



2nd edition

ENCYCLOPEDIA OF
PHILOSOPHY





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DONALD M. BORCHERT
Editor in Chief

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Encyclopedia of Philosophy, Second Edition

Donald M. Borchert, Editor in Chief

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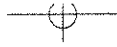
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FORCE [ADDENDUM]

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M. Jammer (1967)

FORCE [ADDENDUM]

Forces, understood as pushes or pulls that are exerted (in the first instance) by particulars and that cause motions, have received little philosophical attention in recent decades, reflecting both that forces no longer play a role in fundamental physical theory and that even where they do play a role (e.g., in Newtonian mechanics), it has seemed advisable (following Jammer, above) to give them a purely instrumentalist interpretation. What attention has been paid however indicates that various aspects of the notion of force (or notions; see below) deserve further philosophical consideration.

One such aspect concerns the ontological status of forces. Jammer's deflationary account of force as a mere "methodological intermediate," enabling the kinematical behavior of particulars to be studied independent of the details of specific configurations, but not to be taken with ontological seriousness, was motivated by traditional empiricist concerns with forces as purely theoretical entities (of the sort that exercised Berkeley); such concerns

also figure in van Fraassen's instrumentalist agnosticism about forces. Another source of concern about forces lies in the redundancy argument (of which Mill was an early proponent), according to which forces are not needed to explain motions (the usual non-force causes and effects being sufficient unto the task) and hence should (by Ockham's razor) be eliminated.

There are however ways of resisting or responding to such concerns. Hesse rejects Jammer's instrumentalism as inappropriately eliminating "the metaphysical, a priori, intuitive and anthropomorphic elements" of the classical notion of force. More straightforwardly one can deny that forces are purely theoretical on grounds that these are experienced in the course of ordinary events (of, for instance, liftings, pushings), in which case instrumentalist concerns with force are misguided. And in response to the redundancy argument, Bigelow et al. note that the appropriate application of Ockham's razor involves a *ceteris paribus* clause: Other things being equal, forces should be eliminated. But, they argue, other things are not equal: In particular, physics without forces does not explanatorily unify phenomena (in particular, motions) as well as does physics with forces. Indeed, one might maintain that, even if other entities unify motions, so long as forces unify these in a distinctive fashion (as they appear to do) Ockham's razor can be resisted.

It remains the case that forces do not play the role in contemporary physics that they once were thought to do. Even within the domain of classical (slow-moving, non-quantum) entities, Newton's force-based formulation of mechanics has been superseded for most explanatory and practical purposes by energy-based (e.g., Lagrangian and Hamiltonian) formulations. And while forces and Newton's laws (the third law being understood as a statement of conservation of momentum) are recognizably present in the relativistic extension of Newtonian mechanics, quantum indeterminacy appears to prevent Newton's theory (which presupposes that bodies have a determinate position and momentum) from being extended to treat quantum phenomena. (This is so, assuming the incorrectness of Bohm's deterministic, force-based interpretation of quantum theory, developed in Bohm and Hiley 1993, on which indeterminacy is given an epistemological spin, as uncertainty.) By way of contrast the concepts and operative principles of energy-based theories (energy, Hamilton's principle of stationary action) straightforwardly extend to both quantum and relativistic contexts. Moreover, in the General Theory of Relativity (GTR), the concept of force disappears altogether:

geometry plus inertial motion, rather than forces, guide motions due to gravity.

Upon closer examination however the above considerations do not show that the concept of force is ontologically obsolete. Concerning the classical domain: Force-based and energy-based formulations of mechanics are not only compatible but are also interderivable (under assumptions generally in place); as Feynman notes, Newtonian and Lagrangian dynamics are “exactly equivalent.” This equivalence reflects, among other things, the fact that both potential and kinetic energies are initially defined in terms of the work done by a force; more generally, it appears that force-based and energy-based mechanics are, from a theoretical point of view, mutually supporting, compatible perspectives on the same phenomena. (Such a take is reflected in an intuitive ontological conception of the relation between forces and potentials or potential energies, according to which the latter are dispositions of which forces are the manifestations.) Moreover the restricted application of Newtonian mechanics needn’t imply that forces don’t exist—at least supposing that the similarly restricted application of special sciences such as chemistry and biology doesn’t impugn the existence of their subject matters.

The question remains whether the posit of force is compatible with more fundamental theories. As mentioned, quantum indeterminacy poses a barrier to taking forces, as traditionally conceived, to exist at the quantum level; but if forces are special science entities, this is no surprise (plants don’t exist at the quantum level, either). Compatibility might rather be indicated by noting that the deep connection between forces and energies persists in quantum theory, albeit at an analogical level; as Jammer says, “No one has ever directly demonstrated the force of attraction between, say, a proton and an electron. And yet, in writing Schrödinger’s equation for such a system, we use the term e^2/r [associated with inverse-square attraction] for the potential energy, carrying it over, so to say, from classical dynamics as a generalization ultimately based on the concept of force.” More to the ontological point, one might take the fact that quantum interactions involve exchanges of momentum to suggest that forces are constituted by quantum particle exchanges.

A greater difficulty from the perspective of common applications of force-based mechanics is GTR’s denial of gravitational forces. It appears that *if* GTR is the correct theory of gravity, then the posit of gravitational forces cannot be maintained. For GTR and Newtonian mechanics agree that inertial motion does not involve forces; hence there is no way of arguing that an object’s inertial

motion along a geodesic “constitutes” the occurrence of gravitational forces. It is presently unclear, however, whether GTR is the correct treatment of gravity. In response to well-known problems in incompatibility between GTR and quantum theories, various attempts are underway to quantize gravity, which if successful might allow for gravitational forces after all.

Philosophers who agree that forces exist may yet disagree over metaphysical details. It remains unclear for example whether forces are independent intermediaries between non-force causes and effects (as Bigelow et al. suggest), or are rather dependent aspects of the latter entities. What (considered) ontological category do forces fall under—are they properties, manifested dispositions, relations, causal relations, *sui generis*? Another question concerns the status of component vs. resultant forces. In cases in which phenomena involve more than one sort of force (e.g., both an electromagnetic and a gravitational force—supposing the latter exist), do the associated component forces (whose occurrence is expressed by Coulomb’s law and Newton’s law of gravitation, respectively) exist alongside the resultant force input into Newton’s second law? Cartwright maintains that only the resultant force exists, while the component forces are mere mathematical fictions; Creary argues that the need to explain by composition of causes (here, forces) indicates that it is better to keep component and reject resultant forces.

Besides what might be called “Newtonian forces,” a distinct but related scientific notion of force also deserves philosophical attention: that of a “fundamental force” or interaction. Paradigmatic fundamental forces/interactions (electromagnetic, gravitational, nuclear) come in many of the same varieties as paradigmatic Newtonian forces; and as already indicated, there are interesting open questions here concerning the relationship between (e.g., electromagnetic) Newtonian forces and the lower-level mechanisms operative in the field-theoretic treatments of the corresponding fundamental forces/interactions. Besides these general metaphysical concerns, fundamental forces/interactions may shed new light on old metaphysical debates. For example, an appeal to fundamental forces/interactions provides what is arguably the best way of formulating physicalism and emergentism as viably contrasting views: With this approach, physicalists maintain that all phenomena are grounded solely in fundamental physical forces/interactions, whereas emergentists maintain that, at certain complex levels of organization (notably, those involved in the having of mental states), a new fundamental force/interaction comes into play.

See also Bohm, David; Cartwright, Nancy; Maxwell, James Clerk; Newtonian Mechanics and Mechanical Explanation; Relativity Theory; Schrödinger, Erwin.

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Jessica Wilson (2005)

FOREKNOWLEDGE

See *Precognition*

FOREKNOWLEDGE AND FREEDOM, THEOLOGICAL PROBLEM OF

Divine foreknowledge, like the other classical theistic attributes, raises philosophical problems of at least three kinds. First, there are problems with understanding the attribute itself. How should it be construed (assuming that it is even coherent)? And how might God come by such knowledge? (Are future events all present in their causes? Does God arrive at foreknowledge by inference from "middle knowledge"? Does he *see* the future as through a "time telescope"? Or does he just know it?) Second, there are questions about how this attribute can be compatible with the other divine attributes. As the creator, sustainer, and providential overseer of the world, for

example, God is supposed to be the supreme agent—but how can God approach the future as an active agent if his foreknowledge presents to him everything, including his own decisions and engagements with the world, as a fait accompli?

Finally, there are problems reconciling God's possession of this attribute with other things that appear undeniable. Of these, the most important is surely human freedom. If God knows before a person is even born exactly what that person will do throughout life, how could this person nevertheless retain the power to do otherwise, as free agency apparently requires? This is the classic foreknowledge problem; efforts to solve it are often what drive proposed solutions to the other two problems.

HISTORICAL BACKGROUND

In *De Interpretatione*, Aristotle worried that accepting the truth of future contingents would result in a necessitarianism incompatible with human freedom; for if it is true either that there will be a sea battle tomorrow or that there will not be a sea battle tomorrow, the admiral on whose decision this event depends either cannot issue the requisite order (if there will not be a sea battle) or cannot refrain from issuing the order (if there will be a sea battle). A similar worry was later elaborated into the influential "Master Argument" of Diodorus Cronus, discussed by the Stoics. Because this threat to human freedom rests solely on logical principles, like the Law of Excluded Middle, it is often called "logical fatalism" in contrast to the "theological fatalism" generated by divine foreknowledge.

The subtheistic nature of the ancient divinities and the pluralism of pagan theology made the problem of theological fatalism avoidable, but this was to change with the advent of Christianity. Augustine provides a classic early exposition of the problem in *On Free Choice of the Will* (III.3):

How is it that these two propositions are not contradictory and inconsistent: (1) God has foreknowledge of everything in the future; and (2) We sin by the will, not by necessity? For ... if God foreknows that someone is going to sin, then it is necessary that he sin. But if it is necessary, the will has no choice about whether to sin ... [So:] either we draw the heretical conclusion that God does not foreknow everything in the future; or ... we must admit that sin happens by necessity and not by will.

Augustine went on to offer his own solution to this problem; his medieval successors added further solutions and