms a synthetic whole, itself contains its moments or its dissolution in the centre, as well as the radii of the circle, which relate it to the dissolution. This plane itself moves however, and so becomes its otherness, an entirety of space, i.e. the motion returns into itself, and the immobile centre becomes a universal point, in which the whole sinks into quiescence. It is in fact the essence of motion which has here sublated the now, the past, and the future, or the different dimensions which constitute its Notion. In the circle these dimensions are precisely one, and constitute the re-established Notion of duration, or of motion extinguishing itself within itself. This is posited *mass*, durability, that which has condensed itself through itself, and displays motion as its possibility.

We have now reached the following position: Where there is motion, there is something which moves, and this durable something is matter. Space and time are filled with matter. Space is not adequate to its Notion, and it is consequently the Notion of space itself which creates its existence in matter. People have often begun with matter, and then regarded space and time as its forms. This is a valid procedure in so far as matter is the reality of space and time, but for us space and time must come first because of their abstraction, and matter must then show itself to be their truth. Just as there is no motion without matter, so there is no matter without motion. Motion is the process; it is the passage of time into space, and of space into time. Matter on the contrary is the relation of time and space as a quiescent identity. Matter is the primary reality, existent being-for-self; it is not merely abstract being, it is the positive subsistence of space as exclusive of other space. The point *should* also exclude other points, but it does not yet do so, for it is merely an abstract negation. Matter is exclusive relation to self, and consequently the first real limit in space. That which is said to fill time and space, which can be grasped and felt, which offers resistance, and which is for itself in its being-for-other, is simply reached in the general unity of time and space.

## CHAPTER TWO

### Matter and motion

#### Finite mechanics

#### (Gravity)

#### § 262

Matter maintains itself **against its self-identity** and in a state of extrinsicality, through its moment of negativity, its abstract *singularization*, and it is this that constitutes the *repulsion* of matter. As these different singularities are one and the same however, the negative unity of the juxtaposed being of this being-for-self is just as essential, and constitutes their *attraction*, or the **continuity of matter**. **Matter is inseparable from both these moments, and constitutes their negative unity, i.e. singularity. This is however still distinct from the immediate extrinsicality of matter, and is therefore not yet posited as being a centre, a material singularity of an ideal nature, i.e. gravity.**

#### Remark

It is to be regarded as one of the many merits of Kant, that in his '*Metaphysical foundations of Natural Science*', he made an attempt at a so-called *construction* of matter, and by establishing a *notion* of matter, revived the concept of a *philosophy of nature*. In so doing however, he postulated the reflective determinations of the *forces of attraction and repulsion* as being **firmly opposed to and independent of one another**, and although *matter* had to be derived from them, assumed it to be *complete* in itself, and **therefore that that which is to be attracted and repelled is already fully constituted matter**. I have dealt more fully with the fundamental flaw in this Kantian exposition in my '*Science of Logic*'. **It should be**

noted moreover that weighted matter is the first totality and real nature in which attraction and repulsion can occur; it has the ideal nature of the moments of the Notion, of singularity or subjectivity. Consequently they are not to be regarded as independent, or as self-contained forces. It is only as moments of the Notion that they result in matter, although matter is however the presupposition of their appearance. 5

It is essential to distinguish gravity from mere attraction, which is simply the general sublation of juxtaposition, and yields nothing but continuity. Gravity on the other hand is the reduction of juxtaposed and yet continuous particularity into unity, into negative relation to self, singularity, a single subjectivity which is however still quite abstract. In the sphere of the primary immediacy of nature, the self-external being of continuity is still posited as subsistent however. Material introflection first occurs in physics, and although singularity is therefore certainly present here as a determination of the Idea, it is external to material being. Consequently the primary essence of matter is that it has weight. This is not an external property which may be separated from it. Gravity constitutes the substantiality of matter, which itself consists of a tendency towards a centre which falls outside it. It is however this externality of its centre which constitutes the other essential determination of matter. As it negates its juxtaposed and continuous subsistence, one can say that matter is attracted to the centre, but if the centre itself is thought of as material, the attraction is merely reciprocal, and is at the same time a being attracted, so that the centre is again different from them both. The centre should not be thought of as material however, for the precise nature of material being is that it posits its centre as external to itself. It is therefore not the centre, but the tendency towards the centre, which is immanent in matter. Gravity is so to speak the acknowledgement by matter of its lack of independence, its state of contradiction, of the nullity of the self-externality involved in its being-for-self. 10  
+  
15  
20  
25  
30  
+

It can also be said that gravity is the being-in-self of matter in so far as it is not yet in its own self a centre or subjectivity, but is still indeterminate, undeveloped, occludent, and lacking as yet in material form. 35

Where the centre lies is determined by means of the weighted matter of which it is the centre; in so far as it is mass, it is deter- 40

mined, and is therefore its tendency, which is consequently a  
 + determinate positing of the centre.

*Addition.* Matter is spatial separation. By offering resistance it repels  
 itself from itself, and so constitutes repulsion, through which it posits its  
 5 reality and fills space. The singularities, which are repelled from another,  
 + all merely constitute a unit of many units; they are identical with each  
 other. The unit only repels itself from itself, and it is this which consti-  
 tutes the sublation of the separation of being-for-self, or attraction.  
 Together, attraction and repulsion constitute gravity, which is the Notion  
 10 of matter. Gravity is the predicate of matter, which constitutes the sub-  
 stance of this subject. Its unity is a mere should, a yearning; this is the most  
 afflicted of efforts, and matter is damned to it eternally, for the unity does  
 not fulfil itself, and is never reached. If matter reached what it aspires to  
 in gravity, it would fuse together into a single point. It is because repul-  
 15 sion is as essential a moment as attraction, that unity is not attained here.  
 This subdued, crepuscular unity does not become free; yet since matter  
 has as its determination the positing of the many within a unit, it is not  
 + so thick as those would-be philosophers who separate the one from the  
 many, and are therefore refuted by matter. Although the two unities of  
 20 repulsion and attraction are the inseparable moments of gravity, they do  
 not unite themselves in a single unity of an ideal nature. As we shall see  
 later, this unity reaches the first being-for-self of its existence in light.  
 Matter searches for a place outside the many, and since there is no dif-  
 ference between the factors which do this, there is no reason for regarding  
 25 one as nearer than the other. They are at the same distance on the peri-  
 phery, and the point sought is the centre; this extends to all dimensions,  
 + so that the next determination we reach is the *sphere*. Gravity is not the  
 dead externality of matter, but a mode of its inwardness. At this juncture,  
 this inwardness has no place here however, for matter, as the Notion of  
 30 that which is Notionless, is still lacking in inwardness.

The second sphere which we now have to consider is therefore finite  
 mechanics, in which matter is not yet adequate to its Notion. This finitude  
 of matter is the differentiated being of motion and of matter as such;  
 matter is therefore finite in so far as the motion which is its life, is external  
 35 to it. Either the body is at rest, or motion is imparted to it from without.  
 This is the primary difference within matter as such, which is subse-  
 quently sublated through its nature, or gravity. Here therefore we have the  
 three determinations of finite mechanics: *firstly* inert matter, *secondly* im-  
 pact, and *thirdly* fall; this constitutes the transition to absolute mechanics,



in which the existence of matter is also adequate to its Notion. Gravity does not occur within matter in a merely implicit manner, but in so far as the implicitness already makes its appearance; in that it does this it constitutes fall, which is therefore the first occurrence of gravity.

5

A

Inert matter

(*Inertia*)

§ 263

Initially, in its mere universality and immediacy, matter has only a *quantitative* difference, and is particularized into different quanta or *masses*, which in the superficial determination of a whole or unit, are *bodies*. **The body is also immediately distinguished from its ideality; it is however within space and time that it is essentially spatial and temporal, and it appears as their content, indifferent to this form.**

10

*Addition.* Matter fills space merely because it is exclusive in its being-for-self, and so posits a real limit in space. Space as such lacks this exclusiveness. The determination of plurality necessarily accompanies being-for-self, but is as yet completely indeterminate difference, and not yet a difference implicit within matter itself; matters are mutually exclusive.

15

§ 264

In accordance with the spatial determination in which time is sublated, the body is durable; in accordance with the temporal determination in which indifferent spatial subsistence is sublated, it is transitory; in general, it is a wholly contingent unit. It is indeed the unity which binds both moments in their opposition, i.e. motion; but in its indifferent opposition to space and time (prev. §), and so to the relation of space and time in motion (§ 261), the body has motion external to it in the same way as its negation of motion, or rest. It is in fact inert.

+

25

4

*Remark*

In this sphere the body is inadequate to its Notion or finite, because as matter it is only posited as the immediate abstract unity of time and space, and not as a single developed restless unity with motion immanent within it. Ordinary physical mechanics accepts the body in this determination, so that it is one of its axioms that a body can only be set in motion or come to rest through an *external cause*, motion or rest being merely a state of the body. Determinations such as this are vaguely envisaged as applying to selfless terrestrial bodies, as of course they do. This is merely finite corporeality in its immediacy and abstraction however. The body as body means this abstraction of body. The imperfection of this abstract existence is sublated in concretely existent bodies however, and the positing of this sublation begins already in the selfless body. Inertia, impact, pressure, draw, fall etc., the determinations of ordinary mechanics, belong to the sphere of finite corporeality and so to finite motion, and should not therefore be transferred to absolute mechanics, where it is rather in the freedom of their Notion that corporeality and motion have their existence.

*Addition.* Mass, posited immediately, contains motion as resistance; for this immediacy is being-for-other. The real moment of difference is external to mass, which has motion either as this Notion, or as sublated within it. Mass is inert when it is fixed in this way, yet it does not express rest. Duration is rest in that as the Notion of its realization, it is opposed to motion. Mass is the unity of the moments of rest and motion; both are sublated within it, for it is indifferent to both of them; it is as capable of motion as it is of rest, and in itself is confined to neither of them. In itself it neither rests nor moves, but merely passes from one state to the other through external impulse, i.e. rest and motion are posited within it by means of another. In so far as it rests, it remains quiescent, and does not, of its own accord, pass over into motion. Similarly, when in motion, it is in fact in motion, and does not pass over of its own accord into rest. Matter is implicitly inert, i.e. it is inert in so far as its Notion is opposed to its reality. Its reality has therefore separated itself and gone into opposition to it, and it is this that first constitutes its sublated reality, or that in which it exists merely as abstraction; it is this abstraction which is always regarded as the implicit nature and essence of matter by those for whom sensuous actuality is what is real, and the form of abstraction constitutes implicitness.

While finite matter is moved from without therefore, free matter moves itself; within its sphere it is therefore infinite, for within the whole, matter belongs to the stage of finitude. The just man is free, although he is bound by the laws which limit the unjust man. In nature each sphere exists not only in its infinitude, but as a finite relationship in itself. Finite relationships such as pressure and impact have the advantage of being known to us through reflection and being drawn from experience. They are defective merely because other relationships are subsumed under a rule constituted in this way. People think that things should happen in heaven as they do at home, but these finite relationships cannot show forth the infinitude of a sphere of nature.

## B

## Impact

## § 265

**When movement which is external to an inert body and therefore finite, sets this body in motion and so relates it to another, the two form the momentary unit of a single body, for they are both masses, and only differ quantitatively. It is thus that both bodies are united by movement through the imparting of motion, but as each is to an equal extent presupposed as an immediate unit, they also resist one another. In the relationship between them, their being-for-self, which is further particularized by the quantum of mass, constitutes their relative gravity. This is weight as the gravity of a quantitatively distinct mass; it is extensive as a number of weighted parts, and intensive as a specific pressure (see § 103 Rem.). As the real determinateness, together with velocity, or the ideal nature of the quantitative determinateness of motion, it constitutes a single determinability (quantitas motus), within which weight and velocity can reciprocally replace one another (cf. § 261 Rem.).**

*Addition.* The second moment in this sphere consists in matter being set in motion, and finding contact with itself in this movement. Matter is also moved because it is indifferent to place. This is contingent, and all necessity is here posited in the mode of contingency; later we shall see that the movement of matter is also necessary in existence. In impact the two colliding bodies are to be regarded as self-motivating, for they conflict

over a single place. The body which produces the impact assumes the place of the body at rest. The latter, the body which receives the impact, retains its place by also moving itself, and attempting to reassume the place which the other has occupied. It is in the *contact* produced by the  
 5 collision and pressure of these masses, between which there is no empty space, that the general ideality of matter begins. It is important to see how this internality of matter arises, for it is always important to see how the Notion arrives at existence. Masses create contact by being one for the other, merely because there are two material points or atoms in a single  
 10 moment of identity, the being-for-self of which is *not* being-for-self. No matter how hard and inflexible one imagines matters to be, it is always possible to postulate an interstice between; as long as they touch one another, they have positedness within a unit, no matter how small one  
 + imagines this point to be. This is the higher continuity existing in matter,  
 15 which is not external and merely spatial, but real. Similarly, the point of time is the unity of the past and the future; for here there are two in one, and in that they are in one, they are also not within it. The precise nature of motion consists in being in one place while at the same time being in another, and yet not being in another, but only in this place.

20 To the extent that they are contained in one, masses also have being-for-self; this constitutes the other moment of repulsion, or the elasticity of matter. The one is merely the surface, and the whole is continuous, because the body is completely *hard*. Since only the whole is one however the one is unposited, and the body simply gives or is absolutely *soft*. By leaving its  
 + whole, however, it correspondingly increases the intensity of its oneness. The very softness, the sublation of the body's outwardly exerted force, constitutes the restoration of this force through a return-into-self. The immediate reversion  
 + of these two sides is *elasticity*. What is soft also repels; it is elastic, it gives way, but only to a certain extent, and it cannot be driven out of place  
 30 altogether. It is here that the being-for-self of matter becomes apparent, and it is by means of this being-for-self that matter asserts itself as internality (which may also be called force), against its externality, which is here its-being-for other, i.e. the being-within-it of another. The ideality of being-for-self consists in another asserting a prevalence within the  
 35 mass, and vice versa. This determination of ideality, which appeared to come from without, shows itself to be the peculiar essence of matter, which at the same time itself belongs to matter's internality; this is the  
 + reason why reflective thought makes use of the concept of force in physics.

The strength of an impact, as an amount of activity, is merely that by  
 40 which matter retains its being-for-self, or resists; for impact is also

to it. This separation of external from essential motion is merely a +  
 product of abstractive reflection, and belongs neither to experience  
 nor to the Notion. It is one thing to distinguish these motions, it  
 is in fact necessary to do so, and to consider them mathematically as  
 separate lines, or treat them as distinct quantitative factors etc., it is 5  
 another thing to regard them as physically independent existences. +

In the postulated flight of this leaden ball into infinity, the  
 resistance of air and friction is also turned into an abstraction.  
 When a perpetuum mobile, no matter how correctly calculated  
 and demonstrated in theory, necessarily passes over into rest in a 10  
 certain period of time, an abstraction is made of gravity, and the  
 phenomenon is attributed solely to friction. The gradual de-  
 crease in the motion of the pendulum, and its final cessation,  
 is also attributed to the retardation of friction, as it is also said of  
 this motion that it would continue indefinitely if friction could be 15  
 removed. This resistance which the body encounters in its con-  
 tingent motion, belongs of course to the necessary manifestation  
 of its dependence. But just as the body is hindered in its effort to  
 reach the middle of its central body without these impediments  
 sublating its pressure and its gravity, so the resistance produced by 20  
 friction checks the projectile motion of the body, without its  
 gravity being removed or replaced by friction. Friction is an im-  
 pediment, but it is not the essential obstacle to external con-  
 tingent motion. Finite motion must be inseparably bound up with  
 gravity therefore, for in its purely accidental form, it passes over 25  
 into and becomes subject to the direction of gravity, which is the  
 substantial determination of matter.

*Addition.* It is here that gravity itself now occurs as the principle of  
 motion, but of motion determined as cancelling this separation or dis-  
 tance from the centre. This is self-generating motion, which posits its 30  
 own determinateness as a manifestation. Direction is the first determinate-  
 ness, and the law of fall is the other. *Direction* is the bearing upon the unit,  
 which is sought and presupposed in gravity; it is a tendency which is not a  
 random indeterminate spatial vacillation, but a unit which matter posits  
 for itself as a place in space which is not however reached by it. One 35  
 cannot say that this centre is present merely as a nucleus to which matter is  
 drawn, or around which it subsequently agglomerates; the gravity of  
 masses generates such a centre, and material points, by seeking one  
 another, posit it as their common centre of gravity. Gravity is the positing

of such a unit. Each particular mass is the positing of the same, and by this it seeks a unit in itself, and so gathers the whole of its quantitative relationship to others into a single point. This subjective unit, which as mere tendency constitutes the objective unit, is a body's centre of gravity. Every  
 5 body has a centre of gravity, by which it has its centre in another body, and it is only in so far as it possesses this centre that the mass constitutes an actual unit or body. The centre of gravity is therefore the primary reality of the unit of gravity, the tendency in which the entire weight of the body  
 + is concentrated. A mass cannot be at rest unless its centre of gravity is  
 10 supported, but if it is supported, the rest of the body might just as well not be there, for its gravity is completely withdrawn into one point. As a line, this point is the *lever*, to which each part of this unit belongs, and in which the centre of gravity divides itself as middle into points of extremity, the continuity of which constitutes the line. Gravity is equally the whole of this unit; the surface  
 + constitutes the unit, but the unit is taken back into the centre as a whole. Whatever exhibits itself here as the juxtaposition of dimensions, is in its immediacy a unit. It is  
 + in this way that the centre of gravity makes itself into the whole individual body.

Each individual mass is then such a body, which strives towards its centre, i.e. the absolute centre of gravity. In so far as matter determines a  
 20 centre towards which it strives, and this centre is a point of unity while matter remains a multiplicity, matter is determined as proceeding out of itself and out of its place. By proceeding out of itself, it also proceeds out of its self-externality, and as sublation of externality, this is the first true inwardness. All mass belongs to such a centre, and each particular mass is  
 25 dependent and contingent as against this truth. It is because of this contingency, that an individual mass can be separated from this central body. In so far as the specific mass which intervenes offers no resistance, the body will not be prevented from moving towards the centre; it will then move on account of there being no impediment, or rather fall on account of  
 30 there being no support. The rest into which external motion is brought by fall is certainly still a tendency, but unlike the first kind of rest, it is not contingent, nor is it a mere condition, or posited externally. The rest we have now is posited through the Notion, like fall, the motion which is posited through the Notion and sublates external and contingent motion.  
 35 Here inertia has disappeared, for we have reached the Notion of matter. In that each mass, through its weight, has a tendency towards the centre, and therefore exerts pressure, its motion is only an attempted motion, which makes itself effectual within another mass, and so posits its ideal nature. Similarly, by offering resistance and maintaining itself, this second  
 40 mass posits the ideal nature of the first. In finite mechanics both kinds of

rest and motion are placed on the same level. Everything is reduced to interrelated forces differing only in direction and velocity; consequently the result becomes all-important. Thus, the motion of fall, which is posited by the force of gravity, is placed on the same level as the force of projection.

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It is imagined that if a cannon-ball were to be shot forth with a force greater than that of gravity, it would escape at a tangent, if, it is added, there were no resistance from the air. It is also thought that the pendulum would go on swinging indefinitely if the air offered no resistance. 'The pendulum', it is said, 'describes an arc. By falling into the perpendicular, it has acquired a velocity by virtue of which it must reach a height on the other side of the arc equal to that of the point from which it started. It must therefore continue to move from side to side'. On one side the pendulum follows the direction of gravity, and this direction is then sublated; that is to say that it is removed from the direction of gravity by the communication of a new determination. It is this second determination which produces the lateral motion. It is then asserted that, 'It is *primarily* because of resistance, that the arc of oscillation becomes progressively smaller and the pendulum finally comes to rest, for if there were no resistance, the oscillatory motion *itself* would continue indefinitely'. Gravitational and transversal motion are not however two opposed kinds of movement. The first is the substantial movement, within which the second is contingently absorbed. Friction itself is not contingent however, for it is the result of gravity, although it can also be reduced. Francoeur realized this ('*Traité élémentaire de mécanique*', p. 175 n. 4-5) when he said, 'Le frottement ne dépend pas de l'étendue des surfaces en contact, le poid du corps restant le même. Le frottement est proportionel à la *pression*'. Friction is therefore gravity in the form of an external resistance; it is pressure as a mutual drawing towards the centre. In order to counteract the variable motion of the body, it has to be attached to something else. This material connection is necessary, but it disturbs the motion and so gives rise to friction. Friction is therefore a necessary factor in the construction of a pendulum, and can be neither eliminated nor thought away. If one imagines what it would be like without it, one is dealing with an empty concept. It is not only friction which brings the movement of the pendulum to rest however, for even if friction ceased, the pendulum would still come to rest. Gravity is the power which brings the pendulum to rest in conformity with the Notion of matter, for as the universal principle of matter, it maintains its preponderance over what is alien, and oscillation ceases in the line of fall. This necessity of the Notion appears in

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this sphere of externality as an external impediment or as friction. A man can be struck dead, but this external circumstance is contingent; the truth of the matter is that the man himself dies.

The combinations of fall with contingent motion, in projection for  
 5 example, do not concern us here, where we have to consider the  
 sublation of purely contingent motion. In projection the magnitude  
 of the motion depends upon the force of the projection and the weight  
 of the mass. It is this very weight however, which is at the same time  
 gravity; in that it gains preponderance as the universal, it overcomes  
 10 the determinateness posited within it. The body is projected only by  
 + means of gravity; it passes out of its determinate direction however, although  
 + only to return into the universal and become simple fall. This return gives a  
 further determinability to gravity, in which motion comes still closer to its  
 unity with it. In projectile motion weight is only one moment of the motive  
 15 force, it is the transition by which the force lying outside gravity is posited  
 within it. This transition increases the extent to which gravity constitutes  
 all motive force. The principle of motion is certainly still external to it,  
 but in a completely formal way as mere impulse, which in fall is simple  
 removal. It is in this way that projection constitutes fall, and both of  
 20 these occur simultaneously in the motion of the pendulum. Gravity is  
 removal-from-self, a presentation of itself as self-sundering, but every-  
 thing is still external. The fixed point, the removal from the line of fall,  
 the holding at a distance of the motivated point, and the moments of the  
 actual motion, belong to something else. The return from projection into the  
 25 line of fall is itself projection, and the oscillation of the pendulum is the falling  
 self-producing sublation of projection.

## C

## Fall

## § 267

Fall is *relatively free* motion: **free, in that it is posited through  
 the Notion of the body and is the** manifestation of the body's  
 own **gravity**; within the body **it is** therefore *immanent*. **At the**  
 30 **same time, it is however only the primary negation of externality,**  
**and is therefore conditioned. Separation from the connection**



with the centre is therefore still a contingent determination, posited externally.

*Remark*

The laws of the motion are concerned with quantity, and in particular with distances traversed in periods of time, and the highest credit accrues to the analysis of the understanding by reason of the immortal discoveries it has made in this field. The further non-empirical proof of these laws has been provided by mathematical mechanics however, for even science which bases itself upon empiricism discovers the inadequacy of the purely empirical mode of demonstration. In the a priori proof in question, it is assumed that velocity is uniformly accelerated. However, the proof consists in the transformation of the moments of the mathematical formula into physical forces, i.e. into an accelerative force which produces a uniform impulse in each moment of time, and a force of inertia, which is regarded as maintaining the increased velocity acquired in each moment of time. These determinations are completely lacking in empirical confirmation, and are in no way in conformity with the Notion. Consequently, the quantitative determination, which here contains a potency relationship, is formed into a sum of two mutually independent elements, so that the qualitative determination, which is connected with the Notion, is eliminated. One of the corollaries drawn from the law supposed to have been proved in this way is, 'That in uniformly accelerated motion, the velocities are proportional to the times.' In fact this proposition is nothing more than the completely straightforward definition of uniformly accelerated motion. In simply uniform motion the spaces traversed are proportional to the times elapsed; in accelerated motion, velocity increases in each successive unit of time; consequently, in uniformly accelerated motion, the velocities are proportional to the times elapsed; hence  $\frac{V}{t}$ , i.e.  $\frac{s}{t^2}$ . This is the simple, genuine proof.  $V$  is the general velocity, which is as yet indeterminate, and so at the same time abstract, i.e. simply uniform. The difficulty of the proof consists in  $V$  being considered at first as an indeterminate velocity, and yet presenting itself in the mathematical expression as  $\frac{s}{t}$ , i.e. as purely uniform. The roundabout procedure of the proof

borrowed from the mathematical exposition, makes it possible to accept velocity as simply uniform  $\frac{s}{t}$ , and to pass over from there to  $\frac{s}{t^2}$ . In the proposition that the velocity is proportional to times, it is primarily velocity in general that is referred to, so that it is  
 5 superfluous to represent it mathematically as  $\frac{s}{t}$ , to posit it as simply uniform, to introduce the force of inertia, and then to attribute to it this moment of purely uniform velocity. If velocity is to be proportional to times, it must be as uniformly accelerated velocity,  $\frac{s}{t^2}$ . Consequently, the determination  $\frac{s}{t}$  has no place here, and is  
 + excluded.

As against the abstract uniform velocity of lifeless and externally determined mechanism, the law of fall is a free law of nature, i.e. it has a side to it which determines itself from the Notion of the body. Since it follows from this that the law must be deducible  
 15 from this Notion, it has to be shown how Galileo's law, 'That the  
 + spaces traversed are as the *squares* of the times elapsed', accords with the determination of the Notion.

The connection here lies simply in this, that since the Notion is here the determinant of motion, time and space, as Notional  
 20 determinations, become free with regard to one another, i.e. their quantitative determinations conform to their Notional determinations. Now since time is the moment of negation, of being-for-self, and the principle of the unit, its magnitude (any empirical number) in relationship to space is to be considered as  
 25 the unit or denominator. Space on the contrary is juxtaposition, the extent of which is determined only by the extent of time, for in the velocity of this free motion, space and time are not mutually external and contingent, but constitute a single determination. The form of the extrinsicality of space, which is  
 30 opposed to unity as the form of time, and which is unmixed with any other determinateness, is the square; it is quantity coming out of itself, positing itself in a second dimension, and so augmenting itself, although only in accordance with its own determinability. This self-extension sets its own self as limit, so that by  
 35 becoming an other, it merely relates itself to itself.

Here the proof of the law of fall is drawn from the Notion of

the matter. The potency relationship is essentially qualitative, and is the only relationship which belongs to the Notion. It should be added in connection with what follows, that since fall, in its freedom, still contains conditionality, time remains an immediate number, a merely abstract unit, and the quantitative determination of space only attains to the second dimension.

*Addition.* The tendency towards the centre is the only absolute factor in fall; we shall see later how the other moment, which is diremption, difference, the removal of the body into a state of supportlessness, also derives from the Notion. In fall mass does not separate itself of its own accord, but when it is separated, it returns into the unity. The motion which produces itself in fall constitutes the transition therefore, it is a middle term between inert matter, and matter in which its Notion finds absolute realization, i.e. absolutely free motion. As merely quantitative indifferent difference, mass is a factor in external motion, but here, where motion is posited through the Notion of matter, purely quantitative difference between masses has, as such, no significance, for masses fall not as masses but as matters in general. In fall it is in fact merely the weightedness of bodies which comes under consideration, and a large body is as heavy as a smaller one, i.e. one of less weight. We know well enough, that a feather does not fall like a plummet, but this is the result of the medium which has to give way, i.e. masses behave in accordance with the qualitative difference of the resistance they encounter. A stone falls faster in air than it does in water for example, but in airless space bodies fall in the same way. Galileo put forward this proposition, and expounded it to certain monks. Only one of the fathers got a slant on it when he said that a pair of scissors and a knife would reach the earth at the same time; but the matter cannot be decided so easily. Knowledge of this kind is worth more than thousands upon thousands of so-called brilliant thoughts.

The empirical extent of the fall of a body is a little over 15 feet per second, although there is a slight variation at different latitudes. If a body falls for two seconds, it covers not double, but four times the distance, i.e. 60 feet; in three seconds  $9 \times 15$  feet, and so on. If one body falls for three seconds and another for 9, the spaces traversed are related not in the ratio of 3:9, but of 9:81. Purely uniform motion is ordinary mechanical movement; motion which is not uniformly accelerated is capricious; uniformly accelerated motion is that in which the law of living natural movement begins to appear. Velocity increases with time therefore. i.e.

$t = \frac{s}{t}$ , i.e.  $s = t^2$ , for  $s = t^2$  is the same as  $\frac{s}{t^2}$ . In mechanics this is proved mathematically by representing the so-called force of inertia by a square, and the so-called accelerative force by the addition of a triangle. This is an interesting procedure, and may well be necessary for mathematical exposition; but this is its only use, and it is a forced representation. Proofs of this kind always assume what has to be proved, so they certainly describe what happens. Mathematical imagination arises out of the need for a transformation of the potency relationship into a more manageable form, e.g. by reducing it to addition, or subtraction and multiplication. It is because of this that the motion which occurs in fall is analysed into two parts. The division has no reality however, and is an empty fiction which merely serves the convenience of mathematical exposition.

## § 268

Fall is merely the abstract positing of a single centre, in the unity of which the difference between particular masses and bodies posits itself as sublated; consequently, mass or weight plays no part in the magnitude of this motion. As this negative relation to self, the simple being-for-self of the centre is essentially a repulsion of itself however. It is formal repulsion into many immobile centres (stars), and living repulsion in that it determines these centres according to the moments of the Notion and so establishes an essential relation within their Notional differentiation. This relation is the contradiction of their independent being-for-self, and their connectedness with the Notion; the appearance of this contradiction between the reality and ideality of these centres is motion, and indeed absolutely free motion.

*Addition.* The deficiency in the law of fall is the result of our regarding space as posited here in a simply abstract manner in its first power as line; this happens because the motion of fall is conditioned as well as being free (see prec. §). Because its condition of being removed from the centre is still contingent and not determined by gravity itself, fall is merely the primary manifestation of gravity. This contingency has still to fall away. The Notion must become wholly immanent within matter. This takes place in the third main section, in absolute mechanics, where matter is completely free and where its determinate being is completely

adequate to its Notion. Inert matter is wholly inadequate to its Notion. Weighted matter, in so far as it falls, is only partly adequate to its Notion through the sublation of plurality as the tendency of matter towards one central place. The other moment, which is the differentiation of the place within itself, is not yet posited by the Notion however; that is to say that the self-repulsion of attracted matter as weightedness is lacking as yet, and that diremption into many bodies is not yet the act of gravity itself. Matter of this kind, which is extended as a plurality and at the same time continuous within itself, and which contains the centre, must be repelled. This is real repulsion, in which the centre is formed out of self-repulsion and diversification, and a plurality of masses is consequently posited, each having its centre. The logical unit is this infinite relation with itself, which is identity with itself, but as self-relating negativity, and consequently as repulsion from itself. This is the other moment contained within the Notion. The self-positing of matter within the determinations of its moments is necessary to material reality. Fall posits matter onesidedly as attraction; it must now also appear as repulsion. Formal repulsion also has a place here, for it is a property of nature to allow an abstract and particular moment to subsist in itself. The stars are the bodies in which formal repulsion finds existence, for as bodies they are as yet simply multiple and exhibit no difference; here, they are not yet to be regarded as luminous, for this is a physical determination.

We could regard the relations between stars as being rational; but they belong to dead repulsion. Their *figurations* could be the expression of essential relations, but they do not belong to living matter, where the centre differentiates itself within itself. The host of stars is a formal world, because only this onesided determination is able to hold sway there. As a system it should not be put on a level with the solar system, which for us is the primary knowable system of real rationality within the heavens. The stars may be admired for their repose, but in worth they are not to be regarded as the equals of the concrete individual body. The content of space explodes into an infinite number of matters; this can delight the eye, but it is only the first breaking forth of matter, and this eruption of light is as unworthy of wonder as an eruption on the skin or a swarm of flies. The tranquillity of these stars means more to the heart, for the contemplation of their peace and simplicity calms the passions. Their world is not so interesting from the philosophical point of view as it is to the sentiments however. As a plurality within immeasurable spaces it is of no significance to reason; it is externality, emptiness, negative infinity. Reason knows itself to be above this, for the wonder is merely negative,

+ an uplifting of the mind which remains strictly limited. The rationality of the stars is to be grasped in the figurations in which they are reciprocally disposed. The eruption of space into abstract matter proceeds according to an inner law, so that the stars present crystalline effects which could  
5 have an inner connection, although interest in these matters can be no more than an empty curiosity. Little can be said about the necessity of these figurations. Herschel has noted forms in nebulae indicative of  
+ regularity. The spaces are emptier as the distances from the Milky Way increase, and from this it has been concluded (Herschel and Kant), that  
10 the stars form the figure of a lens; but this is something wholly indeterminate and general. It must not be thought that the worth of science  
+ depends upon its ability to grasp and explain all multifarious shapes. One must be content with the fact of that which has already come within one's grasp. There is still much that cannot be grasped, and this has to be ad-  
15 mitted in the philosophy of nature. At present, rational interest in the  
+ stars must confine itself solely to stellar geometry. The stars constitute the field of this abstract and infinite diremption, in which contingency has an essential influence upon the disposition of the parts.

## CHAPTER THREE

### Absolute mechanics (*Astronomy*)

#### § 269

Gravitation is the true and determinate Notion of material corporeality **realized as the Idea. Universal corporeality divides itself** essentially into *particular* bodies, and **links itself together in the moment of individuality or subjectivity, as determinate being appearing in motion**; this, in its immediacy, is thus a *system of many bodies*.

#### *Remark*

Universal gravitation must be recognized as a profound thought in its own right. **It has already attracted** attention and inspired confidence, particularly through the quantitative determination bound up within it, and its verification **has been pursued** from the *experience* of the solar system down to that of the phenomenon of the miniature capillary tube. **When it is seized upon in this way** in the sphere of reflection however, it has a merely general abstract significance, which in its more concrete form is merely gravity in the quantitative determination of fall, and it therefore lacks the significance of the Idea developed into its reality, which is given to it in this paragraph. Gravitation is the immediate contradiction of the law of inertia, and it is because of this that matter strives *out of itself* towards another.

As has already been shown, the *Notion* of gravity contains not only the moments of being-for-self, but also that of the continuity which sublates being-for-self. These moments of the Notion suffer the fate of being grasped as distinct forces corresponding to the forces of attraction and repulsion. They are defined more closely as the *centripetal* and

*centrifugal forces* which, being mutually independent and brought to bear upon one another contingently in the body as a third element, are supposed to *work upon bodies* as gravity does. Whatever profundity there might be in the thought of **universal** gravity is annulled by this, and as long as this vaunted purveying of *forces* prevails, the Notion and reason can never penetrate into the science of absolute motion. In the syllogism which contains the *Idea* of gravity, this *Idea* is the Notion disclosing itself **in external reality in the particularity of bodies, and at the same time, in the ideality and intro-reflection of these bodies, displaying its integration into itself in motion.** This contains the rational identity and inseparability of the moments **which are otherwise taken to be independent. In general, motion as such** only has significance **and existence** where there is a system of *several* bodies, which are variously *determined*, and so stand in a certain relationship to one another. **The closer determination of this syllogism of totality, which is in itself a system of three syllogisms, is given in the Notion of objectivity** (see § 198).

*Addition.* Primarily, the solar system is a number of independent bodies, which maintain themselves in this relation, and posit an external unity within another. Difference is posited therefore, and plurality is no longer indeterminate as with the stars, so that determinateness consists of absolutely universal and particular centrality. The forms of motion in which the Notion of matter is achieved follow from these two determinations. The body which constitutes the relative centre is in itself the universal determinability of place, and it is into this that motion falls; but at the same time, place itself is also not determined in so far as it has its centre in another, and this indeterminateness has to find its determinate being, for place determined in and for itself is a mere unit. The particular central bodies are consequently indifferent to particularity of place; this appears in the search for their centre, in which they leave their place and transport themselves to another. The third determination is that they could all be simultaneously equidistant from their centre, and that if they were, they would then no longer be separated from one another. If they then moved in the same orbit, there would be no difference between them; they would be one and the same, each the mere repetition of the other, and their variety would then be purely nominal. The fourth determination is that by changing their place at different distances from one another, they



return to themselves by means of a curve, for it is only in this way that they assert their independence of the central body. Similarly, by moving around the centre in the same curve, they express their unity with it. It is because of their independence of the central body that they keep their place, and do not fall further into it.

There are therefore three movements present here; (1) mechanical motion communicated from without, which is uniform; (2) the motion of fall, which is partly conditioned and partly free, and in which the separation of a body from its gravity is still posited as contingent, although the motion already belongs to gravity itself; (3) unconditioned free motion, the main moments of which we have presented as the great mechanism of the heavens. This motion is a curve, in which the particular bodies posit the central body, which simultaneously posits them. The centre has no significance without the periphery, nor has the periphery a significance without the centre. This disposes of the physical hypotheses which proceed indiscriminately from the centre or from the particular bodies, positing first one and then the other as original. Each aspect is necessary, but is onesided when taken alone. The diremption into different terms and the positing of subjectivity is a single act, a free motion, which unlike pressure and impact, is not external. It is said that the distinct reality of the force of attraction may be seen and demonstrated in gravity. In that it brings about fall, gravity undoubtedly constitutes the Notion of matter, but it does so abstractly, and is not yet self-diremptory. Fall is an incomplete manifestation of gravity, and is therefore not real. The centrifugal force through which a body has the tendency to fly off at a tangent, is supposed, foolishly enough, to impart an impact to the celestial bodies by a swinging side-blow, to which they have evidently always been susceptible. The contingency of externally administered motion of this kind belongs to inert matter; it appears for example when a stone is attached to a string, and swung round so that it tends to fly off. We should not speak of forces therefore, but if we do so, we should remember that there is one force, and that its moments do not pull in different directions as two forces. The movement of the heavenly bodies is not a pulling hither and thither, but free motion; as the ancients said, they go their ways like the blessed gods. The corporeality of the heavens is not of a kind to have the principle of rest or of motion external to it. 'As the stone is inert, and the whole earth is composed of stones, the other heavenly bodies are precisely the same'. This syllogism puts the properties of the whole on the same level as those of the part, but impact, pressure, resistance, friction, attraction, and the like, are only valid in their application to an existence of matter distinct from that of heavenly cor-

+ corporeality. Matter is certainly common to them both, just as a good thought and a bad thought are both thoughts; but the bad is not good because the good is also a thought.

## § 270

In bodies in which **the full freedom of the Notion** of gravity  
 5 is realized, the determinations of their distinctive nature  
 are contained as the moments of their Notion. Thus, one  
 of the moments is the *universal* centre of **abstract relation to  
 self**. Opposed to this extreme is **immediate singularity**, which  
 is self-external and centreless, **and which also appears as an  
 10 independent corporeality**. The *particular* bodies are however  
 + those which simultaneously stand **as much** in the determina-  
 tion of self-externality, as they do in that of being-in-self;  
 they are in themselves centres and find their essential unity  
 through relating themselves to the universal centre.

*Remark*

15 **As that which is immediately concrete, the planetary bodies  
 are the most perfect form of their existence. The sun is usually  
 regarded as the most important, for the understanding tends to  
 prefer what is abstract to what is concrete; it is for the same reason  
 that the fixed stars are more highly regarded than the bodies of the  
 20 solar system. Lunar and cometary bodies are the opposites into  
 which centreless corporeality divides itself in so far as it belongs to  
 externality.**

It is well known that the immortal honour of having dis-  
 covered the laws of absolutely free motion belongs to  
 + *Kepler*. *Kepler proved* them in that he discovered the *univer-  
 + sal* expression of the empirical data (§ 227). It has subse-  
 quently become customary to speak as if *Newton* were the  
 + first to have discovered the proof of these laws. The credit  
 for a discovery has seldom been denied a man with more  
 30 unjustness. **In this connection I have the following observations  
 to make:**

(1) **Mathematicians will admit** that *Newton's* formulae may be  
 deduced from *Kepler's* laws. **The simply immediate derivation**

is straightforward enough. In Kepler's third law  $\frac{A^3}{T^2}$  is the constant.

If this is expressed as  $\frac{A \cdot A^2}{T^2}$ , and Newton's definition of  $\frac{A}{T^2}$  as universal gravity is accepted, one has an expression of this so-called gravity as working in inverse proportion to the squares of the distances.

(2) Newton's proof of the proposition that 'a body subject to the law of gravitation moves in an *ellipse* about a centre' simply gives rise to a *conic section*, whereas the main proposition to be proved consists precisely in the fact that the course of such a body is *neither a circle nor a conic section*, but *simply the ellipse*. **This Newtonian proof. (Princ. Math. bk. I sect. II prop. 1) needs further careful qualification; and although it is the basis of the Newtonian theory, analysis no longer uses it. In the analytical formula, the conditions which make the path of the body a *specific* conic section are constants; and their determination is made to depend upon an *empirical* circumstance, i.e. a particular position of the body at a certain point of time, and the *fortuitous* strength of the original *impulse* it is supposed to have received. In this way the circumstance which determines the curved line into an ellipse falls outside the formula which is supposed to be proved, and the attempt to prove it is never made.**

(3) The Newtonian law of the so-called force of gravity is also merely demonstrated from experience by means of induction.

The only difference to be seen here is, that what Kepler expressed in a simple and sublime manner as *constituting the laws of celestial motion*, is changed by Newton into the *reflectional form of the force of gravity*, and into the form of this force as it yields the law of its magnitude in the motion of fall. For the analytical method, the Newtonian form is not only convenient, but necessary; this is merely the difference of a mathematical formula however, and for some time now analysis has known how to deduce the Newtonian formulation and its dependent propositions from the form of Kepler's laws. On this point I concur with the accomplished exposition in Francoeur's, 'Traité élém. de Mécanique' Bk. II ch. II n. IV. Taken as a whole, the old-fashioned attempt at what is called a proof, presents a confused web,

and entails the *lines* of a simply geometrical construction, given the physical significance of *independent forces*, and empty **reflectional** determinations involving the *accelerating force* and the *force of inertia* already mentioned, and particularly  
 5 the relationship of what is called gravity itself to centripetal and  
 + centrifugal forces etc.

The remarks made here need a far more extensive treatment than can be given them in a compendium such as this. Propositions not in accordance with accepted opinions look like mere assertions,  
 10 and when they contradict sober authorities, seem to be presumptuous, which is even worse. It is however simple facts rather than  
 + propositions which have been adduced here. The import of this reflection is merely this, that the distinctions and determinations employed by mathematical analysis, and the course to which its  
 15 methods commit it, should be sharply distinguished from whatever is supposed to have a physical reality. It is not the assumptions, procedure and results which analysis requires and affords which are questioned here, but the physical worth and the physical  
 20 significance of its determinations and procedure. It is here that attention should be concentrated, in order to explain why physical mechanics has been flooded by a monstrous metaphysic, which, contrary to both experience and the Notion, has its sole  
 + source in these mathematical determinations.

It is recognized that the significant moment added by Newton  
 25 to the content of Kepler's laws—apart from the basis of the analytical treatment, the development of which has moreover rendered  
 + superfluous and even led to the rejection of much that belonged to Newton's essential principles and contributed to his fame—is the  
 + principle of perturbation. In so far as it rests upon the proposition that what is called attraction consists of an action between all  
 30 the individual material parts of a body, the importance of this principle has to be adduced here, and is to be found in the fact that matter in general posits its centre. It follows that the mass of a particular body is to be regarded as a moment in the determination  
 35 of the place which occupies the centre, and that all the bodies of a system posit their sun. The individual bodies themselves also give rise to each relative position which they assume with regard to one another in the general movement however: this is the momentary relation of gravity between them, through  
 40 which they not only possess the abstract relationship of distance,

but posit a particular centre amongst themselves. This centre is partly resolved again in the universal system however, and if it persists, as it does in the mutual perturbations of Jupiter and Saturn, it remains at least partly subordinate to it. +

The connection between the main determinations of free motion and the Notion has only been outlined, and as it is not possible here to develop it any further, it must be left to its fate. The principle of the matter is that the rational demonstration of the quantitative determinations of free motion can rest solely upon the Notional determinations of space and time, for these moments, in their intrinsic relationship, constitute motion. When will science reach an awareness of the metaphysical categories which it employs, and instead of taking these as basic, found itself upon the Notion of the fact in hand! 10

The Notion in general affects the primary form of returning into itself through a curve; this is due to the general particularity and individuality of bodies (§ 269), which have a semi-independent existence, with their centre partly in themselves, and partly in another. It is these Notional determinations which give rise to the postulation of centripetal and centrifugal forces, and which are distorted by being regarding as distinct and independent, as existing outside one another and influencing independently, and as only meeting contingently and externally in their effects. As has already been observed, these are the lines which should be reserved to mathematical determination, but which have been transformed into physical actualities. 15 20 25

Further, this motion is uniformly accelerated, and as it returns into itself, it is in turn uniformly retarded. In free motion, space and time occur in accordance with what they are by differentiating themselves and entering into the quantitative determination of motion (§ 267 Remark), so that they are not related as they are in abstract simply-uniform velocity. It is in the so-called explanation of uniformly accelerated and retarded motion by means of an alternating decrease and increase in the magnitude of the centripetal and centrifugal forces, that the confusion caused by the postulation of such independent forces is greatest. According to this explanation, the centrifugal force is less than the centripetal force in the movement of a planet from aphelion to perihelion; at perihelion itself however, the centrifugal force suddenly becomes greater than the centripetal force, 30 35 40

+ and in the movement from perihelion to aphelion, the forces are  
 supposed to work in the inverse relation. It is clear that it is not in  
 accordance with the nature of forces that the preponderance  
 acquired by one over the other should suddenly switch like  
 5 this into subordinacy. On the contrary, it ought to be concluded  
 that a preponderance acquired by one force over another should  
 not only maintain itself, but lead to the complete annihilation of  
 the other, so that motion must either pass over into rest through  
 the preponderance of the centripetal force, and the planet crash  
 10 into the central body, or pass into a straight line through the  
 preponderance of the centrifugal force. The conclusion drawn  
 from this is simply that it is because the body draws away from the  
 sun after passing perihelion that the centrifugal force increases  
 again, and that as it is furthest from the sun at aphelion, it is just  
 15 there that this force is greatest. In this metaphysical chimera, two  
 opposed and independent forces are assumed, and no further  
 investigation of these fictions of the understanding is thought to  
 be necessary. No enquiry is made into how an independent force  
 of this kind is able, of its own accord, to make itself subordinate  
 20 to the other, and then to make itself predominate, to get the other  
 force to allow this, and to follow this up by cancelling this pre-  
 dominance again, or allowing it to be cancelled. If this inwardly  
 groundless augmentation and diminution is examined more  
 closely, points are found midway between the apsides, in which  
 25 the forces are in equilibrium. The supposed movement of these  
 two forces out of this equilibrium is just as unmotivated as this  
 sudden reversal of their preponderance. It is easy enough to see  
 how this method of explanation, in remedying a fault by means  
 of a further determination, gives rise to further and more be-  
 30 wildering confusions.

+ A similar confusion arises from the explanation of the fact that  
 the oscillation of the pendulum appears to be slower at the equator.  
 This phenomenon is also attributed to a supposedly greater centri-  
 35 fugal force, but it could be ascribed with equal facility to an in-  
 crease in the force of gravity holding the pendulum more firmly  
 40 in the perpendicular, or line of rest.

In so far as it enters into the shape of the orbit, the circle is  
 only to be grasped as the orbit of a simply uniform motion. It is  
 certainly conceivable as it is said, that a uniformly increasing  
 40 and decreasing motion should take place in a circle. This conceiv-

ability, or possibility, is only an abstract representability however, and as it leaves out the determinate situation to which it applies, it is not only superficial, but wrong. The circle is the line returning into itself; all its radii are equal, and it is therefore fully determined through its radius; this is merely a unit, and the unit constitutes the whole determinateness. In free motion however, where various spatial and temporal determinations occur in qualitative relationship with one another, the relationship necessarily occurs as a spatial differentiation, which therefore requires two determinations. Consequently the form of the path returning into itself is essentially an ellipse, which is the first of Kepler's laws.

The abstract determinability which constitutes the circle, also appears in the arc or angle being independent of the two radii by which it is enclosed, and to which it is a purely empirical measure. In motion determined by the Notion however, the distance from the centre, and the arc described in a certain time, must be contained in a single determinability, and constitute a single whole, for the moments of the Notion are not related contingently. It is this that gives rise to the sector, which is a two-dimensional spatial determination. The arc is therefore the essential function of the radius vector, and by its variation in equal periods of time, it carries the inequality of the radii with it. That the spatial determination should appear here, by means of time, as the two-dimensional determination of a plane, is connected with what was said above (§ 267) about the exposition of the same determinateness in fall: now in the root as time, and again in the square as space. Here however the quadraticity of space is confined to the sector by the return of the line of motion into itself. It will be apparent that the second of Kepler's laws, which is concerned with the sweeping out of equal sectors in equal periods of time, rests upon these general principles.

This law only touches the relation between the arc and the radius vector, and within it time is an abstract unity; as time is the unity which determines the various sectors, they are all equal. The further relationship is however that between time and the extent of the orbit, or, for it comes to the same thing, the distance from the centre. Here time is not an abstract unity but the general quantum of time taken to complete the orbit. We have seen that in fall, which is an imperfectly free motion determined partly in accordance with the Notion, and partly from without, time and

space are related to one another as root and square. In absolute motion however, which is the realm of free measures, each determinateness attains its totality. As root, time is a purely empirical quantity, and in that it is qualitative, it is merely abstract unity. As a moment of the developed totality however, it is at the same time a determined unity, a totality for itself, which produces itself, and so relates itself to itself. It is however internally dimensionless, and only reaches a formal identity with itself by producing itself as the square. Space on the other hand, as positive extrinsicality, attains the dimension of the Notion in the cube. It is in this way that their realization simultaneously contains their original difference. This is the third of Kepler's laws, which is concerned with the relation between the *cubes of the distances, and the squares of the times*. The greatness of this law consists in its presentation of the *rationality of the matter* with such simplicity and immediacy. In the Newtonian formula however, it is transformed into a law applied to the *force of gravity*, and so shows how *reflection* which fails to get to the bottom of things can distort and pervert the truth.

*Addition.* It is here in the mechanical sphere that genuine laws make their appearance, for a law is the linking of two simple determinations so that only their simple relation to one another constitutes the whole relationship, although there must be the appearance of mutual freedom between them. In magnetism however, the inseparability of the two determinations is already posited, so we do not call it a law. In higher shapes, the determinations are linked in the individualization of the third term, so that we no longer have the direct determinations of two inter-related terms. It is only in spirit, where there is a mutual confrontation of independent entities, that laws occur again. Now the laws of this motion concern the two aspects of the form of its path, and its velocity. These have to be developed out of the Notion, but this would demand an extensive investigation, and because of the difficulty of the task, it has not yet been fully accomplished.

Kepler discovered his laws empirically, by working inductively with the observations of *Tycho Brahe*; to discover the universal law governing these fragmentary phenomena is a work of genius in this field.

(1) Copernicus still regarded the orbit as circular and the motion as eccentric. Equal arcs are not described in equal times however, and as it



is contrary to the nature of the circle, motion of this kind cannot take place within it. The circle is the curve of the understanding, and posits equality. Circular motion can only be uniform, for equal arcs can only correspond to equal radii. There is no general agreement upon this point, but if it is considered more closely, the opposite is found to be an empty assertion. The circle has only one constant, while other curves of the second order have two constants, the major and the minor axis. If different arcs are described in the same time, then they must be different not only empirically but in their function, i.e. it is in their function itself that the difference must lie. In the circle, these arcs would in fact only be distinguished from another empirically. The radius is essential to the function of an arc in that it is the relation of that which is peripheral to the centre. If the arcs are different, the radii must also differ, and the Notion of the circle be immediately transcended. Consequently, the assumption of acceleration necessarily implies a variation in the radii, for arc and radius are inseparably connected. The path must therefore be elliptical, for its complete motion is a revolution. We know from observation that the ellipse does not correspond completely to the course of the planets, and other perturbations are therefore to be assumed. It is for subsequent astronomy to decide whether or not the path of the orbit has profounder functions than the ellipse, it may perhaps be the oval line etc.

(2) Here the determinability of the arc lies in the radii by which it is intersected; these three lines together form a triangle, which is a single determinate whole, of which they are the moments. Similarly, the radius is a function of the arc, and of the other radius. It should not be forgotten that the determinateness of the whole as an empirical quantity, and a distinct determinability which may be brought into external comparisons, lies in this triangle, and not in the arc as such. The empirical determinability of the complete curve, of which the arc is a certain part, lies in the relation of its axes; the other determinateness lies in the law governing the variation of the vectors; and so far as the arc is a part of the whole, its determinability, like that of the triangle, lies in that which constitutes the general determinability of the whole path. A line can only be subsumed under a necessary determinateness if it is a moment of a whole. The extent of the line is a merely empirical element, the whole first appears in the triangle. This is the origin of the mathematical conception of the parallelogram of forces in finite mechanics, in which the space traversed is presented as the diagonal, which is therefore posited as part of a whole or function, and so susceptible to mathematical treatment. Centripetal force is the radius, centrifugal force the tangent, and the arc is the diagonal of

the tangent and the radius. These are only mathematical lines however; separate the whole from physical reality, and it becomes an empty representation. In the abstract motion of fall, the squares, that is to say the plane involved in the time factor, are only numerical determinations. The square is not to be taken in a spatial sense, because in fall only a straight line is traversed. It is this which constitutes the formal element in fall, and when the space traversed in fall is also represented as a plane expressing a quadratic spatial relationship, this is therefore a merely formal construction. However, as the time which sublates itself here corresponds to a plane, it is here that the self-production of time attains reality. The sector is a plane produced by the arc and the radius vector. The two determinations of the sector are the space transversed, and the distance from the centre. The radii drawn from the focus in which the central body is situated are not all the same. If two sectors are equal, the one with the longer radii will have the smaller arc. Both sectors should be traversed in the same time, consequently, in the sector with the longer radii, both the distance travelled and the velocity will be less. The arc or the distance travelled is here no longer an immediate term, but by its relation to the radius, which is not yet present in fall, it is reduced to a moment, and therefore to the factor of a product. Yet the spatiality determined through time here forms two determinations of the path itself, i.e. the space traversed, and the distance from the centre. The time taken determines the whole, of which the arc is only a moment. It is because of this that equal sectors correspond to equal times; the sector is determined by time, so that the space traversed is reduced to a moment. The situation here corresponds to that in leverage, in which the load and the distance from the fulcrum are the two moments of equilibrium.

(3) Kepler searched for the law that the cubes of the mean distances of the various planets are as the square of the times of their revolutions, for 27 years. He had been on the brink of discovering it earlier, but an error in calculation had prevented him from doing so. It was his unshakeable belief in the inherent rationality of the facts that led him to his discovery. Previous consideration has made it seem likely that time has a dimension less than space. Since space and time are bound together here, each is posited in its singularity, and their quantitative determinability is determined by their quality.

These laws are some of the finest, purest, and least contaminated with heterogeneous matter that we have in the natural sciences. It is therefore of the greatest interest to reach an understanding of them. These Keplerian laws are presented in their purest and clearest form. According to the

Newtonian form of the law, gravity governs motion, and its force works  
 in inverse proportion to the square of the distances. The honour of having +  
 discovered the law of universal gravitation has been attributed to Newton,  
 who, by catching the popular imagination, has won the greatest applause,  
 and obscured the glory of Kepler. The Germans have often looked on 5  
 impassively while the English have assumed authority in this way.  
 Voltaire furthered the acceptance of the Newtonian theory among the  
 French, and then the Germans also followed along. The merit of Newton's +  
 form is of course that it has many advantages in mathematical treatment.  
 It is often envy which motivates the debunking of great men, but on the 10  
 other hand, it is a kind of superstition to regard their accomplishments as  
 unsurpassable.

The mathematicians themselves have been unjust to Newton in so far  
 as they have regarded gravity in two different ways. In the first instance +  
 it is simply the direction in which a stone falls at 15 feet a second on the 15  
 surface of the earth, and as such it is a purely empirical determination.  
 The law of fall is ascribed principally to gravity, but as the moon also  
 has the earth as its centre, Newton applied it to lunar motion, so that the  
 quantity of 15 feet is also taken as basic to the orbit of the moon. The  
 distance of the moon from the earth is sixty times the earth's diameter, +  
 and this fact is therefore used to determine the moment of attraction in  
 lunar motion. It is then found that the earth's power of attraction over  
 the moon (the sinus versus, the sagitta) also determines the entire lunar  
 orbit, and that the moon falls. This may very well work out in this way,  
 but it remains a particular case, in which the empirical extent of fall on 25  
 the surface of the earth is merely extended to the moon. It is not meant to  
 apply to the planets, or would only be valid in the relationship between  
 them and their satellites. It is therefore a limited principle. Fall is said to +  
 apply to the heavenly bodies. These bodies do not fall into the sun how- +  
 ever, and in order to counteract fall, yet another motion is attributed to 30  
 them. This is accomplished easily enough. Boys do the same thing when  
 they whip the side of a top to keep it from toppling over. Such a puerile  
 attitude towards the free motion of the planets is not to be tolerated  
 however. Universal gravitation is therefore only the second meaning of +  
 gravity, and Newton saw in gravity the law of all motion; he therefore 35  
 transferred gravity to the law governing the celestial bodies, and called  
 it the law of gravity. It is this generalization of the law of gravity which  
 constitutes the merit of Newton's work. We are aware of it when we  
 watch the movement of a falling stone, and the fall of an apple from a  
 tree is said to have motivated Newton into making this generalization. +

According to the law of fall, the body moves towards its centre of gravity, and heavenly bodies have a tendency towards the sun; their direction is posited jointly by this and their tangential tendency, the result being this diagonal direction.

5 It seems therefore as though we have found a law here, and that it has as its moments: (1) the law of gravity as attractive force, and (2) the law of tangential force. If we examine the law of planetary revolution however, we shall discover only one law of gravity, for although the centripetal force is supposed to constitute only one of the moments, the centrifugal  
 10 force is a superfluous element, and therefore disappears completely. Consequently, the construction of motion out of these forces shows itself to be futile. The law of one of these moments, i.e. that which is attributed to attractive force, is not the law of this force alone, but shows itself to be the law of the entire motion, the other moment becoming an empirical  
 15 coefficient. Nothing more is heard of centrifugal force. Elsewhere these two forces are readily allowed to separate. Centrifugal force is said to be an impulse received by bodies in accordance with their direction and magnitude. Such an empirical quantity can no more constitute the moment of a law than can the 15 feet. If one wants to determine the laws of centri-  
 20 fugal force as they are in themselves, contradictions will present themselves, as is always the case with opposites of this kind. Sometimes they are credited with the same laws as centripetal force, and sometimes with others. The greatest confusion arises however if one attempts to separate the action of these two forces when they are no longer in equilibrium,  
 25 but one is greater than the other, and one is supposed to be increasing while the other diminishes. The centrifugal force is said to be at its maximum in aphelion, and the centripetal force in perihelion. One could just as well assert the opposite however. If the attractive force of the planet is greatest when it is closest to the sun, it is precisely at this point  
 30 that the centrifugal force ought also to be at its maximum, in order to prevail as the distance from the sun begins to increase again. If one assumes a gradual increase in the force in question instead of a sudden switchover, one has to assume an even greater increase in the other force, so that the opposition admitted for the purpose of explanation, breaks down. In  
 35 some expositions the increase in one is taken to be different from the  
 + increase in the other, but the result is the same. This switching around, in which each is always supposed to be prevailing over the other, merely leads to confusion. It is the same in medicine, when irritability and sensi-  
 + bility are regarded as in inverse ratio to one another. This form of reflec-  
 40 tion ought to be dispensed with completely.

Experience shows that because the pendulum swings slower at the equator than at higher latitudes, it has to be shortened there in order to increase the rapidity of its oscillations. This is supposed to be evidence of a more powerful centrifugal force at the equator, for in the same time a point at the equator will describe a greater circle than the pole, and it is supposed to be the resultant increase in centrifugal force which counteracts the pendulum's force of gravity, or tendency to fall. The opposite might be asserted with equal plausibility and rather more truth. Slower oscillation means that the direction of the vertical, or the line of the rest, is stronger; here therefore motion in general is weakened; the motion is deviation from the direction of gravity; consequently, the truth of the matter is that gravity is augmented. This is the outcome of such oppositions.

It was not Newton but Kepler who first thought of the planets as standing in immanent relation to the sun, and it is therefore absurd to regard their being drawn as a new idea originating with Newton. What is more, 'attraction' is not the right word here, for it is the planets rather than the sun, which take initiative. Everything depends upon the proof that they move in an ellipse. This is the crux of Kepler's law, but the proof of it was never attempted by Newton. *Laplace* ('Exposition du système du monde', vol. II p. 12-13.) admits that, 'Infinitesimal analysis, which on account of its generality embraces everything that may be deduced from a given law, makes it clear that not only the ellipse, but every conic section, may be described by means of the force which maintains the planets in their orbits'. It is in this essential fact that the complete inadequacy of the Newtonian proof becomes apparent. In the geometrical proof Newton employs the infinitely small; it is not a rigorous proof, and modern analysis has therefore abandoned it. Instead of proving the laws of Kepler, Newton did the opposite. An explanation of the matter was called for, and Newton was content with a bad one. The idea of the infinitely small stands out in this proof, which depends upon Newton's having posited all triangles in the infinitely small as equal. The sine and the cosine are unequal however, and if one then says that they are equal when posited as infinitely small quanta, the proposition will certainly enable one to do anything. When it is dark, all cows are black. The quantum has to disappear, but if qualitative difference is also eliminated in the process, there is no end to what can be proved. It is upon such propositions that the Newtonian proof is based, and that is why it is such an utterly bad one. Analysis goes on to deduce the other two laws from the ellipse; it has found a non-Newtonian way of doing this, but it is

precisely the first law, the foundation of the deduction, which remains  
 + unproved. In Newton's law, in so far as gravity diminishes with the  
 distance, it is merely the velocity at which bodies move. The mathematical  
 determination  $\frac{S}{T^2}$  was stressed by Newton when he arranged Kepler's

5 laws in order to express gravity, but it was already present in these laws.  
 The deduction is made in a manner resembling the definition of the circle  
 as  $a^2 = x^2 + y^2$ , i.e. as the relationship between the invariable hypotenuse  
 (of the radius) and the two cathetuses which are variable (abscissa or  
 cosine, ordinate or sine). The abscissa for example, may be deduced from  
 10 this formula in the following way:  $x^2 = a^2 - y^2$ , i.e.  $(a+y)(a-y)$  or the  
 ordinate thus:  $y^2 = a^2 - x^2$ , i.e.  $(a+x)(a-x)$ . We are therefore able to  
 + discover all other determinations from the original function of the curve.

Gravity might be elicited as  $\frac{A}{T^2}$  merely by arranging Kepler's formula  
 so as to deduce this determination. This may be done with each of Kep-  
 15 ler's laws, with his law of ellipses, and with his law concerning the pro-  
 portionalities of times and sectors, but most simply and directly with the  
 third. This law has the following formula:  $\frac{A^3}{T^2} = \frac{a^3}{t^2}$ . We want to deduce

$\frac{S}{T^2}$  from it.  $S$  is the space traversed as part of the orbit;  $A$  is the distance  
 from the sun; both are interchangeable, and may be substituted for one  
 20 another, because the distance (diameter) and the orbit as a constant func-  
 tion of the distance stand in relationship to each other. The diameter being  
 determined, I also know the curve of the revolution, and vice versa, for I  
 have here a single determinability. I now take the formula  $\frac{A^2 A}{T^2} = \frac{a^2 a}{t^2}$ , i.e.

$A^2 \frac{A}{T^2} = a^2 \frac{a}{t^2}$ , and remove gravity  $\left(\frac{A}{T^2}\right)$ , substituting  $G$  for  $\frac{A}{T^2}$ , and  $g$  for  
 25  $\frac{a}{t^2}$  (the different gravitations). I then have  $A^2 G = a^2 g$ . If I then state this  
 relation as a proportion, I have  $A^2 : a^2 = g : G$ , which is Newton's law.

So far we have had two bodies in celestial motion. As subjectivity and  
 determinateness of place in and for itself, the central body had its ab-  
 30 solute centre in itself. The other moment is the objectivity confronting  
 this determinedness in and for itself, i.e. the particular bodies which have a  
 centre not only in themselves but also in another. Since these bodies are  
 no longer the body which expresses the abstract moment of subjectivity,  
 their place is certainly determined, for they are outside it; their place is not

absolutely determined however, the determinateness of the place being indeterminate. The various possibilities are realized by the body as it moves in the curve. Each place on the curve is in fact indifferent to the body, which demonstrates this by simply moving in them around the central body. In this primary relationship, gravity has not yet unfolded into the *totality* of the Notion; for it to do so, it is necessary that the particularization into many bodies by which the subjectivity of the centre objectifies itself, should be further determined within itself. Firstly we have the absolute central body, secondly the dependent bodies with no centre in themselves, and thirdly relative central bodies. The whole gravitational system is complete only if it includes these three types of body. It is said that there must be three bodies present in order to decide which body is moving, as when we are in a boat, and the shore is moving past us. Determinateness could be said to be already present in the plurality of planets; but this is a simple plurality, not a differentiated determinateness. If only the sun and the earth are under consideration, it is a matter of indifference to the Notion which of them moves. Tycho Brahe concluded from this that the sun moved about the earth, and the planets about the sun, and although this tends to make calculations more difficult, it is just as feasible. It was Copernicus who hit upon the truth of the matter; astronomy was providing no real reason when it explained this by saying that it is more fitting that the earth should move about the sun because the sun is larger. If mass is also brought into consideration, the question of the larger body having the same specific density also arises. The law of motion remains essential. The central body represents abstract rotatory motion; the particular bodies simply move about a centre, without independent rotatory movement. The third mode in the system of free motion is movement about a centre combined with a rotatory motion which is independent of this centre.

(1) The *centre* is supposed to be a point, but as it is body and composed of parts which tend towards a centre, it is at the same time extended. This dependent matter involved in the central body causes the latter to rotate about itself, for the dependent points, which are at the same time kept away from the centre, have no self-relating and clearly determined place; they are merely determined in a single direction as falling matter. All other determinateness is lacking, and each point must therefore occupy all the places it is able to. Only the centre is determined in and for itself; the rest, forming as it does the extrinsicality of the centre, is indifferent, for it is merely the distance of each point from the centre which is determined here, not the point's place. This contingency of determination comes

into existence when matter changes its place. The *internal rotation of the sun* about its centre is the expression of this. This sphere is therefore mass in its immediacy as a unity of rest and motion, or it is self-relating motion. Axial rotation does not constitute a change of place, for all points keep the same place in relation to one another. The whole is therefore quiescent motion. In order that it should be an actual motion, the axis should not be indifferent to the mass, and must not remain still while the mass is in motion. There is no real difference between this which moves and its rest, because there is no difference in mass. That which rests is not a mass, but a line, and that which is moved is distinguished solely by places, not by masses.

(2) The dependent bodies do not constitute the connected parts in the extension of a body endowed with a centre, for they have at the same time apparently free existence, and hold themselves at a distance from the central body. They also rotate, but as they have no centre in themselves, not upon their axis. They therefore rotate about a centre belonging to another individual body, by which they are repelled. They are completely indifferent to particularity of place, and they express this contingency of determinate place by rotation. As they remain in the same spatial determination with regard to the central body, they move about it in an inert rigid manner; the relationship of the moon to the earth is an example of this. A certain place A in the mobile peripheral body will always remain in the straight line joining the absolute and relative centres, and every other point B constantly maintain its determinate angle. It is as a mere mass that the dependent body moves about the central body therefore, not as a self-related individual body. It is the dependent heavenly bodies which constitute the aspect of particularity; this is why they fall apart and differentiate themselves, for in nature particularity exists as duality, and not as unity, as it does in spirit. If we regard this double nature of dependent bodies as a mere difference of movement, we have the two aspects of the motion as follows:—

(a) The first posited moment is that in which quiescent motion becomes this restless movement, which is a sphere of *aberration*, or of effort to break out of immediate existence into what is beyond its self. This moment of self-externality, as a mass and sphere, is itself the moment of substance, for each moment here contains its special existence, or has within it the reality of the whole which constitutes a sphere. The second of these is the cometary sphere, and expresses this whirling which makes a permanent effort to disperse and scatter itself into the infinite or void. In this context, the shape of a body, and the whole conception of the comets and celestial bodies which deals merely with their contingency, and is based upon knowledge accumulated simply by look-



ing at them, has to be put out of mind. According to this way of thinking, the comets might just as well not be there, and the recognition of their necessity, the grasping of their Notion, may even seem laughable, used as this mental attitude is to regarding such things as quite beyond our comprehension, and consequently of the Notion too. All the imaginative theories of what is called 'explaining the origin', according to which the comets may be ejected from the sun, atmospheric vapours and so on, belong without exception to this way of thinking. Explanation of this kind may well attempt to state what the comets are, but it merely bypasses the essential point, which is their necessity; and it is precisely the necessity which constitutes the Notion. There is therefore no particular excuse for our taking up these phenomena and tinselling them with a glitter of thought. The cometary sphere threatens to break away from the universal self-relating order, and lose its unity. It is formal freedom, which has its substance outside itself, a pushing out into the future. In so far as it constitutes a necessary moment of the whole however, it does not escape from this whole, and so remains included within the first sphere. Nevertheless it is uncertain whether such a sphere dissolves itself as an individual and other individuals come into existence, or whether it is perpetually moving as a motion about the first sphere, which is external to it, and in which it has its repose. Both possibilities belong to the contingency of nature, and this division or transition by stages from the determinateness of this sphere into another, is to be reckoned with as proper to material existence. Nevertheless, the extreme limit of the aberration itself consists necessarily in an indefinite approach to the subjectivity of the central body, until the point is reached at which repulsion takes place.

(b) It is precisely this moment of unrest in which the moment of whirling attains its centre however; this is not a transition of simple change, for in its self-immediacy this otherness is the opposite of itself. The opposition is the duality of the immediate otherness and the cancellation of this otherness. It is not a pure flux or the opposition as such however, but this opposition as it seeks its rest or centre. It is sublated future, the past as moment, in which the opposition is sublated in its Notion, although not yet in its determinate being. This is the *lunar* sphere, which is not the aberration or issuing forth of determinate being, but relation to self, to what has become, or to the being-for-self. Thus, while the cometary sphere is only related to immediate rotation about an axis, the lunar sphere is related to the new intro-reflected centre, the planet. A satellite does not yet have its being-in-and-for-self within itself nor does it revolve about its axis; its axis is outside it, but it is not the axis of the solar sphere. Considered purely as a motion, the lunar sphere is rigidly controlled by a single centre, to which it is simply *subservient*, and the sphere of

aberration is just as dependent. The first is abstract obedience, and conformity to another, the second is merely intended freedom. The cometary sphere constitutes an eccentricity controlled by an abstract whole, while the lunar sphere is quiescent inertia.

5 (3) The final sphere is the *planetary*, which is in and for itself, and constitutes relation to self and to another; it is formed as much by motion rotating about an axis, as by having its centre outside itself. Consequently, although the planet also has its centre in itself, it is a merely relative centre, and as it does not contain its absolute centre, it is not independent. The  
 10 planet has both determinations within it, and displays them by its change of place. It shows its independence only by its parts' changing place in relation to the position which they hold with regard to the straight line joining the absolute and relative centres; it is this which is the basis of the rotatory motion of the planets. The precession of the equinoxes is caused  
 + by the movement of the orbital axis. The axis of the earth also has a nutation,  
 + and its poles describe an ellipse. As it constitutes the third sphere, the planet concludes and completes the whole. This quadruplicity of celestial bodies forms the completed system of rational corporeality. It is necessary to a solar system, and is the developed disjunction of the Notion. These  
 20 four spheres between them show forth the moments of the Notion within the heavens. It may seem strange to attempt to fit the comets in here, but that which is present must necessarily be contained in the Notion. Differences are still thrown freely apart here. We shall pursue the solar, planetary, lunar, and cometary spheres through all the subsequent stages  
 25 of nature. The deepening of nature is merely the progressive transformation of these four. It is because planetary nature is the totality, the unity of opposites, while the other spheres, being its inorganic nature, merely exhibit its particular moments, that it is the most perfect to come under consideration here; and this is also true of it as a motion. It is for  
 30 this reason that living being occurs only on the planets. Ancient peoples  
 + have glorified the sun and worshipped it; we do the same when we recognize the final supremacy of the abstract understanding, and so determine God for example, as the supreme essence.

This totality is the ground and universal substance on which that which fol-  
 35 lows is borne. This totality of motion is everything, but everything withdrawn into a higher being-in-self, or, to express it differently, realized as a  
 + higher being-in-self. Everything has this totality within it, but is indifferent to it, leaves it behind as a particular existence, as a history, or as the origin against which the being-in-self has turned in order to be for itself. Everything lives in  
 40 this element therefore, and also frees itself from it, for only feeble traces of

everything subsist there. Terrestrial being, and more particularly organic being and self-consciousness, has escaped from the motion of absolute matter but remained in sympathy with it, and lived on with it as within its own inner element. The changes of the seasons and times of day, and the changeover from waking to sleep, constitute the terrestrial life in organic being. In itself each of these moments constitutes a sphere of proceeding out of self, and of returning into its central point or power, so that it embraces or subdues all the multifarious elements of consciousness. Night is the negative to which everything returns, and organic being therefore derives its strength and consequently its negative being from thence, so that it may return again refreshed to the waking multifariousness of existence. Each has the universal sphere within it therefore, and is a sphere periodically returning into itself, and expressing the universal through its determinate individuality. The magnetic needle does so by its periodic deviations; according to *Fourcroy's* observations, man does so partly by his four-day periods of increasing and decreasing, in which he puts on for three days, and on the fourth returns to his original dimensions. The periodic courses of diseases might also be cited here. It is however in the circulation of the blood, the rhythm of which differs from that of the respiratory sphere, and thirdly in peristaltic movement, that the fully developed totality of the sphere occurs. The generally higher nature of physical being prevents this sphere from expressing its peculiar freedom however, and in order to study universal motion, one must concentrate upon its freedom, not upon these trivial appearances. In individuality it is not its free existence, but a mere internality or intention which is present.

The exposition of the solar system has not yet been completed by what has been said, and although the basic determinations have been adduced, there are still supplementary determinations which could be added. The relationship between the orbits of the planets, their reciprocal inclinations, and the inclinations of comets and satellites to them, are all fields of enquiry which could still be of interest to us. The orbits of the planets do not lie in a single plane, and what is more, the courses of the comets cut across the planetary orbits at very different angles. These do not deviate from the ecliptic, but they change the angle of their reciprocal relations; the motion of nodes is secular. It is more difficult to develop these occurrences, and we are not yet able to do so. We have only concerned ourselves with the planet in general, but the distances between the planets should also be considered, for although it is as yet undiscovered, there may well be a law governing the *series* in the distances between the planets. Astronomers tend on the whole to scorn the idea of there being such a law, and will have nothing to do with it, but it is necessary that

this should remain an open question. Kepler considered the numbers in  
 + Plato's 'Timaeus' for example. Taking these as a basis, something like the  
 following conjecture might now be made:—Mercury is the first of the  
 planets and if its distance is  $a$ , then the orbit of Venus is  $a + b$ , the orbit  
 5 of the Earth  $a + 2b$ , and that of Mars  $a + 3b$ . In this way it will certainly be-  
 come apparent that these first four planets form a whole. One might say  
 that the first four bodies of the solar system, constitute a single system in  
 themselves, and that another order subsequently commences, both in the  
 numbers, and in the physical constitution of the planets. These four move  
 10 in a uniform manner, and it is worth noting that there are four with such a  
 homogeneous nature. Of these four, only the Earth has a satellite, and it  
 is therefore the most perfect. Between Mars and Jupiter there is a sudden  
 wide gap, and  $a + 4b$  was not permissible until more recent times, when  
 the discovery of the four smaller planets Vesta, Juno, Ceres, and Pallas,  
 15 filled it and formed a new group. The unity of the planet is here sundered  
 into a crowd of asteroids, all of which have approximately the same orbit.  
 + Dispersion and separation predominate in this fifth position. Then comes  
 + the third group. Jupiter with its many satellites is  $a + 5b$  etc. This only  
 works out approximately, and the rationality of it is not yet recognizable.  
 20 This great mass of satellites is different again from the kind of arrangement  
 found in the first four planets. Then comes Saturn with its rings and  
 + seven satellites, and Uranus, which was discovered by Herschel, with a  
 + host of satellites which few have seen as yet. Here we have a point  
 of departure for the preciser determination of planetary relation-  
 25 ships. It is not difficult to see that the law will be discovered in this  
 + way.

Philosophy has to proceed on the basis of the Notion, and even if it  
 demonstrates very little, one has to be satisfied. It is an error on the part  
 of the philosophy of nature to attempt to face up to all phenomena; this  
 30 is done in the finite sciences, where everything has to be reduced to  
 general conceptions (hypotheses). In these sciences the empirical element  
 is the sole confirmation of the hypothesis, so that everything has to be  
 explained. Whatever is known through the Notion is its own explanation  
 and stands firm however, so that philosophy need not be disturbed if the  
 35 explanation of each and every phenomenon has not yet been completed.  
 Here I have merely traced the foundations of a rational interpretation, as  
 this must be employed in the comprehension of the mathematical and  
 mechanical laws of nature within the free realm of measures. Specialists  
 do not reflect upon the matter, but a time will come when the rational  
 40 concept of this science will be demanded!

## § 271

Gravity, which is the substance of matter, no longer has the self-externality of matter external to it when it is developed into totality of form. The form appears first in its differences in the ideal determinations of space, time, and motion, and in accordance with its being-for-self, as a determinate centre outside self-external matter. In developed totality however, this extrinsicality is posited as determined solely by the totality; this is the juxtaposition of matter, outside of which it has no existence. It is in this way that form is materialized. Looked at in the opposite way, matter has itself attained implicit determinateness of form in this negation of its self-externality in the totality, which was formerly merely the centre which it sought. Its abstract and subdued being-in-self, general weightedness, has been resolved into form; it is qualified matter, or physics.

*Addition.* In this way we conclude the first part; mechanics now constitutes a distinct whole. When Descartes said, 'Give me matter and motion and I will construct the world', he took the standpoint of mechanics as his first principle, and in these words he shows a greatness of spirit which we should not deny, despite the inadequacy of this standpoint. In motion, bodies are mere points, and gravity only determines the spatial relations between points. The unity of matter is simply the unity of place which matter seeks, it is not a single concrete unit. It is in the nature of this sphere that this externality of determinedness should constitute the peculiar determinateness of matter. Matter is weighted being-for-self seeking its being-in-self; in this infinity the point is merely a place, so that the being-for-self is not yet real. It is only in the whole solar system that the totality of being-for-self is posited, so that what the solar system is as a whole, matter should be in particular. The complete form of the solar system is the Notion of matter in general; its self-externality should now be present in each determinate existence of the completely developed Notion. Matter should find its unity by being for itself in the whole of its determinate being, which is the being for self of being-for-self. Put in another way, the self-motivation of the solar system is the sublation of the merely ideal nature of being-for-self, of mere spatiality of determination, of not-being-for-self. In the Notion, the negation of place does not merely give rise to its re-instatement; the negation of not-being-for-self

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is a negation of the negation, i.e. an affirmation, so that what comes forth is real being-for-self. This is the abstractly logical determination of the *transition*. It is precisely the total development of being-for-self which is real being-for-self; this might be expressed as the freeing of the form of matter. The determinations of form which constitute the solar system are 5 the determinations of matter itself, and these determinations constitute the being of matter, so that determination and being are essentially identical. This is of the nature of quality, for if the determination is removed here, being also disappears. This is the transition from mechanics to physics.