

Clarification of the Force and Motion Benchmark

Benchmark 4F(6-8)#3 (Partial) An unbalanced force acting on an object changes its speed or direction of motion, or both.		
Sub Idea Code	Sub Idea Description	Related Prior Student Conceptions
A[†]	<p>A force is a push or pull interaction between two objects, and has both magnitude and direction</p>	<ol style="list-style-type: none"> 2. Force is a property of a single object, not a feature of interactions between two objects. 3. Passive actions (e.g., supporting, blocking, reacting) are not forces. 9. Only animate objects or living things can exert a force. 20. All forces are mediated through contact; forces cannot be exerted between two things if they are not in contact. 37. Moving objects have a force in them that keeps them going. 38. Inertia is a force [that keeps objects in motion.] 45. A force is transferred from one object (e.g., a foot) to another (e.g., a soccer ball) to produce motion. 48. Energy is a force. 49. There is no force acting on an object unless it is moving.
B[†]	<p>All of the forces acting on an object combine through vector addition into a net force; they either balance each other out (net force is zero), or act like an unbalanced force (net force is not zero).</p> <ul style="list-style-type: none"> • If the sum of forces exerted on an object in one direction is the same strength as the sum of forces exerted on the object in the opposite direction, then the forces on the object are balanced (i.e., the net force is zero). • If the sum of forces exerted on an object in one direction is greater than the sum of forces exerted on the object in the opposite direction, then the forces on the object are unbalanced (i.e., the net force is not zero). 	<ol style="list-style-type: none"> 1. Opposing forces necessarily cancel each other. 15. “Balanced forces” means that all forces on an object are equal. 17. When multiple forces act on an object, they act in a sequence. 50. The forces between two objects are unbalanced if the objects have different amounts of a given property (e.g., mass).
C	<p>A force diagram uses arrows to represent the forces acting on an object at a particular moment. The length of the arrow represents the relative magnitude of the force. The direction of the arrow represents the direction of the force acting on the object.</p>	
D[†]	<p>If an object is moving faster and faster, then there is a net force acting on the object in the same direction as the motion.</p>	<ol style="list-style-type: none"> 23. Speed/velocity is proportional to the force acting. 25. Constant force produces constant velocity. 26. Acceleration is due to an increasing force. 28. If a body is moving, there is a force acting on it in the direction of the motion. 32. Sustained motion requires sustained force. 33. If a body is moving, there is a force acting on it. 37. Moving objects have a force in them that keeps them going. 44. Forces always act in the direction of motion. 46. If an object is speeding up, the force on it is becoming greater and greater.

[†] Denotes sub-ideas considered part of the student domain.

Sub Idea Code	Sub Idea Description	Related Prior Student Conceptions
E[†]	If an object is moving slower and slower, then there is a net force acting on the object in the direction opposite to the object's motion.	23. Speed/velocity is proportional to the force acting. 25. Constant force produces constant velocity. 26. Acceleration is due to an increasing force. 28. If a body is moving, there is a force acting on it in the direction of the motion. 29. Forces get things going rather than making things stop. 30. Moving objects stop when the "force" of motion in them runs out. 31. In the absence of forces, objects are either at rest or slowing down 32. Sustained motion requires sustained force. 33. If a body is moving, there is a force acting on it. 34. An object in motion will eventually slow down of its own accord. 37. Moving objects have a force in them that keeps them going. 44. Forces always act in the direction of motion. 47. If an object is slowing down, the force on it is getting smaller and smaller.
F[†]	If an unbalanced force acts on a moving object in a direction that is neither in the direction of the object's motion, nor directly opposed to it, then the object's direction (and possibly speed) will change.	25. Constant force produces constant velocity. 26. Acceleration is due to an increasing force.
G	If there is an unbalanced force acting on an object, the greater the strength of the unbalanced force, the greater the change in the object's velocity.	26. Acceleration is due to an increasing force. 27. There is a linear relationship between force and velocity.
H	If there is an unbalanced force acting on an object, the more massive an object is, the smaller the change in the object's velocity.	36. Objects resist acceleration from the state of rest because of friction (rather than inertia).
I[†]	If an object has constant speed in a straight line (or zero speed), then there is no net force acting on the object. This can occur either when: <ul style="list-style-type: none"> • the forces on the object are balanced; or • there are no forces exerted on the object 	13. If a body is not moving, there is no force acting on it. 23. Speed/velocity is proportional to the force acting. 25. Constant force produces constant velocity. 28. If a body is moving, there is a force acting on it in the direction of the motion. 30. Moving objects stop when the "force" of motion in them runs out. 31. In the absence of forces, objects are either at rest or slowing down 32. Sustained motion requires sustained force. 33. If a body is moving, there is a force acting on it. 34. An object in motion will eventually slow down of its own accord. 37. Moving objects have a force in them that keeps them going. 44. Forces always act in the direction of motion.
J[†]	The force of friction acts to oppose the relative motion of two objects in contact. Friction acts on both objects along the surfaces in contact with each other. The magnitude of friction depends upon the smoothness/roughness of the surfaces and how hard the objects are pushed together.	36. Objects resist acceleration from the state of rest because of friction (rather than inertia). 40. Friction is not a force. 51. Friction is a force in the vertical (holding an object down). 52. Objects cannot exert forces parallel to their surface.
K	Friction is caused by the interaction between tiny bumps and irregularities in the surfaces of objects as they rub together.	51. Friction is a force in the vertical (holding an object down). 52. Objects cannot exert forces parallel to their surface.

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