# MS. Forces and Interactions

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## A Performance Expectations MS.PS2.FI

1 Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. MS.PS2.1

2 Plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. MS.PS2.2

3 Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. MS.PS2.3

4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects and the distance between them. MS.PS2.4

5 Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. MS.PS2.5

## B Science and Engineering Practices MS.FI.SEP

1 Asking Questions and Defining Problems MS.FI.SEP.1

a Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. (MS-PS2-3) MS.FI.SEP.1A

2 Planning and Carrying Out Investigations MS.FI.SEP.2

a Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2) MS.FI.SEP.2A

b Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. (MS-PS2-5) MS.FI.SEP.2B

3 Constructing Explanations and Designing Solutions MS.FI.SEP.3

a Apply scientific ideas or principles to design an object, tool, process or system. (MS-PS2-1) MS.FI.SEP.3A

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4 Engaging in Argument from Evidence MS.FI.SEP.4

a Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-PS2-4) MS.FI.SEP.4A

5 Scientific Knowledge is Based on Empirical Evidence MS.FI.SEP.5

a Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS2-2),(MS-PS2-4) MS.FI.SEP.5A

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**C Disciplinary Core Ideas** MS.FI.DCI

1 PS2.A: Forces and Motion MS.FI.DCI.PS2.A

a For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1) MS.FI.DCI.PS2.A.1

b The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2) MS.FI.DCI.PS2.A.2

c All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-PS2-2) MS.FI.DCI.PS2.A.3

2 PS2.B: Types of Interactions MS.FI.DCI.PS2.B

a Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3) MS.FI.DCI.PS2.B.1

b Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass— e.g., Earth and the sun. (MS-PS2-4) MS.FI.DCI.PS2.B.2

c Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). (MSPS2-5) MS.FI.DCI.PS2.B.3

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**D Crosscutting Concepts** MS.FI.CC

1 Cause and Effect MS.FI.CC.1

a Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2- 3),(MS-PS2-5) MS.FI.CC.1A

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2 Systems and System Models MS.FI.CC.2

a Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2- 4), MS.FI.CC.2A

3 Stability and Change MS.FI.CC.3

a Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. (MS-PS2-2) MS.FI.CC.3A

4 Influence of Science, Engineering, and Technology on Society and the Natural World MS.FI.CC.4

a The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-PS2-1) MS.FI.CC.4A