OpenSciEd Massachusetts Standards Guidance 7th Grade: Contact Forces

This document is to provide guidance to Massachusetts 7th grade teachers who are implementing OpenSciEd. This guidance assumes the OpenSciEd curriculum is being implemented across grades 6-8, following the MA coherent sequence by grade level *(download)*. The following guidance identifies the MA standards addressed in the *Contact Forces* unit, and the most effective use of the OpenSciEd materials for 7th grade teachers.

Scope and Sequence Recommendation

Implement the *Contact Forces* as the first unit in 7th grade, before the *Thermal Energy* unit. *Contact Forces* has built-in support for establishing OpenSciEd routines at the beginning of the year. It develops energy concepts (PS3) and engineering skills (ETS1, ETS2) that will be used in the *Thermal Energy* unit, and builds on the understanding of forces from the *Forces at a Distance* unit (6th grade in MA). *Contact Forces* addresses five 7th grade physical science and engineering/technology standards, two 6th grade engineering/technology standards, and three 8th grade physical science and engineering/technology standards. Refer to the MA coherent sequence by grade level *(download)* for the complete scope and sequence recommendation.

7th Grade Standards in *Contact Forces*

Standards in unit	Lessons building towards standards
7.MS-PS3-1. Construct and interpret data and graphs to describe the relationships among kinetic energy, mass, and speed of an object.	Lessons 1-10
7.MS-PS3-5. Present evidence to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.	Lessons 5-9
7.MS-ETS1-2. **[Partial]** Evaluate competing solutions to a given design problem using a decision matrix to determine how well each meets the criteria and constraints of the problem. Use a model of each solution to evaluate how variations in one or more design features, including size, shape, weight, or cost, may affect the function or effectiveness of the solution.* • **Why partial?** The lessons do have students evaluate design solutions using a design matrix, but do not require students to use models of each solution for evaluation. • Other 7th grade units, ***Ecosystem Dynamics & Biodiversity, Natural Hazards***, and an 8th grade unit, ***Energy in Chemical Reactions***, will reinforce and extend ideas developed about design in this unit to the completion of the standard. • No changes are necessary for this unit because the standard is addressed in other units.	Lessons 11-15
7.MS-ETS1-4. Generate and analyze data from iterative testing and modification of a proposed object, tool, or process to optimize the object, tool, or process for its intended purpose.*	Lessons 11-14
7.MS-ETS1-7(MA). Construct a prototype of a solution to a given design problem.*	Lessons 11-14

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Additional Standards in *Contact Forces*

Include, and teach all 6th and 8th grade standards with *Contact Forces* as planned in the unit. These standards are integral to the understanding of other standards in the unit and are used as an opportunity for application in most lessons. Depending on your students' prior knowledge of this standard, support for students should be adjusted to increase the rigor of explanations or data analysis, or increase the support for students in interpreting data or explanations concerning the body systems' interactions. **Excluding these standards would require substantial redesign of the unit, which is not recommended.**

Standards in unit	Lessons building towards standards
6.MS-ETS2-1(MA). **[Partial]** Analyze and compare properties of metals, plastics, wood, and ceramics, including flexibility, ductility, hardness, thermal conductivity, electrical conductivity, and melting point. • **Why partial?** This unit does not address every specified material in the standard, nor does it address every specified property listed. • Students develop understanding that all materials have elastic limits, and analyze materials for flexibility • The ***Thermal Energy*** unit addresses thermal conductivity across a variety of materials • Melting point is addressed in the ***Chemical Reactions & Matter*** unit • Electrical conductivity will appear as extensions in other units	Lesson 4, Lesson 12
6.MS-ETS2-2(MA). Given a design task, select appropriate materials based on specific properties needed in the construction of a solution.*	Lessons 12-14
8.MS-PS2-1. Develop a model that demonstrates Newton's third law involving the motion of two colliding objects. State Assessment Boundary: State assessment will be limited to vertical or horizontal interactions in one dimension.	Lessons 5-6
8.MS-PS2-2. Provide evidence that the change in an object's speed depends on the sum of the forces on the object (the net force) and the mass of the object.	Lessons 5-10
8.MS-ETS2-4(MA). **[Partial]** Use informational text to illustrate that materials maintain their composition under various kinds of physical processing; however, some material properties may change if a process changes the particulate structure of a material. • **Why partial?** This unit does not address process changes that affect the particulate structure of a material. • The ***Chemical Reactions*** units in 8th grade discuss changes that affect the particulate structures of materials.	Lesson 4

See recommendations below for addressing these 6th and 8th grade standards.

Recommendations for Addressing Standards in *Contact Forces*

Explore additional materials and incorporate the terms **hardness** and **flexibility** to address standard **6.MS-ETS2-1(MA)** in more depth**.** This will help students explore a wider variety of materials as recommended by the standard. Additional properties of materials such as melting point and electrical conductivity will be addressed as extensions in other OpenSciEd units. Teachers can assess for student understanding of these ideas by looking for inclusion of the specific terms **hardness** and **flexibility** throughout the unit.

Lesson	Support for maintaining content coherence
Lesson 4: How much do you have to push on any object to get it to deform (temporarily vs. permanently?	Add to the Learning Plan in the Teacher Guide: **Part 9 – Add to our progress tracker** • During the consensus discussion, introduce the terms hardness and flexibility along with elastic limit and breaking point. All of these words should be added to the class word bank. ○ Materials that can bend a lot without breaking or deforming permanently are **flexible** materials. Elastic limit is related to flexibility. ○ **Hard** materials are materials that resist surface initial deformation or scratching. Harder materials likely will not bend much before they break, but are difficult to break.
Lesson 12: What materials best reduce the peak forces in a collision?	Add to the Learning Plan in the Teacher Guide: **Part 2 – Introduce Materials and Make Predictions** • Add **ceramic** to the materials that are tested for peak force reduction – this could be a small terra cotta saucer or something similar. Add it to the materials sheet as an item to be tested. **Part 5 – Compare Class Data** • Push students to be specific about the patterns they notice in “top performers” and look for students to refer to hardness and flexibility
Lesson 14: How can we use our science ideas and other societal wants and needs to refine our designs?	Add to the learning plan in the Teacher’s Guide: **Part 1 – Revisit Materials Testing Results** • Deliberately incorporate the terms hardness and flexibility in the discussion about materials **Part 3 – Update Criteria and Revisit Constraints** • Encourage students to incorporate hardness and flexibility in the criteria and constraints

Opportunities to Address Additional MA Standards in *Contact Forces*

Standards in unit
7.MS-PS3-7(MA). **[Opportunity to address]** Use informational text to describe the relationship between kinetic and potential energy and illustrate conversions from one form to another.

Recommendations for Extensions in *Contact Forces*

Extend the ***Contact Forces*** Unit to include the grade 7 standard on conversions between kinetic and potential energy. To best address **7.MS-PS3-7(MA),** teachers should explicitly ask students to identify transitions from potential to kinetic energy and vice versa as they come up throughout the unit, although the teacher materials may not directly call for this. Teachers may also add criteria to gotta-have-it checklists and models throughout the unit that indicate that students should identify energy conversions. **The following table highlights some possible areas to integrate this standard, though there may be other opportunities that can be used at teachers' discretion**.

Unit Extension	Support for coherently extending the unit

Lesson 3
 	
Do all objects change shape or bend when they are pushed in a collision?
	Add to the Learning Plan in the Teacher Guide:
	During Part 4 – Predicting and Testing our Predictions
	• Take some time during the investigation to notice if there is a difference in laser motion when the ball is dropped from higher up. Support students in noticing this difference. Some questions the teacher may ask:
	  ○ *What if I drop the ball from a bit higher? How does that affect the laser's movement?*
	  ○ *What do you think dropping the ball from higher does in the system?*

Unit Extension	Support for coherently extending the unit
Lesson 7 **How much does doubling the speed or doubling the mass affect the kinetic energy of an object and the resulting damage that it can do in a collision?**	Add to the Learning Plan in the Teacher Guide: **During Part 4 – Argue From Evidence** • Take time during this discussion to explicitly name potential energy as the kind of energy present in the spring when it is compressed • When we compress the spring, the spring contains potential energy which will transform into kinetic energy when the spring is released **During Part 5 – Analyzing Data** • Support students in thinking about the transfer of potential energy in the spring to kinetic energy in the cart • Support students in identifying that if the amount of potential energy is increased in the system, the amount of kinetic energy will also increase. Help students to reason that compressing the spring more = adding potential energy to the system = more kinetic energy in the system
Lesson 8 **Where did the energy in our launcher system come from, and after the collisions where did it go to?**	Add to the Learning Plan in the Teacher Guide: **During Parts 1-4** • Emphasize the presence of potential energy in the spring when it is compressed. Support student understanding of the energy being "built up" or "stored" in the spring before it is released as kinetic energy. • In the Scientist's Circle (Part 3), ask students questions about the energy in the spring before it is released. • Add a triangle sticky note to the consensus model indicating that the spring contains potential energy when it is compressed at time 0. You might use a different colored sticky note to indicate potential energy. • Assess student models for the presence of potential energy in Part 4